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- Sustainable World Cities -

The influence of global integration corporate networks on the top 50 sustainably ranked world cities

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Summary

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Sustainability, world city network, city position in the network

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Foreword

With all the debates circulating around notions of "to increase or to not increase global integration" with cases such as Brexit, a British exit from the European Union, the emergence of the "Trumpeters" in United States of America shifting towards entrenched nationalism, authoritarianism, protectionism and "keep out immigrants with walls" campaigns, all the while African states seeking to increase integration with proposals for a one passport continent and integrated infrastructure development; global opinions on the influence of global integration and on cities and its sustainability are shifting.

Abbreviations

IHS	Institute for Housing and Urban Development
FDI	Foreign Direct Investment
GDP PPP	Gross Domestic Product Purchasing Power Parity
USD	United States Dollars
GVA	Gross Value Add
Reg	Regression
Sqrt	Square Root

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Chapter 1: Introduction

This chapter provides, firstly, background information on global integration and sustainability and, secondly, an introduction to intercity firm network and the significance of city positionality in the network as one of many forms of global integration, and its significance for city sustainability.

1.1 Background

Three significant moments stand out in particular for me over the last year. The first, Brexit, saw Great Britain vote in a referendum to exit the European union, ushering a potential shift away from the single market in the region, and free trade, in an effort to curb migration and increase "security" (Wheeler and Hunt 2016). The second was the global economic impact of China's devaluation of its currency due to its dependence on its manufacturing sector (Evans-Pritchard 2016). The third was the signing of the Paris Agreement, a global action plan to put the world on track to avoid dangerous climate change by limiting global warming, at the United Nations Framework Convention on Climate Change in December 2015 and the upcoming Habitat 3, United Nations Conference on Housing and Sustainable Urban Development in October 2016.

While these points are merely a few in a myriad of significant moments globally, these especially stand out for highlighting the dual current affairs around global integration and sustainability; the paradoxes around the themes; whether to retreat from or further global integration in light of its conflicting social and environmental advantages and disadvantages. The accelerated growth of the global economy since the 1960's as a result of industrial capitalism, aided by the transaction revolution and transnational financial institutions (Ng and Hills 2003), has largely come into question. Increasing globalisation and tertiarisation of the economy is considered to be disarticulating the world urban system into places for production and advanced business services, reinforcing inequality, marginality and spaces of privilege (Sassen 1996, 1991). At the same time, global uneven division of labour and reinforced spaces of privilege have sparked the desire for more authoritarian and protectionist ideals, as with the Brexit vote - based on the perception of an ignited domestic economy with increased jobs, security and overall improved, localised control of migration, laws and money. The burgeoning social constraints, some of which some are induced by ecological degradation such as global warming and CO2 emissions, have spurred movements towards globally integrated developed strategies such as the Paris Agreement, the UN Sustainable Development Goals (SDG's) and the UN Sendai Framework for Disaster Risk Reduction.

This thesis is rooted in the notion that sustainable development of cities needs to be looked at both in terms of localised territorial conditions of place and the connected global city-to-city network. Although cities have always been globally integrated (Friedmann 1986, Castells 1996), increasing globalisation of economic activity has seen the development of an interdependent single economy functioning at a planetary scale (Brenner 2014). The implication of this on the world urban system, coupled with the informationalisation and financialisation of the economy has seen the spatial dispersion of places for production and for services (Sassen 1991). Within this, a complimentary centre-periphery model exists, of connected core and periphery cities at different stages of development. Based on these inter-linkages, the dependence of cities - on international trade, investment (Alderson and Beckfield 2004) and multinational corporate firms' need to territorialise - ties local conditions to global

processes. This research therefore uses the network of corporate firms as an indicator of cities' global integration and is embedded in the concept that local development is complimented and influenced by global processes. In light of the network being the link between global and urban scales, it highlights the need to simultaneously consider the network and agglomeration scale when looking at urban management and sustainable development.

In contextualising the approach, increasing globalisation of economic activity and rapid urbanisation must be taken into account. The global population is expected to increase by 2,5 billion between 2014 and 2050, so development over the next 40 years needs to meet the demands of urbanisation equivalent to the past 400 years (UNEP 2011). Considering that by the twenty-first century the global economy had consumed between 47 and 59 billion metric tons of resources (equivalent to half of what is physically extracted from the earth), urban policy needs to take a planetary urbanisation and development perspective with consideration of planetary resources and consumption (Brenner 2011). The way in which cities are planned, built, operated and redefined has a huge social, environmental and economic impact (Arcadis 2015) requiring an approach which surpasses simply the local and national to include the municipal, regional, and global levels.

With world city networks having become increasingly international since the Cold War - owing to factors of globalisation and heightened environmental concerns - formal networks of cities collaborating on various issues have grown in number, geographical scale and scope (Forman and Wu 2016). Cities and their networks are regarded as critical for sustainable development. The network model of the world city system has proven to be a tool for cities to share ideas, experiences and innovation (Urban Gateway n.d.). Therefore, building on strategic links between urban innovation and global governance will assist in responding to sustainability challenges (Forman and Wu 2016). Even though the role of cities towards sustainability is acknowledged, cities are still poorly integrated into multilaterally diplomacy, and limits on their powers and budgets threaten their effectiveness as global change-makers (Forman and Wu 2016). This highlights the need to look again at the governance of globalisation and notions of sustainable trade (van den Bergh and Verbruggen 1999).

1.2 Problem Statement

Addressing the topic of global integration and sustainability appears a lot like attempting to understand and achieve mutually exclusive goals. As in Dickens' (1859) *A Tale of Two Cities*, a novel about Paris and London set before and during the French revolution, it is a depiction of the time, emphasising;

> It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us…

The duality of *A Tale of Two Cities* resonates with contrasting perspectives on achieving both a sustainable city and optimal global integration.

Ng and Hills (2003) make a distinction between contemplating a 'world city' versus a 'great city, and critique a world city for just aspiring to global connections. Ng and Hills (2003) highlight that "great cities of the world" need the localised perspective which sustainability

brings - of capacity building, community enterprise and economic solutions, responsible and responsive business development, access to sustainable and fulfilling work and meeting local needs through local resources.

On the other hand, in contrast to Ng and Hills' (2003) consideration of global integration as a flow of capital and its sustainability, van den Bergh et al. (1999) deem the sustainability of trade as the marriage between neoclassical economics, ecological economics and socio-political issues. They highlight that for too long within neoclassical economics the mix of insights from economic theories of long-run growth, international trade and environmental sustainability has been lacking in the approach to environmental economics. This is in part due to the disjuncture between the externality concepts of welfare and sustainability, with the latter occurring largely within the perspective of macro-economic growth, and the former in trade theory and micro-economics. A more comprehensive approach to international trade and environment within neoclassical economics needs to be taken, which includes endogenous locations, international markets and policy competition between countries (van den Bergh et al. 1999).

Similarly to van den Bergh and Verbruggen (1999), Wall et al. (2006) advocate an approach which is cogniscent of both local and global or macro and micro perspectives; regarding sustainability as a normative concept evolved over time to respond to the current needs. They see sustainability suspended between urbanisation and globalisation. Wall et al. (2006) take the perspective that cities are inextricably linked to macro, external influences and cannot be viewed in isolation. This therefore requires an approach which considers a city's fate in relation to its broader global linkages and position in the network. Wall et al. (2007) advocate a network model of sustainability - as an offshoot of Friedmann's (1986) 'World City Network' and Sassen's (1991) Global city theories - which acknowledges the city's increasing role in the global corporate network, as a driver of urban and national growth and, in turn, its certain influence on the urban properties. It takes as its cue that cities' functional and structural position in the world city network is interdependent with city conditions. Therefore, the conditions of the micro level is dependent on its role at the macro level and vice versa.

Wall et al. (2006) regard sustainability as a normative concept evolved to respond to the urban and global challlenges of the day. Like its normative predecessors, it was developed to respond to its status quo and specific economic cycles, such as Haussmann's metropolitan intervention in response services and infrastructure, technology development and need in the 2nd Cycle, to Howard's Regional Garden City Plan in response to city squalor and the desire for the country in the 2nd Cycle, etc., sustainability is seen as a conception which responds to the dualities of an increasingly entrenched world city network in the 6th Cycle (Wall et al. 2011).

While there is renewed interest in cities as loci in the world system, cities are being decoupled from local political geography as a result of its increasing role in the international network of investment and trade (Alderson et al. 2004). This is significant for two reasons, firstly; in line with van den Bergh et al.'s (1999) perspectives on sustainable trade; with ecological systems unbounded by political boundaries, sustainability needs to take on a bioregions instead of a political regions approach. Secondly; the significance of its position in the international network of investment and trade. The new geography of centrality and marginality that cuts across traditional north/south and east/west divides in the world system is restructuring the map of the world city system and the map of the world system (Sassen 1991; Alderson et al. 2004).

The production of global hierarchies, with certain better cities situated than others, and the inherent relational nature of city power, where "cities do not have power in and of themselves; they have power to the extent that they function as command points and centres of planning and thus establish the framework in which other cities operate in the world economy" (Alderson et al. 2004). On the other hand, it is seen to stunt domestic markets that have to compete with "well oiled" international organisations and cheap, migrant-flooded labour markets believed to be due to open, free-trade laws. The inequality, marginality and reinforced spaces of privilege attributed to increasing globalisation and the tertiarisation of the economy are disarticulating the world urban system into places for production and advanced business services (Sassen 1996, 1991).

To date, attempts at understanding cities' locality within the global urban network have tended towards individual nodal qualities consisting of looking at the count of corporate headquarters or banks, rankings of cities in terms of population or air passenger traffic, or the location of stock markets (Short et al. 1996). While this gives the sense of a city 'rank', it does not reflect the relational attributes between cities as an indicator and driver of cities integrated into the global urban network. Since cities do not have power within themselves, being inherently relational, a more complex approach borrowed from social network analysis (SNA) needs to be employed. SNA views power and position as a "consequence of patterns of social relations that generate opportunities and constraints: where some actors are favoured because they occupy positions that are more favourable than others" (Granovetter 1973; Padgett and Ansell 1993; Guiffre 1999).

Further to this, network analysts have developed a set of tools that enable those interested in pursuing the world city hypothesis to assess (1) the degree of power wielded by individual cities and (2) the positions of and roles played by different types of cities within the world city system (Alderson et al. 2004).

Moreover, in terms of sustainability and cities being globally integrated, the intercity network model is a proven tool for cities to share ideas, experiences and innovations (Urban Gateway n.d.). With cities accounting for 70% of global greenhouse-gas emissions, housing more than half of the humanity and their network the driver of economic growth and national prosperity, the role of cities as active partners in global governance, and not just places for markets in the drive towards sustainability, has been recognised (Forman and Wu 2016). As politically organised entities, cities are playing prominent roles in catalysing sustainability. The global importance of cities in addressing pressing challenges has been recognised in the Paris agreement on climate change, the UN Sustainable Development Goals (SDGs) and the UN Sendai Framework for Disaster Risk Reduction. Although cities still have a lot to overcome in terms of sustainability; current solutions include the following examples: Cape Town in South Africa has some of the continent's most ambitious water conservation targets; the City of Johannesburg; one of the leading cities in the C40 network in taking action on climate change; was awarded the prestigious C40 Cities Award for its leadership in tackling climate change through its successful Green Bond initiative (Mail&Guardian 2016).

All considered, a better understanding of the position of cities in the global urban network as intimated by Friedmann's (1986) world city network effect on cities' fates would assist with the governance of its sustainability. More specifically, with intercity firm networks being the drivers of cities' roles and positions in the network, a better understanding of its position specifically within international flows of investment and trade (Alderson et al. 2004), will assist

in developing a response which is targeted at the most influential elements to effectively improve the city sustainability in relation to the way and extent of its global integration.

1.3 Research Objective

Therefore, the objective of this research is to provide knowledge which will be beneficial in developing solutions towards city sustainability by explaining the influence of global integration, from the perspective of city positionality in the network on urban sustainability.

1.4 Research Question

Main research question

To what extent does global integration (intercity firm network) impact city sustainability?

Sub-research questions

1) To what extent does the prestige and power of a city in the intercity firm network influence city sustainability?
2) To what extent does the nodal strength of city ties in the intercity firm network influence its sustainability?
3) To what extent does the linkage structure of the intercity firm network influence city sustainability?

1.5 Significance of the research

The role of cities as active partners in global governance, and not just places for markets has been recognised (Forman and Wu 2016). The intercity network model is a proven tool for cities to share ideas, experiences and innovations (Urban Gateway n.d.). Habitat 3 states that the "battle for sustainable development will be won or lost in cities", however Forman and Wu (2016) state that the promise or potential of cities are hampered by patchy collaboration with national governments, limited access to global governance processes, poor funding and poor data collection and sharing. Although steps have been put in place to further the role of cities with the new urban agenda and the 2030 Sustainable Development Goals, if cities are to be more seriously integrated; while branding and business opportunities have been the major driver of cities; in order to be involved in multi-lateral processes, more directed toward global goals, better equipped to deliver data; and better supported financially and politically; a further understanding of the influential points of the city's position in the network on its sustainability is required.

Furthermore, highlighting global urban network and city sustainability points to the sustainability of intercity trade. Van den Bergh and Verbruggen (1999), note that in order to achieve sustainable trade from the perspective of neoclassical economics an integrated approach needs to be taken which includes a mix of long-run growth, international trade and environmental sustainability. This lack of integration owes largely to sustainability taken from a macro economics perspective and trade theory closer to welfare micro economics. A more complete neoclassical theory of international trade and environment is required which includes endogenous locations, markets and policy competition between countries (van den Bergh and Verbruggen 1999). A practical example of a successful union of the welfare and environmental

economics is in Johannesburg, South Africa, as an extension of its C40 link with Washington DC, working with the World Bank and national bodies is working to implement a 'tax increment financing' scheme to enhance its neighbourhood planning efforts.

In terms of academic significance, many theorists and studies within the fields of sociology (Saskia Sassen), anthropology (David Harvey) and urban planning (John Friedmann), have highlighted the link of city forming processes to larger historical movement of industrial capital; the territorially unbounded influence of the world economy on urban change(Friedmann 1986). There's extensive research on the city as being or becoming a product of social forces set in motion by capitalist relations of production, the individual characteristics of cities in the global urban network, such as the count of head offices, flights etc., although valuable for understanding the city, it does not speak to the relational quality of the network. To date little research has been done on the relationship between cities and its influence on the fate of cities (Alderson et al. 2004). Since, position as intimated by social network analysts is a consequence of patterns of social relations that generate opportunities and constraint(Alderson et al. 2004); understanding the relational value of cities in the network will assist with identifying key influencing factors and develop appropriate response.

1.6 Scope and Limitations

To test the influence of city position in the global interfirm network on city sustainability, would ideally require firstly, the development of a sustainability indicator which included social, ecological, economic and political aspects of a numerous cities. Unfortunately, the conducting this level of research for numerous cities to generate a value of sustainability for testing is outside the temporal scope of this thesis and therefore a value of city sustainability was adopted. The Arcadis sustainable cities ranking was employed, because of the reputable nature of the organisation and the relevance of the sustainability indicators included in the ranking which also considers the world cities ranking. In acknowledgment of the influence of cities global positioning on its sustainability, it seeks to explain in more detail the extent of influence of the intercity firm network.

Secondly, as outlined by Alderson et al. (2004), to truly demonstrate global integration using the world city system/global urban network, a multirelational network combining data on economic, political, social and cultural linkages between cities would need to be constructed. Since comprehensive data for all these factors are scarce, assembled data based on the world city's literature of Alderson and Beckfield (2004), as an extention of Hymer (1972) who regard cities relationship link to the world city system as based on multi national enterprises, regardless of the specificity of the industrial sector. This ties in well with the fact that for the sustainable cities ranking in consideration of world cities network on urban sustainability, uses Sassen (1991) and Taylor (2004) who defines world city based on connectivity and prevalence of corporate services focusing on the advanced producer service sector, which is justified as representing cutting-edge global economic activity because producer service firms have become multinationals in their own right, creating an essential "inter- locking" global network of offices". Foreign direct investment was therefore used to demonstrate directional values in the intercity firm network; as obtained from FDI markets.

Since the ranking of sustainability is from 2015, made up of various sustainability indicators relating to people, planet and prosperity, a cross section method was used. All other variable indicators were selected on the basis of being on or as close to 2015. In order to produce results which covered multiple cities in the network, a quantitative approach using secondary data was

employed. Data was obtained from reputable sources including, Arcadis, FDI markets, Euromonitor passport and Numbeo database.

Chapter 2: Literature Review / Theory

2.0 Introduction

This chapter provides a literature review based on that which this research is constructed. It reviews the two main concepts in question; city sustainability and global integration and the theories which explain each concept, the relationship between them and how the former influences the latter in the context of urban management and development.

While urban sustainability can only be achieved through addressing the economic, ecological and social health of the city, its acknowledged that cities are not autonomous units. Rather they're inextricably linked to their hinterlands, further eco-systems and a hierarchical functionally interconnected city system which transcends the local conditions(Marcotullio 2001).

Within this mutually paradoxical relationship of city sustainability and global integration, it advocates for a view on city sustainability which incorporates global flows and the role of local and international policies in the shifting urban environmental and social conditions of cities(Marcotullio 2001). Though it acknowledges transnational flows and the influence of globalisation on the urban social and environmental conditions, the perspective does not aim to disregard local factors role. Within the multitude of factors influencing sustainability, and the various paths toward development, it takes a view of city sustainability which considers both the traditional environmental footprint and its "print" within the network. Its premised on the notion that the agglomeration scale conditions and performance are dependent on the baseline situation of city network processes, which in turn influence its sustainability. At the heart of this research, in the words of Taylor (2013), the intention is to understand macro forces on urban conditions.

This chapter is divided into six sections. The first section presents an overview of city sustainability within themes of globalisation; including literature of amongst others; (Marcotullio 2001) "Fair shares model", Taylor's (2012) green city network, Jacobs (1969) dual economic localisation and macro urban innovation, Brenner and Schmit (2014) implication planetary urbanism; and Wall and van der Knaap (2006) views of sustainability as an evolved normative concept. The second section provides literature on global integration and the world city system. secondly, to explain themes around the significance of cities role and position in the network, Literature used includes Hymer's (1972) perspectives on the world city system taking on the form of the corporate structure and its implication for urbanisation; Friedmann's (1982, 1986) 'world city hypotheses' of a few cities with power driving the global corporate economy; competitiveness; and Sassen's (2001, 1999, 2004) notions of global polarisation with its network of prioritised global cities.

The third section, on the basis of the preceding section and notions of the inter city firm network driving city growth and city role and position in the city network processes (Alderson et al. 2004), premised on city processes setting up the generalised basis for "how cities work" (Taylor?); the literature review establishes variables indicative of city positon in the network; which relate to the 'strength of city ties', 'city power and prestige in the network' and the city in terms of linkage and structure of the network. The fourth section considers city approaches

to this relationship of the city in the inter-city firm network and its sustainability have been included. The fifth section introduces the case of Johannesburg, South Africa. And the sixth section concludes with a conceptual framework which lays the foundation for the rest of the research.

2.1 Sustainability

This dissertation, takes the view that city sustainability is influenced by its position in the global urban network. On the basis of increased globalisation and corporatisation of the world city network, it uses the global intercity firm networks considered a driver of city growth and hierarchy in the network, as a marker of cities position in the global urban network. Using inter firm greenfield FDI flows, it establishes, with the use network analysis; cities position in the global urban network. Thereby, with reference to Taylor's (2013) green city network perspectives on incorporating the cities environmental footprint and "net-print" for sustainability, it tests cities position in the network (ref. net-print), considered the generalised condition of "how cities work"; against the agglomeration scale (incorporating the environmental footprint) city sustainability ranking. The reasoning for this is as follows:

Sustainable cities according to Satterthwaite (1992) is defined as cities, able to meet their inhabitant's development needs without imposing unsustainable demands on local or global natural resources or systems. Although notions of sustainability emerged way before this time, it was only in the 90's, in the context of urbanization that the first approximations of sustainable cities begun to emerge with the UN 1992 Rio Declaration integrating the "economic, social, environmental and governability dimensions of sustainability and argued for the eradication of unsustainable patterns of production and consumption, the eradication of poverty, and the role of the State, civil society and international community in protecting the environment". Since then, there have been further declarations and sessions addressed at City sustainability, including amongst others Agenda 21 (1993), Habitat Agenda (1997), World Urban Forum (2002) and the Rio+20 declaration which includes a broader aspect of governance including of peace and security and urban governance which fosters urban planning and environmental management, the reduction of ecological footprints, the decentralization of decision-making, and resource allocation, as well as enhanced policy coordination between local and national authorities. In consideration of this, the World Economic and Social Survey 2013 highlights the balanced accomplishment of social and economic development, environmental management and effective governance, within the context of its particular history(DESA 2013). See below break down.

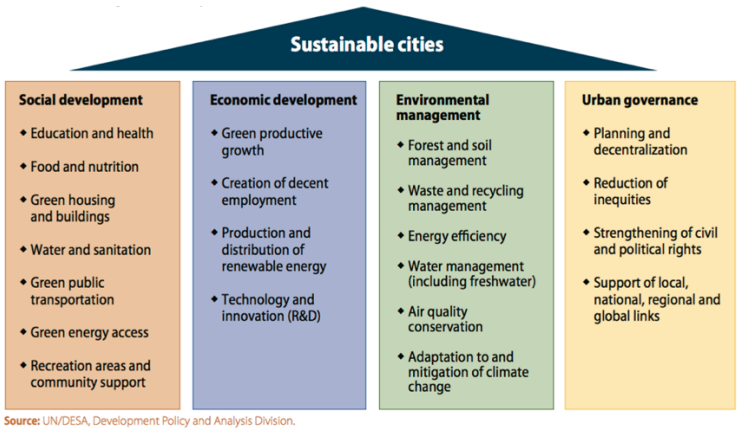


Figure 1: Pillars for achieving sustainability(DESA 2013)

Within the development of the concept of sustainable cities, title and conceptual variations have emerged along the way. This includes "green" cities, which Beatley, ed., (2012), regards as equivalent to sustainability. However, regardless of conceptual nuances, Taylor (2013, p.362) notes that cities to a large extent are inherently green in ability to require less land, less auto travel, less energy and emitting less carbon on a per capita basis. The city according to Glaeser (2011) is the greatest invention, in its ability to make us "richer, smarter, greener, healthier and happier". Its ability to adjust its form and character in the face of shifting forces, to suit each ages set of priorities bears wisdom (Calthorpe, 2011).

As demonstrated with the Schumpeterian framework, while societal development and city growth has brought forth problems or depressions (including socio-economic and ecological challenges (ranging from terrain or resources insufficiencies to climate change)/ major economic shifts in cities corresponding with technological advancement), it is followed by responding urban management and development innovations (Taylor 2013).

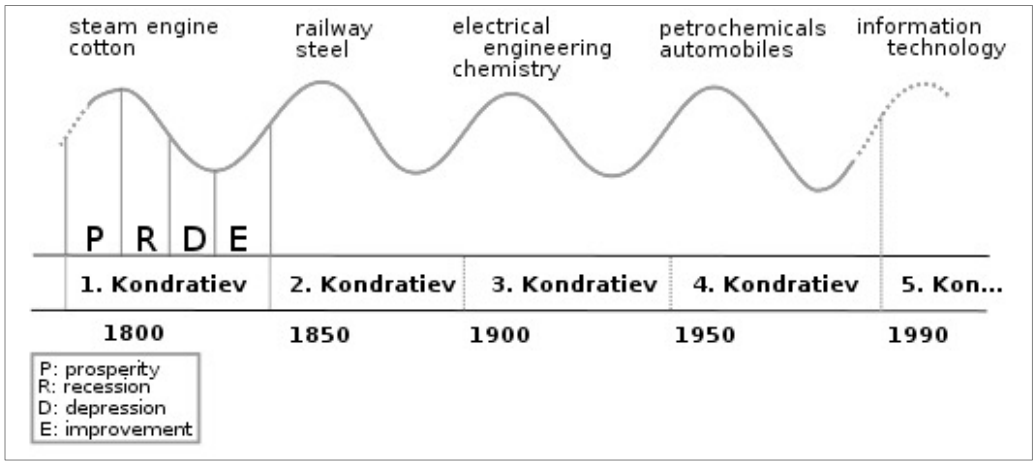


Figure 2: Schumpeterian framework

Cycle 1, although small scale district interventions, the development of turnpike roads and fast mail coach emphasising speedier transport and information, saw the development of von Thunen's (1826) isolated state concept; concentrically organised with a central market and outer agriculture production arranged according to transport costs. This concept formed the base template for Christaller's (1933) central place theory.

Cycle 2 and 3, Haussmann's metropolitan interventions and Howards regional Garden city plan in response to "unsanitary" urban conditions and a return to nature nostalgia saw the internal relations of cities differentiating between industry and residence with citywide infrastructural interventions obliterating "vibrant" communities and entrenched external relations, differentiating between cities and agricultural hinterlands. Aided by the development of the electric telegraph, separating message from human carriage, the development in electrical generation, transmission and information technology as well the development of railroads, streetcars and steel ships (reference).

Cycle 4 and 5, Frank Lloyd Wrights National Broad Acre Plans, among many in response to the notion of "The Disappearing City", envisioned as an expansive city with planned zones dependent on revolutions in information and telecommunications, with the highway as centre stage. It was also at this moment that the Club of Rome emerged; a new Malthusian think tank, advocating for a new world order and population control in response to looming global issues

such as over population, rapid urbanisation and inability of the earth to supply rapidly increasing demand (McCann, 2011), sparking notions of "ecologically" conscious city with evolve with principals of ecology protection, eco infrastructure, eco living and eco residences emerge.

Lastly, in cycle 5-6, today; the tertiarisation (trend toward service society) of economies as a result of information and technological advancements; and worldwide division of labour in an interdependent world city network; has reinforced the role of the sub national and trans-national scale. While on the one hand the local is emphasised through attraction of the enhanced role of the private sector in economy as result of the rise of neoliberalism and the resurgence of 19th century laissez-faire economic liberalism associated with extensive economic liberalization with policies such as privatization, deregulation, free trade and reductions in government spending; the transnational has also spelt a return to the significance of the local and notions of the liveable city with its local considerations of culture, environment, safety and convenience (Harrison and Hoyler 2015).

Like the normative response predecessors, of Haussmann's metropolitan interventions, Howards Garden city plan, and Frank Lloyd Wrights National Broad Acre Plan, if city sustainability is to be viewed as a normative response to current conditions of planetary urbanisation, climate change and globalisation, it needs to be looked at both in terms of its internal conditions and wider external network of interconnected cities. Within this frame, Wall et. al (2006) regards sustainability as a normative response to current conditions. This includes increasing globalisation contributing to new forms of demand and supply worldwide, unequal distribution of technology, capital and labour; and cities increasing role in the world city network inextricably linked to local conditions. Based on this, its believed that a circual causality exists between the city, firm and network with the cities performance a measure of its business relations in the network and societal wellbeing. Sustainability, is therefore regarded as the mediator between the cities economic, social, and environmental wellbeing across its local to global scale and its intercity relations.

Similarly, Taylor (2013) notes that we cannot simply be thinking in terms of a "green city" or "sustainable city" what is required is a "guiding concept of a green network of cities". To move beyond the consideration of the place bound environmental footprint to include the notion of "environmental net-prints" and commercial network measures. This does not mean choosing the one over the other, simply it takes the stance that in order to achieve a "non-catastrophic" future, (Scott and Storper 2015) perspectives on the "issues of cities" and the "issues in cities" need to be taken. Jacobs (1969) notes the cities need for localised, state "guardian" and larger, complex "commercial" practices, demonstrated with continual vertical mechanism of economic localisation in conjunction with urban innovation at the macro scale. See below diagram.

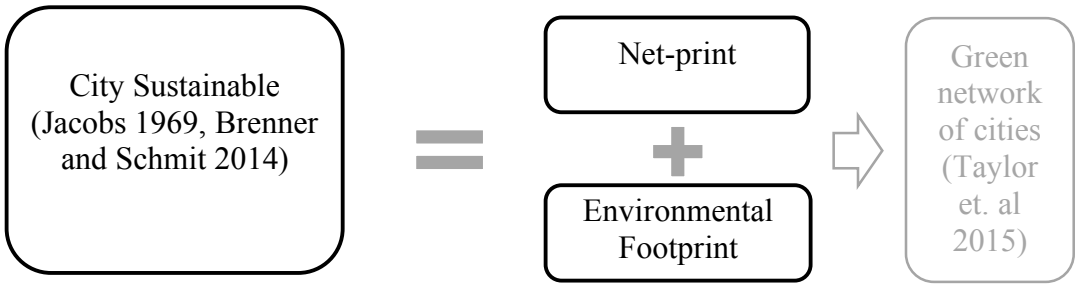


Figure 3: Taylor (2012) Adapted Green city/sustainable city made up of environmental print and net -print leading to green city network

The significance of taking this approach although already briefly highlighted, is elaborated on as follows; firstly, cities are by default considered to be greener than its suburban counterparts in its housing large quantities of people in a smaller footprint. They are the places where people live, work and spend time with their families. Because of this great effort is and required to maximise its green or sustainability potential. Steps toward understanding the sustainability of its attributes, in terms of for instance the prevalence of parks, CO2 emissions, safety etc. has provided insight into understanding or benchmarking city sustainability standards and measure its attributional impact on the environment (such environmental footprint)(Taylor 2013). At the same, emphasis on understanding the attributional level has paved the way for the development of localised responses and visions for newly designed cities and the self reliant city(Marcotullio 2001). These approaches provide ways in which to make cities more equitable and environmentally friendly through the improvement of individual components of the city, preserve natural assets and encourage small decentralised communities. However, the neat packaging of green city proposals planned for local transportation, residence, industrial and commercial activities, within a perceived autonomous region does not deal with external pressures (Marcotullio 2001). Cities interdependence on non-local forces (flows of trade, investment, people, and information) and actors (transnational corporations, multinationals, financial institutions, international non-governmental organisations) (Marcotullio 2001); will ultimately result in the disjointed dotting of green cities across the landscape and fruitless global sustainability (Taylor 2013).

In consideration of an approach which acknowledges non-local and local forces, including processes of cities interdependence with global flows, (Marcotullio 2001) notes two approaches. Firstly; the "free market" approach, with reference to the environmental Kuznets curve, it describes a functional relationship between the environment and income. As income increases, environmental considerations decrease to the point where societal development forces a change in environmental responses. This approach has been criticised for exacerbating global imbalances and inequality. And the post industrial places, having gone through shifts from poverty, manufacturing centred to consumerism are regarded as increasingly polluted. Although having driven down infrastructure pollution has seen the increase in consumer caused, pollution. Secondly, the "fair shares" model, although in its infancy attempts to respond to the inadequacies of the market led fair shares model by encouraging trade flows guided by social and environmental concerns. Recognising global flows relationship to urban development, it looks to understand the international interactions between cities (world intercity network), within an approach which employs increased regional autarky and policies to address imbalances.

	Internally Oriented		Externally Oriented	
	Redesigned	Self Reliant	Free Market	Fair Shares
Orientation	Market-led: Reduce negative external impacts	Bioregion limited: Local capacity driven	Global: Market-driven; unrestricted hinterland	Global-Local: Carrying capacity limits; equity concerns, managed hinterland trading
Regulation	State regulation: Land-use	Self-regulation: Alternative	Market regulation: Market creation	Major Market regulation for trade and investment:

	planning and design controls	markets; extreme decentralization	and deregulation; reduce inappropriate subsidies	Concern for regional carrying capacity
Value System	Anthropocentric: Modify behaviour through planning; "light green"	Ecocentric: Moral sanction; "Deep green"	Market Supremacy: Neoliberalism; "Light Green"	Market Modification: Nature sensitive; "Deep Green"
Technology	Environmentally efficient	Low/appropriate	Smart/High-tech	Mix of Technologies

Table 1: Features of the four models of urban sustainable development(Marcotullio 2001)

In order to achieve a semblance of (Marcotullio 2001) "fare share" model, Taylor's (2013) network of green cities" model highlights the need to 1.) green the modern and 2.)green beyond the modern. This implies firstly; "greening" the existing, in terms of the net-print through modularity of the highly interdependent city network to minimise vulnerability and shock. Greening of modern systems such as green financial services, green accountancy and green advertising. And within notions of city niches and trade, looking at the relationship between destination and source from the perspective of the nearest non-local reducing multiple cities environmental footprint in the network. Secondly, linked to 1, alternative import replacement and shifting toward prioritising production over trade, achieved through the verticality of economic localisation and urban innovation found within Jacobs new trade theory, which advocates for the cities localised guardian and macro commercial processes. Lastly, with reference to Jacobs (1969) Guardian concept, Taylor notes that although guardianship provides a "moral compass" for city or state and stewardship in relation to commercial practices at the scale of "place" (local), what is maintaining the "flows", where are the network stewards, global governance structures.

Similarly, Wall et al.'s (2006) "Archinomics" concept corresponding to Taylor's (2013) "network of green cities" and Marcotullio's (2001) "fare share" model; regards sustainability as dependent on cities internal and external properties, "a corollary between urban indicators and city-firm networks". This is imbedded in the idea, that since the industrial revolution, the informationalization and corporatisation of the global economic structure has resulted in the inter firm network driving urban economic growth and playing a critical role in cities production and performance. And contributing to the increasingly interdependent disproportionate world city firm network, plagued by uneven distribution and inequality. Wall et. al (2006) like Taylor (2013) modularity approach to reduce vulnerability believe that on the basis of an empirical understanding of a cities internal and external properties, strategic social, economic and environmental decisions can be made toward sustainability. By understanding the cities relationship to other cities and its position in the world city firm network, decisions on cities niches, trade, specialisation and strategic partnerships and nearest non-local can be made.

2.2 'Greening beyond the modern'

Taylor's (2013) alternative import replacement, while advocating for economic localisation and urban innovation, in order to green the /beyond the modern calls for an understanding of existing local conditions from a social, environmental and economic perspective. Various approaches have been developed to measure sustainability in all its different focused iterations,

straddled between notions of strong (environment centric) and weak (economic centric) sustainability.

Theses include measures such as the Ecological footprint, Environmental Sustainability Index, Dashboard of Sustainability, Welfare Index, Genuine Progress Indicator (GPI), Index of Sustainable Economic Welfare, City Development Index, Human Development Index (HDI), Environmental Vulnerability Index (EVI), Environmental Policy Index (EPI), Living Planet Index (LPI), Environmentally-adjusted Domestic Product (EDP) and Genuine Saving (GS), the list goes on. With many of the measurements tended toward the national scale.

Since sustainability essentially aims to mediate between societal development and environmental capacity, linked to productivity (toward development) and scarcity respectively; approaches and measurement of sustainability has swung between environmentally oriented strong sustainability and development oriented weak sustainability. Strong sustainability approach takes the position which accepts that non-ecospheric natural capital (minerals) can be depleted but the ecosphere must be protected absolutely - 'there is no substitute to the planet' - a planet over people approach. Weak sustainability takes a position that propounds that human made capital (e.g. technology) will substitute for natural capital so this can be run down, providing a critical minimum level is maintained which invokes essentially a willingness to pay approach.

Because of disproportionate global distribution, with certain nations more developed than others, with developed nations process of industrialization being the major cause of environmental concerns as well as currently being the major pollutants, approaches toward sustainability has tended toward the weak sustainability model as means to respond to global asymmetries and economic development sustainability beliefs (Dresner, 2002). One approach applicable to this is the Human Development Index (HDI), geared toward "developing" nations which aims to measure the equitable distribution of economic growth to deliver the necessary improvements to the human condition.

The environmental footprint approach within consciousness around environmental utilisation aims to reflect limits or pressures on the eco-system through the creation of boundaries (Siebert, 1982; Opschoor, 1987). Nations are motivated to reduce their footprint through employing weak sustainability neoliberal approaches of technology development toward decoupling productivity from non-renewable resources. Further limitations around the footprint approach aims imposed through instruments of the green economy which aims to price the environment through a framework of fiscal controls and incentives based on willingness of pay to internalise all the external costs to the economy in terms of pollution, resource depletion and human health (Pearce, 1989). Through the creation of a tax system for environmental control on consumption and production, governments around the world are able to generate additional income for improved technologies and improvements to the environment (Dresner, 2002).

However, as already noted, the promotion of neo-classical economics weak sustainability approach of the market as a replacement and technology seen as a substitute regardless of limited resources in the face of scarcity and rising resources prices (IIED 1999). Global asymmetries, instead of being circumvented, are exacerbated through 1.) how to apply a monetary value to critical resources, how to ensure equitable redistribution, and how to price resources for future generations. 2.) "sea saw" effect of decoupling maturing (use of less non-renewable industries and extractive manufacturing) in the capital abundant developed world through in part resource and energy efficiency measures, but also burden shifting to the labour

abundant and primary sector based developing world (Dresner, 2002).3.) Further impact of low income nations, already struggling to meet its own needs in terms of accommodation and access to basic services, through formal means being the a.) recipients of the population boom occurring in cities over the next few decades (United Nations, 2007), b.) while considered to not prioritise climate change and ozone depletion (McGranahan et al. 1999), the collective resource lifestyle of the north historically and presently is resulting in poorer nations suffering the most in terms of ecological degradation and socio-economic disparities (Srinivasan et al. 2008).

However, I digress, the reason for highlighting the above besides flagging the inability of one dimensional approach to respond to sustainability requirements, it also highlights the intricate complexities around global asymmetries. With the increased awareness around cities role in shifts toward sustainability as previously stated, there have been increasing demands to construct indicators that can asses' urban sustainability. Indicators include, amongst others the Green City Index and the City Development Index. These indicator sets have tendered toward focusing on local sustainability of place and not city sustainability across the world (Mori and Christodoulou 2012). An approach which considers city sustainability from a systems perspective, in terms of the impact of economic growth in cities on society world wide and the local environment is required. (Mori and Christodoulou 2012) like Wall et. al (2006), Taylor (2013) and Marcotullio (2001) regards sustainability indicators as made up of two paradigms including the top down, macro forces and stakeholders; and bottom up forces and stakeholders. If we are too regard the basis of sustainability indicators as a means to provide tools for policy making, information sharing and community improvement, then both paradigms need to be included.

Although, the quantifying of sustainability, has been critiqued for being reductionist allied to policy makers and scientists toward distilling a single value of highly complex process, the paradigm of sustainability requires proof of a wider application. (Bell and Morse 2008) notes that the evolution of sustainability as a paradigm or a system, leads to a need to quantify sustainability, hence the development of sustainability indicators as means to keep the paradigm alive.

Despite contemporary benchmarking approach which aims to establish a baseline for standardised measurement of sustainability, sustainability diagrams assist with establish the overarching conceptual approach. With benchmarking comes the ability to gage position development in relation to other cities and therefore creates a basis for competition. Stemming fro Porter (1990) competitive advantage notions, international organisations, develop indicators and measures on which gage or rank. This assists with potential investment and future project developments. The Arcadis sustainable city ranking is one example, at the firm agglomeration scale, it considers the urban economies from the perspective of people, planet and profit, including the network scale with the use of Globalization and World Cities (GAWC), 50 top world cities ranking.

More recent indicator sets such as the Arcadis sustainable city indicators which consider the local social, environmental and economic indicators, as well as with reference to the GAWC ranking of world cities as a measure of cities global hierarchy. However, this ranking relates to services in particular at the attributional level and does not speak to the cities relationship to other cities in network.

2.3 ‘Green the modern’

Taylor’s (2013) notions of ‘green the modern’ advocates for modularity as a response to what is perceived as a vulnerable interdependent global system. Taylor recognising the need for local and non-local as means for sustainability, within themes of trade and niches aims for the possibility of a system of nearer non-local interaction and the generation of multiple city greening.

Within this frame, a need for understanding the structure of the global system is highlighted with specific reference to city positionality, inside of intersecting functional (trade) and formal (spatial/physical) nature of global interdependence.

Taylor (2012), in looking at this relationships, notes that world cities (more globalised or connected in the network), have two distinctive features, each with a negative (benefit beyond the market) and positive (bonus locating economic activity in the city) externality. Firstly; “dense pattern of intra-city relations that create agglomeration effects and cluster advantages. Secondly; “strong flows of intercity relations that create network effects and connectivity advantages”. Taylor, goes onto to say that the success of cities lies in the ability to achieve both “agglomeration externalities and network externalities to maximise the bonus of an urban location”. Although there is extensive literature on agglomeration effects, there is limited research on network externality effects Taylor (2012).

Taylor (2012), in consideration of this dynamic, actually purports that although existing alongside each other, the two are not on equal footing. In fact, he notes that city network processes should be treated as the baseline, generalised situation of how cities work and that city hierarchy complimenting the network really is contingent or dependent on the network. City positionality within the system therefore is a determinant of city performance and role, with certain cities “better” situated yielding more power or others offering a linking function (Alderson and Beckfield 2004).

2.4 The world city network

In order to understand the basis of the different positionality functions, an understanding of the world city network is required. While the world city network naturally hints at a formal(spatial) and functional (economic) perspective, societal evolution and technology has resulted in the functional driving and deepening the world city network interdependence.

Taylor (Taylor 2012) defines the world city network from the perspective of the interlocking network model three tiers, which includes the net level, the nodal level and the sub nodal level of advanced producer service firms linked through their everyday transnational practices. The merging of communications and technology industries in 70’s allowed for worldwide coordination based on simultaneous connections. As a consequence, efficiency aspirant firms unbounded by geographical constraints, employing multi-city policy approaches toward ensuring seamless service provision and brand identity. The resultant economic geography 1.) the dispersal of labour to cheaper locales and 2.) the concentration of management and business services industries concentrated in cities.

2.4.1 Financial flows

The numerous flows of finances, professionals and projects constitute the world city network, through firms internationalising when the competitive advantage of establishing subsidiaries abroad outweighs the cost and risk of the operation (Hymer 1976). Referencing Dunning's (1997) OLI paradigm, firms are encouraged to internationalise when they have specific ownership advantages (O) of a product or processes, location advantages (L) in locating activities in a country other than the home base and internalising advantage (I) with foreign activities in fully or partially owned subsidiaries. Through long range investments, (foreign direct investment (FDI)) into countries other than the one the investor is based in; multi national corporation (MNC) networks are expanded. (Wall et al. 2011). There are two forms of investment, namely, greenfield investment (where a parent company starts a new venture in a foreign country by constructing new operational facilities) and mergers and acquisition (M&A) (consolidation of companies or assets). Characterised either as vertical; the relocation of activities geographically toward savings in production costs or horizontal FDI, which is the duplication of activities toward accessing foreign markets (Demirhan and Masca 2008).

There are various factors which influence the locating of FDI including amongst others; 1.) Market seeking FDI, where firms replicate the production of the facilities of host country to serve local market by local production. 2.) Resource seeking; where firms search for natural endowments such as oil and gas, or a good supply of low cost labour. Regarded to have predatory potential. 3.) Efficiency seeking relates to economies of scale and scope in geographical locations, translatable into vertical FDI which involves the relocation of specific activities to low-cost locations – such as today's large-scale relocation of production activities to China (Demirhan and Masca 2008).

FDI, only occurs under particular determinants. Various theories have been developed to explain the determinants of FDI. These involve the micro (e.g., organisational aspects) and macro (e.g., resource allocation) dimensions (Dunning and Lundan, 2008). The micro dimension includes factors intrinsic to the company itself, such as ownership advantages, cost reduction and economies of scale, whereas the macro dimension concerns market specific factors such as barriers to entry, availability of resources, political stability, country risk and market size, amongst others (Faeth, 2009). Demirhan and Masca (2008) list the following 1.) Market size, 2.) Openness, 3.) Labour costs, 4.) Productivity, 5.) Political Risk, 6.) Infrastructure, 6.) Growth and 8.) Tax.

2.4.2 FDI contention

Transnational firms contribute to serving local markets and lowering productivity costs. The flow of FDI supplies capital, boosts competitiveness and assists countries lacking experience to bring their products to market (Goldstein 2004). Foreign capital is seen as essential, at least as a temporary measure, during the period when the capital market is in the process of development, providing scarce productive factors like technical know how, business expertise and knowledge(Rogerson 2009). Principally contributing to economic growth through stimulating innovation and technological progress instead of total capital accumulation. Linked to the host countries ability to achieve a particular level of human capital measured by average schooling years (Wang and Wong 2009). However, increasingly geared to more capital and knowledge intensive activities, has resulted in the shift and decline in labour intensive manufacturing in general, and the share of traditional manufacturing employment (Cherunilam 2010).

With increased opportunity spurred competition and institutional setting playing a significant role in terms of guiding the process, has seen host countries take particular steps toward making their country or city attractive to investors including; image building around creating a positive perception, policy advocacy to support the views of the private sector in terms of investment, investor facilitation of services which assists with investment decisions in the host country and investment generation through the targeting and prioritising of specific sectors(Goldstein 2004). Analogously, many governments, are not creating an environment for maximum sustainable benefit of FDI, instead offering incentives for investment which include tax concessions, cash grants and other means in order to attract investors(Goldstein 2004). Using incentives as a substitute for reform in the business environment (Rogerson 2009), has the potential to exacerbate the gap between foreign and local firms, indirectly assisting in the creation of a dual economy (Bouoiyour, 2003).

In the context of growth, tax revenue and employment, while FDI is not detrimental to economic growth, it does increase the rate of vulnerable employment. The choice of M&A versus greenfield investment is dependent on the trade off the country is willing to make. While the volatility of M&A makes it unstable, between the two its considered to be more stable in crisis with no negative impact on tax revenue and GDP growth. Greenfield investment on the other hand, regarded to have a negative impact on tax as governments incentivise investment through tax reductions, with a resultant lowered social expenditure, its statistically proven to be less volatile over the long term(Staveren 2004).

The dualities within the space sees contrasting views on FDI sustainability with protagonists of anti globalisation and environmentalists viewing FDI as a threat to the welfare of future generations through exacerbated excessive consumption. Fierce competition as a result of market globalisation and enhanced economic freedom is considered to push countries into unsustainable patterns of resource depletion and economic production. Maximizing current profits at the expense of future welfare creates distorted economies, are inefficient and damaging to future generations. The entry of MNC supermarket and hyper market chains are believed to cause severe displacement of small and unorganized shopkeepers and traders. Large, international giants monopolize and take over highly profitable sectors, investing more in machinery and intellectual property than in wages of the local people (de Soysa and Neumayer 2005). On the other hand, positivists advocating FDI see it contributing to the growing economic interdependence and good for global prosperity. On the basis that market globalization and economic freedom leads to a more efficient allocation of resources. Enhancing the role of relative prices and increased productive efficiency due to infrastructure and technology transfer and competitions from multinationals subsidiaries, employment, consumer benefit, increase in savings and investment (de Soysa and Neumayer 2005).

2.4.3 World city network review

Beaverstock et. al (2000), review of world city network literature, reveals two shifts. The first ‘place centric’ and the second, ‘process’ centric.

The first shift, including works of amongst others Hall, Hymer and Friedmann, commences with Hall’s (1966) definition of world cities, drawing on the work of Geddes (1915) depicts world cities as a concentration of international level functions such as corporate headquarters, conceptualized as “entrepots” for their country and region; and centres of political power for national and international trade. Speculating on the impact of increasing international trade and

multinationalization on cities, Hymer (1972) highlights the implication of globalisation for the process of urbanisation, noting:

[It would] tend to produce a hierarchical division of labour between geographical regions corresponding to the vertical division of labour within the firm. It would tend to centralize high-level decision-making occupations in a few key cities in the advanced countries, surrounded by a number of regional sub-capitals, and confine the rest of the world to lower levels of activity and income, i.e., to the status of towns and villages in the new Imperial system. Income, status, authority, and consumption patterns would radiate out from these centres along a declining curve, and the existing pattern of inequality and dependency would be perpetuated. The pattern would be complex, just as the structure of the corporation is complex, but the basic relationship between different countries would be one of superior and subordinate, head office and branch plant. (Hymer 1972, p. 114)

Essentially Hymer (1972) alludes to the translation of the corporate structure onto the world city system. This includes 1.) the division of labour geographically would correspond with that of a corporate structure. 2.) the distribution of industrialisation to low to mid range cities of the developing world, traditionally the "global south". In this structure corporate decision making is corporate decision making confined to a limited number of hub "industrialised" cities with strong ties to transnational capital, markets, media and governmental activities, such as Paris, Tokyo, London etc.

Further to Hymer theory, Friedmann's (1982, 1986), world city hypotheses provides a theoretical and empirical basis for understanding the global corporate economy and world cities. Premised on world cities being fundamental nodes in the global economy with systemic exchanged between them critical for the world system. Friedmann outlines seven theses, highlighting broadly 1.) Cities level of development is pivotal to the extent of its functional integration within the worldwide urban system, 2.) The arrangement of hierarchy within the system is embedded in the economic network, and 3.) Core cities, acting as hubs and spatial organisers, arrange the network according to market and production. Friedmann therefore poses that cities are hierarchically ranked according to the economic strength that they command. Highest ranked cities have power and are the control centres of the global economy, followed by cities that control multiple superregional economies and lastly; cities that articulate national and subnational economies.

Friedmann's world city roster include the following: Cities in the "top class" designated as Alpha world cities, including amongst others London, Tokyo, New York. Cities in the "second class" known as beta world cities, needing to be a global service centre for at least 3 of the 4 services sectors include Moscow, Sydney, Toronto. Cities in the bottom tier known as gamma world cities, required to be a global service centre in at least two service sectors including cities such as Istanbul and Johannesburg(Sassen 2002).

Friedmann's hierarchy focused world cites, ranked according to their ability to attract capital, while empirically identifying world cities within a global order, is methodically flawed in its conception of network conceptualisation(Sassen 2002).

The second shift in the world city literature as intimated by (Beaverstock et al. 2000), begins to talk to the intercity flows of network conceptualization in the works of Sassen global city hypothesis and Castells network society.

Sassen's (2002) 'global city' within themes of global spatial disarticulation, unevenness and inequality; refers to the few cities which run the global corporate economy. Global cities organise its structure of worldwide decentralized establishments through the arrangement of

key resources including infrastructure (information, communication, technologies and international airports), skills and human capital such as professionals. Unlike Friedmann's world cities concept, Sassen (1999) global city relates to the emergence of a particular type of city dealing exclusively with advanced producer services functioning either as command points, a location for business or financial services, sites for production and innovation and markets for products. Prioritised over the national level, the global city articulates the new international division of labour. Service orientated cities in the developed world, a higher share of manufacturing cities in the developing middle-income world; and informal-economy cities, in the least-developed countries weakly connected to global networks (Friedmann and Wolff 1982) and a significant portion of territory which over time is increasingly excluded from global economic processes. From an increasing socio-economic perspective, the urban hierarchy is regarded to exclude a large portion of the worlds population rendering the periphery economically irrelevant. The dualities driving urbanisation sees the simultaneous spatial dispersion and integrated organisation of economic activity (Sassen's 1994, 2001). Despite the dispersion of productivity, such as previous manufacturing shifting places, decentralised control is lagging. Regarded to be generating a new world system. A new morphology which sees a slippage between the map of the world system and map of the world; which cuts across old (e.g. North/south) divides (Friedmann 1995, Sassen 2001).

With similar basis for understanding contemporary social and economic changes; Castells (1989) conceptualizes cities as nodes processing the flows of a global information- and the innovation-driven economy. Dynamic arrangements facilitating innovation, incubators processing flows of ideas, people, capital, and goods etc. As a consequence of Castells theories, reinforced the shift away from reading cities as attributional, hierarchically focused on the static 'space of place' to rather an understanding of cities interacting within a world urban system as 'spaces of flows'.

Castells attributes this to revolutions in information and communication technologies (ICT), restructuring of industrial economies to accommodate an open market and cultural movements (civil rights, feminism and environmentalism) of the 60's and 70's led to new social structures and contemporary globalisation. ICT created far flung networks which resulted in new kinds of social relationships. The broad historical significance of this development paradigm and the economic restructuring besides deepened city linkages, created the conditions for the open market, the weakening of the nation state and the emergence of city importance on the global stage. Deeper sub-nation level linkages and social exclusion between and within countries (Castells 1996). Opposing 'human-capabilities centred" development paradigm focused on human rights created by temporal cultural movements embedding the values of individual autonomy and freedom were instrumental in setting up the open network structure for communication. Playing a significant role in the development of the network technologies, which formed the basis for business to expand globally (Castells, 2004).

Therefore, since cities as the key articulators in the formation of world system new geographies of centralities; as a consequence of their role in linking national economies to global circuits and cross border exchanges binding cities(Sassen 2002). Within Castells frame of conceptualising cities as nodes processing flows, conceptualising the network should be taken from the perspective of the structural relationship of cities as nodes in multiple networks of economic, social, demographic and information flows. Defined by the exchanges that link them on the basis of understanding of systems of cities and the relative dominance of cities within a system. (Smith and Timberlake in (Sassen, 2002).

2.5 City positionality in the network

Therefore, within this research's goal of looking at city positionality in relation to city sustainability; linked to world city literature aim of saying something meaningful about the changing fortunes of cities; and world city network literature developments, an approach of looking at the relations linking cities instead of attributional data is employed.

If we are to assume that city network processes are treated as the baseline, generalised situation of how cities work, city 'hierarchy' (a reference for place conditions) is then dependent on the network (Taylor 2013). Moreover its positon within the system is then a determinant of city performance and role (Alderson and Beckfield 2004). And if "cities are situated in a system", some cities as a result of their position in the system will be better situated than others.

In order to understand this system and positionality relationally, many academics make reference to social network analysis. Polanyi (1944) and Grabher (2006) point out that economic action is fundamentally a social phenomenon and therefore social network analysis is useful for understanding firms; and the critical role of the position of actors in webs of affiliation (George Simmel 1890). Similarly, (Alderson and Beckfield (2004), point out the affinity of literature on world cities and social network analysis:

"... the power of world cities is inherently relational: cities do not have power in and of themselves; they have power to the extent that they function as command points and centres of planning and thus establish the framework in which other cities operate in the world economy.

...social network analysts suggest that power is best viewed as a consequence of patterns of social relations that generate opportunities and constraints: some actors are favoured because they occupy positions that are more favourable than others (Granovetter 1973; Padgett and Ansell 1993; Guiffre 1999).
(Alderson and Beckfield 2004, *p.822)*

Since hierarchy and therefore power is a consequence of patterns of social relations. Position is a result of a cities centrality in terms of its structured favourability in the network (Alderson and Beckfield 2004, Freeman 1979). In fact, in lieu of the link, network analysts have developed a set of tools that enable those interested in pursuing the world city hypothesis to assess (1) the degree of power wielded by individual cities and (2) the positions of and roles played by different types of cities within the world city system. A cities position in the system and its relative dominance (Smith and Timberlake in (Sassen, 2002), is premised on the exchanges that link cities. Where increased exchanges translate into being more favourable. However, this can be further broken down into the type of exchange in terms of those coming in (inward), those going out (outward) and those going through (Linkage). A simple explanation of this, is explained as follows:

2.6 Network stewards

Within lacking network stewards to manage network processes (Taylor 2013); in consideration of cities as networks stewards, the following have been identified as points of departure to boost city network impact (Forman and Wu 2016). They include (1) Investment: while international organizations and corporate sectors are investing, its important for governments to invest more and encourage experimentation. Examples of government development initiatives include the C40 Cities finance facility. Funding should be linked effectively to

spending on sustainable infrastructure. This is echoed in (Mazzucato 2011) notions on the entrepreneurial state, advocating for state owned development finance institutions bordering notions of governance and investment. Theses institutions are able to coordinate investment strategies, becoming the lenders that pick up the high risk end of large scale development making it easier for more risk averse private financial institutions to participate; through blended financing and distributed risk. (2) Collaboration: city networks part of a global action with local governments networking more. An example includes the Johannesburg in South Africa, inspired by its C40 link with Washington DC, is working with the World Bank and national bodies to implement a 'tax increment financing' scheme to enhance its neighbourhood planning efforts. (3) Research: Cities need data gathering, sharing and analyses to become more joined up and effective. Cross-network efforts need consolidating and better access to national and international policymaking processes. The Compact of Mayors set up by the UN is one example. However, links need to be strengthened, span more sectors (including climate, health and security) and support closer ties between science and policy.

2.7 Conceptual Framework

The literature review provides an understanding of city sustainability as a result of shifts toward sustainability approaches which cover broader aspects of governance to include peace, security and urban governance which fosters urban planning, environmental management, the reduction of ecological footprints, the decentralization of decision-making, and resource allocation, as well as enhanced policy coordination between local and national authorities(DESA 2013).

Within this frame, the literature provides an understanding of different approaches to city sustainability. Explaining why within notions of market led inadequacies and global flows relationship to urban development (Marcotullio 2001); sustainability is a normative response to current conditions, mediating the different scales (Wall et. al 2007). Incorporating place bound environmental footprint and the "environmental net-prints" of commercial network measures (Taylor 2013). The literature, therefore provides understanding for an approach which recognises the local, global dynamic (Henderson et al. 2002) intersecting the various scales (Wall and van der Knaap 2011; Alderson et al. 2004). The literature explains the use of measured sustainability at the local scale within Taylors (2013) themes of "greening beyond the modern" the "environmental footprint as well as the significant role of institutions at these scales.

Through addressing the net-print; promoting notions of the "fair shares" model and "greening the modern" of sustainability toward encouraging trade flows which are guided by social and environmental concerns, toward an approach which employs increased regional autarky and policies to address imbalances (Taylor 2013, Wall et el. 2007, Marcotullio 2001). The literature explains the significance of understanding international interactions between cities and the implication of the network on the fate of cities. Employing the theories of Hymer, Friedmann, Sassen and Castells who provide insight into cities development influenced by its role in the network and by implication spatial hierarchies and organisations of core and periphery cities with varying degree of strength of ties (Cerny 1991).

Lastly, the literature explains why when looking at the cities role and position in the network, toward understanding implications on city fate (Sassen 2001, Castells 1989), the relationship and flows of interaction should be the focus, instead of the more commonly used city attribute approach of Friedmann (1982). Since cities are situated within systems, position is established in the web of affiliation (George Simmel 1890); a result of its centrality in terms of its

structured favourability in the network (Alderson and Beckfield 2004, Freeman 1979). A cities position in the system and its relative dominance (Smith and Timberlake in (Sassen, 2002), is premised on the exchanges that link cities. Where increased exchanges translate into being more favourable. And the type of exchanges influences it position; inward relates to prestige, outward relates to power and weight others exchanges, strength of the tie and those going through providing a linkage role.

Based on this the following conceptual framework has been constructed.

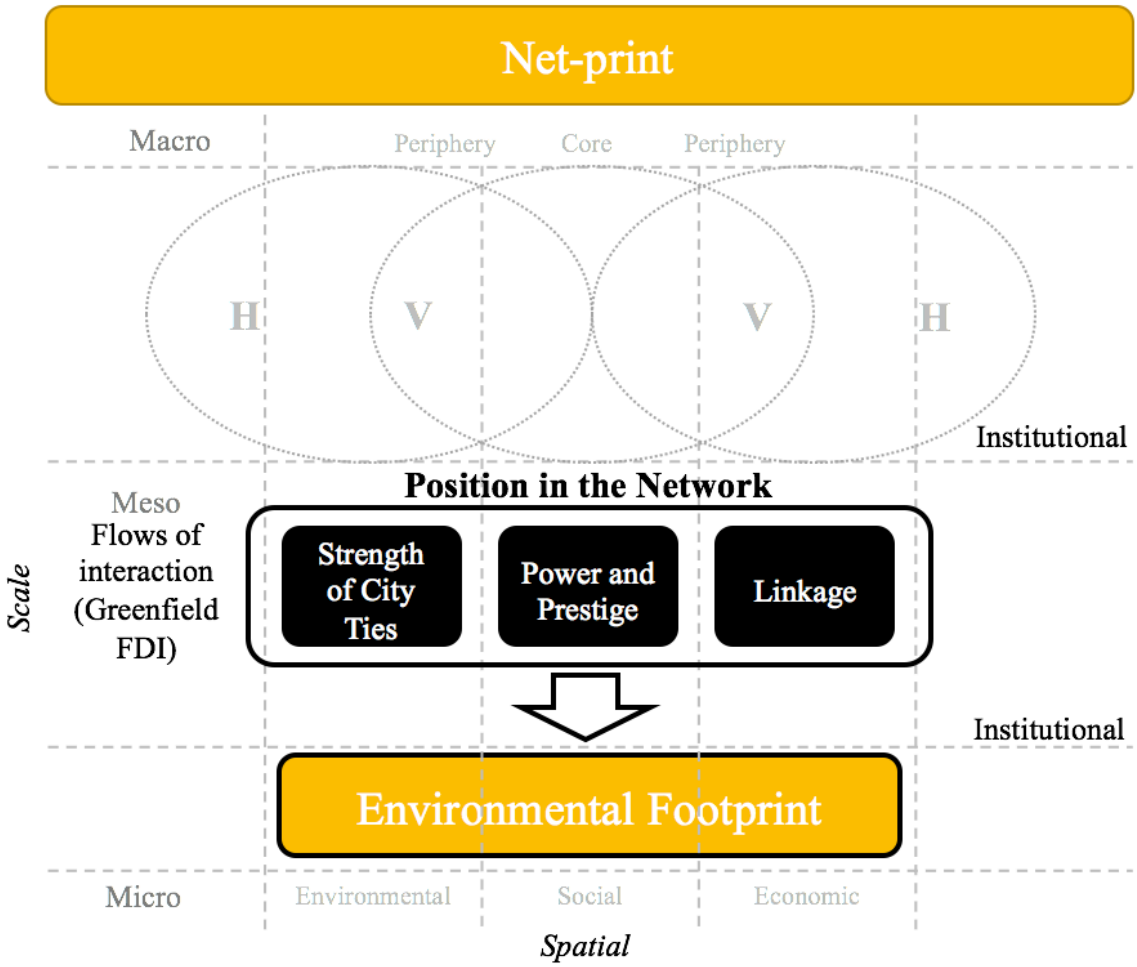


Figure 4: Adapted from Taylor (2013) "network of green cities" concept, Wall et al. (2006) Archinomics model and scale exploration between the world city network

Chapter 3: Research Design and Methods

3.1 Introduction

This chapter describes the developed research questions and the strategy to respond. Followed by a description of the theory and definition of the variables derived from chapter two. The variables are then operationalised by identifying measurable indicators. Post operationalization, the research strategy is described detailing how the research will be carried out, methods and instruments for data collection, sampling procedure and analysis. Lastly, challenges around the limitations, validity and reliability of this research will be highlighted.

3.2 Research Question

As previously described, the objective of this research is to provide knowledge which will be beneficial in developing solutions towards city sustainability by explaining the influence of global integration, from the perspective of city role and position in the network on urban sustainability.

To what extent does city position in the world city network influence city sustainability?

Considering the broad nature of this question, to be able to reliably respond to the question, Yin (2003), proposes that more specific sub questions be incorporated so as to guide a focused approach and outcome. Therefore, the sub questions included are:

Sub-research questions

1) To what extent does the prestige and power of a city in the intercity firm network influence city sustainability?
2) To what extent does the nodal strength of city ties in the intercity firm network influence its sustainability?
3) To what extent does the linkage structure of the intercity firm network influence city sustainability?

3.3 Operationalization

In order to respond to the main research question and sub questions, the key theoretical elements of global integration and sustainability needs to be operationalised as developed and revealed in chapter two. This is an important step in the process as it transitions the research from theoretical to empirical phase. Translating the theoretical concepts (variables) into measurable entities known as indicators which are measurable and quantifiable(van Thiel 2014).

The operationalization was done by defining the theory that forms the backbone of this research, variables of central interest were then derived and given a workable definition captured from the literature review in the previous chapter, lastly measurable indicators were defined.

The sections below present an outline of the operationalization process described above and concludes with the operationalization table.

3.3.1 Theory definitions, variables and indicators

"Green network of cities"; embedded in Jacobs (1992) 'systems of survival' notions around cities viable working life; underpinned by micro 'guardian moral syndrome' need to organise and manage territories; and the macro 'commercial moral syndrome' need to support human activities of trade and production of goods; relates sustainability to the achievement of urban vibrancy without excessive consumption; a condition of local and non-local processes; expressed as "greening beyond the modern" micro conditions of [A] "sustainable city' or environmental footprint contingent on 'greening the modern' net-print baseline commercial processes of how cities work (Taylor 2013, Jacobs 1992, Wall et al. 2006, Marcotullio 2001).

While the significance of a local global dynamic has been recognised for some time, studies to date have focused in particular on micro, meso or macro levels (Henderson et al. 2002). Rarely is the intersection of various scales looked into (Wall and van der Knaap 2011; Alderson et al. 2004). Therefore an approach which looks to the intersection is used.

Two variables were derived from the above mentioned theory, "net-print" of cities as the independent variable and "environmental footprint" represented as micro scale measured "green" attributes. The selection of the dependent and independent variables was explained in chapter 2. Based on the previous chapter literature review, the variables are defined below.

3.3.1.1 Net-print: City positionality in the world city network (Independent variable)

"Greening the modern" refers to the multi-city environmental footprint(net-print) of the highly interdependent city network; purports modularity toward lowered vulnerability to shock and imbalance in the network, promoting nearer non-local and "greening" of systems such as green financial services etc.; through better understanding of the city within the network around notions of trade, city niches and the relationship between source and destination (Taylor 2013).

Since the economic action of trade between cities is fundamentally a social phenomenon, social network analysis is useful for understanding the dynamics of firm interaction (Polanyi 1944, Grabher 2006); a key driver of city interaction. Expressed by Taylor (2012) definition of the world city network as a three tier interlocking model; including the net, nodal and sub-nodal of advanced producer service firms linked through their everyday transnational practices; emphasised with greenfield investment (where a parent company starts a new venture in a foreign country by constructing new operational facilities) (Demirhan and Masca 2008).

Understanding the world city network and city within it therefore is a consequence of social relations. Position is established in the web of affiliation (George Simmel 1890); a result of centrality in relation to structured favourability in the network (Alderson and Beckfield 2004, Freeman 1979). A cities position in the system (Smith and Timberlake in (Sassen, 2002), is premised on the exchanges that link cities; where for example increased exchanges translate into being more favourable.

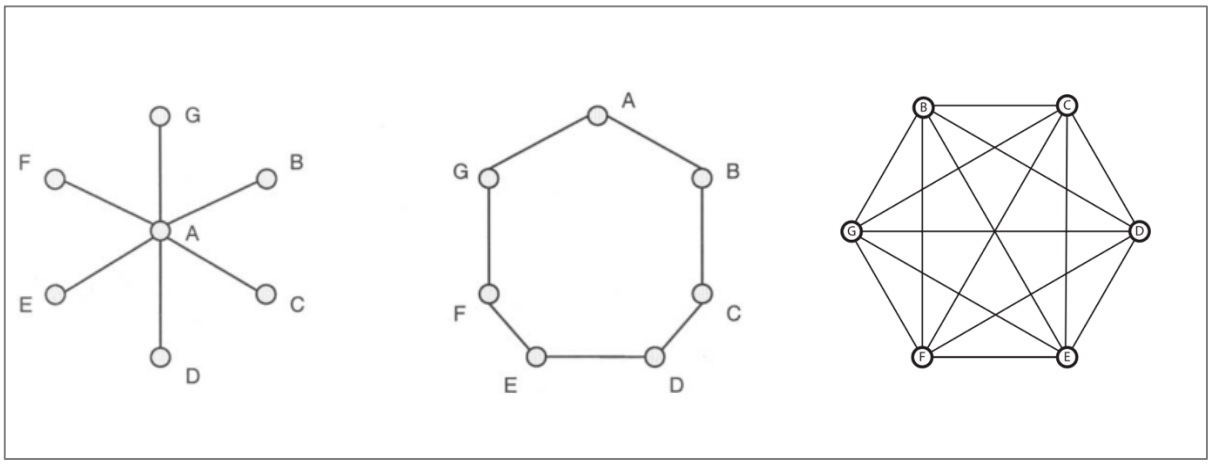


Figure 3:Graphs to illustrate centrality measures (Alderson et al. 2004)Corporate Ownership (Wall and van der Knaap 2011)

For example, in Graph 1: City A is in the most favourable structural position, being the most connected with the rest on equal unfavourable position. This is because City A is evidently more active, with more links and therefore more options. If D or E wont trade, there are many alternatives, where as in turn D and E are limited for choice. In Graph 2, all cities are in the same advantaged or disadvantaged position. In Graph 3: City A in will be in the more favourable structural position with the rest on equal unfavourable position.

These exchanges defined in terms of directional and weighted measures of the exchange (vertices); related to the Node; and linkage structure of the network related to the edge.

As demonstrated above the world city network and positionality in terms of favoured centrality in the structure has many many types, therefore each element is considered as a sub-variable.

City power in the network (sub-variable 1): ties sent and indication of captured control functions in the world economy (Alderson and Beckfield 2004).

Prestige of the city in the network (sub-variable 2): cities which are sought out by other cities, have ties directed to them, and are chosen over others. Put differently, world city–ness involves choices received in addition to choices made. A simple and straightforward measure of a city's prestige is its indegree—the number of ties it receives. Cities that have high indegree are prestigious in precisely the sense discussed above.

Strength of the cities ties (sub-variable 3): weight of total outward and inward domestic investment. And an extension of the 'power' of cities to invest in other cities (Alderson and Beckfield 2004).

City brokerage (sub-variable 4): the ability of the city to broker exchanges and thus has the power to coordinate action and to withhold or distort in- formation to its advantage. With reference to the star network, City A (ref. figure ?) therefore has power to to coordinate action and to withhold or distort information to its advantage. At the same time, City A does not need a broker for exchanger and therefore has a distinct structural advantage. In the circle network all cities are equally disadvantaged and advantaged (Alderson and Beckfield 2004).

City closeness centrality (sub-variable 5): the power of the city relative to the more cities its close to. With reference to the star network, city A has greater power in the sense that it is more independent than the others (or, alternatively, in the sense that it can avoid being controlled by others). For resources to pass from city B to city E, they must pass through A. In contrast, city A can directly communicate with B–G. This gives city A in the star network a distinct structural advantage. In the circle network, all actors are equally close and are thus, again, equally advantaged or disadvantaged. City A is adjacent to all other cities whereas B–G are two steps from all other cities (except A) (Alderson and Beckfield 2004).

Clustering (sub-variable 6): aim is to detect groups of nodes with dense connections within the groups and sparse connections between groups. Aim is to detect communities, with two main approaches can be distinguished: on the one hand there is the hierarchical approach in which the nodes are aggregated in a hierarchy of clusters from the discrete partition to the whole network. This approach evaluates the proximity between two nodes through a similarity measure and builds the groups using an agglomerative strategy, like the single linkage algorithm or the complete linkage algorithm (Combe et al 2010).

Based on the sub-variables; indicators were generated using network analysis.

3.3.1.2 "Greening the modern" Environmental footprint: Agglomeration scale measured city sustainability (Dependent variable)

"Greening beyond the modern", while advocating for economic localisation and urban innovation through the promotion of production over trade toward alternative import replacement; calls for an understanding of existing local conditions (environmental footprint) from a social, environmental and economic perspective (Taylor 2013).

Sustainability essentially aims to mediate between societal development and environmental capacity, linked to productivity (toward development) and scarcity respectively. Defined by the Brundtland Report (1987), which defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their needs". The environmental footprint within consciousness around environmental utilisation aims to reflect limits or pressures on the eco-system through the creation of boundaries (Siebert, 1982; Opschoor, 1987).

Micro scale sustainability initiatives in terms of attributes, such as the park prevalence and provision CO2 emissions, safety etc. has provided insight into understanding or benchmarking city sustainability standards and measure its attributional impact on the environment (such environmental footprint)(Taylor 2013). At the same, emphasis on understanding the attributional level has paved the way for the development of localised responses and visions for newly designed cities and the self reliant city(Marcotullio 2001).

These approaches provide ways in which to make cities more equitable and environmentally friendly through the improvement of individual components of the city, preserve natural assets and encourage small decentralised communities. And contribute to city competiveness (Porter 1990), providing the territory where MNC's transplant, they influence decision making in terms of ownership, location and internalised advantages (Dunning's 1997). Local conditions stage of development and quality of resources available to firms influences and is influenced by firm linkages (Porter 1990). The influence of local conditions on the ability of cities to maintain or improve standards of living (Porter 1990)

Therefore, a comprehensive sustainability measure of the agglomeration scale is used. This approach provides for benchmarking and the establishment of a baseline standardised measurement of sustainability; to gage city development in relation to position (Taylor 2013). As well as assist with a road map for policy making, information sharing and community improvement (Mori and Christodoulou 2012).

As highlighted in the literature, while there are many indicators of sustainability or green measures, all do not consider social, environmental and economic factors. The Arcadis sustainable city ranking is one example, at the firm agglomeration scale, it considers the urban economies from the perspective of people, planet and profit, including the network scale with the use of Globalization and World Cities (GAWC), 50 top world cities ranking.

3.3.2 Operationalization of variables

THEORY	VARIABLE	SUB VARIABLE/ INDICATOR	SOURCE

<table>
<tr><td rowspan="5">Adopted from ‘Green network of cities’ (Taylor 2013). Relates sustainability to consideration place bound environmental footprint and “environmental net-prints” and commercial network measures. Embedded in Jacobs (1992) “systems of survival” demonstrated as continual vertical mechanism of economic localisation in conjunction with urban innovation at the macro scale;</td><td rowspan="4">Net-print (Independent)
City role and position in the world city network

Defined within:
Position a result of favoured centrality in web of affiliation (George Simmel 1890, Alderson and Beckfield 2004, Freeman 1979).

Greenfield FDI less volatile in the long term
(Van Staveren 2004)
Cities positionality in the network determined by its firm linkages (Hymer 1972, Castells 1991)

Network Society (Castells 1996, 2004)

New world system geo-morphology (Friedmann 1995, Sassen 2001).

Corporatisation of the world system (Hymer 1972)</td><td><u>Nodal values</u>
Power: outdegree: measurement of ties sent and indication of captured control functions in the world economy. (Perkins and Niemeyer 2004)</td><td rowspan="4">Centrality measures generated from the network analysis

(Data from FDI Markets, Financial Time. Euromonitor International Passport database)</td></tr>
<tr><td>Prestige: indegree: are those cities which are sought out by other cities, have ties directed to them, and are chosen over others. (Porter 1990, competitive advantage)
Prestige (Alderson and Beckfield 2004)</td></tr>
<tr><td>Strength of the cities ties: weighted outdegree and weighted indegree: measure of the weight of total outward and inward domestic investment.
(Hymer 1976)</td></tr>
<tr><td><u>Linkage values:</u>
City brokerage: ability of the city to broker exchanges and thus has the power to coordinate action and to withhold or distort in- formation to its advantage

Closeness centrality: power of the city relative to the more cities its close to.
(Alderson and Beckfield 2004)

Clustering: detect communities (Combe et al 2010)</td></tr>
<tr><td>Environmental footprint (Dependent)</td><td>Micro scale measurement of city sustainability</td><td>Arcadis Top 50 Sustainable Cities Ranking</td></tr>
<tr><td colspan="4">CONTROL VARIABLES</td></tr>
<tr><td>Continental Geographical Location</td><td>Christaller (1933) central location theory: spatially and increasingly functionally. Castells (2000) path dependency.</td><td>Each continent applied a nominal rate</td><td>Africa (1), Latin America (2), Europe (3), North America (4) Middle East(5), Asia and Pacific (6)</td></tr>
<tr><td>Population in relation to land</td><td>Environmental utilisation: Differences between</td><td>Population Density</td><td>Euromonitor International</td></tr>
</table>

	footprints of different income groups (Allen, 2009).	(Total population divided by land area in square kilometres)	Passport database
Environmental utilisation	Limits or pressures on the eco-system, and boundaries, such as ecological footprint (Siebert, 1982; Opschoor, 1987).	Land Area	Euromonitor International Passport database
Risk	Flow of benefits between different capitals relative meeting human needs and quality of life including well functioning social institution etc. (Ekins et al. 2008)	Risk (Crime and Safety)	Numbeo

Figure 4: Operationalization Table

3.4 Research strategy

This next step outlines the strategy of the research. Three main drivers define the appropriateness of a strategy strategy. These include; the objective of the research, in terms of breadth or depth; primary collected date or secondary data collection in the form of desk research; and lastly preference for quantitative or qualitative research.

The objective of this research is to explain the extent of the influence of global integration and city positionality within the network on city sustainability. It aims at producing broad knowledge that represents numerous cities and their interactions. Thus, a global data (FDI markets) set indicative of a large number of study units representing the multiple interactions (?) and city indicators (sustainable benchmarking) is necessary to empirically analysing multicity relations to establish city positionality in the global network (Alderson and Beckfield 2004). On this basis, quantitative analysis was used.

Considering all the mentioned factors, secondary research was the chosen research strategy. This strategy is most appropriate for three reasons; including 1.) analytical generalisation across broader theory, providing an overview, contributing to external validity, 2.) proven to be efficient with large datasets, and 3.) in requiring existing body of statistical data, is ideal for testing and comparing different types of performance indicators; all relevant to the aim of this research (van Thiel 2014).

3.4.1 Data Collection Instruments

Secondary analysis requires existing body of (statistical) data. The selection of this is based on the prior gathering of the necessary literature toward the theoretical framework which form the basis of the existing empirical material collected. An advantage of using existing data is the availability of information, already quantified. Its important that the sources used are reputable in this research, the data was desktop collated from reputable international research organisations databases with access to multi-city private and public information, whose research have been checked for counted risk, validity and reliability (van Thiel 2014).

The data content and source was selected based on the review of applied methods in sustainability measurement and network analysis; including 1.) environmental footprint measurement at the micro scale, using the definition outlined by the United Nations, as per

Brundtland Report (1987), which defines sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their needs" (Arcadis 2015); 2.) world city network (Alderson et al. 2010; Wall and van der Knaap 2006; Leathers and Patrick Raines 2013; Friedmann 1986; Sassen 1991; Sassen 2001) and 3.) similar empirical research related cities positionality in the network determined by its firm linkages (Hymer 1972, Castells 1991); intervening variables which might influence outcomes (van Thiel 2014) related to "guardian and commercial syndrome" (Jacobs 1969; Jacobs 1992; van der Ploeg and Poelhekke 2008; Hennemann and Derudder 2012).

The network data, was formed using network analysis (only once it was prepared to respond to the node and edge requirements of network analysis using excel). Since positionality is understood relationally within a system, social network analysis forms the basis of network analysis because economic action is fundamentally a social phenomenon (Polanyi 1944, Grabher 2006). Network analysis is enabled through the combined theories of Moreno representing agents by point (nodes) connected by lines (edges) and Cartwright and Harary perspective of using graph theory to analyse the sociogram (Combe et al 2010).

The use of statistical computation of indicator descriptions based on nodes and edges assisted in generating the predictive (independent) variable while also providing visualisations of the network. Of the various network analysis software packages available, Gephi was used. Combe et al (2010), in conducting a study on network analysis and functionalities, comparing different software, highlights the advantages of using Gephi. Although there are many other more complex, commercial software with a rich set of functionalities, Gephi's approach to network analysis separates algorithms and the graphical user interface assists with visualizing analysis. The open source philosophy makes it accessible to anyone and the plugin functionality ensures that it's updated frequently. Secondly, Gephi is suitable for computing common indicators required for this research (Combe et al. 2010).

3.4.1 Area of study

The area of study for this research was the net-print of the interdependent world city network in relation to the fate of cities (environmental footprint).

3.4.2 Unit of Study

The unit of study in this research were cities who have been measured for sustainability (environmental footprint). Thus the study units were those cities which have been measured for sustainability by the Arcadis ranking which were 50 cities measured in 2015. And their position in the intercity net-print represented by FDI network between cities, as a marker of the numerous flows of finances, professionals and projects constitute the world city network (Taylor 2012).

3.5 Sample Selection and Size

The sampling procedure intended to provide data that is representative of multiple city intercity relations influence on city agglomeration scale. Because the unit of study needed measured sustainability at the micro scale, requiring a non probability theoretical sampling approach has been taken (Neuman, 2006); including control variables to limit broader interference on the outcome of the research testing analysis (van Thiel 2014).

The sample size was based on the selection of available micro sustainable conditions for dependent variable (Wall and van der Knaap 2006; Taylor 2013; Marcotullio 2001; Jacobs 1992) were represented by the 50 cities as measured for sustainability by Arcadis formed the basis for the sample size. The sample selection was limited to the same period. Since the aim of the research was to provide an overview, embedded in this research method; cross sectional approach was employed in order to do cross tabulation of multiple indicators, within the same period (van Thiel 2014). Thus, the time period and the non probability theoretical sample size guided the data collection of the sample.

In respect of city positionality in the interdependent world city network (independent variable), the centrality measures were identified and generated (based on theory) using network analysis of intercity flows, namely greenfield FDI. This approach is embedded in Jacobs (1992) systems of survival notions of a viable working life needing micro guardian and macro commercial processes of trade. While the world has always been globally integrated, increasing international trade driven by technological advancements have resulted in the the corporatisation of the world structure (Hymer 1972). Increased network of services and information flows between metropolitan regions has seen the development of hierarchy within the network, which is not necessarily a result of the "only" the city themselves (Pred 1977). With the expanding city firm networks driving intercity, cities place in the network of capital flows is represented by its global reach linkages (Berry 1964). Within this, there exists a complimentary centre-periphery model, of connected core and periphery cities at different stages of development. Certain cities better situated than others(Wall and van der Knaap 2006; Alderson et al. 2010); within a new geography of centrality and marginality that cuts across traditional north/south and east/west divides in the world system is restructuring the map of the world city system and the map of the world system (Sassen 1991; Alderson et al. 2004; Leathers and Patrick Raines 2013; Friedmann 1986).

- The selection of greenfield FDI is due to the following theory; since the numerous flows of finances, professionals and projects constitute the world city network; city position in the network is determined by its firm linkages, the relationship between source and destination cities ((Taylor 2013)Hymer 1972, Castells 1991). Therefore, FDI represents the flows of capital between firms and intercity relations and greenfield FDI specifically used because it reinforces integration and considered more sustainable for being less volatile in the long term (Van Staveren 2004).

- A 2014 sample of total and sectorally differentiated inward and outward FDI was selected from a 120 city sample obtained from FDI markets database linked to the financial times. Inward and outward FDI, as both are required to establish positionality and centrality in the network. Based on world city network and social network analysis theory, position is the result of favoured centrality in a web of affiliation (George Simmel 1890), increased exchanges and its type translate into being more favourable, which includes both nodal (inward and outward) and linkage descriptor types to generate the network sample selected to represent the position (centrality) within the network:

    - The descriptors at the nodal level provide information on the strategic positioning of the node in the network or highlighting those that take an important part in communication such as bridges or hubs. The nodal place in the network is generated using measures based on vertex scoring to determine the measure of the centrality of a vertex to determine its relative importance within a graph (Combe et al 2010). The nodal values concern the directional and weighted measures of the exchange

(vertices). Including the previously mentioned inward and outward flows. Directional outward (outdegree) and inward(indegree) measure related to the power and prestige of the city respectively. Weighted inward (weighted indegree) and outward (weighted outdegree) measures relates to the strength of city ties.

  - The descriptors at the network level describes the proportion of nodes versus edges or to evaluate properties of the graph like the randomness or small world distributions. Linkage values are derived from the linkage structure of the network are more sophisticated measures; based on a dichotomized matrix of binary (0 and 1) values, and do not possess any directionality. They include Betweenness and Closeness. (reference). An additional measure includes clustering which evaluates the proximity between two nodes through a similarity measure.

- The inclusion of a selected sample of sectorally differentiate (manufacturing, hi-tech, service, resources) FDI is linked to perspectives on a new morphology of centrality and marginality in the network (Sassen 1991, 2001; Friedmann 1982, 1986). And by implication spatial hierarchies and organisations of core and periphery cities with varying degree of strength of ties (Cerny 1991); articulated as service orientated cities in the developed world, a higher share of manufacturing cities in the developing middle-income world; and informal-economy cities, in the least-developed countries weakly connected to global networks (Friedmann and Wolff 1982) and a significant portion of territory which over time is increasingly excluded from global economic processes.

The selection of control variables sample was embedded in theory and the use of previous similar studies on firm and global processes and FDI including VCC and WAIPA (2010), Lopez et al. (2007), Voica and Haralambie (2015) have been used to establish which control variables need to be used.

As previously outlined the variables selected relate to firstly the three pillars of sustainability and their relevance for FDI and secondly to city administration in the form of an institutional variable which is GVA Public Administration, and indicator of public spend relative to private investment. All the variables relate to the city level. The following selected sample of control variables were included;

Firstly, the standard variables included for testing the influence of investment into cities are land area and population (total population). Blewitt (2008) and Partridge (2005) highlight the people and power component linked to social sustainability; and the corresponding link to policy and public service.

Secondly, socio-economic variable relates broadly to accessibility in terms economic and physical access, variables used includes employment (population and rate). Corresponding to the one; with reference to Dunning's (1997) OLI paradigm of ownership advantages (O), location advantages (L) and internalising advantage (I); the guardianship (Jacobs 1992) conditions established contributes to the decisions around beneficiation of international trade over localised production (Staveren 2004; Taylor 2013). The implication of making cities attractive to private capital in relation to public spend (Campbell and Fainstein 2003; Scott and Storper 2015; Campbell 1996); in terms of gross domestic product purchasing power (GDP PPP) and unemployment rate; linked to the host country ability to serve local market by local production and propensity of the local market (Demirhan and Masca 2008; Wang and Wong 2009).

Lastly, variables related to the environment besides land area but related includes Gross Value Add (GVA) Mining making reference to resource extraction. linked to notions of global division of labour and the morphology of core and periphery cities (Swilling 2012; Sassen 2001; Brenner 2014; Friedmann 1986).

3.6 Data collection

The micro sustainable conditions, environmental footprint was collated from the Arcadis Top 50 Sustainable Cities Ranking (reputable organization with extensive experience in research, having already conducted agglomeration scale analysis on city sustainability), using this definition as outlined by the United Nations, developed a measure of single aspects of urban performance which relate to people, planet, profit which correspond to the three dimensions of sustainability – social, environmental and economic.

As already noted, Greenfield FDI for the period of 2014 was extracted from the FDI markets (a crossborder investment monitor which tracks crossborder greenfield investment across all sectors and countries administered by the Financial Time database linked to the financial times) of 120 cities. This included sectorally categorised data of manufacturing, hi-tech, services and resources. The total count of 4118 exchanges were then arranged into inward and outward investments (all sectors) for the base sample cities as per the Arcadis 50 cities sustainably ranked. For the purposes of this analysis, the weight or rather the sum (instead of count) of the capital investment for each city to city interaction was used.

Since knowing the extent of inward and outward FDI is insufficient to understanding the city to city interactions and city positionality in the network, the independent variable; global integration had to be generated from the FDI exchanges which included 1261 exchanges between the sample cities previously highlighted; using network analysis software (Gephi). The network values generated include based on the main research question and sub research questions; city power (outdegree) and prestige (indegree), strength of city ties (weighted outdegree and weighted indegree) and 3.) City centrality measures (brokerage (betweenness), closeness) and clustering.

These needed then to be taken into Gephi, the network analysis computer programme to generate the network indicators (independent variable). The nodal value in the network is generated or described using measures based on vertex scoring, including centrality measures which determine its relative importance within a graph. Therefore, the nodal values relating to the directional and weighted measures of the exchange (vertices), was established measuring degree centrality which emphasises nodes with high degrees; including (Combe et al 2010):

a. Incoming degree of a vertex: in relation to prestige of the city and strength of city ties. Graph defined below:

$$\mathbf{N_{+}(v) = |\{i\ 2\ V : (i, v)\ 2\ E(G)\}|}$$

b. Outgoing degree of a vertex: related to power of the city and strength of city ties. Graph defined below:

$$\mathbf{N_{-}(v) = |\{i\ 2\ V : (v, i)\ 2\ E(G)\}|}$$

The linkage value in the network is generated using measures based on edge scoring, derived from the linkage structure of the network are more sophisticated measures; based on a dichotomized matrix of binary (0 and 1) values, and do not possess any directionality (Alderson and Beckfield 2004). The following edge scoring measures were established:

a. Closeness centrality; for connected graphs; is the inverse of the average distance to all other nodes. Defined below as:

$$\mathbf{CC(v)} = \frac{\mathbf{V\,|\,-\,1}}{\mathbf{Pu2V, u6 = v\ d(v, u)}}$$

b. Betweenness centrality; is the measure of a vertex within a graph. Vertices that occur on many shortest paths between other vertices have higher betweenness than those that do not. An improved implementation of this indicator has been proposed by Ulrik Brandes with a running time of O(|V |.|E|). The betweenness of vertex u is defined by:

$$\mathbf{BC(v)} = \sum_{\mathbf{(u,w)2V \times V, u6=w, u6=v, w6=v}} \frac{\mathbf{\sigma\_uw(v)}}{\mathbf{\sigma\_uw}}$$

An additional measure clustering which evaluates the proximity between two nodes through a similarity measure and builds the groups using an agglomerative strategy, like the single linkage algorithm or the complete linkage algorithm (Combe et al 2010).

a. Clustering or community, unlike the vertex and edge scoring, expresses similarities between nodes and graphs. The aim of clustering is to detect groups of nodes with dense connections within the groups and sparse connections between groups. And communities, with two main approaches can be distinguished: on the one hand there is the hierarchical approach in which the nodes are aggregated in a hierarchy of clusters from the discrete partition to the whole network.

The control variables were taken from the Euromata International Passport database, a global research database providing statistics, analysis, reports and surveys.

3.7 Validity and Reliability

3.7.1 Validity

This selected research methodology aims for an overview of the subject and the ability to generalized the finding, therefore external validity (Neuman 2006). It thus depends on how representative the sample is (Verschuren and Doorewaard 2010). While the base sample of city units were limited to the measure ranked 50 cities, the multitude of FDI intercity exchanges provided a yield in order to generalise. The use of ordinal data allows in line with the research strategy allows for a relative generalizable outcome. While the use of the ranking means the dependent variable uses an ordinal scale, which is could influence the construct validity, the use of statistical techniques that take into consideration the specifics of ordinal data to focus the central tendencies and significance allowed for validity(van Thiel 2014).

3.7.2 Reliability

Reliability means the dependability of the measurement method, which means the numerical results produced by an indicator do no waiver due to the characteristics of the measurement instrument(Verschuren and Doorewaard 2010). This research approach reliability hinges on on 1.) clearly conceptualised constructs, 2.) precise level of measurement, 3.) multiple indicators and 4.) pilot tests (Neuman 2006, p.191).

The constructed concepts refer to quantifiable indicators (van Thiel 2014), obtained from reputable sources embedded in literature of a similar nature (Wall and van der Knaap 2006; Alderson et al. 2010). The quantity of indicators for the independent variable ensured standardization and the precision of the computer software used ensured precision of measurement. Control variables influencing city sustainability as taken from Passport and Numbeo database contributes to a more precise level of measurement with increased equivalence reliability and consistency across different variables in the cross sectional model (Neuman 2006).

In order to ensure that there were no sampling errors, the theoretically selected data construct was statistically pre-tested for deviation and miss specification (Neuman, 2006), resulting in a final sample size of 30 cities.

3.8 Data Analysis Methods

The quantitative data collected, organised in excel and entered into STATA, a data analysis and statistical software to test the relationship between global integration and city sustainability, as previously mentioned in the research strategy. The ordinary least squares (OLS) model has been used to test the linearity and estimate the maximum likelihood of the relationship. The relationship was tested and analysed according to the initial guiding sub questions in order to ultimately respond appropriately to the main question. Network analysis of city positionality to generate network indicator; was conducted using Gephi, a graphic data programme.

The sustainable city rankings were computed for each city (excel). The quantified greenfield FDI data was arranged according to inward and outward investments pertaining to the cities as measured by Arcadis, organised into edges (links, investment) and nodes (city, geolocation). These were then taken into Gephi, network analysis software for generating the network position indicators. Once the network indicators were established, they were reorganised (in excel) with city sustainability measures in preparation for statistical analysis.

Once the dependent variable; sustainable ranking, the independent variables were calculated from Gephi and the control variables collated from the Euromonitor passport and Numbeo database was tabulated, it was taken through a series of pre-test assumptions tests to verify data and ensure the outcome or results of the OLS regression are not misleading.

1. Multicollinearity was checked to establish if the predictors were highly collinear, linear (a variable should not be linear function of another) related can cause issues in estimating the regression coefficients.

2. Homogeneity was check for homoscedasticity which implies that the error variance across data is constant. Testing covariance, the assumption is that the variance in the residuals has to be homoscedastic or constant. The results of the tests based on the fact

that the results are not significant (Prob>chi2=0.5165) indicates that the null hypothesis is not rejected and the residuals are homoscedastic.

3. Normality was checked to establish if the errors are normally distributed. Testing the normality of the data, the assumption is that the residuals behave 'normal'. The test involves checking residuals 'e', which is the differences between the observed value (y) and the predicted values (yhat) e=y=yhat.

4. Linearity was checked to establish if the relationship between the predictor and outcome variables are linear. Testing the linearity of the data. The assumption is that the relationship between the dependent variable (y) and the independent (x) is linear. When checking the linearity using two-way scatter plot and a histogram of the variables, all of the independent variables besides closeness centrality and the control variables were skewed, see below histogram.

5. Model specification was tested to establish the inclusion or exclusion of relevant or irrelevant variables in the model. Testing the model specification; the assumption is that the error term and the independent variables in the model are not correlated. The results of the test did not come up significant (Prob.F=0.2760) indicating that the model is not incorrect and has no omitted variables.

6. Lastly, a test was conducted to check for influential data or outliers which may exert undue influence on the coefficients. In order to draw conclusions across the sub-research questions, it was important for all tests to have the same base variables.

An indication of significance was represented by the P value of less than 0.5.

Chapter 4: Research Findings

4.1 Introduction

The chapter presents the research findings of the quantitative secondary data analysis approach as described in the previous chapter. It unfolds with firstly a description of the research areas variables and considerations. Section 4.1) briefly describes the case 4.2) describes the resultant dependent, independent and control variables operationalized in the previous chapter; and Section 4.3) is where the measured variables are tested using statistical analysis and network analysis to answer the sub research questions and main research question.

4.2 Description of the case

The research is based on 1261 inward and outward 2014 greenfield FDI exchanges between the previously specified 50 sustainably measure cities. The objective of this research is to provide knowledge which will be beneficial in developing solutions towards city sustainability by explaining the influence of global integration, from the perspective of city positionality in the network on urban sustainability.

The research strategy employed secondary desktop data collation of Greenfield FDI, sustainability measures and network position variables generated using network analysis. The development of the independent variables involved, as previously mentioned the collation of FDI (2014) data from the FDI markets pool of 120 cities. However, of the data obtained, a

portion of the investments were missing source cities. Once the FDI data was collated, it was cleaned and organized to include only 2014 investments and prioritize inward and outward FDI which relates to the 50 sustainably ranked cities. Since there were missing variables for some of the cities, the observations while conducting regressions were reduced.

The total count of 4118 exchanges were then arranged into inward and outward investments (all sectors) for the base sample cities as per the Arcadis 50 cities sustainably ranked. For the purposes of this analysis, the weight or rather the sum (instead of count) of the capital investment for each city to city interaction was used. The centrality measure was generated within the network of 1.) total Greenfield FDI data breakdown including 2.) Hi-tech, 3.) Manufacturing, 4.) Resources, 5.) Services).

4.3 Data collection results (description of the variables)

This section provides a detailed description of how each of the variables (sustainability, global integration and control) were generated and key findings/interpretations and trends presented in the form of descriptive charts and tables.

4.3.1 Dependent Variable

As previously mentioned, the Arcadis Sustainable ranking of 50 world cities, measured in 2015 has been used. The 50 cities cover 31 countries and were selected to demonstrate wide-geographical coverage, variety of economic conditions and sustainability challenges. The ranking covers a detailed evidence based metric headlined by the three categories of sustainability namely, people (social), planet (ecological) and profit (economic). This basis is rooted in the UN sustainable development definition of "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"(Brundtland 1987). The sub-indices or breakdown of sustainability relates to the following:

- People: "Measures social performance and quality of life: including transport infrastructure, health, education, income inequality, work-life balance, the dependency ratio and green spaces within cities".
- Planet: "Captures environmental factors like energy emissions and pollution: including city energy consumption and renewable energy share, recycling rates, greenhouse gas emissions, natural catastrophe risk, drinking water, sanitation and air pollution".
- Profit: "Assess business environment and economic performance: including performance from a business perspective, combining measures of transport infrastructure (rail, air, other public transport and commuting time), ease of doing business, the city's importance in global economic networks, property and living costs, GDP per capita and energy efficiency".

Broadly, the results of the Arcadis ranking indicates that European cities dominate the top ten sustainable cities with Frankfurt scoring high for planet and profit due to unfavourable population dependency in terms of the ratio of non-working age to work age population; and London scoring high for profit and people with good health and high education outcomes. Three Asian cities make the top ten including Seoul, Hong Kong and Singapore.

At the same time some of the least performing cities are the fastest growing cities including Jakarta, Manila, Mumbai, Wuhan and New Delhi. Included in this group, in the bottom 10 are three middle eastern cities, namely Doha, Jeddah and Riyadh; as well as Moscow and Nairobi.

At the same time there are cities who score are completely unbalanced, such as Doha scoring high for profit but at the other spectrum for people and planet. Rio de Janeiro and Sao Paulo score high for planet but low comparatively for people and profit. While these cases present a clearer way forward for improvements, they also prove to sensitivity to changing economic conditions and environmental policy.

Interestingly the results of the report from which the ranking measures were retrieved highlight that across the world cities are performing better for profit and planet sustainability but failing with people sustainability. Trade offs between planet and profit are seen largely in the middle east with Doha and Dubai; the gap between their profit and planet ranking quite wide. Rotterdam score high for people ranking. Top performing profit cities like, New York, Paris and London ranking are brought down by their souring unaffordability. And German cities leading the way in terms of planet sustainability(Arcadis 2015).

A brief over of the scored sub-index present the following:

- People: refers to the interaction between the city and its people, with nine sub indicators. The top 10 for this index are found within Europe with almost all having good public transport infrastructure for commuting. Rotterdam which scores the highest has good public transport, affordable property prices and relatively low hours worked; so better work-life balance. Rotterdam also has an ambitious sustainability plan with an allocated spend required. This plan is complimented by the Rotterdam Climate Initiative (a public private partnership) which aims at 50% CO2 reduction by 2025. Two Asian cities appear in the top 10 for green spaces, quality education and long life expectancy. Scores brought down by the general Asian phenomenon of long working hours. At the other end of the spectrum, cities scored well in terms of relative price of property however this was offset by poor infrastructure, education and health.

- Planet: “looks at resource consumption, resource disposal and risk of exposure to natural disasters”. The top ten in this index is made up mostly of European cities, with the exception of Toronto and Singapore. US cities generally fair poorly in this category, with high energy requirement and proportionally low renewable energy alternatives. Middle eastern cities fair low in renewable energy. Spain and Denmark are leaders in Europe for renewable energy. In terms of natural catastrophes; Los Angeles and San Francisco score the lowest; European and middle eastern cities the highest. In terms of air quality; Middle eastern cities, Nairobi and Chinese are the worst performers due to manufacturing industries. Green house gas emission is lowest in some developing cities, such as Nairobi, Sao Paulo, and Manila; and highest in the Middle East and US due to high automobile usage. As for environmental waste management; Berlin, Frankfurt and Brussels score the highest and Latin American cities such as Sao Paulo score the lowest.

- Profit: measuring economic sustainability, the cost of doing business as measured by the cost of living and property. Frankfurt, London and Hong Kong are the top performers in this index. Shanghai’s score is influenced by per capita GDP, energy efficiency and ease of doing business. Sao Paulo similarly for poor transportation, ease of doing business and low GDP per head. In terms of energy efficiency; energy to GDP ratio, the US and Europe are the leaders with Copenhagen the top performer. In terms of ease of business which relates to setting up business, contracts and ease of trading; Singapore is the leader with Hong Kong, Denmark and South Korea; Cities in India, Singapore and Brazil score the lowest. Lastly, global importance based on prevalence of advanced producer service firms are led by London and New York.

It must be noted, that while many of the top performing cities appear to be from Europe, the choice of cities to be ranked and the make up of the indicators as a result of international standards led by global north organisations are also contributing factors toward the outcome.

Since the ranking considers the most sustainable as 1 descending to 50, and the statistical program used considers degree of importance in ascending order, the values for sustainability were inverted. Although the initial count of cities was 50, limitations of the obtainable data for the independent variables and control variables lowered the number to 46.

See below table of cities used eventually. Keep in mind, as indicated in Chapter 3, the selection of sustainably ranked cities includes the selection from a pool of cities already considered to be global cities and highly connected in the global network. Tying into the purpose of this study which is understand the influence of the degree or extent of city positionality in the network influence on city sustainability. See table below for the list of cities and their overall ranking.

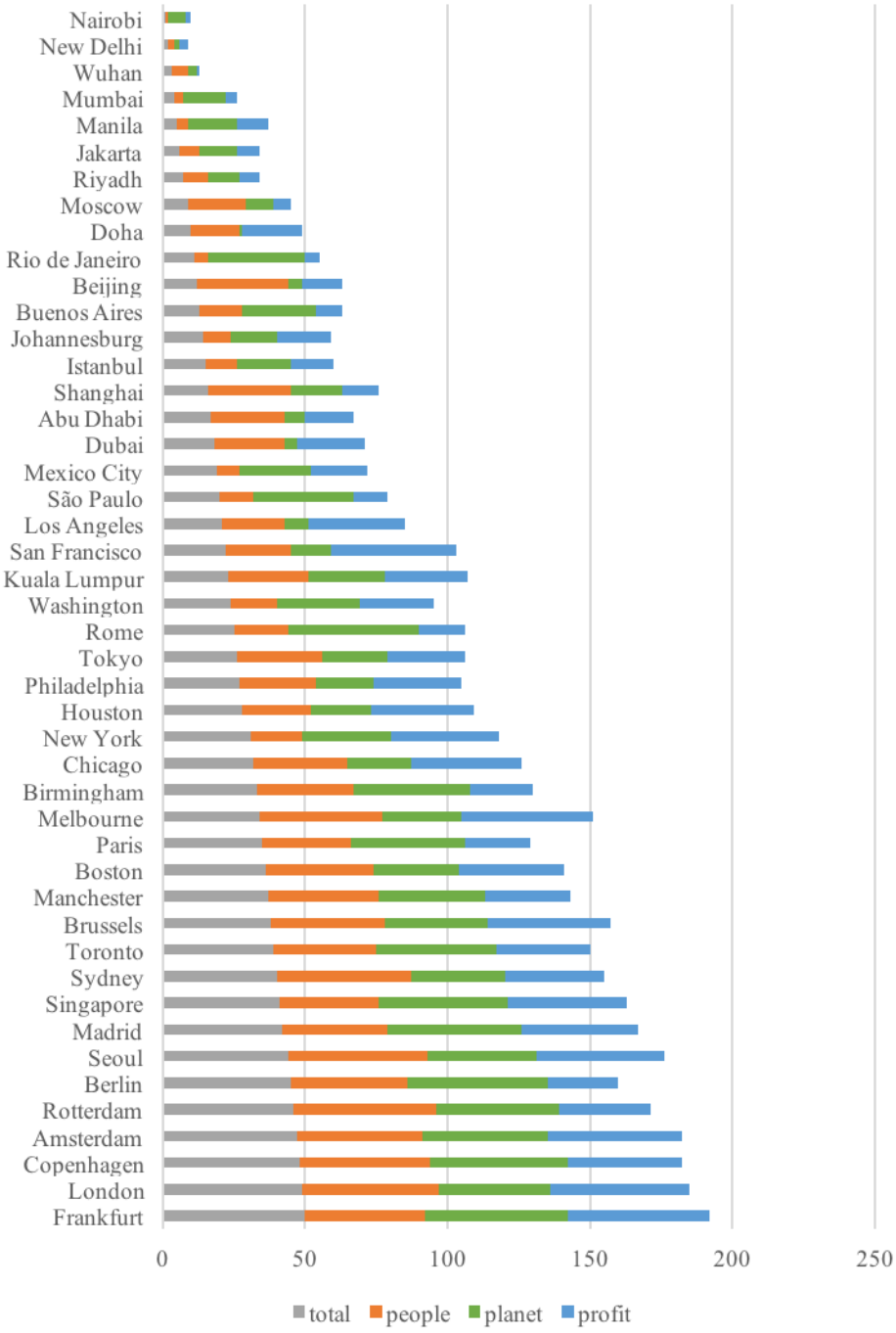


Figure 5: Final list of Sustainable Cities (Arcadis 2015)

The chart above demonstrates the least to the most sustainably ranked cities in grey, as per Arcadis 2015 ranking; followed by the proportional focus of the cities between the sub-indices of people, planet and profit. Of the top 10, while most seem to be focusing more or less equal measure between sub-indices, Berlin stands out for being more focused the least on profit between, prioritising people and planet; Sydney has a high people focus, and Singapore, less on people and more planet and profit.

The bottom ten on the other hand, generally focuses less on people and more profit and planet, except for Beijing and Moscow. The bottom 10 has more uneven distribution; highlighted by Manila, Mumbai and Nairobi which all focus more on planet, then profit then people. This is

interesting, because these are also the cities with the higher current future expected population numbers. The chart below demonstrates comparatively the population numbers of 2010 (Series 1, blue) and the projects population numbers in 2030 (Series 2, orange)(Arcadis 2015).

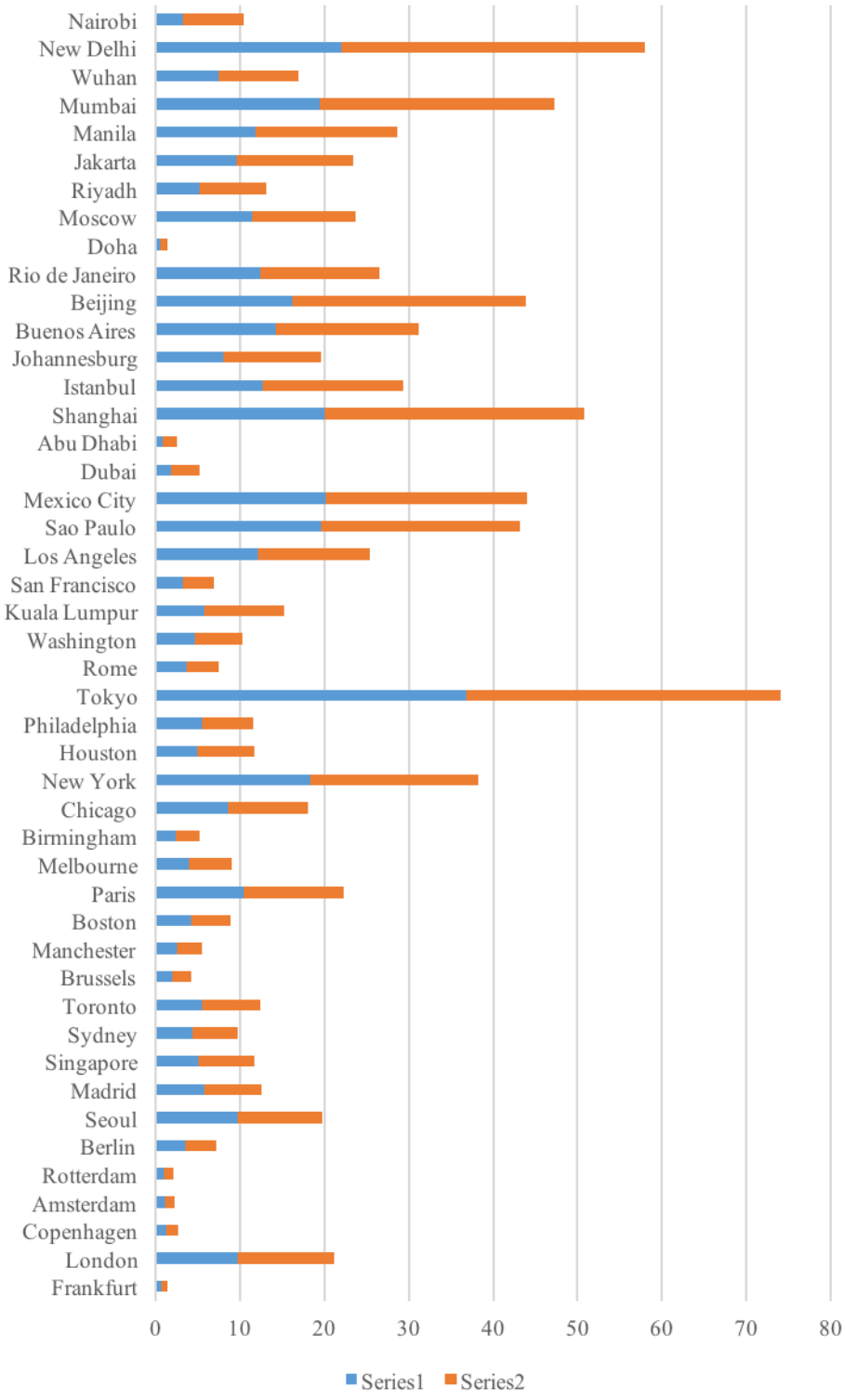


Figure 6: population numbers 2010 (Series 1, blue) and projected numbers in 2030 (Series 2, orange)(Arcadis 2015)

The below map demonstrates the distribution of more connect cities which is significant to understand in terms of population growth distribution. Looking at the map in relation to the population urbanisation patterns distributed geographically demonstrates the spatial disarticulation and morphology as intimated by (Friedmann 1995, Sassen 2001); articulating the new international division of labour. Service orientated cities in the developed world, a higher share of manufacturing cities in the developing middle-income world; and informal-economy cities, in the least-developed countries weakly connected to global networks (Friedmann and Wolff 1982).

Figure 7: Map demonstrating geographic distribution (generated by author using Gephi)

4.3.2 'Greening the modern' City positionality in the Network (Independent Variable)

Position in the network is defined as centrality in relation to structured favourability in the network (Alderson and Beckfield 2004, Freeman 1979); increased exchanges translate into being more favourable. Premised on the notion that cities exist within systems, its position is therefore a result of its web of affiliation (George Simmel 1890). The affiliations or exchanges are made up of nodal and linkage values; including 1.) directional and weighted measures of the exchange (vertices) which related to the node; these incorporate outward (outdegree) and inward(indegree) measure related to the power and prestige of the city respectively; and 2.) Linkage values are derived from the linkage structure of the network are more sophisticated measures; based on a dichotomized matrix of binary (0 and 1) values, and do not possess any directionality. They include Betweenness and Closeness. And an additional measure includes clustering which evaluates the proximity between two nodes through a similarity measure (Combe et al. 2010).

These values were generated using network analysis, which incorporate the principals of social network theory; forms the basis of network analysis because economic action is fundamentally a social phenomenon (Polanyi 1944). Since the aim of the research is to look at position in relation to the patterns of economic trade regarded to be inherently a social phenomenon; centrality measures are looked at in web of intercity investments and the sectors the include. Thus, the following demonstrates the results of the network analysis in relation to the total greenfield FDI and the sectors of manufacturing, services, resources and hi-tech.

4.2.2.1 Network Indicators: Total Greenfield FDI

Positionality in the Total FDI network broadly demonstrates the following; London scores almost evenly across strength of ties and brokerage. More sustainable cities generally have high strength of city ties, as well as brokerage. Less sustainable cities are less evenly distributed.

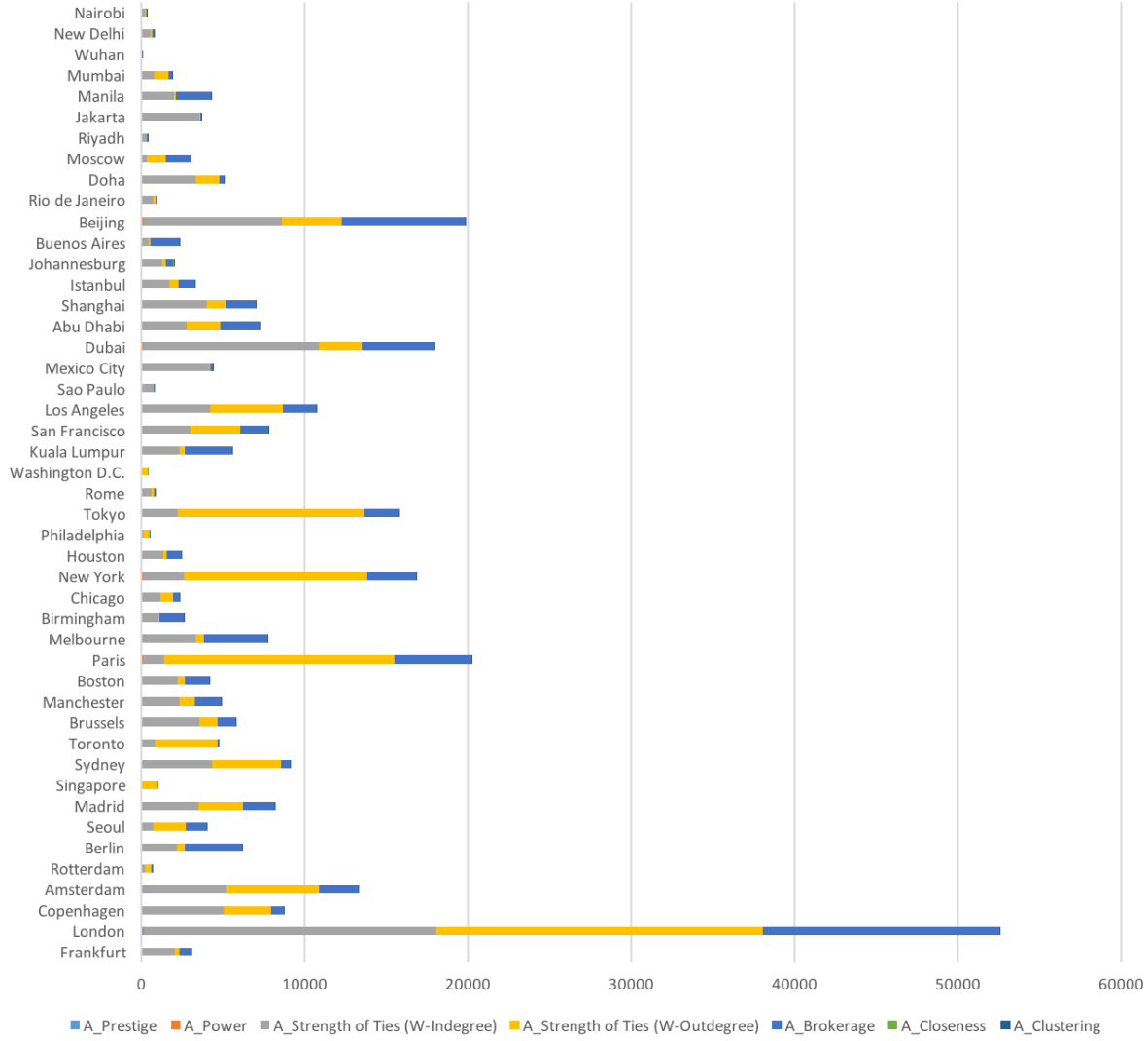


Figure 8: Network Position Indicators: Total Greenfield FDI (Author, 2016)

4.2.2.2 Network Indicators: Sector: Hi-tech Greenfield FDI

Within the Hi-tech sector, more sustainable cities are less evenly distributed, scoring higher for strength of cities ties weighted outdegree; and less sustainable cities scoring higher for strength of city ties weighted indegree. Brokerage is less prevalent; most significant for London, Sydney, Paris and San Francisco.

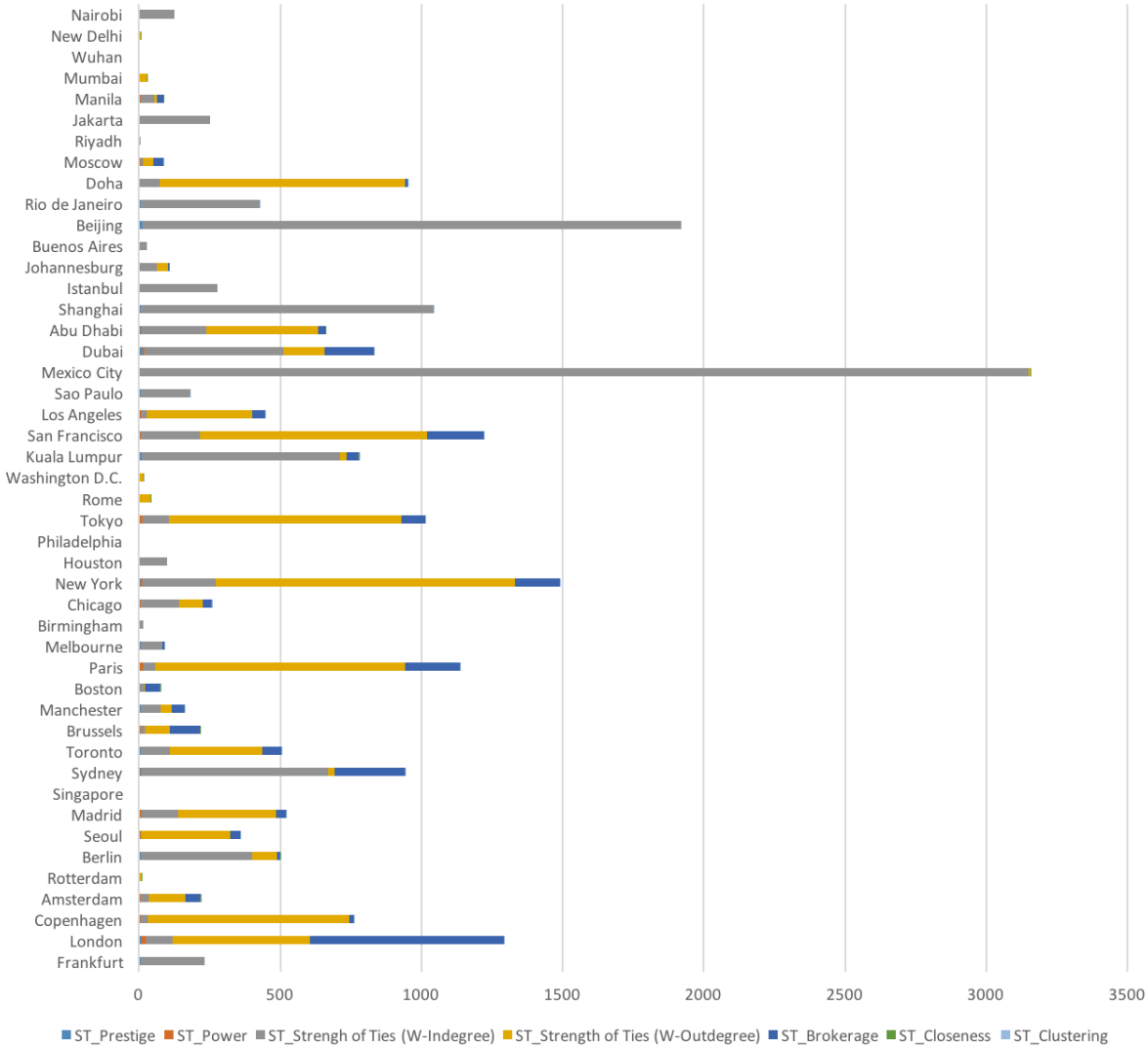


Figure 9: Network Position Indicators: Hi-tech sector (Author, 2016)

4.2.2.3 Network Indicators: Sector: Manufacturing

For the manufacturing sector, brokerage is more prevalent in the outcomes, strength of city ties weighted indegree and then strength of city ties weighted outdegree.

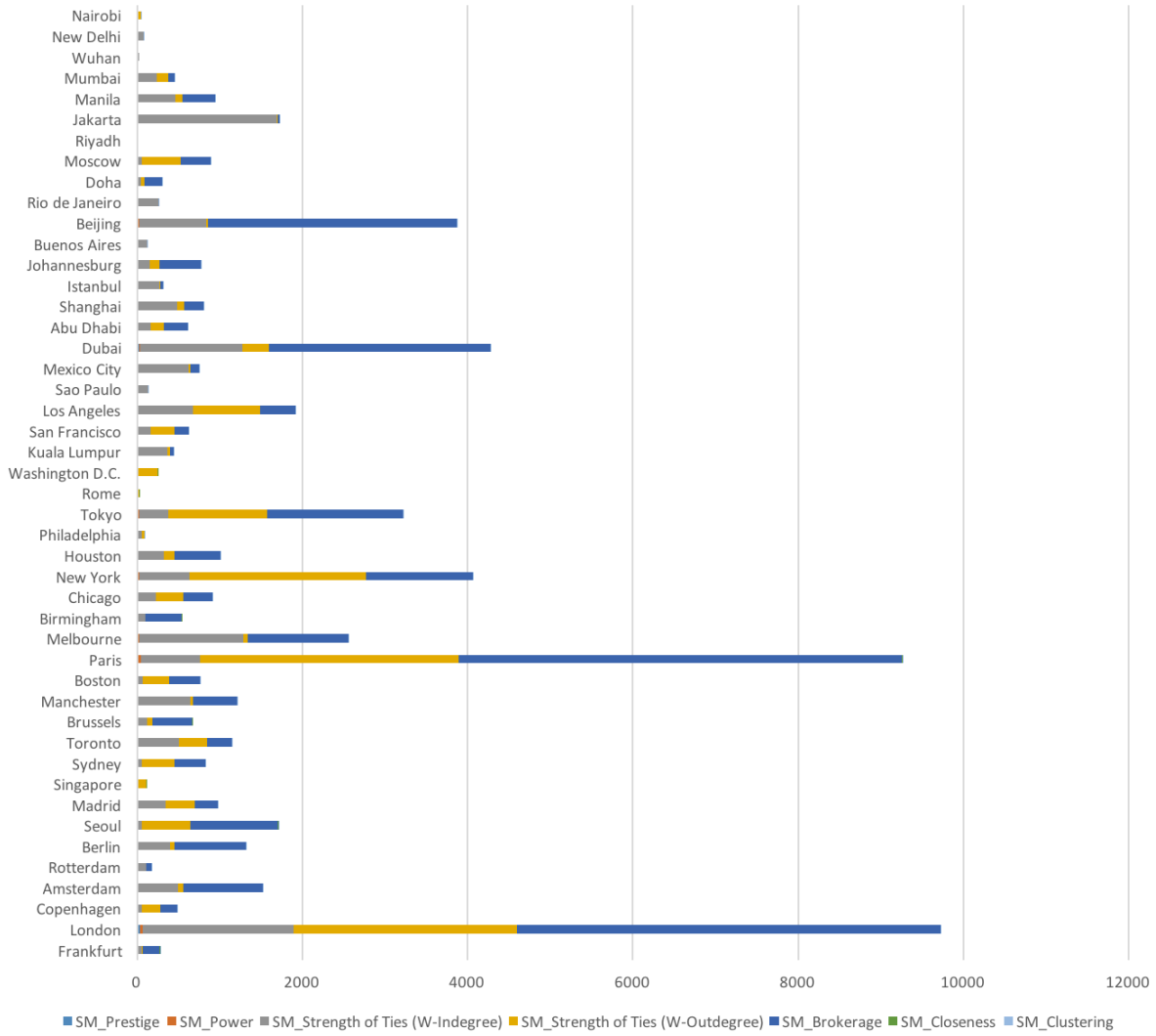
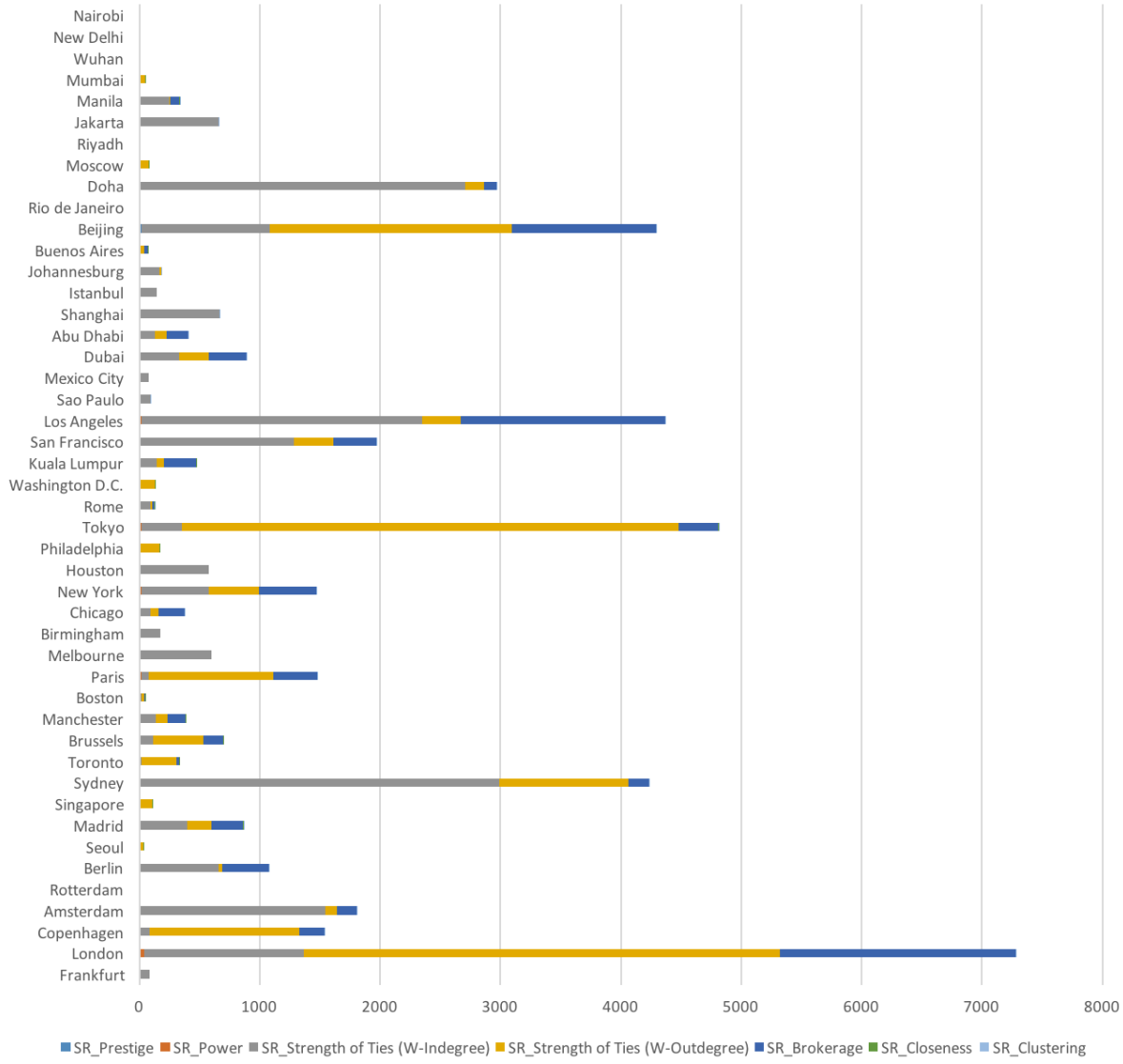


Figure 10: Network Position Indicators: Manufacturing (Author, 2016)

4.2.2.4 Network Indicators: Sector: Resources

In the resources sector, brokerage is less prevalent; strength of ties weighted outdegree is most prevalent across the board followed by strength of city ties weighted indegree.



4.2.2.5 Network Indicators: Sector: Services

In terms of the services sector; positionality is dominated by strength of city ties weighted indegree and outdegree. Less sustainable cities with higher brokerage in comparison to more sustainable cities with higher strength of city ties.

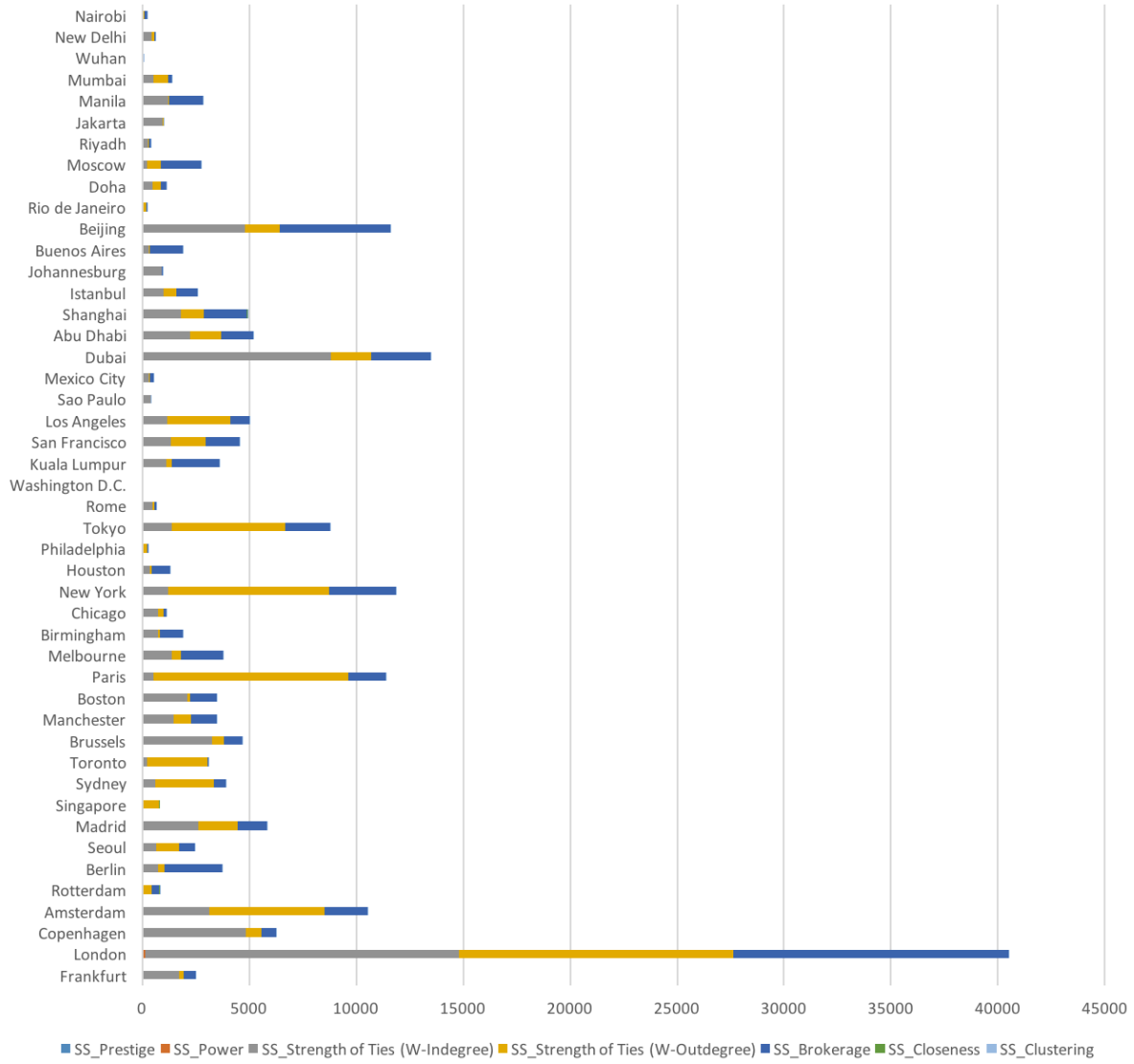


Figure 11: Network Position Indicators: Services sector (Author, 2016)

4.2.2.6 Network Indicators: Across all sectors: Top and Bottom 10

Across the sector the top 10 sustainable cities demonstrated with the warm red to yellow colours dominating. The sectors, hierarchy is ordered in the following way; 1.) services, 2.) Resources, 3.) Manufacturing, 4.) Hi-tech. The measures most dominant with, are strength of city ties in services, resources and hi-tech, followed by brokerage in manufacturing.

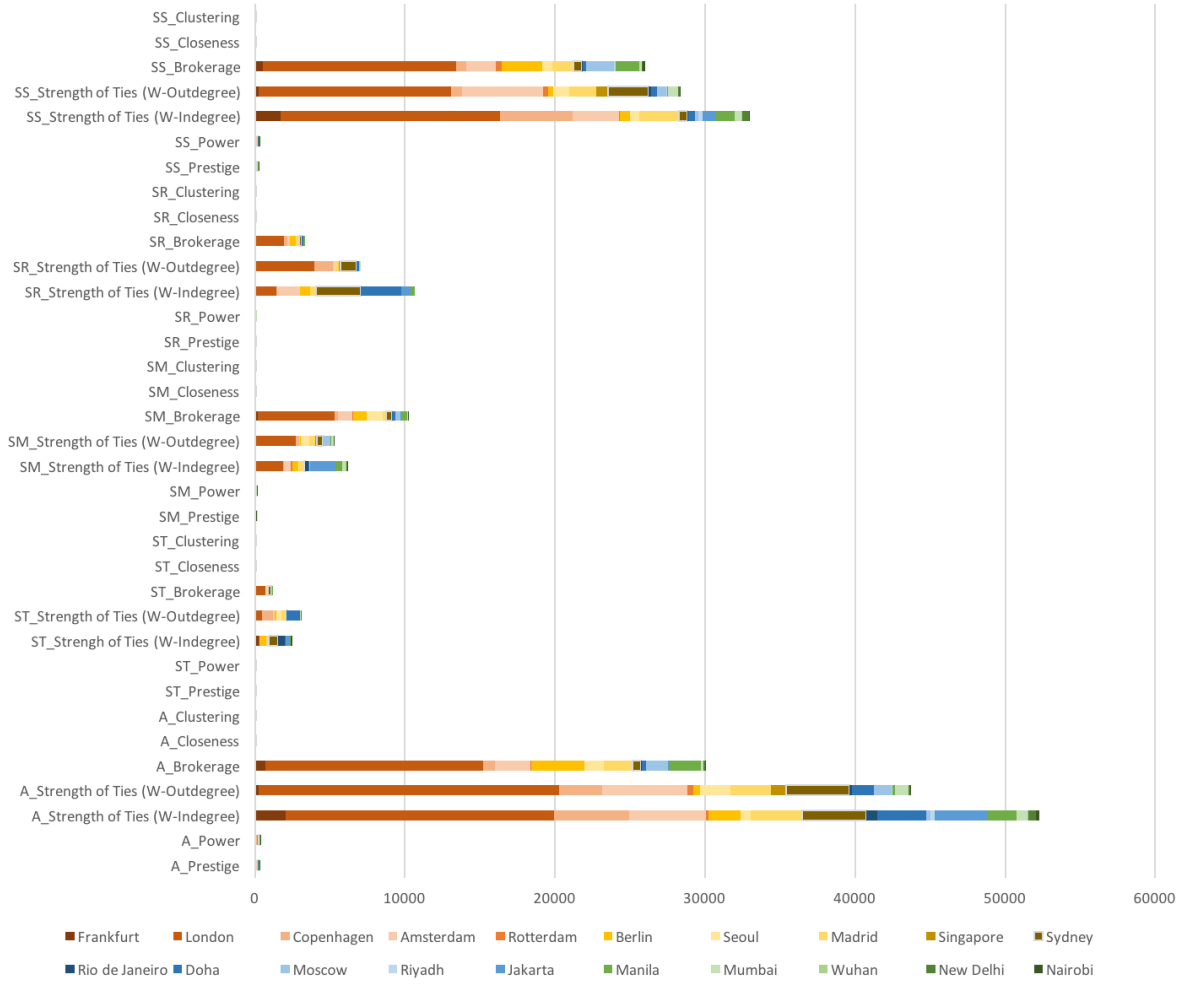


Figure 12: Network Position Indicators: Across all sectors: Top and Bottom 10

4.3.3 Control Variables

The control variables were defined based on theory and the use of previous similar studies on firm and global processes and FDI including amongst others VCC and WAIPA (2010), Lopez et al. (2007), Voica and Haralambie (2015). As previously outlined the variables selected relate to firstly the three pillars of sustainability and their relevance for FDI and secondly to city administration. Thus, five influential variables were included; namely GVA Public Administration in terms of the role of people and power linked to policy and public service influence on sustainability (Blewitt 2008, Partridge 2005); which leads to the incorporation of population numbers and land area (Brenner 2014). Socio-economic variables of employment and GDP PPP linked to Dunning's (2000) OLI paradigm, amongst others and the host country ability to serve local market by local production and propensity of the local market (Demirhan and Masca 2008; Wang and Wong 2009). Lastly, variables related to the environment besides land area but related includes Gross Value Add (GVA) Mining making reference to resource extraction, linked to notions of global division of labour and the morphology of core and periphery cities (Swilling 2012; Sassen 2001; Brenner 2014; Friedmann 1986).

Thus, the control variables for the cities are indicated below demonstrating their proportional relationship to intra-city conditions and intercity relations.

Within the control variables, it was noted that the more sustainable cities have higher proportion of GVA public administration in the comparison to cities in the bottom 10, which also fair proportionally higher for population.

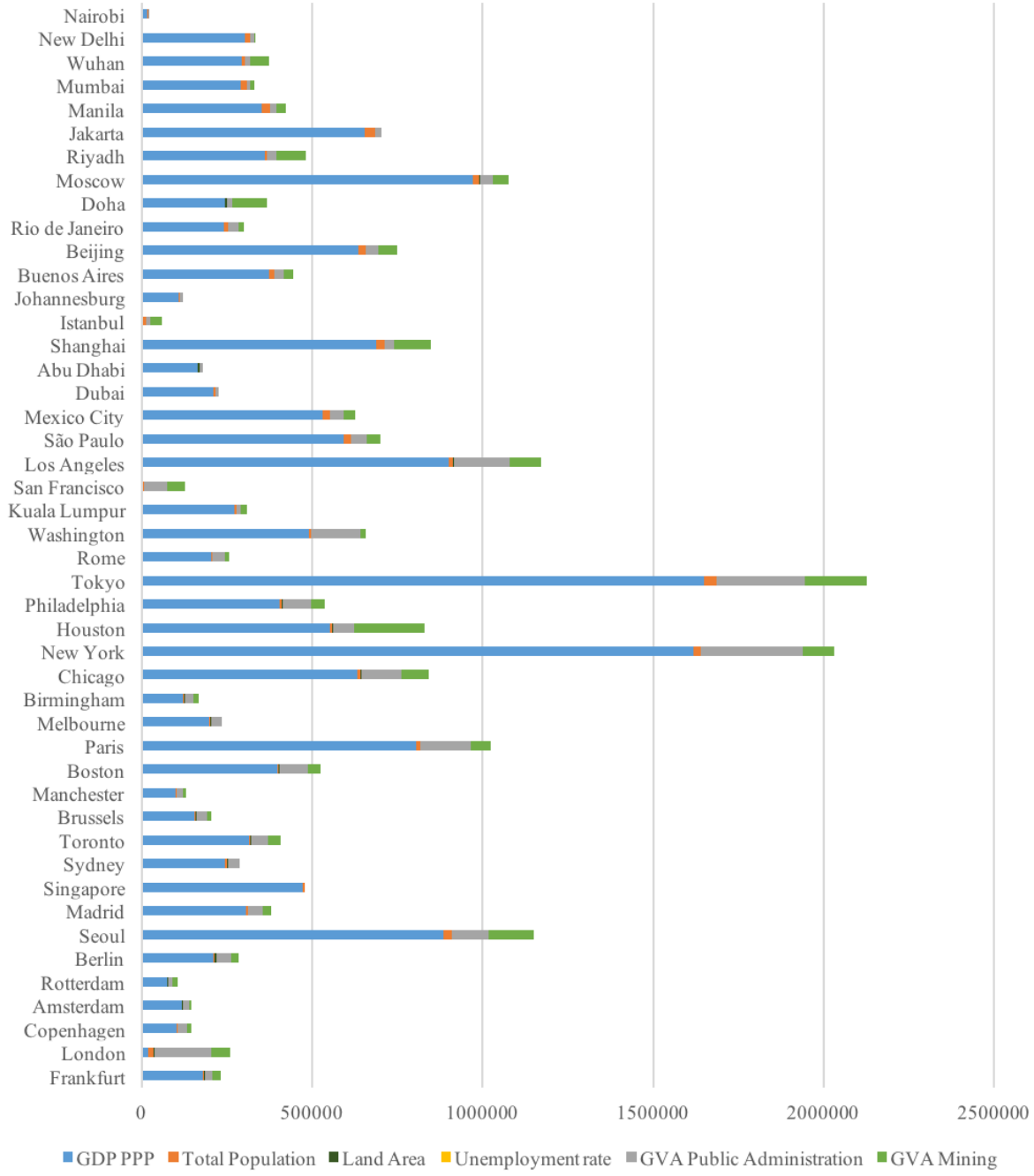


Figure 13: Control Variables (Author, 2016 adopted from Passport database)

4.4 Data analysis

In this section; the variables collated and generated of the previous section; specifically, each indicator of the sub-variables of positionality in the network was tested against sustainability, employing OLS regression to examine the influence of each element on sustainability.

Whereas its been established that both nodal and linkage type values of exchange need to be incorporates in established positionality, or rather centrality, due to the different make up of these values(Combe et al. 2010), the first few statistical tests, separate the analysis of nodal and linkage values.

Prior to analysis, as previously prescribed the data was tested to ensure construct validity (van Thiel 2014); and ensure the outcome or results of the OLS regression are not misleading. The data was checked for multicollinearity; the data was thereby treated for highly collinear predictors. The test for homogeneity indicated based on the fact that the results were not significant (Prob>chi2=0.5165) indicated that the null hypothesis was not rejected and therefore the residuals were homoscedastic. The test for normality indicated that the residuals were behaving normal based on the kernel density test, which indicated normal behaviour with a bell shape(Uriel 2013).

The test for linearity, based on a two-way scatter plot and a histogram of the variables indicated that the relationship between the predictor and outcome variables were linear and all of the independent variables besides closeness centrality and the control variables were skewed. Thus, in order to correct them, a nonlinear transformation known as a square root was employed to change the distributions shape with the aim of making the skewed distributions more symmetrical and nearly normal. The resultant variables post linearity testing include: square root indegree, square root outdegree, square root weighted indegree, square root weighted outdegree, square root betweenness, square root cluster coefficient, closeness centrality, square root GDP PPP and Land Area. The model specification test results were not significant indicating that the model was not miss specified(Uriel 2013).

Lastly, the test for influential data indicated that there were no outliers which may exert undue influence on the coefficients. Lastly, to ensure no further outlier influence robust was used in the statistical tests(Welling 2005).

An indication of significance was represented by the P value of less than 0.5.

Once all the pre-tests were conducted, the analysis preceded to respond to the main research question which questioned: To what extent does city position in the world city network influence city sustainability? And sub –research questions; 1.) To what extent does the prestige and power of a city in the intercity firm network influence city sustainability? 2.) To what extent does the nodal strength of city ties in the intercity firm network influence its sustainability? 3.) To what extent does the linkage structure of the intercity firm network influence city sustainability?

The analysis unfold accordingly: starting with 4.4.1) which analyses city prestige and power of the city in the network and its influence on its sustainability. 4.4.2) looks at the significance of city ties. 4.4.3) Influence of linkage attributes on sustainability; and lastly 4.4) tests the significance of the measured position in relation to all indicators; combining nodal and linkage values.

Each sub-research question, has been broken down into sub-sub research questions and statistically analysed. 1.) Total FDI analysis which is tied to the notion that the fate of cities has become increasingly tied to their position in international flows of investment and trade (Alderson and Beckfield 2004) and 2.) Cross Sector FDI including hi-tech, manufacturing,

resources and services on the basis that global control functions are directly reflected in the structure and dynamics of their production sector's and employment (Hymer 1972).

Within this, on the basis of cities increasing position in international investment and trade being criticized for decoupling cities from local political geography (Friedmann 1986) has warranted increased research on the relationship between sustainable development, firm strategies and intercity firm networks (Lopez et al. 2007), therefore the top and lowest 10 performing cities in each sub-sub research question will be presented using graphs to present nuances between city sustainability and network positionality measures.

Each sub-research question incorporates a map and graphic tables indicating the location of the top and least performing cities in the network to give credence to Sassen and Friedmann's perceptive of shifting world system loci dynamics; with globalisation considered to be generating a new geography of centrality and marginality that cuts across the old core /periphery , north/south, and east/west divides in the world system (Sassen 1991; Alderson et al. 2004; Leathers and Patrick Raines 2013; Friedmann 1986).

4.4.1 Does the Prestige (Indegree) and Power (Outdegree) of the city in the network in terms of total foreign direct investment influence city sustainability?

4.4.1.1 Total Foreign Direct Investment Prestige (Indegree) and Power (Outdegree) across sectors influence on city sustainability

From the Table below, its noted that the prestige (Indegree) of the city, being significant has a positive influence on city sustainability. The power (Outdegree), although not significant, is positive indicating that cities which have more power or outdegree in the network are more sustainable.

Total FDI	Sustainability
Prestige (Indegree)	3.53**
	(1.23)
Power (Outdegree)	1.47
	(1.14)
Total Population	-0.00***
	(0.00)
Land Area	0.00
	(0.00)
Unemployment rate	0.39
	(0.41)
GVA Mining	-0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP Purchasing Power Parity	1.35
	(1.56)
Constant	1.29
	(19.19)
Observations	33

Adjusted R^2	0.62

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 14: Testing the influence of City prestige (Indegree) and power (Outdegree) in the FDI network across all sectors.

Out of the control variables, total population is generally significant, a phenomenon supported by Chesnais (1985) who highlights from the perspective of neo-Malthusian literature, population influences economic development, and one of the pillars of sustainability.

The results for power (outdegree) and prestige (indegree) in the network, as highlighted above indicate only prestige to be significant. Since sustainability ranking is measured at the agglomeration or localised scale, the impact of outdegree on local conditions are lower than for indegree which requires particular localised conditions to attract attract indegree and be labelled prestigious (Porter 1990).

The prestige of the city is highly significant for total FDI, with the positive correlation suggesting that with the increase in city prestige will increase sustainability by 300%. While its acknowledge that the major impact of FDI is on economic growth, the effect of FDI is ambiguous, depending to a large extent on the sector which its being channelled. FDI to primary sector is associated with a negative impact and the manufacturing sector associated with a positive impact (Dufey and Grieg-Gran 2011) on sustainable development. However, a sector break-down will occur in the next question.

4.4.1.2 Prestige (Indegree) and Power (Outdegree) across the different sectors (High-Tech, Manufacturing, Resources and Services) influence on city sustainability.

The table below demonstrates the prestige and power of the city Hi-tech, manufacturing, resources and services sector. In contrast to Leader and Ong (2011) as mentioned above, Hi-Tech, Manufacturing and Resources are positively and significantly correlated to city sustainability. The results suggest that with the cities increase in prestige in the hi-tech, manufacturing and resources sectors will increase city sustainability by 495%, 400% and 399% respectively. The services sector although positively correlated is not significantly correlated to city sustainability.
Once again, none of the outdegree is significant, however all positively correlated.

Sustainability	(1)	(2)	(3)	(4)
Hi-Tech Prestige (Indegree)	4.95*			
	(1.78)			
Hi-Tech Power (Outdegree)	2.30			
	(1.99)			
Manufacturing Prestige (Indegree)		4.02*		
		(1.80)		
Manufacturing Power (Outdegree)		1.94		
		(2.06)		
Resources Prestige (Indegree)			3.99*	
			(1.64)	
Resources Power (Outdegree)			1.42	

			(1.92)	
Services Prestige (Indegree)				1.42
				(1.31)
Services Power (Outdegree)				2.00
				(1.16)
Total Population	-0.00*	-0.00**	-0.00*	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Land Area	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment rate	0.66	0.51	0.32	0.25
	(0.42)	(0.43)	(0.46)	(0.45)
GVA Mining	0.00	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
GVA Public Administration	0.00*	0.00	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
GDP PPP	-5.66	-3.48	-5.42	-4.29
	(2.84)	(3.30)	(2.85)	(2.45)
Constant	83.89*	58.35	86.89*	72.47*
	(34.01)	(41.04)	(34.33)	(31.26)
Observations	34	33	34	33
Adjusted R^2	0.64	0.65	0.62	0.66

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 15: Testing city power and prestige in the Hi-tech intercity network influence on city sustainability. (Source: Author)

Of the control variables, besides total population in terms of testing the hi-tech, resources, and services sectors GVA Public Administration is significant and positively correlated with city sustainability.

With reference to figure 5, looking at the top performing cities in the resources sector, only two, London and Berlin of top performing (in top 10) sustainable cities fall with in the top performing cities for prestige in the resources sector. However, since London is an outlier generally, only one can really be considered. What makes Berlin a top performing city in the resources sector and in terms of sustainability? However, it must be noted that in consideration of large portion of the city highly primary sector factor endowed are not prevalent in the sample study as the requirement for cities included as per the Arcadis sustainability ranking was also to be a World City.

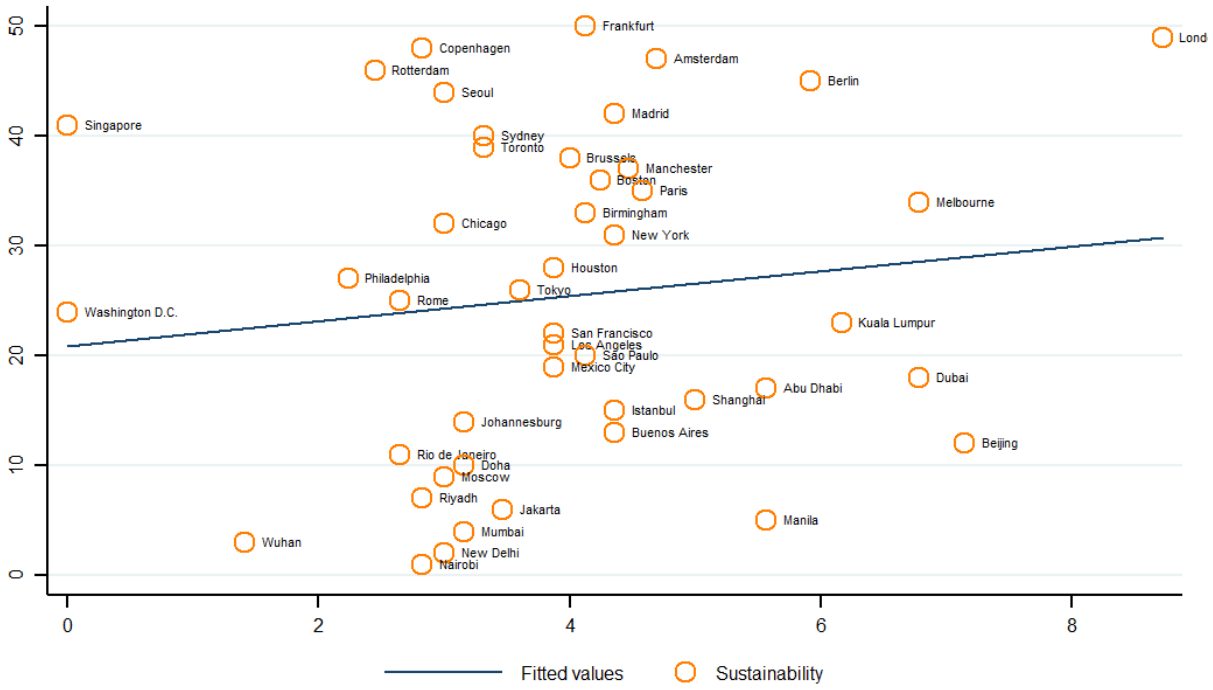


Figure 16: City Prestige for total FDI and Sustainability scatterplot
Source: Author (Stata using sustainability ranking and generate network variables)

Although indegree is an indicator of city prestige in the network, Beckfield et al. (2004), highlights the strong relationship between the population raw demographic prominence of a city and its power, prestige and positions in the city system. With power command concentrated in the USA, western Europe and Tokyo Taylor et al. (2002), suggests the notion of network power being more geographically diffused, transcending old North-South divide.

With the bulk of the cities centred, for both sustainability and prestige (indegree), confirming the relationship between the two. Of the cities sitting in the top half of the sustainable cities, none of them are from the global south. Of the two Africa cities, Johannesburg is the better performer of the two and 14th on the sustainability list, with 50 being the most sustainable.

Johannesburg, looking at Figure 4 scatter plot, is more or less in the same tier as Sydney in terms of city prestige however finding itself on the opposite end of sustainability. Although Sydney is in the same tier as Johannesburg for prestige, it's in the top 10 sustainable cities. Looking at figure 5, which demonstrates the performance of the top 10 prestigious cities in hi-tech, manufacturing and resources sector, as well as Johannesburg. As represented, Johannesburg in terms of prestige, Johannesburg is more prestigious firstly in manufacturing, secondly resources and lastly hi-tech. Considering that Johannesburg falls in a similar tier to Sydney in terms of prestige, with Sydney being in the top 10 prestigious cities and in the top 10 most prestigious cities in the hi-tech sector, if Johannesburg would like to be more sustainable from the perspective of prestige, it should look to Sydney and its policies on hi-tech sector. The promotion of Technology as per the Vale Columbia Centre on sustainable international investment (2010) for sustainability offers 1.) Economic development in the form of linkages, technology transfer and training, 2.) Environmental sustainability in amongst other mobilizing environmental technologies for conservation, and 3.) social development in the form of training with technology transfer and R/D and employment creation with economic development considerations exhibiting the biggest increases, followed by linkages with

domestic firms. Similarly, the argument can be made that an increase in the hi-tech sector might promote economic development.

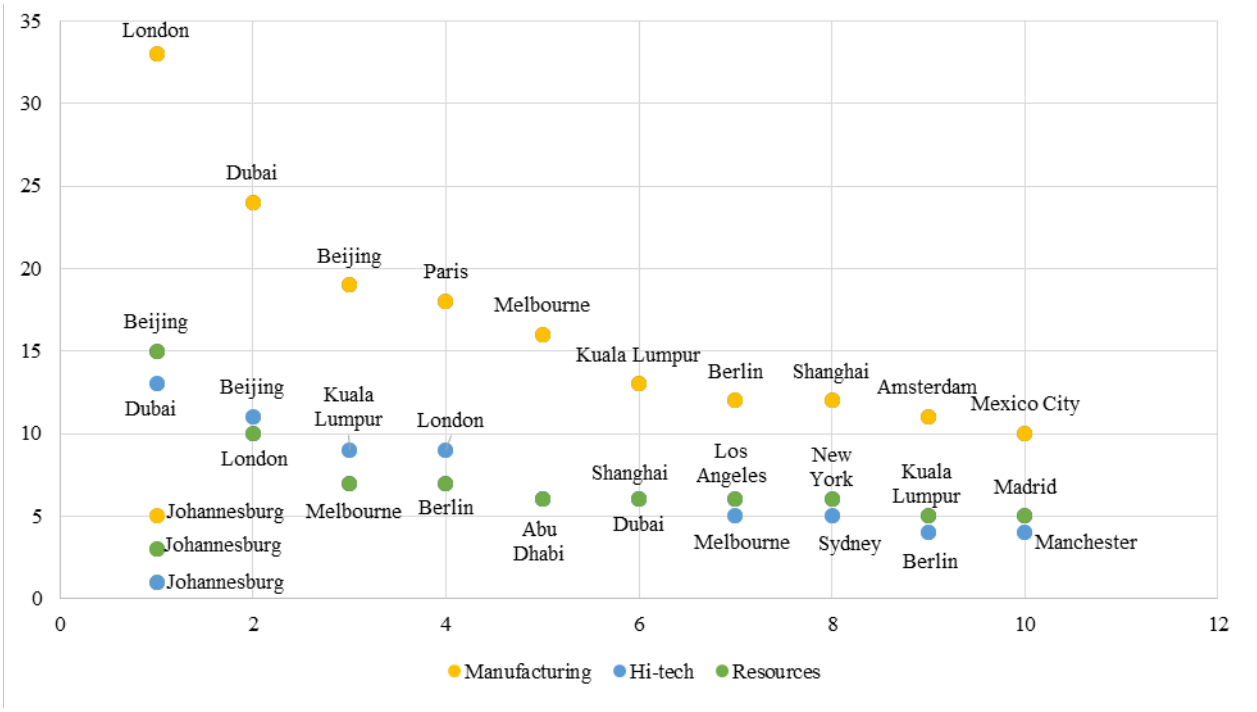


Figure 17: Graph of city prestige performance for total FDI and the significant sectors (hi-tech, manufacturing, resources). Source: Author (network centrality measures)

Figure 18: Map demonstrating the geographic distribution of sustainable city prestige in the high tech sector.

In concluding sub-research question 1, it's been demonstrated that the prestige of the city in the total FDI network, has a positive impact on city sustainability. In general, population influences city sustainability, both for total FDI and across sectors. When analysing city prestige in terms of the sector break down, hi-tech, manufacturing and resources have a positive impact on city sustainability. Services did not come up as significant for city sustainability,

which could be attributed to an emphasis on external links, lower labour requirements and the need for specialized skills lowering the labour pool. Out of the sectors significantly correlated to city sustainability, hi-tech sector has the highest amount of cities prevalent in the top 10 list of sustainably ranked cities. From the perspective of Johannesburg, who as demonstrated prioritizes manufacturing, followed by resources and lastly hi-tech sector. Taking a cue from Sydney who is in more or less the same tier as Johannesburg for city prestige, and falls within top 10 of sustainable cities, and priorities the hi-tech sector as demonstrated in figure above; similarly, if Johannesburg increase its focus on the hi-tech sector it has the possibility of increasing city sustainability.

4.4.2 Does the nodal strength of city ties in terms of weighted outdegree and weighted indegree influence city sustainability?

4.4.2.1 Nodal strength of city ties, weighted outdegree and weighted indegree of total Foreign Direct Investment (FDI) across sectors influence on city sustainability

In this sub-research question, the interest is to determine whether the strength of city ties has an influence on its sustainability. The weighted indegree and weighted outdegree which looks the weight or volume of inward and outward investments were therefore tested.

From Table below, the strength of city ties in terms of weighted indegree of the city significant and positively correlated. An increase in weighted indegree increases city sustainability by 24%. The weighted outdegree although not significant, however is positively correlated.

Sustainability	(1)
Weighted Indegree	0.24**
	(0.08)
Weighted Outdegree	0.05
	(0.07)
Total Population	-0.00***
	(0.00)
Land Area	0.00
	(0.00)
Unemployment rate	0.62
	(0.40)
GVA Mining	-0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP PPP	1.74
	(1.37)
Constant	1.25
	(17.99)
Observations	33
Adjusted R^2	0.60

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 19: Nodal strength of city ties, weighted outdegree and weighted indegree of total Foreign Direct Investment (FDI) across sectors influence on city sustainability (Source: Author)

The case of increased sustainability with increased strength of city ties lies in the notion that the economic strength of countries and cities lies in the strength of ties (UN, 2013).

4.4.2.2 Nodal strength of city ties, weighted outdegree and weighted indegree of the Sectors (High Tech, Manufacturing, Resources, Services) Foreign Direct Investment (FDI) influence on city sustainability

As demonstrated in the table below out of all the sectors, high-tech is the only significant sector. City sustainability increases by 35% when the strength of the city ties weighted indegree increases and by 58% with increased weighted outdegree. The rest of the sectors although not significant are positively correlated for indegree and outdegree, except manufacturing outdegree which is negatively correlated demonstrating an increase in outward investment in manufacturing decreasing sustainability. An increase of weighted outdegree and indegree or rather an increase in the strength of city ties in terms of the volume of inward and outward investment of hi-tech, manufacturing, resources and services would not significantly influence the sustainability of the city. The significance and positive correlation corresponds with Zhao and Zhang (2007) who note that strong outward linkages are a major engine of growth in the global city or extended metropolitan regions.

Sustainability	(1)	(2)	(3)	(4)
High-Tech Weighted Indegree	0.35**			
	(0.10)			
High-Tech Weighted Outdegree	0.58***			
	(0.15)			
Manufacturing Weighted Indegree		0.44		
		(0.25)		
Manufacturing Weighted Outdegree		-0.01		
		(0.25)		
Resources Weighted Indegree			0.21	
			(0.18)	
Resources Weighted Outdegree			0.20	
			(0.13)	
Services Weighted Indegree				0.14
				(0.09)
Services Weighted Outdegree				0.12
				(0.06)
Total Population	-0.00**	-0.00*	-0.00*	-0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
Land Area	0.00*	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment rate	0.38	0.47	0.52	0.34
	(0.39)	(0.49)	(0.45)	(0.40)
GVA Mining	0.00	-0.00	-0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
GVA Public Administration	0.00	0.00	0.00*	0.00
	(0.00)	(0.00)	(0.00)	(0.00)

GDP PPP	-7.46***	-5.66	-4.73	-2.78
	(1.93)	(3.18)	(2.81)	(3.10)
Constant	109.94***	87.52*	79.50*	56.11
	(22.91)	(39.81)	(34.20)	(38.58)
Observations	34	33	34	33
Adjusted R^2	0.70	0.57	0.59	0.65

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Source: Author

Figure 20: Nodal strength of city ties, weighted outdegree and weighted indegree of the Sectors (High Tech, Manufacturing, Resources, Services) Foreign Direct Investment (FDI) influence on city sustainability. (Source: Author)

Of the control variables, besides total population, GVA Public Administration is also significant and positively correlated to influence city sustainability under strength of city ties for the resources sector. With reference to Swilling (2012) notions of resource metabolic rates, and notions of decoupling resources from productivity highlighting the sensitivity around the sector the need for proper management, corresponding to the results of the test which pegs GVA public administration as significant for the resources sector. Land Area is significant and positively correlated with the Hi-tech sector.

(Barrios et al. 1177) highlights that hi-tech firms ability to not have to concentrate in allocated urban nodes, hi-tech activities will or could locate in greater urban areas; where the land is cheaper, more available space with greenfield investment in hi-tech industries in greater urban areas. The requirement for substantial investment into the machinery, plant etc. for the host country or city also contributes to increased economic and skills transfer benefits from sector(Barrios et al. 1177) linking to the reason for GDP PPP significance under hi-tech.

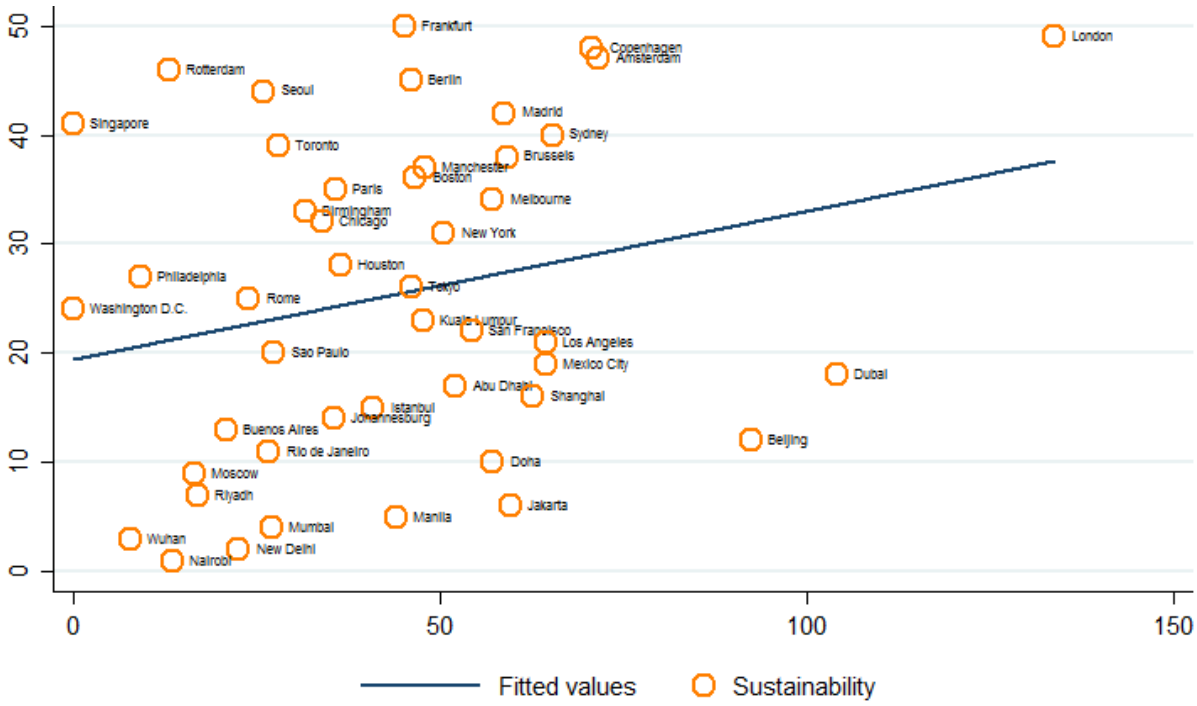


Figure 21: Strength of City ties for total FDI and Sustainability scatterplot (weighted indegree)
Source: Author (Stata using sustainability ranking and generate network variables)

Looking at the distribution of city sustainability in relation to the strength of its ties, besides London, a general outlier, while Dubai and Beijing are the next top performers for strength of city ties, they are not in the top 10 for city sustainability. Of the cities which are in the top 10 for both Sustainability and statistically significant hi-tech sector for strength of city ties (see below figure), Berlin ticks both boxes and in close range to Johannesburg in terms of strength of city ties. Although contextually different, which cues can Johannesburg take from Berlin to be more sustainable.

The cities represented below are the top performing cities for strength of city ties for the sector which was significant and positively correlated in the statistical analysis. Johannesburg has been included for comparative understanding.

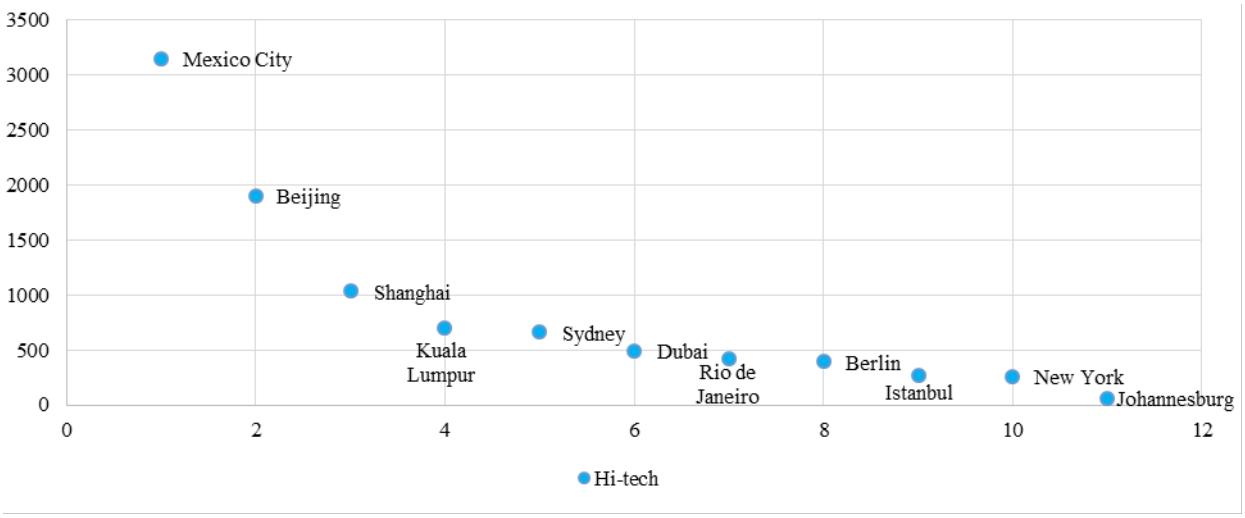


Figure 22: Strength of City ties for the Hi-tech sector – demonstrating only the top 10 cities
Source: Author (Excel and generated network variables)

On close inspection when looking at the industry breakdown of top performing sustainable cities and cities with strong ties, Berlin and Sydney in relation to Johannesburg (ref. graph below), where as Berlin focuses on the automotive industry, Sydney focuses on the chemicals industry.

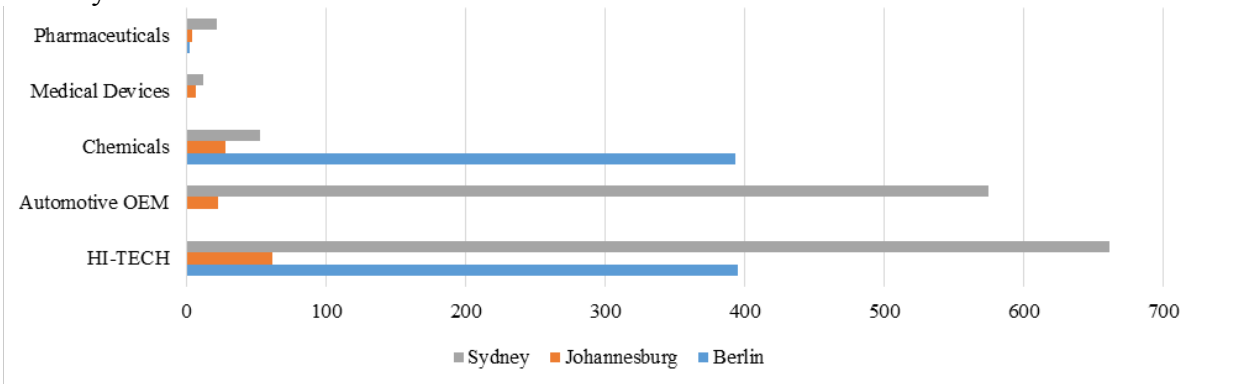


Figure 23: Industry breakdown of cities which are both in the top 10 cities for strength of city ties and sustainability
Source: Author (Excel and generated network variables)

Regionally, although Mexico City, a Latin American City is the top performer it's the cities in the Asian and Pacific region which have the most top performers for strength of city ties in the hi-tech sector, followed by Latin America and Europe.

Weighted Indegree and Region	Africa	Asian and Pacific	Europe	Latin America	Middle East	North America
Hi-tech		2	10	1	8	12
		3	11	9		
		4				
		5				
		6				
		7				

Figure 24: Table of regional distribution for strength of city ties for the Hi-tech sector – demonstrating only the top 10 cities
Source: Author (Excel and generated network variables)

The Map below represents a filtered version of the geographical spread of city ties in the hi-tech sector prioritising cities with the strongest ties. The size of the circle represents the strength of the cities in the network. As demonstrated, Mexico is the largest as the table above. The thickness of the link represents weight or volume of the ties between cities.

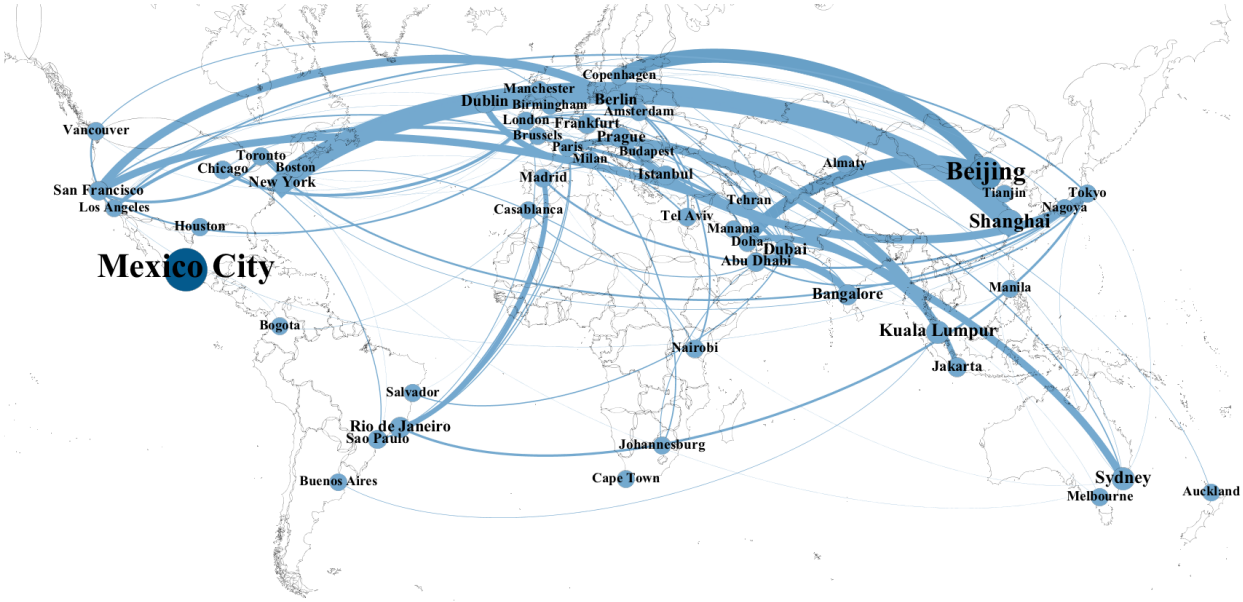


Figure 25: geographical spread of city ties in the hi-tech sector (Source: Author)

Looking at the focus on regional ties for the Berlin, Sydney and Johannesburg, most of Germany links are with links in Europe, most of Sydney's links are with cities in Asian and Pacific. Johannesburg differs in that most of its ties are not with its own region, but rather Europe for strength of city ties with weighted indegree and begs the questions of were Johannesburg to increase regional ties would it be able to increase its sustainability.

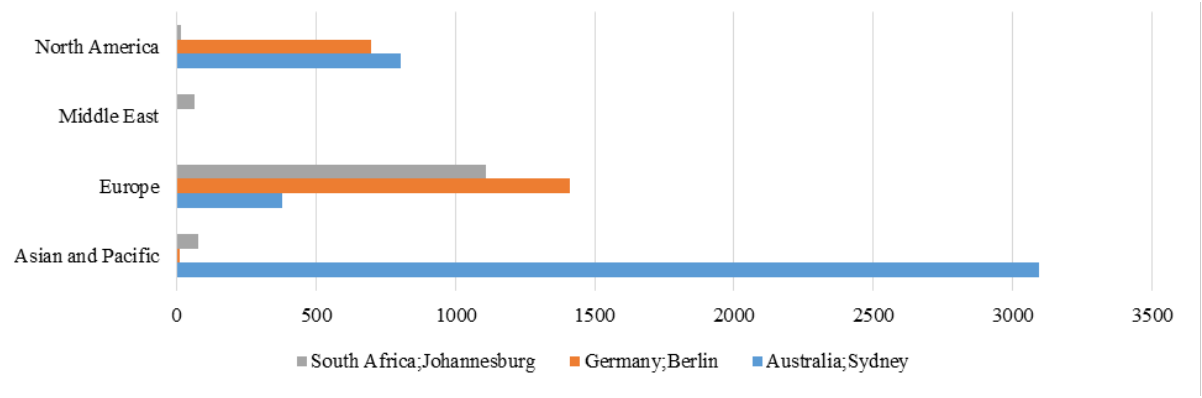


Figure 26: Main regional ties for Berlin, Sydney and Johannesburg in the hi-tech sector
Source: Author (Excel and generated network variables)

In concluding sub –question strength of ties influence on city sustainability, the key points emerged from the analysis include 1.) The strength of city ties for weighted indegree increases city sustainability by 24% for total FDI. 3.) The strength of city ties for weighted indegree and weighted outdegree in the hi-tech sector increases city sustainability by 35% and 58% respectively. Land area is significant and positively correlated to the hi-tech sector and GDP PPP negatively influences city sustainability in the hi-tech sector. This could be attributed to the increase in technology and machinery verses human capital which has a socio-economic impact. Although Latin America has the top performing city for strength of city ties in the hi-tech sector, it's Asian and Pacific region cities which have the highest number of the cities for strength of ties in the hi-tech sector. Of the top 10 sustainably ranked cities, two are amongst the top performing cities for strength of ties, Sydney and Berlin. Since the industries of focus for these two cities are chemicals and automotive, is there opportunity for Johannesburg to improve theses industries. Secondly, looking at the ties of these cities, with Johannesburg, unlike Berlin and Sydney's main ties with Europe and not its own region, could focusing on its own region in terms of strength of city ties in the hi-tech sector contribute to increased city sustainability.

4.4.3 Does the linkage structure of the network influence city sustainability?

4.4.3.1 Total Foreign Direct Investment across all sectors between cities in the network

When testing the network independent variables across the total FDI network against sustainability, Betweeness centrality was the only variable which came up as significant. Betweeness centrality is the brokerage or linkage ability of the city. When cities increase their brokerage capacity, linking to other cities, they increase their sustainability by 28%. As for the two other network independent variables, clustering coefficient; the measure of the structure of the network in terms of how loose or how dense the connections between nodes are and the closeness centrality; a measure of the proximity of the selected node to all other nodes, although not significant does positively influence sustainability.

Total FDI	Sustainability
Brokerage	0.28**
	(0.09)

Cluster Coefficient	15.42
	(14.34)
Closeness	2.37
	(19.27)
Total Population	-0.00**
	(0.00)
Land Area	0.00
	(0.00)
Unemployment Rate	0.67
	(0.42)
GVA Mining	-0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP PPP	0.93
	(1.72)
Constant	4.31
	(26.24)
Observations	33
Adjusted R^2	0.52

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 27" Total Foreign Direct Investment across all sectors between cities in the network (Source: Author)

Beside total population, none of the other control variables are significant. See below scatterplot of city brokerage for total FDI. As demonstrated in the scatterplot below, the top performing sustainable cities are also top performers for brokerage.

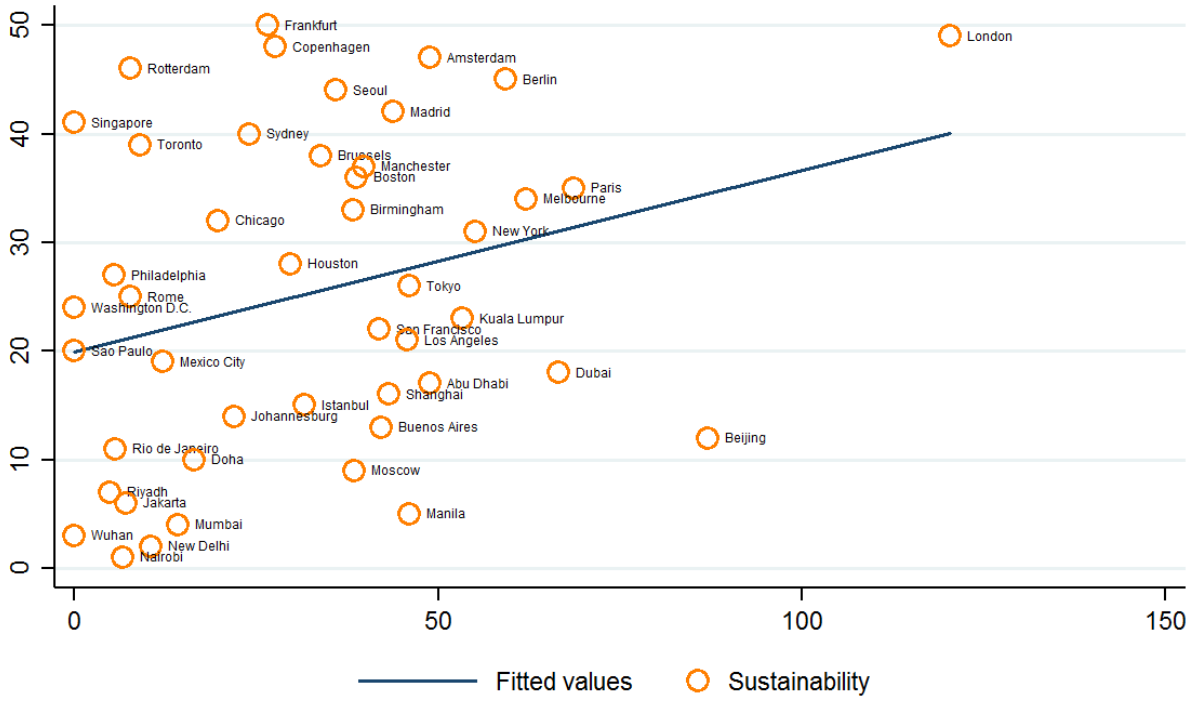


Figure 28: Scatterplot of City Brokerage (betweenness) for Total FDI and city sustainability

Source: Author (Generated in Stata)

4.4.3.2 Sectoral breakdown (Hi Tech, Manufacturing, Resource, Services) Foreign Direct Investment (FDI) between cities in the network

The table below represents the influence of the network independent variables on High-tech, Manufacturing, resources and services sectors. Of all the sectors, Manufacturing is the only sector which comes up significant indicating that sustainability increases by 30% when manufacturing brokerage increases.

Sustainability	(1)	(2)	(3)	(4)
High-Tech Betweeness	0.27			
	(0.47)			
High-Tech Closeness	0.44			
	(5.79)			
High-Tech Cluster	19.01			
	(10.75)			
Manufacturing Betweeness		0.30*		
		(0.12)		
Manufacturing Closeness		9.63		
		(6.60)		
Manufacturing Cluster		15.75		
		(7.76)		
Resources Betweeness			0.09	
			(0.20)	
Resources Closeness			-1.37	
			(7.38)	
Resources Cluster			11.96	
			(11.45)	
Services Betweeness				0.12
				(0.15)
Services Closeness				11.37
				(15.83)
Services Cluster				7.82
				(13.93)
Total Population	-0.00	-0.00**	-0.00*	-0.00*
	(0.00)	(0.00)	(0.00)	(0.00)
Land Area	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
Unemployment rate	0.68	0.45	0.34	0.37
	(0.40)	(0.38)	(0.54)	(0.51)
GVA Mining	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
GVA Public Administration	0.00*	0.00*	0.00**	0.00**
	(0.00)	(0.00)	(0.00)	(0.00)
GDP PPP	-7.42*	-3.90	-7.47**	-4.77
	(2.91)	(2.49)	(2.52)	(2.68)

Constant	107.93**	62.45*	114.99***	73.93*
	(34.87)	(29.36)	(30.50)	(32.39)
Observations	34	33	34	33
Adjusted R^2	0.59	0.68	0.53	0.60

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 29: Scatterplot of City Brokerage (betweenness) for Total FDI and city sustainability (Source: Author (Generated in Stata))

Of the control variables, total population and GDP PPP once again is significant and negatively correlated representing an increase in population results in lowered sustainability and network independent variables and global integration results in the declining GDP PPP. GVA Public Administration is significant and positively correlated indicating that with increased GVA Public Administration results in increased sustainability.

With the manufacturing the only significant independent variable for city brokerage influence on city sustainability, correlating with the trend toward global city regions and contemporary strategies of MNC's in terms of the relocation of manufacturing in the era of the new division of labour with foreign driven development highly location selective(Zhao and Zhang 2007). With manufacturing being process oriented in terms of assembling and labour intensive, the sector not only finds itself central and therefore linking resources for production and the assembled goods, which explains its significant and positive correlation for city brokerage. Looking at the scatter plot below, demonstrates by virtue of more dual well performing brokerage and sustainable cities the positive correlation of city brokerage in manufacturing to sustainability.

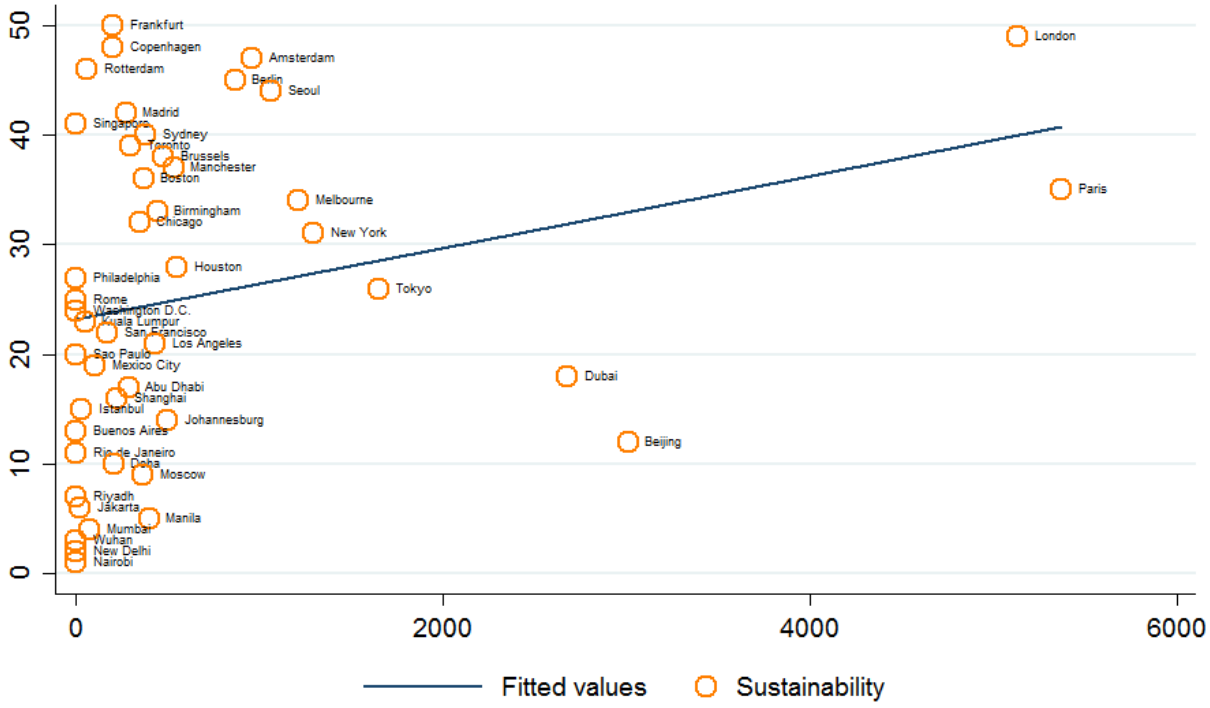


Figure 30: Scatterplot of City Brokerage (betweenness) for the manufacturing sector and city sustainability. (Source: Author (Generated in Stata))

There are four cities occurring in the top 10 for sustainability and brokerage, including London, Berlin, Amsterdam and Seoul.

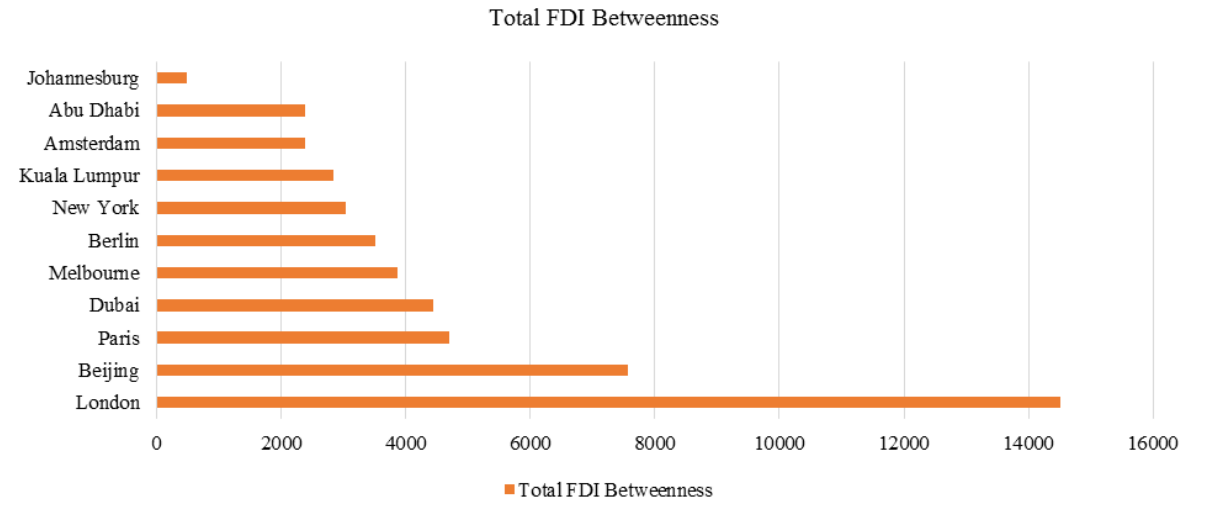


Figure 31: Scatterplot of City Brokerage (betweenness) for Manufacturing Sector and city sustainability (Source: Author (Generated in Stata))

Although understanding which cities are top performers for brokerage is important, knowing which cities they are brokering for and with is as important, the map below gives an indication of city and regional interactions of the top performing cities.

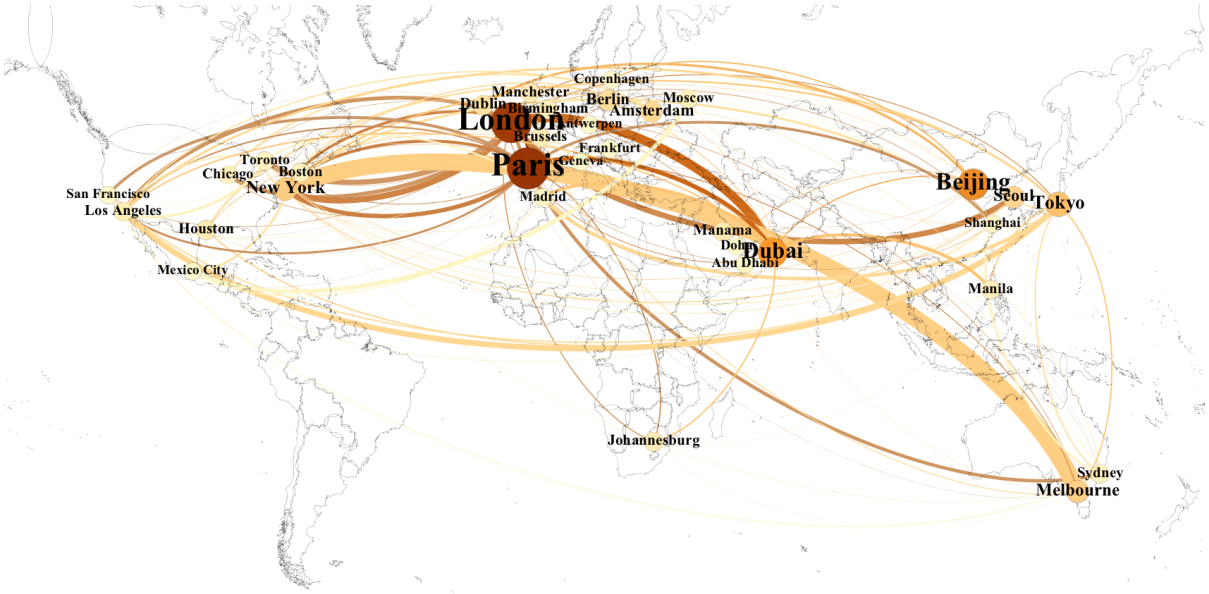


Figure 32: Map of top cities for brokerage (betweenness) distribution (Source: Author (Generated in Gephi))

With manufacturing sector, a priority for Johannesburg, how can it improve the sector for increases brokerage and sustainability. Looking at the top cities in both areas as demonstrated in the graph above, the below break down gives an indication.

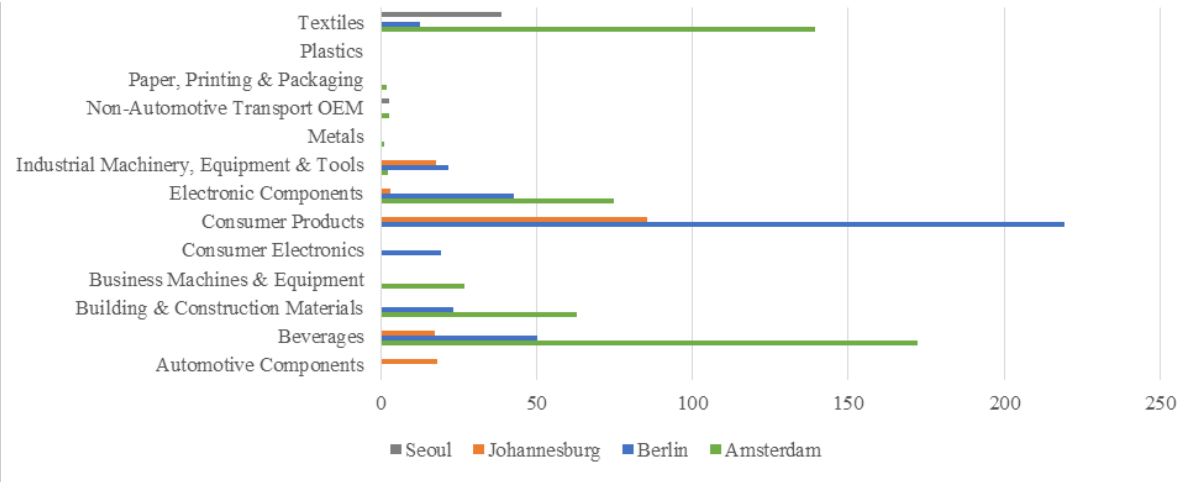


Figure 33: Industry distribution amongst the top performing cities in the manufacturing sector (Source: Author (Generated in Excel from FDI markets data))

As demonstrated above, the top industries for the top performing cities include Textiles (Seoul), Consumer Products (Berlin) and Beverages (Amsterdam). With London being an outlier, it was removed.

4.4.4 Does the linkage structure of the network influence city sustainability?

Lastly, with reference to Taylor's (2013) 'greening the modern' notions of modularity, intercity regions and the idea of nearer non –local; statistical analysis incorporating network (linkage) and nodal values were tested for significance across all measures; total FDI and across the sectors. The results are indicated below:

Firstly, Total FDI, the results for this demonstrate that a decrease in closeness centrality lowers sustainability by 22%.

Total FDI	Sustainability
City Prestige	5.01
	(2.44)
City Power	5.13
	(2.73)
Strength of City Ties (weighted indegree)	0.17
	(0.11)
Strength of City Ties (weighted outdegree)	-0.14
	(0.19)
City Brokerage	-0.26
	(0.16)
Clustering	-4.35
	(12.90)

Closeness	-22.18*
	(9.36)
Total Population	-0.00***
	(0.00)
Land Area	-0.00
	(0.00)
Unemployment rate	0.12
	(0.42)
GVA Mining	-0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP Purchasing Power Parity	2.21
	(1.80)
Constant	-2.72
	(24.92)
Observations	33
Adjusted R^2	0.62

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 34: Linkage and Nodal values in the network influence city sustainability: Total FDI (Source: Author)

Secondly, in relation to Hi-tech FDI, the results demonstrate that City Power (out degree) results increased sustainability by 26%, when measured against the nodal and linkage values; and decreased GDP PPP.

Hi-tech	Sustainability
City Prestige	1.93
	(2.85)
City Power	-0.96
	(5.25)
Strength of City Ties (weighted indegree)	0.26*
	(0.11)
Strength of City Ties (weighted outdegree)	0.59
	(0.37)
Total Population	-0.00*
	(0.00)

Land Area	0.00*
	(0.00)
Unemployment rate	0.65
	(0.42)
GVA Mining	0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
City Brokerage	-0.23
	(0.71)
Clustering	-0.03
	(7.88)
Closeness	7.34
	(12.78)
GDP Purchasing Power Parity	-8.25**
	(2.81)
Constant	115.26**
	(33.73)
Observations	34
Adjusted R^2	0.66

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 35: Linkage and Nodal values in the network influence city sustainability: Hi-tech sector (Source: Author)

Secondly, in relation to Hi-tech FDI, the results demonstrate that City Power (out degree) results increased sustainability by 26% and closeness increases sustainability by 19%. GVA public administration is also significant.

Manufacturing	Sustainability
City Prestige	7.07*
	(2.54)
City Power	2.23
	(4.70)
Strength of City Ties (weighted indegree)	-0.79
	(0.46)
Strength of City Ties (weighted outdegree)	-0.39

	(0.44)
City Brokerage	0.20
	(0.27)
Clustering	9.76
	(5.61)
Closeness	19.15*
	(7.85)
Total Population	-0.00**
	(0.00)
Land Area	0.00
	(0.00)
Unemployment rate	0.80
	(0.41)
GVA Mining	0.00
	(0.00)
GVA Public Administration	0.00**
	(0.00)
GDP Purchasing Power Parity	-4.73
	(2.59)
Constant	63.56
	(30.90)
Observations	33
Adjusted R^2	0.71

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 36: Linkage and Nodal values in the network influence city sustainability: Manufacturing sector (Source: Author)

Thirdly, in relation to Resources, the results demonstrate that city prestige (out degree) results in increased sustainability by 700%, when measured against the nodal and linkage values; city power results in 37% increase in sustainability; and negative value of city brokerage decreased city sustainability by 92%.

Resources	Sustainability
City Prestige	7.14**
	(2.48)
City Power	5.01
	(2.55)

Strength of City Ties (weighted indegree)	0.18
	(0.16)
Strength of City Ties (weighted outdegree)	0.37*
	(0.15)
City Brokerage	-0.92**
	(0.27)
Clustering	-11.26
	(7.85)
Closeness	10.36
	(9.42)
Total Population	-0.00***
	(0.00)
Land Area	0.00
	(0.00)
Unemployment rate	0.03
	(0.41)
GVA Mining	-0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP Purchasing Power Parity	-2.56
	(2.56)
Constant	56.27
	(31.69)
Observations	34
Adjusted R^2	0.72

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 37: Linkage and Nodal values in the network influence city sustainability: Resources sector (Source: Author)

Lastly and interesting, there are significant measures across all the tested indicators for Services.

Services	**Sustainability**
City Prestige	4.02
	(2.84)
City Power	4.33
	(4.49)

Strength of City Ties (weighted indegree)	0.15
	(0.11)
Strength of City Ties (weighted outdegree)	-0.07
	(0.26)
City Brokerage	-0.39
	(0.30)
Clustering	-6.01
	(15.61)
Closeness	-8.12
	(13.03)
Total Population	-0.00
	(0.00)
Land Area	0.00
	(0.00)
Unemployment rate	-0.05
	(0.55)
GVA Mining	0.00
	(0.00)
GVA Public Administration	0.00
	(0.00)
GDP Purchasing Power Parity	-4.73
	(3.42)
Constant	76.70
	(42.36)
Observations	33
Adjusted R^2	0.63

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 38: Linkage and Nodal values in the network influence city sustainability: Services sector (Source: Author)

Prestige and Power of the City in the Network

Total FDI	Prestige of the City is significant	350%
Sectoral	Prestige	
	Hi-tech	495%
	Manufacturing	402%
	Resources	399%
	Population, Public administration for everything except manufacturing	
Nodal and Network	Prestige – Manufacturing	707%
	Prestige – Resources	714%

Strength of city ties (weighted indegree and weighted outdegree)

Total FDI	Weighted Indegree	24%
Sectoral	Weighted Indegree (and population – negative)	35%
	Weighted Outdegree	58%
	Hi-tech	495%
	Population for all, land area and GDP PPP for hi-tech	
Nodal and Network	Weighted outdegree (Resources)	37%
	Weighted indegree (hi-tech) land with negative GDPPPP (-8.25**)	26%

Linkage (Brokerage, closeness and clustering)

Total FDI	Brokerage	-28%
Sectoral	Brokerage (manufacturing)	30%
	GVA public admin	
Nodal and Network	Brokerage (resources)	-90%
	Closeness (manufacturing)	-22%

The results above, demonstrate all the network position significant indicators influence of sustainability across the Total FDI, Sector test and combined nodal and linkage tests.

Between prestige and power, prestige is the most influential for sustainability; covering all the sectors except for services.

In strength of city ties, although fairing almost equally, weighted indegree leads between the two sub-variables. Hi-tech dominated in terms of strength of city ties with resources featuring in weighted outdegree.

Within linkage, brokerage dominates; clustering does not feature and the manufacturing sector dominates. Generally, the linkage measures are negatively correlated to sustainability, except for brokerage in manufacturing.

Of the variables, prestige appears to be the most influential, followed by strength of city ties weighted indegree and brokerage. Although these are more prevalent, the most significant correlation is strength of city ties weighted outdegree for hi-tech.

Chapter 5: Conclusions and recommendations

This chapter outlines the main findings and conclusions as taken from the data analysis, in terms of the research objective, main research question and sub research questions; finally concluding with recommendations for policy and further research.

This research was premised on the notion that the position of cities within the global urban network impacts its fate (Alderson and Beckfield 2004), and that hierarchy is determined rather by functional connections of networks of services and flows between metropolitan regions, and not cities themselves (Pred 1977). Furthermore, with reference to Friedman and Sassens perspectives on the world city system and notions of global core and periphery impacting the fate of cities, it set out to test the influence of city positionality in the network on city sustainability. A seemingly ambitious task, given the magnitude of both variables, but considering that the city sustainability had already been measured and ranked at the agglomeration scale, the aim of this thesis was then simply to test the relationship between the measured city sustainability and global integration.

It therefore borrowed from Hymer (1972) and Castells (1991) the perspective on global integration as cities positionality in the network, determined by its interfirm linkages. Using FDI networks between cities as a measure of global integration, it used network analysis to generate city positionality in the network, to generate variables related to 1.) City prestige and power in the network, 2.) Strength of city ties in the network, 3.) City Linkage and clustering. Through a process, statistical network and graph analysis, the conclusions and recommendations are as follows. Considering the magnitude of the topics covered in this research, the analysis approach does not claim to be all encompassing, it simply aims to add to a body of knowledge related to further understanding global intercity networks and begin to chip away at the topical elephant in the room; global integration and its sustainability.

With this in mind, the results as highlighted in Chapter 4 clearly indicates that global integration or city positionality in the network does influence city sustainability, albeit not in all areas.

The more prestigious a city, the more sustainable the city will be. However, this is limited to the hi-tech, resources and manufacturing sectors. City policies therefore need to be geared to attracting indegree in these sectors and in particular the hi-tech sector. With Sydney a top performer both in city prestige for the hi-tech sector and city sustainability it would be a good benchmark for improving city sustainability with regard to city prestige in the hi-tech sector. The hi-tech sector as outlined by Dufey and Grieg-Gran (2011), provides environmental benefits of driving up standards by transferring of both cleaner technology and better management expertise in controlling environmental impacts for the host country. The technology that foreign investors bring with them is likely to be relatively advanced, newer and less environmentally damaging than the ones available in the host country. Increased city prestige (indegree) in the hi-tech sector, results in increased attractiveness access to capital implied by FDI and assists in relieving constraints on investment into environmentally preferable technology(Dufey and Grieg-Gran 2011).

Increased prestige in the manufacturing sector has a positive impact on sustainability (Dufey and Grieg-Gran 2011). The vertical or export oriented FDI of the manufacturing and resources sectors requires multinationals to provide parts of the production chain to the host country, needing direct investment in order to export with high consideration of factor costs, promoting skills transfer and labour production (Demirhan and Masca, 2008). Although the resources

sector is significant and positively correlated, the resources sector is a contentious sector in terms of sustainability, linked to the previously mentioned notions of weak versus strong sustainability approaches with the former advocating for a less drastic approach in an attempt to balance social and environmental linked to economic factors sustainability, and the latter acknowledging the metabolic case of industrialization and advocating for decoupling resources from productivity (Swilling, 2015).

With much of the resources and manufacturing sector activity occurring in the lower brackets of the sustainably ranked cities and the top tier cities geared toward the services /tertiary sectors, it brings up two point of significance crucial to this research, 1.) the significance of global integration and distribution of labour and significance to city sustainability and 2.) questions the approach of analysing city sustainability independently when much of its performance hinges on greater city interactions. And 3.) The already statistically noted significance of public contribution or public administration which was generally not significant for Total FDI but significant for all sectors for power and prestige of the city in the network excluding manufacturing, significant for all sectors for strength of city ties in the network excluding resources and significant for all sectors for city linkages. Therefore, sector focused policies and spend needs to be focused on in terms of city sustainability. The fact that GVA public administration for services and the hi-tech sectors were always significant suggests increased policies around these two sectors, ironically since they are considered more environmentally sustainable. Dufey and Grieg-Gran (2011), highlights governments need to to increase with increased FDI and city prestige (indegree), noting the prevalence of generous tax concessions or direct financial incentives by host governments to attract FDI which stands the risk of offsetting potential benefits from the services sector through the increase of government revenues, especially when it surpasses the spill over benefits. Incentives and the creation of an environment for rent seeking and corruption, dissipating increases in government revenue and undermining systems of corporate and political governance in the host country can create circumstances which support or create anticompetitive industries, distort local politics and thwart regulation(Dufey and Grieg-Gran 2011). In this sense, the significance of GVA public administration particularly in the hi-tech, resources and services sectors are of particular importance in the potential for corruption in these sectors and distorted local politics.

In relation to the strength of city ties, weighted indegree it generally increases sustainability by 24%, and sectorally only hi-tech was significant for both weighted in and outdegree increasing sustainability. Policies related to city strength of ties with consideration of land would assist cities in increased sustainability. Notable cities which could be referenced with an understanding of contextual difference would assist. Cities highlighted for future consideration includes Berlin and Sydney whose hi-tech sector foci are the chemicals and automotive industry. Although the industries of the top performing sectors were considered, the main city ties in the form of investments, it was noted that the of the top performing cities, they all have more same region investment, unlike Johannesburg who has the majority of its inward investment cross continental. Policies to promote regional investment is one way of responding to this observation.

City brokerage capacity as per the analysis positively influences sustainability, particularly in the manufacturing sector. The top performing sustainable cities for city brokerage in manufacturing, were London, Berlin, Amsterdam and Seoul. The top notable manufacturing industries of these cities include consumer products, beverages, textiles and electronic components. Brokerage and linkage capacity requires a degree of openness of the city and offers smaller cities the opportunity to access the market both nationally and internationally.

It's a critical part of the functioning of the network, ironically in light of the top performing brokerage city London's Brexit, it highlights the significance of this topic and the need for analysis of city's position, and a further understanding of cities role and sustainability in the global playing field.

5.2 Recommendations for policy makers

In order to improve sustainability of the cities in relation to its position in the network; policy makers need to look at the city in relation to its position in the network in terms of sector, current conditions and geographical location.

This is demonstrated with the variation of focal sectors across the sub-variable foci. Taking a perspective on the prestige of the city which begins to respond to all sectors, not just services for instance, which did not come up as significant. Increasing inward ties in the hi-tech sector and outward ties for resources. While brokerage came up negative broadly, it was positive for manufacturing; and relates to the 'greening beyond the modern' of alternative import replacement and production (Taylor 2013). The dual strengthening of city ties in hi-tech and prestige, which was the most influential of the sub-variables, begins to respond to the negative influence on GDP PPP as indicated in the research. And lastly, in response to negatively correlated brokerage and closeness warrants the need for stewardship and guardianship of cities interactions at the network scale.

5.3 Recommendations for future research

The research looked at complex broad constructs and theories, in an area of research which is still in its infancy, while the network analysis provided precise measurement of network position across a range of sectors, in relation to city sustainability ranking. There is value in 1.) focusing on one sector in relation to specific sustainability indicators around city regions toward a deeper engagement with the notions of nearer non-local (Taylor 2013).

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Annex 1: Sustainable City Indicators(Arcadis 2015)

INDICATOR	PEOPLE	PLANET	PROFIT	SOURCE
Literacy	X			World Bank Development Indicators
Education	X			QS World University rankings
Green Spaces	X			Siemens Green City Index, municipality websites, others
Health	X			World Bank World Development Indicators
Dependency ratio	X			World Bank World Development Indicators
Income inequality	X			World Bank World Development Indicators
Work-life balance	X			International Labour Organization, UBS and OECD
Property prices	X			UBS prices and earnings and Numbeo
Transport	X			
Public Transport	X			Siemens Green City Index, others
Commuting				TomTom trac index, Numbeo commuting times
Rail infrastructure				World Metro Database
Airport satisfaction				Skytrax World Airport Awards
Energy use and renewable		X		Energy Information Administration
Energy consumption		X		Energy Information Administration
Renewable consumption		X		EM-DAT: International Disaster Database
Natural Catastrophe		X		World Health Organization Ambient Air Pollution
Air pollution		X		Carbon Disclosure Project
Greenhouse gas emissions		X		World Bank
Solid waste management		X		WHO/Unicef Joint Monitoring Program for Water Supply
Drinking water and		X		WHO/Unicef Joint Monitoring Program for Water Supply and Sanitation
Drinking water				
Sanitation				
Energy Efficiency			X	Energy Information Administration
Importance to global			X	Globalization and World Cities (GaWC) Research
GDP per capita			X	Brookings institute
Ease of doing			X	World Bank Ease of Doing Business Index
Cost of doing business			X	
Goods and services costs				World Bank Ease of Doing Business Index
Property prices				UBS prices and earnings and Numbeo

Annex 2: List of Cities

Rank	City	Country	World Region
1	Frankfurt	Germany	Europe
2	London	England	Europe
3	Hong Kong	Hong Kong	Asia and Pacific
4	Amsterdam	The Netherlands	Europe
5	Melbourne	Australia	Asia and Pacific
6	Seoul	South Korea	Asia and Pacific
7	San Francisco	United States of America	North America
8	Brussels	Belgium	Europe
9	Singapore	Singapore	Asia and Pacific
10	Madrid	Spain	Europe
11	Copenhagen	Denmark	Europe
12	Chicago	United States of America	North America
13	New York	United States of America	North America
14	Boston	United States of America	North America
15	Houston	United States of America	North America
16	Sydney	Australia	Asia and Pacific
17	Los Angeles	United States of America	North America
18	Toronto	Canada	North America

19	Rotterdam	The Netherlands	Europe
20	Philadelphia	United States of America	North America
21	Manchester	England	Europe
22	Kuala Lumpur	Malaysia	Asia and Pacific
23	Dallas	United States of America	North America
24	Tokyo	Japan	Asia and Pacific
25	Washington	United States of America	North America
26	Berlin	Germany	Europe
27	Dubai	United Arab Emirates	Middle East
28	Paris	France	Europe
29	Birmingham	England	Europe
30	Doha	Qatar	Middle East
31	Mexico City	Mexico	Latin America
32	Johannesburg	South Africa	Africa
33	Santiago	Chile	Latin America
34	Abu Dhabi	United Arab Emirates	Middle East
35	Rome	Italy	Europe
36	Istanbul	Turkey	Europe
37	Beijing	China	Asia and Pacific
38	Shanghai	China	Asia and Pacific
39	Sao Paulo	Brazil	Latin America
40	Manila	Philippines	Asia and Pacific
41	Jeddah	Saudi Arabia	Middle East
42	Buenos Aires	Argentina	Latin America
43	Jakarta	Indonesia	Asia and Pacific
44	Riyadh	Saudi Arabia	Middle East
45	Moscow	Russia	Europe
46	Rio de Janeiro	Brazil	Latin America
47	Mumbai	India	Asia and Pacific
48	New Delhi	India	Asia and Pacific
49	Nairobi	Kenya	Africa
50	Wuhan	China	Asia and Pacific

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