Understanding the varieties of green-driven growth: Cities and renewable energy in the Global South

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Citation for published version (APA):
CHAPTER 2

Understanding the position of end-nodes in the world city network

Introduction

Much of the World City Network (WCN) discourse has focused on those urban centres that are central to global production networks. In this, corporate office locations have become an important indicator for a city’s integration in the world of global business. Two of the most renowned origins of this research agenda can be found in Friedmann’s world-city hypothesis and Sassen’s work on a city’s control function within the global economy (Friedmann 1986; Sassen 1991). Whereas Friedmann argues that city relations are hierarchical and can be judged based on their economic weight, Sassen emphasises the need to look more specifically at advanced producer services and the level of dominance these firms create for cities vis-à-vis other cities. These two separate WCN perspectives still define the different schools of thought within the current academic debate. In a recent article, Wall and van der Knaap (2011: 269) point out that the two most prominent approaches used today both represent a continuation of this original discussion: on the one hand, Alderson and Beckfield’s (2004) analysis based on the Fortune 500 represents Friedmann’s approach, while P.J. Taylor and his colleagues of the Global and World City (GaWC) research group follow Sassen’s call to focus on specific companies offering advanced producer services such as accounting, management consulting financial services, etc..

Despite the differences, both share a strong emphasis on the most affluent parts of the world economy. As Coe et al. (2010: 142) formulate, ‘this “one city tells all” approach in WCN analysis reflects the dominance of representational theories of urban change and the subtle effects of Eurocentrism and structurally influenced globalist perspectives in urban studies’. While these tools are well-suited to describe international firm networks, and how they determine inter-city linkages within the global economy, the evident bias towards the central nodes of these networks runs the risk of
merely reconfirming the status quo. Coe et al. (2010: 143) therefore call for a different, more nuanced understanding of how firms and cities shape economic geography: ‘given the diversity of actor roles and capacities around the world, we should ... equally expect diverse forms of world city formation and transformation processes mediated by actors spearheading global commodity chains and global production networks’. Recently, this call is being answered. For example, Derudder et al. (2011) show that the major economic hubs in Asia are becoming increasingly important and that Western cities, especially in the USA, are losing significance within the world city network. At the same time however, their work does not offer an in-depth analysis of specific trends, which define economic developments beyond the best-connected city hubs. Instead the debate still has a strong tendency to focus on those cities that already are major players in the global market place. As a consequence, very little conceptual work has been done to highlight the network dynamics at the other end of the spectrum: the cities that, according to Robinson (2002) tend to ‘fall off the map’.

In an attempt to fill this gap in academic enquiry, the article zooms in on Taylor’s work and aims to build on his model for assessing city connectivity, in a bid to enhance our understanding of non-hub cities and their interlinkages with other cities. By doing so, I follow Godfrey and Zhou’s (1999: 268) call not to ‘understat[e] the diversity and complexity of global interaction’. I use the concepts of ego-networks and peer cities, which help using Taylor’s methodology from the perspective of a non-hub city and to assess its relative position within a sector-specific network. India’s renewable energy sector serves as a test case, which is a recent example of how emerging market cities are becoming part of the world city network in the context of an increasingly multi-polar world economy.

The following section first discusses the need for the WCN discourse to become more inclusive. I then argue that sector-specific networks can be assessed from a non-hub perspective and introduce the idea behind ego-networks and peer city analysis. The subsequent section analyses trends in emerging markets and presents the three cities selected for this study, followed by a section with the results from the peer city analysis. Finally I discuss the findings and argue that the empirical findings support the original argument made for such an alternative WCN analysis from a non-hub perspective.
WCN analysis from a non-hub perspective

The WCN discourse has come a long way since Friedmann first introduced his seven world city hypotheses in 1986. From its initial focus on the most dominant urban centres in the industrialized world, the scholarly debate has gradually expanded its reach beyond the well-known megacities, and today includes the emerging centres at the edge of the world city network. For example, Taylor shows that in international comparison, non-Western countries score relatively well regarding overall network connectivity in 2011: Shanghai and Beijing rank 9th and 10th respectively, and cities like Buenos Aires (16th), Kuala Lumpur (18th) and Johannesburg (44th) also feature on the top 50 ranking. In total, ‘only’ 24 of the cities are located in the EU or in North America (Taylor et al. 2011: 24-5). Similarly, Wall and van der Knaap (2011: 281) argue that Mexico City, Buenos Aires, Jakarta and Bangkok ‘have important subsidiary functions’.

Nevertheless, much of the urban analysis done for developing countries is still limited to the major hubs of the respective region. In the same volume, Taylor et al. include connectivity rankings on Sub-Sahara Africa and Middle East/North African cities, which almost exclusively feature the political or economic capitals of the individual countries (Wall 2011: 137-47 and Bassens et al. 2011: 102-13); and even though the presented connectivity rankings for China, India, Brazil and Mexico include cities that have thus far been side-lined in economic analyses, the individual connectivity scores only reconfirm their low-ranking status vis-à-vis their more global city brethren. Fifteen out of 21 Chinese cities score in the range of 0.13 and 0.05 overall connectivity, a great distance to the lowest score in the top 6 (Shenzhen) with 0.25 (Pengfei et al. 2011: 207). A similar imbalance between the best-connected cities and the rest can be found in the rankings for Brazil and Mexico.

In other words, whereas today’s research agenda in this field has entered new territory, it seldom features a detailed investigation on what is beyond the most obvious cases of globalization. This is the case despite the fact that megacities are losing significance and that it is the medium-size cities, which are expected to become an increasingly important demographic force in the coming decades. A recent report published by the McKinsey Global Institute in 2011 states that this will also translate into economic growth:
“Today’s 23 megacities – with populations of ten million or more—will contribute about 10 percent of global growth to 2025, below their 14 percent share of global GDP. In contrast, 577 middleweights-cities with populations of between 150,000 and ten million are seen contributing more than half of global growth to 2025, gaining share from today’s megacities” (McKinsey Global Institute 2011, website summary).

In a similar vein, the United Nations calculates that urban centres with populations between one and five million people represent 23 per cent of the world’s urban population in 2007, compared to only 6.5 per cent that live in cities of one to five million inhabitants, and 8.7 per cent in megacities with more than ten million inhabitants. Even though megacities are expected to grow a little (to 9.7 per cent), this ratio between medium-size, large and megacities is expected to remain unchanged until 2025 (UNDESA 2008: 9). How important are these emerging urban centres, and how can the field of economic geography contribute to a better understanding of how these cities position themselves – in the short-, medium and long-term – within the world city network?

**Shifting from powerful hubs to end-nodes**

Much of the WCN literature has been written with a view to establish a hierarchical order between urban centres and to ‘trace who gets power over whom, and who loses out at the expense of others’ (Allen 2008: no page). In 1991, Sassen introduced a clear distinction between those cities with a command function and those at the receiving end of the city hierarchy (Sassen 1991: 3). Alderson and Beckfield (2004: 818) support this idea of city hierarchy: ‘the more globalized the economy becomes, the higher the agglomeration of central functions in a relatively few cities, that is, the global cities’.

Ever since, London, New York and Tokyo have been the unchallenged leaders within the urban globalization debate, dominating the thinking of how city power can be measured. This holds true for both the more hierarchical paradigm (for example Friedmann 1986; Sassen 1991) and the more network-driven vision on urban affairs (for example Castells 1996; Taylor 2004). Even though the research efforts presented by Taylor’s
group regard city network analysis as a tool to establish a city’s ‘power to service global capital’ and therefore sees power as ‘both a capacity expressing hierarchical tendencies and as a collective medium with differences in power expressed through position in the network’ (Taylor et al. 2002: 232-3), the degree of power remains a key theme. Allen (2008: no page) argues that still, ‘domination and control remain the defining characteristics’ of city network research.

The best-connected cities indeed tend to have a disproportionally large number of connections – the powerful hubs in Sassen’s view – but there are good reasons to also look at those cities emerging from the edge of the network. In a recent article on the conceptual commonalities between WCN and Global Commodity Chain (GCC) literature, Derudder and Witlox (2010: 8) point out that the WCN discourse would benefit from ‘a more de-centred approach to the study of globalized urbanization’. Similarly, Neal (2008: 95) argues that while a focus on the ‘most advantaged cities … is sometimes a useful task’, the question of how much better top cities are ‘relative to those lower in the hierarchy’ remains unanswered. Following these authors’ line of thought, the paper at hand aims to contribute to the current debate on world city network analysis while not to underestimating ‘the important centers of regional production and administration in less top-heavy economies and in the developing world’ (Godfrey and Zhou 1999: 269).

Let me first try to arrive at a workable definition of non-hub cities. Taylor’s widely acknowledged methodology is based on the idea that firms in the advanced producer service sector and their office networks create de-facto working flows through city locations. His interlocking model then assigns scores from one to five for functional importance to each office found in a given city. The more important the office, the greater its score and the resulting city ranking. This approach is particularly useful when looking at cities positioned at the centre of the global economy, which are nodes that are well-connected within a network. Because these cities tend to have a sufficiently high amount of service companies (score 5), such an analysis provides interesting insights in a city’s relative position vis-à-vis other cities within a global business network.

It says little however about those cities with much fewer advanced producer services. This is because office locations in emerging market cities are often smaller, and are generally not central to a company’s international
business network. They are end-nodes at the outer end of the network. For these cities, office scores often do not exceed ‘one’ in Taylor’s interlocking model. Because his methodology multiplies the office scores between each city pair in order to create a ranking, an analysis of non-hub cities becomes much more ‘flat’ and does not allow for establishing a city ranking with sufficient explanatory value: a pair of end-node cities would nearly always score ‘one’. Differentiation becomes difficult as a result, and makes the interpretation of a city’s position in terms of connectivity markedly different. These cities should not be seen as a node at the centre of the working flow, but as nodes that are positioned at the receiving end of those networks. As a consequence, the challenge lies in finding an alternative way to differentiate between those non-hub cities.

**Applying the interlocking model with a different perspective: focus on peer cities**

Whereas the geographic location of a given office is a clear indicator for a given firm’s economic activity in that particular city, it is possible to instead argue from a city perspective; and the focus on company networks invites for a comparison with those cities that also host offices of those firms that are part of the same economic sector. This creates what could be called a city’s ‘ego-network’, which depicts the linkages between a given city and other ‘peer cities’ that are part of the same sector’s firm networks. Even though Taylor’s methodology remains in essence unchanged, this way of looking at city networks allows for a different assessment. Where Taylor’s analysis starts with the hubs, the focus here rests on a particular non-hub city and its indirect linkages to those end-nodes that are connected through the headquarters of companies present in the ego-city. This city network can highlight the geographic distribution of a given sector, and allows measuring a certain city’s position within a broader (global or national) network.
The star-shaped graph in figure 1 illustrates this argument. The various lines represent some of the possible linkages between firm headquarters and those cities serving as an office location. As Neal points out, these can either be measured ‘binary’ (present, not present) or ‘valued’. The latter is possible when two cities host offices of the same firms (Neal 2011: no page). For example, firm 4 has offices in cities a, g, f and l; whereas firm 8 only has an office in the two cities e and m. From a city perspective, the assessment can be done the other way around. City g hosts offices of three different firms (4, 5 and 6). The peer city connection runs from city-firm-city and can include many different connections. For example, peer cities for city g include cities h, f and c (connected through firm 6), as well as cities i, h and
f (connected through firm 5) and cities a, f and l (connected through firm 4). Some cities do not have peer cities (city d). Because each individual firm can create such a peer city connection, some peer cities can also be a ‘multiple’ peer city vis-à-vis another city: 2nd, 3rd,..., xth degree peer city. This is visualized in figure 2 below.

Figure 2: Four different types of end-node connection with zero, 1st, 2nd, 3rd degree peer cities

The highlighted connections in the four boxes illustrate a zero, 1st, 2nd and 3rd degree peer city respectively. Box I: city e has zero peers, as both companies 3 and 8 do not have other office locations outside city e itself. Box II: city k’s network features city l as a 1st order peer city. Box III: city a’s peer city network includes city c as a 2nd order peer city, which means that both cities host office locations of two identical companies in that particular sector. Box IV: city g’s network includes city f as a 3rd degree peer city. When two given cities
have exactly the same economic profile in terms of office presence, the peer
city degree can be as high as the number of offices in a given city.

This way of scoring end-nodes uses the interlocking model so that the
‘working flows’ between cities created by those companies are no longer at
the centre of attention, but the focus instead rests on those linkages that
connect the non-hub cities, via a headquarter location, to the other end-
nodes. This way, city connectivity can be measured without using function-
al (valued) office scores from one to five. Office locations in a given city link
the city to those other peer cities, in which the mother company retains
another office presence. Because there are different degrees of peer cities,
it is possible to compare a city’s position vis-à-vis another city within a net-
work. Even though such a peer city assessment does not offer data to arrive
at a city ranking in terms of connectivity, it helps depicting the geographic
scope of a given network. The analysis presented in this article therefore
aims to answer two questions:

1. Does such a peer city analysis enhance our understanding of a
city’s relative position within the sector-specific city network?
   Is it possible to use the peer city data in order to identify clusters of cit-
   ies that share a similar economic profile within that particular network?
2. The underlying hypothesis is based on the argument discussed above:
   if we do world city network analysis from a non-hub perspective, it
   leads to a more differentiated understanding of how these networks
   integrate other non-hub cities.

Using peer cities to guide network analysis

This way of applying Taylor’s methodology leads to a less hierarchal anal-
ysis. While the hub-centred assessment emphasizes the differences be-
tween high and low city connectivity, the various degrees of peer cities
allow for more variety between individual end-node cities than Taylor’s
method would suggest for this part of a city network. In other words, us-
ing these different types of peer cities helps unravelling the existing con-
nections between those cities that would otherwise score a mere ‘one’ in
the interlocking model. A city’s sector-specific network would for example
include a certain amount of 1st, 2nd and 3rd degree peer cities while other
cities would present a network with a number of 1st degree or a single 6th
degree peer city.
To be clear, such a differentiation is not particularly useful for creating an alternative city ranking for end-nodes. Rather, it serves as an indicator for the relative position of a non-hub city within a sector-specific city network. For example, a city with most (or even all) high-degree peer cities in a neighbouring country would have a very different economic profile than a city with high-degree peers only in the immediate environment (i.e. within the province).

This type of analysis has another advantage. A small number of cities and their respective networks can, when taken together, serve as an indicator for an emerging cluster of cities in the sector-specific network. Because this approach establishes the peer-degree status of the various peer cities, it is possible to identify those other cities that share the same set of firms. This can be done by looking at a selected number of end-node cities and the existing overlap between the various multiple-degree peer cities. For example, such an analysis would for cities a and c in figure 1 identify cities b and m as part of such a cluster of cities. They can be considered to be more integrated in that particular business sector than city d, which only is a 1st degree peer city to cities a, b, c and m.

In the following, I put this analytical tool to an empirical test. In order to do so, I focus on a specific economic sector: renewable energy. The next section presents current trends in the global renewable energy business and identifies a number of cities that are worth investigating further.

**Case study: The renewable energy sector in emerging markets**

Today’s fast-paced globalization has created a new reality for many economic sectors. Production networks are shifting their focus from developed to transition economies; consumption in emerging markets are becoming increasingly important to global trade patterns. A recent trend towards greater sustainability also created much interest in different modes of production, and led to the establishment of more resource-sensitive value chains. Much of this has not resulted in radical changes of the global economy, but has introduced new players and new business areas. In this, emerging markets have been given much attention in terms of how these economies deal with today’s major industries, and how they shape those emerging industries that are gradually replacing the structural features of the twentieth century global production system.
Despite these significant changes in the international economy, the well-established business sectors are still disproportionally represented in the top echelons of global business. The finance, oil & gas and the automotive sectors for example feature prominently in the global revenue rankings. In order to investigate trends in emerging markets it is therefore useful to look beyond the current corporate establishment. This paper focuses on an economic sector that has experienced its greatest boom only after the millennium, marking a period in which large US or EU-based firms are no longer the only drivers of a globalizing economy.

**Emerging business: the renewable energy sector**

The renewable energy business is a recent addition to the global business horizon. Even though its origins can be traced back various decades, the sector only recently been marked by significant growth. Since 2004, global investment in renewables has increased five-fold by 2010 (DIREC 2010: 20). Official figures from Bloomberg New Energy Finance cite a total of US$ 35 billion in 2004, up to US$ 186.6 billion in 2009 and US$ 243 billion in 2010. In 2009, revenue from only the three sectors solar, wind and biofuel grew by 11.4 per cent, reaching a total of US$ 139 billion.25 The data show that this sector is relatively resilient to the difficulties associated with the financial crisis: ‘[a]lmost all renewable energy industries experienced manufacturing growth in 2009, despite the continuing global economic crisis, although many capital expansion plans were scaled back or postponed’ (REN21 2010: 11). Looking at the level of investments in non-renewable energy confirms this trend. 2008 was ‘the first year that investment in new power generation capacity sourced from renewable technologies [including large hydro] was more than the investment in fossil-fuelled technologies’26 (UNEP 2009: 11).

The term renewable energy is closely related to – and often mentioned together with – terms such as cleantech, green energy or sustainable energy. For the purpose of this article however, I use the definition of renewable energy:

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25 For more information see www.renewableenergyfocus.com, accessed on 15 February 2011

26 These figures include both capital investments directed at companies developing renewable energy technology and those directed at major renewable energy generation projects.
energy as used by the newly-established International Renewable Energy Agency (IRENA 2009, p.4):

“all forms of energy produced from renewable sources in a sustainable manner, which include, inter alia: bioenergy; geothermal energy; hydropower; ocean energy, including inter alia tidal, wave and ocean thermal energy; solar energy; and wind energy.”

Key drivers in the renewable energy business are the USA, Europe, but also India and China. The latter two have seen phenomenal growth and are expected to consolidate this position in the coming years. In terms of sectors, the smaller-scale energy products (such as solar rooftop panels in Germany) are an important contributor to global growth in demand, as are large-scale wind energy machinery (such as wind turbines, gear parts, etc). As a consequence of this sustained growth, the individual companies active in this sector have experienced a major period of expansion. A large number of new companies have joined the ranks of green energy business, and added offices to their production and sales networks, many of which in emerging market economies.

Emerging markets: G11
Definitions on what emerging markets are differ significantly. In 2001, Goldman Sachs introduced the term BRIC, which in turn gained popularity to describe the four largest countries outside the Western ‘triad’ US, EU and Japan (de Graaff 2009: 262-83): Brazil, Russia, India and China. Since then, some analysts have argued that Russia, due to declining economic growth figures in the early 2000s, should not be part of this definition. A different view adds South Africa as a fifth emerging market economy (BRICS or BICS). The FTSE list of emerging markets and the MSCI Barra list also give different interpretations, including for example countries in Eastern Europe.

Instead of using any of the above definitions, I take a different approach. In 2008, at the height of the financial crisis, the G20 emerged as a new political forum for multilateral dialogue on the world economy (Helleiner and Pagliari 2009: 275). This de-facto consolidated the G20 as a more legitimate platform than the G8 – which had until then been
the sole authority on the world’s economic policies. This group includes eleven newcomers (Argentina, Australia, Brazil, China, India, Indonesia, Mexico, Saudi Arabia, South Africa, South Korea, and Turkey) and in fact seems a suitable (more political) delimitation for emerging markets. It includes China and India as well as Brazil, while also taking account of other, politically and economically relevant countries outside the scope of the G8. This ‘G20-minus-eight’ formula (the EU is not a country member and is therefore excluded from the G20 count, resulting in 11 instead of 12 remaining countries) creates an interesting set of countries that – while similar in terms of national GDP – portrays a wide diversity in terms of geographic location, population size, political orientation and cultural history. This ‘G11’ serves as the starting point for this analysis of the global renewable energy industry.

Trends in renewable energy business across the G11

The findings presented below are based on a dataset that was purchased in 2011 from GlobalData, an international business information company.27 The original dataset included a total of 10,904 entries, with the company names and physical addresses, divided into three sub-groups: headquarters, branch offices, and subsidiaries.28 Each entry also featured the sub-sector(s) in which a company was active: wind, solar PV, solar thermal, biomass, biogas, hydropower, geothermal, ocean/tidal and ethanol/biodiesel. It included the world’s national economies excluding North America (USA and Canada), Japan, Russia, the European Union and non-EU member states in Europe.

The dataset was used for two purposes. First it was used to quantify the number of offices in emerging market economies – the national level. For this part of the assessment, the dataset was cleaned of erratic entries, which could not be referenced correctly (i.e. where the city address did not match

27 Looking at company locations, geographic office data could be taken for example from the companies themselves, through the internet or by a third party provider. In order to safeguard possible follow-up research, consistency in data collection is paramount. Buying data from a specialized service provider is therefore preferable to manual data collection.

28 It is important to note that these offices can have various ‘functions’, including manufacturing locations, sales offices, regional representations or R&D locations.
the country). Second, the data were used to focus on the exact location within a given country – the city level. This was done for eleven individual emerging market countries. The cleaning process for this part was more thorough, and involved a) corrections regarding a streamlined spelling for city names, and b) counter-referencing each city location with the actual location. This was done by using Google Maps. The resulting dataset linked metropolitan suburb areas in immediate proximity (not more than 15 kilometers) with the corresponding city. For example, the location ‘Navi Mumbai’ was counted as a ‘Mumbai’ entry. The final dataset for the eleven selected countries included a total of 8721 entries. Based on these two datasets, it was possible to derive tables and graphs for the highest scores on both national and city level. These in turn served as input for the world- and country maps as presented in figures 3 to 7.

Looking at the renewable energy sector’s total office count per country (including headquarters, subsidiaries and branch offices) the G11 countries score 8,721 out of 10,904 entries in total, which equals 80 per cent of the offices in the renewable energy industry across all emerging market economies. Figure 3 illustrates the distribution of office locations. Each G11 country is dark-shaded on the map; and the office count is visualized by a doughnut shaped graph. Each graph’s size corresponds to the office count score, and includes the three type offices, each marked in different shading. By far the highest scores can be found in India (4234), followed by China (2404) and Australia ranking third (888). Reflecting its status as one of the BICS countries, Brazil ranks 4th overall (342), but remains far behind China and India. Australia’s overall score is much higher than any of the other G11 peers; South Africa scores relatively low but its office count (130) is still good enough for the 7th overall position. Saudi Arabia’s remote position (24) might not be surprising given the country’s oil reserves, and therefore – one could argue – its limited attractiveness for renewable energy businesses. However, the United Arab Emirates for example score significantly higher (88) even though they too are a key business location for the oil industry. Turkey presents another remarkable score. As one of the major emerging economies, and the only one that is placed in the vicinity of the European market, the relatively low score (126) puts Turkey on 8th position, just behind South Africa.
There are a number of interesting observations regarding the distribution of the type of business location in each country. The higher the overall country score, the higher the percentage of headquarters. The three lowest ranks in the G11 (Saudi Arabia, Argentina, Mexico) have less than one third of all office counts in the category ‘headquarters’, while China (79 per cent), India (74) and Australia (61) have significantly higher scores. In other words, there is a correlation between the total amount of renewable energy company offices and the amount of companies that have their headquarters in that particular country. With most companies in the G11 countries being headquarters (69 per cent), and significantly less branch or subsidiary locations, the interconnections between cities is much less than in other global business sectors. The renewable energy market in 2011 therefore seems to have a limited global character.

The following sections focus on India’s city networks within the context of the renewable energy sector. India is the top scorer in the dataset, one of the largest emerging markets and has experienced strong growth rates over the last couple of years. As far as renewable energy is concerned, India is an international frontrunner in overall installed capacity. This is due to India’s national and state policies aimed at promoting various forms of renewable energy solutions, and driven by the general boom in global green economics. In June 2010, renewable energy capacity in India stood at 17.5GW, which represents ten percent of the domestic energy supply (DIREC 2010). Existing policies include a large variety of regulatory and financial support
mechanisms for the uptake of renewables. According to the National Action Plan for Climate Change (NAPCC), India will generate fifteen per cent of the country’s energy through renewable sources by 2020. A number of states across India have started with feed-in tariffs and renewable portfolio standards; and India’s national solar cities program encourages cities to compete for national subsidies to introduce solar technology in their municipalities. This clear commitment to renewables has attracted a significant share of private investment, particularly in the wind energy businesses. By 2008, India’s wind turbine industry was ranked 4th worldwide, after the EU member states Denmark, Spain and Germany (WWF & Roland Berger 2009: 14). As a consequence, India is considered a particularly important player in the global wind energy industry.

This also translates into economic development on the urban level. Where the national economy grows, cities often are a preferred location for company headquarters, manufacturing sites and sales offices. Figure 4 presents the renewable energy office business office count for the top twelve cities within India.
Figure 4: India’s top 12 cities in terms of renewable energy companies office count (2011 data)

Looking at the city scores, it is evident that India’s megacities feature as the key hubs for the national renewable energy industry. In line with the WCN discourse, these are the dominant trading centres, which act as major linchpins for economic activity. Today’s megacities continue to attract a large number of businesses; companies often choose to locate where other, relevant business services are readily available. Following the argument presented in the first section of this article however, it is worth investigating those cities in India that can be found beyond these best-connected nodes.

In order to do so, it is possible to filter out those cities, which a) are not major business hubs (for this purpose defined as cities with more than five million inhabitants); and b) have a significant number of branch and subsidiary locations (as we are interested in end-nodes). The remaining cities include Gurgaon, Jaipur, Ahmedabad and Pune. Given Gurgaon’s geographic proximity to New Delhi it is useful not to include this city for the study at hand. The three cities of Ahmedabad, Pune and Jaipur serve as the baseline cities for the following analysis.
Peer city analysis of three selected Indian cities

Figures 5, 6 and 7 depict the geographic distribution of peer cities\(^{29}\) for each of the three cities Ahmedabad, Pune and Jaipur. This is done in four steps. The first step includes taking all company names in each city from the dataset. For this, only those offices that are marked ‘branch locations’ are used. The second step looks at each individual company and lists all other branch offices elsewhere (peer cities). This creates a city-specific table with a company name in each row, and the found branch office locations (peer city name) in each column. In a third step, the total number of offices in each peer city is added to the bottom of each column. Table 1 illustrates these steps 1-3 for the city of Ahmedabad.

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Table 1: Steps 1-3 of establishing the ego-network for the city of Ahmedabad

The final step deletes those peer cities that only have 1 shared office (box II in figure 2) and transfers the list of 2\(^{nd}\), 3\(^{rd}\), 4\(^{th}\), … \(^{x}\)th degree peer cities into a city-specific map. Each of these maps shows the respective baseline city as a

\(^{29}\) In order to safeguard comparability, and to keep in line with the focus on emerging markets, this analysis takes account only of peer cities in emerging markets, outside North America, EU, Japan and Russia.
black square with an inserted white triangle. All other cities are represented by a square in 6 degrees of shading. The two letters stand for the city name as explained in the legend. The cities are positioned at the proximate geographic location within the map of India and can be distinguished in terms of population: the size of each square stands for three categories: below one million inhabitants; between one and five million; and more than five million.

Figure 5: Ahmedabad’s ego-network (visualization modified from Taylor 2004)
Figure 6: Pune's ego-network (visualization modified from Taylor 2004)
In order to answer the first research question, it is useful to exclude all those city connections that link to 1st degree peer cities. These connections are very common (many firms in the dataset have a relatively unique office network within India with no shared presences with other firms) and say nothing about whether or not peer cities have a similar business presence. This is in contrast to 2nd, 3rd or even higher degree peer cities, which can be considered to be of similar interest to the businesses in the sample. The various squares in the above maps therefore only include those cities that are at least 2nd degree peers; the darker the shading of a square, the higher the peer city degree (see legend).

The city of Ahmedabad (figure 5), with its 23 firms and 51 peer cities shows a total of 29 1st degree peers. Interestingly, all international peer cities (8 in
total) are of 1st degree, except for Dhaka, which lists two shared office presences. This is an indication for a nationally-oriented peer city network as few of the firms in the sample – whether national or international firms – have a shared presence outside India. Further, the data show that the highest degree peer cities (more than 10 shared presences) are all located in the large metropolitan centres: Mumbai (15), New Delhi (14), Bengaluru (11) and Chennai (11). The well-known business hubs Kolkata (10) and Hyderabad (9) score high as well. Ahmedabad has various peer cities with degree scores between 5 and 8. These include the two other baseline cities Pune (6) and Jaipur (5), as well as Raipur (6) and Lucknow (5). Cities with 3-4 shared offices are Chandigarh (4), Kochi (4) and Vadodara (3).

The city of Pune (figure 6) has a total of 31 firms, and 59 peer cities. 42 of these are 1st degree peer cities. Similar to Ahmedabad, all but one international peer city (out of 10) are not higher than 1st degree (Beijing being the exception with two shared offices). The megacities again are the peers with the highest degrees: Bengaluru (9), New Delhi (7), Chennai (7), Mumbai (6) and Kolkata (6). Hyderabad (5) also scores relatively high. The two other baseline cities Ahmedabad (6) and Jaipur (2) show different profiles, with Ahmedabad having a score three times higher than Jaipur. The cities of Chandigarh (3), Raipur (3) and Vadodara (3) are in the lower range but still have more shared presences than the remaining six 2nd degree peers.

The city of Jaipur (figure 7) features 12 firms in the sample and a total of 26 peer cities. None of these peers is a city outside India. Only 8 of them are of 1st degree, a significantly lower percentage (30%) than is the case with Ahmedabad (57%) and Pune (71%). This means that the firms investing in an office presence in Jaipur show a more similar office network than the firms present in Ahmedabad and Pune. The business hubs Bengaluru (8), Hyderabad (8), New Delhi (7), Mumbai (6) and Chennai (6) are the peers of highest degree. Ahmedabad (5), Kolkata (4) and the small Chandigarh (4) follow; then Coimbatore (3), Raipur (3) and Pune (3).

The data from these three Indian cities show that the individual networks have distinct features and include a variety of connections between a particular city and other end-nodes. On the one hand, there are similar patterns, for example the fact that the well-known business centres such as Mumbai and New Delhi all are high degree peer cities. This is not surprising and
confirms the notion that major business hubs have an important function as a facilitator for many economic sectors. Another commonality lies in the low scores of international higher degree peer cities. This seems to suggest that firm networks in the renewable energy sector (still) have a predominantly national orientation.

On the other hand, there are location-specific differences between the three baseline cities and their respective networks: the number of low degree peers and the geographic distribution of higher degree peer cities. Low degree peers (1st degree) are less common in Jaipur’s peer city network compared to Pune and Ahmedabad. This indicates that there is a more diverse set of firms with an interest in Ahmedabad and Pune; in the case of Jaipur, the firm networks seem to show more overlap in office locations. Lower degree peer cities (2nd degree) also differ per city network. Ahmedabad connects to Bhubaneswar, Indore, Bhopal, Coimbatore, Madurai, Nagpur. Throughout the entire range of peer cities, these differences in terms of geographic distribution allow each city to connect to unique peer cities as their individual connections to non-hub cities differ: Ahmedabad for example is the only city that links to Dhaka and Surat; Pune is the only one with a link to Beijing; and Jaipur’s network includes the cities of Guwahati and Patna.

Finding an answer to the second research question regarding the cluster of cities requires a closer look at the overlap between these three individual networks. The previous paragraphs described the three cities’ firm networks and identified those peer cities that have a low or higher ranking degree. With a simple overlay of the three maps, it is possible to determine which of the various peer cities feature in all three networks. Also, by excluding those cities that are at the lower end of the peer city spectrum (1st or 2nd degree), we can filter out those cities that all have a relative high degree peer city status vis-à-vis one of the three baseline cities Ahmedabad, Pune and Jaipur.

Figure 8 visualizes this overlap in a single map. In this, the three baseline cities themselves are not of interest and can be neglected for the analysis. Further, it is not surprising that the large metropolitan centres feature prominently in this map. These include Bengaluru with an aggregate score of 28 shared office presences, New Delhi (28), Mumbai (27), Chennai (24), Hyderabad (22), and Kolkata (20). These figures once more confirm the ap-
plicability of the interlocking model for city connectivity when it comes to major business hubs.

*Figure 8: Non-hub-cities with highest number of multiple degree peer cities with Ahmedabad, Pune and Jaipur*

What is more important for the argument at hand however is whether or not this overlap includes cities beyond those well-established business centres. Figure 8 (where the major business centres are crossed out) shows three cities where this is the case (marked with circles): the cities of Raipur (12), Chandigarh (11) and Lucknow (10). The three cities can be considered being part of a city cluster that spans a network between the baseline cities and other office locations, which have – from a firm perspective – a similar business portfolio within the renewable energy sector. In the context of a growing renewable energy sector across India, these patterns of geographic conversion within business networks point us towards those urban centres
that have already become part of an emerging city network in this particular sector. While it is still at the edges of the network, in which cities like Mumbai and Chennai have a dominant position, it also offers a glimpse at the frontline of today’s economic activity in non-hub cities. These clusters of cities, as they reveal themselves based on a peer city analysis, include those cities that have emerged in addition to the major business centres. Looking at the medium-term, it would be interesting to see whether they will be able to consolidate this position as a business location in India’s growing renewable energy sector.

**Discussion and conclusion**

The network analysis as introduced in this paper applies Taylor’s interlocking model with a different lens. By looking at the linkages between a non-hub city and its peers within a sector-specific network it contributes to a better understanding of those types of networks which connect more peripheral cities that are positioned at the edge of the World City Network. This allows for measuring differences between cities that in Taylor’s analytical perspective would have fallen off the map. The argument moves away from advanced producer services and instead focuses on sector-specific city networks – in this case the renewable energy business. Taking the individual city as a starting point, it becomes possible to create a city network from a non-hub perspective and to identify the existing linkages between different types of peer cities within as well as between selected ego-networks. Recounting the research questions presented earlier in this paper, the empirical data confirms that this methodology indeed contributes to a better understanding of the world city network.

First, the peer city analysis indeed offers an alternative assessment for city connections and how they are being shaped at the outer end of the world city network. It makes it possible to distinguish between different degrees of peer cities and to determine a city’s relative position in the network. In the case of India’s renewable energy sector, this type of analysis reveals that the three baseline cities have few – and only lower-degree – peer cities outside the country. This suggests that India’s renewable energy sector is still emerging from its relatively local beginnings. As a possible next step, it would be interesting to see how these international peer city structures develop over time. Furthermore, the analysis helps understand-
ing the structure of inter-city linkages from a city’s point of view. Each of the three baseline cities has a network that includes low-, medium- and high-degree peer cities. The lower ones link the baseline city to those urban centres that have only few firms with an interest in the city. The high-degree peers mainly feature the main business hubs and often do not offer surprising results. The cities with medium-degree scores reveal linkages of intermediate strength between the baseline city and its peers, and therefore allow for identifying geographic trends in the renewable energy sector. In the case of India, these medium-degree (non-hub) peer cities are well-spread across the national territory for each of the three selected ego-networks (Ahmedabad, Jaipur and Pune).

Second, the differences between low- and high-degree peer cities can be interpreted as an aggregate, multiple-firm indicator for corporate location strategies. When similar firms invest in similar cities, firms create interlinkages between end-nodes and de-facto make a city part of a set of cities with a similar economic profile. These sets of cities can be considered as a cluster of cities. The geographic distribution of cities within these clusters provides interesting entry points for scholars in economic geography, in particular regarding the unfolding dynamics at the edges of these networks. These urban centres are worth a closer look when investigating developments within the World City Network: at a time of a gradual economic shift from megacities in industrialized countries to medium-size cities in emerging markets, the city linkages across India’s renewable energy businesses point to a new type of middleweight city that is ‘in their own way’ integrated in the world city network.

The case of India’s renewable energy industry illustrates that this shift is already creating new city networks across emerging markets. India is one of the most important markets for renewable energy firms and many of its cities are hosts to local offices in this sector. The peer city analysis shows that this development follows a geographic pattern, which can be traced beyond the usual suspects. The ego-networks of the three cities of Ahmedabad, Jaipur and Pune show that various firms in the renewable energy sector follow similar locational strategies and thus create a cluster of Indian cities with a relative high number of branch offices. These cities have the opportunity to consolidate this position when the sector grows further.
At the same time, it should be noted that this tool has a particular focus on end-nodes: without adding headquarters to the equation, it remains an end-node specific assessment and should be interpreted as such. A combined analysis of branch locations and headquarters could be a useful next step. This disclaimer points to the exploratory nature of this study. More questions have to be answered, in particular regarding longer-term developments, other economic sectors and varieties between firm networks. Whereas the renewable energy sector provides for a valuable case study at the time of writing, further studies on how to use such an assessment would be useful. The evolving debate on world city networks would therefore benefit from a) a follow-up study on how this particular network evolves over time; b) additional efforts to test the applicability of a peer city analysis in other sectors; and c) more detailed assessments of how the geographic features of such a network affect the corporate operations of different types of firms. Scholars in the field of economic geography are invited to suggest possible ways forward.
References


Wall, R. S., van der Knaap, G.A. (2011) ‘Sectoral Differentiation and Net-
work Structure within Contemporary Worldwide Corporate Networks’, Economic Geography, July 2011, 267-308.
