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The Rise of the Mega Region

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Abstract

This paper uses a global dataset of nighttime light emissions to produce an objectively consistent set of mega-regions for the globe. We draw on high resolution population data to estimate the population of each of these regions. We then process the light data in combination with published estimates of national GDP to produce rough but useful estimates of the economic activity of each region. We also present estimates of technological and scientific innovation. We identify 40 mega-regions with economic output of more than $100 billion that produce 66 percent of world output and accounts for 85 percent of global innovation.

Introduction

When we think about economic growth and development, we usually think in terms of nation-states. But the past two or three decades have seen the rise of a new economic unit – the mega-region. At the time when the great classical economists were framing economic theory, nations truly were the space over which labor and capital were reallocated by the economic process. International investment and travel existed, but they were burdensome and not nearly as common as they have become. Nations were thus natural units of macroeconomic analysis and these nations were productively conceived as being composed of cities and hinterlands. In the 21st century, however, the emergence of globalization makes national boundaries mean a lot less. Capital can now be allocated freely around the globe – seeking maximum returns wherever they may be. Even labor, particularly highly creative and productive and labor, can be reallocated globally in a way that would once have been impractical.

This has meant that the nation is beginning to lose some of its appeal as a logical unit of analysis. We propose that the mega-region can be conceived as a parallel macro-structure. Mega-regions are integrated sets of cities and their surrounding suburban hinterlands across which labor and capital can be reallocated at very low cost. The 40 that we will identify here all have economies on the scale of $100 billion or more. Similarly, the 40th largest nation in terms of GDP also has an economy of about $100 billion.

The mega-regions of today perform functions that are somewhat similar to those of the great cities of the past – massing together talent, productive capability, innovation and markets. But they do this on a far larger scale. Furthermore, while cities in the past were part of national systems, globalization has exposed them to

world-wide competition. As the distribution of economic activity has gone global, the city-system has also become global – meaning that cities compete now on a global terrain. Urban mega-regions are coming to relate to the global economy in much the same way that metropolitan regions relate to national economies.

While others have used different methods to define mega-regions in various parts of the world (see e.g. Scott, 2001; Yusuf, 2007; PricewaterhouseCoopers, 2007; Regional Plan Association, 2006; Lang and Dhavale, 2005; Gottman, 1961) or contributed to the understanding of their evolution and significance (Ohmae, 1993; Axtell and Florida, 2001; Glaeser, 2007), there has not, to date, been a method for systematically defining the global set of mega-regions and consistently estimating their attributes. This paper seeks to do this, based on a global dataset of nighttime lights. We use these data to produce an objectively consistent set of mega-regions for the globe. We draw on high resolution population data to estimate the population of each of these regions. We then process the light data in combination with published estimates of national GDP to produce rough but useful estimates of the economic activity of each region. Finally, we draw on other sources to estimate both technological and scientific innovation for each.

Concepts and Theory

The classical economists Adam Smith (1776) and David Ricardo (1817) both argued that nation-states were the geographic engines behind economic growth. Most students of economic history see a progression from rural villages to cities to nation states. The reality is that economic activity—such as trade, commerce, and innovation—has always originated in cities. Cities, and now mega-regions, are the central engines of economic growth and development (Jacobs, 1961, 1969, 1984). A

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dynamic city, according to Jacobs, integrates its hinterland and becomes a "city-region." As nearby farmland is revolutionized by city-created technology and innovation, rural dwellers move closer to town to assume jobs in urban industry. As the city generates more output, more money becomes available for civic and infrastructure improvement as well as new technology and innovation to aid the city's outlying areas. Jacobs refutes the longstanding theory that cities emerged only after agriculture had become sufficiently productive to produce a surplus beyond what was needed to survive. In fact the earliest cities, according to Jacobs, formed around rudimentary trade in wild animals and grains, which led them to discover agriculture and the fiscal benefits of product exportation. Even activities typically considered "rural" originated in cities before proliferating in outlying regions. Productivity improvements in agriculture, Jacobs points out, always originated in cities before they were adopted in farming areas: The mechanical reaper, for instance, was originally invented, perfected, and used in cities before the technology reached and revolutionized rural agricultural areas.

The importance of trade identified by Ricardo and given mathematical form by Ohlin and Heckscher (1933), still matters today, but national borders no longer define economies. Instead, the mega-region has emerged as the new "natural" economic unit. The mega-region is not an artifact of artificial political boundaries, like the nation state or even its provinces, but the product of concentrations of centers of innovation, production and consumer markets. Today's mega-regions extend far beyond individual cities and their hinterlands (e.g. Meijers, 2005).

Mega-regions are more than just a bigger version of a city or a metropolitan region. As a city is composed of separate neighborhoods, and as a metropolitan region is made up of a central city and its suburbs, a mega-region is a polycentric

agglomeration of cites and their lower-density hinterlands. It represents the new,

natural economic unit that emerges as metropolitan regions not only grow upward and

become denser but grow outward and into one another. Just as a city is not simply a

large neighborhood, a mega-region is not simply a large city – it is an "emergent"

entity with characteristics that are qualitatively different from those of its constituent

cities.

Gottman coined the term "megalopolis" to describe the emerging economic

hub that was the Boston-to-Washington corridor (Gottman, 1957). Derived from the

Greek and meaning "very large city," the term was later applied to a number of other

regions: the great swath of California stretching from San Francisco to San Diego; the

vast Midwestern megalopolis running from Chicago through Detroit and Cleveland

and down to Pittsburgh; and the bustling Tokyo-Osaka region of Japan.

Ohmae later argued that "region states" had replaced nation states as the

organizing economic units the global economy (Ohmae, 1993).

> "Region states may lie entirely within or across the borders of a nation state.
> This does not matter. It is the irrelevant result of historical accident. What
> defines them is not the location of their political borders but the fact that they
> are the right size and scale to be the true, natural business units in today's
> global economy. Theirs are the borders—and connections—that matter in a
> borderless world."

But not all metropolitan areas function successfully as mega-regions. Large

but poor "mega-cities" like Calcutta or Delhi are "immense human aggregations,"

Ohmae writes that "either do not or cannot look to the global economy for solutions to

their problems or for the resources to make those solutions work. They look instead to

the central governments of the nation states in which they reside." Ohmae's point is

important. Population is not tantamount to economic output. Unlike mega-cities,

which are termed as such simply for the size of their populations, mega-regions are by definition places that claim large populations, large markets, significant economic capacity, substantial innovative activity, and highly skilled talent.

Examining mega-regions in terms of population can be highly misleading. Mega-cities are generally conceived in terms of population (often as metropolitan areas of 10 million or more). In many cases these mega-cities seem to have arisen with a price, especially in the underdeveloped parts of the world. Retsinas (2007) describes the problems stemming from developing world mega-cities in terms of poverty, diseases and despair in many of the fastest growing regions in the world, comparing those with the problems related to the urbanization process during the industrial revolution as experienced by Dickens and Marx.

There have been attempts to describe the evolution of the mega-regions. Glaeser (2007) examines the factors behind the growth of American metropolitan regions into mega-regions. He comes to the conclusion that it is the initially less dense areas that have experienced the fastest growth and speculates that this reflects the importance of accessibility by car. He also finds that climate seems to play a part in the development of the fastest growing regions. In contrast to a number of results concerning metropolitan areas (Ciccone and Hall, 1996; Glaeser and Mare, 2001; Overman and Venebles, 2005), Glaeser finds no evidence that initial income impacts population growth in the mega-regions; finding instead that population growth is an effect of successful housing supply.

Looking at economic growth and the creation of wealth solely through nation-state data is also misleading. Globalization renders national political borders less relevant in economic terms. Firms locate where skill, capabilities and markets cluster; capital flows to where the returns are greatest; and highly skilled people move where

opportunity lies. To be sure, this results in a more fully integrated global economy. But it also means that both capital and talent concentrate where opportunities for productivity and returns are highest—hence every nation experiences massive concentrations of population and productivity in its largest urban regions. This is true in the advanced economies of the U.S. Europe and Japan, and even more so for the emerging economies like China and India (Wilson and Purushothaman, 2003).

National borders also have increasingly less to do with defining cultural identity. We all know how different two cities can be within the same state, much less the same country. Cities that have not become a part of the global economy are experiencing more than just lagging economies: they are becoming culturally distinct from their mega-region neighbors as well. These growing pains, on top of glaring economic disparities, are exacerbating the divide between the haves and the have-nots—the urban sophisticates and rural people—of the world.

At the same time that cities within national borders are diverging, mega-regions whose geographic locations could not be farther apart are growing closer. The more two mega-regions—regardless of their physical distance or historical relationship—have in common in terms of their economic output, the more likely they are to develop similar social mores, cultural tastes, and even political leanings. This isn't true just for New York and London; even New York and Shanghai arguably have more in common than, say, New York and Louisville.

Data and Methods

Since comprehensive sub-national data on global economic activity do not exist, we developed a straightforward strategy and method to identify the world's mega-regions. We distilled estimates of economic activity by using satellite images of the world at night. We define mega-regions in terms of contiguously (or very nearly contiguously) lighted areas as seen from space at night. We begin with data from the Earth Observation Program of NOAA's National Geophysical Data Center. These data provide a measure of light intensity for each 30 arc second cell between -65° and 65° latitude. These cells cover approximately $1km^2$ at the equator and become somewhat smaller at higher and lower latitudes.

We then set a light threshold that captures the essence of the US mega-regions described by Lang (2005) and the Regional Plan Association (2006). These authors and others have used much more complex methods, including measures of commuting patterns, etc. We find that while these factors are critically important for understanding the functioning of a mega-region, contiguous development is a good enough proxy for economic integration that it can meaningfully be used in this context. Intuitively, then, we are defining a mega-region is a very large area across which one could walk, carrying only money, without getting hungry.

After we determine the threshold that gives the best approximation of the established US mega-regions, we apply this same threshold to the nighttime lights dataset for the rest of the world. This produces tens of thousands of lighted patches representing the full range of settlement sizes – from the largest mega-regions covering thousands of square kilometers to small villages and other light sources that are on the order of a single square kilometer. We then proceed to close small gaps, merging lighted areas that are separated by less than 2 kilometers. In some cases, in

the heavily industrialized regions of Northeastern North America, Europe, and Japan, this approach generates mega-regions that tenuously connect to one another. In these cases, we split the conjoined regions at their narrowest connections. Finally, we estimate economic activity for each of the areas using the method described below and establish a threshold of economic activity that defines an area as a global mega-region.

The use of light footprints to define mega-regions produces a precise and complex boundary for each region. While this boundary bears a meaningful resemblance to the pattern of urbanization it describes, it often does not bear much resemblance to the political and administrative boundaries for which statistics are generally calculated – making it difficult to develop indicators for these regions. We begin to address this by estimating values for four variables that are important to understanding the relative size and global importance of each region. These variables are: economic activity, population, patent activity as a proxy for technological innovation, and highly cited scientific authors as a measure of basic scientific innovation.

Economic Activity: Light-Based Regional Product: We use the light that is visible from space at night as a basis for estimating economic activity. The relationship between light emission and GDP is complex and their correlation is imperfect. We take a pragmatic and empirical approach that we are still refining. We will present a detailed account of this procedure elsewhere. Here, we will simply outline the method.

We begin with light emission data for the year 2000 (Doll, Muller, & Elvidge, 2000). These data have limited range. While they capture low light levels that are consistent with low-density suburban and electrified semi-rural areas, the measured emission level saturates far from the most economically intense center of a major city due to the design of the sensors and the processing algorithms used by NGDC. The fall-off in brightness gradient as this threshold is approached is quite steep and occurs in the inner suburbs of large American cities. While this presents a challenge in producing estimates, we find that it is not insurmountable. This data limitation in some ways liberating because we suspect that the relationship between light emissions and economic activity breaks down as higher levels of urbanization expand vertically rather than horizontally. We would thus be forced to estimate central cities differently from their surroundings in any case.

(Figure 1 about here)

To deal with the problem of saturation of urban cores, we break the process of estimating economic activity from light emissions into two stages: we estimate activity levels for low light areas, including urban peripheries, as a direct function of light level. We separately estimate urban cores as a function of both area and shape.

We calibrate our model using estimates of 2001 GDP for the 356 metropolitan areas in the lower 48 US states prepared by the US Conference of Mayors (Global Insight, 2006). We deal with the problem of translating physical economic activity into standard units by renormalizing the total for each nation to agree with that nation's 2000 GDP in 2000 US dollars at current market exchange rates (World Bank, 2006). We thus use the light-derived estimates to establish the relative importance of

pixels within nations while maintaining consistency with published estimates at the national level.

Finally, in cases where we have high quality metropolitan region estimates for areas with well-defined borders, we renormalize those areas to agree with the published estimates. At this point, we use such data only for the 365 metropolitan areas estimated by the US Council of Mayors, but this could be expanded to cover other metro areas for which reliable numbers can be obtained. In this case, the light-based estimates represent the relative level of activity within the metropolitan region. When such sub-regional adjustments are made, we again renormalize the national total to coincide with WDI national estimates.

The result of this process is an estimate of economic activity for every 30 arc second grid cell (less than one square kilometer) in the world. We refer to this indicator as Light-based Regional Product or LRP. While it is expressed in the same nominal dollars as GDP and designed to aggregate up to published estimates of GDP, we believe that it is different enough in terms both of its derivation and its conceptual design that is best identified with its own name.

LRP can be summed for any arbitrarily defined area including our newly defined mega-regions. While it is less reliable inside the urban core areas, where economic activity is estimated as a function of area and shape rather than directly inferred from light levels, this does not present a problem for mega-region estimation because mega-region boundaries can not, by definition, pass through urban cores.

Population: Population is estimated by summing population estimates for 30 arc second grid cells from the 2005 LandScan dataset (Oak Ridge National Laboratory, 2006) within each light-based mega-region polygon. Because light data are used as one of several inputs for producing these estimates, we find that they produce more plausible estimates for light-based urban regions than does the similar Gridded Population of the World dataset (CIESIN, 2006) which is based on local census and administrative records.

(Figure 2 about here)

Patents: We estimate patents for world mega-regions by conflating city specific data from the US Patent and Trademark Office (USPTO) with nationally aggregated data from the World Intellectual Property Office (WIPO).

(Figure 3 about here)

Because inventors from around the world file for patent protection in the United States, and the USPTO tracks the city of residence of the inventor, we can count the number of US patents for each city in the world. While this file provides a fine portrait of inventions in US cities, it undercounts (sometimes radically) inventions in other countries due to the fact that not every inventor files for a US patent. We compensate for this by using the USPTO data to estimate the relative importance of the cities within each country. We then take the number of patents

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reported to WIPO by each national patent office as granted to domestic inventors and reallocate them to cities using the weights derived from the USPTO data. We thus assume that inventors who patent in the United States have the same spatial distribution as inventors who patent domestically. This may overstate the importance of major cities (where access to the world patent system might be easier), but we believe that this is not a large source of bias.

When the city estimates are complete, we sum the estimated patents for all of the cities that fall within a given mega-region.

Star Scientists: We use the location of highly cited scientific authors as a proxy for basic scientific innovation. We derive this from data compiled by Batty (Batty 2002), aggregating upward from the city level to the mega-region. It is important to note that the scope of these data are limited, excluding mathematics, the social sciences and the humanities and are thus skewed heavily toward medicine (Batty 2002).

(Figure 4 about here)

Findings

Tables 1 and 2 summarize key statistics on the economic size and scale of the world's largest mega-regions. Table 3 provides a list of the top 40 mega-regions world-wide. As our findings make clear; out of roughly 200 nations in the world and their thousands upon thousands of cities, only a small number of economic mega-regions power and structure the world economy. There are 2 mega-regions – Greater Tokyo and Bos-Wash which generate more than $2 trillion in LRP, while another 5 produce in excess of $1 trillion in LRP.

(Table 1 about here)

As Table 1 shows, if we take the largest mega-regions in terms of population, the world's 10 biggest are home to roughly 666 million people or 10.5 percent of world population; the top 20 comprise close to 1.1 billion people, 17 percent of the world total; while the top 40 are home to 1.5 billion people, 23 percent of global population.

(Table 2 about here)

As Table 2 shows, the economic role of mega-regions becomes even clearer when we look at economic output measured as LRP. The world's 10 largest mega-regions in terms of LRP, house only about 416 million people, or 6.5 percent of the world's population, but account for 42.8 percent of economic activity ($13.4 trillion), 56.6 percent of patented innovations, and 55.6 percent of the most-cited scientists. The top 20 mega-regions in terms of economic activity account for 10 percent of population, 56.6 percent of economic activity, 76 percent of patented innovations and 76.5 percent of the most-cited scientists. And the top 40 mega-regions in economic activity, which make up about 17.7 percent of the world's population, produce 66 percent of economic activity, 85.6 percent of patented innovations, and 83.3 percent of the most-cited scientists.

We find that there is a marked concentration of economic activity in the mega-regions of the United States and the European Union. In the US, LRP per capita is nearly 30% higher in the mega-regions than it is in the rest of the country. In the EU, this figure is over 40%.

(Table 3 about here)

Having identified a consistently defined set of global mega-regions, we can set about the task of examining them to better understand the role each one plays in both its regional and global context. The following sections provide maps and discussion of the major mega-regions in North America, Europe, Asia and the emerging economies.

North America

Figure 5 is a map of the largest mega-regions in North America. The Boston-New York-Washington corridor is the second largest mega-region in the world. When originally identified by Gottman in 1961, it was home to about 32 million people; today it is home to some 54.3 million, more than 18 percent of all Americans. Generating $2.2 trillion in LRP it is larger than all but two national economies – those being the US and Japan. Its economic output is greater than that of France or the United Kingdom, and more than double the size of India's or Canada's.

(Figure 5 about here)

The Chicago-Pittsburgh mega-region, originally dubbed "Chi-Pitts" by Gottman, covers more than 100,000 square miles, and is home to 46 million people and $1.6 trillion in LRP. The So-Cal or Southern California mega-region, which runs from Los Angeles to San Diego and Tijuana, is home to 21.4 million people and the source of $710 billion in LRP.

A second mega-region in California is Nor-Cal surrounding the San Francisco Bay area (rank 14). Claiming 12.8 million people and more than $470 billion in LRP, it is a leading center of technology industry and venture capital and is home to a

cluster of world-class universities, The Char-lanta mega-region that runs from Charlotte through Atlanta is home to 22 million people and produces $730 billion in LRP, making it bigger than India's GDP and about the same size as Canada's. A second mega-region in California is Nor-Cal surrounding the San Francisco Bay area. Claiming 12.8 million people and more than $470 billion in LRP, it is a leading center of technology industry and venture capital and is home to a cluster of world-class universities.

In Texas, there is the substantial economic triangle that encompasses Dallas, San Antonio, and Austin, housing 10 million people and producing $370 billion in LRP. Also in Texas, running from Houston to New Orleans is a mega-region of 10 million people and the source of $330 billion in LRP. The Cascadia corridor stretches up from Portland, Oregon through Seattle and into Vancouver, Canada. It is also strong in technology-based industry, particularly with regard to software publishing and aerospace manufacturing, but the region also specializes in lifestyle industries. Microsoft, Amazon, Real Networks, Starbucks, REI, and Costco all have their roots in this mega-region. Denver-Boulder and Phoenix-Tucson each generate about $140 billion in LRP.

Europe

Figure 6 is a map of the mega-regions of Europe. Like America's 50 states, the countries of Europe nation are also historical artifacts defined by political boundaries. The real economies of Europe are six or seven world-class mega-regions that compose the bulk of the continent's innovation and production. European mega-regions are comparable in size to their North American and Asian counterparts, even

though most of the metropolitan areas of which they are composed are smaller (with the notable exceptions of London and Paris). We believe that this makes a mega-regional perspective particularly important in the European context.

(Figure 6 about here)

Europe's largest mega-region is the enormous economic composite spanning Amsterdam-Rotterdam, Ruhr-Cologne, Brussels-Antwerp, and Lille. Housing 59.2 million people and producing nearly $1.5 trillion in economic output, this mega-region's production exceeds Canada's and as well as China's or Italy's. Next in size is the British mega-region stretching from London through Leeds, Manchester, Liverpool and into Birmingham. This mega-region is home to 50 million people and responsible for $1.2 trillion in economic output. The Italian mega-region stretching from Milan through Rome to Turin is a leading center for fashion and industrial design. 48 million people produce some $1 trillion in output, making it the 3rd largest economic conglomerate in Europe and the 7th largest in the world. In Germany, the mega-region encompassing Stuttgart, Frankfurt, and Mannheim is home to 23 million people. To the west is Greater Paris, a mega-region of 14.7 million people accountable for $380 billion in LRP. The bi-national Euro-Sunbelt mega-region (rank 11), which stretches from Barcelona into Marseille and then Lyon, claims some 25 million people who produce $610 billion in LRP. Vienna-pest ($180 billion in LRP), Prague ($150 billion LRP), Lisbon ($110 LRP), Scotland's Glas-burgh ($110 LRP), Madrid ($100 billion LRP) and Berlin ($100 billion LRP) round out the list of Europe's mega-regions.

Asia

Figure 7 is a map of the mega-regions of Asia. Japan is home to four significant mega-regions. Greater Tokyo (rank 1), home to more than 55 million people and responsible for nearly $2.5 trillion in economic output, is the world's largest mega-region, with world-class strengths in finance, design, and high-technology. The mega-region stretching from Osaka to Nagasaki is home to 36 more million people who generate $1.4 trillion in output. Fuku-kyushu houses 18.5 million people and produces 430 billion in LRP. Greater Sapporo is home to 4.3 million people, producing $200 billion in LRP. Our light mapping procedures indicates that the boundaries between these megas are indeed blurring and that much of Japan may be becoming an integrated super-mega-region. This merging is illustrated by the fact that three of Japans four mega-regions are served by the same high-speed rail system (with extensions planned for service to Sapporo).

(Figure 7 about here)

The mega-region that runs from Seoul to Busan (rank 13) houses 46 million people and produces 500 billion in LRP. Greater Singapore is a classic city-state, whose population of 6 million (nearly 2 million of whom are actually across the border in Malaysia) generates a GDP of more than $100 billion. It has "willingly and explicitly given up the trappings of nation states," Kenichi Ohmae writes about the country, "in return for the relatively unfettered ability to tap into…the global economy." (Ohmae, 1993). The Bangkok mega-region is home to 19 million people, producing $100 billion in economic output.

Mega-regions in the Emerging Economies

There are also mega-regions in the emerging economies. Recall that we identify mega-regions as significant economic centers producing at least $100 billion in LRP. Mega-regions, per our definition, thus differ from the global cities of the emerging economies and developing world, which though they house large populations do not meet our threshold for economic activity.

China is home to three significant mega-regions. The Hong Kong - Shenzhen (or Hong-zhen) mega-region is anchored by the established manufacturing powerhouse of Hong Kong, but also includes the fast growing centers of Shenzhen and Guangdong. It includes 44.9 million people and produces $220 billion in LRP. The Shanghai mega-region is home to 66 million people, producing $130 trillion in LRP in 2000, making it the 31st largest mega-region in the world. With its considerable rate of growth, we can assume it has grown substantially bigger since that time. The Beijing mega-region is home to 43 million people, producing $110 billion in economic output. China's three leading mega-regions account for 38 percent of its LRP. Furthermore, in China, LRP per capita is a whopping 360% higher among the 12% (154 million) of the population living in the Bejing, Shanghai, and Hong-Sen mega-regions than it is among the 88% of the populace living elsewhere in the country. This wealth disparity is driving the most massive urbanization trend in history.

India is home to one mega-region meeting our criteria for contiguity and economic output (Delhi-Lahore). We also identify two rapidly expanding regions that are destined to join the ranks of mega-regions soon, if they have not already. One of these, anchored by Bangalore and Madras, is home to 72 million people and produces 49 billion in LRP. The other is the Mumbai-Poona region with 62 million people and

57 billion in LRP. Recall again that these figures are for 2000. We can expect that both are substantially bigger now. These areas, however, have an LRP per capita that may be as much as 10% lower than the rest of the country. It seems that the continuing crowding and poverty associated with the third world mega-city status of these cities is offsetting the remarkable wealth creation associated with their emerging status as global mega-regions.

Mega-regions play an increasingly significant role in other emerging economies around the world. In Latin America, Greater Mexico City (rank 20) is home to 45.5 million people while generating $290 billion in LRP. In Brazil, the mega-region which goes from Sao Paolo to Rio de Janeiro (rank 22) generates $230 billion in LRP and is home to 43 million people. In the Middle East, the mega-region that runs from Tel Aviv to Amman and Beirut is home to 31 million people and $160 billion in LRP.

Conclusions

We have examined the rise of global mega-regions. Initially identified, by Gottman, mega-regions are natural economic units, arising as metropolitan regions become increasingly integrated with one another. Previous research has documented existence of mega-regions in specific countries like the United States or continents like Europe. Until now, research has been regionally specific and cross regional comparisons were limited by the absence of systematic definitions and comparable global data. We have begun to address this by identifying a consistent set of global mega-regions using satellite imagery of the nighttime light emissions for the globe.

We then use these light-footprints, combined with other data, to estimate population, innovation and scientific discoveries, along with economic activity, for each of them.

Our findings indicate that mega-regions are a considerable economic force globally. The world's 40 largest mega-regions, those which produce in excess of $100 billion in LRP, account cover only a tiny fraction of the habitable surface of the earth, and are home to less than 18% of the world's population, yet, they are responsible for 66% of global economic activity and about 85% of technological and scientific innovation. Mega-regions not only define the economies of the advanced nations but play a central role in emerging economies as well. Our findings suggest that it makes little sense to think of the growth of India and China as a national phenomenon but rather as mega-regional one.

Furthermore, our research suggests that geography and location matter a great deal to economic development. While it has become a commonplace to argue that advances in transport and communication technology have allowed the world to become "flat" (Friedman, 2005), the reality is that both economic activity and innovation remain greatly concentrated. Thus the great paradox of our time: at the same moment that technology enables the geographic spread of economic activity, economic activity continues to cluster and concentrate around this mega-regional unit. The reasons for this are beyond the scope of this paper but revolve around the human capital externalities initially identified by Jacobs (1969) and codified into economic theory by Lucas (1988). Developing deeper understanding of the role of these human capital externalities in the formation, growth and function of mega-regions is an important task of future research.

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Figures

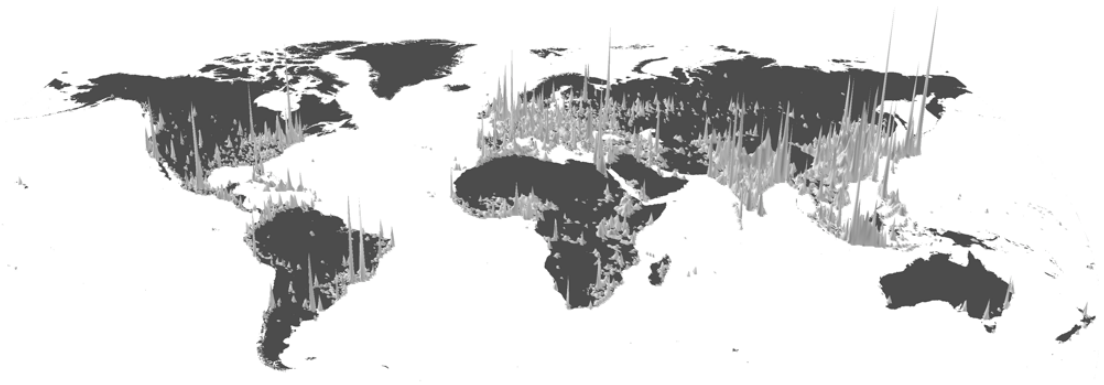**Figure 1:** Global distribution of economic activity (LRP)

Figure 2: Global Distribution of Population

Figure 3: Global distribution of patent activity

Figure 4: Global distribution of star scientists (highly cited science authors)
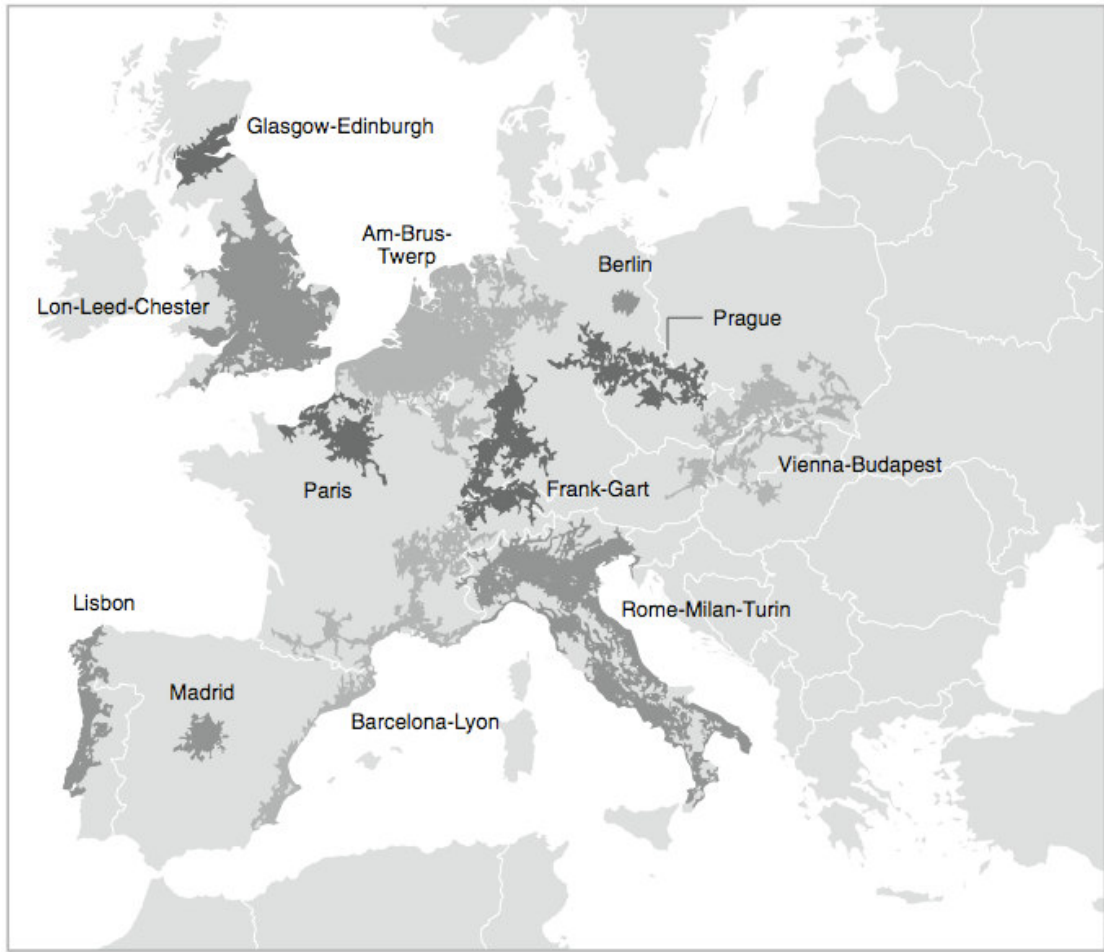
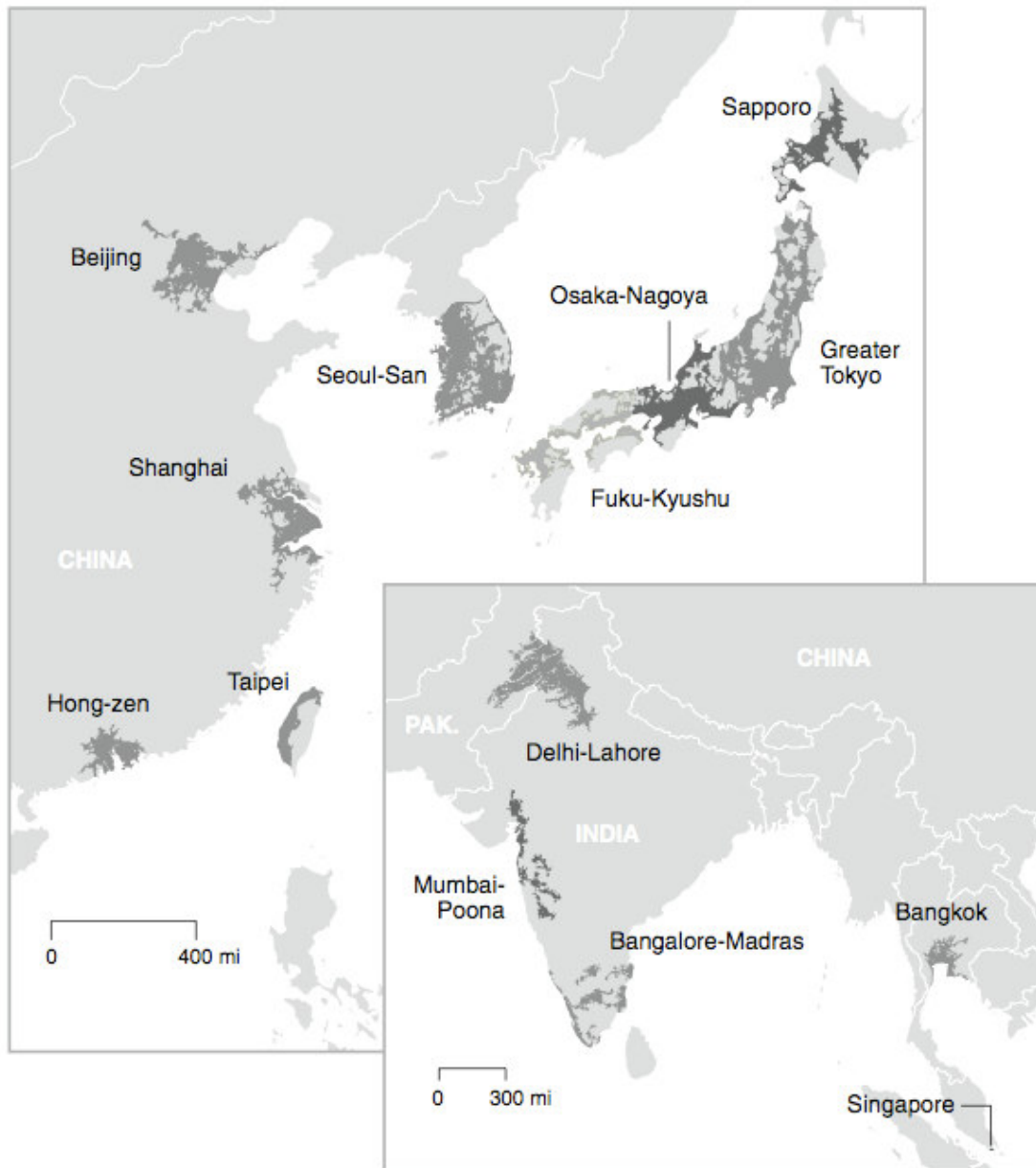**Figure 5:** North America mega-regions

Figure 6: Europe mega-regions

Figure 7: Asia mega-regions

Tables

Table 1: Distributions Based on Population Rankings

	LRP		Population		Patents		Scientific Citations	
	Absolute Number ($Billions)	Share	Absolute Number (Millions)	Share	Absolute Number	Share	Absolute Number	Share
Top 10	7891	25.1%	666	10.5%	123932	41.1%	423	35.0%
Top 20	13433	42.8%	1081	17.0%	184240	61.1%	520	43.1%
Top 40	18489	58.9%	1478	23.2%	231797	76.8%	785	64.9%

Table 2: Distributions Based on LRP Rankings

	LRP		Population		Patents		Scientific Citations	
	Absolute Number ($Billions)	Share	Absolute Number (Millions)	Share	Absolute Number	Share	Absolute Number	Share
Top 10	13433	42.8%	416	6.5%	170885	56.6%	672	55.6%
Top 20	17777	56.6%	636	10.0%	229212	76.0%	925	76.5%
Top 40	20711	66.0%	1125	17.7%	258181	85.6%	912	88.3%

Table 3: Top 40 Mega-regions Based on LRP

Name	Population (Millions)	Pop. Rank	LRP 2000 ($Billions)	LRP Rank	Patents (2001)	Pat. Rank	Authors (2001)	Auth. Rank
Greater Tokyo	55.1	4	2500	1	91280	1	11	16
Bos-Wash	54.3	5	2200	2	21307	3	293	1
Chi-Pitts	46.0	9	1600	3	17686	4	67	5
Am-Brus-Twerp	59.3	3	1500	4	6985	9	29	11
Osaka-Nagoya	36.0	14	1400	5	15897	5	9	20
Lon-Leed-Chester	50.1	6	1200	6	3315	14	89	3
Rom-Mil-Tur	48.3	7	1000	7	4000	33	12	14
Char-lanta	22.4	18	730	8	4188	11	49	7
So-Cal	21.4	22	710	9	6902	10	74	4
Frank-Gart	23.1	17	630	10	3199	15	39	8
Barce-Lyon	25.0	16	610	11	1896	23	10	17
Tor-Buff-Chester	22.1	19	530	12	3402	12	56	6
Seoul-San	46.1	8	500	13	21833	2	0	40
Nor-Cal	12.8	28	470	14	11567	6	108	2
So-Flo	15.1	25	430	15	2693	19	8	22
Fuku-kyushu	18.5	24	430	16	1965	21	9	20
Paris	14.7	26	380	17	9007	8	16	13
Dal-Austin	10.4	30	370	18	3149	17	16	13
Hou-Orleans	9.7	32	330	19	2724	18	30	10
Mexico City	45.5	10	290	20	91	35	0	40
Cascadia	8.9	33	260	21	3179	16	33	9
Rio-Paulo	43.4	12	230	22	457	30	0	40
Hong-Zen	44.9	11	220	23	2231	20	1	31
Sapporo	4.3	37	200	24	232	32	0	40
Vienna-pest	21.8	21	180	25	1365	26	1	31
Tel Aviv-Amman-Beirut	30.9	15	160	26	377	31	8	22
Prague	10.4	29	150	27	3400	13	2	25
Buenos Aires	14.0	27	150	28	95	34	0	40
Denver-Boulder	3.7	40	140	29	1921	22	11	16
Phoenix-Tucson	4.7	36	140	30	1652	24	6	24
Shanghai	66.4	2	130	31	988	27	0	40
Taipei	21.8	20	130	32	5000	37	1	31
Lisbon	9.9	31	110	33	44	39	1	31
Beijing	43.1	13	110	34	1582	25	0	40
Delhi-Lahore	121.6	1	110	35	160	36	0	40
Glas-burgh	3.8	39	110	36	643	29	9	20
Berlin	4.1	38	110	37	9998	7	7	23
Singapore	6.1	34	100	38	170	40	1	31
Madrid	5.9	35	100	39	849	28	1	31
Bangkok	19.2	23	100	40	58	38	0	40