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What Makes Cities More Productive? Agglomeration Economies and the Role of Urban Governance: Evidence from 5 OECD Countries

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Abstract

This paper estimates agglomeration benefits across five OECD countries, and represents the first empirical analysis that combines evidence on agglomeration benefits and the productivity impact of metropolitan governance structures, while taking into account the potential sorting of individuals across cities. The comparability of results in a multi-country setting is supported through the use of a new internationally-harmonised definition of cities based on economic linkages rather than administrative boundaries. In line with the literature, the analysis confirms that city productivity increases with city size but finds that cities with fragmented governance structures tend to have lower levels of productivity. This effect is mitigated by the existence of a metropolitan governance body.

Keywords: Cities, productivity, governance, agglomeration economies
JEL Classifications: R12; R23; R50; H73

1. Introduction and literature review

A country's productivity is, in large part, determined by the productivity of its large cities. Metropolitan areas – urban agglomerations with more than half a million inhabitants – are home to over half of the population of OECD member countries and account for an even larger share of total GDP. Given the need to raise the potential for long term growth, understanding how to increase the productivity of these cities is therefore an urgent challenge. That the economic productivity of a city increases with its size (Figure 1) is well documented in many single country studies. Part of this relation stems from the sorting of better educated and more able individuals into larger cities. However, beyond this compositional effect, an emerging body of evidence suggests that the productivity of a given individual increases with the size of the city in which they work. A less well-documented relationship is between a city's governance structure and its residents' productivity. While, for some aspects, a larger number of local governments might offer productivity advantages due to competition, on the other hand it can lead to lower productivity if it is associated with lack of coordination in infrastructure investment or land-use planning.

This paper uses a novel database, with a harmonized definition of cities, which enables a cross-country analysis of the impact of city size and governance structures on urban productivity. The analysis follows a two-step empirical strategy that accounts for potential sorting of more productive individuals into certain cities.

The novelties of this paper are twofold. Firstly, using a a functional definition of cities as unit of analysis allows a multi-country investigation into the magnitude and causes of urban productivity that is not biased by differentially defined national administrative city boundaries. The "Functional Urban Areas" [1] that are underlying the analysis are functionally – rather than administratively – defined following an internationally consistent and coherent methodology developed by the OECD and the EU.[2] As a result, whereas existing research has been confined to single country studies, this paper combines evidence from five OECD member countries (Germany, Mexico, Spain, United Kingdom, and United States).[3]

1 . Throughout the paper "city" will be used synonymously with "Functional Urban Area". When specific reference to the core city of a Functional Urban Area is made, this is indicated in the text.

2 . See OECD (2012a) for the methodology and http://www.oecd.org/gov/regional-policy/functionalurbanareasbycountry.htm for the defined Functional Urban Areas for 29 OECD countries.

3 . Ideally this study would cover all OECD countries. The methodology used in this study made this infeasible, given the constraints to gain access to adequate microdata sources. The data required for this study need to contain information on individual characteristics, earnings, detailed information on the place of residence and they need to represent a large enough sample to guarantee a sufficient number of observations in each city. The five countries studied were selected for their data availability and to maximise the number of available city observations.

The second novelty of the paper is its focus on the role of urban governance and the complexity that arises from administrative fragmentation within a city's boundaries. The paper investigates how a city's governance structure might affect its residents' productivity. Governance failures in agglomerations often result from the fact that administrative boundaries are based on centuries-old borders that do not correspond to current patterns of human settlement and economic activity. Problems arise in particular in fields, such as transport or spatial planning, that require not only coordination across different levels of government, but also horizontal coordination across numerous local governments at the same level. The use of the "Functional Urban Area" as our unit of analysis allows us to investigate the impact of the administrative boundaries on the productivity of the city.

In its analysis of the drivers of urban productivity this paper spans two related fields of the literature – the rapidly developing literature on agglomeration economies, and that which investigates the role of local governance and governmental fragmentation on city prosperity.

The large theoretical literature on agglomeration economies tends to conclude that agglomeration benefits accrue through learning, through knowledge sharing, through specialisation, and through deep labour markets (see the reviews of Rosenthal and Strange, 2004; Duranton and Puga, 2004; and Puga, 2010). Recent empirical evidence highlights the importance of controlling for selection effects when estimating agglomeration benefits. Urban productivity arises, in part, from a tendency of more talented individuals to co-locate in larger cities. This may occur either because the initial distribution of workers' skills differs by city size, or because workers sort by skills (Berry and Glaeser, 2005; Baum-Snow and Pavan, 2012). A large body of empirical work on urban productivity finds evidence that skill levels indeed increase with city size (e.g. Combes, Duranton and Gobillon, 2008; Gibbons, Overman and Pelkonen, 2010) , but there remains a substantial degree of heterogeneity across estimates and across countries (Melo, Graham and Noland, 2009). These studies also show that a sizeable share of the urban wage premium can be explained by observable and unobservable worker characteristics. It is therefore critical to account for the sorting of highly skilled individuals into cities when estimating productivity differentials across cities.

A second concern in identifying causal effects is that not only the quality of labour is influenced by city characteristics, but also its quantity. Successful cities that offer high wages attract more workers. Empirically, this issue has been addressed by instrumenting current city size with historical size or density (following the contribution by Ciccone and Hall, 1996), relying on persistence in city size and the assumption that factors that determined growth of cities in the past are unrelated to current productivity. Other instruments aim to capture factors that made certain locations more attractive explicitly, e.g. by using topological characteristics (Combes et al., 2010). Recent studies use politically driven impacts on city sizes as natural experiments (see e.g. Ahlfeldt et al., 2014; Brülhart, Carrère and Trionfetti, 2012; and Redding and Sturm, 2008) to identify a causal link. Neither of the strategies has been possible to implement in a multi-country setting.[4] However, empirical studies typically find that the bias from differential quality of labour is far more severe than the reverse causality bias in the quantity of labour (Combes, Duranton and Gobillon, 2011). For example, estimating agglomeration benefits for Germany, Ahrend and Lembcke (forthcoming) find only marginal differences when instrumenting current city size with historical city characteristics.

The second strand of literature that is relevant to this paper investigates the relationship between the structure of local governance and productivity, and highlights two possible underlying mechanisms. In the first place, there is the possibility that more administrative fragmentation – a larger number of local governments – is associated with more choice in the provision of public services. If this increased choice and the associated competition among local governments drives up the quality of local public services, then a positive association between fragmentation and productivity may result (Tiebout, 1956).[5]

However, Functional Urban Areas frequently consist of more than a hundred municipalities (OECD, 2013), adding a degree of complexity to the design and implementation of policies that require coordination, which can stymie the productivity of urban agglomerations. This suggests an alternative mechanism through which fragmentation in local governance may – in this case negatively – affect productivity or growth. Furthermore, local governmental units may fail to take into account the positive externalities associated with the public goods relevant at the level of the Functional Urban Area (see e.g. Pinto, 2007). Thus administrative fragmentation can, for example, obstruct transport infrastructure investments and effective land-use planning, thereby increasing congestion and reducing a city's attractiveness for individuals and businesses (see Ahrend, Gamper and Schumann, 2014). Fragmentation may also pose problems in the area of business and environmental regulation if the additional bureaucracy associated with fragmented governance impedes growth through its effect on the ease of doing business.[6] According to this mechanism local governance fragmentation is likely to be negatively associated with productivity within the Functional Urban Area.

Concrete negative impacts of fragmentation have also been documented in a number of case studies. For example in Chicago, administrative fragmentation was one of the factors that led to an overly complex and not particularly efficient governance structure of public transit providers in the metropolitan area. This, in turn, is reflected in relatively low levels of integration of the public transit system, and has also contributed to underinvestment into its infrastructure (OECD, 2015). Similarly, in the Austrian

4 . A limitation that also pertains to our paper since we could not find similar suitable instruments for all the countries examined.

5 . There is a vast literature investigating the impact on quality of choice in specific public services (e.g., Bayer and Macmillan, 2005, and Rothstein, 2006, for education).

6 . See Djankov, McLiesh and Ramalho, 2006, on the impact of business regulation on growth.

metropolitan area of Vienna, some metro lines end suddenly in areas that have still fairly high population densities, when they have reached the administrative borders of the city of Vienna. In general, policy areas with significant externalities, like transport and land-use planning (OECD, 2015) or growth promoting policies (Cheshire and Magrini, 2009) are likely to be adversely affected by high coordination costs arising from administrative fragmentation.

Quantitative work regarding the nature of this relation has, thus far, reached little consensus. Where Stansel (2005) identifies a positive association between fragmentation and growth – both population growth and income growth – other work has found a negative relation.[7] Recent work by Hammond and Tosun (2011) shows that metropolitan areas and non-metropolitan areas are differently affected by administrative fragmentation. Interpreting the number of local governments within a US county as degree of fiscal decentralisation, they find that the number of special purpose districts (local governments formed to deliver a variety of specific public goods and services, e.g. water and waste management) positively affects employment and population growth, but not income growth in metropolitan counties. On the contrary, the number of general purpose local governments does not affect metropolitan counties, but has a negative impact on population and employment growth in non-metropolitan counties[8].

While the US literature tends to find a positive relationship between administrative fragmentation and economic growth, the existing evidence from Europe points mainly to a negative relationship. The hypothesis put forward is that a smaller number of jurisdictions and closer match of the highest tier authority with the functional economic region would increase the chances of forming a 'territorially competitive club', since the encompassed jurisdictions would face smaller transaction costs and spillover losses to neighbouring ones (Cheshire and Gordon, 1996). Linking this hypothesis with growth promotion, Cheshire and Magrini (2009) examine the impact of government fragmentation on functionally defined urban regions in Europe. Their empirical analysis finds that the proportion of the functional region's population located in the largest administrative jurisdiction is positively associated with economic growth.

The findings of the paper suggest that, in line with the previous literature on agglomeration economies, productivity tends to increase with city size for each of the five countries considered. When the five samples are combined, robust evidence for these agglomeration benefits is found with an estimated elasticity in the range of 0.02-0.05, implying that doubling a city's population is associated with roughly a

7 . Where Akai and Sakat (2002) for US States and Stansel (2005) for US metropolitan areas, have identified a positive association between fragmentation and growth – both population growth and income growth – other studies, such as Zhang and Zou (1998) and Xie, Zou and Davoodi (1999) identify a negative relation between fiscal decentralisation and growth.

8 . Unlike our study, they consider fragmentation within an administrative entity like the 'County', and not a functionally defined metropolitan area.

2-5% increase in productivity.[9] Within countries, cities with fragmented governance structures have lower levels of productivity. For a given population size, having twice the number of municipalities within a metropolitan area is associated with around 6% lower productivity, an effect that is mitigated by almost half when a governance body at the metropolitan level exists. The results also provide evidence that proximity to nearby populous cities affects positively the productivity of a city, implying that – in a certain sense – cities can take advantage of the agglomeration of their neighbours. Port access, skilled human capital and specialisation in high-tech manufacturing, finance and business services are also found to contribute to city productivity.

The remainder of the paper is organised as follows: section 2 presents some descriptive evidence, section 3 discusses the methodology adopted in this paper, section 4 presents the estimation results, and section 5 concludes.

2. Descriptive evidence

Figure 2 presents the level of city productivity premiums on the vertical axis and plots these against the size of the city – as measured by its resident population. Panel A combines the five countries studied in this paper while Panels B to F are disaggregated by country. For all countries studied, productivity is higher in larger cities; an upward trend is identified in each of the country cases, though with varying degrees of steepness. Countries differ also in the extent to which productivity varies across cities of similar size, with city productivity in Germany, the United Kingdom and the United States being far more homogenous than the productivity across cities in Spain or Mexico.

In the case of the United Kingdom, it is interesting, but perhaps unsurprising, to note that city productivity premiums in London are larger even than those that would be expected given its size. Furthermore, alongside human capital, proximity to London appears to account for much of the performance of the positive outliers. Bracknell, Wokingham, Basingstoke, High Wycombe and Guilford – all with high levels of tertiary education – are all within a 50km radius from London (with the exception of Basingstoke, which is located 77km away). In contrast, there is no specific geographical pattern among the negative outliers, but all have education levels below the UK average.[10]

9 . Combes, Duranton and Gobillon (2011) find the same range in their review of the literature.

10 . Walsall and Hastings are the two largest negative outliers. The former is an industrial town in West Midlands with particularly low levels of tertiary education at 12%, and the latter a south-east town with similarly low tertiary education levels at 15%. The average share of university graduates across UK cities was 19% in 2007.

In Spain, city productivity premiums in Madrid are slightly below what would be expected given its size, a result that is, in part, driven by particularly strong city productivity premiums in a number of mid-sized cities. In Germany, the most noteworthy feature is probably the strong east-west divide, with city productivity premiums in East German cities being, on the whole, significantly below the levels found in West German cities of comparable size. In line with this finding, the city productivity premium in Berlin lies in between the trends in East and West Germany. It is also noteworthy that a number of mid-sized German cities have city productivity premiums at levels similar to Munich, Stuttgart and Frankfurt – the most productive large agglomerations. This probably reflects a number of highly productive SME clusters in the manufacturing sector that – often for historical reasons – are located in smaller agglomerations.

In Mexico, there is a clear north-south divide. Negative outliers are mostly agglomerations in the south of the country, whereas positive outliers are generally located in the north, on or close to the US border. In contrast, some of the negative outliers in the United States are located on or close to the Mexican border. Also, other underperforming cities (including Chicago and Los Angeles) are relatively sprawled cities with low employment densities and relatively fragmented labour markets.[11]

The descriptive country charts in Figure 3 illustrate the degree to which administrative fragmentation is associated with productivity levels in cities. The degree of fragmentation of urban areas is measured by the number of municipalities per 100,000 inhabitants.[12] The charts show a tendency for more fragmented cities to have lower levels of economic productivity. The effect varies across countries and is largest in Mexico (Panel E).

For some time, the urban planning literature has highlighted the role of horizontal co-operation and coordination among local governments as a substitute for administrative consolidation in enhancing urban productivity (e.g. Blair, Staley and Zhang, 1996). This substitutability may shed some light on the strength of the impact of fragmentation in Mexico. Mayors of Mexican cities are elected for a three year term and are prohibited from running for immediate re-election. Furthermore, a large share of civil servants is replaced after each election cycle. This discontinuity in personnel may render it difficult to establish lasting co-operation across municipalities, potentially multiplying effects of fragmentation. In contrast, in the other countries, many cities have reasonably well-functioning coordination bodies, which – to some degree – may mitigate problems of fragmentation.

11 . In the case of Chicago, a relatively fragmented labour market, due to deficiencies in the public transport system, might contribute to its underperformance (c.f. OECD, 2012b).

12 . Municipalities for Germany, Mexico, Spain; local authority districts for the United Kingdom, and counties for the United States.

3. Methodology

Empirical work attempting to quantify the productivity premium, while accounting for selective sorting, has followed two paths. The first is based on the equilibrium location decisions of firms – under the assumption that firms will locate where they are most productive (see e.g. Ellison and Glaeser, 1997; Rosenthal and Strange, 2003). The second strand of empirical work, the one followed in this paper, focusses instead on the productivity of workers. Empirical work along these lines has found a relation between urban density and productivity – proxied by wages – that continues to hold after controlling for both observable and (permanent) unobservable individual characteristics (e.g. Glaeser and Maré, 2001).[13]

The main contribution of this paper, in terms of its methodological approach, is the common empirical strategy applied across five OECD countries. This not only ensures that the individual country results are comparable, but allows for pooled regressions on the full sample of cities from five countries. The latter aspect is of critical importance, given the limited number of cities in each country. Pooling helps create a sample with mass not only among small and medium sized cities or administratively congruent cites, but also among large or very fragmented cities. The harmonised approach is made possible through the use of an internationally comparable definition of "city" that is based on economic linkages, rather than administrative boundaries.

Administrative and functional definitions of cities do not always coincide. Many who work in central London, for example, commute to work from its surrounding municipalities. Likewise, manufacturing sites that are located on the outskirts of a city could require their workers to commute out. According to an administrative definition such commuting workers would not live and work in the same urban area, whereas a functional definition avoids this bias. More generally, a sole focus on the central administrative unit of a city will underestimate the population size of an urban area, overestimate the density, and might over- or underestimate its productivity. The empirical analysis of this paper therefore employs the Functional Urban Area (FUA) definition of cities.

The specific definition of a "Functional Urban Area" is a new city definition proposed by the OECD and EU that is based on urban economic functions rather than administrative boundaries. It has been applied in a comparable way across most OECD countries, aggregating contiguous lower spatial units that form part of a common Functional Urban Area, by taking into account density and population as well as

13 . Much of the literature uses wages as a proxy for productivity. Under standard wage setting mechanisms, the marginal product of labour should be reflected in wages. Even if higher wages are offset by larger commuting and housing costs (from the perspective of the worker), if there were no productivity advantages in urban areas, firms would move to low wage location.

commuting patterns (OECD, 2012a). The results are 1,148 largely self-contained urban labour markets with at least 50,000 inhabitants across 28 OECD member states (OECD, 2012a).[14]

Specifically, municipalities or similarly small administrative units are used to build up the Functional Urban Areas in a comparable way across countries. Units that include a majority of its population living in high-density contiguous grids of 1,500 inhabitants per square kilometre (km^2) are designated as "urban centres".[15] Urban centres that have more than 15% of their population commuting from one to the other are considered to belong to the same FUA. Less densely populated municipalities that have at least 15% of their workforce commuting to an urban centre are included in the same FUA and form its commuting zone.

To address the concern of non-random sorting of skilled individuals, a two-step empirical approach is applied separately to national microdata surveys for the five countries in the study (see Combes, Duranton and Gobillon, 2011, for a theoretical discussion of this methodology).[16] In the first step, the functional OECD-EU definition of cities is matched with large scale administrative or survey-based microdata from each of the five countries. The resulting data sets are then used to estimate productivity differentials – net of individual skill differences and other individual level observables – across cities using an OLS regression of the natural logarithm of wages on individual level characteristics and a set of fixed effects for each city-year combination.[17]

$$y_{iat} = \beta X_{iat} + \gamma_{at} d_{iat} + \varepsilon_{iat} \qquad (1)$$

y_{iat} denotes the natural logarithm of wages for individual i in city a at time t, X a vector of individual characteristics, d a vector of dummy variables that take the value 1 if the individual resides in the city a at time t, and ε denotes an error term. The coefficient vector of interest, γ, captures the productivity differential across cities, net of (observable) skill differences.

Since the primary concern in this study is to create comparable estimates for all five countries (Germany, Mexico, Spain, United Kingdom, and United States), the specific controls that can be included are limited to the controls available in all five data sets. Not all variables are available in all countries and the different data sources include both panel data as well as repeated cross-sections. The common set of

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14 . For the United States the local unit matched differs between small and medium-sized Functional Urban Areas (with 50,000-500,000 inhabitants) and metropolitan areas with more than 500,000 inhabitants. Therefore this study only considers only metropolitan areas for the United States.

15 . For Canada and the United States the threshold deviates and is set at 1,000 inhabitants per km^2.

16 . See Combes, Duranton and Gobillon (2008) or Monastiriotis (2002) for earlier implementations of the empirical methodology.

17 . This model follows the seminal work by Mincer (1974) and the large body of empirical literature that followed it. The German data is right-censored, which introduces a bias in OLS estimation. However comparing the results from a Tobit model, which accounts for censoring, and the OLS model shows that the bias is negligible (see Ahrend and Lembcke, 2014).

controls selected includes age (and its square), education (dummies for degree categories), occupation (dummies for occupational categories), gender (dummy) and an indicator for part-time work (dummy), in addition to the city-year fixed effects.[18]

The city-year fixed effects obtained in the first step capture city productivity differentials, net of the observable skill-relevant characteristics of the urban workforce for each of the five countries (c). The estimated productivity differentials ($\hat{\gamma}_{cat}$) are used as the dependent variable in the second step, in which they are regressed on indicators for structural and organisational determinants of city productivity – both time varying (Q_{cat}) and non-time varying (Z_{ca}). Additional country-year fixed effects d_{ct} control for time-fixed differences across countries, national business cycles and country specific inflation (the first step estimates nominal productivity differentials).

$$\hat{\gamma}_{cat} = \delta Q_{cat} + \mu Z_{ca} + \theta d_{ct} + u_{cat} \qquad (2)$$

The standard errors in the OLS estimation are clustered at the city level to allow for heteroscedasticity and arbitrary autocorrelation over time (for each city) in the error term. In addition to the main specification, which uses a balanced panel of all cities for the three years that are available for all five countries (2005-2007), estimates are reported on a subsample that focuses on metropolitan areas – cities with more than 500,000 inhabitants – only. This restriction is necessary as data on the presence of formal co-operation arrangement across municipal boundaries (in the form of metropolitan governance bodies) are only available for metropolitan areas. Furthermore, an alternative indicator for administrative fragmentation, previously used in the literature, is used as a robustness check. A second robustness check aims at assessing whether individual countries in the study are driving the results. Since the number of metropolitan areas in each country is small, individual country regressions that evaluate the link between governance structures and productivity are infeasible. Instead, a jackknife-style procedure is used, i.e. the key results are re-estimated using a sample that leaves out one of the countries at a time.

There is a range of city characteristics (Q_{cat} and Z_{ca}) considered in this study. The five countries' samples are used to construct city-year indicators that capture city size, industrial structure and human capital. The share of employees working in 1-digit industries, with manufacturing split into four categories based on technology intensity, and the Herfindahl index of employment shares at the 2-digit industry level are used to capture the industrial structure. The Herfindahl index is defined for each city as the sum of the squared employment shares in each industry. The country samples are also used to estimate the population

18 . Panel data are available for three countries (Germany, Spain, and United Kingdom). The common specification can therefore not account for individual specific unobserved skill differences in the first step. Results for such specification are reported in separate individual country studies. See Ahrend and Lembcke (forthcoming) for Germany, Georgiadis and Kaplanis (forthcoming) for the United Kingdom, and Diaz and Kaplanis (forthcoming) for Spain. Kaplanis and Tello (forthcoming) report additional results for Mexico that, however, do not allow for panel estimation.

in each FUA and year.[19] Finally, the share of university degree holders among the 25-64 year old workforce in the city is used as a measure for human capital. Further descriptions of the data used for each country, as well as summary statistics, are provided in the Appendix.

The indicators constructed from the different country samples are then combined with data from the OECD Metropolitan Database on administrative fragmentation (the number of local governments within a city), the presence of a governance body (from Ahrend, Gamper and Schumann, 2014), a dummy variable for the presence of a port in the city (based on data from Lloyd's List "Ports"), and the surface area covered by the city (own calculations from different administrative sources).[20] The measure of administrative fragmentation refers to an earlier time period (2001) than the estimated city-year productivity differentials (2005-2007), which thus alleviates endogeneity concerns.

4. Empirical results

Putting numbers to the suggestive trends in the descriptive graphs of Section 2, country-by-country regressions show productivity to be higher in larger cities across all five countries in this study (Table 1). When city productivity differentials are regressed on city population, the estimated elasticities range from 0.016 (United Kingdom) to 0.063 (United States). That is, a US city with double the population of another comparable US city is, on average, about 6.3% more productive.[21] The main results from the pooled regression, reported in Table 2, present equally strong evidence for sizeable agglomeration benefits. They indicate that, a city with double the number of residents is associated with 3.8%higher productivity.

The source of agglomeration benefits can be further disentangled by a specification that uses both population density and surface area of the city. The coefficient of (ln) population density gives the elasticity of city productivity with respect to its size, holding constant the surface area covered by the city. The coefficient on (ln) city surface area captures the impact of an expansion of city limits while population density remains constant; that is, when population and area expand at the same rate. Finally, the difference

19 . Spain and Germany are exceptions. For Spain, internal OECD estimates for city population are used. For Germany, only total employment can be observed; after the results from the last German census, municipality level population data became unavailable. To estimate population in German FUAs the ratio of employment to population for 2000 (OECD estimates) is used to rescale the observed employment levels for all years.

20 . For the OECD Metropolitan database see: http://dotstat.oecd.org/Index.aspx?Datasetcode=CITIES and http://www.oecd.org/gov/regional-policy/functionalurbanareasbycountry.htm. For port cities see http://directories.lloydslist.com/ accessed 01.07.2013.

21 . Interpreting the elasticity multiplied by 100 as the percent increase in productivity associated with a "doubling in city size" is commonly used in the literature to give an idea of the size of the impact. The interpretation is not exact as the ln-approximation error is only negligible for small changes. The exact marginal effect for a doubling in city size is the product of the estimated coefficient with ln(2)≈0.693.

between the area and the density coefficients gives the estimated impact of increasing the surface area covered by a city while holding the total population constant (i.e. decreasing density with the given population spreading out over a larger surface).

Interestingly, coefficients for population and area are similar (Table 2, second column), indicating that both an increased population for a given surface area, and an increased spatial extent, while population density remains constant, have similar productivity effects. As explained, the impact of an increase in the spatial extent of a FUA, holding the population constant, is calculated as the difference between these two elasticities. In this specification the difference is zero. This confirms that – for a given population – agglomeration benefits do not increase with the surface area covered by a city. The introduction of additional city characteristics as controls leads to estimated agglomeration elasticities ranging from 0.02 to 0.05, with highly statistically significant coefficients in all specifications (Table 2, remaining columns).

In addition to agglomeration benefits, the focus in this study is on horizontal governmental fragmentation. An indicator for fragmentation is included in Table 2 from the third column onwards. It is measured as the natural logarithm of the number of municipalities within a city.[22] It is important to note that the specification controls for city size, since size is already captured by the population density and area indicators in the regression. The variable is also implicitly normalised for each country since the empirical specification includes a full set of country-year fixed effects. The result of the inclusion of this variable is a striking productivity penalty for more fragmented cities. The estimated coefficient (-0.032) is negative and highly statistically significant. It indicates that between two cities of the same size, in the same country, if one has twice the number of municipalities within its functional boundaries it is on average about 3.2% less productive. The magnitude of this result remains largely unaffected when further controls are introduced to the estimation.

The penalty is likely to be a lower bound for the impact of administrative fragmentation. Co-operation and coordination across municipalities, for example in the form of governance bodies, is common in OECD countries and can alleviate, to some extent, the problems associated with fragmentation. If this is the case, not explicitly controlling for coordination bodies will result in underestimates of the true extent of the fragmentation penalty (i.e. the estimated coefficient is too small in absolute value).

Ahrend, Gamper and Schumann (2014) collect information on governance bodies for OECD metropolitan areas, i.e. Functional Urban Areas with at least 500,000 inhabitants, a subset of the cities considered in this study. Accounting explicitly for governance bodies therefore limits the analysis to 140 metropolitan areas. While this decrease in the size of the available sample reduces the available degrees of

22 . Local authority districts for the United Kingdom and counties for the United States.

freedom and therefore the precision of the estimates, especially when the full set of controls is considered, it can nonetheless shed some light on the true impact of fragmentation.

To ensure that estimates on the selected sample are comparable, Table 3 replicates the key results from Table 2, for metropolitan areas only. The estimates are similar compared to the specification that includes the full sample of cities. The impact of administrative fragmentation is the same, but point estimates for agglomeration benefits are slightly higher. This difference is however not statistically significant. Columns III, V, and VII introduce the impact of horizontal fragmentation in metropolitan areas with and without the mediating presence of a metropolitan governance body. The estimated impact of horizontal fragmentation becomes even more severe when the presence of governance bodies is taken into account. Without a governance body the negative impact on productivity is about 6%. The fragmentation penalty is halved if the city has a governance body. With a governance body, a doubling of the number of municipalities is associated with just 2.5-3% lower productivity.[23]

Given the small number of metropolitan areas in each country, it is not possible to consider the impact of fragmentation and governance bodies in each separately. However, it is possible to use a jackknife approach and re-estimate the models excluding one country at a time, which can reveal whether the results are driven by a single country. Table 4 presents the results with each column excluding the metropolitan areas from the indicated country. Without controlling for industry shares the results are qualitatively the same as the main results in Table 3. The weakest impact of administrative fragmentation is found when Mexico is excluded from the model, but even in this specification the productivity penalty is 3.2%. For the remaining subsamples the estimates range from 5-8% with governance bodies alleviating 40-60% of the impact. For completeness, the table also reports results that include industry shares, results that suffer from severe identification problems as the number of degrees of freedom in these models becomes very small.[24]

Arguing that coordination is simplified if residents are heavily concentrated in a single administrative unit, Cheshire and Magrini (2009) proxy for the degree of fragmentation in urban regions using the proportion of residents living in the largest municipality. Table 5 considers this alternative measure of fragmentation. The results in the first three columns show that concentration of a city's inhabitants does indeed appear to ease fragmentation penalties. A 10 percentage point decrease in the share of the population residing in the core municipality is estimated to reduce productivity, on average, by 0.5-0.7%.

23 . The coefficient on the interaction term indicates the difference in the impact of fragmentation for cities that do have a governance body compared to cities that do not have a governance body. E.g. the marginal effect of an increase in (ln) fragmentation in column (III) of Table 3 is: -0.057 + 0.031 x *gov.body*

24 . Standard errors are clustered at the metropolitan area level, which makes the number of metropolitan areas and not the number of observations the base degree of freedom.

One might take this result to also indicate that the estimated penalty from administrative fragmentation is not truly related to the cities' governance, but captures some unfavourable effects of urban structure.[25]

However, when both indicators, concentration and administrative fragmentation, are combined in the same specification – columns (IV) through (VI) – horizontal fragmentation measured by the (natural logarithm) of the number of municipalities is very robust and in line with the main estimates, but concentration of residents becomes insignificant. Dominance of a single municipality, in terms of the share of residents, cannot solve the coordination problems raised by fragmentation and it is the presence of administrative boundaries, rather than urban structure that turns out to be the more relevant measure. To capture the urban structure, we have experimented by using the Herfindahl Index of the population across municipalities within the city, which should account to some extent for the density distribution within the city. The Herfindahl Index behaves qualitatively in a similar pattern with the population share in the largest municipality and does not change the reported results. Therefore, while urban structure can certainly have an impact on local conditions, our results suggest that administrative fragmentation still plays a key role when it comes to urban productivity premia.

Going back to Table 2 and the remaining indicators, aggregate human capital, measured by the share of university graduates in the city, increases productivity. A 10 percentage point increase in the share of university graduates is associated with a 3% increase in productivity. It is important to note that this result does not indicate the direct impact of human capital on productivity, but only the externality associated with working in a city with many university graduates. And, while port cities exhibit higher productivity – on average port cities are 2-4% more productive than comparable cities without a port – there appears to be no evidence that capitals differ systematically from other cities.

Industrial specialisation, measured by the normalised Herfindahl Index of employment shares at the 2-digit industry level, has a negative and weakly significant impact. This suggests that a diversified industrial structure has a positive impact on productivity. However, variation in estimates across specifications suggests that this finding is not overly robust. Moreover, clear evidence can be found that cities with a high share of employees in specific industries exhibit higher productivity. The base category in the regressions is the share of employees in construction, such that when an increase in an industry share is considered, the share of employees in construction is reduced by the same amount. The results (column IX in Table 2) indicate that a 1 percentage point increase in the share of high-tech manufacturing workers (and a concomitant one percentage point decrease in the share of construction workers) is, on average, associated with a 1.2% increase in productivity in the city. This productivity premium gradually reduces with the technological intensity of the manufacturing industry: it is 0.8% and 0.6% for medium-high-tech and

25 . The authors would like to thank the anonymous referee who voiced this concern.

medium-low-tech manufacturing respectively, while it becomes insignificant for low-tech manufacturing. The productivity premium for financial intermediation is estimated at 1.0% for a 1 percentage point increase in the employment share, while that of business services and real estate activity is 0.4%. Interestingly, it is not only the knowledge intensive services that yield a productivity premium, but also technology intensive manufacturing.

The final variable considered to determine productivity is the proximity of a Functional Urban Area to other cities. The variable captures the idea that the exchange of people, ideas and goods is greatly simplified by close connections between places. The indicator measures the number of people that residents of a given city can directly interact with, within a "reasonable" amount of time, the idea being that a meeting of several hours can take place going back and forth within a day. It is defined as (the natural logarithm) of all inhabitants in other Functional Urban Areas within a 300 kilometre radius around a city, divided by the distance. For the sample of all cities the estimates in Table 2 indicate that, ceteris paribus, doubling the (distance weighted) number of city residents within 300km is associated with 1-2% higher productivity. The estimated effect is stable across specifications.

5. Concluding remarks

This paper estimates productivity differentials of functionally defined cities – "Functional Urban Areas" – across five OECD countries (Germany, Mexico, Spain, United Kingdom, and United States) and investigates the relationship of urban productivity with a city's size and its governance structure – the degree of horizontal administrative fragmentation and the presence of a governance body. It contributes to the literature on agglomeration benefits, by offering a coherent and comparable identification strategy that is applied to microdata from each of the five OECD countries. The two-step econometric approach adopted in this paper enables the analysis to capture the pure productivity advantages that arise at the city level, accounting for the potential sorting of more productive individuals into certain cities. The comparability of the analysis is supported through the use of an internationally harmonised definition of urban areas, according to functional economic linkages, rather than administrative boundaries. Finally, as far as the authors are aware, this paper represents a first attempt in the literature to empirically examine the relationship between administrative fragmentation, metropolitan governance structures and city productivity across a large number of cities.

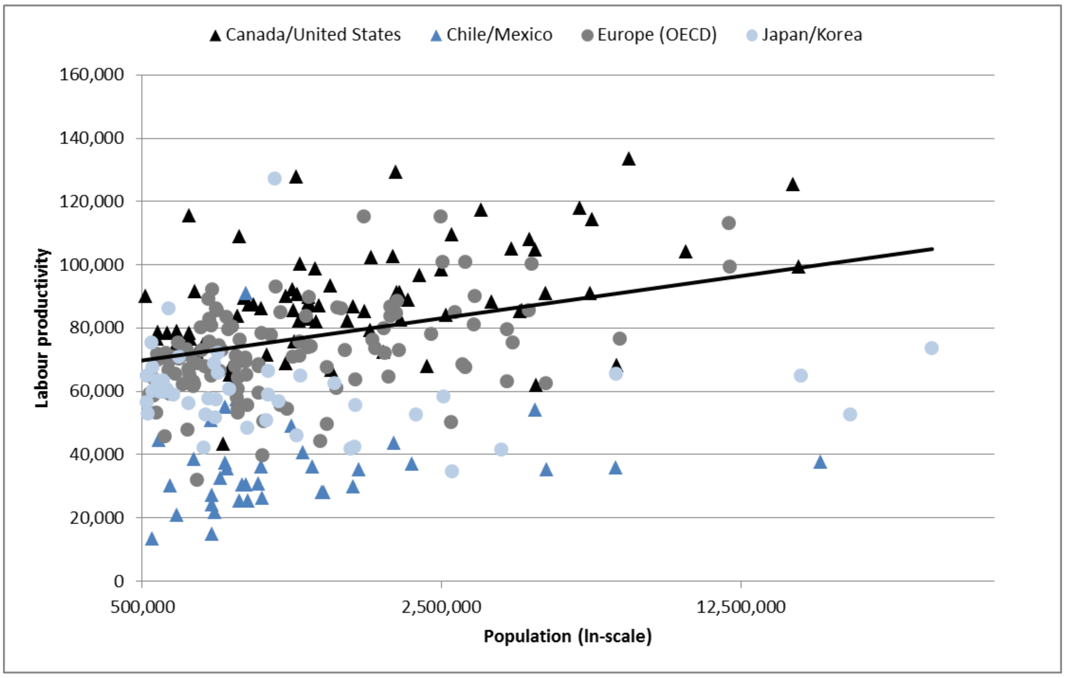
In line with the previous literature, the analysis confirms that city productivity premiums tend to increase with city size. Pooled across five OECD countries, estimates indicate that, ceteris paribus, a twofold increase in city size is associated with a 2-5% increase in productivity. The analysis indicates that urban productivity is also influenced by the population size of nearby cities.

Crucially, this paper identifies a significant role for horizontal administrative fragmentation of a city's governance structure in determining the magnitude of city productivity premiums. Specifically, for two cities of similar size and population composition in terms of observable characteristics, but with one city having twice the number of municipalities, the estimates indicate that productivity in the more fragmented city is between 3 and 4% lower. The estimate is likely a lower bound, as alleviating mechanisms are likely to be present. This study finds that if the presence of a metropolitan governance body is taken into account, the fragmentation penalty lies around 6%, with governance bodies alleviating the penalty to about half its size.

While the presence of a governance body mitigates the negative effect of fragmentation, little is known about the underlying transmission mechanisms from administrative fragmentation, via governance arrangements to stymied productivity. Important policy areas that are likely to create inefficient outcomes at the metropolitan level are land-use and transport polices, which can greatly benefit from adequate metropolitan coordination. Descriptive evidence suggests that the presence of governance bodies is associated with less sprawling development, and that transport authorities at the metropolitan level are linked with better quality in public transport provision (Ahrend, Gamper and Schumann, 2014). But the influence of administrative fragmentation may stem from a variety of associated factors and warrants further investigation. This paper constitutes a first attempt to establish a link between governance arrangements and economic outcomes; a full examination of the causes of lower productivity in more administratively fragmented urban areas will require more detailed information on urban governance structures.

Figures and tables

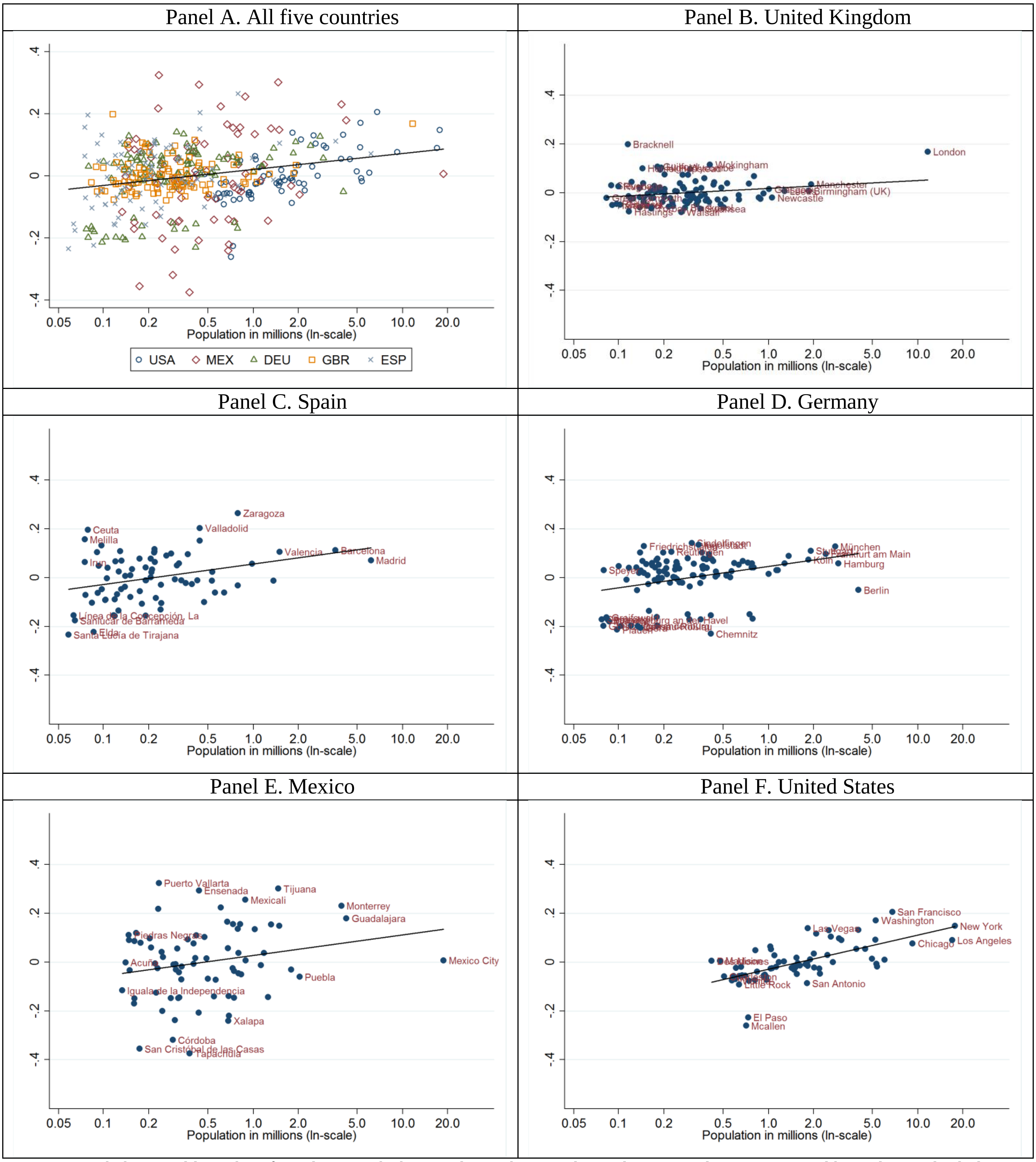
Figure 1. City size and labour productivity (2010)



Notes: Labour Productivity is measured as GDP (Millions of US$ constant PPP, constant prices, reference year is 2005) divided by the total number of employees in a Functional Urban Area. Data refer to 2010 or the closest available year.

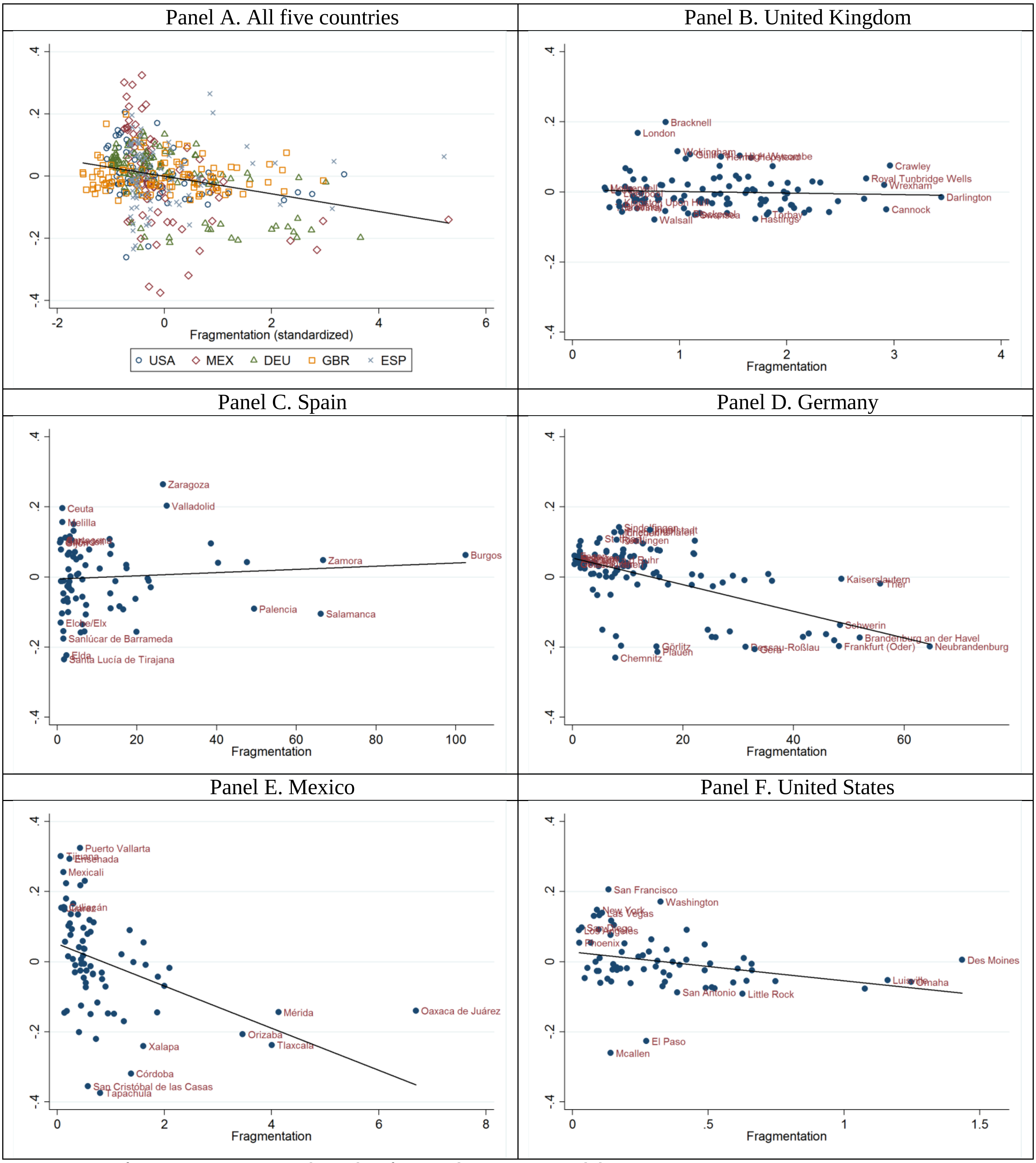
Data source: OECD Metropolitan Explorer.

Figure 2. City size and city productivity (2007)



1. With the natural logarithm of population on the horizontal axis, the vertical axis plots city productivity, estimated by applying individual wage regressions to national microdata in order to control for workforce composition of cities. Log hourly wages/earnings are regressed on gender (dummy), age, age squared, education (dummies), occupation (dummies) and city-year dummies; the coefficients of the latter are taken to denote productivity differentials. The analysis is conducted at the Functional Urban Area level. Source: Own calculations based on microdata from national surveys.

Figure 3. Horizontal administrative fragmentation and city productivity



1. See note of Figure 1. Fragmentation is the number of municipalities per 100,000 inhabitants.

Table 1. Regressions from individual country regressions

	UK	Spain	Germany	US	Mexico	UK	Spain	Germany	US	Mexico
ln(population)	0.016*	0.034***	0.037***	0.063***	0.042**					
	(0.009)	(0.012)	(0.010)	(0.008)	(0.020)					
ln(pop.density)						0.009	0.046***	0.068***	0.066***	0.022
						(0.009)	(0.011)	(0.010)	(0.009)	(0.019)
ln(area)						0.019*	0.032**	0.020**	0.058***	0.083***
						(0.01)	(0.013)	(0.009)	(0.010)	(0.021)
R-squared	0.666	0.294	0.191	0.914	0.483	0.649	0.314	0.328	0.915	0.569
Observations	808	532	981	345	825	808	532	981	345	825
FUAs	101	76	109	69	75	101	76	109	69	75

Notes: Table reports OLS regressions with estimated Functional Urban Area (FUA) productivity as dependent variable. FUA productivity is estimated by applying individual wage regressions to national microdata in order to control for workforce composition of cities. Log hourly wages/earnings are regressed on a gender (dummy), age, age squared, education (dummies), occupation (dummies) and city-year dummies; the coefficients of the latter are taken to denote productivity differentials. (see text for details). Variable definitions in section 4. Standard errors are clustered at the Functional Urban Area level, all specifications include time fixed effects.
Data sources: UK: ASHE/LFS; Spain: MCVL; Germany: IAB; US: IPUMS; Mexico: ENE/ENOE
***/**/* indicates a statistically significant coefficient at the 1%/5%/10% level
Sample years are: 2003-2010 (UK); 2005-2011 (Spain); 1999-2007 (Germany); 1990, 2000, 2005-2007 (US); 2000-2010 (Mexico)

Table 2. Pooled regressions: common years (2005-2007)

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)
ln(population)	0.038***									
	(0.005)									
ln(density)		0.038***	0.048***	0.045***	0.042***	0.043***	0.037***	0.034***	0.018***	0.016**
		(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
ln(area)		0.038***	0.064***	0.070***	0.066***	0.066***	0.062***	0.058***	0.039***	0.036***
		(0.006)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)	(0.008)	(0.008)
ln(municipalit.)			-0.032***	-0.035***	-0.037***	-0.037***	-0.036***	-0.036***	-0.029***	-0.029***
			(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
ln(pop. in				0.017**	0.015*	0.015*	0.018**	0.017**	0.013*	0.012*
catchment area)				(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.007)
% university					0.273***	0.275***	0.283***	0.258***	0.287***	0.275***
graduates					(0.077)	(0.077)	(0.077)	(0.075)	(0.076)	(0.073)
Capital						-0.017	-0.011	-0.000	0.019	0.028
						(0.042)	(0.037)	(0.038)	(0.030)	(0.030)
Port							0.027**	0.027**	0.038***	0.039***
							(0.011)	(0.011)	(0.010)	(0.010)
Herfindahl								-0.698*		-0.704***
index								(0.358)		(0.266)
Agriculture									0.085	0.0808
									(0.253)	(0.257)
High-tech									1.176***	1.104***
manufacturing									(0.227)	(0.234)
Med. high-tech									0.824***	0.840***
manufacturing									(0.140)	(0.135)
Med. low-tech									0.591***	0.494***
manufacturing									(0.146)	(0.146)
Low-tech									0.069	0.082
manufacturing									(0.161)	(0.149)
Electricity									-0.812*	-0.931**
									(0.454)	(0.463)
Trade									0.229	0.223
									(0.174)	(0.171)
Catering									0.381	0.472**
									(0.259)	(0.230)
Transport &									0.002	-0.126
communication									(0.193)	(0.200)
Finance									0.955***	0.878***
									(0.176)	(0.181)
Real estate									0.449**	0.410**
& business									(0.183)	(0.176)
Public									0.079	0.057
administration									(0.260)	(0.261)
Educ., health									-0.100	-0.120
& social work									(0.157)	(0.154)
Other services									0.561**	0.535*
									(0.276)	(0.275)
R-Squared	0.760	0.760	0.779	0.783	0.788	0.788	0.791	0.794	0.852	0.854

Observations	1,290	1,290	1,290	1,290	1,290	1,290	1,290	1,290	1,290	1,290
FUAs	430	430	430	430	430	430	430	430	430	430

Notes and data sources: see Table 1
Includes an interaction control of country and year fixed effects (Country x Year FE).
***/**/* indicates a statistically significant coefficient at the 1%/5%/10% level

Table 3. Pooled regressions on governance indicators (2005-2007)

	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
ln(density)	0.049***	0.064***	0.065***	0.049***	0.047***	0.035***	0.035***
	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)	(0.010)	(0.011)
ln(area)	0.057***	0.082***	0.085***	0.086***	0.087***	0.069***	0.070***
	(0.010)	(0.012)	(0.012)	(0.014)	(0.013)	(0.014)	(0.014)
ln(municipalit.)		-0.032***	-0.057***	-0.035***	-0.066***	-0.029***	-0.033***
		(0.010)	(0.016)	(0.008)	(0.017)	(0.007)	(0.013)
ln(municipalit.)			0.031**		0.036**		0.006
× govern. body			(0.014)		(0.015)		(0.011)
Governance			-0.079**		-0.092**		-0.024
Body			(0.034)		(0.038)		(0.027)
ln(pop. in				0.021**	0.022**	0.013	0.013
catchment area)				(0.010)	(0.010)	(0.008)	(0.008)
% university				0.426***	0.478***	0.378**	0.390**
graduates				(0.150)	(0.138)	(0.155)	(0.152)
Capital				-0.051	-0.025	-0.046*	-0.045
				(0.039)	(0.040)	(0.027)	(0.030)
Port				0.026*	0.025*	0.030***	0.031***
				(0.014)	(0.013)	(0.010)	(0.010)
Herfindahl				-1.013	-1.136	0.492	0.349
index				(1.332)	(1.328)	(0.846)	(0.858)
Agriculture						0.378	0.429
						(0.556)	(0.547)
High-tech						1.073**	0.998**
manufacturing						(0.436)	(0.450)
Med. high-tech						1.077***	1.052***
manufacturing						(0.335)	(0.344)
Med. low-tech						2.031***	2.003***
manufacturing						(0.544)	(0.544)
Low-tech						1.054***	1.076***
manufacturing						(0.356)	(0.352)
Electricity						-0.488	-0.412
						(1.408)	(1.433)
Trade						0.687	0.704
						(0.475)	(0.480)
Catering						0.184	0.130
						(0.780)	(0.729)
Transport &						-0.029	-0.0766
communication						(0.574)	(0.583)
Finance						1.717***	1.668***
						(0.421)	(0.420)
Real estate						0.352	0.420
& business						(0.493)	(0.487)
Public						1.028**	1.023**
administration						(0.466)	(0.445)
Educ., health						-0.134	-0.113
& social work						(0.351)	(0.341)

Other services						2.291***	2.265***
						(0.478)	(0.491)
R-Squared	0.829	0.847	0.855	0.869	0.880	0.928	0.929
Observations	420	420	420	420	420	420	420
FUAs	140	140	140	140	140	140	140

Notes and data sources: see Table 1
Estimates include only metropolitan areas, i.e. Functional Urban Areas with at least 500,000 inhabitants, since information on the presence of a governance body is not available for smaller FUAs.
Includes an interaction control of country and year fixed effects (Country x Year FE).
***/**/* indicates a statistically significant coefficient at the 1%/5%/10% level

Table 4. Pooled regressions excluding one (2005-2007)

	Pooled estimates for USA, MEX, DEU, GBR & ESP, except:									
	USA	MEX	DEU	GBR	ESP	USA	MEX	DEU	GBR	ESP
ln(pop.density)	0.068***	0.037***	0.048***	0.048***	0.055***	0.024	0.039***	0.031***	0.036***	0.039***
	(0.028)	(0.01)	(0.012)	(0.012)	(0.011)	(0.021)	(0.010)	(0.011)	(0.011)	(0.011)
ln(area)	0.140***	0.059***	0.092***	0.092***	0.088***	0.068***	0.052***	0.066***	0.072***	0.069***
	(0.026)	(0.011)	(0.014)	(0.013)	(0.013)	(0.021)	(0.012)	(0.014)	(0.014)	(0.014)
ln(municipalit.)	-0.075***	-0.032*	-0.052***	-0.066***	-0.080***	-0.022*	-0.018*	-0.018	-0.032***	-0.044***
	(0.022)	(0.020)	(0.021)	(0.019)	(0.016)	(0.016)	(0.013)	(0.015)	(0.013)	(0.013)
ln(municipalit.)	0.027*	0.031**	0.024	0.037**	0.049***	-0.013	0.012	-0.007	0.003	0.014
× gov. body	(0.020)	(0.016)	(0.019)	(0.016)	(0.015)	(0.015)	(0.011)	(0.013)	(0.011)	(0.011)
Governance	-0.054	-0.070**	-0.084**	-0.092***	-0.111***	0.038	-0.027	-0.018	-0.017	-0.041*
body	(0.055)	(0.042)	(0.041)	(0.039)	(0.036)	(0.041)	(0.026)	(0.028)	(0.030)	(0.027)
ln(pop. in	0.029**	0.025**	0.022**	0.024***	0.015**	0.016*	0.017**	0.011*	0.012*	0.009
catchm. area)	(0.015)	(0.012)	(0.010)	(0.01)	(0.009)	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)
% university	-0.020	0.489***	0.593***	0.532***	0.459***	0.108	0.396***	0.418***	0.427***	0.319**
graduates	(0.274)	(0.138)	(0.143)	(0.165)	(0.151)	(0.320)	(0.143)	(0.164)	(0.162)	(0.164)
Capital	-0.077	-0.021	-0.046	-0.044	-0.010	-0.024	-0.042*	-0.062**	-0.060**	-0.029
	(0.063)	(0.035)	(0.041)	(0.047)	(0.040)	(0.051)	(0.027)	(0.031)	(0.034)	(0.032)
Port	0.001	0.024***	0.027**	0.022*	0.028**	0.019	0.025***	0.035***	0.032***	0.034***
	(0.025)	(0.009)	(0.016)	(0.015)	(0.013)	(0.017)	(0.009)	(0.011)	(0.010)	(0.009)
Herfindahl						0.330	0.028	0.440	0.449	0.344
index						(1.159)	(1.600)	(0.976)	(0.958)	(0.905)
Agriculture						-0.185	1.130*	0.528	0.566	0.341
						(0.520)	(0.700)	(0.582)	(0.561)	(0.548)
High-tech						-0.008	0.996	-2.132*	-0.085	-0.389
manufacturing						(2.265)	(1.591)	(1.469)	(1.675)	(1.466)
Med. high-tech						1.832***	0.668*	0.914**	1.183***	0.974**
manufacturing						(0.596)	(0.460)	(0.461)	(0.483)	(0.462)
Med. low-tech						0.753*	0.903**	1.081***	1.200***	0.891***
manufacturing						(0.487)	(0.440)	(0.340)	(0.364)	(0.348)
Low-tech						1.698***	1.339***	2.007***	2.261***	1.833***
manufacturing						(0.689)	(0.552)	(0.661)	(0.587)	(0.573)
Electricity						0.255	1.289**	1.119***	1.245***	1.047***
						(0.543)	(0.602)	(0.362)	(0.366)	(0.370)
Trade						1.351***	0.459	0.581	0.886**	0.571
						(0.554)	(0.516)	(0.529)	(0.500)	(0.479)
Catering						-0.836	1.046*	0.175	0.385	-0.015
						(0.848)	(0.813)	(0.751)	(0.793)	(0.693)
Transport &						-0.759	-0.035	0.086	0.114	-0.185
communic.						(0.860)	(0.579)	(0.635)	(0.616)	(0.601)

Finance						1.999***	1.359***	1.547***	1.970***	1.599***
						(0.721)	(0.545)	(0.422)	(0.453)	(0.435)
Real estate						0.326	0.267	0.630	0.407	0.504
& business						(0.518)	(0.510)	(0.589)	(0.498)	(0.559)
Public						-0.031	1.284***	0.950**	1.332***	1.044**
administration						(0.659)	(0.486)	(0.453)	(0.550)	(0.451)
Educ., health						-0.171	-0.208	-0.052	-0.010	-0.147
& social work						(0.506)	(0.361)	(0.385)	(0.348)	(0.382)
Other services						1.566**	1.792***	2.386***	2.515***	2.059***
						(0.689)	(0.704)	(0.525)	(0.511)	(0.513)
R-squared	0.652	0.926	0.889	0.855	0.879	0.843	0.952	0.935	0.917	0.926
Observations	216	342	348	378	396	216	342	348	378	396
FUAs	72	114	116	126	132	72	114	116	126	132

Notes and data sources: see Table 1
Estimates include only metropolitan areas, i.e. Functional Urban Areas with at least 500,000 inhabitants, since information on the presence of a governance body is not available for smaller FUAs.
Includes an interaction control of country and year fixed effects (Country x Year FE).
***/**/* indicates a statistically significant coefficient at the 1%/5%/10% level

Table 5. Robustness checks with alternative fragmentation indicators (2005-2007)

	(I)	(II)	(III)	(IV)	(V)	(VI)
ln(density)	0.043***	0.031***	0.016**	0.046***	0.032***	0.016**
	(0.006)	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)
ln(area)	0.044***	0.036***	0.022***	0.064***	0.057***	0.036***
	(0.008)	(0.009)	(0.007)	(0.008)	(0.010)	(0.008)
ln(municipalit.)				-0.037***	-0.041***	-0.029***
				(0.007)	(0.007)	(0.006)
% of pop.in	0.054**	0.063**	0.072***	-0.037	-0.037	-0.001
largest municip.	(0.026)	(0.026)	(0.021)	(0.029)	(0.027)	(0.022)
ln(pop. in		0.012	0.009		0.017**	0.012*
catchment area)		(0.008)	(0.007)		(0.008)	(0.007)
% university		0.226***	0.299***		0.247***	0.275***
graduates		(0.078)	(0.075)		(0.075)	(0.074)
Capital		-0.031	0.004		0.003	0.028
		(0.044)	(0.036)		(0.035)	(0.030)
Port		0.035***	0.046***		0.026**	0.039***
		(0.012)	(0.010)		(0.011)	(0.010)
Herfindahl		-0.558	-0.567**		-0.752**	-0.705***
index		(0.344)	(0.270)		(0.366)	(0.270)
Agriculture			0.160			0.0805
			(0.264)			(0.257)
High-tech			1.237***			1.103***
manufacturing			(0.249)			(0.237)
Med. high-tech			0.854***			0.839***
manufacturing			(0.133)			(0.136)
Med. low-tech			0.656***			0.493***
manufacturing			(0.150)			(0.146)
Low-tech			0.060			0.0816
manufacturing			(0.145)			(0.149)
Electricity			-0.938*			-0.930**

			(0.479)			(0.463)
Trade			0.318*			0.222
			(0.172)			(0.171)
Catering			0.527**			0.472**
			(0.234)			(0.231)
Transport & communication			-0.241			-0.126
			(0.210)			(0.200)
Finance			0.877***			0.878***
			(0.181)			(0.180)
Real estate & business			0.392**			0.411**
			(0.181)			(0.176)
Public administration			0.107			0.0565
			(0.257)			(0.263)
Educ., health & social work			-0.167			-0.119
			(0.156)			(0.154)
Other services			0.579**			0.535*
			(0.276)			(0.276)
R-Squared	0.763	0.775	0.845	0.780	0.794	0.854
Observations	1,290	1,290	1,290	1,290	1,290	1,290
FUAs	430	430	430	430	430	430

Notes and data sources: see Table 1
Includes an interaction control of country and year fixed effects (Country x Year FE).
***/**/* indicates a statistically significant coefficient at the 1%/5%/10% level

Appendix A. Data description and summary statistics

United Kingdom

The estimation of the first-stage is based on data from the UK Annual Survey of Hours and Earnings (ASHE) for 2003-2010. ASHE is the largest survey on labour market statistics with approximately 160,000 employees a year. It is a random sample of around 1% of the National Insurance pool, as it tracks employees whose national insurance ends with a specific pair of digits. The information is collected by questionnaires sent to employers in April each year, with questions on wages, job and individual workers characteristics. It is an unbalanced panel as individuals can be followed over time, but would drop from the survey if they become unemployed or move to self-employment. The sample is restricted to main jobs only.

ASHE provides detailed information on individual earnings and hours worked and for our analysis we use gross hourly earnings as our wage measure. Additional information on individual characteristics includes occupation, industry, whether the job is in the private or public sector, the worker's age and gender. Information on education is not available via ASHE and thus we have to impute education using the UK Quarterly Labour Force Survey for 2003-2010. Specifically, an individual's years of schooling in ASHE are simulated using estimates of the coefficients of the Best Linear Predictor of education from the Labour Force survey over the same period.[26] Quarterly Labour Force Survey (QLFS) is also used to construct most of the city controls of the second stage, like population, the share of university graduates, Herfindahl Index (2-digit SIC2003) and the various industrial shares. A more detailed description of the data used is offered in Georgiadis and Kaplanis (2014).

26 . In particular, education was simulated using coefficients' estimates of regressions of education on year of birth and year of birth squared separately by two-digit occupation in the Quarterly LFS (2003-2010) and information on year of birth and two-digit occupation code in ASHE. Other studies based in ASHE use occupation controls as proxies for education arguing that the former is a fairly good proxy for the latter (Kaplanis, 2010; Gibbons, Overman and Pelkonen, 2010).

Spain

For the empirical analysis, the Muestra Continua de Vidas Laborales, MCVL, (Continuous sample of working histories), an administrative data set provided by the Social Security Administration is used. The recently released MCVL contains information of individuals who had an active record with the Social Security system at any time during the years 2005-2011. Each year the sample is a 4% non-stratified random draw from a reference population that includes employed workers (wage earners and self-employed), unemployment benefits recipients and pension earners. It consists of nearly 1.1 million individuals per year. The MCVL tries to reconstruct the employment and contribution history of the selected individuals. The information available on labour histories dates back to 1967 while earnings records are tracked since 1980.

Individuals that are registered in the Social Security as wage earners between 2006 and 2011 are selected and their working histories are used to construct most of the individual variables of the first stage. Since 2006, the MCVL can be matched with the tax records, which contains the summary for each fiscal year of all the withholdings and prepayments of personal income tax on earned income, economic activities, prizes and income imputations. Since, the aim is to investigate issues related to wages, this data is suitable as this category of income is well represented by the reliability and the general scope of the tax data for earned income. These tax records allow the construction of an annual panel covering the period 2005-2011, with very precise information about individual earnings. Therefore all individual wages for all workers in the MCVL for that period are accounted for. In order to have the maximum number of observation the tax records are merged for all the available years, i.e. 2005-2011. The analysis is restricted to wage earners, self-employed are left out of the sample.

The OECD defines 76 FUAs in Spain, which represents about 62% of the Spanish population. In the MCVL, only municipalities with more than 40,000 inhabitants can be identified. For a detailed description of the necessary adjustments in order to construct FUAs well as further information on the variables used in the regressions, the reader should refer to the relevant OECD working paper (Diaz and Kaplanis, 2014).

Germany

For the German individual level regressions the Employment Panel of the German Federal Employment Agency (BA) hosted by the Research Data Centre (FDZ) at the Institute for Employment Research (IAB) is used.[27] The data contains a 2% sample of all registered employees who are subject to social security contributions on the reference date. The sample is a panel data set that covers the years from 1998 to 2007 and the on-site version of the data set contains information on the municipality (*Gemeinde*) of residence.[28]

The data does not contain information on hours worked (other than part-time status). It is therefore necessary to estimate earnings- rather than wage differentials across FUAs. As controls gender, age (and its square), educational attainment, occupational standing (apprentice, white or blue collar, master craftsmen, etc.: 7 categories), and occupation (3-digit) are added.

United States

For the United States of America the sample combines the U.S. Census from 1990 and 2000 with the American Community Survey for the years 2005 to 2007. The data are provided as a scientific use-file by the IPUMS project.[29] The available information on county of residence is used to link the IPUMS data with the OECD (2012a) definition of Functional Urban Areas. Since not all counties are identified in the scientific use-file, the metropolitan statistical area/s (MSAs) that coincide with a FUA is identified and observations from those MSAs are added. The resulting IPUMS based estimates for FUA size are close to the corresponding OECD calculations.

To estimate the wage equations hourly wages are constructed as the sum of all earnings from wages in the last year divided by the product of the number of hours usually worked per week in the previous year and the number of weeks worked. The estimates include controls for part-time status (using the Bureau of

27 . See Schmucker and Seth (2009) for a detailed description of the data.

28 . The sample changes slightly in 1999. The study is therefore limited to the years 1999-2007.

29. Ruggles et al. (2010)

Labor Statistics definition of usually working less than 35 hours per week), gender, educational attainment, age and its square, and occupation (3-digit codes). Sampling weights are used in all calculations.

Mexico

The data refer to 2000-2010 and come from the Labour Force Surveys (National Occupation and Employment Survey, ENOE and the National Employment Survey, ENE), carried out by the National Institute of Statistics and Geography of Mexico (INEGI). Data from 2000 to 2004 are derived from the National Employment Survey (ENE) and from 2005 to 2010 data refer to the National Occupation and Employment Survey (ENOE). Both are household surveys, whose selection units are dwellings selected by sample techniques.

The Mexican labour force surveys (ENE and ENOE) are representative of urban and rural areas, as well for each of the 32 Mexican States, include a quarterly rotating panel of survey respondents, and is a rotating panel (rotation scheme of 20%, i.e., workers are observed at most five times over a five-quarter period).

The data provide information on both economically active (labour force) and non-economically active population and is referred to persons aged 15 years old onwards. The surveys cover social and demographic information and provide details about job characteristics, incomes, work duration, demographics and education. Schooling was aggregate in five categories: no schooling or incomplete primary; complete primary; lower secondary; upper secondary and higher or tertiary. The data contain a monthly earnings variable from which we calculate logarithmic hourly wages as the ratio of monthly earnings to 4.3 times the hours worked weekly. For individuals who report their wages as a multiple of the minimum wage, we assign as their wage the mean of the interval.

Additional city controls that are not from ENE or ENOE, have also been used. For city population we use information from the Census for the years 2000, 2005 and 2010 and interpolate the intermediate years. (Source: INEGI, General Census of Population and Housing, 2000, 2005 and 2010). For the land area, the data come from the Mexican Statistical Office, INEGI (Cartography of land use and vegetation 2002 and

2005). Finally, port data come from the Mexican Ministry of Transportation and Communications (STC), through the General Coordination of Seaports and Merchant Marine.

Table A1. Summary statistics

Variables	USA	Mexico	Germany	UK	Spain
Population	2.470	0.880	0.465	0.457	0.389
	(3.115)	(2.211)	(0.615)	(1.169)	(0.810)
Surface area	11.233	4.322	1.208	0.741	1.566
	(12.907)	(6.989)	(1.136)	(.878)	(2.205)
Population density	0.349	0.414	0.512	0.735	0.625
	(0.379)	(0.542)	(0.513)	(0.518)	(0.913)
% of residents with university degree	0.276	0.156	0.136	0.194	0.122
	(0.056)	(0.051)	(0.041)	(0.070)	(0.054)
Capital city	0.014	0.013	0.009	0.010	0.013
	(0.120)	(0.115)	(0.096)	(0.100)	(0.115)
Port city	0.478	0.187	0.174	0.158	0.316
	(0.503)	(0.392)	(0.381)	(0.367)	(0.468)
Herfindahl Index (industry 2-dig.)	0.060	0.063	0.046	0.050	0.068
	(0.006)	(0.018)	(0.013)	(0.009)	(0.025)
Agriculture	0.018	0.062	0.008	0.015	0.007
	(0.015)	(0.056)	(0.011)	(0.021)	(0.006)
Manufacturing	0.105	0.170	0.240	0.143	0.120
	(0.040)	(0.088)	(0.083)	(0.044)	(0.080)
Electricity	0.007	0.006	0.005	0.009	0.007
	(0.003)	(0.004)	(0.008)	(0.006)	(0.005)
Construction	0.077	0.093	0.053	0.084	0.130
	(0.016)	(0.026)	(0.016)	(0.018)	(0.042)
Trade	0.220	0.209	0.150	0.149	0.203
	(0.014)	(0.036)	(0.022)	(0.028)	(0.047)
Catering	0.012	0.069	0.022	0.043	0.077
	(0.013)	(0.037)	(0.013)	(0.016)	(0.052)
Transport & communication	0.061	0.053	0.058	0.070	0.055
	(0.014)	(0.019)	(0.019)	(0.029)	(0.026)
Finance	0.056	0.010	0.029	0.040	0.035
	(0.018)	(0.006)	(0.017)	(0.020)	(0.025)
Real estate & business	0.115	0.050	0.144	0.109	0.147
	(0.017)	(0.018)	(0.028)	(0.036)	(0.042)
Public administration	0.038	0.061	0.064	0.070	0.045
	(0.016)	(0.043)	(0.021)	(0.022)	(0.040)
Educ., health & social work	0.209	0.099	0.157	0.213	0.102
	(0.027)	(0.033)	(0.036)	(0.039)	(0.037)
Other services	0.081	0.120	0.044	0.056	0.073
	(0.016)	(0.028)	(0.015)	(0.016)	(0.020)
High-tech manufacturing	0.022	0.007	0.026	0.021	0.005
	(0.020)	(0.016)	(0.023)	(0.016)	(0.007)

Med. high-tech manufacturing	0.024	0.036	0.095	0.039	0.026
	(0.021)	(0.047)	(0.064)	(0.020)	(0.030)
Med. low-tech manufacturing	0.023	0.047	0.060	0.037	0.038
	(0.013)	(0.027)	(0.041)	(0.020)	(0.041)
Low-tech manufacturing	0.037	0.080	0.052	0.046	0.052
	(0.012)	(0.055)	(0.024)	(0.021)	(0.049)
# local governments per 1,000 inh.	5.000	5.400	44.266	4.337	31.803
	(3.800)	(10.144)	(50.390)	(7.003)	(52.161)
% of resident living in largest municip.	0.665	0.810	0.522	0.717	0.717
	(0.233)	(0.232)	(0.183)	(0.221)	(0.165)
Governance body	0.868	0.810	0.833	0.286	0.125
	(0.341)	(0.402)	(0.381)	(0.469)	(0.354)

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