Neighborhoods to Nations via Social Interactions

Yannis M. Ioannides*

Department of Economics

Tufts University

Medford, MA 02155, USA

+1 617 627 3294   yannis.ioannides@tufts.edu   sites.tufts.edu/yioannides/

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1 Motivation

Social interactions analysis, which goes at least as far back as Schelling (1969) and Becker (1974), extends the methodological individualism of economics in new directions by focusing on the feedbacks between aggregate outcomes and individual behaviors. All of us engage in social interactions throughout our lives, though we do not label them as such, just as we speak prose without labeling it: Adopting recycling practices; deciding where to live and which schools to send our children to; finding out about "killer apps" from chance encounters at a Silicon Valley barbecue; getting pregnant or not; becoming obese; getting involved in community service; enforcing building code violations; mobile telephony and the sizes of rural settlements in LDCs; changing racial and ethnic prejudices, or using them strategically; revitalizing decaying urban neighborhoods; learning from your classmates; is acne contagious; introducing new farming techniques; naming your newborn child; how does a standing ovation start? Social interactions effects among individuals are thus ubiquitous; they occur in residential neighborhoods, schools, workplaces, or emanate from random encounters and their serendipity. They take the form of neighborhood effects, peer effects, role models, and other ways of social influences across agents that are not mediated by the market.[1]

Among individuals, preferences, beliefs, and constraints faced by one person may be directly influenced by the characteristics and choices of others. The effects of social interactions are similar to those of externalities, but unlike many instances of externalities are not a "side show." In choosing which school to go to or what club to join, one considers how to avail oneself of networking opportunities. Interactions are pervasive and naturally generated in the high densities of population and economic activity that define urban settings, occurring in a multitude of dimensions and scales, spatial and social. For example, does Edinburgh's urban layout has anything to do with the Scottish Enlightenment? Thus one can see them best in an urban setting, and this explains the emphasis of Ioannides (2013). The concept applies equally fruitfully to firms, too. For firms, proximity to their suppliers and to com-

[1] See Arrow and Dasgupta (2009) for the consequences for market valuation of "social" goods.

petitors is a key ingredient of new economic geography [Krugman (1992)], but it has been emphasized by urban economics at least as far back as Henderson (1974; see also Glaeser (2000).

Loury (1982) pioneered the use of variables measuring community and family background on educational achievement. Manski (1993; 2000) established a canonical typology which has served as an overarching scheme since then. It goes as follows. Social influences within individuals' social milieus that emanate from the *decisions* of members of one's reference group, like keeping up with the Joneses, are known as *endogenous* social effects. Effects on an individual due to *characteristics* of members of one's reference group(s) are known as *exogenous, or contextual* effects, as when individuals value living close to others with similar ethnic backgrounds, or backgrounds that are likely conducive to practices they themselves value. *Correlated* effects refer to circumstances with different individuals acting similarly because they have similar characteristics, observable or unobservable, or face similar institutional environments.

The fact that the actions of individuals in social contact with one another are interdependent suggests that in seeking to econometrically identify social effects one should exercise caution when using the actions of one's neighbors as explanatory variables. However, such estimates can inform important policy questions. Interestingly, when individuals actually choose their neighbors and thus their neighborhood effects as well, Brock and Durlauf (2001) show that it is possible to identify endogenous social effects, provided that one appropriately corrects for selection bias. Sometimes, interactions are assumed to be group-based, in which case individuals value appropriate aggregates describing entire communities and/or groups within them. Other times, interactions are one-to-one, in which case social network models and appropriate estimation techniques are helpful in providing a primary focus on the microstructure of interactions. Blume, Brock, Durlauf, and Ioannides (2011) and Blume, Brock, Durlauf, and Jayaraman (2014) offer thorough reviews of the state of the art in identifying social interactions and Graham (2014) reviews the state-of-the-art on methods based on social network data.

Here is an example emphasizing the importance of separate identification of different types of social effects. Recent research has noted that faculty in economics departments led by widely cited department chairs are more productive in research [Goodall *et al.* (2014)]. There can be competing explanations of what type of effects are at work. Professors who have been selected with similar observable or unobservable characteristics have similar productivity, in which case we have *correlated effects*. If faculty "follow the department's official leader", we have *endogenous social effects*. If department chairs help create environments that are conducive to research, by attracting the "right" people, we have *contextual effects*. Naturally, all of the above can be present simultaneously, in which case it would be important to distinguish their relative contributions so as we may learn for policy purposes from such experiences. That is, the answer to the question can help provide policy guidance on what a university needs to do to help improve the research performance of a particular department's faculty. Estimation of peer effects in education settings raises similar issues [see Angrist and Lang (2004) and Arcidiacono and Nicholson (2005); Sacerdote (2014) reviews the state-of-the-art].

Clearly, choice of neighborhood implies choice of neighborhood effects. This in turn implies that individuals through their location decisions contribute to shaping neighborhoods, cities, and regions, and via international migration, countries as well.[2] Equally important is the role of firms' location decisions, which are influenced by proximity to workers, suppliers, and competitors.

Proximity does not have to be defined as *group membership* only. It is also important to understand how economic agents operate in actual physical space, defined as *distance* between each other, and distance to urban centers within cities, or in social space, which is much harder to define. In particular, the role of social interactions in *human capital spillovers* has motivated considerable empirical research [Moretti (2004)], whose rich findings have been helpful in forming aggregative city-level models that in turn may be integrated into models of the national economy with geographical space receiving particular attention.

[2] The US and Canada are known immigration countries with well defined, though hotly debated and changing immigration policies. Some Western European countries are following their lead, by encouraging immigration of highly skilled professionals.

Social interactions thus serve as an overarching theme in many different settings, and this is central to the approach taken by Ioannides (2013).

Urban settings are particularly fruitful in many different ways. Larger city size allows for greater variety of intermediate goods and services, which are the conduits of modern industrial innovations. The resulting agglomeration of many activities raises urban productivity, but the ensuing increase in congestion is costly. This in turn leads to a key trade-off between the benefits of urban agglomeration and its costs, that would likely depend critically on the industrial composition of cities. Thus there can be a variety of city types in terms of sectoral and functional composition, with different city sizes associated with different city types and functions. Thus, specialized, diversified, satellite, or "bedroom" communities make up entire metropolitan areas, and in turn entire economies, whose urban structure is critically affected by physical geography via travel and shipping costs.

Consideration of the city as the unit of analysis has recently led to the emergence of *urban macro* [Rossi-Hansberg and Wright (2007)], which has been an important and very fruitful approach to understanding the *real* structure of modern economies. These approaches build on foundations of social interactions as cornerstones of individual city economies and the interactions among different cities of an economy.

In the remainder of this paper, I first examine decisions by individuals and firms in the presence of social interactions and then turn to cities as the units of analysis. Of particular interest of the city-based analysis is the critical role of intercity trade and its impact on urban sectoral and functional specialization. I also take up the single empirical fact about city sizes throughout the world that has generated interest much beyond economics: Zipf's law and its relationship to long-run economic growth in economies made up of cities. The paper is not meant as an exhaustive review of the literature. Hopefully, Ioannides (2013) does that and more (up till the time it went to press). Instead, it is meant to highlight central issues in the broad literature, taking off from key concepts, as presented in Ioannides (2013) and drawing attention to key recent contributions by other researchers.

2 Individuals

The important issue here is that individuals' location decisions contribute to giving neighborhoods their distinguishing characteristics. People in choosing where to live plan to do their best with their resources in the neighborhoods where they choose to locate. Neighbors remodeling their homes, or maintaining them better than me provide incentives for me to keep up with the maintenance of my house, much like when an informed friend touts a particular stock and also holds it in her portfolio. This is an instant of *endogenous* social effect: I am influenced by deliberate *decisions* by other members of my social milieu. If people with kids like to live in neighborhoods where other people also have kids, we would have an instance of *exogenous,* or *contextual* effects, which are also *social* effects. Such concerns influence, *inter alia,* house hunting strategies. E.g., people with young children are known to look for pamper boxes in the trash outside homes in neighborhoods they are considering to live in, or conduct a "Values Audit!" [Lieber (2014)] People choosing to live near others of the same ethnic group may act similarly because they have similar characteristics (or face similar institutional environments), an instance of *correlated* effects. Distributions of attributes/demographic characteristics, the *"character"* of neighborhoods, cities, and regions are thus profoundly influenced by individuals' decisions.

2.1 Basic analytics of individuals' decisions in the presence of social interactions

Let us denote i's action by $y_i = \arg\max_{y_i} U(y_i, \mathcal{E}[y_{\nu(i)}]; \mathbf{x}_i; \mathbf{z}_{\nu(i)}; \text{parameters})$; i's characteristics by $\mathbf{x}_i$, which give rise to correlated effects; i's neighborhood (or social milieu) by $\nu(i)$, with characteristics $\mathbf{z}_{\nu(i)}$, which give rise to contextual effects; expected action among the members of i's neighborhood $\nu(i)$ by $\frac{1}{|\nu(i)|}\sum_{j\in\nu(i)} \mathcal{E}[y_j]$. For quadratic $U(\cdot)$, endogenous social effect, conditional on i's information, Ψ_i :

$$y_i = \alpha_0 + \alpha\mathbf{x}_i + \theta\mathbf{z}_{\nu(i)} + \beta\frac{1}{|\nu(i)|}\sum_{j\in\nu(i)} \mathcal{E}[y_j|\Psi_i], +\epsilon_i; \tag{1}$$

parameters α, θ are row vectors, α_0, and β are scalar. The stochastic shock ϵ_i is assumed to be i.i.d. across observations.

A Nash equilibrium for the group and its solution in *reduced form*, $y_i(\mathbf{x}_i, \mathbf{x}_{\nu(i)}, \mathbf{z}_{\nu(i)})$ requires an assumption about expectations. If i's expectation is equal to the average behavior of the group,

$$\frac{1}{|\nu(i)|} \sum_{j \in \nu(i)} \mathcal{E}[y_j | \Psi_i] = \text{mean}_{j \in \nu(i)} \, [y_j],$$

then (1) may be solved to yield:

$$y_i = \frac{\alpha_0}{1-\beta} + \alpha \mathbf{x}_i + \frac{\beta}{1-\beta} \alpha \mathbf{x}_{\nu(i)} + \frac{\theta}{1-\beta} \mathbf{z}_{\nu(i)} + \epsilon_i. \tag{2}$$

To highlight the identification problem, assume that contextual effects coincide with neighborhood averages of individual characteristics: $\mathbf{z}_{\nu(i)} \equiv \mathbf{x}_{\nu(i)}$, then:

$$y_i = \frac{\alpha_0}{1-\beta} + \alpha \mathbf{x}_i + \frac{\beta\alpha + \theta}{1-\beta} \mathbf{x}_{\nu(i)} + \epsilon_i.$$

Estimation of such an equation yields an interesting measure, a multiplier associated with changes in $\mathbf{x}_{\nu(i)}$, $\frac{\beta\alpha+\theta}{1-\beta}$. However, such estimations are subject to an identification problem [Brock and Durlauf (2001); Blume *et al.* (2011); Moffitt (2001)]: from an estimate of $\frac{\beta\alpha+\theta}{1-\beta}$, parameters β, α, θ may not be separately identified. Kline and Tamer (2011) emphasize that one has to go back to the behavioral model in order to establish the proper interpretation of the estimated coefficients of the resulting linear response functions.

Two recent areas of related research are worth mentioning. First, Angrist (2013) has emphasized "*perils*" afflicting estimations when observations for *all* interdependent agents are used. He considers a simpler version of (1), with $\alpha = 0$; when the mean in the R.H.S. is either inclusive of each observation, or exclusive of it, and when the number of agents is large, he shows that it must be the case that $\hat{\beta} = 1$. If $\alpha \neq 0$, the mean is exclusive, and group sizes vary across observations, then the estimation is immune from Angrist's "perils." Furthermore, the best chances of avoiding Angrist (2013) "*Perils*" occur when the subjects of a peer effects investigation are not at the same time "effect-causing" peers. He proposes a test based on the following. Going back to the reduced form (2), consider OLS and 2-stage

LS estimates of ϕ_0, ϕ_1 :

$$\phi_1 = \frac{\mathcal{E}\left(\mathcal{E}[y|\nu(i)]\mathcal{E}[x|\nu(i)]\right)}{Var[[x|\nu(i)]]}, \phi_0 = \frac{\mathcal{E}\mathcal{E}[\mathbf{x}y]}{Var[\mathbf{x}]}.$$

These should be the same in the absence of peer effects, leading to a test.

Interdependence among agents who are socially networked may be expressed in terms of a system of simultaneous equations for agents' decisions:

$$\mathbf{Y} = \alpha_0 \iota + \mathbf{X}\alpha + \mathbf{\Gamma}\mathbf{X}\theta + \beta\mathbf{\Gamma}\mathbf{Y} + \varepsilon,$$

where $\mathbf{Y}$ denotes the vector of decisions by network members, $\mathbf{X}$, the matrix whose rows are the $\mathbf{x}_i$, and $\mathbf{\Gamma}$, the adjacency matrix (sociomatrix) describing the network. Such circumstances are more conducive to identification. See Blume *et al.* (2011), Blume *et al.* (2014); Christakis and Fowler (2009); Graham (2014).

2.2 Self-selection to groups, communities, cities, regions

Individual i evaluates neighborhood ν using observables $W_{i,\nu}$ which enter with weights ζ, and unobservable component $\vartheta_{i,\nu}$:

$$Q^*_{i,\nu} = \zeta W_{i,\nu} + \vartheta_{i,\nu}, \tag{3}$$

where ν ranges over all neighborhoods being considered by i. The random variables ϵ_i in (1) and $\vartheta_{i,\nu}$ in (4) are assumed to have zero means, conditional on regressors $(\mathbf{x}_i, \mathbf{z}_{n(i)}, W_{i,\nu})$ across the population. But among those who choose a particular, their optimal, neighborhood, shocks no longer have zero means. Thus, given the joint distribution of $(\epsilon_i, \vartheta_{i,\nu})$, conditional on choosing $\nu(i)$: the expectation $\mathcal{E}[\epsilon_i|\mathbf{x}_i, \mathbf{z}_{\nu(i)}; \Psi_i; i \in \nu(i)]$, the Heckman "correction" term [Heckman (1979)], which is proportional to a function $\delta(\zeta; W_{i,\nu(i)}, W_{i,-\nu(i)})$, allows us to rewrite (1) as follows:

$$y_i = \alpha_0 + \mathbf{x}_i\alpha + \mathbf{z}_{\nu(i)}\theta + \beta\frac{1}{|\nu(i)|}\sum_{j\in\nu(i)}\mathcal{E}[y_j|\Psi_i] + \kappa\delta(\zeta; W_{i,\nu(i)}, W_{i,-\nu(i)}) + \xi_i, \tag{4}$$

where $W_{i,-\nu(i)}$ denotes the observable attributes of all neighborhoods other than $\nu(i)$. This allows for the estimation according to (4) for outcomes when individuals choose their neighborhoods to become immune from Angrist's "perils."

Equ. (4) constitutes the main "engine" of individuals' and firms' location decisions and are examined in Ioannides (2013), Chapters 3 and 4. It is consistent with maximizing behavior, because the basic choice equation above may be motivated by the underlying indirect utility function, which in addition to prices and income also depends on $(\mathbf{x}_i, \mathbf{x}_{\nu(i)}, \mathbf{z}_{\nu(i)}; \mathbf{x}_{-i}, \mathbf{x}_{-\nu(i)}, \mathbf{z}_{-\nu(i)})$, as well as stochastic shocks. The associated decisions, $y_i = \arg\max_{y_i} U(y_i, \mathcal{E}[y_{\nu(i)}]; \cdot)$, are jointly determined as Nash equilibria for each neighborhood.

2.3 Schelling's Models of Spatial Clustering

Social interactions are central in research by Thomas Schelling that led to his *self-forming neighborhood model* [Schelling (1978), p. 147]. According to that model, individuals choose locations on a lattice (checkerboard) and have preferences over the skin color of their neighbors. The resulting spatial equilibrium patterns exhibit residential segregation across neighborhoods which are stark. Schelling's other model, the "bounded-neighborhood model" (*neighborhood tipping model*) [Schelling (1978) p. 155], aims at understanding how neighborhood composition "tips" in favor of particular groups and produces clustering of racial groups. In Schelling's own words, "[t]hat kind of analysis explores the relationship between the behavior characteristics of the *individuals* who comprise some social aggregate, and the characteristics of the *aggregate*"[*ibid.*, p. 13]. Thus, social outcomes, arguably unintended, magnify of individual propensities. Ioannides (2008) argues that Schelling's models are instances of *emergence* in social settings. See also Zhang (2004; 2011) who modernized Schelling's models.

Schelling's neighborhood tipping model has more recently motivated empirical research, aimed at addressing the following policy questions: Are stable, economically and racially mixed neighborhoods feasible? Can vigilant policy tools (such as zoning restrictions combined with mandates of mixed income housing) counter market forces driving segregation? Card, Mas, and Rothstein (2008a; 2008b) are first to offer direct evidence in support of Schelling's prediction that segregation is driven by preferences of white families over the (endogenous) racial and ethnic composition of neighborhoods. Using the Neighborhood Change Database to create a panel of US Census tracts over 1970 – 2000, they show that white population flows exhibit tipping-like behavior in most US cities. The estimated tipping points range within [5%, 20%], expressed in terms of the minority share. They also find that US cities vary in terms of underlying social fundamentals. E.g., Memphis and Birmingham are associated with strongly held views against racial contact, while in San Diego and Rochester views against racial contact appear to be weak. Grauwin, Goffette-Nagot, and Jensen (2012) is the latest contribution to studying segregation along the lines of Schelling's pioneering work. Bruch and Mare (2006) report esitmations with the Schelling neighborhood tipping model.

Hardman and Ioannides (2004) report evidence that US "micro" neighborhoods (5–13 households) are quite mixed, in terms of income. They work in terms of joint and conditional distributions ("Schelling statistics") portraying neighbors' characteristics conditional on a neighbor's housing tenure, race, and income. Their results are confirmed by Wheeler and La Jeunesse (2008), who find that between 80% and 90% of income variance within US urban areas is driven by within-neighborhood differences rather than between-neighborhood differences. These authors also find that increasing numbers of foreign-born individuals increases income heterogeneity within but not between neighborhoods, and that rising educational attainment seems to influence both measures of inequality, which are stronger with income variation within neighborhoods. Another contribution along broadly similar lines is Brodeur and Flechey (2013). Yet, the basic Hardman-Ioannides-Wheeler and La Jeunesse facts have not yet been adequately explained. Explanations probably will involve social interactions models with particular sensitivities of location decisions to socioeconomic characteristics of neighborhoods.

2.4 Estimation results

Several papers exploit special data settings to estimate neighborhood effects. Notable among them are Goux and Maurin (2007) and Sacerdote (2001). See also Ioannides (2013), Chapter

2.

2.4.1 Estimations of joint neighborhood choice and housing demand models

Ioannides and Zabel (2008) carry the neighborhood choice model to its logical conclusion by conducting a structural estimation of neighborhood choice jointly with housing demand, using data on US micro neighborhoods and US metropolitan areas. The novelty here is that observations in US micro neighborhoods are linked, using confidential data, with the census tracts in which they lie within their respective metropolitan areas. This allows them to use contextual information at several levels of aggregation. Although the observations in each micro neighborhood are treated as those of interacting agents in Nash equilibrium, they have avoided the "perils" emphasized by Angrist (2013). The contextual effects are computed using exclusive means. The advantage of structural modelling is, of course, that theory lends discipline to the process, and the estimation of social effects, which are reported in Ioannides and Zabel (2008), Tables 3.1, 3.2, and are very significant, is robust. This approach leads to an associated hedonic price, which is discussed in Ioannides (2013), p. 112–115, in the context of empirical results by Kiel and Zabel (2008). See also Sieg *et al.* (2002).

This research contributes to our understanding of sorting, where the state of the art is given by Epple and Sieg (1999) and Epple *et al.* (2001) on sorting across communities, and by Calabrese *et al.* (2006) who also allow for contextual effects expressed in terms of the community relative mean income. However, in the context of the social interactions literature, it also contributes to clarification of priced versus non-priced interactions. That is, one may think of private clubs that control admission to membership via fees, or local communities in economies like that of the US and others with local fiscal systems that charge for access to locally supplied services (like schools) indirectly via local taxes. Yet, social interactions and neighborhood effects abound in all cities of the world and are typically not priced and therefore not mediated by the market.

3 Firms

The role of interactions in location decisions of firms may be formulated in terms of an overarching framework. Such questions as whether the effect of a firm's proximity to other firms in the *same* industry may be separately identifiable from other factors, such as those of proximity to firms in *other* industries, the size of the total urban economy, availability of a suitable labor force, or other factors are important for urban policy.

From a methodological viewpoint, Alfred Marshall's famous typology [Marshall (1920)] *is* about social interactions. That is, labor market pooling for workers with specialized skills favors both workers and firms; availability and variety of nontraded inputs (including natural amenities) is valuable to all firms in an industry; information exchanges, whether deliberate or inadvertent, are widespread in urban areas. All key questions may be addressed by building on a classic and simple model, due to Koopmans and Beckmann (1957), where firms choose among sites, whose productivities differ, using a simple logit model, which allows for direct interdependence. That is, if firm k chooses site ℓ its profit is given by

$$a_{k\ell} - \sum_{k'} \sum_{j} b_{kk'} c_{\ell j} \mathcal{E}\left\{p^k_{k'j}\right\} - \varrho_\ell + \epsilon_{k\ell},$$

where the a's, b's and c's are unknown parameters, ϱ_ℓ is site rent, $\mathcal{E}\left\{p^k_{k'j}\right\}$ is firm k's expectation that firm k' would locate at site j, and $\epsilon_{k\ell}$ is a random variable. If the ϵ's are i.i.d. extreme-value distributed, then the probability that firm k chooses ℓ is given by:

$$p_{k\ell} = \frac{e^{\varpi\left(a_{k\ell} - \sum_{k'} \sum_j b_{kk'} c_{\ell j} \mathcal{E}\left\{p^k_{k'j}\right\} - \varrho_\ell\right)}}{\sum_{i=1}^{L} e^{\varpi\left(a_{ki} - \sum_{k'} \sum_j b_{kk'} c_{\ell' j} \mathcal{E}\left\{p^k_{k'j}\right\} - \varrho_i\right)}}, \ k, \ell = 1, \ldots, L. \quad (5)$$

Given site rents, ϱ_ℓ, we can solve for $p_{k\ell}$'s, assuming $\mathcal{E}\left[p^k_{k'j}\right] = p_{k'j}$. The condition that all sites be occupied determines relative rents: $\varrho'_\ell = \varrho_\ell - \varrho_1$.

$$\sum_{k=1}^{L} p_{k\ell}(\varrho_1, \ldots, \varrho_L) = 1, \ \ell = 1, \ldots, L.$$

Site rents reflect, in turn, all exogenous and endogenous attributes of sites. The similarity of the choice problem in (5) to that in (2.2) is evident.

In studying firms' location decisions for the purpose of informing policy questions in the area of urban industrial development, modern approaches distinguish between agglomeration, localization and urbanization effects. Referring to (5) above, a *localization externality effect*, also known as *Marshall–Arrow–Romer effect*, on firm k's decision, may be thought of as the empirical roles of terms such as $\hat{p}^k_{k'j}$'s. They may be measured by shares of employment in locations j by different firms in the same industry, $k' \in \mathcal{K}_j$. The *urbanization (Jacobs) externality* is measured by shares of employment in location j by *all other* industries, $k' \in \mathcal{K}_j$. Thus, the modern social interactions approach helps structure this area of urban economics.

In many investigations of firms' location decisions, researchers work with the gross profit function for firm k in industry g at site ℓ, which is defined more generally than in (5) as:

$$\pi_{kg\ell} = \theta \mathbf{z}_{g\ell} + \eta_{g\ell} + \epsilon_{kg\ell}, \ell = 1, \ldots, L,\ g = 1, \ldots, G,$$

where shock $\eta_{g\ell}$, depends only on the industry, and $\epsilon_{kg\ell}$ is a random error. For example, wages are more important for textiles, because their technologies are more labor-intensive; small vessel manufacturing need not be near oceans. If the random variables $\epsilon_{kg\ell}$ are assumed to be extreme-value distributed, the logit model readily applies and allows us to write closed forms for the choice probabilities:

$$P_{kg\ell}\left(\eta_{g\ell}\right) = \frac{e^{\varpi[\theta \mathbf{z}_{g\ell} + \eta_{g\ell}]}}{\sum_{j=1}^{L} e^{\varpi[\theta \mathbf{z}_{gj} + \eta_{gj}]}} = \frac{\lambda_{g\ell} e^{\varpi \eta_{g\ell}}}{\sum_{j=1}^{L} \lambda_{gj} e^{\varpi \eta_{gj}}}. \tag{6}$$

It follows from our formulation that location decisions of firms, as modeled by (6), are consistent with the type of locational equilibrium for which (5) serves as a rudimentary description.

3.1 Applications of firms' choice models

The logit formulation (6) accommodates a large class of models, and helps clarify the Ellison-Glaeser, "dartboard approach" index [Ellison and Glaeser (1997)] and its numerous empirical applications. Other approaches involve explicit dynamics [Dumais *et al.* (2002), industry case studies, such as advertising in NYC [Arzaghi and Henderson (2008)], and measures of localization via geometric-distance, where it is shown firm-to-firm distances are less for firms in own industry [Duranton and Overman (2005)]. Aarland *et al.* (2007) illuminate how firms' decisions support the changing urban structure with regard to functional versus sectoral specialization.

Quasi-experimental settings lend themselves admirably to identification of agglomeration spillovers, because they get around selection issues. A case in point is unusual, inventive use of data for "Million Dollar Plants " (MDP) by Greenstone, Hornbeck, and Moretti (2010). These researchers identify MDP's from an industry publication, *Site Selection,* along with site selected *and* sites rejected. These authors work with plants' total factor productivities, Ξ_{kcjt}, and show that it increases after accounting for all measured inputs. Specifically, estimated trends in the TFPs of incumbent plants in winning and losing counties are statistically equivalent in the 7 years before million dollar plant location. Five years later, an MDP's opening is associated with 12% relative increase in incumbent plants' TFPs. On average, incumbent plants' output in winning counties is $430 million higher 5 years later (relative to incumbents in losing counties), holding constant inputs. This is indeed clear evidence of meaningful productivity spillovers from increased agglomeration.

New economic geography approaches to the study of firms' location decisions emphasize the role of market potential, an *ad hoc* concept proposed by Harris and modernized by Krugman (1991a, b; 1992); see Fujita, Krugman and Venables (1999) and Royal Swedish Academy of Sciences (2008). This concept (which in its full generality is essentially an aggregation of social interaction effects) adjusts, elegantly via a local price index, real spending power of individuals in a particular location on account of distance to markets at other locations where spending occurs. In a notable application, Head and Mayer (2004) find that market potential does matter for location choice of Japanese plants in the EU: a 10% increase in market potential raises the likelihood of a region's being chosen by 3% to 11%, depending on the particular specification. Krugman's real market potential does not perform as well, interestingly, as the *ad hoc* Harris measure. Additional agglomeration measures, such measures of preexisting Japanese plants, suggest important "path dependence," a form of social interactions. The impact of jurisdictional boundaries and their associated tax implications on firms' location decisions may also be studied via the concept of market potential; see

Rossi-Hansberg (2005) for an international trade application.

4 Social interactions and the Alonso-Muth-Mills Model

It is natural to seek the effects, if any, of social interactions, in the Alonso-Muth-Mills model [Alonso (1964); Muth (1969)], the workhorse model of urban economics, which describes location decisions of firms and individuals, relative to a central business district (CBD). The CBD as a key amenity has a profound effect on the location of economic activity in urban areas. If individuals work at the CBD but cannot all live there, they will spread out over locations further away from it. Their location decisions, which trade off the convenience of being near the CBD to the cost of getting to it, are supported by equilibrium land rents. If, however, spatially dispersed amenities, defined by $a(\ell)$, as function of ℓ, the distance from the CBD, are also available, they have an effect on the rent gradient. Imposing locational equilibrium in such a setting leads to an equilibrium rent gradient as follows:

$$R'(\ell) = -\frac{\mathcal{T}'(\ell)}{h^*(\ell)} + \frac{\mathcal{O}_3}{h^*(\ell)\mathcal{O}_2} a'(\ell), \tag{7}$$

where $\mathcal{T}(\ell)$ is transportation cost to the CBD, $h^*(\ell)$ is demand for land (housing),and $\mathcal{O}$ is the indirect utility function, a function of land rent, income and amenities. Only if amenities vary with ℓ, the distance of the CBD, $\mathcal{O}_3 \neq 0$, would the rent gradient differ from the quantity that is just necessary to compensate individuals for the extra transportation cost incurred when living further away from the CBD, $-\frac{\mathcal{T}'(\ell)}{h^*(\ell)}$ in the RHS of (7). If amenities are positive and sufficiently stronger as one moves away from the CBD, then the rent may in fact increase accordingly [Brueckner *et al.* (1999)]. In alternative formulations one may model that individuals value being near other individuals, and firms value being near other firms. In such case, a characteristic *sigmoid* distortion of land gradient is generated [Beckmann (1976)]. The CBD no longer plays as dominant a role. Land rents express value of (relative) proximity to other agents; see Ioannides (2013), Chapter 5.

Yet another formulation assumes that individuals value the consumption of other individuals, like Ioannides and Zabel (2008), except that where unlike Ioannides and Zabel the effect is adjusted by distance to others' locations. Specifically, Rossi-Hansberg *et al.* (2010) assume that the housing externality is a component of the housing term in the utility function, that is:

$$\tilde{H}(\ell) = \delta \int_{\underline{\ell}}^{\bar{\ell}} e^{-\delta|\ell - s|} H(s) ds + H(\ell), \tag{8}$$

where $H(\ell)$ is own housing consumption and $H(s)$ housing consumption at other locations. To this formulation, there corresponds an equilibrium land gradient, given by:

$$R(\ell) = \Upsilon - \tau\ell + \delta \int_{\underline{\ell}}^{\bar{\ell}} e^{-\delta|\ell - s|} H(s) ds - \beta^{-1}\bar{H}, \ \ell \in [-\bar{\ell}, \bar{\ell}]. \tag{9}$$

Rossi-Hansberg *et al.* use their model to evaluate Neighborhoods-in-Bloom, a local urban renewal program in Richmond, VA. They find that increases in land values are consistent with externalities, as modelled in (8–9), that fall exponentially with distance, as in (9), by half per every 990 feet. Land prices in targeted neighborhoods are up by 2% to 5%, per annum, relative to the control neighborhood (Bellemeade, a Richmond neighborhood). Increases translate into land value gains of \$2 – \$6 per dollar invested in the program, over 6 years, a substantial effect that demonstrates empirically the importance of neighborhood effects and social interactions in evaluating urban interventions.

5 Urban macro

Urban macro, a term that has been established over the last few years and owes its popularity basically to important research contributions by Esteban Rossi-Hansberg. It involves looking both at the urban system from an aggregative perspective and at the aggregate properties of economies that are made up of cities. Urban externalities, or more fundamentally, social interactions are critical to understanding the properties of individual cities as well as the properties of urban systems, which are made up of interacting cities. Individuals and ideas flow across cities, being attracted by interactions, and so do goods and services of all kinds, that support the technological improvements that cities continuously fuel. Different activities benefit from proximity with one another and that is why dense concentrations of economic activities emerge in the form of cities. Different city sizes are associated with different tradeoffs among the benefits, in the form of agglomeration effects, and costs of urban concentrations, in the form of congestion costs, which in turn depend on the industrial composition of different cities. This in turn gives rise to city sectoral or, alternatively, functional specializations, a matter taken up in Ioannides (2013), Chapter 7, among several other issues examined. The nature of social interactions that characterize the urban economy are central to the tradeoff. The city size tradeoff is long-standing in the system of cities literature [Henderson (1974)], which, *inter alia,* elaborates the efficiency of urban structures that emerge in modern market economies. A free market economy might or might not bring about a socially optimum city size. This is an ancient question: Plato's *Republic* puts the optimum city size at 7!; Aristotle in *Nicomachean Ethics* thinks in terms of bounds.[3]

The modern literature considers the important role of intercity trade, within both the domestic economy and the international economy, where openness to trade has a profound effect on urban structure via sectoral/functional specialization [Duranton and Puga (2005)], on one hand, and the overwhelming presence of large, diversified cities, on the other. The literature is also concerned about whether established economic theories can come to terms with an important persistent empirical fact about city sizes: Zipf's law (or, more generally, Pareto/power law), which documents that city size distributions have very fat tails [Ioannides (2013), Chapter 8].

To see why different types of economic activities may give rise to different tradeoffs, one can employ static models of intercity trade and urban structure. Using such models, we can solve for equilibrium in each city, after specifying how urban activities benefit from

[3]Papageorgiou and Pines (2000), p. 520, set the matter back to Plato and Aristotle. Plato in *The Laws* [circa 350BC] sets optimal city size precisely set at 7! = 5040 (presumably male) citizens. The repeated arguments in favor of 5,040 throughout *The Laws* include that its arithmetic property of admitting 59 divisors is advantageous for the mechanics of urban government in the fictitious city of *Magnetes*, whose design *The Laws* addresses. Notably, there is a proscription with severe penalties against these citizens' being retail traders or merchants! This number does not include optimal support personnel (women, children, slaves, and alien residents) which would make Plato's total considerably higher. According to Aristotle's *Politics* (circa 340BC), optimal city size should be constrained from below by *self-sufficiency* and from above by *efficiency.* Too small a city cannot satisfy all the needs of its citizens; too large, it becomes unwieldy. Thus "there can be no city with ten citizens, and neither can there be one with ten times ten thousand" [*Nicomachean Ethics* (circa 330BC)].

social interactions. These are assumed to be external to individual agents but internal to city economy. As with neighborhood choice, it is decisions by economic agents, such as individuals, firms and institutions, that shape the character of urban economies.

Ioannides (2013), Chapter 7, builds on Anas and Xiong (2003) and Henderson (1987) to develop a model of urban structure. Let N be city size. In diversified cities, all trade is internal, giving rise to internal terms of trade. We assume that two final goods are produced, X and Y, by means of a Cobb Douglas production function, using raw labor, H_X, and a range of differentiated inputs, $z_{d_{\ell m}}$, themselves produced under increasing returns to scale using raw labor. Use of such differentiated inputs in this model expresses pecuniary externalities. The more varieties are used, the more productive the economy. These are known as market size effects. Thus, other things being equal, larger city size confers productivity advantages, but generates more congestion.

Specialized cities emerge if there is intercity trade. With spatial equilibrium, within as well across cities, equilibrium terms of trade are determined. Let typical city sizes be (N_X, N_Y): Both city sizes affect the terms of trade and welfare at equilibrium. With individual preferences given by: $U = \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}P_X^{-\alpha}P_Y^{-(1-\alpha)}\Upsilon$, where Υ denotes individual income, then utility at equilibrium, given the terms of trade, has the following form:

$$U_{\text{spec-}X} = \lambda_X \left(\frac{P_X}{P_Y}\right)^{1-\alpha} \left[1 + (n_X - 1)\tau^{\sigma-1}\right]^{\frac{1-u_X}{\sigma-1}} N_X^{\frac{1-u_X}{\sigma-1}} \left(1 - \kappa N_X^{\frac{1}{2}}\right)^{\frac{\sigma-u_X}{\sigma-1}}.$$

It depends on city size, N_X, the number of all cities of type X, n_X, and transport costs, (κ, τ). This results reflects interactions via city size and the range of intermediates (pecuniary externalities). At equilibrium, prices are determined in the entire economy, given city sizes associated with city specialization. Thus, the external terms of trade for cities engaged in intercity trade with sizes (N_X, N_Y) are given by:

$$\frac{P_X}{P_Y} = \text{par's}(n_X, n_Y; \text{costs}) \frac{N_Y^{\frac{1-u_Y}{\sigma-1}}}{N_X^{\frac{1-u_X}{\sigma-1}}} \frac{\left[1 - \kappa N_Y^{\frac{1}{2}}\right]^{\frac{\sigma-u_Y}{\sigma-1}}}{\left[1 - \kappa N_X^{\frac{1}{2}}\right]^{\frac{\sigma-u_X}{\sigma-1}}}, \tag{10}$$

where par's$(n_X, n_Y; \text{costs})$ is a function of (n_X, n_Y) and parameters. In contrast, internal terms of trade, that are established in diversified cities of size N are given by:

$$\frac{P_X}{P_Y} = \text{par's} \left[N \left[1 - \kappa N^{\frac{1}{2}} \right] \right]^{\frac{u_X - u_Y}{\sigma - 1}}, \tag{11}$$

where par's is a different function of parameters. Whereas with intercity trade, the terms of trade for different types of specialized cities depend on the entire urban structure, including the numbers of different cities and their sizes, for autarkic diversified cities only own city size matters. These models can provide the basis for studying growth in a system of cities, as we see further below. Social interactions are expressed in reduced-form in these functions, which originate in the productivity effect of greater varieties of intermediates.

Market structure has a profound impact on these tradeoffs and on the urban structure. So, under the assumption of frictional labor markets [Pissarides (2000)] and diversified cities, labor market tightness, υ_j, in the labor market for good $j = X, Y$, satisfies:

$$u_{j,a} \left(1 + \frac{d_j}{\upsilon_j q(\upsilon_j)} \right)^{1-u_j} \left[N \left(1 - \kappa_e N^{\frac{1}{2}} \right) \right]^{\frac{1-u_j}{\sigma-1}} (N) = \frac{\rho + d_j}{1 - \vartheta} \frac{\gamma}{q(\upsilon_j)},$$

where $q(\upsilon_j)$ denotes the arrival rate of workers to firms. This condition determines unemployment and employment rates, $\frac{d_j}{d_j + \upsilon_j q(\upsilon_j)}$ and $\frac{\upsilon_j q(\upsilon_j)}{d_j + \upsilon_j q(\upsilon_j)}$, respectively, as functions of city size. The internal terms of trade for an autarkic (diversified) city are given by:

$$\frac{P_Y}{P_X} = \frac{\frac{\pi_X}{d_X + \pi_X}}{\frac{\pi_Y}{d_Y + \pi_Y}} \frac{q(\upsilon_Y)}{q(\upsilon_X)} \frac{\rho + d_X}{\rho + d_Y},$$

where d_j and $\pi_j = \upsilon_j q(\upsilon_j)$ denote the rate of job destruction and, respectively, the rate at which workers find jobs in industry $j = X, Y$. The external terms of trade, again under frictional labor markets, are given by:

$$\frac{P_X}{P_Y} = (\text{par's } (n_X, n_Y; \text{costs}) \frac{\left[1 - \kappa_e N_Y^{\frac{1}{2}} \right]^{\frac{\sigma - u_Y}{\sigma - 1}}}{\left[1 - \kappa_e N_X^{\frac{1}{2}} \right]^{\frac{\sigma - u_X}{\sigma - 1}}} \frac{\frac{\pi_X}{d_X + \pi_X}}{\frac{\pi_Y}{d_Y + \pi_Y}}.$$

It follows that urban unemployment rates at the steady state differ across diversified cities with different mix of industries, specialized cities with different sectoral/functional specializations, and for the same industries, across diversified or specialized cities. Considering the question of optimum city size in such a setting would yield very different answers than in the absence of frictional labor markets. We note that frictional labor markets themselves connote another type of social interactions and thus enhance the scope of social interactions. Individuals' employment prospects depend on their likelihood of matching with firms that have vacancies.

The literature has established important stylized facts here, such as persistence over time in unemployment rates across US MSAs, as has been emphasized by Kline and Moretti (2013). See Figure 1 and Table 1 [NBER version], and the author's own plotting for 1990 and 2012; see Figures 1 and 2 below.

5.1 Zipf's law and urban emergence

Zipf's law for cities takes the following simple form:

$$\ell n[\text{Rank}_\ell] = \bar{s}_o + \zeta \ell n N_\ell + \epsilon_\ell. \tag{12}$$

See Ioannides (2013), Figure 8.1, reprinted below as Figure 3, for regressions lines fitted to data for the France, UK, and US. A vast literature considers the case of an estimate $\hat{\zeta} = -1$ as an immutable law; it is *not*! See Ioannides *et al.* (2008). Still, city size distributions throughout the world have characteristically thick tails, an important stylized fact. Econometric analyses along these lines are stymied by the fact that Zipf regressions are not standard regressions: the left hand side and right hand side of (12) are correlated; they track the countercumulative distribution of city sizes.

If urban growth rates are i.i.d., in other words, if they follow Gibrat's law, then the evolution of unconstrained evolution of city sizes at the limit tend to a lognormal, but the variance blows up. Imposing a lower bound creates a mode at the lower tail of the city size distribution, and thus thickens the upper tail sufficiently to lead to a power law. Zipf's law corresponds to the fattest tail for which the variance exists; see Gabaix (1999), Giesen *et al.* (2010), Rossi-Hansberg and Wright (2007), Skouras (2009), and Ioannides (2013), Chapter 8. Skouras considers Zipf's law as a special case of urban growth following reflected geometric Brownian motion. Other notable results in the literature are that an approximate Zipf's law as a limit when urban growth follows general geometric Brownian motion [Gabaix (2009)];

Zipf's law follows from a "spatial" Gibrat's Law, which describes a mix of urban activities giving rise to contemporaneous ("spatial") aggregation similar to temporal accumulation of geometric shocks; see Lee and Li (2013) and Ioannides (2013), p. 356.

5.2 Urban macro and national economic growth

Ioannides (2013), Chapter 9, shows, by adapting to an economy with cities the main international trade model in Ventura (2005), that convergent or divergent urban growth are both compatible with intercity trade. In a model with identical individuals, using an overlapping generations demographic structure, where individuals work when young, consume in both periods of their lives, may move when old, preferences over first and second period consumption, c_{1t}, c_{2t+1}, are given by: $U_t = S^{-S}(1-S)^{-(1-S)}c_{1t}^{1-S}c_{2t+1}^{S}$, with $0 < S < 1$, a parameter. Cities produce either one (specialized) or both (autarkic) of two manufactured tradeable goods, X, Y. Both manufactured goods are produced using raw labor, physical capital and intermediates. The cost of production of quantity Q_{Jt} of good J is

$$B_{Jt}(Q_{Jt}) = \left[\frac{1}{\Xi_{Jt}}\left(\frac{W_t}{1-\phi_J}\right)^{1-\phi_J}\left(\frac{R_t}{\phi_J}\right)^{\phi_J}\right]^{u_J}$$

$$\times\left[\sum_m P_{Zt}(m)^{1-\sigma}\right]^{\frac{1-u_J}{1-\sigma}} Q_{Jt},\ J = X, Y, \sigma > 1,$$

where Ξ_{Jt} is TFP in industry J, W_t is the wage rate for raw labor, R_t is the cost of capital, and $P_{Zt}(m)$ the price of intermediate m. This cost structure exhibits the productivity improvement associated with an increase in the range of varieties. Since $\sigma > 1$, as the range of the m's increases, holding $P_{Zt}(m)$ constant, cost decreases. Manufactured goods are combined to produce a non-tradeable composite, using a Cobb-Douglas production function that recalls the utility function in the static model discussed above: $Q_t = Q_{Xt}^{\alpha}Q_{Yt}^{1-\alpha}$. The non-tradeable composite is also the numeraire, and thus its price = 1. The composite is allocated to final consumption and investment in each city:

$$Q_{it} = C_{it} + K_{i,t+1}.$$

The law of motion in each city, under autarky, is:

$$K_{i,t+1} = SN_{it}\left(1 - \kappa N_{it}^{\frac{1}{2}}\right)W_{it}.$$

This becomes:

$$K_{i,t+1} = (1-\phi)S\Xi_{i,t}^{*}\left(N_{i,t}\left(1 - \kappa_i N_{i,t}^{\frac{1}{2}}\right)\right)^{\mu(1-\phi)-\upsilon} K_{i,t}^{\mu\phi+\upsilon}, \tag{13}$$

where the elasticity of capital is defined as follows:

$$\mu\phi + \upsilon \equiv \alpha\mu_X\phi_X + (1-\alpha)\mu_Y\phi_Y;$$

the auxiliary variable μ_J, are defined as

$$\mu_J \equiv 1 + \frac{1-u_J}{\sigma-1},$$

they may be interpreted as measures of the importance of market size effects. We may define μ as a weighted market size effects parameter:

$$\mu \equiv \alpha\mu_X + (1-\alpha)\mu_Y = 1 + \frac{1-(\alpha u_X + (1-\alpha)u_Y)}{\sigma-1} > 1,$$

and ϕ as the weighted share of capital in aggregate output:

$$\phi \equiv \alpha\phi_X + (1-\alpha)\phi_Y.$$

Finally, υ may be interpreted as the "covariance" between $\mu_J, \phi_J, J = X, Y$,

$$\upsilon \equiv \alpha(\mu_X-\mu)(\phi_X-\phi) + (1-\alpha)(\mu_Y-\mu)(\phi_Y-\phi) = -\alpha(1-\alpha)\frac{1}{\sigma-1}(u_X-u_Y)(\phi_X-\phi_Y).$$

The respective law of motion for output:

$$Q_{i,t+1} = \hat{\Xi}_{i,t}Q_{i,t}^{\mu\phi+\upsilon},$$

where $\Xi_{i,t}^{*}, \hat{\Xi}_{i,t}$, are functions of $\Xi_{Jt},\ J = X, Y$, and of parameters.

Thus, combination of weak diminishing returns and strong market size effects can lead to increasing returns to scale in each autarkic city. The model can be extended to allow for government investment to reduce urban transport costs and thus increase city size.

Economic growth is examined in the presence of intercity trade in manufactured goods and free factor mobility. Cities specialize and thus an industry with greater economies of scale need not be weighted down and be forced to compete for resource with another industry, which exhibits lower economies of scale. Still, the law of motion for capital of the integrated economy has the same dynamic properties as its counterpart for an economy with autarkic cities: When cities specialize, the advantage of specialization is exactly offset by the effect of its superior performance on the terms of trade. Different specialized cities grow in parallel, just as autarkic cities can growth in parallel. Unceasing growth is possible, and sustains a divergent pattern in city sizes.

The open city model allows for free movement of labor and spatial equilibrium: lifetime utility is equalized across cities. The nominal return to capital is also equalized. Intercity trade in final goods X, Y is allowed, and so could trade in intermediates, too. Cities specialize in final goods X, Y and produce their own intermediates.

The law of motion for capital in the national economy is:

$$K_{t+1} = S\left[n_X(1-\phi_X)\mathcal{N}_{\mathcal{X}} + n_Y(1-\phi_Y)\mathcal{N}_{\mathcal{Y}}\right]\left(\frac{K_t}{\bar{N}}\right)^{\alpha\mu_X\phi_X+(1-\alpha)\mu_Y\phi_Y}, \tag{14}$$

where $\mathcal{N}_{\mathcal{X}}, \mathcal{N}_{\mathcal{Y}}$ functions of city populations. It turns out that the elasticity of total savings with respect to capital is the same as in autarkic case: $\mu\phi + \upsilon$, and μ, ϕ, υ are defined in terms of fundamental parameters; see above and Ioannides (2013), Chapter 9. Thus, if a city's "representative" industry has strong diminishing returns and weak market-size effects: $\mu\phi + \upsilon < 1$, then increasing physical capital reduces the output–capital ratio. If the "representative" industry has weak diminishing returns and strong market-size effects: $\mu\phi + \upsilon \geq 1$, increasing physical capital increases the output-capital ratio. These properties are also transmitted to the law of motion. That is, in this model, sustained growth is possible, even if the national population is constant, provided that the "representative" industry have weak diminishing returns and strong market-size effects: $\mu\phi + \upsilon \geq 1$. Strong market-size effects here proxy for social interactions.

Utility maximizing city populations are proportional to internal transportation costs:

κ^{-2}. Real national income of the integrated economy is proportional to

$$(K_t)^{\alpha\mu_X\phi_X+(1-\alpha)\mu_Y\phi_Y}\ \bar{N}^{1-[\alpha\mu_X\phi_X+(1-\alpha)\mu_Y\phi_Y]}.$$

Thus, the model implies *constant returns to scale* at the national economy [Rossi-Hansberg and Wright (2007)]. The intuition of this result is as follows: just as with industry equilibrium with free entry of firms, here we have national equilibrium with free entry of cities, each operating with U-shaped average cost curves. Thus, the national economy may be described as operating with constant returns to scale, at unit cost equal to minimum average cost. Clement (2004) has this evocative reaction to this result: "A national economy, like a living organism, shapes its internal structure so that the nation as a whole can expand on a stable course" [Clement (2004)].

5.3 Urban growth empirics: "Barro style" versus random growth

How studies of urban growth link with the type of aggregative growth theory developed here? Starting from a standard, "Barro-style" urban growth regression, such as this,

$$\Delta_{t+1,t}\ell nN_{i,t} = \beta_0 + \beta_1\ell nN_{i,t} + D_{it}\beta_2' + \epsilon_{i,t},$$

one naturally wonders where do explanatory variables and shocks, like $D_{it}, \epsilon_{i,t}$ above, come from, that is, what urban growth theory can justify them rigorously. Most of our improved understanding in this area is due to Duranton and Puga (2014), who explore different formulations of random growth theories.

Specifically, let us assume that output per worker reflects a city size-based, or market-size) effect, that is external to each activity and internal to the city economy. That is: output per worker$_{it}$ is given by $\text{TFP}_{it}N_{it}^{\sigma-\gamma}$, where σ denotes the size elasticity of the market-size (agglomeration) effect, γ the size elasticity of the congestion effect, and Ξ_{it} city-specific productivity shocks. This implies that for output to remain finite, congestion dominate agglomeration, $\gamma > \sigma$, and economic activity is dispersed rather than concentrated in a single city. Spatial equilibrium takes the form of equalization of output per worker, which in turn implies that $\Xi_{it}N_{it}^{\sigma-\gamma}$ = constant throughout the economy. With a large number of cities, this in turn implies that the constant above be deterministic. Thus, city size may be written as: $N_{it} = \Xi_{it}^{\gamma-\sigma}$. Assuming that Ξ_{it} evolves by means of i.i.d. shocks, $\Xi_{it} = (1 + g_{it})\Xi_{i-1,t}$. It thus follows that:

$$\ell n N_{i,T} \approx \ell n N_{i,0} + \frac{1}{\gamma - \sigma} \sum_{t=1}^{T} g_{it}.$$

As discussed earlier, the distribution of city sizes within the economy tends to a lognormal, $N_{i,T} \sim$ lognormal, unless there exists a lower bound, in which case the upper tail thickens and $N_{i,T} \sim$ Pareto.

Much of modern urban theory emphasizes that the serendipity of urban encounters facilitates human capital accumulation. It is easy to modify the theory and add human capital accumulation as an additional component on the right hand side of the urban growth equation. But, depending upon how it is specified, the result that the city size distribution tends to the Pareto might no longer apply; see Duranton and Puga (2014), 840–845.

Empirical results by Black and Henderson (2003), also reported by Ioannides (2013), Table 8.1, p. 390, establish that there exists mean reversion in US urban growth. The coefficient of lagged city size in urban growth regressions ranges in $[-0.05, -0.02]$ even when time-invariant geographic and climate characteristics, such as degree-days, precipitation and coastal dummies, are included as well as market potential, which is time-varying, because the urban system is time varying. See also Ioannides and Overman (2004) and Henderson (2005).

6 Conclusion

The introduction to *From Neighborhoods to Nations* ends by assessing the role of social interactions ideas in economics as follows: " While urban economics lends basic components to social interactions as an organizing principle, it is not the only branch of economics in which the social interactions approach is leading to significant advances. Labor economics, economics of health and the economics of education have benefited enormously from this perspective. So too have spatial economics and the economics of international trade. For example, individuals and firms benefit from being in a larger city because its economy can accommodate a greater variety of goods and services. They in turn allow for more attractive lifestyles, greater ability to innovate, and improved ways to mitigate risk." It also suggests that "[u]nderstanding international trade from the lens of an economy's urban structure is a promising area of research, and so is understanding the forces of urban business cycles, a new area of research, ... Yet above all, the book aims at integrating empirical findings, mainly by economists, and thus help establish social interactions as a central tool of modern economics."

The concluding chapter of *From Neighborhoods to Nations* ends by alluding to an archipelago metaphor, itself borrowed from Joshua Lederberg [*The New Yorker* (1978)]. A city is like an archipelago, that allows the most rapid diversification of species, "where you have islands that are not totally isolated from one another but have sufficient isolation so that each one can develop a distinctive flavor and sufficient communication so that there is some gene flow between them." [Ioannides (2013), p. 455-456]. It then continues as follows.

"Perhaps, the archipelago metaphor offers the best picture of the magic of cities. Those of us, and indeed it is most of us, who live in cities nowadays live within a set of networks that are superimposed on one another. There is the physical urban space and its natural representation through streets, neighborhoods, actual and mental routes and links. There is also the pattern of social and personal interdependence. And there is the ever-changing technological framework within which all other networks merge. Education, culture, entertainment and life itself involve the internet and the world wide web in a myriad ways. The archipelago metaphor highlights the urban magic in another way: the archipelago's geological and climatic features underpin its biodiversity. The creation of cities over physical space locate the urban archipelago and their internal social and economic structure, which are man made, adapt to each other in a never-ending pattern of interdependence."

To the preeminent role of the study of markets in economics, the social interactions literature, and social economics more generally, argues in favor of the importance of understanding how they may be affected by ubiquitous social interactions. The present paper provides a selective review of key concepts and identifies areas that deserve attention in future research. This includes several areas of macroeconomic significance, including notably urban business cycles. The national business cycle is made up of made up of cycles characterizing the economy's key components, with different urban areas making up most of the economy and accounting for most of its output. But typically urban areas account for a small share of national space. Creativity and innovation results from people being close to one another. So do urban ills. Yet we know that the total social benefits outweigh the social costs. Social interactions research may also provide guidance fore understanding policy that would help mitigate social ills. Although it has not been emphasized in this paper, "bad" social interactions are also important to understand. Yet the point remains that agent-to-agent interactions that are not mediated by the market are an important feature of the modern economy.

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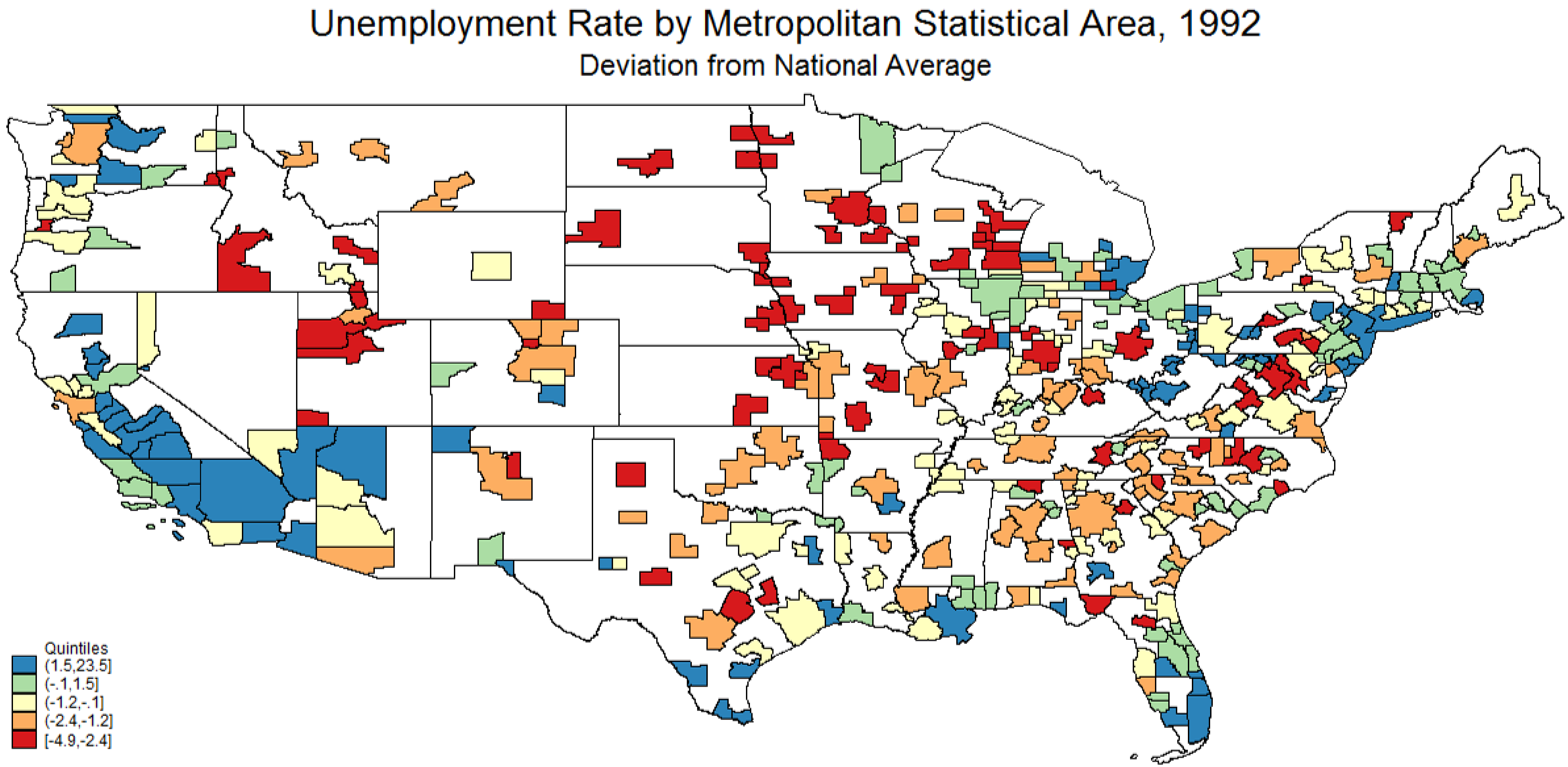

FIGURE 1

Source:author's calculations

Unemployment Rate by Metropolitan Statistical Area, 2012

Deviation from National Average

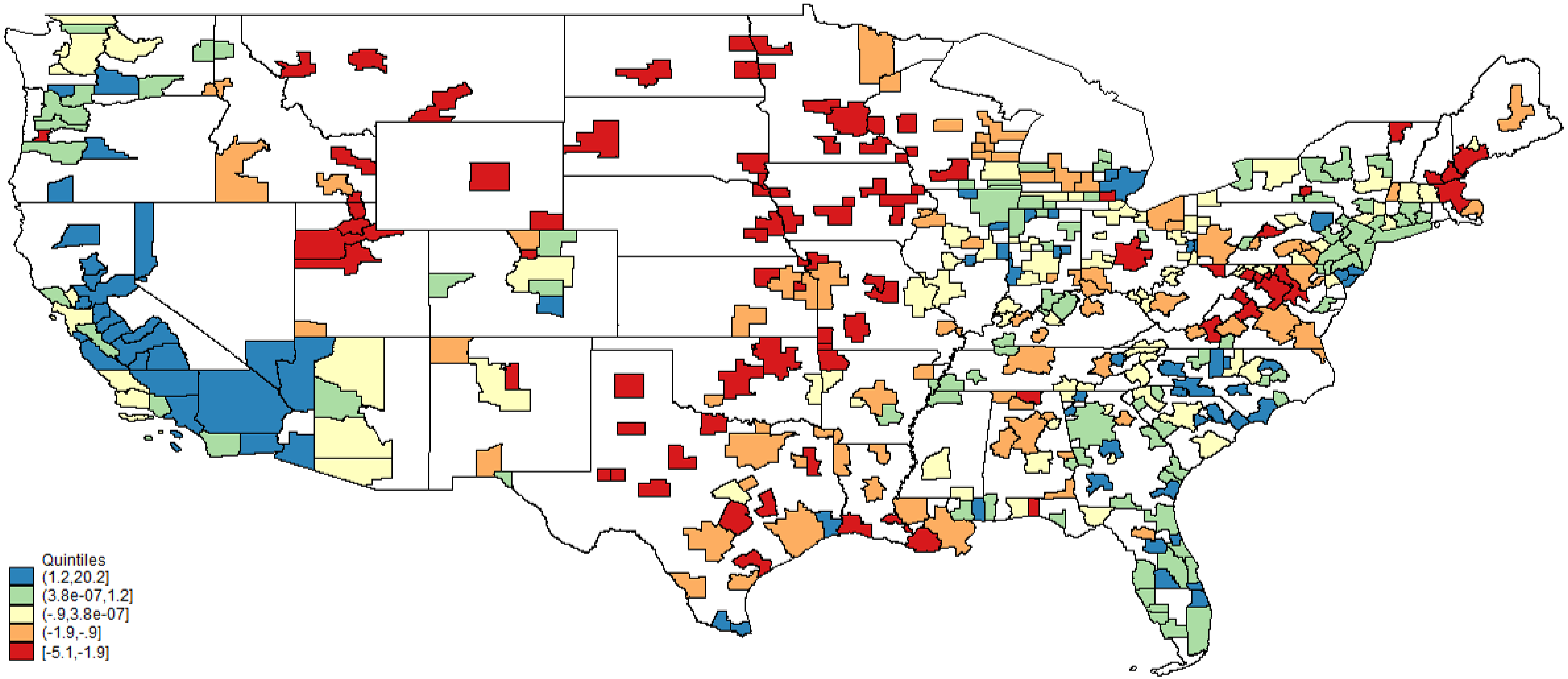

FIGURE 2

Source:author's calculations

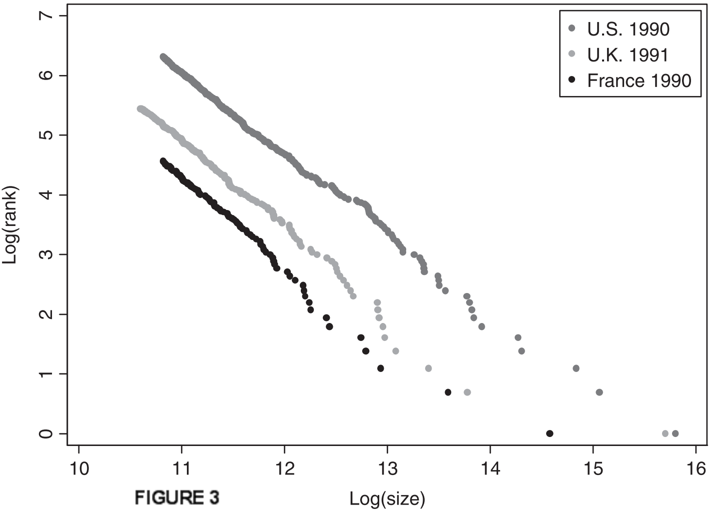

FIGURE 3

Source: Ioannides (2013), Figure 8.1