TOWARDS NETWORK SUSTAINABILITY

Between Corporate Network Analysis and Development Indicators.

FINAL REPORT FOR
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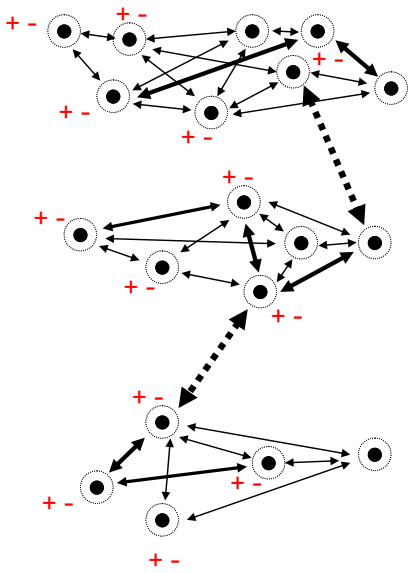

RONALD WALL, BERT V.D. KNAAP, WILFRED SLEEGERS

FACULTY OF APPLIED ECONOMICS
ERASMUS UNIVERSITY ROTTERDAM

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ASSIGNMENT:

SUSTAINABILTIY WITHIN A WORLD CITY NETWORK

In 2006 Fred Langeweg deputy director of The Netherlands Environmental Assessment Agency (MNP) assigned the Faculty of Applied Economics Erasmus University Rotterdam (EUR) to do an explorative research into the relationship between city-firm networks and their impact on the performance of cities and nations. This based on the PhD research that is currently being developed by Ronald Wall under professorship of Bert van der Knaap (director of the Faculty of Applied Economics). The research team was later extended with Wilfred Sleegers (EUR) and Aldert Hanemaaijer (MNP). The results in this report concern an analysis on city-firm networks at both global and European scales. In 2007 a second assignment has been awarded to continue the research at the scale of The Netherlands (still in progress).

Central to this report is the argument that to achieve effective sustainability, cities should be developed as interdependent systems. A 'network' model of sustainability is proposed which requires knowledge of a both a city's internal properties and its external linkages to other cities. Today corporate relations between cities are increasingly important to their development. Therefore it is arguable that a city's sustainability depends highly on its corporate connectivity within the world-city-network. In the first chapter the theoretical relationship between sustainability, scarcity, and city-firm networks is discussed – leading to the second chapter in which a 'network sustainability' model is conceptualized. In third chapter, three hypotheses are explored. The first hypothesis concerns the structure and network centrality of city-firm connectivity - revealed at both global and European scales. The second hypothesis investigates the statistical disproportionality of these networks, while the third hypothesis investigates relationships between city-firm connectivity and contemporary sustainability indicators, such as the Human Development Index, Ecological Footprint, Global Competitivity Index and Infrastructural Accessibility Index.

CONTENTS:

1. THEORETICAL INTRODUCTION:

1.1 Introduction to Network Sustainability:

In this report it is argued that sustainability is a transformative concept that is strongly related to the evolution of city-firm networks over time, whereby the issue of sustainability can only properly be tackled from a network perspective. Because sustainability is a measure of the performance of human interaction with the environment where local and global scales interact more than ever, there is a need for an integral understanding and operationalization. This means that a network conception of sustainability is required that ties municipal, national, and regional policies and interventions into an integrated model. It requires a move from a static understanding 'within' spatial locations (municipal, national, regional, global) to an interactive understanding 'between' these units. In this way a contribution can be made to horizontal and vertical policies within and between different spatial scales. Hereby it is proposed that 'bottom-up' environmental theories such as *Islands of Sustainability*[1] can be combined with the more 'top-down' *City Network* theories to form an integral, 'relational' understanding of sustainability. In this sense a worldwide archipelago of interrelated islands becomes more plausible. Obviously there are many types of networks which can be explored - but for this research it is restricted to economic networks such as corporations, foreign direct investment, (FDI) and trade – because these networks are fundamental to the age-old processes of globalization and urbanization, from which most other networks stem. The research stresses that the sustainable performance of cities or nations is strongly related to the development of firms, trade and capital flows – and specifically the degree of network connectivity related to this. More importantly, the research argues for an improved understanding of the 'relational structures' of power exercised by individual cities and nations upon others. From this, at an even higher level, the structure of the entire network as an integral system can be scrutinized. Hence, sustainability should be defined under nodal, relational and structural components! At a methodological level it is argued that today's different environmental and network approaches, should eventually become unified into a novel 'network sustainability theory' - where this explorative research serves to contribute towards such an endeavour.

The question of how economic networks evolve is important if we are to understand how markets become organized and what their impact is on worldwide development[2]. Three decades ago Stephen Hymer produced a remarkable essay that clearly described the economic network structure of the 21st century. The report is remarkable in that it anticipated the implications of globalization on urbanization and what increasing 'multinationalization' of the world economy would mean for cities. In Hymer's seminal report 'The Multinational and the Law of Uneven Development'[3] he defined a global system in which the hierarchical division of labour between geographical regions

matches the vertical division of labour within firms. The system would 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. 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. Indeed, it appears that a disproportionate system has evolved over the past centuries, and where its impact on issues of population growth, social inequalities, and environmental degradation are paramount to contemporary and future sustainability. To improve this system, many believe that demographic and new world economic forces should be curbed - but this is highly unlikely as these forces are not driven by deliberate decisions but rather by self-organizing demographic and technological developments. Instead the challenge is to sophisticate governance so that it is attuned to the powerful forces surging ahead. Thus, we have to deal with both a 'crisis of complexity' and a 'crisis of governance', or in the words of German philosopher Jurgen Habermas - 'domestic policy on the scale of the planet'[4]. However, today integral multidisciplinary definitions of sustainability are hard to find – where instead hundreds of fragmented and highly specific variants exist. Therefore a new definition for sustainability should become coherent, interdisciplinary and adaptable to shifting content and different users.

1.2 Sustainability and Scarcity:

The word 'sustainability' 'nachhaltigkeit' was first used in 1712 by the German scientist Hans Carl von Carlowitz - but the notion of sustainability as a 'normative' concept only truly developed during the first phase of the Industrial Revolution with the 'Principle of Population' by political economist Thomas Malthus (1798). It is in this period that city-firm networks and trade started to flourish, gradually progressing towards today's higher scales of inter-scalar interdependency. It is therefore not surprising that the true conception of 'sustainable development' dates from the latter half of the 20th century when population increase and resource demand began to escalate. For instance, the 'Limits to Growth' (Meadows et al 1972) published by the Club of Rome reasoned that the world's economy 'could not continue to grow infinitely'. Later, the Bruntlandt report was created as a complete vision of 'global' human development and sustainability. The results of this report formed the basis of Agenda 21 which led to a worldwide acceptance of the interrelation between economy, equity, and ecology. Today, humanity is at a crossroads in dealing with multiple social and environmental threats - with a premise being that we are in a new 'planetary' phase of civilization and at the beginning of a fundamentally new type of engagement with history[5]. New opportunities and threats accompany our expanding

global connectivity and heightened disjuncture around nation, ethnicity and class[6]. These transformations in sustainability appear to be motored by cyclic socio-economic innovations and spatial jumps in global interdependency – while the space in which we survive remains constrained. Parallel to this development we see the sophistication of the concept of sustainability - for instance the Club of Rome (1968), the Kyoto Protocol (1997) or the World Summit on Sustainable Development (2002). The main trends are increasing scalar awareness of the interdependence between cities and nations, more sophisticated indexes to measure sustainability and the stronger interaction between science, policy and development.

Since 1900 the world population has more than quadrupled. Not surprisingly, the 20th century has been called 'the century of population[7]. This means a quantitative and qualitative increase of human demand in an already overburdened world. 20 percent of the world's population consume 85 percent of the goods and services, while 3 billion live in extreme poverty. By the year 2020 most people will live in crowded cities where the gap between rich and poor will be bigger than ever[8]. It is evidently is a global problem that requires a global solution! Furthermore, the world's food production will have to increase by 40 percent over the next 20 years.[9] Energy consumption in 2020 will rise to a point where the developing world will overtake the developed countries in total carbon emissions. Today, both the increase of world population and the new world economy create unprecedented complexity in economic, social, political and environmental matters[10]. The rates of transformation produced by these two forces contrasts strongly with the slow evolution of governmental institutions because they lack flexibility and prove to be extremely hierarchic and overburdened. In this context The World Bank's vice-president for Europe, J. F. Rischard argues for 'network institutions' which should be highly adaptive, horizontally organized and highly competent. However, before 'network governance' can be made, it has to become empirically clearer what the networks are that people are to govern!

1.3 Governance and Nation States:

To what extent should political leaders see their role narrowly in terms of promoting the interests of their citizens and to what extent should they be concerned with the welfare of people everywhere?'[11] A central problem to answering this question is the issue of the nation state and the concept of national sovereignty - a phenomenon which can roughly be traced back to the Treaty of Westphalia in 1648. The nation state which started as a relatively simple territorial model within geographically determined borders has slowly been shaken by globalization - this leading to the weakening of the political system that is embedded within the nation and producing the obvious tensions between national, regional and global policies. This means that these 'overlapping communities of fate' can no longer be the sole *decisive* units from which to conduct global democratic discourse[12].

Even G7-type groupings and international institutions do not have the proper ability to tackle present and future global issues efficiently. A new kind of 'network governance' is necessary - which according to economist Hayek would better engage with the forces of competition so as to bring about a market that equalises opportunity within the system[13]. In corporate network terms this would mean – how to increase the probability of poorly connected areas forming corporate connections with the existing network system. However, this is still not the case today, where instead there is evidence that globalization is simply generating shifts in self-interest, where states are adopting mercantilist strategies to consolidate their power in what Saskia Sassen has termed a 'de-nationalization of national territory' - because states need firms in the process of material wealth creation, while firms need states to provide the necessary supportive infrastructures. Nonetheless, what is most evident is that multinational corporations today tie national and local economies more closely into the global economy than ever before – where the internationalization of business operations increases the permeability of firm boundaries and the fragmentation of markets.[14]

1.4 City-firm networks:

World cities like New York, Paris and Tokyo today exist on a global scale, making them much larger and more spatially extensive than other objects of social enquiry. It has been said that mapping the structure of world cities presents a methodological challenge for collecting, compiling and analysing data, in some ways comparable to the problems faced by astronomers in charting galactic structures. To date most research on world cities and on the structure of the larger world city system has tended towards the impressionistic. A large part of this discrepancy is attributable to the paucity of data, which would be appropriate for a rigorous exploration of the structure of the world city system[15]. Nonetheless, it is important to get a grip on the structures of world cities and their impact on global sustainability - because their luxury tends to obscure the poverty upon which their wealth is based – 'where rich and poor define each other'[16]. This system is structured on inequalities of immense power and profound weakness, in which vast wealth coexists with extreme poverty and depends on the marginalisation of the majority of world cities. Within this system for instance the fate of Sub-Saharan Africa's trade is principally that of being only a supplier of raw material and a captive market for relatively mundane goods. Through this the continent has generally been unable to develop since its decolonisation and this issue is central to Africa's peripheralization and current crisis! Therefore we need to be sceptical about the disproportional manifestation of 'world city hierarchy'. It raises questions about what this structure is, how it got to be that way, and what can be done about it!

The literature on world cities is rich with claims regarding the effects of current globalization on the world system. Friedmann and Sassen argue that the 'restructuring'

that the world economy has 'recently' undergone has generated a new urban hierarchy that cuts across the traditional divides in the world system. Hymer, in contrast thought that globalization would largely reproduce 'pre-existing' cross-national patterns of inequality and interdependency[17]. The literature on world cities strongly suggests that the world city system is characterized by a simple core/periphery structure, where in the core one will find those cities that play the role of 'world city.' The cities occupying this position act as 'headquarter cities' acting as 'basing points in the spatial organization and articulation of production and market and as 'concentrated command points in the organization of the world economy'. In the periphery one finds the role of 'branch plant cities' cities to which only the mundane activities of the world economy are assigned. This to the extent that such a structure exists - (1) cities within the core/headquarter city category always tend to be adjacent to other headquarter cities, (2) headquarter cities are adjacent to some peripheral/branch plant cities and, (3) peripheral/branch plant cities will tend not connect with other branch plant cities.

While Hymer's (1972) essay has been widely cited, most contemporary research on the world city system takes its lead from John Friedmann (1986), whose statement of the world city hypothesis consists of a series of generalizations regarding urbanization within the context of globalization[18]: In this - (1) the form and extent of a city's integration with the world economy and the functions assigned to the city in the new spatial division of labour, will be decisive for any structural changes occurring within it. (2) Key cities throughout the world are used by global capital as 'basing points' in the spatial organization and articulation of production and markets. The resulting linkages make it possible to arrange world cities into a complex spatial hierarchy. (3) The global control functions of world cities are directly reflected in the structure and dynamics of their production sectors and employment. (4) World cities are major sites for the concentration and accumulation of international capital. (5) World cities are points of destination for large numbers of both domestic and/or international migrants. (6) World city formation brings into focus the major contradictions of industrial capitalism-among them spatial and class polarization. (7) World city growth generates social costs at rates that tend to exceed the fiscal capacity of the state. Today the conceptions of Friedmann and Hymer seem more evident than before!

Friedmann's world city hypothesis has opened up a new way of questioning cities - one that situates the city in the context of capitalism, rather than merely principles of human ecology. In this sense it is observed that world cities play a distinct role in the articulation of regional, national, and international economies, into a global economy - serving as the organizing nodes of a global economic system. World cities are firstly centres that have power, linking the fields that they are central to into the world economy. Secondly, the regional, national and international fields that are articulated by world cities are smaller than the world as a whole. Many regions around the world are isolates (not connected)

with respect to the world city system. Thirdly, the boundaries of world cities are ultimately not defined by administrative or political criteria but by patterns of interaction[19]. Fourth, world cities are sorted into a hierarchy on the basis of the economic power that they command. Cities of the first rank are those that serve as the 'command and control centres of the global economy'. Below these are the cities that articulate the economies of multiple nations into the world economy and at a lower level are those that articulate national and sub-national economies. The world map is one of a core space articulated by a small number of regional control centres and a fragmented marginalized periphery'[20].Fifth, the world city system generates 'the transnational capitalist class' that shares common economic interests, a common culture of cosmopolitanism and a common ideology of consumerism. Furthermore Friedmann characterized the world city system with ranks and entrance criteria that are principally open - to the extent that cities attract investment and capture most of the command and control functions of the world economy. While generally cities such as New York, London and Tokyo emerge as cities of the first rank - in any empirical analysis cities, may shift rank either dropping or rising in hierarchy.

Saskia Sassen's (1991) account of the world city hypothesis has also had strong influence on world city system analysis. Sassen's account stresses the novelty of the 'complex duality' presently driving processes of urbanization - that of the 'spatially dispersed yet globally integrated organization of economic activity'. While globalization has resulted in relocation of many mundane secondary sector activities it has not been accompanied by any corresponding decentralization of control. Instead control has become even more centralized. The fundamental dynamic Sassen suggests, is that the more globalised the economy becomes, the higher the agglomeration of central functions in the global cities'. While sharing much in common with Hymer and Friedmann, Sassen's approach is distinctive to the extent that it problematises power in the world city system. The case studies of New York, Tokyo and London presented in her book 'The Global City' focus less on the position of cities in a global network and more on the practice of control. Where earlier statements of the world city hypothesis assumed the production and reproduction of control - Sassen stipulates the emergence of a range of specialized producer and financial services that facilitate the global control exercised by firms.

Hence, according to Sassen, in addition to their traditional roles as centres of trade and banking, world cities function in four novel ways: (1) as highly concentrated command points in the organization of the world economy, (2) as key locations for finance and specialized service firms which have replaced manufacturing as the leading economic sector, (3) as sites of production which include the production of innovations in these leading industries, (4) as markets for the products and innovations produced. Furthermore, Sassen stresses that in addition to their distinctive role as centres of control and of finance and producer services world cities exhibit a similar income and occupational

distribution characterized by sharp and growing polarization. Considering the world city system as a whole, Sassen's vision is similar to Friedmann's – where the new urban hierarchy generated by globalization cuts across old divides in the world system. Certain areas in the developed world which were once 'core' areas (e.g. Detroit, Liverpool and Nagoya) are now being peripheralized. On the other hand, cities such as Sao Paulo and Mexico City have begun to emerge as cities of the first rank - areas once conceptualized as 'peripheral' are joining the core[21]. However, as previously mentioned, there remains a vast territory such as sub-Saharan Africa that has been increasingly excluded from the major economic processes that fuel economic growth in the new global economy.

Furthermore, Friedmann's 'world city hypothesis' represents a flat horizontal structure and its nodal pattern reflects the conventional structure of vertically organized central place hierarchies. But in today's urban network systems these types of hierarchies are becoming significantly more complex. On the one hand there is a growing differentiation in the economic functions between cities at the same level whereby a blurring of its hierarchy generates a 'horizontal' network structure[22]. On the other hand this horizontal network will also have 'vertical' linkages to networks at other levels. Therefore the previous structure is becoming even more blurred than before. Through this an intricate three-dimensional network is being formed, defined specifically by types of economic functions and information necessity. The development of new information technology has significantly contributed to economies of scale and through digitisation has made services and knowledge highly transmissible over long distances. Besides, it appears that changes in proximity requirements is resulting in a momentous decentralisation of production from core areas to peripheral regions, hereby again breaking the rigidity of Friedmann's world city hierarchy. In fact, Friedmann's model still continues to persist, except that it has shifted to a higher scale of observation.

It seems increasingly clear that world systems analysis should transcend as merely an instrument to interpret history, and move towards a novel empirically based theory that captures the underlying tendencies of development. This understanding may someday help to construct a more humane, less exploitive world society[23]. In this sense it should be realized that network analysis comprises more than economic networks alone, but constitutes social, cultural, environmental, spatial, infrastructural and political manifestations as well! Through internet and other forms of communication technology, these networks are expanding rapidly, slowly turning regions, nations and cities inside out, by implying new relationships between national, regional developments, rural and urban production and consumption, and between advanced countries and the developing world. In this sense, proximity is no longer a concept that refers simply to physical distance but instead encompasses techno-economic, cultural and geographical proximity of the actors. In the urban sense the advance of networks is more profound than simply a move from monocentric networks towards dispersed polycentric ones. Instead, complex

intricate hierarchies between different social and environmental parameters emerge, both dispersed and concentrated. Furthermore, anomalies such as terrorist attacks or massive breakdowns of power grids in cities demonstrate a highly ignored fact of our globalizing world – that the true vulnerability of mankind is our extreme dependence on interconnectivity[24].

1.5 Theory Conclusions:

At a policy level we can say that to effectively address sustainability we need to better understand the issue of scarcity. It is this force that arguably lies at the heart of all other social and environmental issues on sustainability. To supply increasing human demand, a highly uneven system has evolved with enormous prospects and severe predicaments, where the issues of population growth, social inequalities and environmental degradation are clearly evident. The world needs to deal with both an increasing crisis of complexity and a crisis of governance. To take on complexity, governments need to understand scarcity and the formation of interscalar economic networks. In that way governments will better understand how markets are organized in geographic space and what their impact is on worldwide development. By placing economics at the heart of all other sustainability issues, a more effective and unified approach may someday be achieved. In a steadily globalizing world this approach will eventually require domestic policy at the scale of the planet. Today's piecemeal and generally isolated governmental approaches are no longer effectual. Instead, a systemic policy approach is required that matches the unrestrained networks of the world economy! It is these networks that already connect all governments and governance levels – more so today than ever before. Therefore, to achieve a more unified policy approach, a clearer understanding of the system is needed – one that reveals its structures, processes and impacts upon the planet. This means that to become truly effective, universal policies (global governance) of the entire system are necessary - and within that, different subscales of governance (regional, national and municipal).

It is clear that governments are slowly becoming more aware that the increasing integration of our global society is simultaneously causing greater social and environmental impact on the planet. However, this understanding remains rather generic, where the impacts and responsibilities of nations are still treated quite commonly. It seems that a more sophisticated understanding of the interactions between and within countries regions nations and cities is needed so as to pinpoint specific responsibilities. In this way for instance, the precise impact (network relationships) of The Netherlands upon other areas can be uncovered, from which appropriate policies at each level can be developed. Dutch policies at global, regional and local scales! To do this it is argued in this research that a network approach to sustainability is needed, which treats the world as an interactive multilayered system, instead of merely a collection of isolated nations. It means a move from the simple 'international' policy thinking of the past, towards a global

'network' policy. It is obvious that as populations grow and scarcity increases so too will the environment be put under further stress, as more and more energy and resources are consumed. The complexity is composed of both a supply and demand problem. People are challenged to resolve the social inequalities of the masses which ironically lead to higher consumption and further stress on the environment. If governments are to alleviate human poverty, they have to do so without further devastating the environment. As globalization surges, so too do the levels of complexity and uncertainty increase – all driven by escalating scarcity.

A network economy has emerged that is best characterized as a self-organizing system regulated to a certain degree by policies which primarily benefit the developed world. Because of continuing protectionist measures such as trade barriers - true specialization and comparative advantages have not yet been effectively implemented in the world. This raises the question of what kind of governance will someday match the complexity and elusiveness of the network economy and what kind of policies will benefit more people. It seems that firstly an improved understanding of the worlds economic system will be needed in which it becomes clearer what the structures of command; control and subservience are better understood. Because multinationals connect nations regions and cities - driving the world economy - it seems evident that if governments wish to improve worldwide social and environmental conditions, they need to start with policies to regulate global multinational activity. However, because multinationals are more flexible than nations, they can easily move when threatened. Therefore, to properly tackle the impacts of multinationals will require specified consensus amongst nations and the application of the same laws everywhere! These laws should both facilitate and stimulate multinational activity, while decreasing the detrimental impact on societies and environments. The laws should attempt to stimulate economic growth, competitivity and trade liberalization to a greater number of nations and cities. Because national economies are increasingly dependent on international relations, national governance should equally address domestic issues as well as international ones. Prospects and predicaments at the international level greatly effect domestic developments. To achieve this, clearer understanding of the economic relationships between cities nations and regions is required. This means an understanding of the corporate networks which tie our world together and that have highest impact on societal and environmental development – which implies a more elaborate definition and conceptualization of sustainability. The emergence of globalisation and urban networks should compel policy makers and planners to reconsider the reach of their professions - where the effects and intricacies of new economic socio-cultural and environmental dynamics should become more pronounced. This certainly refers to our extreme dependence on interconnectivity and our subsequent vulnerability. Core-periphery and command-control relations of global cities upon others should be addressed, whereby network analysis can provide a means for a more sophisticated multi-scalar approach towards policy making.

Because the restructuring and reinforcing of worldwide economic networks is fragmenting the more domestic urban and regional patterns a lot can be learnt from the interaction between network and agglomeration analysis. Because the restructuring is creating higher scales of spatial awareness, so too should governmental policy cover higher scales of responsibility. This questions the degree of interaction between decentralization and centralization policies. Furthermore, as advanced producer services appear to be the gatekeepers of the world economy it becomes interesting how governments can address these firms in future.
Although social political technological and business networks tie our world together governments lack an appropriate understanding of what business networks are and a suitable mode of network analysis to deal with our everyday problems. By knowing the patterns of networking we can better understand how to take action. Two important forces for governments to tackle are the forces of deregulation and liberalization which have increased the opportunities of firms to access foreign markets and to enter different business systems – but which carry the common social and environmental predicaments. These policies have also increased the risk and the uncertainty of the environment for international business operations.

The power of world cities is inherently relational, where cities do not have power within themselves - but to the extent that they function as command points and centres of planning - thus establishing the framework in which other cities operate within the world economy. Moreover, network analysts have developed a set of tools that enable those interested in pursuing city networks: (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. Smith and Timberlake characterize this potentially mating of theory and method as a 'perfect marriage.' Unfortunately few researchers have pursued this union.

The network is a map of the history of the system. In networks, the past matters - where a memory of it is frozen in place and shapes the present. These networks provide a comprehensible graphic image of how our lives become entwined in ways as innumerable as they are barely understandable. To comprehend these networks we first have to reveal the configuration of present and absent connections between actors. While present connections obviously are the existing relationships and exchanges between members the notion of absent connections remains controversial and could be interpreted in many ways. Absent connections could be for example needs for resources and information which are not satisfied or potential relationships that lead to new opportunities for linking network members that have some resources at their disposal. We can say that there is a potential link which is absent at a given moment. Comprehending such characteristics will contribute to a network understanding of sustainability which can be understood as 'the relationship between different strengths of linkage, ranging from high connectivity to zero

connectivity'. Who is and is not linked and how disproportionate are these linkages? Furthermore, the probability of a future connections is determined by the potential resources and returns located in a particular node. The level of potential in nodes determines the configuration and behavior of its participants – and the integrity of the entire system. Both network understanding and a new definition of sustainability will be investigated in the subsequent chapters.

2. CONCEPT:

2.1 Scarcity, Networks, Globalization and Urbanization:

In the previous chapter sustainability and networks have been explored at the contemporary level. Many characteristics and relationships have been identified such as scarcity, scale increase, nation state versus corporation, protectionism and liberalization etc. However, it now becomes interesting to investigate how networks have evolved over the past centuries, so as to give better insight into the temporal characteristics of network formation. This, especially seeing that ever since the Industrial Revolution, technological and social innovations have been paramount to global economic development, supplying and creating new forms of demand. Shifting scarcity appears to be leading to a type of progression that is suspended between the processes of globalization and urbanization - generating an increasingly unequal distribution of technology, capital and labor. A new form of society is emerging which requires a paradigmatic shift in how we perceive and engage with the world[25]. Pivotal to this will be the re-conception of sustainability and the derivation of appropriate policies and interventions. Because cities form increasingly interdependent systems in which societal and environmental prospects and predicaments are evident - they should become developed as integral components of an emergent world-city-network. A contested 'networked space' that is increasingly limited in scope and resources. Within this evolutionary context, the city's transition can be observed, reflecting the ancient struggle between economic production and societal wellbeing. Here, a 'circular causality' exists between firms, cities and their networks, - where a city or nations performance is a measure between its business relations and the wellbeing of its people. A city therefore must develop itself according to its relative position within the network. But today little is known about city-firm network relationships and their environmental impact. An understanding of corporate 'network footprints' and how these coincide with urban development becomes exceedingly important, where sustainability is defined as the interrelationship between inter-scalar city-firm networks and social, economic and environmental indicators within cities.

In the following section an attempt is made at investigating how humans overcome 'changing scarcity' by means of globalization (functional integration) and urbanization (spatial integration). It is argued that both of these phenomena concern network

formation, where the former concerns the more non-physical entities (economic, social, political functions) and the latter specifically physical ones (urban and infrastructural elements). It is the reconciliation between these two phenomena that forms the greatest challenge to humanity. At a deeper level urbanization is explored as the unfolding of an integrating urban spatial system, comprised of 'network' (space and connections between cities) and 'nodal' (space and connections within cities) properties.

2.2 Networks and Globalization:

Globalization reflects the increased international mobility of goods, people, contracts and thoughts – which especially over the past three decades have become a recognised force throughout the world and their impact on societies, ubiquitously leading to differing viewpoints on issues such as 'homogenization' and 'equality' and where a divide between globalization's supporters and contenders has appeared. This emergent condition stems from globalization's seemingly contradictory properties of 'convergence' and 'divergence'. More importantly, globalization itself is a century's old process – whereby an important observation can be made - that all of today's developed countries began their process of development before the 1880s. Today, hierarchies of economies and cities exist just as before, reflecting on the one hand an 'integrating' world and on the other 'fragmenting' societies. In this report it is argued that answers to developmental progress are equally dependent on an improved theoretical and empirical understanding of the co-evolutionary processes between globalization and urbanization. From this we may become better equipped at understanding the present phase of the 'network society' and anticipate its future development. Because globalization and urbanization are not entirely new phenomena, it pays to seek explanations that can account for more than just the prominent events over the past few decades. Before proceeding with this, it is interesting to first discuss the origin of these phenomena, namely 'scarcity'.

Humanity has always and will probably always be subjected to scarcity, in which a perpetual imbalance between societal demand and supply exists. This imbalance is not simply due to more people needing more resources, but especially due to the diversification of demand, whereby people want an increasing variety of goods and services to satisfy themselves. 'Because wealth has increased, so too has human desire - and while incomes continuously rise, human satisfaction does not'[26]. Where GDP per capita, health and life expectancy have escalated, so too paradoxically have scarcity and unsatisfaction, and this rising demand increasingly puts pressure on supplies in a world where space and resources are limited. Increasing scarcity has led to rising complexity in mans pursuit to satisfy demand and it is through societal and technological innovation that the limited resources have slowly been optimized – or as once captured in Plato's epigram - 'necessity is the mother of invention'. We should take note that scarcity is a relative concept which has transformed throughout human history, especially over the last few centuries. Even today, scarcity remains a relative concept, in a world in which the gap

between rich and poor is increasing and where the needs of the poor majority are quite different to that of the wealthy. Most important to consider is that scarcity deems to have a highly disproportionate structure, which will be shown in following chapters. Defining the inherent structure and properties of scarcity, will play a vital role in defining normative concepts such as 'sustainability' and 'equality'. In this report the increase of scarcity (and the uncertainty it entails) are seen as the driving force behind globalization (functional integration) and urbanization (spatial integration), which in turn both serve as human devices to overcome it.

2.3 Networks and Urbanization:

It is plausible that a more effective route to future city development is to avoid developing cities as isolated, 'closed' entities, but instead as integral components of an emergent world-city-network. In this report the 'network society' and it's related 'world-city-network' are viewed as fundamental to the human condition and not merely the contemporary outcomes of human development - as is often popularized today[27]. In this light, the understanding of the co-evolution between 'globalization' 'urbanization' and its subsequent 'network-formation' can be seen to follow an extensive historical tradition in which the transition of the city as both a real and conceptual entity can be traced, from simplified models towards today's highly complex urban networks. A transition that appears to reflect the perpetual interaction between the 'self-organising' processes of an emerging world-city-network and the 'planned' often utopian national and urban concepts of a transforming network society- a struggle between a mode of economic production versus the preconceived ideals of societal wellbeing. Over the last few decades there has been increased interest in the role and nature of the dynamics of urban systems[28] which has been fuelled by the globalization debate and is closely related to world systems theory of Wallerstein and Chase-Dunn. In this, we see the shift from the perception of cities as single entities to cities as part of city systems (v.d. Knaap 2005). Although frequently theoretical reference is made to cities being part of a network of cities, there is neither much theoretical concern nor empirical evidence concerning the role of cities in such networks! Cities continue to be regarded as singular nodes operating in isolation rather than being part of a larger system (v.d. Knaap 2005). For instance, within this context Peter Taylor has shown that within the world city literature, there are 375 references to attribute data which far exceed the 51 relational data references (Taylor 2004). Taylor further explains that 'defining a hierarchy requires more than producing attribute measures - there has to be some notion of control up and down different levels'.

However, although the reinvigorated talk of the 'network society' is fashionable today, the conception of the city as a 'node' in a network and a 'place' in space is not entirely new – although it has certainly become more sophisticated. The network concept was already evident in the ancient Egyptian hieroglyphic for the city, consisting of a cross (the external

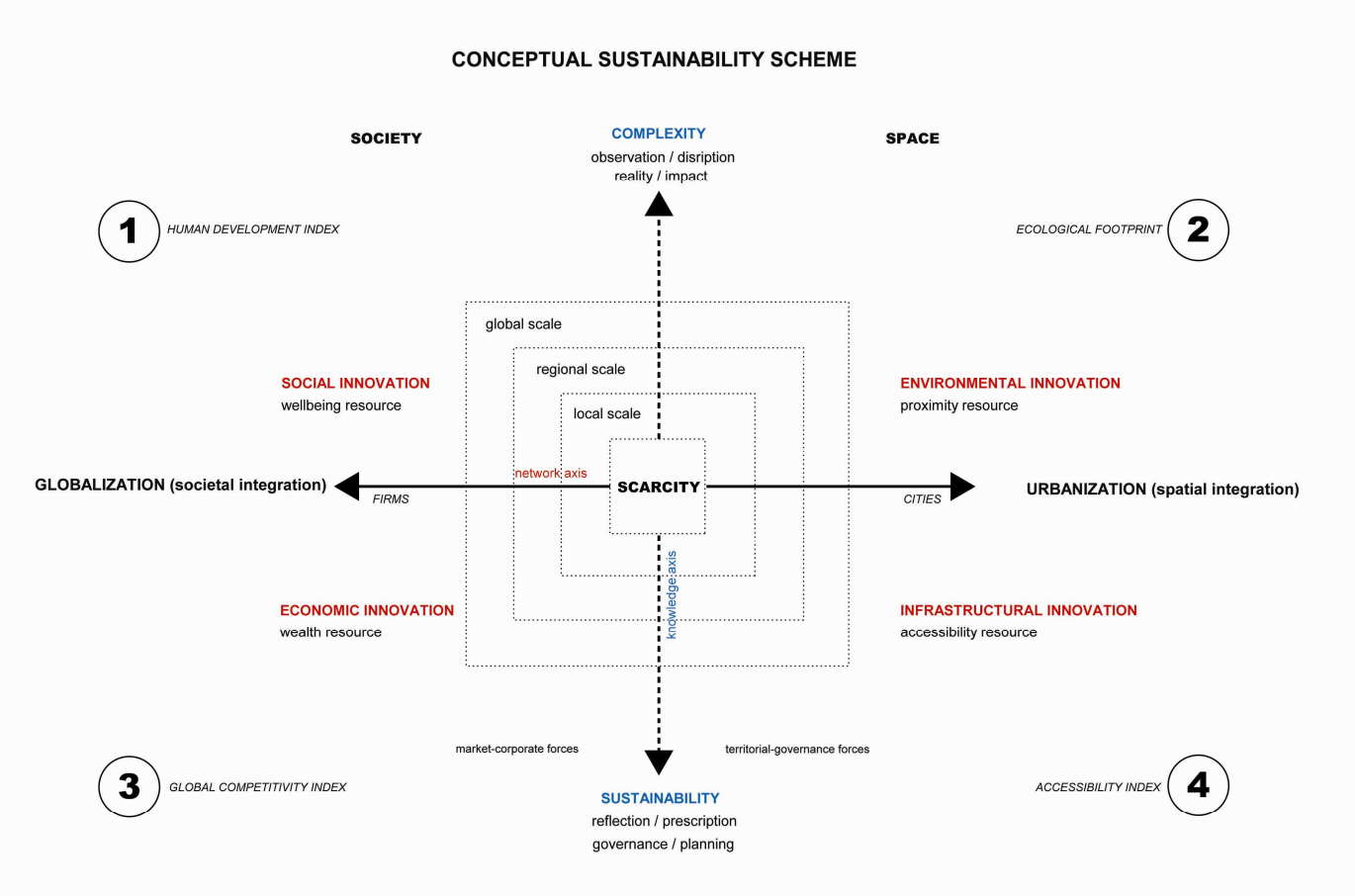
networks) inside a circle (the place) - already synthesizing the dual 'exogenous' and 'endogenous' roles of the city (Camagni 1993)[29]. And according to historians J.R and W.H. Mc Neill (2003), authors of The Human Web, the complete chronological progression of mankind can be equated to the gradual formation of worldwide networks or 'webs' initiated by the development of speech and the consequential invention of archaic technologies[30]. These primordial networks allowed for trade and communication and have progressively become more and more complex and diverse over time, especially since the advent of industrialization, population explosions and the more recent developments of globalization. It is especially the rate at which ideas are passed between people that has determined the rate of human progress. Where long ago the only way to transfer ideas was via person-to-person conversations progress was measured in millennia starting with the evolution of homo-sapiens in 200 000 BC. Egyptian hieroglyphs led the way to 'writing' and much later Gutenberg's press (circa 1455) allowed for the increased mobility and dissemination of ideas. Without printed books it is hard to imagine that there could ever have been an Industrial and Scientific Revolution, and no advanced technology and communication networks – at least not so quickly. Today, internet and search engines like Google have boosted human communication collaboration potential and knowledge capacity to an unprecedented height.

If we consider planning through the ages, we see that it has always been a means of controlling uncertainty and facilitating a desired destiny. This raises questions about what kind of plan can manage the dynamic complexities which influence today's cities. Furthermore, 'does planning need the plan' as Michael Neuman[31] posits, or do we need to plan processes? This is addressed in the works of Juval Portugali, in which he conceives cities as self-organizing processes - systems that are profoundly unstable, chaotic and unpredictable. Cities are both 'open' in the sense that they exchange matter, energy, information and people with their environment and 'complex' in the sense that their parts are so numerous and changing that there is no way to describe them simply in terms of cause and effect. Portugali[32] imagines that a new type of urban planning is needed, in which the aim is not to control the city by enforcing blue prints, but instead to participate with the system. Order in such a system is temporarily realized through the interaction of the spatial scales beyond and below the level of observation. This does not mean we have no influence, but that the city can be guided by identifying and intervening with a cities 'order-parameters', which can imaginably be the intersection points of multiple transport and communication networks, which form the vital interface (order-parameters) between a cities internal and external relations.

2.3 Conceptual Scheme of Sustainability:

In this research it is argued that an important step forward to the development of sustainability and environmental planning will be an improved understanding of the

complex formation of network relationships between firms and cities across different spatio-temporal scales – and how this coincides with the social, economic and environmental performances of these cities. Based on knowledge from the previous chapters, this chapter will focus on a specific definition and problematization of the concept of sustainability, structured around the scheme provided below. The scheme is a spatio-temporal construct in which it is posited that *sustainability* is a 'normative' concept that has gradually developed over the past two centuries and which is embedded between the co-evolutionary processes of *globalization* and *urbanization*. These intertwined processes have led to an incremental increase of *complexity,* which has primarily been driven by the less normative forces of profit maximization and capital accumulation.



At the heart of this scheme we find the phenomenon of *scarcity,* in which the human struggle between demand and supply is progressively overcome and regenerated by two different approaches, namely 'network formation' and 'knowledge formation'. Network formation in this scheme consists of a functional *societal* component i.e. 'globalization' and a structural *spatial* component i.e. 'urbanization'. Globalization in turn is comprised of two parts namely 'social innovation' and 'economic innovation'. On the opposite side, urbanization is composed of 'environmental innovation' and 'infrastructural innovation'. The former addresses the performance of cities or nations and the later targets infrastructures that connect cities. From this focus is made on the clustering of different types of firms within cities and the spatial network relationships between cities that derive

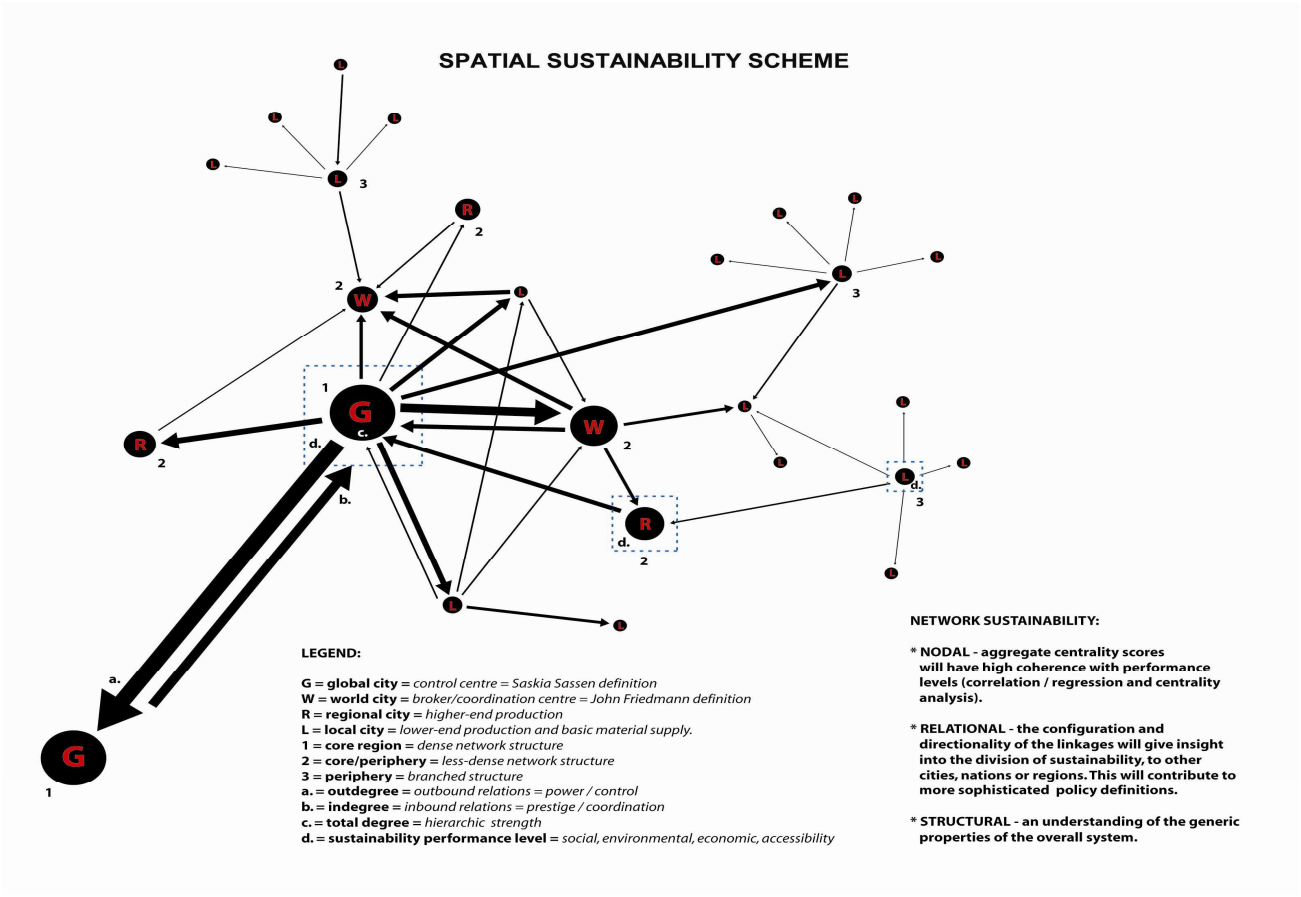
from this. Also the coherence to existing environmental variables will be sought (marked by numbers).

As the scheme further indicates, the gradual development of our 'network society' has coincided with an increased 'jumping of scales' (from micro, meso, towards macro scale). In this sense scarcity has been overcome by both an increased exploitation of space and an increased socio-economic system to manage it. Suspended between this, a growing complexity is found, from which societal and spatial problems emerge, and which generally leads to uncertainty within the system. Complexity (and the uncertainty endemic to it) is the unintentional but inevitable result of the overcoming of scarcity and it in itself forms the trigger for new innovations. In this context, complexity is continuously being challenged by corporate and political forces, either in the act of self-interest or through collective-interests. Shown in the scheme the conception of sustainability is positioned at the opposite pole of the 'axis of knowledge formation', as a normative and interventional action, which seeks a conscious and continuous optimization between *market* and *territorial* values – in pursuit of the reduction of uncertainty. As with the other three components of the scheme, sustainability is also steadily subjected to increases in scale. The provided scheme serves merely as means to position and discuss the concept of sustainability, and to structure the research. In a nutshell, our focus will be on the emergent network relationships between firms and cities, the complexity endemic to this, and the development of a better understanding of sustainability within a growing network society.

2.4 Relational Scheme of Sustainability:

Another important conceptual scheme is the one concerning the more empirical part of this report. This concerns a conception of the relational properties of city-firm networks. In the scheme provided below, some of these properties are explained to form an initial understanding. In this research it is argued that a more comprehensive conception of sustainability will be a relational one in which not just isolated measures are made, but specifically a more integral understanding of the relationships between actors and the directions and intensities of their authority. Economics is basically about exchanges between actors (cities, firms, businessmen etc.) concerning resources, production and consumption – with the aim of maximizing profit. It is a self-organizing system which as discussed in the theory has evolved over centuries. It is this socio-economic system which has impact upon society and the environment and this output can be observed and scrutinized in terms of collective good – hence, the gradual emergence of a gradually up-scaled conception of sustainability, not just for matters of well-being, but equally important matters of wealth and power. The scheme below shows the basic aspect of the structure of economic power.

The two main components are simply 'points' (nodes or actors) and 'lines' (connections or ties). The more lines and the stronger the *magnitude* of those lines towards a point - the stronger the magnitude of that point will be. In other words, Amsterdam will expectedly have more connections than Tilburg, which would make Amsterdam's node bigger than Tilburg's. This nodal strength is called the *degree*. In the diagram we also see arrows. If a connection is directed outwards from Amsterdam to Tilburg then the outbound connection is called the *outdegree* and expresses command and control over Tilburg. Because Tilburg is at the receiving end, the connection to Tilburg is its *indegree* reflecting its subservience to other cities. The cities in the world with the highest degree are known as global cities (G) and there are very few of them (New York, Paris London and Tokyo). According to Sassen this is because they are control centres of the higher value information industries of our world – for instance the 'finance, insurance and real-estate' (FIRE) industries. This function of control is specifically captured in their high outdegree, and 'global cities' will always have higher outdegree than indegree – or in other words, they control the global network much more than it controls them. In network analysis the most powerful cities are placed at the centre – which is known as *centrality*. Less high-value connected cities are what Friedmann might call world cities (W) and although they still play a vital role in the world system, they will be placed slightly off centre. These are cities such as Amsterdam or Munich and they often play an important role as brokers and facilitators within the network – which in network jargon is called *betweeness*. In turn, the third order of cities is the regional (R) type. They play important functions as intermediaries between local and global dynamics. These are cities such as Rotterdam or Johannesburg. The smallest type of city is the local (L) which is generally only connected to other local and regional cities in the close proximity. As we drop from global to local levels several structural characteristics appear: (a.) the diversity of economic functions decreases; (b.) the overall strengths of the ties decreases; (c.) the network moves from an integrated criss-cross (vertically and horizontally directed) structure to very hierarchically star-shaped structure; (d.) there is a move from core to peripheral significance; (e.) there is a shift from multi-directional ties to one-directional ties. What we see is that there are in fact different regions of connectivity and in network analysis these are called *clusters*. In our approach we imagine that different types of cluster will require different levels of sustainability policy. Lastly the blue box represents the crux of this research. It is argued that the higher the connectivity of a city nation or regional cluster the higher the level of sustainability measured by indicators in the four quadrants of the conceptual sustainability scheme. The derived network structure tie-strengths and directionality give a sophisticated understanding of the powers of command and control that regulate supply and demand in the quest to overcome scarcity.



3. EMPIRICS:

In this section we investigate two hypotheses which have been derived from the previous theoretical and conceptual formulations. The first hypothesis explores the structure of the global corporate system; the second shows the relationship between city-firm network connectivity and sustainability indicators of nations.

3.1 The structural hypothesis on sustainability:

Hypothesis: *As with statistical distribution the geographic structure of corporate networks between cities will reveal high disproportionality. It is assumed that the total corporate connectivity of cities, nations or supra-regions (nodal scores) will reflect their overall levels of development. More importantly the 'relational' alliances strengths and directions of the connections between nodes will reveal the corporate governance structures of our world. This will give targeted insights into the power relationships (command and subservience) between nodes - and therefore a deeper specification of those held responsible for contemporary sustainability levels.*

3.1.1 Context:

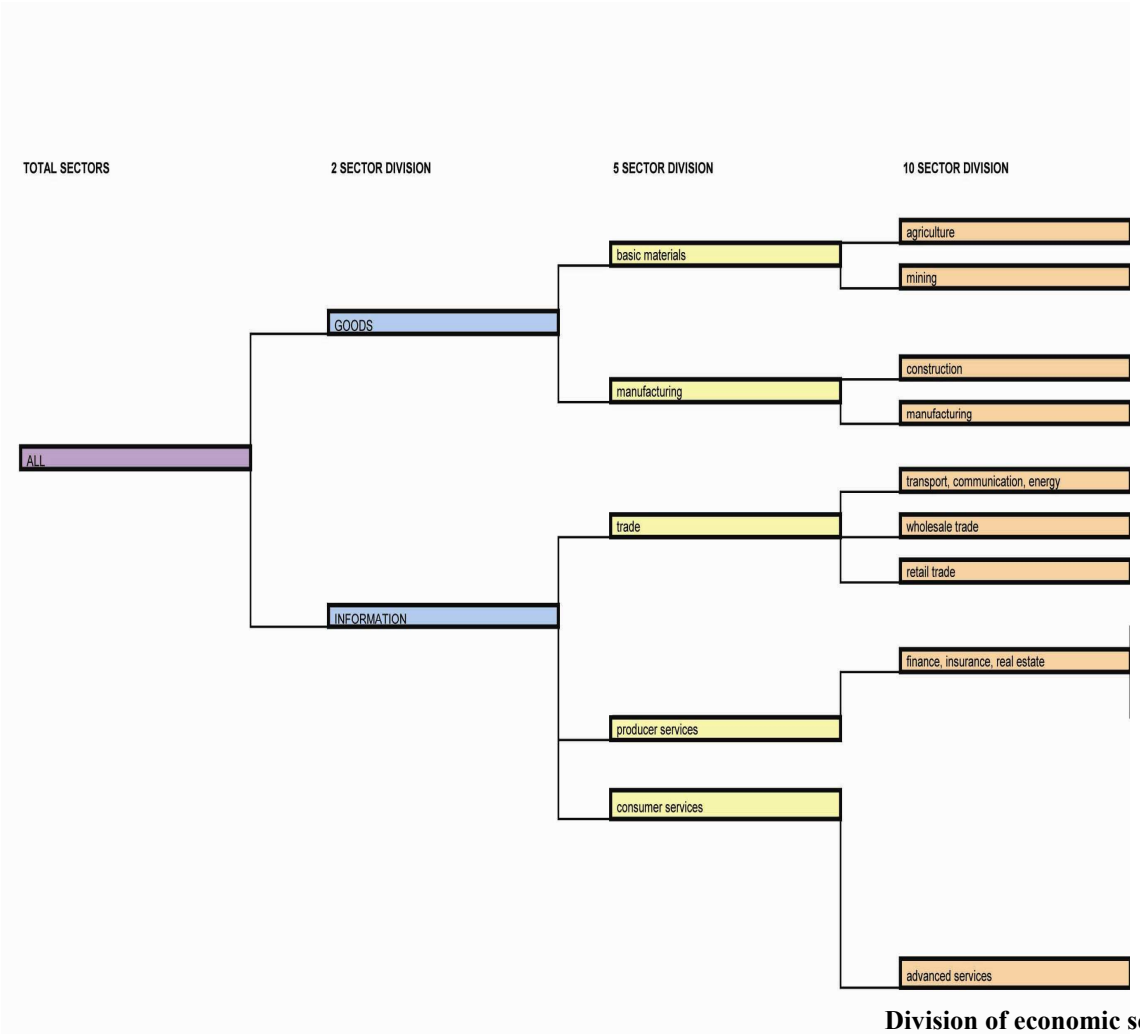
Literature on world cities typically identifies the multinational enterprise as a central agent in the generation of the world city system and generally their economic and political power symbolizes the predicaments of globalization. Multinationals are richer than most countries in the developing world. For instance, in 2004 the revenue of General Motors was greater than the GDP of more than 148 countries. In 2005 Wal-Mart's revenues were greater than the combined GDP of sub-Saharan Africa. Besides being wealthy, these organizations are politically powerful. If governments threaten to tax or regulate them, they simply move to countries who welcome their tax revenues, jobs and foreign investment. A multinationals priority is to survive and exceed in an increasingly ruthless and risky world. The reduction of costs is a generic strategy of every multinational and they will do so in any legal way they can. Yet multinationals also provide the benefits of globalization to developing countries helping raise the standards of living throughout the word. They enable developing countries to trade with developed markets provide jobs and economic growth make market knowledge instantaneously accessible and transfer advanced technology to the developing world. The almost $200 billion dollars they channel each year in foreign direct investment to developing countries has narrowed the resource gap[33].

In general, multinationals are not consciously out to exploit and damage societies and the environment. They operate within an unforeseeable sea of complexity and their successes are more attributed to chance than to controlled planning. Multinationals are highly unstable and the failure rates far exceed the successes. In the theoretical chapters it was discussed that they have a power-law distribution and are therefore are characterized by self-organizational dynamics. Therefore, if society intends to intervene - then the central question is not whether multinationals are good or bad, but instead how governance can strategically intervene to minimize their damage and maximize their benefits to society. Because corporate structures are truly global by nature, piecemeal and dislocated governance will no longer suffice, if sustainability is endeavoured. But without government regulation and pressure from civil society, corporations lack incentives to protect environments and societies sufficiently. It is nothing new that 'glocal' governance is needed and that governments should facilitate corporate, social and environmental responsibility, channel the power of corporations, improve corporate governance, ensure global laws for a global economy, and reduce the scope of corruption. The question is how to understand this system better and operationalize these incentives within a clearer framework. Therefore, what are the corporate relationships between actors (firms, cities, nations and regions)? What is the geographic and inter-scalar structure of the overall system? Who are the governors and the governed of this structure? Who is not a contender within the system?

Geographically the global economy is now multi-polar as new centres of production have emerged in parts of what has historically been the periphery of the world economy. The world is now more accurately described as a mosaic of unevenness, in a continual state of

flux. As previously discussed, these transformations of the geo-economy are influenced primarily by multinational corporations that are the primary movers and shapers of the global economy, because they have the ability to control and coordinate production networks across different countries, so as to take advantage of geographical differences in factor distributions and to switch and re-switch resources globally. To reveal this corporate geography, the first analysis was to map the network. This was done for two different scales of firm aggregation (global and European). The first concerns the top global 100 multinationals of the Fortune 500 listing (2005) – while the second represents the top 100 European multinationals. The ranking of these firms is based on factors such as company revenue and employees. The top 100 of these datasets always claims roughly 60% of the entire datasets corporate revenue. This means that this selection strongly represents the primary economic power of the entire system. For this reason the top 100 have been consistently used for both analyses. The top 100 only represents the leading headquarters, but by evaluating the financial reports of these firms the complete chain of subsidiaries were collected.

The derived global dataset consists of 9243 connections and the European dataset equals 8307 connections. All firms in these datasets have been coded into various divisions of economic sectors (see figure 1). This is an important scheme to keep in mind as it forms the structure of different levels of sectors analysed throughout this research. Horizontally the scheme divides quantitatively into different aggregation levels of firm sectors, moving from 'all-sectors' then '2-secors' '5-sectors' the '10-sectors'. In the vertical axis the scheme is divided qualitatively into functional differentiations starting with a division into material (goods) and immaterial (information) sectors and then divided into various sublevels of these. This could be divided all the way down to the individual names of all respective firms if necessary. Sectors from top to bottom are also ordered according to their importance within the value chain of industries from basic materials (raw-production) to consumer services (end-consumption). Important is that the scheme allows for selective mapping and analysis in which sectors are differentiated and explored. Furthermore, the city location (name), country, supra-region and geographic coordinates for each firm have been identified. From this a formula was used to calculate the linear distances between spatial units. Furthermore, the directionality (outgoing or incoming relation) of every linkage has been identified. From these properties, 'geographic information system' analyses (GIS), statistical analyses (SPSS), and network analyses (UCINET) were carried out. These will be discussed below.



Division of economic sectors
FIGURE 1

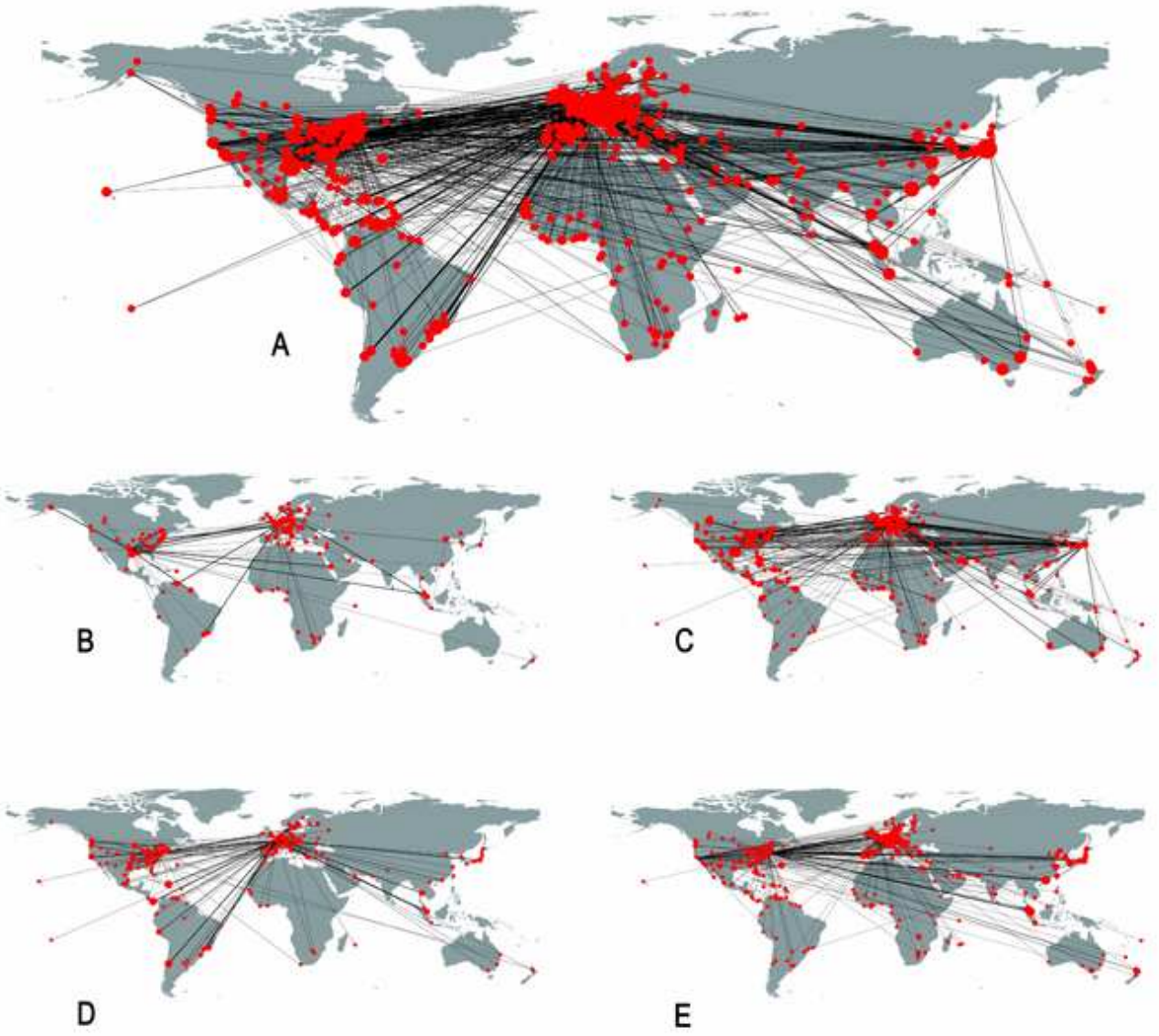
3.1.2 GIS analysis: Networks at the global scale:

Firstly GIS analyses were made, so as to get a first impression of the geographical distribution of corporate networks in Cartesian space. The first diagram reveals city-firm connectivity (figure 2) of the 9243 linkages at the global level. At the top (map A) we see the network of all combined sectors in which the triad of Europe, USA, and Japan becomes immediately visible. It is also evident that the east cost of USA has the highest density of corporate clustering. If we define 'regional intensity' as connectivity over distance, then an increase in the number of connections is proportionate to a decrease in the distance of those connections. This means that regional intensity exponentially decreases from the core to the peripheral regions. Furthermore, the more globally connected a region is, the more regionally connected it will be - indicating that the world in these terms is still strongly polarized and still far from becoming homogenous – which is contrary to popular belief that the world is becoming 'flatter'[34]. This simultaneous structure of 'fragmentation and integration' relates to the rise in business links and destinations within and between regions that have been fuelled by the new transportation and communication technologies and the profit maximizing redistribution of basic material, manufacturing and services industries. Although cheaper transportation and IT networks elude a 'shrinking' world, 'real distance' still apparently matters. Considering that multinational networks account for

roughly one third of world GDP, then this map approximates the division of global economic performance within the core regions. It is clear that although the emerging markets of China and India have impressive national growth rates, their global multinational presence is no that evident. This will presumably change within the next decades in which the South-East Asian core is expected to intensify. Looking at Africa southern Asia and South America we see that activities do exist but that the density is low. Actually this map is somewhat misleading – as the intensity levels in these regions is far lower than it appears on the map - as will be statistically shown later on. This is because the two-dimensional map only partially reveals the diversity of clusters but not the stacked density (3rd dimension) of activities upon each other.

To show an indication of sectoral difference, four basic sectors have been disentangled. In these maps the three core economic regions prevail where variations in economic modes define core, semi-peripheral and peripheral relations. In map B the network of basic materials multinationals is shown. The first insight is that this is the thinnest of the maps - revealing that these industries do not form a significant part of the top-end of the global corporate network structure. However, this does not mean that they are insignificant, but that these networks have been assigned to a relatively lesser position in the world economic system. This means that these networks are found at the bottom of the value-chain. Interesting is that almost all cities are port cities from which resources are distributed to the rest of the world. It is important to realize that the networks represented in these maps reveal different configurations of coordination and production units within specified sectors. This means that for instance the basic-materials map not only represents the physical producers of the resources but also the related coordination facilities of these producers. In this map it is interesting that oil related cities are well represented and that the dominance of Houston is strongly indicated. Map C forms the densest network of the four sub-maps already indicating the dominance and strong distribution of the manufacturing industries. The outsourced division of labor and functions is strongest in this map with strong functions of command and control in the three core markets. Asia's importance to Europe and USA in the manufacturing industries is very clear - and to a lesser degree Africa and Asia. It is also evident that much of the production of manufactured articles for the core market is located within the immediate vicinity of these core regions. The network of trade connectivity is shown in map D. Evident is that Europe forms the heart of the trade industry, stipulating its dependence on trade with other regions, especially USA, South America and South Asia. Although USA is also strong in trade connectivity, its dominant relationship is with Europe. In map E the producer service networks are revealed. It appears that USA (both east and west coast) has the strongest producer service relationships with the world. This is not surprising since much of its manufacturing industry takes place in foreign countries, but is financed, insured and facilitated by producer service headquarters in the US and their subsidiary

regional offices in the foreign countries, where the actual production takes place. Map F 'consumer services' exists but is not shown.



Global dataset networks
FIGURE 2

Map 1: Global city-firm networks:

A = total connections.

B = basic materials connections.

C = manufacturing connections.

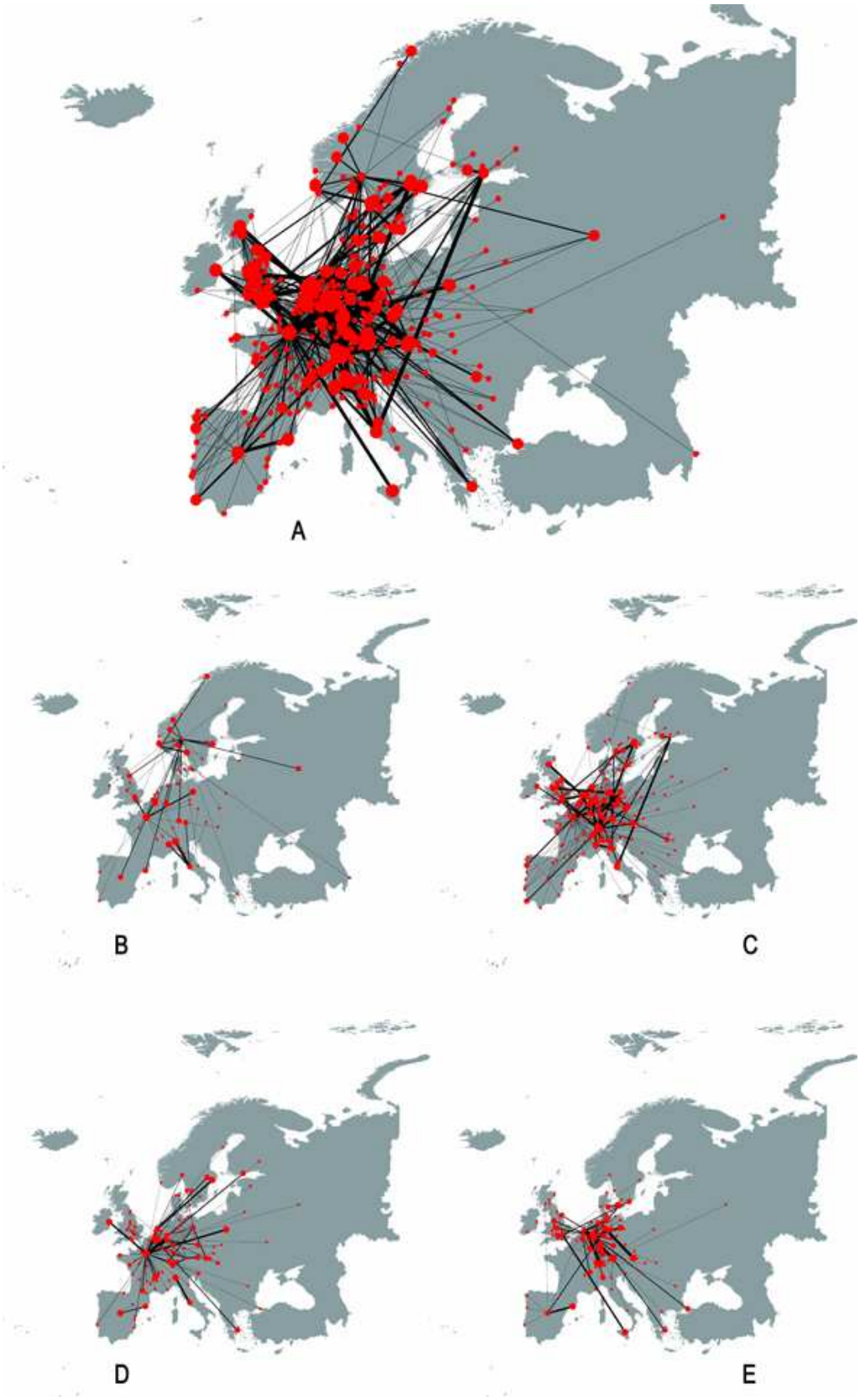
D = trade connections

E = producer services connections

3.1.3 GIS analysis: Networks at the European scale:

Similar to the global network analysis, the European network is illustrated (figure 3). This now concerns the top 100 multinationals located in Europe and all their associated subsidiaries, forming a dataset of 8307 linkages. These were once again mapped using GIS, producing comparable results to that of the global dataset. Here we only see the linkages of these corporations within Europe. The linkages that connect to other parts of the world are not shown here, but are included within the statistical analyses (see later). In map A we immediately see (in terms of proximity) that NW Europe is Europe's core-economic-region and that the once consistent 'blue banana' from London to Rome has dissolved into a nebulous web of cities. It is clear that Eastern Europe plays a subordinate role within Europe's primary corporate networks. The currently emerging participation of East European countries and cities is obviously happening at a lower scale of activity and business importance. It is at these lower scales of network that high competitivity instability and vulnerability occurs – and where contenders are not only from neighboring countries but similar regions throughout the world. These more mundane network areas are often also the areas with highest social and economic turbulence.

Taking a deeper look at the sectoral maps, it is evident that basic materials (map B) are not an intense network. Much of the resources are coordinated through Paris (which is the primary city within this network). Although some resources are obtained in Europe (see Norwegian oil cluster) most is imported from elsewhere. Besides, much of Europe's basic materials is transformed into manufactured goods elsewhere and only enters the European market as manufactured articles. In map C we see that Europe's strongest sector is manufacturing, concerning the more advanced production industries. The network is not only very dense, but also very dispersed and integrated. It is the sector which has the most connections with East Europe, to which particular production activities are outsourced. Trade appears highly centralized in Paris (map D) in which the gross of trade activity is coordinated. In map E we see that the core of producers services are situated right in the heart of the manufacturing activity, illustrating that these firms are located in close proximity to manufacturing firms so as to finance, insure and facilitate their activities. This signifies a high priority on face-face contact between producers and services.



Map 2: European city-firm networks:

A = total connections.

B = basic materials connections.

C = manufacturing connections.

D = trade connections

E = producer services connections

European dataset networks
FIGURE 3

3.1.4 Statistical analysis at the global scale:

In the provided table of regional corporate connectivity (figure 4) further insight into network relations are shown. The table is divided into global and European scales of results so that comparisons can be made. Each scale shows a 2-sector and 5-sector model of corporate sectoral divisions. Important here is that when the model is read left to right it concerns 'governor' relationships. When read from top to bottom it concerns 'governed' relationships. A governor relationship is an expression of command and control over other firms, while a governed relationship is one of subservience to higher corporate authorities. Both relationships are mutually dependent on each other. Furthermore, the supra-regional division of connectivity is shown in three parts (all, goods and information connections). Each part displays the percentage share of 'internal' 'outward' and 'inward' connections. In the global section an additional yellow box shows the division of world trade connectivity (in dollars) in a similar fashion as the corporate networks. At the global scale 2-sector model, command relations (governor) over goods (4674) and information (4569) industries prove to be equally important, while information subsidiaries (5710) are 60% controlled from above and goods only 40%. This shows that information networks will have much denser and more dispersed networks of control and coordination than that of goods. In the 5-sector model it is seen that basic material (335) hold only a 4% share of all command (governor) networks, while manufacturing command relationships hold almost 50%. In the other direction, manufacturing subsidiaries (3234) are 35% controlled from above, followed by trade (2259) at 25%. Looking down the columns we see that basic materials subsidiaries are governed most by manufacturing governors, and manufacturing subsidiaries are most controlled by manufacturing and producer service governors. Trade producer service and consumer service industries are most governed by manufacturing governors.

Observing the supra-regional division of connectivity firstly of 'all connections' we see that the North America and Europe are exceedingly the most dominant core regions, followed at a distance by the region of 'China and Japan'. North America is the most internally connected within its own region (35%) followed by Europe (30%). In outward relations, Europe is by far the strongest, holding (50%) of all outbound connections, while North America holds merely (35%). This means that North America is much less dependent on international corporate relations than Europe – or conversely that Europe is more integrated with the world Economy than North America. Turning to the goods and information sections we see that the shares in internal relations remain roughly the same with North America - always more home dependent than Europe. However, North America (42%) proves to be slightly more outward dependent in the goods industries, while Europe claims the lion's share of information outward connections (67%) – and North America merely (25%). This indicates that Europe is much more an information society than North America and that it is far more globalised and integrated with the world.

Interesting is that developing regions like Sub-Saharan Africa and South East Asia score highest in inward relations, indicating that they are strongly being governed by Europe and North America. Looking at world trade connectivity, which is an entirely different database on import/export (dollars) – we see similar trends. Europe proves to trade most within its own region (24%) and export slightly more than China/Japan and North America. The strongest importer of goods is North America followed by Europe and at a distance China/Japan. More specifically, USA, Germany, Japan, UK, France, China and Italy are the largest importers and exporters. The Netherlands is 12th in import and 9th in export.

3.1.5 Statistical analysis at the European scale:

Looking at the second partition concerning the European dataset, similar observations can be made. Under 'all connections' we see that the percentage share of the European corporate connectivity network is similar in proportion to that of the global dataset, but that these results are pumped up (figure 4). This means that the more one focuses on a region, the higher the relative share of that region will be compared to that of the global dataset's scores. It is important to realize that the European dataset is not a scaled zoom-in of the global dataset (otherwise the scores would remain the same), but that it concerns a 'deepened' dataset which excludes non-European multinationals and includes only the top 100 European multinationals. It is a functional zoom-in, rather than a spatial one. It shows that by deepening the research at the regional level, other trans-regional and trans-national configurations will emerge. These differences are interesting to different policy formations for sustainability. If we were to functionally deepen into only the top 100 firms in The Netherlands, then again an entirely different set of relationships would occur. Imaginable from this are a Dutch, European and global policy on sustainability. It then becomes interesting to question what the interaction will be across these three functional scales. In the table it is clear that the European network consists of almost (40%) internal relations. In the global dataset this was almost (30%). Its outward relationships play a far more significant role at this level (68%) than in the global dataset (50%). This means that the European top 100 multinationals (who have weaker combined revenue than the global 100) are far more internationally active. This could mean that smaller multinationals operate more trans-nationally than larger ones? Peter Dicken has shown that it is indeed generally the smaller firms that have the highest 'transnationality index'. Furthermore, North America is Europe's leading trading partner. North America is far more controlled by European firms (38%) than that it that it commands European firms (26%). All other regions are far more controlled by European industries than that they carry out any influence upon Europe.

GLOBAL DATASET

	goods	information	total
goods	1846	2828	4674
information	1687	2882	4569
total	3533	5710	9243

governed / *governor*

WORLD TRADE	internal connections %	outward connections %	inward connections %
north america	5.9	17.7	28.3
central america	0.1	6.3	6.8
south america	0.6	3.4	2.6
europe	23.7	20.0	22.3
north africa and middle east	0.3	7.2	4.3
sub-saharan africa	0.1	2.2	1.4
east europe and central asia	1.0	8.8	4.7
china and japan	3.6	19.3	15.0
south east asia	2.0	13.2	12.7
australasia	0.1	1.9	2.1
	37	100	100

	basic materials	manufacturing	trade	producer services	consumer services	total
basic materials	6	50	48	134	97	335
manufacturing	171	1619	1113	925	511	4339
trade	67	462	373	328	229	1459
producer services	30	611	366	337	321	1665
consumer services	25	492	359	260	309	1445
total	299	3234	2259	1984	1467	9243

governed / *governor*

	ALL CONNECTIONS			GOODS CONNECTIONS			INFORMATION CONNECTIONS		
	internal connections %	outward connections %	inward connections %	internal connections %	outward connections %	inward connections %	internal connections %	outward connections %	inward connections %
north america	34.9	35.8	20.1	29.6	42.3	17.9	40.2	24.7	24.0
central america	0.3	0.5	7.5	0.2	0.1	7.3	0.3	1.3	7.9
south america	0.3	0.2	7.3	0.2	0.1	8.0	0.4	0.4	6.1
europe	27.5	50.0	23.1	23.0	39.8	26.6	32.1	67.4	17.1
north africa and middle east	0.1	0.5	4.1	0.0	0.0	4.1	0.1	1.3	4.2
sub-saharan africa	0.2	0.1	7.4	0.2	0.1	7.0	0.2	0.3	8.0
east europe and central asia	0.1	0.0	4.7	0.1	0.0	4.4	0.0	0.0	5.2
china and japan	3.5	11.9	7.7	5.5	16.8	6.5	1.3	3.6	9.6
south east asia	0.4	1.0	12.2	0.3	0.9	12.5	0.4	1.0	11.7
australasia	0.2	0.1	5.9	0.0	0.0	5.8	0.3	0.3	6.2
	67	100	100	59	100	100	75	100	100

EUROPEAN DATASET

	goods	information	total
goods	3052	879	3931
information	452	3924	4376
total	3504	4803	8307

governed / *governor*

	basic materials	manufacturing	trade	producer services	consumer services	total
basic materials	245	0	0	0	197	442
manufacturing	0	2807	0	682	0	3489
trade	9	224	1025	2	10	1270
producer services	0	0	854	935	0	1789
consumer services	0	219	0	0	1098	1317
total	254	3250	1879	1619	1305	8307

governed / *governor*

	ALL CONNECTIONS			GOODS CONNECTIONS			INFORMATION CONNECTIONS		
	internal connections %	outward connections %	inward connections %	internal connections %	outward connections %	inward connections %	internal connections %	outward connections %	inward connections %
north america	5.3	26.2	38.6	4.4	25.0	41.7	6.0	27.4	35.6
central america	0.0	0.5	4.7	0.0	0.2	4.3	0.0	0.7	5.2
south america	0.0	1.2	7.0	0.0	0.7	7.2	0.1	1.6	7.0
europe	37.5	68.3	18.7	36.8	71.9	16.9	38.1	64.8	20.4
north africa and middle east	0.0	0.5	2.6	0.0	0.0	2.2	0.0	0.9	3.0
sub-saharan africa	0.0	0.6	4.0	0.0	0.5	3.4	0.0	0.7	4.5
east europe and central asia	0.0	0.8	9.1	0.0	0.9	9.4	0.1	0.7	8.8
china and japan	0.0	1.0	5.6	0.0	0.8	5.9	0.0	1.1	5.3
south east asia	0.0	0.6	5.8	0.0	0.0	5.6	0.0	1.1	6.0
australasia	0.1	0.5	3.9	0.0	0.1	3.5	0.1	1.0	4.2
	43	100	100	41	100	100	44	100	100

Internal outward and inward connectivity of supra-regions - for both global and European dataset
FIGURE 4

3.1.6 Network analysis:

In this section the global and European datasets are analyzed through a social science technique called 'network-analysis', which has its roots in 'graph theory'. It is a useful tool to answer questions of a 'relational' and 'structural nature'. It provides knowledge on relationships between actors (e.g. people, firms or cities) and can reveal relative knowledge about the individual actors (nodes), their connections (linkages), and the overall system (structure). The most common technique within network analysis is called 'centrality', which can reveal the importance of an individual within the network - called 'point centrality' or the importance of coherent clusters in the network - called 'group centrality'. Centrality provides knowledge of (1) whether an actor is or is nor connected (2), the strength of the connection called the 'degree' (3), the direction of the connection - where the commanding relationship outwards is called the 'outdegree' and the recipient relationship inwards is called the 'indegree'. The software used for analysis is called UCINET and it provides both statistical outcomes and network diagrams. Below is a glossary of the terms which will be used in the network analysis.

- *Degree*: The total neighbouring points to which a particular point is adjacent is called its degree. The 'indegree' is the number of points directed towards a certain point. The 'outdegree' is the number of points directed outwards from a point.
- *Distance*: The distance between two points is the length of the shortest path (the geodesic) that connects them.
- *Density*: The density of a network is defined as the number of lines in a network expressed as a proportion of the maximum possible number of lines.
- *Betweeness*: This concept measures the extent to which a particular point lies 'between' the various other points in a network. It is an indicator of the 'intermediary' role of a point – or 'gatekeeper' or 'broker'.
- *Power*: A measure of how a certain point is 'boosted' by the environment of points it is connected to. This in turn boosts the centrality of that point. Negative outcomes represent 'zero-sum' relations and positive outcomes to 'non-zero-sum' relations.
- *Core-periphery*: An analysis which 'blocks' the network into a core and periphery component.

Applying UCINET to the global and European datasets a better understanding of the corporate relationships of our world are shown. The analyses are divided into components. The first division is the global and European network. Each of these is in turn divided into an analysis of 'all', '2-sector', '5-sector', '10-sector' and 'specific-sector' (see previous sectoral division figure). Finally these sectoral divisions are separated into 'governor' and 'governed' relationships. Governor relationships concern the direct relationships of multinational headquarters to their immediate subsidiary – which gives the first level of command. On the other hand governed relationships concern the intricate linkages

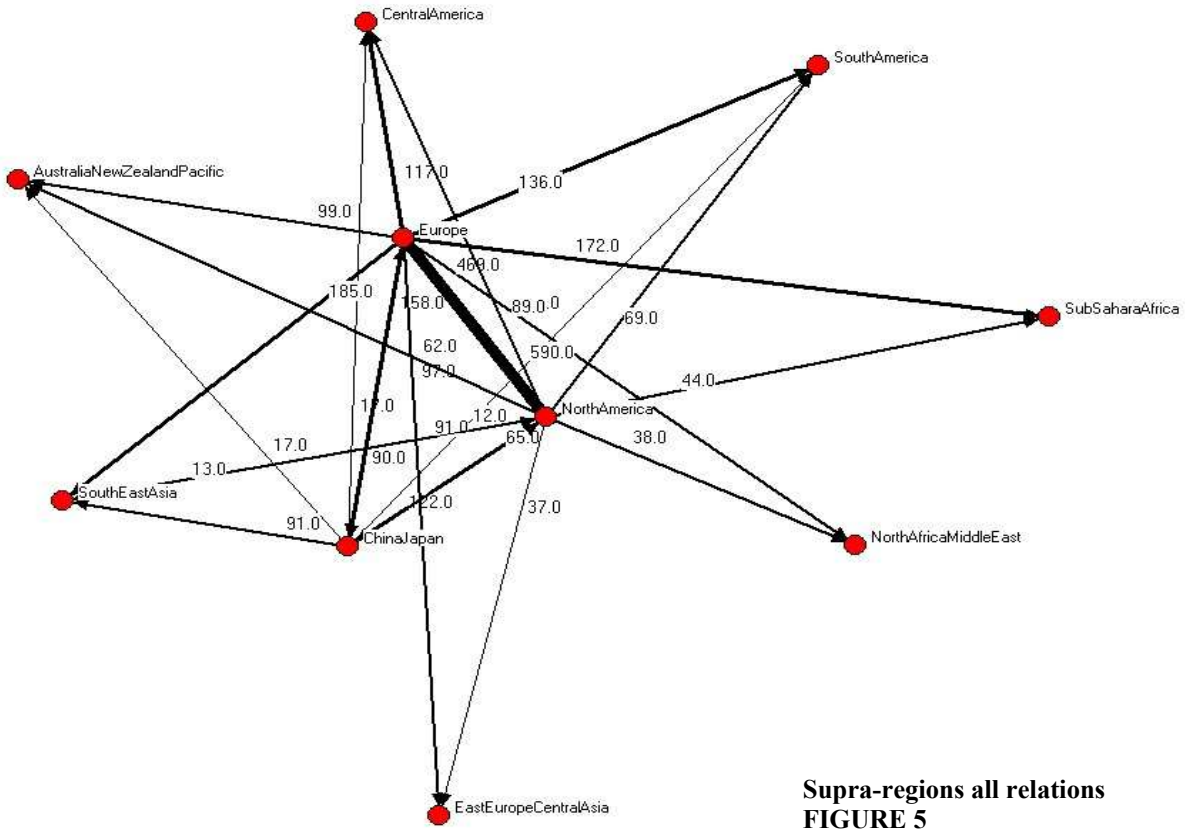
amongst different levels of subsidiaries. This set is subordinate to the governor set in terms of authority, but its advantage is that its network is much thicker. However, in this report we will only discuss the governor relationships. These results are described below.

3.1.7 Network analysis based on the global dataset:

Supra-regions:

The results of the supra-regional network are clearly evident in the diagram (figure 5). The first observation is that the network is star-shaped, with Europe and North America placed at the centre and all other regions situated at the periphery. The closer a region is to the centre, the stronger the relationship. This is seen with China/Japan. Europe and North America together form the core of the world economy and their strongest relationship is between themselves. In the table it is also evident that North America has stronger corporate ties with other regions (4307) than Europe (4058) – making it the most globally integrated region. It is interesting that Europe has the strongest ties with sub-Saharan Africa and South East Asia than any other region. Europe's relation to Africa is certainly one of command and control (172) with only (17) relations of command the other way around. If we look specifically at the goods and information components of this network we discover that North America is the strongest region in the governance of the goods sector, while Europe takes the lead in the governance of the information sector. In the 5-sector model we see that Europe takes the lead in the governance (command) over basic materials, consumer services and producer services, while North America takes the lead in governance over trade and manufacturing. In the 10-sector model, Europe takes the lead in command over finance insurance and real estate (FIRE). If we look at some of the other generated centrality variables we see that of all regions, Europe has the strongest 'betweeness', marking it as the broker of the world economy, due to its strong coordinatory position. In terms of 'power', which is a measure of how important a node is to its surrounding network – we see that North Africa/Middle East takes the lead. This is obviously because of the world's dependence on this region's oil.

These results tell us that the corporate network which provides one third of world GDP is actually only run by Europe and North America, with China/Japan lagging at a distance. It tells us that even regionally, the corporate world is highly disproportionate and far from truly globalised. It reminds us that those regions that are weak participants are actually those with the majority of world population. Furthermore, because the global corporate network correlates highly with GDP, foreign direct investment (FDI) and trade (in dollars) – it serves as a reliable model of the structure of these issues as well. A sustainable future would therefore depend on restructuring this network.



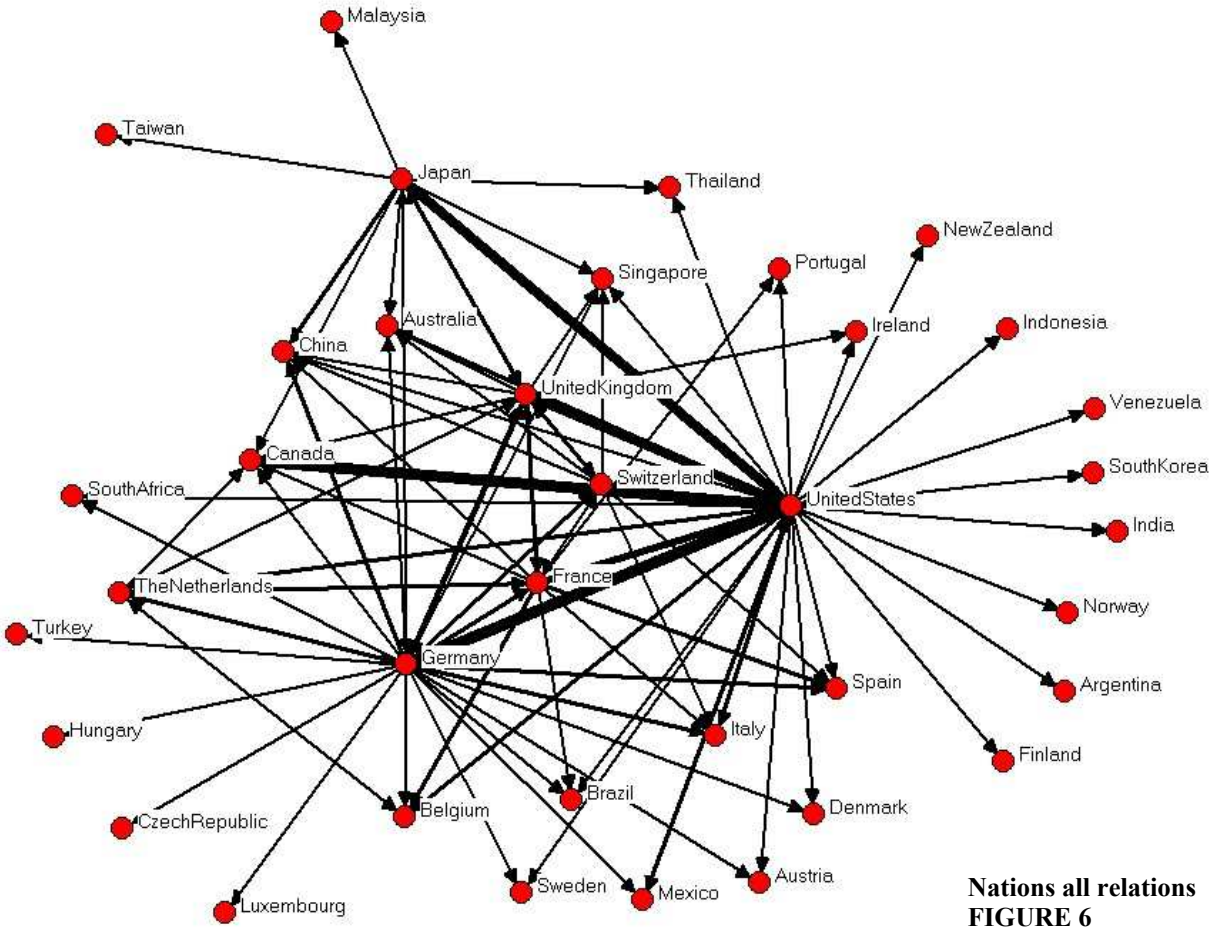
Supra-regions all relations
FIGURE 5

	AustraliaNewZe	CentralAmerica	ChinaJapan	EastEuropeCen	Europe	NorthAfricaMidd	NorthAmerica	SouthAmerica	SouthEastAsia	SubSaharaAfrica	
AustraliaNewZealandPacific	14	0	1	0	0	0	0	0	2	0	**17**
CentralAmerica	1	23	1	0	7	0	6	0	1	0	**39**
ChinaJapan	17	17	319	4	90	3	122	12	91	4	**679**
EastEuropeCentralAsia	0	0	0	5	0	0	0	0	0	0	**5**
Europe	99	117	158	97	2541	84	469	136	185	172	**4058**
NorthAfricaMiddleEast	0	1	0	2	9	5	0	1	0	1	**19**
NorthAmerica	62	89	65	37	590	38	3222	69	91	44	**4307**
SouthAmerica	0	1	0	0	1	0	0	28	0	3	**33**
SouthEastAsia	1	3	8	1	3	0	13	0	36	0	**65**
SubSaharaAfrica	0	0	0	0	0	0	0	4	0	17	**21**
	194	**251**	**552**	**146**	**3241**	**130**	**3832**	**250**	**406**	**241**	**9243**

Nations:

Where the previous study explored supra-regional relations of the corporate system, this part focuses on the same corporate relations but aggregated under nations. In this way we deepen the understanding of the network. In the diagram below (figure 6) it is evident that USA is the primary node in terms of diversity of connections as well as strength of the ties. This is followed by Germany, UK, France, Japan, Switzerland and The Netherlands (7th position). This is the case for total degree, outdegree and indegree. These countries are the central command of the world economy. USA's strongest overall relationships are with Canada, then Japan, Germany, UK, and France – then Switzerland, The Netherlands

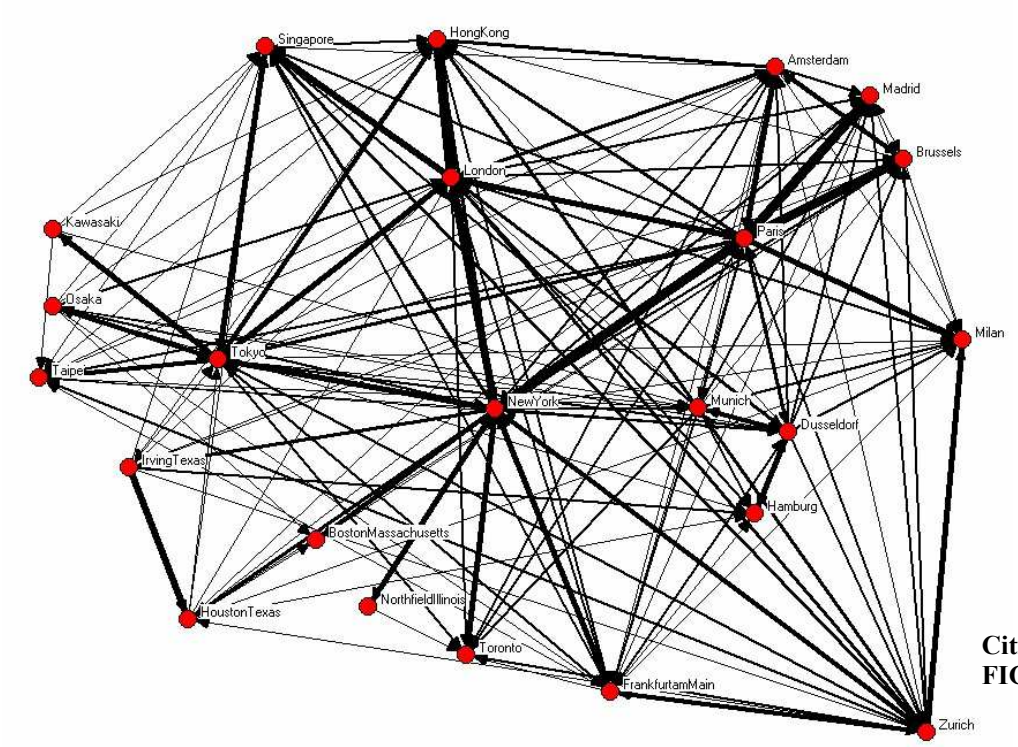
and Mexico. The Netherlands is most connected to USA, Germany and France. In terms of 'betweeness' – it is interesting that UK takes the lead as broker between nations, followed by USA, France and The Netherlands (4th position). Concerning 'power', Tunisia, Ireland, Switzerland, The Netherlands (4th position) and then Bermuda (offshore banking) play key roles. This means that the network structure of the world amplifies these nations to primary status of which the world is highly dependent. If we look only at the goods sector it is evident that The Netherlands is a key node in terms of 'betweeness' and 'power' – which means that the world of goods firms depends highly on coordinatory strengths of The Netherlands. In terms of the information sector this role is fulfilled by the UK.



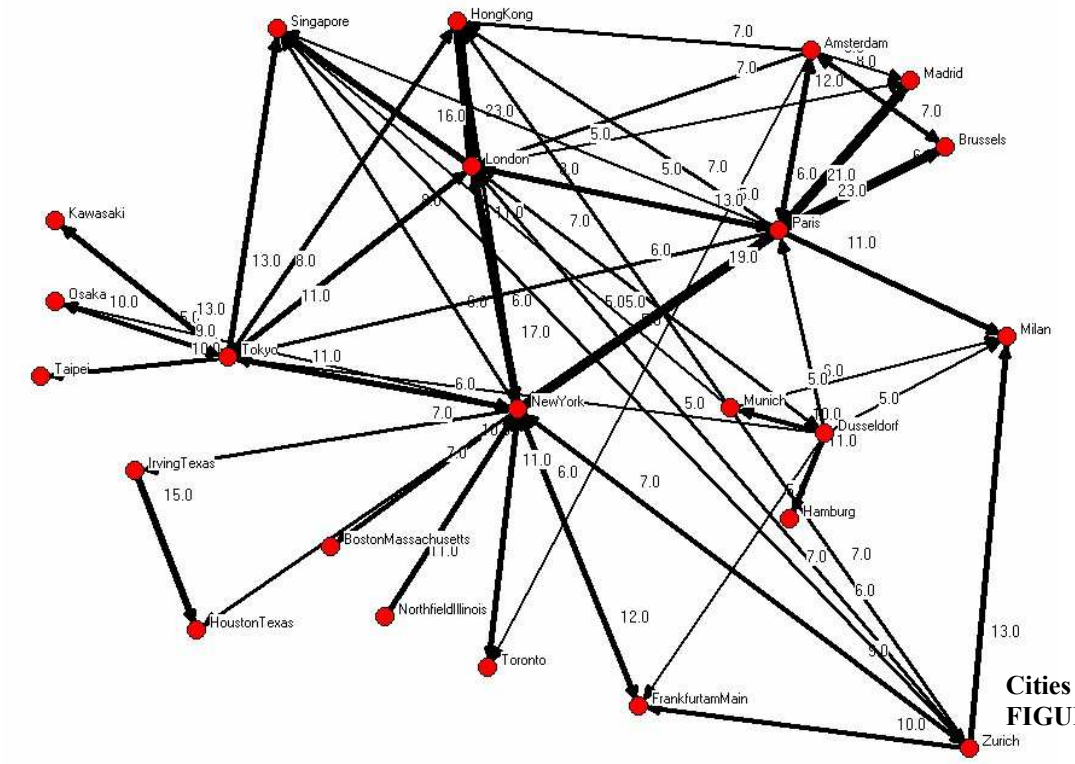
Nations all relations
FIGURE 6

In this part, the research is deepened into the corporate network structure at the level of cities. In this way it becomes easier to identify the more specific actors who have shaped and are shaping our world economy. In the diagram (figure 7a - b) two densities of the same network are shown. The top concerns linkages of more than 5, the bottom greater than 0. The top image shows more clearly the primary structure of the corporate city network, while the bottom image illustrates how complex and diverse the relationships are. Important to know is that these images only show the core and immediate surroundings (core-periphery). If all connections were shown, an incomprehensible thicket of connections would be seen, including the peripheral cities of the world corporate system. The first observation is that the core cities of the world economy, in terms of total degree, are in order – New York, Paris, Tokyo, London, Zurich, Dusseldorf, Amsterdam,

Houston, Brussels, and Munich. Concerning the Randstad cities, the rankings within the world system of 2557 cities are – Amsterdam (7th), The Hague (23rd), Utrecht (67th) and Rotterdam (82nd). It is also discovered that Amsterdam ranks 6th in terms of betweeness – revealing its importance as broker to other cities. In the diagram we see that New York's strongest ties are with Paris, then London and Tokyo. Paris's strongest relations are firstly with Brussels, then Madrid, New York, Amsterdam and Milan. London is firstly connected to Hong Kong, then to New York, Singapore and Tokyo. Tokyo is strongly connected to New York London and Singapore.

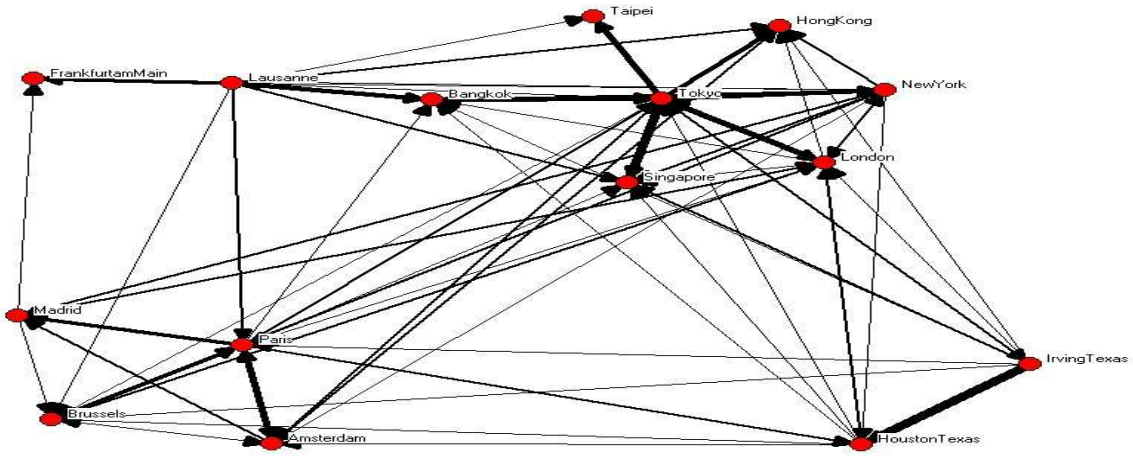


Cities all relations
FIGURE 7a

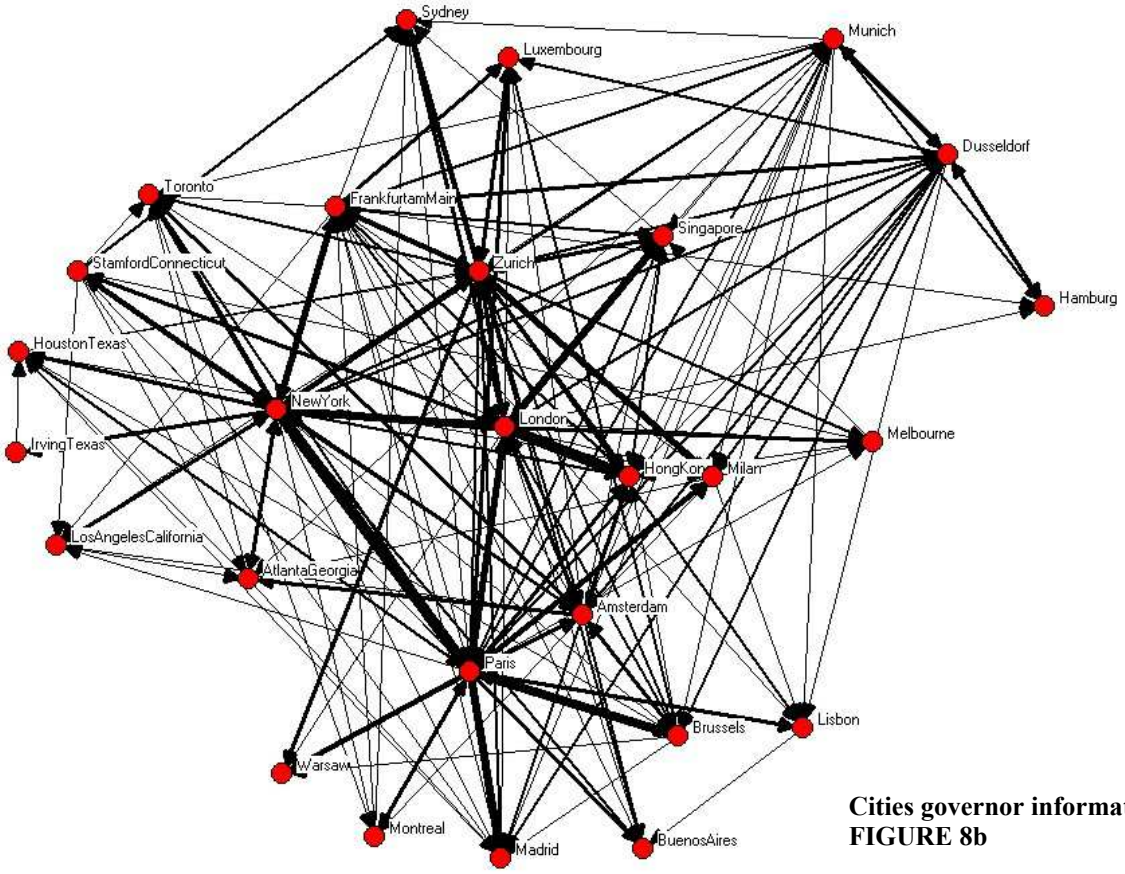


Cities all relations
FIGURE 7b

If we now look under the specific 2-sector model (figure 8a -b), we see that the top diagram concerns the command network of goods, while the bottom diagram concerns the control of information firm networks. In goods it is interesting that the central role is taken by Tokyo, followed by New York, Paris, London, then Houston. The Hague ranks 11th followed by Amsterdam's at 20th place, Rotterdam 72nd, and Utrecht 84th. Interesting is that London ranks highest in 'betweeness', making it the broker of this specific network. In terms of goods structure, we see in the diagram that Tokyo commands the Pacific region, while Paris forms its counterpart in the European region. We also see that Houston and Irving form a third region or sub-graph. Exploring the command network of information corporations, we discover that the rank order based on total degree is first New York, then Paris, Zurich, London, Dusseldorf, Amsterdam, Brussels and Frankfurt. Amsterdam has 6th position of command and the other Randstad cities play a relatively insignificant role. In terms of betweeness, New York, Paris, and then Amsterdam (3rd) play leading roles as broker cities. In terms of power, Basel, Chicago and Frankfurt are strong – with Amsterdam 7th. Important to note is that in terms of information, Tokyo does not play a significant role – making New York, Paris and London the triad of the information society. Also seen in the graph is that Munich, Dusseldorf and Hamburg form an important sub-graph.



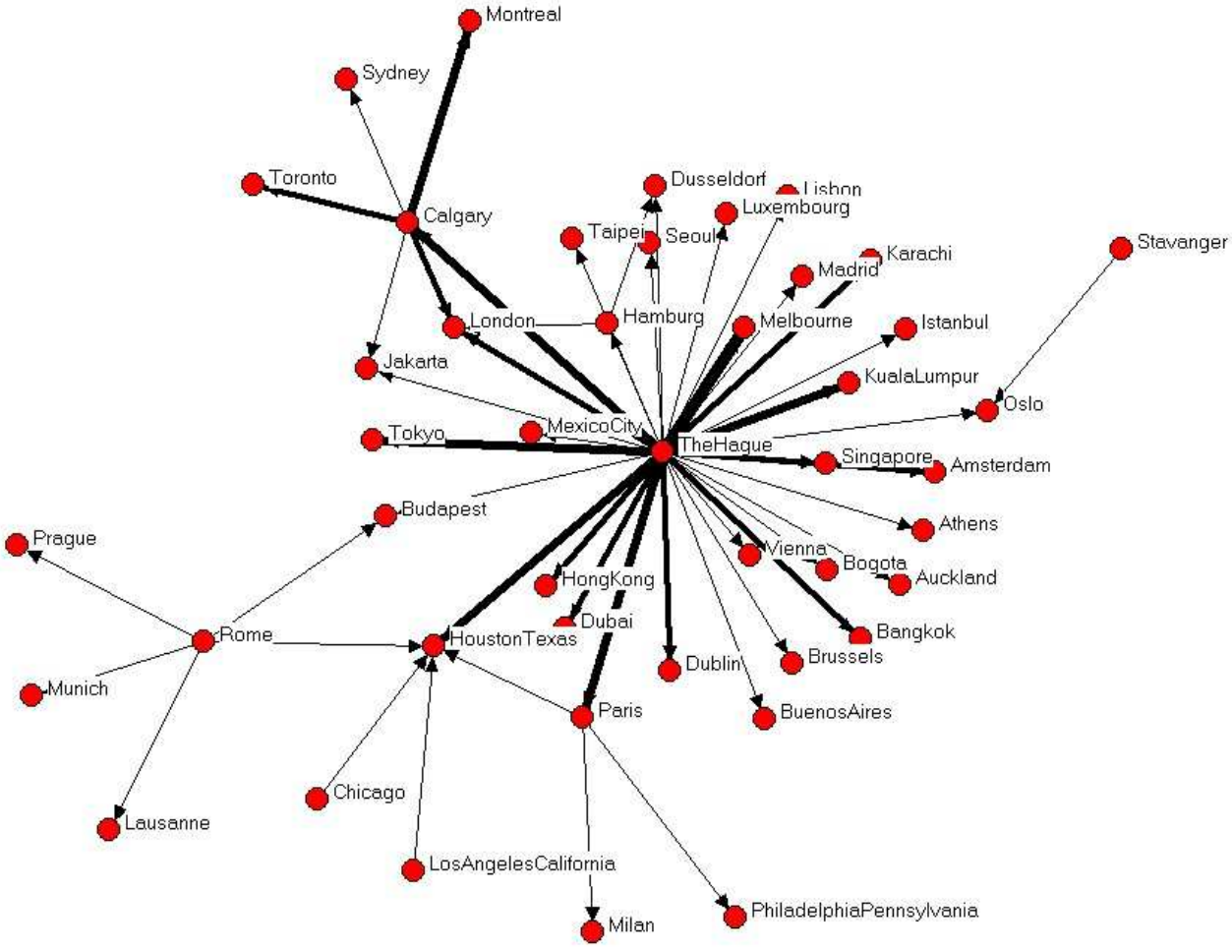
Cities governor goods
FIGURE 8a



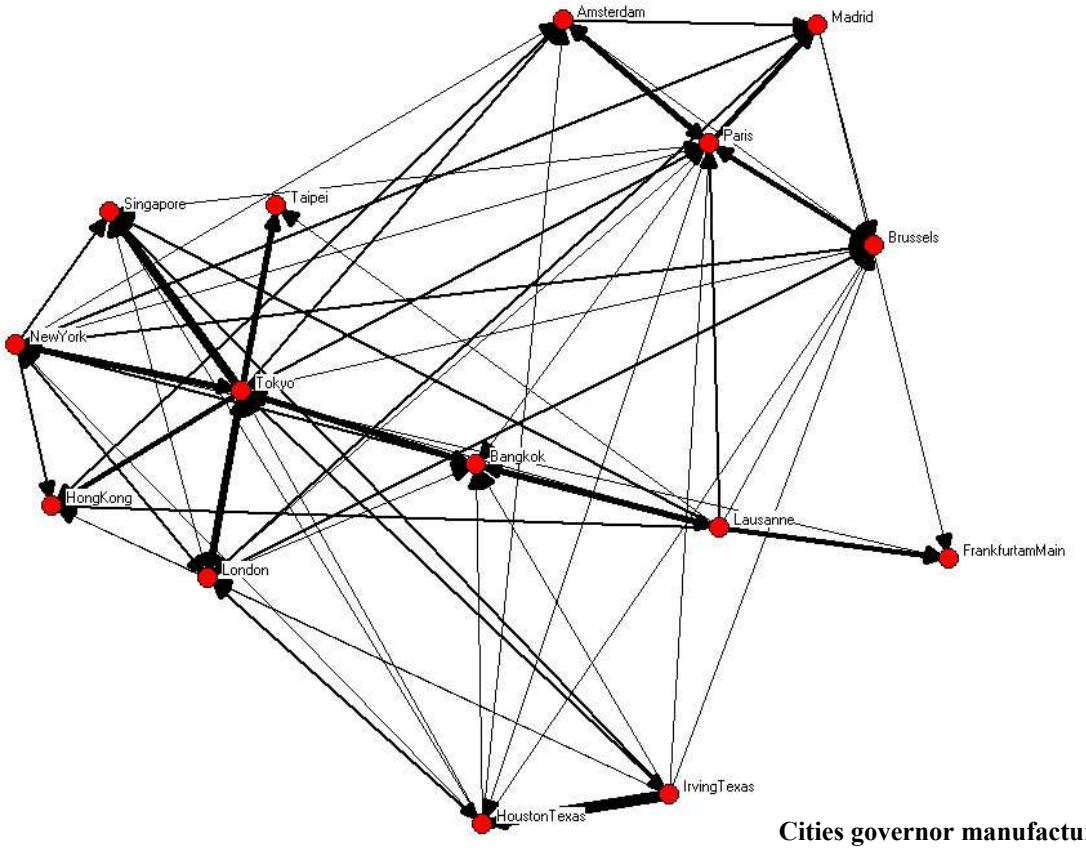
Cities governor information
FIGURE 8b

Once again we deepen our analysis to the 5-sector model (figure 9a - e). Here it becomes explicit who is in command of the basic materials corporate networks. Because Shell is situated in The Hague, it is not surprising that this city is at the heart of the resource network, followed by Calgary, Houston, Paris and Rome. Measured by betweeness and power, The Hague remains the primary city – in which its brokerage over others is evident, as well as the dependency of all basic materials on it. If we look at manufacturing, then Tokyo is by far the most powerful, followed by New York, Paris, London, Munich, Houston and Lausanne. In the graph, a clear Pacific, European and Texan region are defined – with Tokyo at the heart of the Pacific region and Paris at the heart of the European sub-graph. Interesting is that for basic materials and manufacturing, the more mundane type cities surface to the top, implicating that many of these are the industrial cities of this era. As far as the trade sector is concerned, we see that New York and Paris are the commanding cities of the network. If we were to look at the governed subsidiary networks (not shown), then we would see that London and Tokyo also play an important, but more subordinate role in trade. New York claims its strength especially due to its strong tie to manufactured petroleum goods in Irving Texas – while Paris obtains its strength due to a whole array of city connections. Paris plays a more integrating role in the network than New York. Lastly, in the graph we can identify four regional sub-graphs.

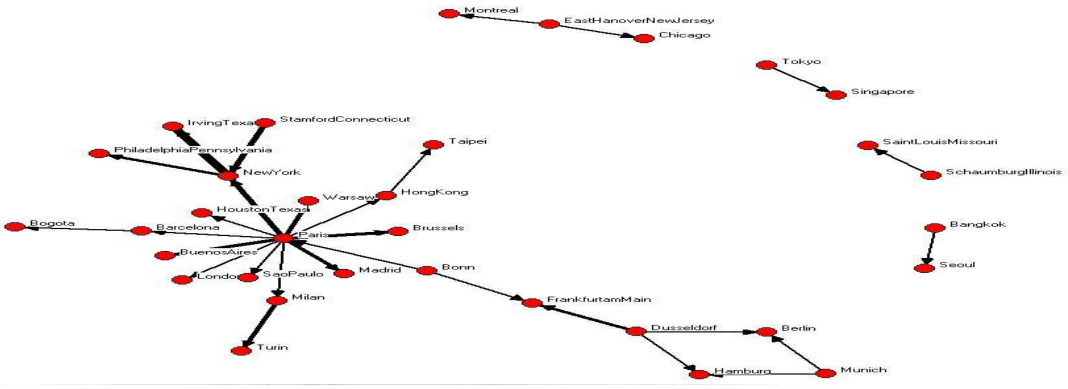
Looking at the producer services, we see based on total degree, the hierarchy of New York, London, Paris, Zurich, Frankfurt, Dusseldorf, Brussels and Amsterdam. This approximates similar research done by Peter Taylor and the GaWC research group. In terms of the Randstad this is Amsterdam 8th, Utrecht 23rd, Rotterdam 63rd, and The Hague 70th. Considering the betweeness, we see that New York and Frankfurt are the leading brokers in the producer service network – and in terms of power, Frankfurt heads the pack followed by Chicago, Basel, and London. Concerning the last of the 5-sector model – the consumer services – we see that the hierarchic order is New York, Zurich, Paris, Amsterdam, London, Munich, Dusseldorf, Hong Kong and Tokyo. These are the cities with the biggest consumption patterns – forming the primary end markets of the world economic system. A further deepening of the producer services, into the so called finance insurance and real estate (FIRE), shows the ranking order of New York, Paris, London, Zurich, Amsterdam, and Frankfurt (figure 10).



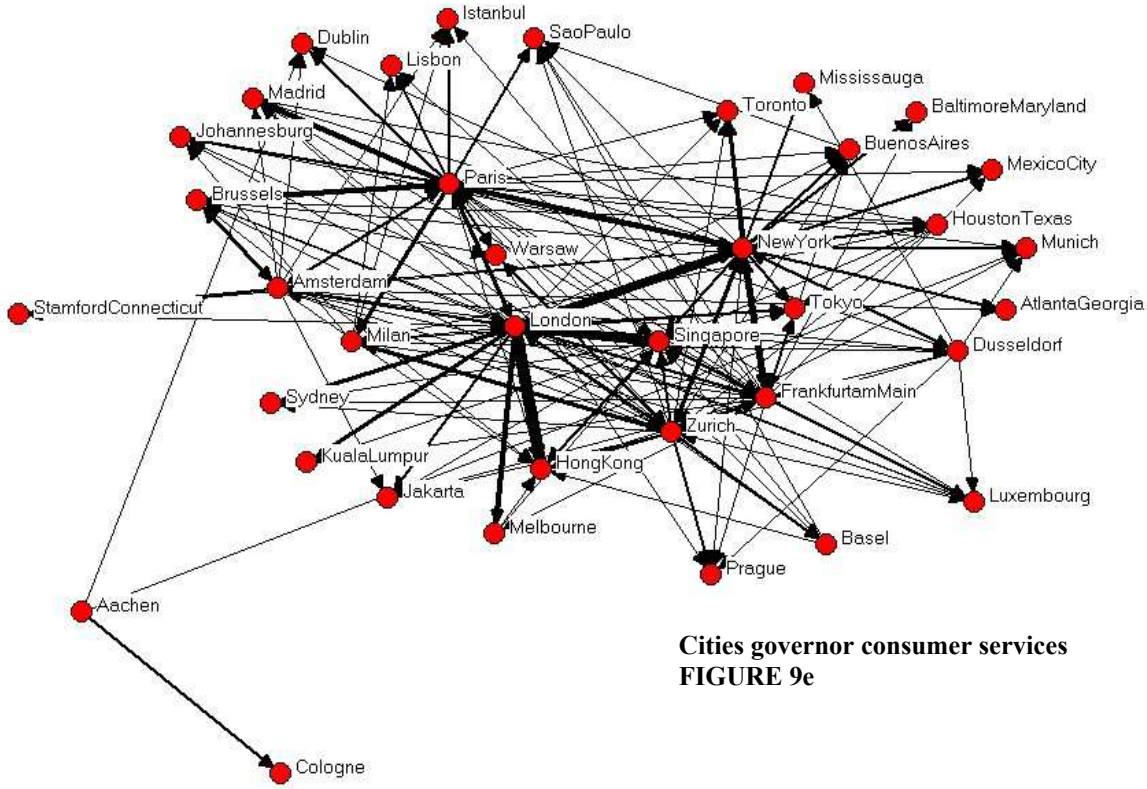
Cities governor basic materials
FIGURE 9a



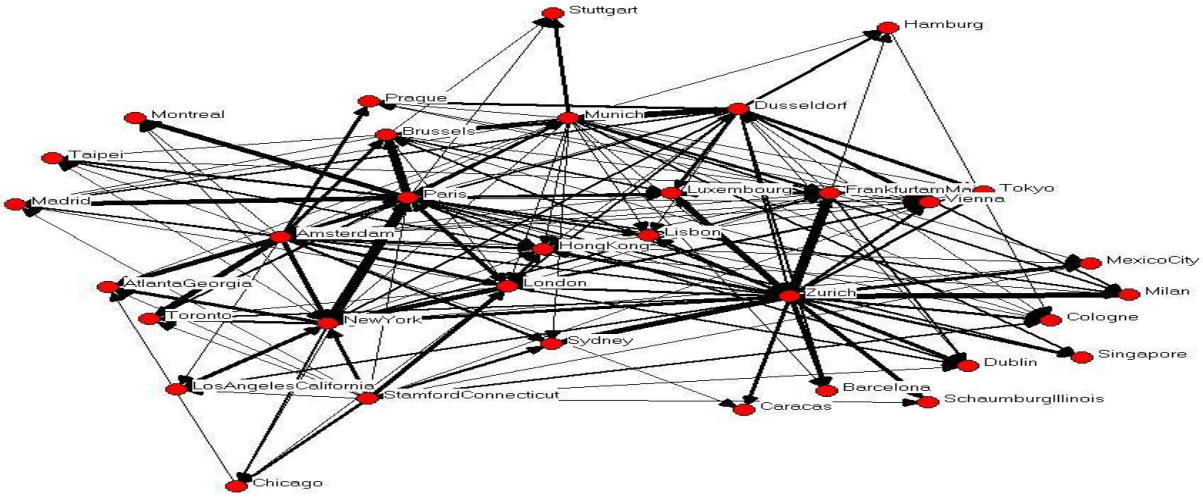
Cities governor manufacturing
FIGURE 9b



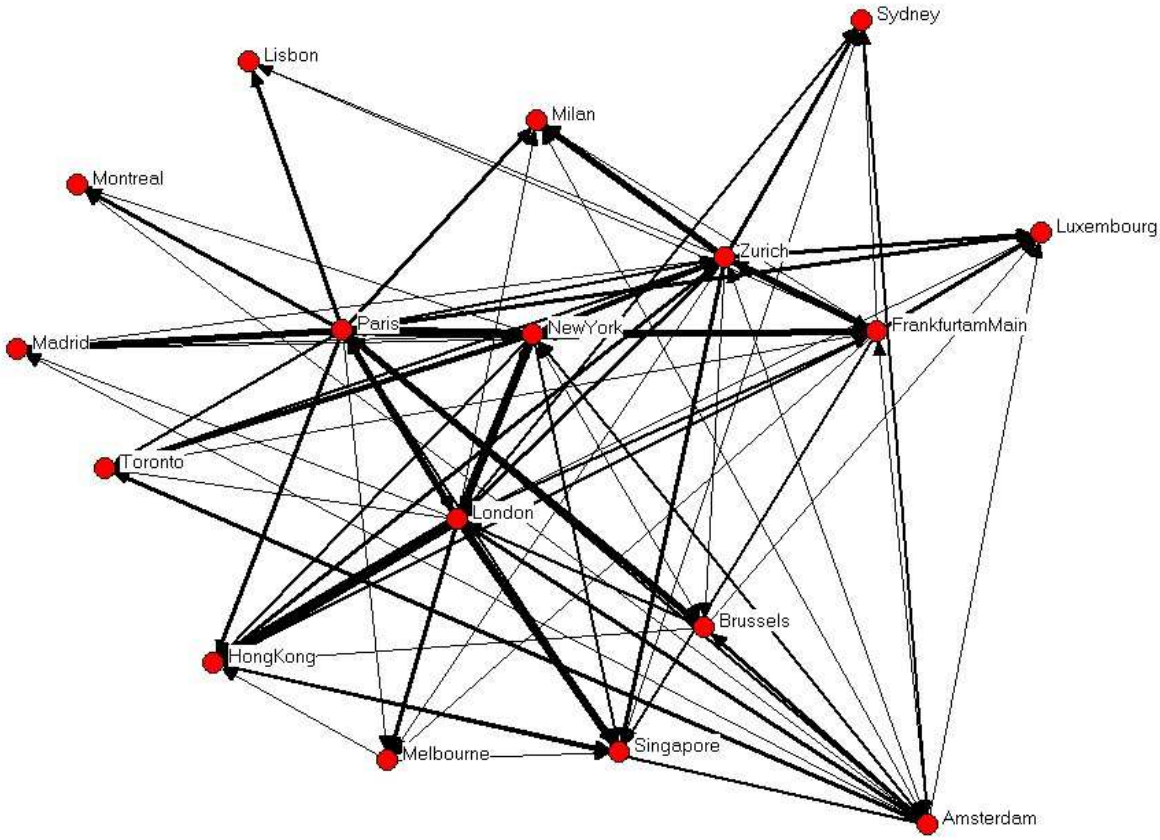
Cities governor trade
FIGURE 9c



Cities governor consumer services
FIGURE 9e



Cities governor producer
FIGURE 9d



Cities governor FIRE
FIGURE 10

3.1.8 Network relationships between cities, nations, supra-regions and the world:

The last part of the structural analysis of the global dataset concerns the network relationships between different scales of connectivity aggregations. The purpose of this is to understand how much of the connectivity of a particular city is (1) related to cities within its own nation (2), to cities within its own supra-region and (3), to all cities in the world. From this one can deduce which scales have the most influence upon particular groups of cities. Following this, the 'outdegrees' and 'indegrees' for each city's relationship to its own nation, supra-region, and the world - were collected for analysis. Based on a statistical technique called cluster analysis, these cities were organized into similar clusters. The first discovery (not shown) is that city-firm connectivity (for both outdegree and indegree) within nations is evenly distributed following a Gaussian distribution. Connectivity to own supra-region and the world is highly disproportionate (for both outdegree and indegree). This means that within a country, the network is far more integrated and diverse – while connectivity to supra-regional and international cities is more fragmented and uneven.

In the list below (figure 11), clusters of similar type cities have been derived. *Cluster 1*: concerns cities that are (a) strongly commanded by the world scale and (b): have strong command over other cities in their own nations. *Cluster 2*: concerns cities that are (a) strongly commanded by their own supra-region and (b) have strong command over other cities in their own nations. *Cluster 3*: concerns cities that are (a) strongly commanded by the world and their own supra-region and (b) simultaneously have strong command of the world itself. *Cluster 4*: concerns 'primary' cities that have (a) strong intermediary (broker) function with the world scale and that of the supra-region. *Cluster 5*: concerns 'secondary cities' that have (a) strong intermediary (broker) function with the world scale and that of their nations. *Cluster 6*: concerns cities that are (a) commanded by the world scale and (b) have command over other their own supra-region. *Cluster 7*: concerns two cities with mundane relationships. *Cluster 8*: concerns cities with medium outdegree relationships but no indegree. *Cluster 9*: concerns cities with medium indegree relationships but no outdegree.

CLUSTER 1
MexicoCity
SaoPaulo
Santiago
Karachi
Bogota
Bangkok
Sydney
Singapore
BuenosAires
HongKong
Dubai
Melbourne
Seoul

CLUSTER 2
Stockholm
Prague
Barcelona
Toronto
Mississauga
Cologne
Stavanger
Rome
Oslo
Vienna
Utrecht
Milan
Madrid
Brussels
Luxembourg

CLUSTER 3
Tokyo
Berlin
Munich
Stuttgart
Dusseldorf
Turin
Ingolstadt
Detroit Michigan
Cleveland Ohio
Dallas Texas
Atlanta Georgia
Saint Louis Missouri
Irving Texas
Houston Texas
Chicago
New York
Stamford Connecticut
Philadelphia Pennsylvania
Los Angeles California
Baltimore Maryland
Schaumburg Illinois
Aachen
Hamburg
Lake Forest Illinois

CLUSTER 4
Lausanne
Basel
Zurich
Paris
Swindon
Amsterdam
Terni
Bonn
Frankfurt am Main
Montreal
The Hague
London

CLUSTER 5
Toyota
Yokohama
Werdohl
Newbury
Ludwigshafen
Trieste

CLUSTER 6
Istanbul
Jakarta
Johannesburg
Budapest
Rotterdam
Dublin
Calgary

CLUSTER 7
Taipei
Lisbon

CLUSTER 8
Wolfsburg
Gerlingen
Cincinnati Ohio
Chesterbrook Pennsylvania
Dearborn Michigan
Bocholt
East Hanover New Jersey
Saint Paul Minnesota
Bloomington Illinois
Omaha Nebraska
Columbia Maryland
San Ramon California
Palo Alto California
New Brunswick New Jersey

CLUSTER 9
Kuala Lumpur
Caracas
Auckland
Moscow
Athens
Warsaw

City clusters
FIGURE 11

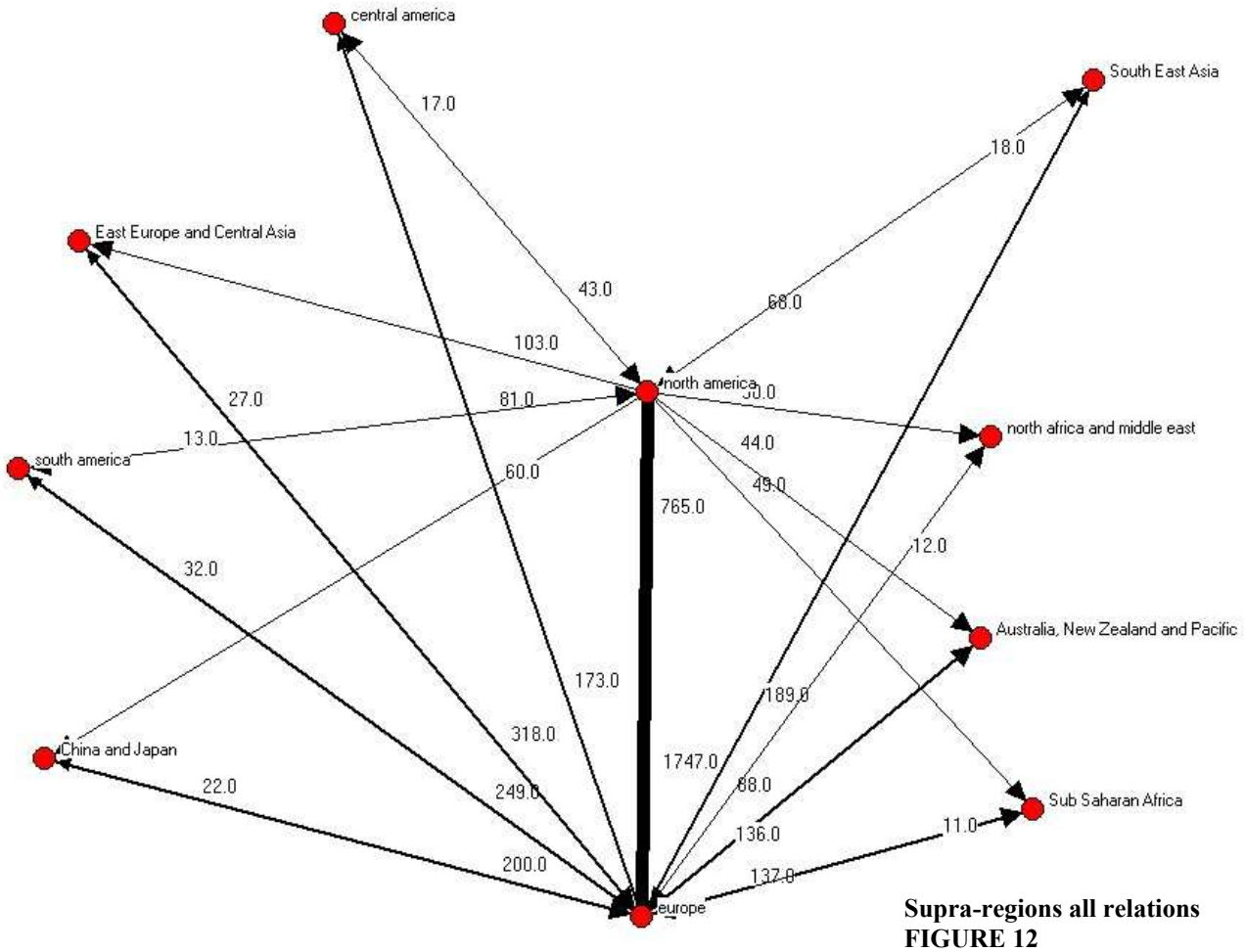
3.1.9 Network analysis based on the European dataset:

Supra-regions:

Similar to the analysis at the global scale we now investigate in a comparable way the network structures of the European dataset. In the provided diagram (figure 12) we still see that the central position of the European corporate network is again taken by Europe and North America. The difference with the global corporate network is that now Europe claims the highest connectivity, with a degree of 10356 linkages followed by North America with 3946 linkages. This means that in this network Europe's share is almost three times that of North America. In the global network this relationship is one to one. To improve sustainability this could roughly mean that at a global scale of sustainability policy, both North America and Europe share an equal responsibility towards worldwide improvement, while at the European scale of policy, Europe is responsible for approximately seventy percent of the improvement within the European corporate network. Obviously things are more complicated than that, where this insight merely serves as a first proxy. Europe primarily trades within its own region (40%). Of all outbound connections of the European network it claims almost 70% followed by North America which holds roughly 25%. Its strongest tie is with North America followed by Eastern Europe/Central Asia (4%) then South America then China/Japan. It appears less oriented on the Asian markets than the North American region. It obviously could improve its relationship with neighbouring Eastern Europe. Its relationship with Africa is totally one of command and control, with very little governor relations the other way around. In terms of 'betweeness' both North America and Europe each hold an equal position as brokers of the European corporate network. In terms of 'power' we see that the Asian and African regions play a vital role to the European network – in which Europe is dependent on oil other resources and cheap manufacturing.

If we take a look at the goods and information component of this network, we see that the European corporate network is 53% in goods and 47% in information activities. Both sectors are strongest first with Europe itself, followed by North America. Its strongest relationships in basic materials are also with itself which means that these are probably more coordinatory functions, while the actual production network of this sector falls into a category much lower than in this dataset. Furthermore basic materials are at the bottom of the commodity chain where it is known that these networks tend to be much shorter than higher up the chain. Besides North America, Europe's strongest manufacturing ties are firstly with Eastern Europe, followed by South America. Its strongest sectors with sub-Saharan Africa are manufacturing and the related producer services. Besides North America, its strongest producer service and trade ties are with Eastern Europe, where it probably coordinates and facilitates local manufacturing branches. This is even clearer

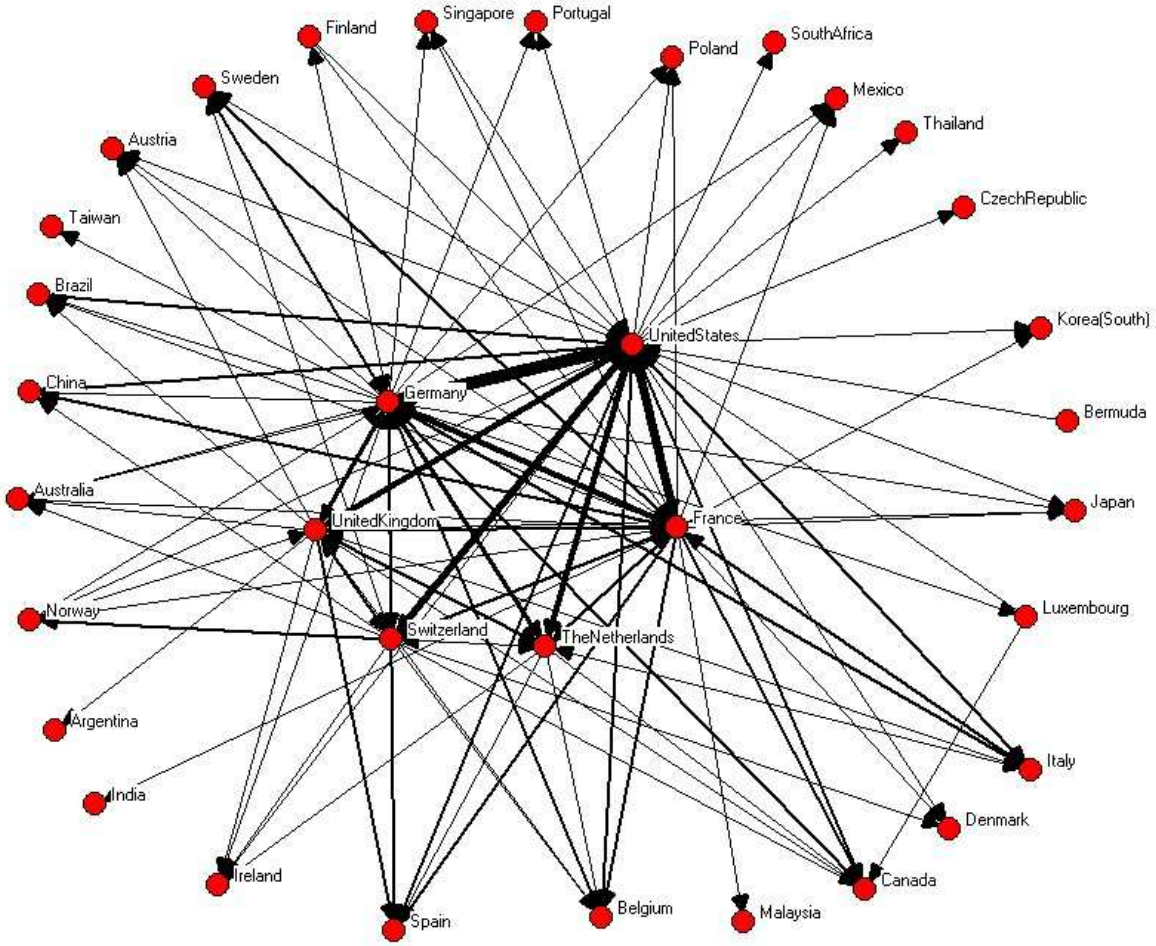
when we see that finance, insurance and real-estate are similarly strong in Eastern Europe.



Supra-regions all relations
FIGURE 12

We now deepen our investigation of the European corporate network by looking at aggregations of firm networks at the national level. The provided diagram (figure 13) indicates that even though this is the network of the European top 100 multinationals and their subsidiaries, North America still takes the lion's share of the total degree relations (3542), followed by Germany (2530), France (1924), UK (1354), Switzerland (1116), The Netherlands (825), Belgium (456) and Italy (399). If we were to calculate the 'network per capita' (NPC), it is interesting to see that the order is quite different. Switzerland has the highest NPC by far, followed by The Netherlands, Belgium, France, Germany, UK, USA, and lastly Italy. This shows how dependent small countries like Switzerland and The Netherlands are on connectivity. Similar results are seen in trade, FDI, and the trans-nationality index (TNI). This means that The Netherlands is highly dependent on international relations to maintain its current standard of living. In the diagram the other countries form the periphery of Europe's corporate economy. Furthermore, France and USA score highest in 'betweeness', while Spain, Sweden, Finland, Luxembourg, and Canada score highest in 'power'. Interesting is that if we look specifically at the governor goods part of this network, that the strongest command relationship by far is with United Arab Emirates, indicating the European corporate network's dependency on their oil.

Germany is most connected to the United Arab Emirates (241), followed by Switzerland (194), then USA (109), then France (95), and lastly The Netherlands (81). Another important node in Europe's goods network is Brunei Darussalam. This is followed by Germany, USA, and France. In terms of information this is firstly with USA, Germany, France, UK, Switzerland and The Netherlands. In terms of information 'betweeness', Switzerland then Brazil, then South Africa, then USA form important brokers for Europe's network. More specifically the strongest command in FIRE is in order, Germany, France, UK, USA, Switzerland and The Netherlands.



Nations all relations
FIGURE 13

Cities:

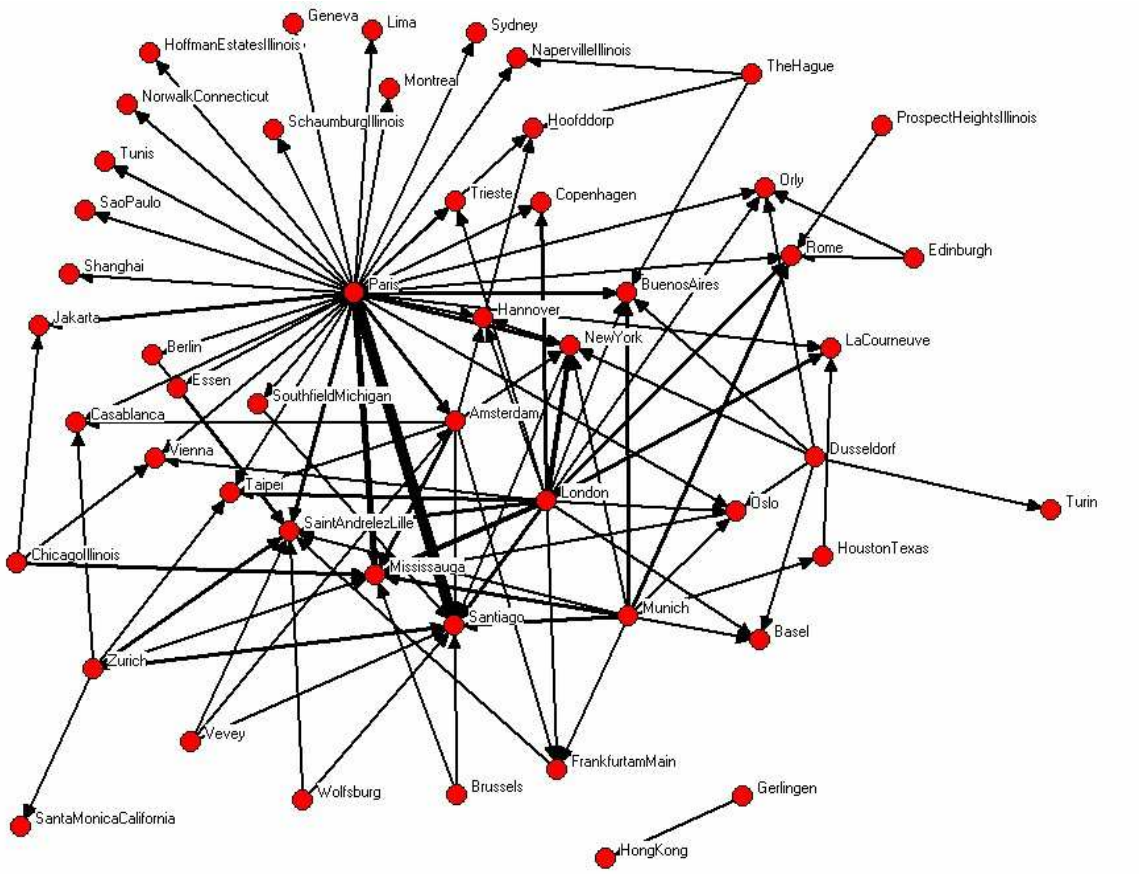
The next step was to investigate the corporate activity of European multinational networks at the scale of cities (figure 14a – b). In descending order the outdegree of cities are: Paris, London, Munich, Amsterdam, Zurich, Dusseldorf, The Hague, New York, Brussels and Frankfurt. These are the major cities of command. If we look at the indegree of these cities we see something quite different. The descending order is now: Santiago, Saint Andrelez, Lille, Mississauga, New York, Buenos Aires, Oslo, Taipei, Orly, Vienna, Casablanca, Rome, La Courneuve, and Jakarta. These cities are being commanded and it is striking that many are not European, or are regional type cities. The order of 'betweeness' is New York, Paris, Oslo, Amsterdam, Santiago, Frankfurt, and Basel –

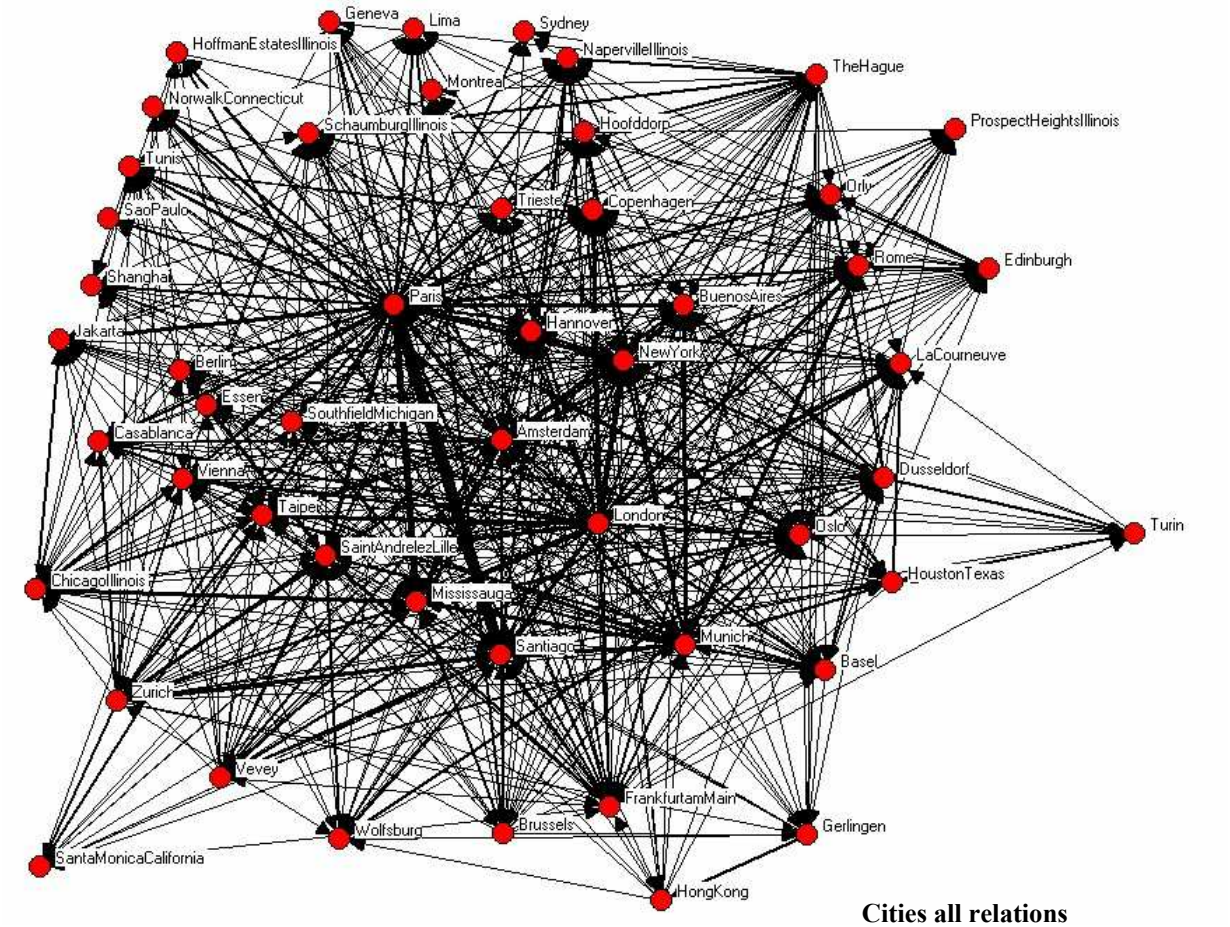
placing these cities as the brokers or intermediates of the European network. In terms of 'power', the core cities are first London, then The Hague, Paris, Brussels, and Zurich. The strongest linkages of the primary city Paris are firstly with Santiago (64), then Mississauga (30), then Lille, Amsterdam, and Buenos Aires. The second strongest city, London is firstly connected to Mississauga, then New York, Lille, Taipei. Munich is also strongly related to Santiago Mississauga and Buenos Aires.

If we now specify the network under goods and information networks the following becomes clear (figure 15a – b). Looking at goods, the outdegree ranking is Paris, The Hague, London, Munich, and Buenos Aires. In indegree, ranking is Buenos Aires, The Hague, Turin, Beijing and Gothenburg. In betweeness this is Paris, Gothenburg, The Hague, Munich, and Oslo. In terms of power this is London, Vevey, Basel, Paris, and Zurich. Paris's strongest goods tie is with Buenos Aires, then Amsterdam. If we specify governor information networks in total degree, the hierarchy is Paris, London, The Hague, Amsterdam, Dusseldorf, Singapore, Munich, New York, Zurich and Frankfurt. In outdegree the line of command is Paris, London, Dusseldorf, Amsterdam, Munich, Zurich, Frankfurt, New York, and Brussels. In indegree this is The Hague, Singapore, Paris and Buenos Aires. Concerning betweeness this is Paris, The Hague, London, Amsterdam, New York and Frankfurt. In terms of power this is Munich, Zurich, Frankfurt, Brussels and Dusseldorf. Paris's strongest tie of command in the information sector is with The Hague, then Amsterdam, Singapore, Lisbon, and Chicago. The Hague is strongly controlled from above by Paris, London and Zurich – which obviously concerns producer services related to Shell.

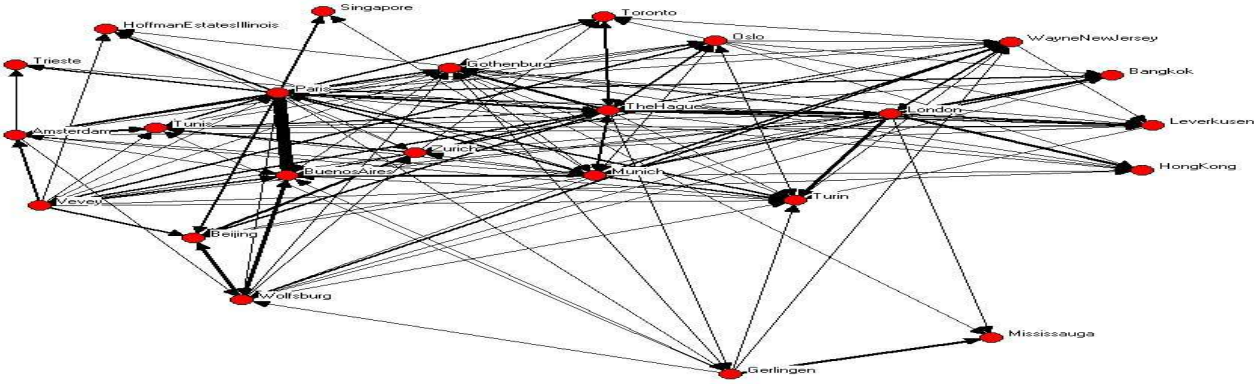
Dropping down to the next level, the 5-sector model reveals the following (figure 16a – e). In the case of basic materials, the outdegree hierarchy is The Hague, Oslo, Paris, Chicago, Los Angeles and Houston, while the indegree hierarchy is Budapest, Rome, Bogota, Vienna, Copenhagen, Singapore and Beijing. The hubs of this network are obviously dominated by The Hague and Oslo due to oil industries. Strangely these two hubs are not directly connected to each other but through other cities. This star-shaped hierarchy displays strong vertical command and control of basic materials. In terms of betweeness, The Hague plays the central role as broker, while in terms of power Oslo doesn't play a role at all. In terms of power The Hague is 1st, followed by Oslo. Looking at manufacturing the order of command relations is Paris, London, Munich, Vevey, Basel, Zurich, Wolfsburg, Gothenburg and Amsterdam. In indegree this is Caracas, Toronto, Braunschweig, Vienna, Zurich, Schaumburg-Illinois, Gothenburg, Tunis, and Beijing. Paris is highly connected to Caracas, then Toronto, while London is strongly connected to Toronto, Beijing and Hong Kong. The three broker cities are Gothenburg, Zurich, and Espoo, while in terms of power these are Paris, London, Basel, Wolfsburg, and Munich. If we look at 'governed' subsidiary relationships (not shown) - we would see that London plays the primary role in this subordinate network of relationships.

The trade network's hierarchy of outdegree cities is Paris, New York, London, Munich, Houston, and Hannover, while the indegree cities are Dublin, Santiago, Budapest, Essen, Amsterdam, and Johannesburg. In terms of betweeness the order is Paris, Hannover, Gothenburg, Essen,and London – and in power it is Paris, New York and London. In the case of producer services the outdegree rankings are London, Paris, Frankfurt, Chicago, Munich, Zurich, Amsterdam, Berlin and then Brussels. Indegree-wise this is Casablanca, Espoo, Vienna, Edinburgh, Athens, Taipei, Moscow and Rotterdam. Interesting is that Rotterdam plays an important role as controlled producer service city, which is due to port-related insurance companies. In terms of betweeness this is Zurich, London, Edinburgh, New York, Frankfurt, Paris, Amsterdam, Munich, Madrid and Johannesburg. In power this is London, Paris, Chicago, Munich and Berlin. London proves to be the true broker and commander of the producer service industry, while Casablanca has high prestige – in other words others are highly dependent on it. Even at the subsidiary level, London plays a vital role in producer services, together with Mexico City. Looking at consumer services we see that the wealthy end-market cities of Dusseldorf, Paris, Amsterdam, Zurich, Munich for the key players. In indegree this role is taken by Auckland, Beijing, Stuttgart and Budapest. The betweeness 'broker' position is taken by Amsterdam, Munich and then Trieste. Power is defined by Dusseldorf, Zurich, Paris, London, Brussels, Amsterdam and Frankfurt. Amsterdam's strongest consumer service relationships are with Auckland and Beijing.

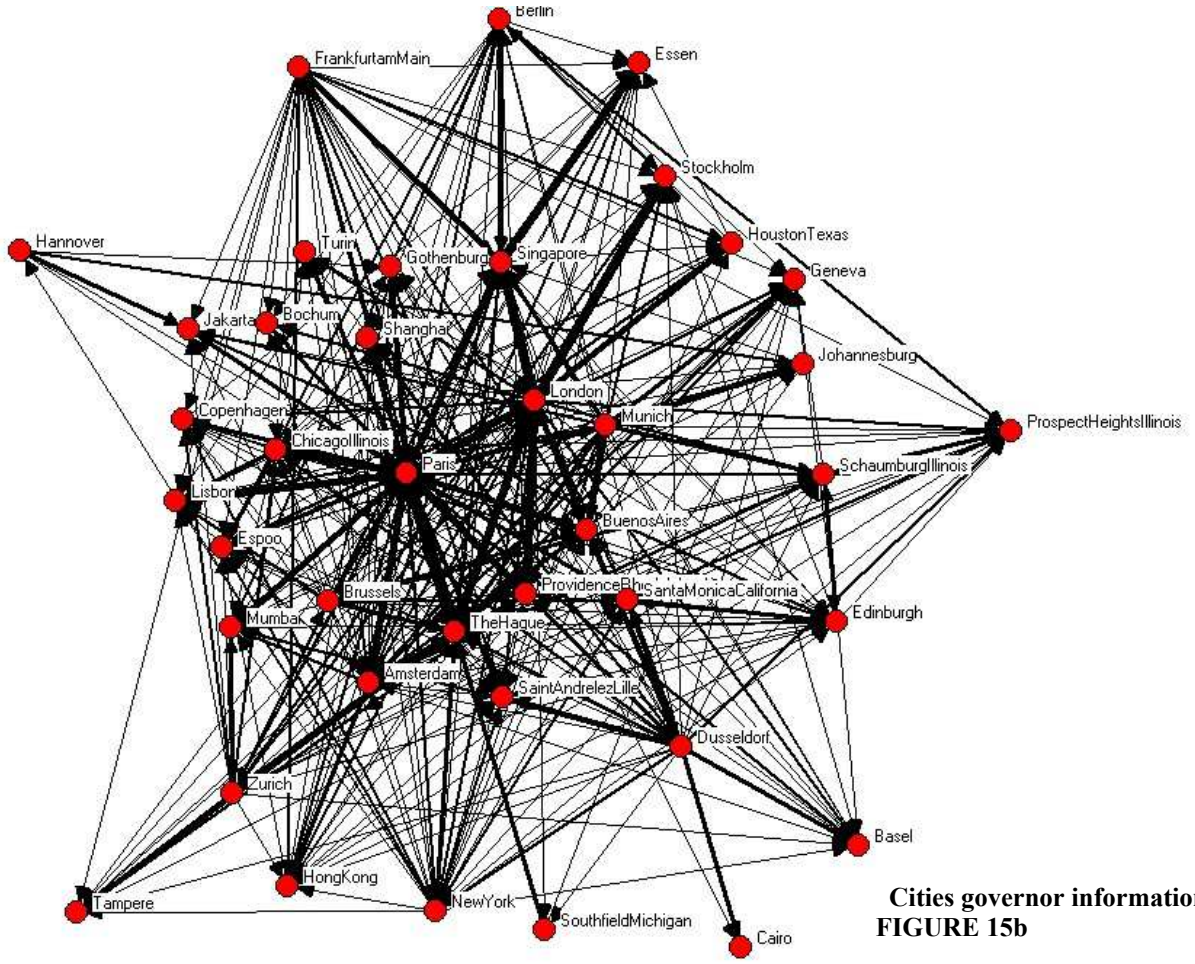




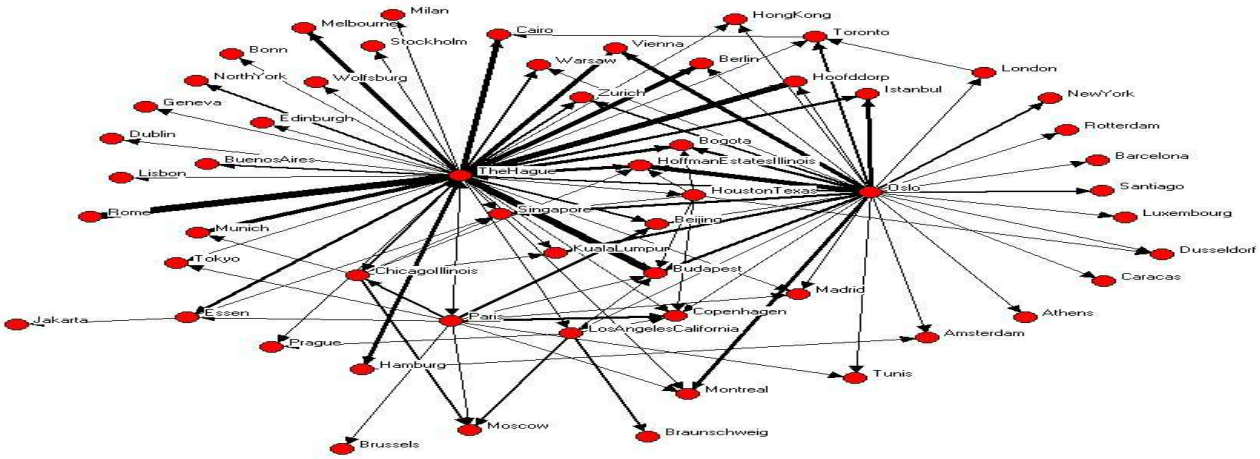
Cities all relations
FIGURE 14a



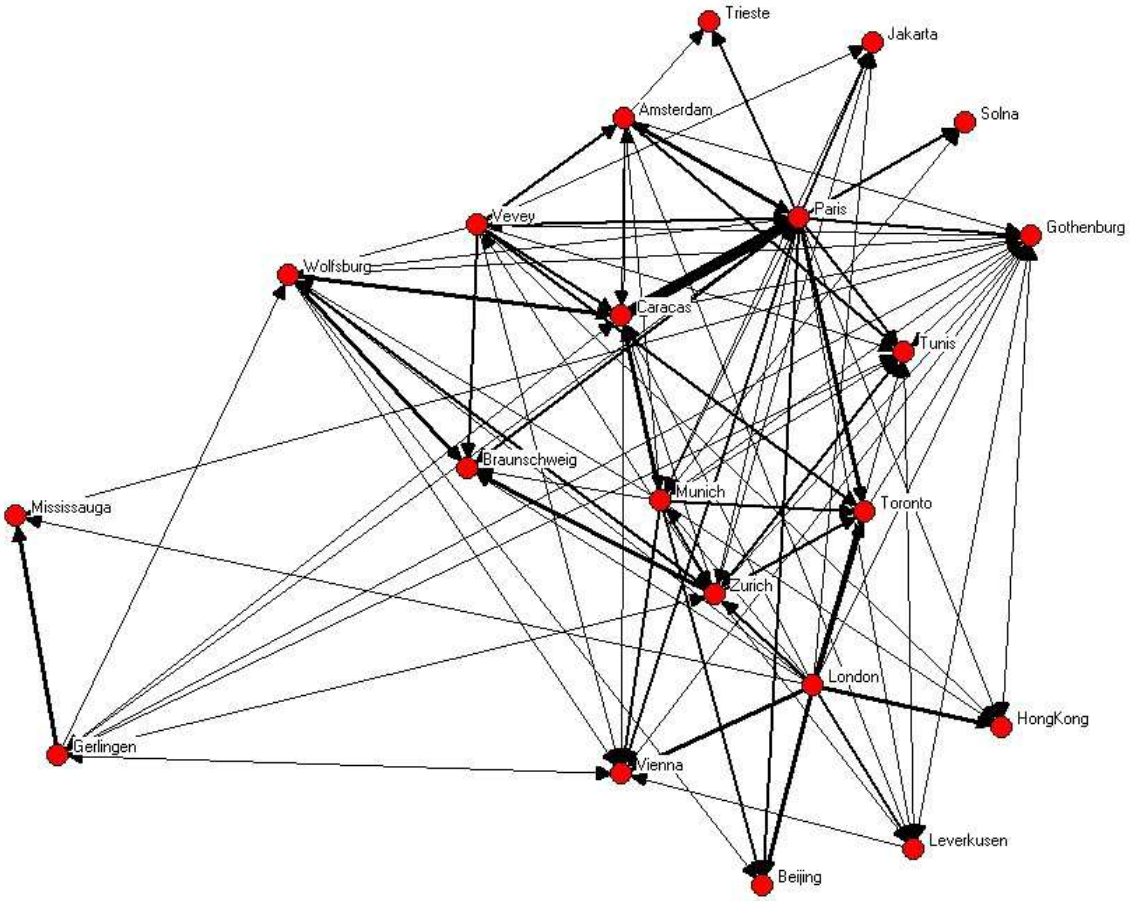
Cities governor goods
FIGURE 15a



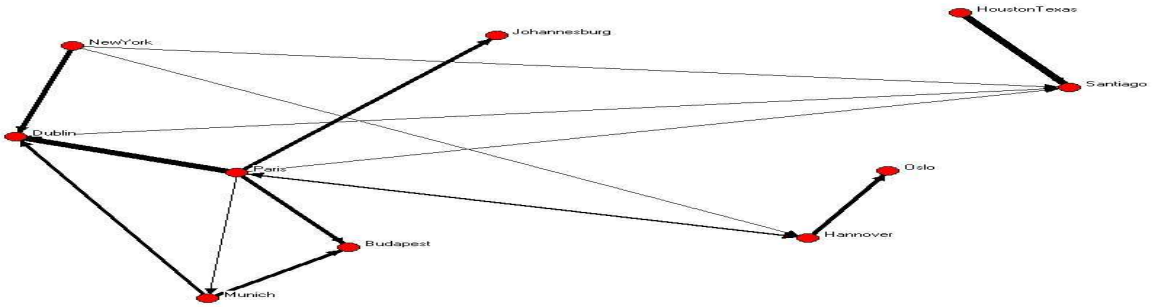
Cities governor information
FIGURE 15b



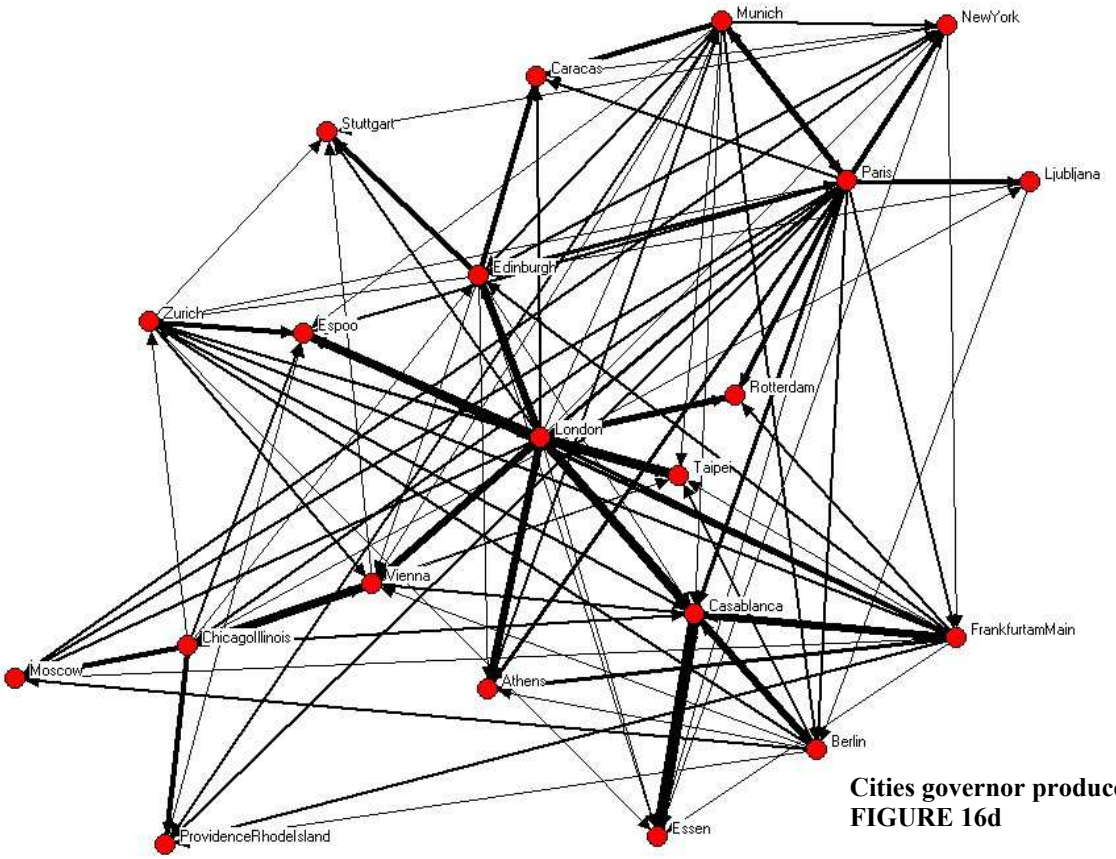
Cities governor basic materials
FIGURE 16a



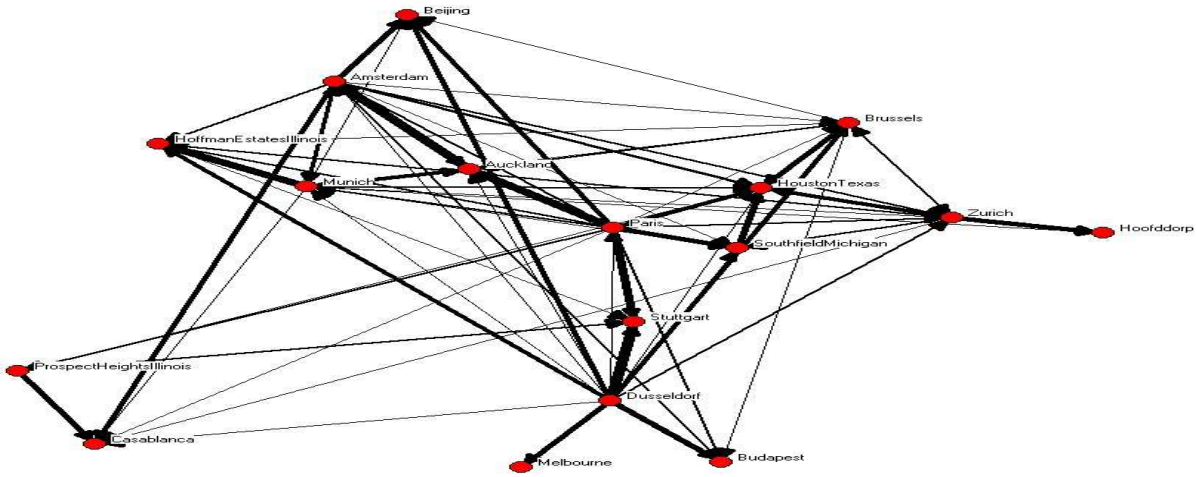
Cities governor manufacturing
FIGURE 16b



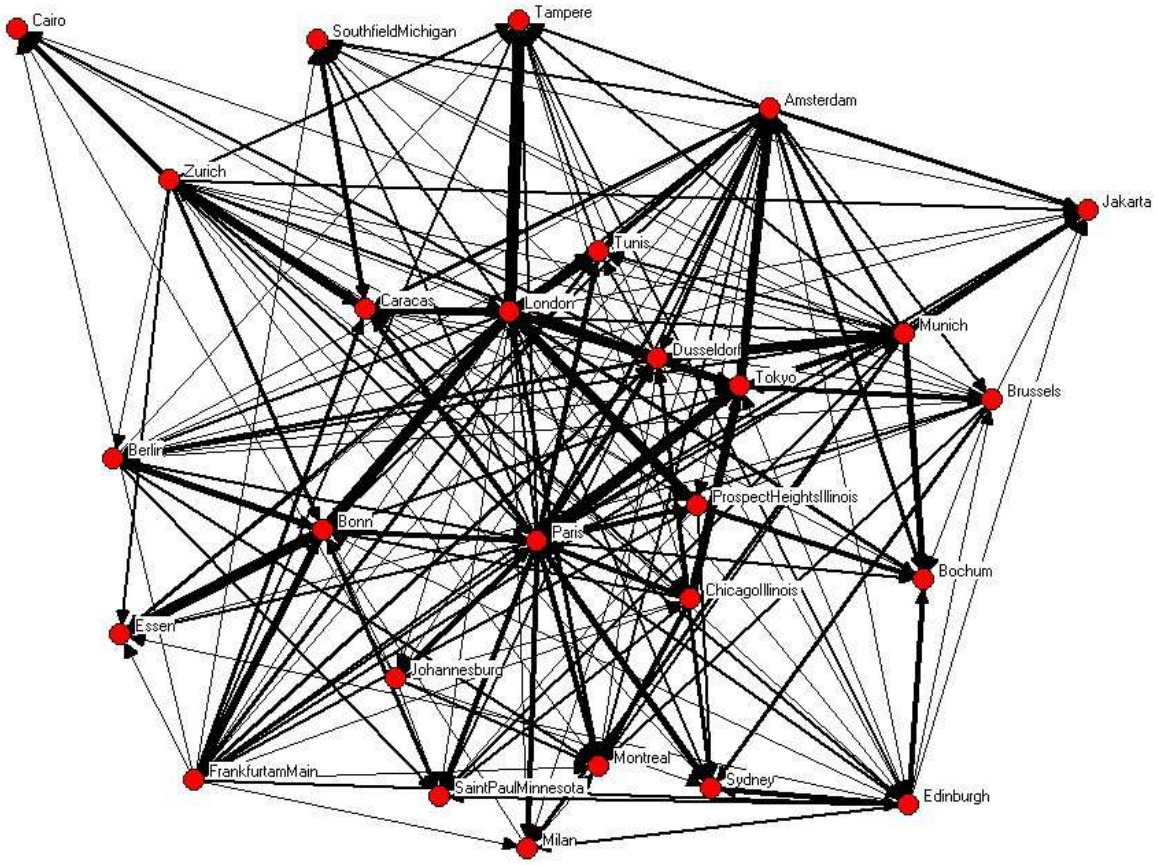
Cities governor trade
FIGURE 16c



Cities governor producer services
FIGURE 16d



Cities governor consumer services
FIGURE 16e



Cities governor FIRE
FIGURE 17

If we look deeper at on sub-level of the finance insurance and real-estate firms (FIRE) we see that the key command cities are London, Amsterdam, Munich, Frankfurt, Zurich, and Chicago (figure 17). The indegree cities are Bonn, Tokyo, Caracas and Dusseldorf. Interesting is that Tokyo, although strong in FIRE, is subordinate in directionality. Tokyo is strongly controlled by first Paris, then Amsterdam, Chicago, and Tokyo. Bonn is controlled by Essen, Frankfurt, and Berlin. In terms of betweeness, the order is Paris, London, Tokyo, Amsterdam and Utrecht. This means that two Randstad cities play a vital role in the brokerage of Europe's FIRE network. The positions for 'power' are taken by London, Zurich and Chicago.

3.1.10 Network relationships between cities, nations, regions and world:

Similar to the global dataset we now turn to an understanding of relationships of cities between different spatial scales. This with the intention to define how much of the connectivity of a particular city is (1) related to cities within its own nation (2) to cities within its own supra-region and (3) to all cities in the world. Again this can be used to deduce which scales have the most influence upon particular groups of cities – but now within the European corporate networks. For methodology see global scale. Using cluster analysis the different clusters of cities were defined. In a box-plot (not shown) it is discovered that connectivity within nations for both indegree and outdegree is

asymmetrical (bottom-heavy) - unlike the global dataset where the distribution was highly symmetrical at this level. Instead the connectivity distribution at the supra-regional level is more symmetrical (although not a Gaussian distribution). This means that at the supra-regional level the network is more integrated and diverse. Connectivity towards the world is again highly skewed (top-heavy).

In the list below, 8 clusters of similar type cities have been derived. *Cluster 1*: concerns cities that are (a) strongly commanded by the world scale and (b) also have strong command over the world scale. *Cluster 2*: concerns cities that are (a) strongly commanded by their own supra-region and (b) have strong command over their own supra-region. *Cluster 3*: concerns cities that are (a) strongly commanded by their own supra-region and (b) have moderate command over their own supra-region and the world. *Cluster 4*: concerns cities that are (a) strongly commanded by their own supra-region and (b) have extreme command over the outbound networks to the world. *Cluster 5*: concerns cities that are (a) strongly commanded by their own supra-region and (b) have moderate command over the outbound networks to the world – and even less control to their own supra-region. *Cluster 6*: concerns cities that are (a) moderately commanded by the world and their own supra-region and (b) have strong command over the outbound networks to the world. *Cluster 7*: concerns cities that are (a) strongly commanded by the world and (b) have moderate command over the outbound networks to the world and (c) have strong control over the networks of their own nations. *Cluster 8*: concerns cities that are (a) strongly commanded by their own nation and (b) have strong command over the outbound networks to the world. From this we can derive that clusters 2 3 4 and 5 are strongly commanded by the European supra-region. Cluster 1 and 7 are strongly commanded by the world scale. Cluster 8 is commanded by own nation. Clusters 1 and 4 have strong command over the world network. Cluster 2 has strong command over the European supra-region, and cluster 7 has strong control over own nation.

3.1.11 Conclusions on the structural hypothesis:

In this section it has been argued that governance should strategically intervene to minimize the damage caused by multinationals and maximize their benefits to society. Because corporate structures are truly global by nature, piecemeal and dislocated governance will no longer suffice - if sustainability is endeavoured. But without sophisticated government regulation and pressure from civil society, corporations lack incentives to protect environments and societies sufficiently. The question is how to understand the system better and operationalize these incentives within a clearer framework. For these reasons the corporate relationships between firms, cities, nations and regions have been explicated – but also the geographic and inter-scalar structure of the overall system. It has been shown that the more globally connected a region is, the more regionally intense its connectivity will be, indicating that policy should address this

regional-global interdependence. The dominance, asymmetry and command of Europe and North America over other regions has been clearly shown in this part – and that the more connected a region is, the more developed it will be. Policy should therefore be geared to improving corporate connectivity of the other regions. It is shown that Europe is most integrated with the world and that it exercises strong command over others. The results indicate that the corporate network which provides one third of world GDP is run by Europe and North America with China/Japan lagging at a distance. It tells us that even regionally, the corporate world is highly disproportionate and far from truly globalised. It reminds us that those regions that are weak participants are actually those with the majority of world population. Furthermore, because the global corporate network correlates highly with GDP, foreign direct investment (FDI) and trade in dollars – it serves as a reliable model of the structure of these issues as well. A sustainable future would therefore depend on restructuring this network. Nationally, The Netherlands proves to be a big player within the global networks in absolute numbers, but even more so relatively in network per capita. Because The Netherlands has a major broker position it can also become an interesting country to develop policy and could hereby have strong spill-over to other countries. At a city level, Amsterdam serves as a major city within the global network, especially in information sectors, followed by The Hague, which has a reasonable position in the goods network, mainly due to the presence of Shell. It is also interesting that if we sum the connectivity of the Randstad cities, that this conurbation becomes the 5th most connected city in the world.

At the European scale of top 100 multinationals networks, the concentration of network connectivity within Europe and its internal regional dominance is evident. Europe's effect upon the world increases at this level. After the US, Europe trades most with Eastern Europe, although this corporate activity can be strongly improved. This is an important consideration for policy development. Furthermore, its command over Africa is excessive and policy should start opening up African business towards Europe. If we look at the national level, it is interesting to see that Switzerland and The Netherlands have the highest network per capita. These less endowed countries once again show the high degree of external linkages needed to sustain their living standards. From this, one can question the scale of sustainability that these countries are responsible for. At the city level we see that Amsterdam is the 4th most important city within the European networks, in terms of command, but also as broker to other cities. The Hague plays a vital role in the goods sector, specifically the oil industry networks. Rotterdam's significance in the European networks is shown by its high indegree in producer services. This means that it is strongly controlled by controller cities like London and this relationship concerns port related insurance industries. Amsterdam also serves as the third most important consumer market, which is clear from the high level of consumer service outdegree. Amsterdam and Utrecht are also top cities within the sublevel of finance, insurance and real estate networks.

3.2 The disproportionality hypothesis on sustainability:

Hypothesis: *To address sustainability in a systemic way the statistical distribution of corporate networks is to be understood. It is expected that similar to the corporate hierarchies, the distribution and intensity of the city-firm network will be highly disproportionate and that it will have power-law and self-organizational characterisitics. If so, then it is questionable how to challenge this structure and determine what a future 'sustainable distribution' could be.*

3.2.1: Context:

In a perfect market it is said that firms exist to maximize profits where they aim to establish revenue that is far above costs. However the assumption of perfect competition side steps the fact that companies are interdependent – that the behaviour of one firm can affect the pricing of goods and profitability of others. The free market is not a condition of perfect competition between equal sized firms and instead a high disproportionality exists in firm sizes and their influences upon each other. Many small firms can modify the behaviour of oligopolies, while a few big firms can constrain the competitiveness of the small ones. Most firms are certainly not merely maximizers of profit. Instead, each pursues its own agenda which consists of many conflicting ingredients. Already in 1931 Robert Gibrat published in *Inegalites Economiques* the first universal theory of how firms get to be of unequal sizes[35]. It was clearly revealed that the distribution of firm sizes is highly skewed and that there is an almost universal law behind it. According to economist Robert Axtell, 'the stability of this distribution over time makes it…perhaps the most robust statistical regularity in all the social sciences'[36]. Furthermore, a power-law characterizes many complex 'real-world' networks, such as social networks, computer networks, neural networks, and epidemiological networks. In power-law relationships, sometimes called scale-free networks, a few nodes act as 'highly connected hubs', with a high degree of connectivity (far above the average), while the majority of nodes have low degrees. Furthermore, the more connected a city is, the higher the future probability of new connections, known as 'preferential attachment'. This means that the likelihood that a multinational will make a new business relationship with a firm in New York is far higher than with for instance Utrecht. Based on the existing distribution of corporate networks, the probable 'corporate potential' of all cities can be calculated and used as a proxy for future development. This is a natural probability, in what proves to be a self-organizing system and raises the question if and how a city could artificially increase its corporate or urban potential, so that the probability of new business linkages is increased. Networks generated by preferential attachment typically place the high-degree nodes in the middle of the network, connecting them together to form a core with

progressively lower-degree nodes making up the regions between the core and the periphery.

The distinguishing property of a power-law network is that if its degree distribution follows a relationship where the *beta* coefficient is close to -1, then it is known as 'the characteristic of self-organized criticality'. In the diagrams (figure 18), the beta coefficient has been determined by taking the logarithm of connectivity and rank, then calculating through regression the slope of the trend-line. Indeed, in all cases shown, the distribution has a near -1 value (see standardized coefficients in figure 1e). This means that the distribution of city-firm connectivity amongst cities is highly disproportionate, in which a few cities are extremely connected 'hubs' in the world city network. In the global network of 9243 connections, 25% of the outgoing (outdegree) connections are held by New York, Paris, Tokyo and London. This means that these four global cities have extreme authority over worldwide corporate activity. If we add the outgoing connectivity of Amsterdam, Utrecht, The Hague and Rotterdam (Randstad), this forms 6% of global corporate activity. This is quite large considering that 435 cities in the dataset have outbound connections. If we consider incoming connections (indegree), then New York, Paris, Tokyo and London together claim 10%, which emphasises the world's dependence on these four cities. This percentage is lower than that of outbound (governor) relations because a far larger population of 2557 cities participate as indegree (governed) types, which means that there are almost 6 times as many cities governed than governor.

It is shown later that the connectivity of cities correlates highly with the GDP of those cities and nations, reflecting the disproportionate structure of wealth in the world. Because power-laws are inherent in most dynamic 'real world' and 'natural' systems, it raises the question whether an alternative, more evenly distributed distribution is possible - or whether global economic activity structurally depends on the uneven distribution of corporate power. Another characteristic of scale-free networks is that their structure and dynamics are 'independent' of the system's size. Therefore, a network that is scale-free will have the same properties, no matter what the number of its nodes is. To check this, a section of the dataset was analysed, in which only cities with 10 or more connections were included. From this (figure 19), we see that the distribution of connectivity versus rank, still follows a power-law of -1. This means that corporate inequality is a characteristic independent of the scale of observation. It runs throughout the system.

The power-law distribution highly influences the network topology. It turns out that the major hubs are closely followed by smaller ones. These ones in turn are followed by other nodes with an even smaller degree and so fourth. This hierarchy allows for a fault tolerant behaviour, which means that if a hub city were severely damaged, the network will not lose its connectedness, which is taken over by the remaining hub cities – a form of rerouting. However, if we were to damage all the hubs cities simultaneously, then the

entire system would collapse, turning it into a set of isolated systems. Therefore, New York, Paris, London and Tokyo are both the strength and Achilles' heel of the world city network. They have evolved over centuries to achieve this position and maintain the world-order as it is today - therefore it is plausible that if all four of these were to be 'unplugged', this would have a devastating, long-lasting effect on the world economy.

Another important characteristic of scale-free networks is the 'clustering coefficient' distribution, which decreases as the node degree increases - also following a power-law. This means that the low-degree cities belong to very dense sub-systems (regional) which are connected to each other by high-degree (global) hub cities. Furthermore certain cities such as Amsterdam and Hong Kong serve as intermediaries between regional and global systems (as will be discussed later). These cities have less corporate control functions than global hubs, but have extremely important coordination properties and positions within the network (see Sassen). This is also the underlining principle of the 'small-world' and 'six-degrees of separation' phenomena, which means that every city in the world is connected to every other city within approximately six steps. This indicates how integrated and immediate our world has become and is indeed the case within the corporate networks of this research as will be shown later.

3.2.2: Power-law results:

In the power-law analysis on city-firm connectivity, several categories have been made. The first is a 'scale' division of global and European corporate networks. In this way it can be investigated which scalar systems have higher disproportionality? Within these systems a 'functional' division of the network is made (all-connections, goods and information connections). These are in turn divided into 'directional' graphs on *outbound* relations (outdegree) and *inbound* relations (indegree). In the first graphs we observe the global outdegree of all firms. The first graph shows the real distribution of all the 9243 city-firm connections in the global dataset. It is clear that only a handful of cities carry the majority of all connections. The probability of 'preferential attachment' for future connectivity, with these cities is therefore also very high. On the other hand the vast majority of cities are weakly connected within the corporate system. The second graph shows the logarithmic computation of the above graph, from which the beta coefficient can be calculated through regression analysis. The evident linear distribution is already a sign of a power-law. In the table, rank is the dependent variable and outdegree the independent variable.

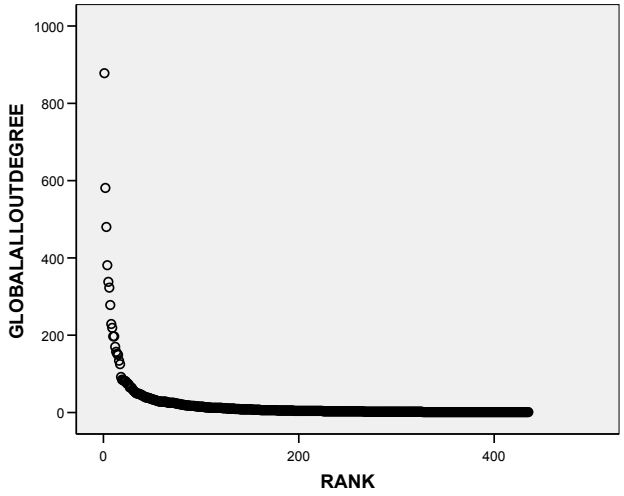


Figure 1a.

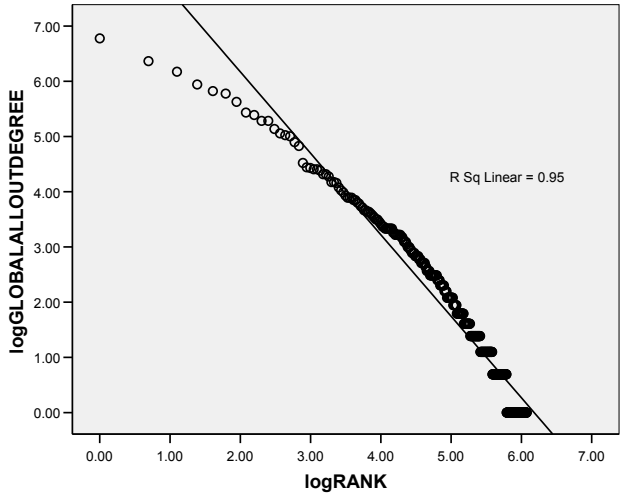


Figure 1b.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	6.127	.016		395.148	.000
	log GLOBALALLOUTDEGREE	-.644	.007	-.975	-90.864	.000

a. Dependent Variable: logRANK

Figure 1c.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	9.124	.084		108.504	.000
	logRANK	-1.476	.016	-.975	-90.864	.000

a. Dependent Variable: logGLOBALALLOUTDEGREE

Figure 1d.

POWERLAW COMPARISSON

		beta	standardized beta	y-intercept	r-squared
a.	**global all firms outdegree**	-0.6	-1.0	9	0.95
b.	**global all firms indegree**	-1.1	-1.0	6	0.95
c.	**global outdegree goods**	-0.6	-1.0	8	0.95
d.	**global outdegree information**	-1.1	-1.0	6	0.93
e.	**EU all firms outdegree**	-0.6	-1.0	9	0.95
f.	**EU all firms indegree**	-1.1	-1.0	6	0.94
g.	**EU outdegree goods**	-0.6	-1.0	8	0.95
h.	**EU outdegree information**	-0.7	-1.0	8	0.93

Figure 1e.

Power-law:
FIGURE 18

The beta coefficient of -1.4 indicates that global corporate connectivity is highly uneven, where only a few cities or nations have almost all activity. It shows that the current system is more polarized than before and that the popular belief in an 'emerging flat world' is still far from evident. The beta coefficient can be used to make estimations of a city's hierarchic rank within the system. This means that if in future one only knows the rank of a certain city, its connectivity within the system can be estimated. From this output the constant of 9.124 is useful as it forms the intercept on the y-axis of the graph. This is useful to compare the steepness of the different graphs. The steeper the graph the more asymmetric the network system proves to be. In the graphs the r2 serves as a measure of how much variance between connectivity and rank can be statistically explained. In all cases 95% of the variance is explained and furthermore all outcomes display high statistical significance.

In the following graphs (figures 19) only the logarithmic graph is shown. From these results some interesting discoveries are made. Firstly all graphs are clearly power-law distributions regardless of scale, function or direction. However, if we compare the angle between the x-axis and trend-line, levels of difference can be revealed in the particular graphs. For instance the global outdegree network is much steeper than that of the EU outdegree. This means that the global network of corporate control is more asymmetrical than that of the EU – which also explains that to achieve the same level of rank in both systems (say rank 4), a city in the global network requires a higher relative connectivity than that of a city within the EU system. Simply speaking, it is easier to be important in the EU network than in that of the world.

Looking at the same comparison, but now concerning global versus EU indegree, we see no significant difference. This means that the relative magnitude of connectivity needed to obtain the same rank in both networks is roughly the same. Therefore, *prestige* (the reliance of other cities on a particular city), is not scale dependent (at least not for these two scales). In other words, the hierarchy of *governor* relations (outdegree) is more scale dependent than those cities that are prone to be *governed* (indegree). Looking at the difference between the outdegree of information versus goods networks, it is seen that within the global system, the goods network is steeper than that of information, meaning that it requires a higher level of connectivity for cities in the goods network to achieve the same rank as those cites within the information network. Looking at EU goods and information, we see hardly any difference. It takes the same level of connectivity in both sectors to achieve the same rank. Finally, to prove that the city-firm networks are scale-free, the last graph is a selected part of the total global network. Here only cities with 10 or more connections have been chosen. Once again, this zoomed in scale reveals a power-law distribution. Therefore these corporate networks are scale-free and hence portray the characteristics of a self-organized system. It means that the unevenness and hegemony of

global and European corporate networks have not been consciously planned that way, but have naturally evolved in this manner over time. This raises the question what a fair system would be, what an even distribution might mean, and if it is possible at all!

3.2.3: Context: Conclusions on the disproportionality hypothesis:

In this section it has been shown that the free market is not a system of perfect competition between equal sized firms, but that instead high disproportionality exists in firm sizes and their influences upon each other. This power-law has a characteristic gradient of -1. It appears to be a universal law found in many self-organizing systems and has been argued to be the most robust statistical regularity in all the social sciences. Furthermore it has been indicated that the more connected a city is, the higher its probability of future corporate potential. The stronger the network structures is, the more robust - and the weaker the structures, the more they are subjected to change and uncertainty. These are statistical probabilities of what proves to be a truly self-organizing, economic system – a system which is not new or unique – but found in many natural dynamic systems. Because power-laws are inherent in most dynamic, 'real world' and 'natural' systems, it raises the question whether an alternative more evenly distributed distribution is possible - or whether global economic activity structurally depends on the uneven distribution of corporate power. For governments, it becomes interesting to how they should address this system and what a fairly distributed network-connectivity will be. Will it be above or below the gradient of -1, and to what magnitude? For policy, the question can be how to artificially increase the potential for corporate connectivity within and between countries. For developing countries and cities, this concerns how to become more connected to the existing system. The more connected they become, the more their sustainability levels will improve. So, when many weaker cities become connected to the system, will this lead to a more even Gaussian distribution and diminished gradient of the power-law – or will this simply lead to an amplification of the system, where the strongest cities become even more connected, and where the power-law structure continues to prevail?

Because New York, Paris, London and Tokyo claim 25% of command relations within the network and have extremely high levels of performance – it raises questions about what the impact of these four cities on the world is - and what should be done about it. Should these cities become less or more powerful, so as to raise overall improvement of the system? The same question can be asked about the Randstad, which serves as the 5th most powerful city in the world, claiming 6% of global command connectivity. Another issue for governments to consider is the world's vulnerability due to its high dependency on the four major hub cities, which serve as both the strength and Achilles heel of the world city network. Similarly, the protection of cities like Amsterdam (high betweeness) is equally vital, as these types of cities form strong intermediary positions between global,

regional and national subsystems. Another insight from this research is that the global system proves to be steeper than the European one – which means that global policy has to deal more emphatically with inequality at this level, than European policy would. Furthermore, how would today's slow-moving governance, plan and intervene in the fast dynamics of the corporate self-organized system? What would an efficient, rapid-response governance look like?

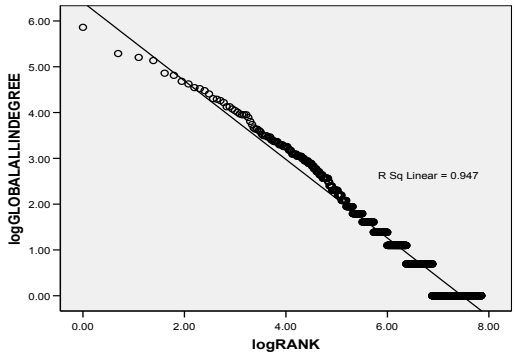


Figure 1f.

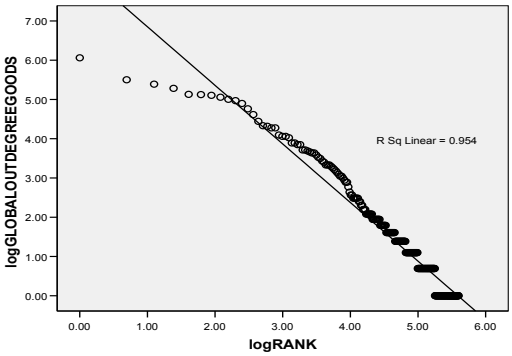


Figure 1g.

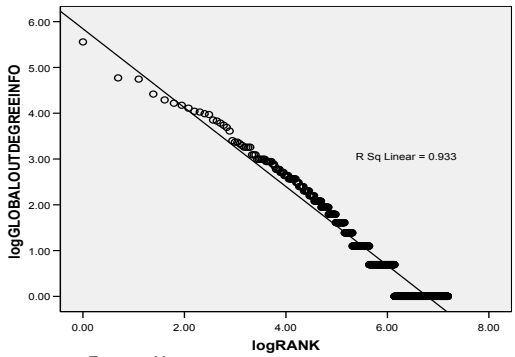


Figure 1h.

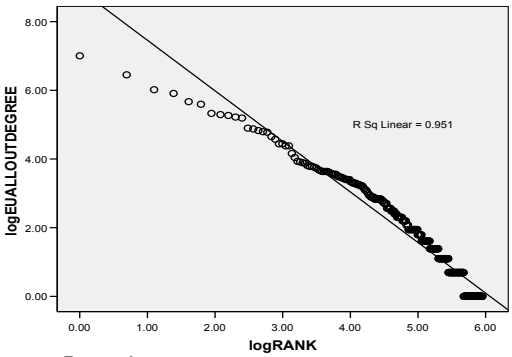


Figure 1i.

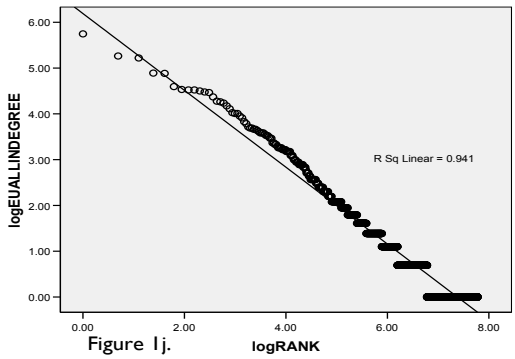


Figure 1j.

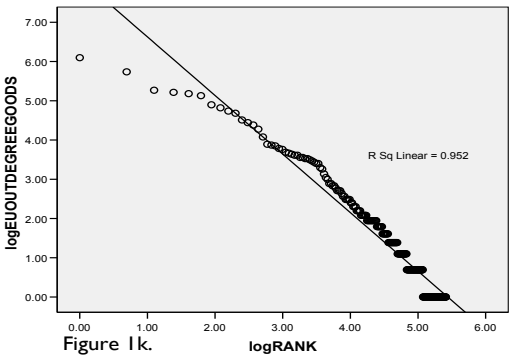


Figure 1k.

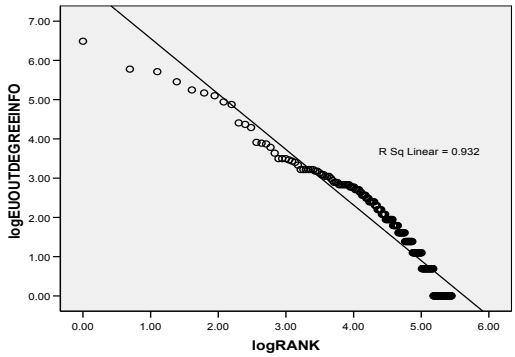


Figure 1l.

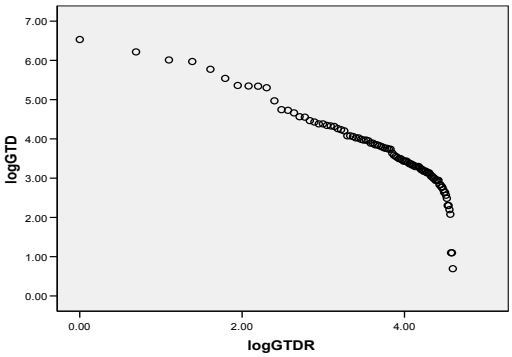


Figure 1m.

Power-law: FIGURE 19

3.3 The performance hypothesis on sustainability:

Hypothesis: *Network connectivity variables (city-firm, trade and FDI) will function as strong predictors of the performance of nations. Performance in turn is based on four selected sustainability indicators that are positioned in the four quadrants of the sustainability scheme. Because strong coherence is expected, the previous 'structural hypothesis' will give insight into the 'relational distribution' and 'directionality' of sustainability in our world – and those responsible for the current situation.*

The four central indicators (see sustainability scheme in the conceptual chapter), used are based on existing, but dissimilar theories on sustainability. These are Human Development Index (social), Ecological Footprint (environmental), Global Competitivity Index (economic), and Network Accessibility Index (infrastructure). These will first be theoretically discussed.

3.3.1 Theory of Four Different Sustainability Indicators:

Human Development Index

The concept of human development is much deeper and richer than what can be captured in any composite index or even by a detailed set of statistical indicators. Yet, to monitor progress in human development a simple tool is needed. Thus the HDI reflects achievements in the most basic human capabilities-'leading a long life', 'being knowledgeable' and 'enjoying a decent standard of living'. Three variables have been chosen to represent those dimensions-life expectancy, educational attainment and income. It has been developed by the United Nations Development Program (UNDP). The HDI is a more comprehensive measure than only GDP per capita income. Income is only a means to human development, not an end. Thus by focusing on areas beyond income and treating income as a proxy for a decent standard of living, the HDI index provides a more comprehensive picture of human life than income alone. With normalization of the values of the variables that make up the HDI, its value ranges from 0 to 1. The HDI value for a country shows the distance that it has already travelled towards the maximum possible value of 1 and also allows comparisons with other countries. The difference between the value achieved by a country and the maximum possible value shows the country's shortfall-how far the country has to go. A challenge for every country is to find ways to reduce its shortfall.

Ecological footprint

The term was first coined in 1992 by Canadian ecologist and professor at the University of British Columbia, William Rees. It is now widely used around the world as an indicator of environmental sustainability. It can be used to measure and manage the use of resources throughout the economy. The phrase 'ecological footprint' is a metaphor used to depict the amount of land and water area a human population would hypothetically need to provide the resources required to support it and to absorb its wastes given prevailing technology. Ecological footprint analysis approximates the amount of ecologically productive land, sea, and other water area required, to sustain a population, manufacture products, or undertake certain activities that require the use of energy, food, water, building material, and other consumables. The calculations used, typically convert this into a measure of land area used in 'global hectares' (gha) per capita. It is a way of determining relative consumptions - for the purpose of educating people about their resource use and possibly triggering them to alter their over-consumption. It can be combined with overpopulation concerns and stated as 'the number of Earths it would take to support every human living exactly the way developed countries do.' Ecological footprints have been used to argue that current lifestyles are not sustainable. For example, the average 'earthshare' available to each human citizen is approximately 1.9 gha per capita. This, while the US average footprint is 9.5 gha per capita.

Global Competitivity Index:

The global economy is undergoing tremendous change, not only bringing about huge opportunities, but also important challenges. In several countries most notably the United States, the rapid development of information technology has led to increased productivity and higher economic growth. In Europe, a cyclical recovery is underway and it is hoped that monetary unification will provide renewed impetus for further deregulation and accelerated market-oriented reforms. In the emerging markets, the financial crises are left behind and many countries have begun to return to a sustained growth path. On the other hand, large disparities in the global economy continue to exist. Indeed, there is a nontrivial risk that the digital divide-the gap between those countries that have access to communications and infrastructure and those that do not-will widen further undermining economic integration and development in a large part of the world. Understanding the determinants of prosperity at any point in time, is as important as understanding the growth drivers, particularly since focus is on growth that increases the standard of living. The Competitivity *Index*, developed chiefly by economist Michael Porter, aims to measure the conditions that determine a nation's sustainable level of productivity. This index builds on the Microeconomic Competitiveness Index introduced in 1998 and 1999 Reports. The influences on current competitiveness are divided into two major categories. The first category is the sophistication with which a nation's firms compete. It aims to gauge the

knowledge, technology, physical capital, and managerial skill - reflected in the firms' operating practices and strategies. The second category is the quality of the nation's business environment. It measures the quality of the infrastructure, skills, technology, stocks, rules and regulations and institutions that constitute the context in which a nation's firms operate.

ICT accessibility

For the first time in history, the basic unit of economic organization is not a subject - be it individual or collective, but instead the network. Today's technological transformations are intertwined with another transformation-globalization, and together they are creating the paradigm of 'the network age'. These transformations expand opportunities and increase the social and economic rewards of creating and using technology. They are also altering how-and by whom -technology is created and owned, and how it is made accessible and used. A new map of innovation and diffusion is appearing. Technological growth hubs, centers that bring together research institutes, business startups and venture capital - are dotted across the globe, from Silicon Valley to Bangalore, linked through technological networks. But these new networks and opportunities are superimposed on another map that reflects a long history of unevenly diffused technology, both among and within countries. No individual organization, business or government can ignore these changes. The new terrain requires shifts in public policy - national and global - to harness today's technological transformations as tools for human development. ICT is a fundamental feature of knowledge based economies and the driver of current and future productivity improvements. An indicator for ICT investment is crucial for capturing innovation in knowledge based economies, particularly due to the diffusion of new IT equipment services and software.

3.3.2 The Coherence between Connectivity and Indicators:

In the next part we investigate the relationship between connectivity variables (city-firm relations, trade and FDI), and performance indicators - under the four quadrants of the sustainability scheme, societal, environmental, economic and accessibility. These are explored in relation to the global dataset and the European dataset to see what the differences might be. For this, a simple regression analysis is used, in which the connectivity variables are used as the independent variables to predict the performance variables. Multiple regressions could not used, because the three network variables have a too strong multicollinearity (figures 20 – 29). For each calculation, three types of results are found, two top ones in smaller corps and one below in bigger corps. The biggest 'in bold' represents the standardized beta coefficient, which is the standardization of the beta coefficient found at the top left. It is standardized so as to make all outcomes comparable. The standardized beta coefficient is a number between 0 and 1. Because this involves a

singular regression, the outcomes are the same as correlations scores. A score below 0.6 is weak and between 0.6 and 0.7 is a reasonably strong, and above 0.7 reveals a very strong relationship. The normal beta coefficient (top left) is used if a prediction is to be made in future, where one knows the connectivity variable and wants to predict the probable performance score of a nation. The number at the top left is the r^2 which is simply the square of the standardized beta coefficient. This number is useful because it tells us how much of the variance between the x and y variable is explained as a percentage. For instance an r^2 result of 0.581, means that 58% of the variance is explained by that particular relationship. The results, (tables 1 – 10) will now be discussed under different headings that associate with the four quadrants of the sustainability scheme. The horizontal rows marked in 'blue' concern the most interesting outcomes for coherences with corporate connectivity trade and FDI.

3.3.3 Table 1 and 2: Global and European connectivity and societal indicators:

In these tables (figure 20 – 21) we see that a good relationship (0.751) exists between the corporate *total connectivity* and the *human development index* (HDI). This means that the more connected a city or nation is, the higher will be its level of human development. The governor goods indegree and outdegree is higher than that of information, meaning that there is less variance in the goods network – and that it is more structured. The relationship to two different education indexes is shown. The first one (0.654) is a sub-index of the HDI, the second (0.734) a sub-index of Michael Porter's *global competitivity index* (GCI). Porter's is a more sophisticated and reliable measure. Both scores prove that the more connected a city is, the higher its education level will be. The causality between the two is not evident. It is probably a circular causality. The sub-indexes of life-expectancy and health/primary services have no significant relationship with total outdegree.

Looking at trade relationships we see the same results, except that it serves as a slightly stronger predictor. This specifically concerns the value of imports. Exports on the other hand show weaker significance to the performance of human development. This could mean that the more import oriented a city or nation is, the more developed and higher educated its people will be. It is known that much of the information society's goods are produced in developing countries, to which it has high import relations. Therefore, strong import potential is a sign of a strong information society level and subsequently a very high education level. This is clear where the GCI of higher-education (0.805), forms the highest result in this table and where 71% of its variance with imports is explained. The relationship of foreign direct investments (FDI), with human development also shows good results – particularly the FDI outdegree. This relates to the import levels of a city or nation. Because developed countries invest heavily in outsourced production to the developing world (outward FDI) – which they command from above – it is not surprising

that the FDI outdegree has stronger coherence with development levels, especially the education levels needed to carry out complex command activities of the network.

Remembering that the European dataset is entirely different to the global one, because it concerns the top 100 European multinationals and all their subsidiaries worldwide, we can now investigate how this functionally different dataset corresponds with the performance variables, and what differences are seen between the two dataset's. We firstly see that the total connectivity here is lower than that of the global dataset. This applies to all scores – which are all proportional to the global results, but lower in magnitude. This is because there is more variance (less structure) between European connectivity and performance indicators (which are constant in both datasets) than between global connectivity and performance indicators. So what is the difference between the global and European connectivity – that creates this variance? The reason for this might be that the share of regional connectivity within Europe itself (37%) in the European dataset is much higher than that in the global dataset (27%). It means that Europe has tighter structure in the European set than in the global set. This is also seen in the power-law study, that the world graph is more disproportionate than the European one. Furthermore, because the performance indicators have been defined at a world level by the United Nations, World Bank et al – it is not surprising that it has higher coherence to the structure of global connectivity. If similar data was collected within a European scale, then probably the results would be the other way around. Therefore, we should not be misled to think that the lower scores for Europe means that European connectivity contributes less to national performance. In fact, it would probably contribute more – if the performance data were more compatible. More important is to see that the strongest relationships within both datasets are relatively the same.

3.3.4 Table 3 and 4: Global and European connectivity and environmental indicators:

Because the horizontal structure proves to remain relatively strong in all tables (total connectivity trade imports FDI outdegree) we will keep these constant throughout all tables (blue rows). Instead focus is put on the affects on performance indicators (figure 22 – 23). In terms of total connectivity (for both sets) we see that the core with ecological footprint is moderate (0.6) where only 35% of the variance is explained in the relationship. This means that the more connected a city or nation is, the higher its consumption of world resources. More specifically, but now looking at two of the ecological footprints sub-indexes, we see much stronger correlations. Energy consumption has a very strong standardized beta coefficient (0.82), meaning that the higher the connectivity, the more energy consumption – where 66% of the variance is explained. The same applies to nuclear footprint (0.75).The carbon footprint scores low with connectivity, making the direct relationship insignificant. However, because of the strong coherence

with energy consumption, we know that there is a strong indirect relationship with CO2 emissions. If we look at the two sub-variables of an entirely different dataset - namely that of Yale University's 'Environmental Sustainability Index' (ESI), we see the strong relationships with human environmental vulnerability (0.74) and the institutional capacity of a nation (0.68). This means that the more connected a city is, the more vulnerable it is, but that the institutional capacity will be high. The same characteristics are seen for trade and FDI – although higher in magnitude. In the European dataset the same patterns are evident.

3.3.5 Table 5 6 7 and 8: Global connectivity and economic indicators:

In this part we see that total connectivity has very high coherence with GDP per capita (0.918), where 84% of the variance is explained (figure 24 – 27). This means that the more connected a city or nation is, the higher the total market value of all the final goods and services – network per capita is thus a very good predictor for GDP per capita. If we look at the GDP of 2003, we see a lower score than GDP of 2005. This is possibly because the connectivity results are based on 2005 data. Next we see very high scores with innovation index, meaning that the higher the level of innovation of a city, the more connected it will deem to be – or vice versa. The same trends are seen at the level of technological achievement, business efficiency index, the number of patents granted, Porter's global competitivity index, institutional capacity, market efficiency and business sophistication. The five GCI indexes also indicate that the coherence with total outdegree is higher than with total indegree. The explanation for this is that cities with high commanding power over others are in fact more advanced type cities, than cities with strong subservience to others. Once again, the same pattern is discovered in trade and FDI connectivity – and compared to the European dataset, the pattern remains the same, although watered down for reasons previously mentioned.

3.3.6 Table 9 and 10: Global and European connectivity and accessibility indicators:

In the last set of comparisons we see how vital expenditure in network technology and infrastructure is, for doing business and raising corporate connectivity (figure 28 – 29). In fact, the more ICT network capacity a city has to communicate world wide, the higher the worldwide corporate network integrity is. It is an indication that the corporate connectivity we see in the previous GIS maps and network diagrams, serves as a mirror of Castells 'information society'. Furthermore, the corporate networks in this research are immaterial – they merely represent business relationships (shareholds of firms in each other). Because they correlate so highly with ICT networks, it indicates that the GIS maps and network diagrams may also well approximate the ICT networks of our world. If we download a map of gigahertz bandwidth distribution in the world, we will see that this is in

fact the case. The strongest outputs in this series are with the level of investment (Porter's GCI) a country puts into national ICT infrastructure (0.923), followed by the number of computers a nation has (0.848), the internet capacity of a nation measured in bandwidth megabytes per second (0.836), and the number of secure servers (0.878). Also telephone mainlines (0.77) and (Porter's GCI) overall infrastructure correlate very high. Another striking fact is that across the row of total outdegree, the scores are higher than for total indegree. It appears that networks of command and control make more use of the facilities of the information society. Lastly, we again see that trade imports, as well as FDI are also good indicators – and that again the same patterns are evident in the European set for reasons already explained earlier on.

3.3.7 Conclusions of the performance hypothesis:

In this section the relationship of corporate trade and FDI connectivity to four different indicators have been explored. The first relationship is with the social indicator - the Human Development Index (HDI), which in itself is a comparative measure of life expectancy, literacy education, and standard of living for countries worldwide. The correlation is strong, but even stronger with the sub index of education. Furthermore, the more import oriented a city or nation is, the more developed and higher educated its people tend to be. Therefore, strong import potential is a sign of a strong information society levels and subsequently a very high education level. It is shown that because developed countries invest heavily in outsourced production to the developing world – which they command from above – it is not surprising that the FDI outdegree has strong coherence with development levels especially the education levels needed to carry out complex command activities of the network.

The second relationship of connectivity is with the environmental indicators of the ecological footprint, which in itself is an analysis which approximates the amount of ecologically productive land, sea and other water mass area required to sustain a population, manufacture products, or undertake certain activities that account for the use of energy, food, water, building material, and other consumables. Correlations of connectivity with ecological footprint prove to be reasonable, but the sub-index of energy consumption has a very strong relationship, meaning that the higher the connectivity the more energy consumption. A strong relationship also exists with human environmental vulnerability and the institutional capacity of a nation, meaning that the more connected a city is, the more vulnerable and that the institutional capacity will be high. The connectivity and footprint relationship indicates that the more connected a city or nation is the more dependent it is on resources from afar. With a footprint more than double its own biological capacity, Europe's well-being depends on ecological capacity from elsewhere – and the networks show us the structure and power relationships of this interdependency. To improve ecological footprint therefore means addressing the

interdependencies of this network. This is essential for both Europe's competitiveness and its credibility, as a force for international collaboration. Europe can use its undoubted intellectual, financial, social and cultural advantages, to lead the world onto a different path. By understanding the structure of the networks, Europe could facilitate the transition towards a more sustainable future.

The third relationship is with economic indicators, such as Michael Porter's global competitivity index, which in itself measures competitiveness based on the sophistication with which a nation's firms compete - gauging the knowledge, technology, physical capital, and managerial skills, reflected in the firms' operating practices and strategies. The index also measures the quality of the nation's business environment, based on the quality of the infrastructure, skills, technology, stocks, rules and regulations, and institutions that constitute the context in which a nation's firms operate. The correlation of the global competitivity index with connectivity proves to be very high – also with the sub-indexes of technological achievement, business efficiency index, the number of patents granted, institutional capacity, market efficiency and business sophistication. Furthermore, it is shown that the coherence of these indexes with total outdegree is higher than with total indegree. The explanation to this is that cities with high commanding power over others are in fact more advanced type cities than cities with strong subservience to other cities. Also, it is shown that total connectivity has very high coherence with GDP per capita; meaning that the more connected a city or nation is, the higher the total market value of all the final goods and services.

The fourth relationship concerns network accessibility. Connectivity proves to correlate very high with innovation index, meaning that the higher the level of innovation of a city, the more connected – or the other way around.
In fact, the more ICT network capacity a city has to communicate globally, the higher the worldwide corporate network integrity is. It is an indication that the corporate connectivity serves as a mirror of Castells 'information society'. According to Castells, 'dominant functions and processes in the information age are increasingly organised around networks'. Networks constitute the new social morphology of our societies and the diffusion of networking logic substantially modifies the operation and outcomes, in the processes of production, experience, power and culture. The new information technology paradigm provides the basis for its pervasive expansion throughout the entire social structure. It becomes vital to be present in a network and not to be excluded from it. Because they correlate so highly with ICT networks, it indicates that the GIS maps and network diagrams must also well approximate the ICT networks of our world.
The strongest outputs in this series are with the level of investment (Porter's GCI) a country puts into national ICT infrastructure (0.923), followed by the number of computers a nation has (0.848), the internet capacity of a nation measured in bandwidth megabytes per second (0.836), and the number of secure servers (0.878). Also telephone

mainlines (0.77), and overall infrastructure correlate very highly. Another striking fact is that across the row of total outdegrees, the scores are higher than for total indegree. It shows that networks of command and control make more use of the facilities of the information society. This raises questions on how to better equip developing countries to participate within the economic system – where countries obtain the domestic capacity to identify technology's potential benefits and to adapt new technology to their needs.

	HDI human development index		HD-1 education Index		HD-3 life expectancy index		GCI-4 health and primairy services		GCI -5 higher education	
Firm Connectivity										
total outdegree	.037	.544	.020	.437	.046	.217	.012	.124	.056	.581
	(.737)		**(.661)**		**(.466)**		**(.352)**		**(.762)**	
total indegree	.049	.529	.025	.396	.056	.182	.014	.098	.066	.457
	(.728)		**(.630)**		**(.426)**		**(.312)**		**(.676)**	
total connectivity	.046	.565	.024	.428	.054	.207	.014	.111	.066	.539
	(.751)		**(.654)**		**(.455)**		**(.334)**		**(.734)**	
governor info outdegree	.030	.410	.017	.370	.038	.162	.009	.073	.049	.479
	(.641)		**(.608)**		**(.402)**		**(.270)**		**(.692)**	
governor goods outdegree	.034	.501	.020	.485	.044	.209	.013	.156	.056	.639
	(.708)		**(.696)**		**(.458)**		**(.395)**		**(.799)**	
governor info indegree	.040	.455	.016	.231	.037	.125	.008	.046	.041	.277
	(.675)		**(.481)**		**(.353)**		**(.214)**		**(.526)**	
governor goods indegree	.059	.585	.032	.479	.066	.196	.019	.137	.090	.648
	(.765)		**(.692)**		**(.443)**		**(.370)**		**(.805)**	
governed info outdegree	.035	.494	.019	.407	.044	.201	.012	.118	.055	.563
	(.703)		**(.638)**		**(.449)**		**(.343)**		**(.751)**	
governed goods outdegree	.036	.531	.016	.332	.038	.178	.009	.087	.044	.425
	(.729)		**(.576)**		**(.422)**		**(.294)**		**(.652)**	
governed info indegree	.014	.160	.008	.140	.013	.035	.003	.020	.015	.089
	(.400)		**(.375)**		**(.187)**		**(.142)**		**(.298)**	
governed goods indegree	.048	.522	.022	.326	.049	.158	.012	.075	.057	.389
	(.722)		**(.571)**		**(.397)**		**(.274)**		**(.624)**	
International Trade										
Trade -1 value imports	.060	.594	.034	.505	.084	.288	.027	.241	.096	.716
	(.771)		**(.710)**		**(.537)**		**(.491)**		**(.846)**	
Trade -2 value exports	.031	.320	.015	.205	.040	.136	.010	.069	.031	.138
	(.566)		**(.453)**		**(.369)**		**(.262)**		**(.372)**	
Trade -6 outdegree	.041	.429	.021	.308	.055	.188	.015	.117	.048	.253
	(.655)		**(.555)**		**(.434)**		**(.341)**		**(.503)**	
Trade -7 indegree	.040	.443	.020	.311	.053	.201	.014	.120	.045	.252
	(.666)		**(.557)**		**(.448)**		**(.346)**		**(.502)**	
Foreign Investments										
FDI – cumulative stock	.040	.426	.022	.359	.047	.150	.014	.111	.053	.339
	(.653)		**(.599)**		**(.387)**		**(.333)**		**(.582)**	
FDI-flows-outdegree	.025	.572	.014	.480	.029	.204	.008	.127	.033	.468
	(.756)		**(.693)**		**(.451)**		**(.357)**		**(.684)**	
FDI-flows-indegree	.033	.426	.018	.352	.036	.136	.010	.080	.041	.316
	(.653)		**(.593)**		**(.369)**		**(.283)**		**(.562)**	

Global connectivity / societal indicators.
FIGURE 20

	HDI human development index		HD-1 education Index		HD-3 life expectancy index		GCI-4 health and primairy services		GCI -5 higher education	
Firm Connectivity										
total outdegree	.022	.321	.011	.229	.020	.075	.004	.028	.029	.290
	(.567)		**(.479)**		**(.273)**		**(.167)**		**(.538)**	
total indegree	.040	.437	.022	.361	.041	.124	.010	.060	.054	.372
	(.661)		**(.601)**		**(.352)**		**(.245)**		**(.610)**	
total connectivity	.034	.422	.018	.350	.035	.119	.008	.056	.047	.384
	(.649)		**(.592)**		**(.345)**		**(.236)**		**(.619)**	
governor info outdegree	.022	.287	.002	.028	.006	.018	.000	.000	.008	.066
	(.536)		**(.168)**		**(.133)**		**(.022)**		**(.258)**	
governor goods outdegree	.003	.034	.003	.055	.003	.006	.000	.001	.004	.018
	(.184)		**(.235)**		**(.080)**		**(.027)**		**(.133)**	
governor info indegree	.004	.012	.003	.021	-.005	.004	-.001	.002	.005	.009
	(.111)		**(.145)**		**(-0.062)**		**(-0.047)**		**(.093)**	
governor goods indegree	.016	.190	.010	.201	.014	.037	.005	.046	.032	.345
	(.435)		**(.449)**		**(.192)**		**(.214)**		**(.587)**	
governed info outdegree	.023	.304	.002	.032	.006	.018	.000	.001	.008	.071
	(.551)		**(.180)**		**(.135)**		**(.026)**		**(.266)**	
governed goods outdegree	.001	.008	.001	.012	.001	.001	.000	.000	.001	.002
	(.090)		**(.109)**		**(.026)**		**(.000)**		**(.048)**	
governed info indegree	.038	.428	.020	.327	.040	.128	.009	.056	.048	.335
	(.654)		**(.572)**		**(.358)**		**(.236)**		**(.579)**	
governed goods indegree	.043	.434	.024	.394	.043	.115	.011	.064	.061	.420
	(.659)		**(.628)**		**(.340)**		**(.252)**		**(.648)**	
International Trade										
Trade -1 value imports	.060	.594	.034	.505	.084	.288	.027	.241	.096	.716
	(.771)		**(.710)**		**(.537)**		**(.491)**		**(.846)**	
Trade -2 value exports	.031	.320	.015	.205	.040	.136	.010	.069	.031	.138
	(.566)		**(.453)**		**(.369)**		**(.262)**		**(.372)**	
Trade -6 outdegree	.041	.429	.021	.308	.055	.188	.015	.117	.048	.253
	(.655)		**(.555)**		**(.434)**		**(.341)**		**(.503)**	
Trade -7 indegree	.040	.443	.020	.311	.053	.201	.014	.120	.045	.252
	(.666)		**(.557)**		**(.448)**		**(.346)**		**(.502)**	
Foreign Investments										
FDI – cumulative stock	.040	.426	.022	.359	.047	.150	.014	.111	.053	.339
	(.653)		**(.599)**		**(.387)**		**(.333)**		**(.582)**	
FDI-flows-outdegree	.025	.572	.014	.480	.029	.204	.008	.127	.033	.468
	(.756)		**(.693)**		**(.451)**		**(.357)**		**(.684)**	
FDI-flows-indegree	.033	.426	.018	.352	.036	.136	.010	.080	.041	.316
	(.653)		**(.593)**		**(.369)**		**(.283)**		**(.562)**	

European connectivity / societal indicators.
FIGURE 21

	Total Ecological Footprint		Carbon Footprint		Nuclear Footprint		Energy Consumption (kgtoe p. cap)		ESI -3 Human vulnerability		ESI -4 soc/inst. capacity	
Firm Connectivity												
total outdegree	.569	.349	.337	.311	.557	.546	.221	.581	2.99	.480	5.54	.561
	(.59)		**(.56)**		**(.74)**		**(.76)**		**(.69)**		**(.75)**	
total indegree	.755	.345	.423	.274	.884	.584	.323	.699	4.36	.573	5.87	.354
	(.59)		**(.52)**		**(.76)**		**(.84)**		**(.76)**		**(.60)**	
total connectivity	.699	.356	.406	.305	.721	.557	.287	.664	3.89	.551	6.13	.464
	(.60)		**(.55)**		**(.75)**		**(.82)**		**(.74)**		**(.68)**	
governor info outdegree	.463	.249	.297	.265	.575	.586	.203	.522	2.36	.383	4.22	.349
	(.50)		**(.51)**		**(.77)**		**(.72)**		**(.62)**		**(.59)**	
governor goods outdegree	.561	.358	.341	.335	.550	.534	.181	.461	2.65	.401	5.84	.655
	(.60)		**(.58)**		**(.73)**		**(.68)**		**(.63)**		**(.81)**	
governor info indegree	.539	.273	.323	.249	.540	.348	.221	.505	3.47	.566	3.64	.211
	(.52)		**(.50)**		**(.59)**		**(.71)**		**(.75)**		**(.46)**	
governor goods indegree	.890	.370	.477	.270	.968	.609	.356	.653	5.20	.629	7.49	.444
	(.61)		**(.52)**		**(.78)**		**(.81)**		**(.79)**		**(.67)**	
governed info outdegree	.535	.311	.347	.332	.521	.480	.216	.556	2.77	.415	5.16	.489
	(.56)		**(.58)**		**(.69)**		**(.75)**		**(.64)**		**(.70)**	
governed goods outdegree	.520	.346	.284	.262	.478	.467	.179	.453	2.83	.510	4.91	.524
	(.59)		**(.51)**		**(.68)**		**(.67)**		**(.71)**		**(.72)**	
governed info indegree	.170	.062	.070	.027	.346	.198	.118	.336	1.42	.219	1.64	.099
	(.25)		**(.17)**		**(.45)**		**(.58)**		**(.47)**		**(.31)**	
governed goods indegree	.688	.326	.374	.244	.750	.494	.284	.614	4.16	.596	5.44	.345
	(.57)		**(.49)**		**(.70)**		**(.78)**		**(.77)**		**(.59)**	
Trade												
Trade -1 value imports	.706	.214	.400	.173	1.03	.630	.342	.620	4.74	.483	6.70	.324
	(.46)		**(.42)**		**(.79)**		**(.79)**		**(.70)**		**(.57)**	
Trade -2 value exports	.374	.121	.193	.082	1.08	.599	.239	.543	2.61	.293	3.20	.150
	(.35)		**(.29)**		**(.77)**		**(.74)**		**(.54)**		**(.39)**	
Trade -6 outdegree	.521	.177	.275	.125	1.00	.578	.291	.609	3.49	.398	4.53	.227
	(.42)		**(.35)**		**(.76)**		**(.78)**		**(.63)**		**(.48)**	
Trade -7 indegree	.524	.201	.289	.156	.941	.604	.278	.625	3.36	.414	4.07	.206
	(.45)		**(.40)**		**(.78)**		**(.79)**		**(.64)**		**(.45)**	
FDI												
FDI – cumulative stock	.546	.214	.275	.138	.695	.414	.251	.497	3.91	.548	4.16	.210
	(.46)		**(.37)**		**(.64)**		**(.71)**		**(.74)**		**(.46)**	
FDI-flows-outdegree	.397	.391	.220	.305	.412	.584	.158	.683	2.17	.583	3.50	.515
	(.63)		**(.55)**		**(.76)**		**(.83)**		**(.76)**		**(.72)**	
FDI-flows-indegree	.471	.241	.251	.173	.635	.495	.219	.577	3.17	.546	3.74	.257
	(.49)		**(.42)**		**(.70)**		**(.76)**		**(.74)**		**(.51)**	

Global connectivity / environmental indicators.
FIGURE 22

	Total Ecological Footprint		Carbon Footprint		Nuclear Footprint		Energy Consumption (kgtoe p. cap)		ESI -3 Human vulnerability		ESI -4 soc/inst. capacity	
Firm Connectivity												
total outdegree	.357	.251	.154	.119	-.076	.001	.138	.412	2.32	.528	3.37	.380
	(.501)		**(.345)**		**(-.033)**		**(.642)**		**(.727)**		**(.617)**	
total indegree	.609	.280	.298	.169	-1.04	.080	.266	.589	4.03	.611	5.05	.326
	(.529)		**(.412)**		**(-.283)**		**(.767)**		**(.782)**		**(.571)**	
total connectivity	.517	.274	.245	.157	-.558	.031	.216	.528	3.41	.594	4.73	.390
	(.524)		**(.396)**		**(-.177)**		**(.726)**		**(.771)**		**(.625)**	
governor info outdegree	.132	.099	.070	.070	-.137	.010	.041	.106	1.19	.403	.951	.087
	(.315)		**(.265)**		**(-.102)**		**(.326)**		**(.635)**		**(.295)**	
governor goods outdegree	.154	.187	.056	.063	.437	.147	.028	.070	.545	.117	1.46	.285
	(.432)		**(.251)**		**(.384)**		**(.265)**		**(.342)**		**(.534)**	
governor info indegree	.027	.001	-.032	.005	-.737	.102	.067	.096	.929	.083	.605	.012
	(.038)		**(-.070)**		**(-.320)**		**(.310)**		**(.288)**		**(.109)**	
governor goods indegree	.119	.028	.021	.002	-.540	.057	.128	.364	.981	.096	2.04	.141
	(.168)		**(.048)**		**(-.239)**		**(.604)**		**(.310)**		**(.375)**	
governed info outdegree	.134	.103	.072	.075	-.165	.015	.042	.111	1.21	.418	.984	.094
	(.320)		**(.275)**		**(-.123)**		**(.333)**		**(.647)**		**(.306)**	
governed goods outdegree	.082	.073	.022	.013	.471	.235	.014	.024	.307	.051	1.00	.184
	(.270)		**(.115)**		**(.484)**		**(.154)**		**(.226)**		**(.428)**	
governed info indegree	.550	.254	.299	.190	-.977	.078	.244	.553	3.71	.576	4.35	.269
	(.504)		**(.436)**		**(-.280)**		**(.744)**		**(.759)**		**(.519)**	
governed goods indegree	.687	.307	.301	.150	-1.00	.064	.289	.602	4.45	.639	5.93	.388
	(.554)		**(.388)**		**(-.253)**		**(.776)**		**(.800)**		**(.623)**	
Trade												
Trade -1 value imports	.706	.214	.400	.173	1.03	.630	.342	.620	4.74	.483	6.70	.324
	(.46)		**(.42)**		**(.79)**		**(.79)**		**(.70)**		**(.57)**	
Trade -2 value exports	.374	.121	.193	.082	1.08	.599	.239	.543	2.61	.293	3.20	.150
	(.35)		**(.29)**		**(.77)**		**(.74)**		**(.54)**		**(.39)**	
Trade -6 outdegree	.521	.177	.275	.125	1.00	.578	.291	.609	3.49	.398	4.53	.227
	(.42)		**(.35)**		**(.76)**		**(.78)**		**(.63)**		**(.48)**	
Trade -7 indegree	.524	.201	.289	.156	.941	.604	.278	.625	3.36	.414	4.07	.206
	(.45)		**(.40)**		**(.78)**		**(.79)**		**(.64)**		**(.45)**	
FDI												
FDI – cumulative stock	.546	.214	.275	.138	.695	.414	.251	.497	3.91	.548	4.16	.210
	(.46)		**(.37)**		**(.64)**		**(.71)**		**(.74)**		**(.46)**	
FDI-flows-outdegree	.397	.391	.220	.305	.412	.584	.158	.683	2.17	.583	3.50	.515
	(.63)		**(.55)**		**(.76)**		**(.83)**		**(.76)**		**(.72)**	
FDI-flows-indegree	.471	.241	.251	.173	.635	.495	.219	.577	3.17	.546	3.74	.257
	(.49)		**(.42)**		**(.70)**		**(.76)**		**(.74)**		**(.51)**	

European connectivity / environmental indicators.
FIGURE 23

	GDP 2005 per capita (calculated)		GDP 2003 per capita (worldbank)		R&D personel		Business Efficiency Index		Innovation Index		Technical Achievement Index	
Firm Connectivity												
total outdegree	.423	.784	.508	.691	.449	.423	9.03	.550	1.43	.700	.051	.556
	(.885)		**(.832)**		**(.651)**		**(.742)**		**(.837)**		**(.746)**	
total indegree	.578	.818	.679	.693	.613	.373	15.24	.618	2.11	.682	.067	.477
	(.905)		**(.832)**		**(.611)**		**(.786)**		**(.826)**		**(.691)**	
total connectivity	.534	.842	.634	.729	.563	.415	13.05	.637	1.86	.720	.064	.540
	(.918)		**(.854)**		**(.644)**		**(.798)**		**(.848)**		**(.735)**	
governor info outdegree	.358	.617	.393	.463	.318	.219	7.66	.450	1.31	.619	.048	.515
	(.785)		**(.681)**		**(.468)**		**(.671)**		**(.787)**		**(.718)**	
governor goods outdegree	.381	.712	.441	.683	.434	.436	7.07	.400	1.26	.589	.048	.556
	(.844)		**(.827)**		**(.661)**		**(.632)**		**(.767)**		**(.746)**	
governor info indegree	.400	.611	.483	.545	.371	.209	12.27	.544	1.53	.564	.038	.234
	(.782)		**(.738)**		**(.458)**		**(.738)**		**(.751)**		**(.484)**	
governor goods indegree	.666	.840	.731	.620	.690	.429	16.88	.623	2.15	.648	.068	.472
	(.917)		**(.788)**		**(.655)**		**(.789)**		**(.805)**		**(.687)**	
governed info outdegree	.400	.702	.471	.597	.397	.338	8.11	.479	1.37	.649	.047	.491
	(.838)		**(.773)**		**(.581)**		**(.692)**		**(.805)**		**(.701)**	
governed goods outdegree	.377	.737	.478	.726	.434	.455	9.16	.547	1.26	.641	.042	.423
	(.858)		**(.852)**		**(.674)**		**(.740)**		**(.801)**		**(.651)**	
governed info indegree	.200	.354	.243	.319	.201	.100	2.97	.078	0.71	.206	.021	.120
	(.595)		**(.565)**		**(.316)**		**(.279)**		**(.454)**		**(.346)**	
governed goods indegree	.527	.776	.628	.675	.551	.351	15.72	.632	1.85	.629	.056	.379
	(.881)		**(.822)**		**(.592)**		**(.795)**		**(.793)**		**(.615)**	
Trade												
Trade -1 value imports	.643	.761	.619	.505	.580	.284	12.30	.396	2.16	.510	.079	.536
	(.872)		**(.711)**		**(.533)**		**(.629)**		**(.714)**		**(.732)**	
Trade -2 value exports	.399	.558	.525	.594	.697	.355	12.65	.401	2.16	.478	.079	.512
	(.747)		**(.770)**		**(.596)**		**(.634)**		**(.692)**		**(.715)**	
Trade -6 outdegree	.508	.682	.628	.641	.676	.355	12.13	.386	1.98	.445	.073	.485
	(.826)		**(.800)**		**(.596)**		**(.622)**		**(.667)**		**(.697)**	
Trade -7 indegree	.482	.690	.572	.597	.546	.270	11.81	.379	1.92	.470	.070	.487
	(.831)		**(.772)**		**(.520)**		**(.616)**		**(.686)**		**(.698)**	
FDI												
FDI – cumulative stock	.465	.628	.485	.420	.395	.176	9.31	.292	1.58	.426	.043	.251
	(.793)		**(.648)**		**(.419)**		**(.540)**		**(.652)**		**(.501)**	
FDI-flows-outdegree	.295	.876	.348	.745	.344	.476	7.17	.566	1.03	.705	.035	.566
	(.936)		**(.863)**		**(.690)**		**(.753)**		**(.840)**		**(.752)**	
FDI-flows-indegree	.399	.700	.436	.514	.384	.228	9.98	.388	1.49	.539	.042	.323
	(.837)		**(.717)**		**(.478)**		**(.623)**		**(.734)**		**(.569)**	

Global connectivity / economic indicators Part 1
FIGURE 24

	TA-8 Patents granted		Global Competitive Index (Porter)		GCI - 1 Institutions		GCI – 6 Market efficiency		GCI - 7 Techno-logical readiness		GCI – 8 Business sophisti-cation	
Firm Connectivity												
total outdegree	.715	.463	.230	.679	.312	.588	.169	.464	.321	.611	.255	.714
	(.681)		**(.824)**		**(.767)**		**(.681)**		**(.782)**		**(.845)**	
total indegree	.805	.282	.276	.550	.443	.664	.235	.501	.435	.627	.256	.404
	(.531)		**(.741)**		**(.815)**		**(.708)**		**(.792)**		**(.635)**	
total connectivity	.813	375	.274	.649	.409	.681	.220	.529	.404	.654	.276	.566
	(.612)		**(.805)**		**(.825)**		**(.727)**		**(.809)**		**(.752)**	
governor info outdegree	.662	.457	.202	.562	.267	.480	.140	.370	.297	.561	.226	.603
	(.676)		**(.750)**		**(.693)**		**(.609)**		**(.749)**		**(.776)**	
governor goods outdegree	.716	.511	.210	.595	.250	.403	.143	.351	.275	.480	.250	.722
	(.715)		**(.771)**		**(.635)**		**(.592)**		**(.693)**		**(.850)**	
governor info indegree	.391	.105	.187	.390	.323	.547	.178	.448	.285	.419	.181	.312
	(.323)		**(.625)**		**(.740)**		**(.669)**		**(.647)**		**(.558)**	
governor goods indegree	.850	287	.337	.629	.519	.702	.279	.547	.506	.656	.314	.469
	(.536)		**(.793)**		**(.838)**		**(.740)**		**(.810)**		**(.685)**	
governed info outdegree	.684	.433	.222	.632	.295	.529	.162	.426	.303	.546	.246	.667
	(.658)		**(.795)**		**(.727)**		**(.652)**		**(.739)**		**(.817)**	
governed goods outdegree	.551	.323	.191	.557	.277	.548	.156	.467	.268	.503	.217	.612
	(.659)		**(.746)**		**(.741)**		**(.683)**		**(.709)**		**(.782)**	
governed info indegree	.275	.087	.075	.146	.168	.343	.068	.153	.145	.252	.052	.061
	(.294)		**(.382)**		**(.585)**		**(.391)**		**(.502)**		**(.246)**	
governed goods indegree	.635	.207	.247	.500	.416	.665	.222	.510	.388	.568	.233	.380
	(.455)		**(.707)**		**(.816)**		**(.714)**		**(.754)**		**(.616)**	
Trade												
Trade -1 value imports	.879	.267	.348	.611	.490	.583	.247	.392	.514	.631	.317	.434
	(.517)		**(.782)**		**(.764)**		**(.626)**		**(.794)**		**(.659)**	
Trade -2 value exports	.989	.302	.166	.283	.292	.411	.130	.219	.292	.405	.137	.166
	(.549)		**(.532)**		**(.641)**		**(.468)**		**(.637)**		**(.408)**	
Trade -6 outdegree	.965	.302	.223	.387	.368	.493	.169	.280	.369	.488	.194	.249
	(.550)		**(.622)**		**(.702)**		**(.529)**		**(.699)**		**(.499)**	
Trade -7 indegree	.833	.260	.205	.368	.336	.462	.159	.280	.348	.487	.182	.248
	(.510)		**(.607)**		**(.680)**		**(.529)**		**(.698)**		**(.498)**	
FDI												
FDI – cumulative stock	.485	.116	.207	.367	.364	.529	.180	.349	.339	.451	.171	.214
	(.341)		**(.605)**		**(.728)**		**(.591)**		**(.671)**		**(.463)**	
FDI-flows-outdegree	.517	.469	.139	.569	.210	.609	.108	.433	.216	.631	.144	.524
	(.685)		**(.754)**		**(.780)**		**(.658)**		**(.795)**		**(.724)**	
FDI-flows-indegree	.537	.199	.171	.379	.299	.543	.147	.353	.288	.494	.157	.273
	(.446)		**(.616)**		**(.737)**		**(.594)**		**(.703)**		**(.522)**	

Global connectivity / economic indicators Part 2
FIGURE 25

	GDP 2005 per capita (calculated)		GDP 2003 per capita (worldbank)		R&D personel		Business Efficiency Index		Innovation Index		Technical Achievement Index	
Firm Connectivity												
total outdegree	.257	.528	.300	.442	.254	.226	6.08	.362	.921	.516	.021	.173
	(.727)		**(.665)**		**(.476)**		**(.602)**		**(.718)**		**(.416)**	
total indegree	.489	.730	.546	.559	.454	.251	11.31	.433	1.67	.557	.047	.300
	(.855)		**(.748)**		**(.501)**		**(.658)**		**(.746)**		**(.548)**	
total connectivity	.411	.703	.463	.548	.374	.251	8.69	.401	1.34	.514	.039	.285
	(.838)		**(.740)**		**(.501)**		**(.633)**		**(.735)**		**(.534)**	
governor info outdegree	.092	.197	.117	.194	.067	.051	5.89	.344	.343	.231	.001	,002
	(.443)		**(.441)**		**(.225)**		**(.587)**		**(.481)**		**(.047)**	
governor goods outdegree	.051	.083	.688	.093	.106	.112	.912	.035	.819	.449	.007	.060
	(.288)		**(.305)**		**(.335)**		**(.187)**		**(.670)**		**(.244)**	
governor info indegree	.128	.128	1.21	.070	-.017	.001	-3.03	.070	.058	.001	.003	.003
	(.358)		**(.264)**		**(-0.027)**		**(-0.264)**		**(.037)**		**(.050)**	
governor goods indegree	.207	.349	2.03	.204	.188	.141	3.29	.149	.607	.216	.026	.248
	(.590)		**(.452)**		**(.375)**		**(.386)**		**(.465)**		**(.498)**	
governed info outdegree	.095	.208	1.20	.206	.069	.053	5.88	.346	.343	.234	.001	.002
	(.456)		**(.454)**		**(.231)**		**(.588)**		**(.484)**		**(.046)**	
governed goods outdegree	.030	.200	.510	.070	.045	.034	.104	.001	.204	.080	.003	.018
	(.040)		**(.264)**		**(.183)**		**(.028)**		**(.283)**		**(.135)**	
governed info indegree	.448	.682	5.02	.525	.393	.202	10.80	.438	1.66	.574	.044	.279
	(.826)		**(.725)**		**(.449)**		**(.662)**		**(.757)**		**(.528)**	
governed goods indegree	.534	.753	5.82	.548	.503	.288	11.49	.402	1.65	.521	.049	.307
	(.868)		**(.741)**		**(.537)**		**(.634)**		**(.722)**		**(.554)**	
Trade												
Trade -1 value imports	.643	.761	.619	.505	.580	.284	12.30	.396	2.16	.510	.079	.536
	(.872)		**(.711)**		**(.533)**		**(.629)**		**(.714)**		**(.732)**	
Trade -2 value exports	.399	.558	.525	.594	.697	.355	12.65	.401	2.16	.478	.079	.512
	(.747)		**(.770)**		**(.596)**		**(.634)**		**(.692)**		**(.715)**	
Trade -6 outdegree	.508	.682	.628	.641	.676	.355	12.13	.386	1.98	.445	.073	.485
	(.826)		**(.800)**		**(.596)**		**(.622)**		**(.667)**		**(.697)**	
Trade -7 indegree	.482	.690	.572	.597	.546	.270	11.81	.379	1.92	.470	.070	.487
	(.831)		**(.772)**		**(.520)**		**(.616)**		**(.686)**		**(.698)**	
FDI												
FDI – cumulative stock	.465	.628	.485	.420	.395	.176	9.31	.292	1.58	.426	.043	.251
	(.793)		**(.648)**		**(.419)**		**(.540)**		**(.652)**		**(.501)**	
FDI-flows-outdegree	.295	.876	.348	.745	.344	.476	7.17	.566	1.03	.705	.035	.566
	(.936)		**(.863)**		**(.690)**		**(.753)**		**(.840)**		**(.752)**	
FDI-flows-indegree	.399	.700	.436	.514	.384	.228	9.98	.388	1.49	.539	.042	.323
	(.837)		**(.717)**		**(.478)**		**(.623)**		**(.734)**		**(.569)**	

European connectivity / economic indicators. Part 1
FIGURE 26

	TA-8 Patents granted		Global Competitive Index (Porter)		GCI - 1 Institutions		GCI – 6 Market efficiency		GCI - 7 Techno-logical readiness		GCI – 8 Business sophisti-cation	
Firm Connectivity												
total outdegree	.330	.176	.128	.384	.216	.513	.100	.298	.190	.390	.138	.384
	(.419)		**(.619)**		**(.716)**		**(.546)**		**(.624)**		**(.620)**	
total indegree	.630	.218	.220	.435	.382	.616	.180	.368	.355	.521	.210	.337
	(.467)		**(.660)**		**(.785)**		**(.607)**		**(.722)**		**(.581)**	
total connectivity	.533	.231	.195	.464	.330	.624	.154	.367	.301	.508	.196	.399
	(.480)		**(.681)**		**(.790)**		**(.606)**		**(.713)**		**(.632)**	
governor info outdegree	.009	.000	.042	.120	.090	.259	.050	.216	.051	.082	.053	.159
	(.020)		**(.347)**		**(.509)**		**(.465)**		**(.286)**		**(.399)**	
governor goods outdegree	.213	.211	.019	.035	.022	.020	.001	.000	.029	.036	.042	.141
	(.459)		**(.188)**		**(.143)**		**(.015)**		**(.190)**		**(.376)**	
governor info indegree	.061	.004	.015	.005	.081	.071	.011	.004	.068	.049	.016	.005
	(.064)		**(.073)**		**(.266)**		**(.059)**		**(.222)**		**(.071)**	
governor goods indegree	.332	.206	.115	.317	.194	.421	.073	.159	.190	.398	.079	.127
	(.454)		**(.563)**		**(.649)**		**(.399)**		**(.631)**		**(.356)**	
governed info outdegree	.011	.001	.043	.123	.092	.273	.051	.222	.051	.082	.052	.158
	(.025)		**(.351)**		**(.523)**		**(.472)**		**(.287)**		**(.398)**	
governed goods outdegree	.118	.106	.011	.016	.004	.001	-.004	.003	.011	.007	.036	.139
	(.326)		**(.125)**		**(.029)**		**(-0.051)**		**(.081)**		**(.373)**	
governed info indegree	.576	.194	.203	.411	.351	.578	.170	.366	.324	.483	.197	.331
	(.440)		**(.641)**		**(.760)**		**(.605)**		**(.695)**		**(.575)**	
governed goods indegree	.675	.236	.242	.451	.415	.627	.191	.357	.390	.544	.230	.351
	(.486)		**(.672)**		**(.792)**		**(.598)**		**(.738)**		**(.592)**	
Trade												
Trade -1 value imports	.879	.267	.348	.611	.490	.583	.247	.392	.514	.631	.317	.434
	(.517)		**(.782)**		**(.764)**		**(.626)**		**(.794)**		**(.659)**	
Trade -2 value exports	.989	.302	.166	.283	.292	.411	.130	.219	.292	.405	.137	.166
	(.549)		**(.532)**		**(.641)**		**(.468)**		**(.637)**		**(.408)**	
Trade -6 outdegree	.965	.302	.223	.387	.368	.493	.169	.280	.369	.488	.194	.249
	(.550)		**(.622)**		**(.702)**		**(.529)**		**(.699)**		**(.499)**	
Trade -7 indegree	.833	.260	.205	.368	.336	.462	.159	.280	.348	.487	.182	.248
	(.510)		**(.607)**		**(.680)**		**(.529)**		**(.698)**		**(.498)**	
FDI												
FDI – cumulative stock	.485	.116	.207	.367	.364	.529	.180	.349	.339	.451	.171	.214
	(.341)		**(.605)**		**(.728)**		**(.591)**		**(.671)**		**(.463)**	
FDI-flows-outdegree	.517	.469	.139	.569	.210	.609	.108	.433	.216	.631	.144	.524
	(.685)		**(.754)**		**(.780)**		**(.658)**		**(.795)**		**(.724)**	
FDI-flows-indegree	.537	.199	.171	.379	.299	.543	.147	.353	.288	.494	.157	.273
	(.446)		**(.616)**		**(.737)**		**(.594)**		**(.703)**		**(.522)**	

European connectivity / economic indicators. Part 2
FIGURE 27

	Telephone Mainlines		Internet-1 secure services		Internet-2 users		Internet-3 bandwith in mbps		Personal Computers		ICT exp. in US$		GCI-2 infra-structure	
Firm Connectivity														
total outdegree	.152	.611	.782	.688	.269	.562	.823	.707	.352	.700	.473	.811	.430	.707
	(.782)		**(.817)**		**(.750)**		**(.841)**		**(.837)**		**(.901)**		**(.841)**	
total indegree	.202	.532	1.13	.777	.340	.503	1.05	.645	.470	.669	.675	.813	.488	.510
	(.729)		**(.881)**		**(.709)**		**(.803)**		**(.818)**		**(.902)**		**(.714)**	
total connectivity	.188	.594	1.02	.771	.324	.548	.997	.698	.439	.720	.609	.853	.496	.634
	(.771)		**(.878)**		**(.740)**		**(.836)**		**(.848)**		**(.923)**		**(.796)**	
governor info outdegree	.136	.522	.667	.548	.256	.564	.725	.595	.319	.615	.420	.666	.393	.645
	(.723)		**(.740)**		**(.751)**		**(.771)**		**(.784)**		**(.816)**		**(.803)**	
governor goods outdegree	.140	.566	.686	.554	.238	.468	.773	.656	.332	.660	.415	.693	.380	.579
	(.752)		**(.744)**		**(.684)**		**(.810)**		**(.813)**		**(.832)**		**(.761)**	
governor info indegree	.127	.330	.811	.625	.217	.317	.738	.495	.303	.433	.469	.597	.336	.376
	(.575)		**(.791)**		**(.563)**		**(.703)**		**(.658)**		**(.773)**		**(.613)**	
governor goods indegree	.209	.518	1.33	.839	.393	.517	1.26	.711	.558	.721	.707	.817	.571	.537
	(.719)		**(.916)**		**(.719)**		**(.843)**		**(.849)**		**(.904)**		**(.733)**	
governed info outdegree	.138	.518	.738	.598	.262	.537	.792	.658	.337	.637	.445	.736	.428	.702
	(.720)		**(.773)**		**(.733)**		**(.811)**		**(.798)**		**(.858)**		**(.838)**	
governed goods outdegree	.132	.551	.710	.652	.211	.411	.679	.571	.297	.592	.418	.733	.344	.535
	(.742)		**(.807)**		**(.641)**		**(.756)**		**(.769)**		**(.856)**		**(.732)**	
governed info indegree	.076	.199	.378	.314	.102	.162	.344	.241	.140	.218	.275	.334	.142	.154
	(.446)		**(.560)**		**(.403)**		**(.491)**		**(.467)**		**(.578)**		**(.393)**	
governed goods indegree	.175	.467	1.05	.769	.297	.436	.931	.576	.414	.596	.612	.764	.438	.467
	(.684)		**(.877)**		**(.660)**		**(.759)**		**(.772)**		**(.874)**		**(.683)**	
Trade														
Trade -1 value imports	.201	.422	1.19	.622	.434	.586	1.35	.755	.609	.726	.683	.706	.604	.551
	(.650)		**(.789)**		**(.766)**		**(.869)**		**(.852)**		**(.840)**		**(.742)**	
Trade -2 value exports	.220	.468	.674	.397	.233	.338	.659	.362	.304	.407	.708	.688	.308	.290
	(.684)		**(.630)**		**(.581)**		**(.602)**		**(.638)**		**(.829)**		**(.538)**	
Trade -6 Outdegree	.210	.451	.866	.495	.297	.412	.897	.506	.394	.517	.675	.673	.398	.366
	(.672)		**(.704)**		**(.642)**		**(.712)**		**(.719)**		**(.820)**		**(.605)**	
Trade -7 Indegree	.190	.410	.841	.525	.292	.449	.845	.507	.379	.527	.649	.693	.382	.378
	(.640)		**(.725)**		**(.670)**		**(.712)**		**(.726)**		**(.833)**		**(.615)**	
FDI														
FDI cumulative stock	.140	.320	.892	.577	.254	.333	.927	.590	.367	.479	.496	.541	.359	.327
	(.566)		**(.760)**		**(.577)**		**(.768)**		**(.692)**		**(.736)**		**(.572)**	
FDI outdegree	.109	.625	.544	.741	.178	.566	.526	.663	.236	.724	.347	.863	.253	.558
	(.791)		**(.861)**		**(.752)**		**(.814)**		**(.851)**		**(.929)**		**(.747)**	
FDI indegree	.138	.420	.764	.642	.225	.394	.733	.564	.311	.535	.476	.665	.311	.372
	(.648)		**(.801)**		**(.628)**		**(.751)**		**(.731)**		**(.815)**		**(.610)**	

Global connectivity / accessibility indicators.
FIGURE 28

	Telephone Mainlines		Internet-1 secure services		Internet-2 users		Internet-3 bandwith in mbps		Personal Computers		ICT exp. in US$		GCI-2 infra-structure	
Firm Connectivity														
total outdegree	.097	.463	.490	.480	.146	.302	.518	.512	.194	.390	.290	.528	.256	.455
	(.681)		**(.693)**		**(.549)**		**(.716)**		**(.624)**		**(.727)**		**(.675)**	
total indegree	.176	.520	.929	.658	.268	.389	.921	.617	.375	.541	.564	.697	.398	.423
	(.721)		**(.811)**		**(.624)**		**(.786)**		**(.736)**		**(.835)**		**(.650)**	
total connectivity	.152	.556	.772	.618	.225	.375	.802	.637	.316	.533	.465	.675	.361	.472
	(.746)		**(.786)**		**(.612)**		**(.798)**		**(.730)**		**(.822)**		**(.687)**	
governor info outdegree	.023	.078	.209	.251	.032	.042	.180	.178	.051	.076	.098	.186	.084	.140
	(.280)		**(.501)**		**(.205)**		**(.422)**		**(.275)**		**(.431)**		**(.375)**	
governor goods outdegree	.024	.122	.073	.043	.035	.070	.093	.065	.069	.129	.046	.055	.058	.094
	(.349)		**(.207)**		**(.265)**		**(.256)**		**(.359)**		**(.235)**		**(.306)**	
governor info indegree	.021	.018	.248	.120	.030	.012	.185	.064	.077	.060	.100	.054	.004	.000
	(.135)		**(.346)**		**(.110)**		**(.252)**		**(.245)**		**(.233)**		**(.010)**	
governor goods indegree	.077	.317	.367	.273	.138	.275	.391	.290	.207	.380	.233	.372	.218	.337
	(.563)		**(.522)**		**(.525)**		**(.539)**		**(.616)**		**(.610)**		**(.580)**	
governed info outdegree	.023	.083	.211	.257	.032	.041	.183	.185	.052	.079	.099	.193	.084	.144
	(.288)		**(.507)**		**(.204)**		**(.430)**		**(.281)**		**(.439)**		**(.380)**	
governed goods outdegree	.015	.061	.027	.008	.016	.020	.077	.061	.029	.036	.025	.022	.038	.056
	(.248)		**(.088)**		**(.142)**		**(.248)**		**(.190)**		**(.150)**		**(.238)**	
governed info indegree	.160	.462	.857	.623	.249	.373	.847	.581	.345	.505	.530	.665	.373	.413
	(.680)		**(.790)**		**(.611)**		**(.762)**		**(.711)**		**(.816)**		**(.642)**	
governed goods indegree	.189	.553	1.02	.681	.293	.401	1.01	.642	.412	.568	.586	.695	.431	.428
	(.744)		**(.825)**		**(.633)**		**(.801)**		**(.754)**		**(.834)**		**(.654)**	
Trade														
Trade -1 value imports	.201	.422	1.19	.622	.434	.586	1.35	.755	.609	.726	.683	.706	.604	.551
	(.650)		**(.789)**		**(.766)**		**(.869)**		**(.852)**		**(.840)**		**(.742)**	
Trade -2 value exports	.220	.468	.674	.397	.233	.338	.659	.362	.304	.407	.708	.688	.308	.290
	(.684)		**(.630)**		**(.581)**		**(.602)**		**(.638)**		**(.829)**		**(.538)**	
Trade -6 Outdegree	.210	.451	.866	.495	.297	.412	.897	.506	.394	.517	.675	.673	.398	.366
	(.672)		**(.704)**		**(.642)**		**(.712)**		**(.719)**		**(.820)**		**(.605)**	
Trade -7 Indegree	.190	.410	.841	.525	.292	.449	.845	.507	.379	.527	.649	.693	.382	.378
	(.640)		**(.725)**		**(.670)**		**(.712)**		**(.726)**		**(.833)**		**(.615)**	
FDI														
FDI cumulative stock	.140	.320	.892	.577	.254	.333	.927	.590	.367	.479	.496	.541	.359	.327
	(.566)		**(.760)**		**(.577)**		**(.768)**		**(.692)**		**(.736)**		**(.572)**	
FDI outdegree	.109	.625	.544	.741	.178	.566	.526	.663	.236	.724	.347	.863	.253	.558
	(.791)		**(.861)**		**(.752)**		**(.814)**		**(.851)**		**(.929)**		**(.747)**	
FDI indegree	.138	.420	.764	.642	.225	.394	.733	.564	.311	.535	.476	.665	.311	.372
	(.648)		**(.801)**		**(.628)**		**(.751)**		**(.731)**		**(.815)**		**(.610)**	

European connectivity / accessibility indicators.
FIGURE 29

4. Final conclusions:

4.1 General:

This explorative research stresses that in a steadily globalizing world, a network understanding of sustainability will be required which reveals not merely the comparative strengths and weaknesses of individual cities and nations, but more importantly the relationships exercised between these entities. It is argued that an economic network understanding of sustainability will be useful to policy makers at different levels (municipal, national, supraregional and global) as these networks are in fact increasingly 'borderless' and tie different governance levels together. Therefore, before governments can talk of sustainable policy, it becomes vital to reveal what these networks are! For this research the focus has been on multinational networks, as these form the backbone of the world economy. The results show tentative insights, upon which new policy can be speculated.

In the analysis corporate networks have been investigated for top 100 multinationals and all their subsidiaries at both the global and European scale. It is important to know that the European networks are not just a subset of the world data set, but are constructed on the basis of the 100 largest European multinationals. This represents a functional zooming in and not a scalar enlargement. These networks represent the primary corporate structure of our world, in which the sharehold structure of the multinationals are unravelled from headquarters, to regional offices, to manufacturers, suppliers and distributors. It illustrates to a large degree the supply chain of these firms and their geographic positions and command structures across the globe. These firms have different business relationships (connections) with other firms - all in various cities. From this the central hypotheses of this research have been that (1) the geographical structure of these connections will be highly uneven and (2) will follow a 'power-law' statistical relationship of inequality, and (3) that their will be a high correlation between sustainability indicators e.g. 'ecological footprint' and the corporate connectivity of countries or cities. These hypotheses have been validated in the reported results. From these initial conclusions the research is momentarily being continued for MNP, in which the network structure of for instance the ecological footprint is being calculated (relative trade-off between cities/nations), the probabilities of cities or nations getting more connections, and the interdependencies between global, European and Dutch datasets are being investigated. For the purpose of this report, the focus will be on drawing conclusions based on the three hypotheses stated above.

In the analysis it has been discussed that governments are becoming more aware that the increasing integration of our global society is simultaneously causing greater social and environmental impact on the planet. However, to deal with this it appears that a more

sophisticated understanding of the interactions between and within countries, regions, nations and cities is required, through which specific responsibilities can be pinpointed. From this it has been shown in this report what for instance the precise impact of The Netherlands is upon other areas, through which eventually appropriate policies at each level may someday be developed. In this manner the world can be observed as a multilayered system of power relationships, instead of simply a collection of comparative nations – which could lead to a move from the flat, 'international' policy thinking (e.g. Kyoto Protocol) of the past, towards global 'network' policies – through which the current 'crisis's of complexity and governance' can be effectively tackled.

4.2 Network structure:

To recapitulate, the results illustrate the complexity of corporate relationships between firms, cities, nations and regions– but also the geographic and inter-scalar structure of the overall system. The basis of the analysis is the institutionalized interaction between headquarters and subsidiaries and the spatial networks generated by these firms. From these observations we can deduce that the structure of the corporate networks form the key determinant of the global production network. These value chains can be producer or producer driven chains. It is shown that a different sectoral composition viz. a basic material, a manufacturing, or service firm, will generate entirely different network structures, which may be mutually related- functionally and or spatially. Core-periphery relations emphasize the nature and direction of this interdependency. Furthermore, the networks exhibit a remarkable structural stability (see temporal and disproportionality hypothesis). Changes in the network structure can possibly be induced by the creation of loose coupling (ties), forming a source of possible future innovation activity. Furthermore, because the global corporate network correlates highly with the linkages of GDP, foreign direct investment (FDI), and trade (in dollars) – it serves as a plausible model of the structure of these variables as well.

The dominance, asymmetry and command of Europe and North America over other regions have become clear in this research. Furthermore, it is shown that Europe is the most integrated with the world and that it exercises strong command over others. The results indicate that the corporate network which provides one third of world GDP is formidably run by Europe and North America, with China/Japan lagging at a distance. It tells us that even regionally the corporate world is highly disproportionate and far from truly globalised. It reminds us that those regions that are weak participants are actually those with the majority of world population. Global and EU sustainability policies should therefore question the improvement of corporate connectivity to other less connected regions. This in turn raises the question of what the effect of this will be on the European region. Will global policy which activates corporate activities of weaker nations or cities, lead to the improvement of EU connectivity- or instead a demise? At the European scale of

top 100 multinational networks, the concentration of network connectivity within Europe and its internal regional dominance is evident. Europe's effect upon the world increases at this level. After the US, Europe trades most with Eastern Europe, although this corporate activity can be strongly improved. This is an important consideration for policy development. Furthermore, Europe's command over Africa is excessive and policy might need to start opening up African business towards Europe. If we look at the national level, it is interesting to see that Switzerland and The Netherlands have the highest network per capita. These less endowed countries once again show the high degree of external linkages needed to sustain their living standards. From this one can question the scale of sustainability that these countries are responsible for.

Furthermore, the basic materials network for Europe is less dense than the other sectoral networks and most of the resources do not enter Europe directly (Paris plays a key role here in the coordination of these activities). Europe is at the heart of the world trade flows, occupying a central position as an intermediary. Within Europe there is spatial coincidence of the networks by the producer services and the manufacturing industry. Compared to the US, the network of information industry is stronger in Europe and it is more integrated (through it dominant outward linkage structure (67%) in the world economy, through it diversity of linkages than the US (25%) is. The US outward linkages are more dominated by the resource industries. The manufacturing firms on a world level are organized through the triad US, Europe and Asia. Within the triad, the US and Europe clearly dominate and Asia is subordinated. The reverse is the case for Sub Saharan Africa and SE Asia, which are characterized by inward linkages. This indicates a strong dependency relationship with Europe and the US.

Regarding the transnationality index, small firms are more internationally oriented viz. outside Europe than large firms, which are 40% internally oriented and 30% to the rest of the world. European firms are much stronger (3 times) in terms of their connectivity than US firms are. The networks are more fragmented on a supra-regional level than on intra country level. Considering all relations, there appears to be two network structures that coincide- rather strong horizontal network that consists of the US, Germany, the UK, Switzerland, The Netherlands and France. This operates as the core of the second network, which is star shaped, indicating a clear hierarchical dominance. Furthermore, in terms of 'betweeness', Europe acts as gatekeeper and broker in the global structure of intra-industry relations. The European network of goods handling activities is rather thin in terms of number of linkages and connecting nodes, when compared to that of the information handling sector, which displays a dense and well connected structure.
At the urban level - for the FIRE group (finance, insurance and real estate) a well connected structure of triangular relations exists between a large number of cities, such as the London, Paris and Tokyo triangle- but also the London, Tokyo, Amsterdam triangle. In terms of betweeness (brokerage) the order is Paris, London, Tokyo, Amsterdam and

Utrecht, which indicate that a high number of connections will also attract new connections. This structure is independent of the size of a place. This accumulation effect increases the uneven distribution as observed by the power-law. For the European network at large, one can observe that the power-law gradient is less steep, thus the balance between hierarchical and horizontal (equivalent) relations is more equitable.

Nationally, The Netherlands proves to be a strong player within the global networks, in absolute numbers, but even more so relatively in network per capita. Because The Netherlands has a major broker position, it can also become an interesting country to develop policy and could hereby have strong policy spillovers to other countries. At a city level, Amsterdam serves as a major city within the global network, especially in information sectors, followed by The Hague which has a reasonable position in the goods network, mainly due to the presence of Shell. It is also interesting that if we sum the connectivity of the Randstad cities, that this conurbation becomes the 5th most connected city in the world – although this is highly accounted for by Amsterdam's share of connections. At the city level we see that Amsterdam is the 4th most important city within the European networks, in terms of command but also as broker to other cities. The Hague plays a vital role in the goods sector, specifically the oil industry networks. Rotterdam's significance in the European networks is shown by its high indegree in producer services. This means that it is strongly controlled by controller cities like London and this relationship concerns port related insurance industries. It is surprising that Rotterdam is firstly most connected to London, than it is to itself, or even other Dutch cities. Of all cities, Amsterdam also serves as the third most important consumer market, which is clear from the high level of consumer service outdegree. Amsterdam and Utrecht are also top cities within the sublevel of finance, insurance and real estate networks.

4.3 Network disproportionality:

It has been discussed that the majority of top firms were founded towards the end of the 19th century, indicating a considerable degree of temporal stability. Furthermore, dynamics prove to occur through the location of subsidiaries, based on four types of responses – quiet, active, autonomous and receptive. In this sense, the control of assets becomes a competitive advantage, where their main objective is not to maximise profits, but to ensure corporate stability in the long run. Higher order firms prove to have a large degree of positional stability and thereby reinforce the stability of their networks. A second source of dynamics is created by the entry and exit of firms. Three types have been identified in this research: (1) exiters (2) enterers and (3) shifters. In this, nation states and national boundaries play a limited role in the strategizing of multinational networks, but that this will become increasingly necessary in future. The question is how policy can begin to properly address tackling the free market, which has proven to be not a system of perfect competition between equal sized firms, but that instead high disproportionality

exists in firm sizes and their influences upon each other. This characteristic (known as a power-law) has a statistical gradient of -1. It appears to be a universal law found in many self-organizing systems and is arguably the most robust, statistical regularity in all the social sciences. So, if we are to consider a sustainable world, what can be done about this uneven structure and what would a sustainable model look like?

The research has shown that the more connected a city is, the higher its probability of future corporate potential. The stronger the network structures, the more robust - and the weaker the structures, the more they are subject to change and uncertainty. These are statistical probabilities of what proves to be a truly self-organized economic system. Because power-laws are inherent in most dynamic 'real world' and 'natural' systems, it raises the question whether an alternative more evenly spread distribution is actually possible - or whether global economic activity structurally depends on the uneven distribution of corporate power! For governments, it becomes interesting how they should address this system, and what a sustainably distributed network will be. Will it be above or below the gradient of -1, and to what magnitude? For policy, the question can be how to artificially increase the potential for corporate connectivity within and between countries. For developing countries and cities, this concerns how to become more connected to the existing system. According to this research the more connected they become, the more their sustainability levels will improve. Because New York, Paris, London and Tokyo claim 25% of command relations within the network and have extremely high levels of performance – it raises questions about what the impact of these four cities on the world is - and what is to be done about it. Should these cities become less or more powerful - so as to raise overall improvement of the system? The same question can be asked about the Randstad, which serves as the 5th most powerful city in the world claiming 6% of global command connectivity.

Another issue for governments to consider is the world's vulnerability due to its high dependency on the four major hub cities, which serves as both the strength and Achilles heel of the world city network. Similarly, the protection of cities like Amsterdam (high betweeness) is equally vital, as these types of cities form strong intermediary positions between global, regional and national subsystems. Another insight from this research is that the global system proves to be steeper than the European one – which means that global policy has to deal more emphatically with inequality at the worldwide level, than European policy would. Furthermore, what is the intercept between such policies? And how does slow-moving governance plan and intervene in the fast dynamics of the corporate self-organized system?

4.4 Network performance:

Scarcity is changing as a consequence of the co-evolution of functional integration (globalization) and spatial integration (urbanisation). This has consequences for the type of network space and nodal properties that emerge. Sustainability, which is motored by scarcity, concerns the creation of the right balance between equity and efficiency (people-profit-planet), from an intergenerational perspective. For this reason, the networks which supply human demand (corporate chains) have been shown to have a strong impact on social ecological and economic performances of different nations. In the analysis the relationship of corporate, trade and FDI connectivities, have been explored in conjunction to the existing sustainability indicators. The first relationship is with the social indicator - the Human Development Index (HDI) which in itself is a comparative measure of life expectancy, literacy, education and standard of living for countries worldwide. The correlation is strong, but even stronger with the sub-index of education. Furthermore, the more import oriented a city or nation is, the more developed and higher educated its people tend to be. Therefore, strong import potential is a sign of a strong information society level and subsequently a very high education level. It is shown that because developed countries invest heavily in outsourced production to the developing world – which they command from above – it is not surprising that the FDI outdegree has strong coherence with development levels, especially the education levels needed to carry out complex command activities of the network.

The second relationship of connectivity is with the environmental indicators of the ecological footprint, which in itself is an analysis which approximates the amount of ecologically productive land, sea and other water mass area required to sustain a population, manufacture products, or undertake certain activities by accounting for the use of energy, food, water, building material and other consumables. Correlations of connectivity with ecological footprint prove to be high, but the sub-index of energy consumption has a very strong relationship, meaning that the higher the connectivity, the more the energy consumption. A strong relationship also exists with human environmental vulnerability and the institutional capacity of a nation, implying that the more connected a city is, the more vulnerable, and that the institutional capacity will be high. The connectivity and footprint relationship indicates that the more connected a city or nation is the more dependent it is on resources from afar. With a footprint more than double its own biological capacity, Europe’s well-being depends on ecological capacity from elsewhere – and the networks show us the structure of this interdependency. To improve ecological footprint therefore means addressing the interdependencies of this network. This is essential for both Europe’s competitiveness and its credibility as a force for international collaboration. Europe can use its undoubted intellectual, financial, social and cultural advantages, to lead the world onto a different path. By understanding the structure of the networks, Europe can facilitate the transition towards a sustainable future.

The ecological footprint of Europe is more than double its own biological capacity. A reduction of this impact is not just philanthropic, but essential for its future competitiveness and its credibility in international collaboration. Remarkable is the exclusion of the 4th world (especially Sub Saharan Africa) from the networks analysed.

The third relationship is with economic indicators such as Michael Porter's global competitivity index, which in itself measures competitiveness, based on the sophistication with which a nation's firms compete - gauging the knowledge, technology, physical capital and managerial skill reflected in the firms' operating practices and strategies. The index also measures the quality of the nation's business environment, based on the quality of the infrastructure, skills, technology, stocks, rules and regulations and institutions that constitute the context in which a nation's firms operate. The correlation of the global competitivity index with connectivity proves to be very high – also with the sub-indexes of technological achievement, business efficiency index, the number of patents granted, institutional capacity, market efficiency and business sophistication. Furthermore, it is shown that the coherence of these indexes with total outdegree is higher than with total indegree. The explanation to this is that cities with high commanding power over others are in fact more advanced type cities, than cities with strong subservience to other cities. Also it is shown that total connectivity has very high coherence with GDP per capita, meaning that the more connected a city or nation is, the higher the total market value of all the final goods and services

The fourth relationship concerns network accessibility. Connectivity proves to correlate very highly with the innovation index, meaning that the higher the level of innovation of a city or nation, the more connected it will be – or the other way around. In fact, the more ICT network capacity a city has to communicate worldwide, the higher the global corporate network integrity is. It is an indication that corporate connectivity serves as a mirror of Castells 'information society'. According to Castells, dominant functions and processes in the information age are increasingly organised around networks. Networks constitute the new social morphology of our societies and the diffusion of networking-logic substantially modifies the operations and outcomes, in the processes of production, experience, power and culture. The new information technology paradigm provides the basis for its pervasive expansion throughout the entire social structure. It becomes vital to be present in a network and not to be excluded from it. Because they correlate so highly with ICT networks it indicates that the GIS maps and network diagrams must also well approximate the ICT networks of our world. The strongest outputs in this series are with the level of investment (Porter's GCI) a country puts into national ICT infrastructure (0.923), followed by the number of computers a nation has (0.848), the internet capacity of a nation measured in bandwidth megabytes per second (0.836), and the number of secure servers (0.878). Also telephone mainlines (0.77) and overall infrastructure correlate very high. Another striking fact is that across the row of total outdegree, the

scores are higher than for total indegree. It shows that networks of command and control make more use of the facilities of the information society. It raises questions about how to better equip developing countries to participate within the economic system – where countries obtain the domestic capacity to identify technology's potential benefits and to adapt new technology to their needs.

4.5 Final observations:

Four questions are at the heart of each policy evaluation.

- Where is intervention (action) possible?
- What type of intervention (action) is required?
- When is intervention (action) effective?
- How is intervention (action) directed?

Obviously these questions are mutually related and given the analysis discussed here one should bear in mind the particular nature of the networks under analysis. The type of action is dependent upon the time frame of the economic process under consideration, where some of these are already fully matured, while others are still underway, and this is clearly linked to the non-linear nature of the development process. The type of action is also constrained by the nature of the network, taking into account the direction of the flows in the network and their spatial structure. Networks are unevenly distributed across the globe and vary by type of activity. Given the unequal distribution, one should also reconsider the responsibilities of governmental agreements like the Kyoto Protocol. An equitable distribution of emission generated through emission trade, does not necessarily alter the local or regional impact, provided one can buy from emission poor countries. It may have two consequences. On the one hand it will not stimulate a shift in the location of the polluting industries. It only contributes to a control of the global level, irrespective the local of regional degradation that will occur. Alternatively it may lead to relocation along branches of the network, to countries which have a lower level of pollution (the branch plant economies). In this sense, the discussion whether Japan has effectively relocated its polluting industries to Southeast Asia is still not resolved. This type of decision making is based on efficiency and not on an equity approach.

Another issue is the lack of connectedness of a country or city to the network. The most likely possibility of interventions is that opportunities will arise with the opening of a new window of opportunities, such as the introduction of a new technological paradigm. Globally this is expected to be in the area of biotechnology and nanotechnology. Could countries in Sub-Saharan Africa profit from this – leapfrogging previous technologies – or are they doomed to attach to the more mundane economic networks of our world? An important precondition for such innovation is the social and institutional capabilities to deal with these new types of technologies, on different levels in society. Africa might not

yet be equipped for this! Another issue is that the competitiveness of the economies of the European countries (Lisbon strategy). Given the considerable impact and economic power of multinational networks, as is evidenced in this research, raises questions about the effectiveness of setting ceilings or formulating constraints. The structure of the networks concerned show a remarkable stability, where these companies certainly govern the structure. The issue should therefore be reformulated in such a sense that is becomes profitable for these firms (in the sense of maintaining corporate stability) to collaborate, take initiative and thereby securing long term profitability. By directing towards the firm, one should take into account that action should be scale dependent, linking scale and type of interventions, instead of taking global measures that are scale insensitive. Once governance becomes flexible, integrated and interscalar – 'network sustainability' can start to emerge!

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