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A Beer Index for International Food Security?

- A Cross-Network Dynamic Evolutions Study

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Summary

In his influential book entitled *Guns, Germs and Steel*, Diamond (1999) explains the various important aspects of the consequences of the interaction between 'geography' and 'economics' by covering an extensive period of 13,000 years. From a historical perspective, Diamond explained how human societies interacted with their physical environment and with other societies and how the innovation and economic accumulation process evolved. In essence, our past determines our future.

The history of beer also spans over 8000 years. As a simple product made with mostly water, what is the significance of the global trading network and how and why did it evolve? Why do certain countries remain in their leading position over the years? As a traditional network, what kind of connections does the trading network with other emerging network such the investment network in the food sector? Does countries with more trade in beer tends to have more investment ties in the food and beverages sector?

The above questions and hypotheses are investigated with dynamic network modeling techniques. One of the statistically significant hyphothesis is that there is significant positive influence of the presence of beer trade tie on the formation of investment tie in the Food and Beverages sector. Moreover, presence of trade tie in beer will also significantly increase the probability of a reciprocal investment tie. This result points to that when everything is connected to everything, we can discover connections in unexpected places. When the general indexes provided by world organizations fail to explain certain specific phenomenon in a rapidly changing world, it is maybe more worthwhile to study the real flow and connections by people, goods and knowledge with the help of the advent in computer technology and large amount of available recent data.

Connectivity is important for a country's economic development. These connectivity can be trade and commodity ties, investment ties, but also in tourism, social media and culture. Establishment of investment ties with partners with advanced knowhow in logistics management, water management can bring valuable knowhow and developmental benefits to the emerging countries and to build more sustainable and robust supply chains. The importance of tourism points that there are important enabling factors that attracts international people flow such as: good environment, good urban facilities and infrastructure. Such factors are beyond the scope of this research but the important conclusion may be that the 'soft' factors are equally important to a city or country's competitiveness.

Keywords

Network evolution; SIENA; graph theory; trade and investment; urban development

Acknowledgements

Foreword

Abbreviations

IHS	Institute for Housing and Urban Development
LPI	Logistic Performance Index
GCI	Global Competitiveness Index
SAOM	Stochastic Actor Oriented Model
SIENA	Simulation Investigation for Empirical Network Analysis
R	R Statistical Computer Environment
FDI	Foreign Direct Investments
F&B	Food & Beverages
WDI	World Development Indicators
WCN	World City Network
GCC	Global Commodity GCC
M&A	Mergers and Acquisitions
APS	Advanced Producer Services sector
(ICT)	Information and Communication Technologies

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Chapter 1. Introduction

1.1 Background

International food security is increasingly recognized as one of the top societal challenges facing the world in the coming years. It is no longer an issue confined to the global south, but becoming a major challenge for the global north as well. Today's global agro food system is increasingly characterized by interconnected and inter-dependent networks of trade, investment and firms, which is currently dominated by the transnational powers in the developed countries. While emerging countries such as China, India, and African nations are fast becoming the biggest consumers for food, one of the fundamental challenges is that the development of the agricultural economy severely lags behind that of the economic growth. In search of sustainable solutions for the common global challenges, the global value chains of the agro food industry need to be better integrated between the developed and developing countries to capitalize on technology, finance and markets ((Pfitzer & Krishnaswamy, 2007)

A growing world population and developments such as urbanization, internationalization, scarcity of water and raw materials and climate change are giving rise to many societal challenges for the global agri-food systems such as the efforts to realize higher resource efficiency and food security, the management of food safety and quality, as well as increasing the natural resistance against pests and diseases and stress factors such as drought and cold. In an increasingly segmented and fragmented society, the international consumer is demanding innovative solutions and efficient, robust, sustainable and economically profitable chains to deliver products the consumer needs. Both now and for the coming decade, the global food system is under considerable pressure to become more sustainable(Trienekens et. al., 2003).

The history of beer brewery has been closely associated with the history of agriculture and food, and hence the history of civilization and urbanization (Diamond, 1999). Today, the EU brewing sector is of significant importance in the overall economic picture. In Europe, which is home to around 4500 breweries and to the headquarters of the world's largest brewing companies, the brewing sector is estimated to be responsible for 2 million jobs, 51.5 billion Euro in value added in the supply chain, and 53 billion Euro in government revenues (Brewers of Europe, 2013). While the brewing sector in Europe remains global leaders, it is recognized that there are 'untapped potential' in the sector to help maintain its global standing and provide growth and jobs (European Economic and Social Committee, 2013).

The dynamics forces that shaped the beer industry in the last century and the emerging trends reflect the wider societal transformations as well, such as: trans-nationalization & industry consolidation, globalization vs. localization, emerging market dynamics and transition towards a 'green' model. With the rapidly changing global dynamics, the beer industry is a strategic 'lens' through which to view the interplay of the globalization and urbanization forces shaping the global agro food systems and to explore cross-sectoral synergies.

1.2 Problem Statement

In the last decade, most nations in the world moved away from food self –sufficiency policy and relied instead on international trade. Due to technological advances and improved agricultural yields, the world has (for the most part) enough food supply and prices have been stable. However in the last few years, food prices have been rapidly rising due to a multitude of factors: climate change which led to draught and flooding, competition between bio-fuels and food, rapid urbanization and so on. There are increasing outcries for the issue of 'food security'. Nations such as China and the Arab countries are re-instating 'self-sufficiency' as a top policy agenda. Study by Rask & Rask (2011) pointed out that the world will face 'critical food supply' issues in the coming years due the compounding effect of income growth on dietary change alone, even before considering population growth.

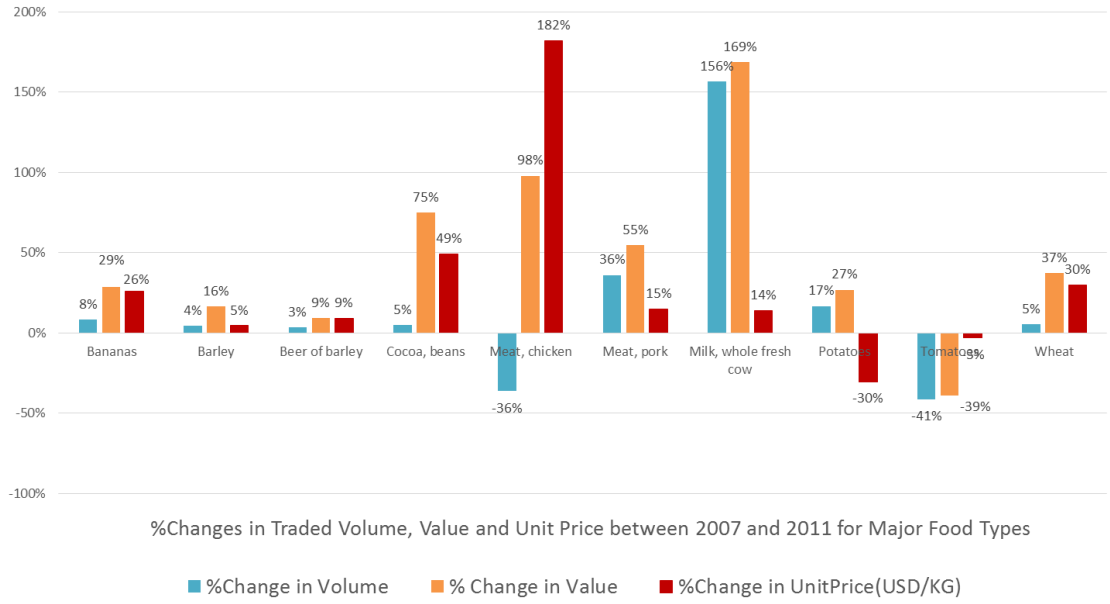

Figure 1: Production and consumption dynamics for ten basic food items between 2007 and 2011 as reflected by international trade

Traded value for basic commodities as wheat had increased by 30%; while that of chicken had nearly tripled showing impact of demand and dietary changes

While emerging countries such as China, India, and African nations are fast becoming the biggest consumers for food, one of the fundamental challenges is that the development of the agricultural economy severely lags behind that of the economic growth. In search of sustainable solutions for the common global challenges, the global value chains of the agro food industry need to be better integrated between the developed and developing countries to capitalize on technology, finance and markets ((Pfitzer & Krishnaswamy, 2007)

The supply chain systems of the brewing sector overlap with the other agri-food sectors and increasingly with the energy/chemistry sector (bio-based economy). Below are the two trends that

Trend 1. Urban revolution & 'green' development in emerging countries
Driven by rapid urbanization and income growth, Asia has seen strong growth of trade and direct investments across all sectors in the last years. At the same time, Africa is experiencing dramatic demographic transition. The continent is expected to have the highest growth in overall GDP over the next five years. More than 50% of the population will be urban dwellers by 2030. There are 'unbridled' optimism from the private sector that Africa will be the next fastest growth consumer markets which then leads to trade and investment. However there lacks a better understanding of the spatiotemporal dynamics of this 'revolution' and how to capitalize the urban potential as the global economy transition towards new paradigms of development (bio-based, resource efficient) (Parnell & Pieterse, 2014)

Trend 2: Cross-sectoral supply chain synergies for emerging markets:
Over the past few years, brewers from mature, stagnating beer markets have been investing in emerging markets to achieve volume growth. The favorite destinations have been the BRIC countries and Asia, where consumption growth has been highest. As these countries mature and growth rates decline, brewers need to explore new areas of growth. Based on demographics and economic developments, Africa may become the continent that will witness fastest growth over the next five years. However, large regional differences, supply chain security and logistics are the major hindering factors.

PROBLEM: Up till today, major beer brands as well as major investors in the food sector are concentrated in the developed world. On the one hand, the existing beer market in this world is stagnating. On the other hand, there is enormous demand for beer in emerging markets, with the highest growth potential in Africa. It is evident that there are untapped growth potential to strengthen the global competitiveness of the EU brewing sector while developing sustainable value chains with emerging economies.

1.3 Research Objectives

The study focus on the beer industry as a lens through which to view the spatiotemporal interplay of the globalization and urbanization forces shaping the agro food systems. Longitudinal data in trade and investment will be analyzed to understand dynamics within each network and the dynamics between the networks and to explore cross-sectoral synergies.

The key objectives are:

- Understand how the trading network of beer and the investment network in the food sector evolve in the past decades regarding network structure and country positions;
- Compare the network dynamics between the trading network of beer and the investment network in the food sector in response to their respective endogenous network structure and exogenous environment and identify important explanatory factors;
- Explore cross-network dynamics between the two networks

1.4 Research Questions

What are the network dynamics both within and between the trading network of beer and the investment network in the food sector in response to endogenous network structures and exogenous environment?

- what are the respective typology, dynamics and evolution of the trade network in beer and the F&B investment network regarding network structure and country positions?
- Which endogenous and exogenous factors are important for the network dynamics for the two networks respectively?
- How do the two networks inter-relate to each other?

1.5 Significance of the Study

Scientific: The combination of statistical analyses with network analyses is a fast emerging field and offers exciting new opportunity to explore complex systems and chains. This study adds to the knowledge of applying dynamic network analysis techniques to the field of international trade and investments.

Policy: in understanding how to facilitate trade and investment and bring about development benefits. Policy makers, trade associations and firms should look beyond border issues to understand the interlocking factors, both endogeneous and exogenous, in promoting trade and investment relations.

1.6 Scope and Limitations

Trade data is only systematically available at national level, this limits the scope to go beyond countries and look deeper into city level.

Data available for investment in the food & beverages sector is very limited. The fDi market data is based on greenfield investments and there are limited number in the last 10 years. This poses limitation to the study of the evolution investment networks of the brewing sector.

The modelling techniques chosen focuses on binary relations, or in another words, presence or absence of trade and investment ties, but not the strength or valued ties.

Chapter 2. Literature review

2.1 Globalization and Trade Theories

2.1.1 Gains of Trade

At the global scale, traditional international economics has long used trade theory, location theory and growth theory to explain the phenomena of globalization, most importantly trade and Foreign Direct Investments (FDI) flows. The most dominant theory until the 1980s to explain trade flows is the Heckscher-Ohlin theory that emphasized the comparative advantages of countries (Blonigen, 2005). The simplest version of the Heckscher-Ohlin model can be summarized as the '2 x 2 x 2" model: two countries produce two goods using two factors of production and identical techniques(Caves, Frankel, & Jones, 1999). Countries have different ratios of capital to labour in their factor endowments and the goods differ in their input requirements: one of the goods require more capital per person-hour in order to be produced than does the other good. The former good is said to be capital-intensive (for example, food), and the latter is said to be labour-intensive (for example, clothing). The Rybzynski Theorem states that if the endowment of one factor of production increases, then production of the good using it intensively goes up, while production of the other good falls(Caves et al., 1999). Suppose one country now has an influx of capital while the other one influx of labour. Following the Rybzynski Theorem, food production goes up in the former while clothing expands in the latter. When trade is opened up for, the Heckscher-Ohlin model states that a country has a comparative advantage and thus exports the good that uses its abundant labour. In the illustrating example, this means that the former country exports food, and the latter clothing.

In a world of any commodities and many countries, it is no longer possible to characterize bilateral trade flows as functions in factor endowments. However, in a weaker sense, the Heckscher-Ohlin model can still hold that a country will tend to specialize in the few goods for which its factor endowment is particularly suitable(Caves et al., 1999). In another words, a country's export bundle reflects its factor endowment so that a capital-rich country, for example, will tend to export capital-intensive goods as compared to a country with less capital.

Since the 1980s, Krugman led the development of what is called the 'new trade theory' to explain trade between countries with similar characteristics (Krugman 1979). Krugman's model involves two key assumptions: that consumers prefer a diverse choice of brands, and that production favours economies of scale. In this situation, a remarkable result can be derived: two countries, which are identical in all respects, can gain from trading with each other. There are now four possible sources of gains from trade(Caves et al., 1999; Krugman and Obstfeld, 1994): a terms-of-trade effect (prices differ from autarky prices), a volume-of-trade effect (consumers acquire more of goods whose domestic price exceeded world price), a varieties effect in consumption (consumer enjoys a larger number of varieties) and finally a cost effect (average costs fall worldwide as each country produces half of the number of varieties it did before international trade).

At the same time, the more empirically based 'gravity model' was able to successfully fit and predict trade flows between countries despite the lack of theoretical foundations (Blonigen,

2005). The gravity model specifies trade flows between countries as primarily a function of the GDP of each country and the distance between the two countries. However, Blonigen (2005) observed that recent trade literature has led to a melding of theory and empirics. With recent developments in theoretical foundations and the realization that the gravity specification characterizes basic predictions by many various models of trade, including variations of Heckscher-Ohlin, the gravity model is gaining more academic attention in recent years.

2.1.2 The great 'unbundling' forces behind globalization

Baldwin (2011) attributed the globalization dynamics to the great 'unbundling' forces that brought about the 'compression of space' and 'speed-up of time' of modern society (Baldwin, 2011; Henkdrickson & Heffernan, 2002). From the steam revolution till the mid or late 1980s, most advanced economies industrialized as part of what Baldwin called globalisation's 'first great unbundling' (p.2, 2011) which was mostly about falling trade costs. Early in the industrial era, high transport costs restricted trade. But as the industrial revolution progressed, steamships and railways slashed transport costs and therefore the most productive firms were those best able to take advantage of economies of scale. A single large plant could produce goods at a lower unit cost than lots of smaller factories, and a cluster of large suppliers at lower cost still. Production clustered in massive cities in a few economies.

Since 1980, trade costs changed little but the revolutions in Information and Communication Technologies (ICT) enables the 'second great unbundling" with 'startling differences in outcomes' (p.2, Baldwin 2011). Cheaper communications allowed firms to manage supply chains over ever greater distances, and offered firms greater possibilities of 'product fragmentation', which is defined by specialization across vertically linked stages of the production processes (Johnson & Noguera, 2012). Storper (2009) concluded that we are at a brink of a 'great transformation' of local versus long distance relationships. Firms have new possibilities in fragmenting production both organizationally and geographically, giving rise to not just traditional vertical integrated production, but networked 'heterogeneous' production.

The significance of the second unbundling is that it fundamentally changed the nature of globalization and the pace of global development. Since the supply chains span across nations and geographical regions, it is more important for nations to join the supply chain, then to build one from ground up (Baldwin 2011). This means that emerging countries can industrialize at a much faster pace than previous times with the technology and management provided by rich-nation firms.

Baldwin(2011) further differentiated globalization in two phases: the 20th versus the 21st century trade. The 20th century trade is about selling of goods made in factories in one nation to customers in another. Hence, in line with the Heckscher-Ohlin model, a country's export patterns reflects a 'single' nation's comparative advantage in productive factors, technology, social capital, governance capacity, and so on. In comparison, the 21st century trade involves continuous, two-way flows of things, people, training, investment, and information. Therefore, comparative advantage shifted from a very national concept to a regional concept. In another words, goods are now packages of 'many' nations' productive factors, technology, social capital, governance capacity, and so on.

With the focus on the two-way flows, the 21st century trade can also be characterized by the 'trade-investment-services' nexus(Baldwin, 2011) which reflects the intertwining of: trade in parts and components; international movement of investment in production facilities,

personnel, technology, long term business relationships; and services to coordinate the dispersed production, such as telecoms, internet, cargo and shipment services, trade related finance, customs and so on.

However, the great unbundling forces do not mean the 'death of distances'(Baldwin, 2011). Johnson & Noguera (2012) studied the role of proximity in explaining the global fragmentation patterns, and hence trade patterns over time. They found that supply-chain fragmentation has been greatest among neighbours, giving rise to regional clusters. In their analysis, the authors defined 'proximity' as regional membership and geographical distances. They found that over time gross trade increasingly travels shorter distances than value added trade. Distance matters most directly due to costs of transporting goods across space. Distance is also a proxy for other variables that enhance or impede trade, such as language dissimilarity. Moreover, the effect of deepening of regional integration such as EU and NAFTA is also reflected in distance or geographic regional membership.

Time costs is another important issue. Even with today's ICT, coordinating a production network still requires human interactions. Technicians and managers must be able to travel from the advance-technology headquarter nations to the developing host nation quickly and conveniently. Timely shipments of components are indispensable. An analysis by Hummels and Schaur (2012) estimated that each day in transit is worth 0.6 to 2 percent of the value of the good, and that long transit delays significantly lower the probability that a country will successfully export a good.

The importance of time and distance underpins that globalization has a fundamental link with transportation and logistics, even though the significance of distribution has been overlooked in globalization studies (Hesse & Rodrigue, 2006). The complex networks involving flows of information, commodities, parts, and finished goods demands a high level of command of logistics and freight distribution. Hence, concurring with Baldwin's 'trade-investment-services nexus', Hesse and Rodrigue (2006) further differentiated a 'third phase' of global economic system development with the focus shifting to the geographical and functional integration of production, distribution, and consumption. In this phase, powerful actors have emerged who are not directly involved in the function of production and retailing, but mainly taking the responsibility of managing the web of flows. The global economic system is thus one characterized by a growing level of integrated services, finance, retail, manufacturing, and nonetheless distribution. Examples of these powerful actors are Wal-Mart and Amazon. These global players demonstrate what may be called the future 'age of logistics'(Lecavalier, 2014)

Hesse & Rodrigue (2006) therefore emphasized the need to consider transport and logistics as an integral part of global production and value-added activities. Globalization is associated with a reconfiguration of space-time patterns, while transport and particularly logistics are major means of coordination between both. A joint perspective is needed between the geography of production and the geography of distribution.

2.1.3 Global-regional inter-dependency: WCN, GCC, GPN

As trade theories more and more focus on the complex cross border flows of goods, know-how, investment, services and people, significant emphasis of various studies has been

placed on the interrelations between the global system of trade, production chains, and networks and the notion of 'regional development'. (Beaverstock, Smith, & Taylor, 2000; Brown et al., 2010; Coe, Hess, Yeung, Dicken, & Henderson, 2004; Sassen, 2004). Several conceptual terminologies that evolved in recent years include: World City Networks (WCN), Global Value Chains (GVC) or Global Commodity Chains (GCC), and Global Production Networks (GPN). The WCN analysis focus on the emergence of global cities as 'command centers' of the global economy(Sassen, 2004). The GCC or GVC analysis focus on the production of commodities as a sequential chain in which value creation takes place(Brown et al., 2010). Lastly, the GPN analysis built on the earlier GCC analysis and focus on the 'strategic coupling' of global production networks with regional assets. Regional development is emphasized to be a set of 'relational' and 'interdependent' processes (Coe et al., 2004).

In a lively debate between scholars regarding integrating these various schools of thoughts, Brown et al., (2010) propose to integrate the World City Network (WCN) analysis with Global Commodity Chains (GCC) analysis by returning to their common 'world systems analysis' origin using the core-periphery framework as the spatial structure to understand the process behind globalization. In this framework, value is unevenly distributed across the chain with World Cities being the critical nodes in the chain.

The strength of the GCC approach is that it includes inter-city relations beyond the leading world cities through flow of capital, labour, goods and services; also Global City Network (GCN) includes primary production. Therefore GCC can help better understand the city transformation and trade processes.

Along the same discussion, Coe et al., (2010) broadly support the proposition of Brown et al., while caution that the Core-periphery structure is no longer relevant in today's world as GCCs can bypass the world cities. Also network actors should go beyond corporate realm and include

NGOs, governments and so on. The authors concur with the needs for empirical studies to "identify actual flows and connectivity between cities, and add 'flesh' to WCNs through industry specific analyses that reveal the connections and material links between cities".

Other studies focus on the importance of the inter-dependent multi-scalar networks for regional development(Wall & Knaap, 2011). At the global level, both the GCC and GPN represent a functionally integrated network of production, trade, and service activities that covers all the stages in a supply chain, from the transformation of raw materials through intermediate manufacturing stages to the delivery of a finished goods. At the regional level, World Cities are 'command centers' that regulate the 'new international division of labor' in the global value chain. At the local level, cities are not just physical entities, but are products of the process of transnational network formation which resulted in inter-personal relationships.

The study by Wall & Knaap (2011) contributes to the empirical understanding of the relationship between these 'spaces of flows' by conducting in-depth analysis of the corporate networks of leading MNCs and their geographical locations and providing empirical evidence of the complex inter-dependency between global production networks and world city networks at global and regional scales. Their study also supports that the Advanced Producer Services sector (APS) indeed interlock strongly with the overall economic system. However, by differentiating ownership structure, it shows that while APS do lead the way in city formation, other economic sectors construct alternate forms of network among cities.

2.2 Trans-nationalization and Firm Theories

2.2.1 Multi-Nationals Firms

Multinationals (MNC), or the trans- nationalization of firms, occurs via Foreign Direct Investment (FDI), which occurs when a firm from one country obtains a controlling ownership stake(usually 10%) in an enterprise in another country or when a financial flow occurs between parties that reside in different countries but are related by ownership(Yeaple, 2013) . One difficulty in studying the behaviours of multinationals is that publicly collected data on the global operations of firms are rare.

Due to the second 'unbundling' forces driving globalization, growth of multinational activities in the form of foreign direct investment (FDI) surged as firms became increasingly flexible in the global positioning of their assets, especially with regards to manufacturing activities. In recent decards, FDI has grown at a faster rate than most other international transactions, particularly trade flows between countries. According to the estimates of UNCTAD World Investment Report 2011, multinational firms account for 25% of global GDP and one-third of international trade (Yeaple, 2013). Further, almost half of trade flows are intra-firm; i.e., trade within an MNC(Blonigen, 2005).

Today, international activity is increasingly concentrated in a small number of very large firms. The heterogeneous nature of multinational firms is well documented by several studies. The top multinationals dominate global commodity chains, production, distribution and allocation of resources. For instance, the top 100 companies account for over 50% of OECD revenues, as well as 50% of global FDIs (Wall et.al., 2011). The study by Wall et.al., (2011) further highlighted that not only most multi- national activity is confined to developed countries, but even within the rich countries, there are only the 'happy few' – namely US, Japan and Germany.

2.2.2 Determinants of FDI

As a result of the importance of multinationals in the global economic system, international trade theories increasingly focus on the firm as an important unit of analysis. The key questions regarding firm behaviour centre on firms' decisions regarding location choices and modes of entry which includes opening new establishment, buying an existing facility or joint venture with a local firm.

Theories in the field of international business and international economics offer different angles to study multinational firm behaviour. The OLI model by Dunning which stands for Ownership, Location and Internalization explains why, where and how firms internationalize from business point of view; whereas the economic point of view focus on the vertical and horizontal characteristics of FDI(Wall et al., 2011).

Following Dunning's `OLI paradigm' (Dunning, 1977; 1993), firms invest abroad if: they have market power given by the ownership (O) of products or production processes; they have a location advantage (L) in locating their plant in a foreign country rather than in their home country; and have an advantage from internalizing (I) their foreign activities in fully or

partially owned subsidiaries, rather than carrying out business through market transactions (trade) or networked relationships with other firms (e.g. licensing and franchising)

Study by Wall et al., (2011) revealed several characteristics of multinational location choices. First of all, the home-country-specific ownership advantages arise from access to resources that are abundant in the home country, such as availability of economic resources, technology, and skills. These charateristics are also refered to as 'non-tradable' externalities by Scott & Storper (2003). Secondly, MNCs particularly prefer to locate their headquarters and subsidiaries close to production and consumer markets. In this, MNCs are more particular about the location of their headquarters than about the location of their subsidiaries. In addition, transactional distance between countries, in the form of physical and cultural distance, still keeps countries apart in the global playing field. Thirdly, a country's market size is more important for connections targeted at rich countries than those targeted at poor countries. Lastly, the findings reveal differences in economic activities conducted between countries, where connections into poor countries are primarily related to labor-intensive activities, and FDI into rich countries is mainly targeted at services. In addition, FDI into poor countries is more natural resource seeking and efficiency seeking than is FDI into rich countries.

2.3 Developmental impacts of trade and investment

Amighini & Sanfilippo (2013) studied the developmental impact of trade and investment on African economies. Their research points to the importance of external 'flows' in the form of imports and inward flows on the upgrading of African exports. They further points out that the origin of the flows are also important. South south flows in low tech sector such as agriculture and food process brings greater benefits due to smaller technology gap and similar level of production capacities.

Bosker & Westbrock (2014) used social network methodology to analyze the network characteristics of the global supply chain. Their research highlights that the well-being of any one nation depends on the technologies and geographical locations of all other nations. They identified the key player nations in the global production network, and show that the proximity to these nations is crucial for a country's income development.

2.4 Network Theories

2.4.1 Actors and Links

The field of network studies has its roots in sociology and Social Network Analysis. Firms can be considered as 'a constellation of network relationships governed by social actors'. Storper (2009) focused on the interaction of ‘actors’ with their ‘contexts’ to explain the persisting regional differences (p.13). ‘Context’ is defined by ‘the division of labor and the networks in which the actor finds herself or himself’ and it is the decisions and actions of the actor(s) and their interactions with their networks that are increasingly responsible for the global flow of

goods, services, and investments. How power and governance is organized at various organizational and spatial scales is a central theme for such networks. Today's firms are moving away from the top-down, static hierarchical organization form into more hybrid forms exhibiting heterarchical characteristics which are: inter-dependence, reciprocity and unequal power relations (Wall & Knaap, 2011).

Dynamic understanding of change in networks poses interesting angle to the study of networks. Gluckler (2007) proposes the integration of Economic Geography and the Evolution of Networks to understand geographical 'network trajectory', which is defined as 'a geographically and historically specific development path of a network in which every change of the relationships and nodes impacts the next formation'.

Every flow leaves a trajectory in the city network, the strength of this trajectory depends on its frequency and repetitiveness. Needless to say, geographical network trajectories are not created randomly, they are the product of an evolutionary process consisting of selection, retention, and variation (Glückler, 2007).

Selection is made based on the advantages and disadvantages that an actor perceives in a linkage. The shift of the global system to the network society widened the range of factors that make a network attractive. For example, connectivity, or the access one network can grant to additional networks, is key to determine its competitiveness in the system (Castells, 2002, Castells 2005).

Once a selection has been made, the relation will often remain and strengthen. Network retention means that, amongst the competition, a link remains the best option for both nodes. This decision is affected by factors including proximity, strength and history of ties, organizational inertia, etc.

Preferential attachment hypothesis highlights the importance of reputation in network retention, it states that firms with many ties are more likely to build new ties in the future than firms with fewer ties. Meanwhile, the embedding hypothesis calls attention to the role of the leading actors by expressing that referrals favor ties around existent strong ties. Finally, the multi-connectivity hypothesis shows how similar firms tend to network with the same partners when trying to expand their networks (Glückler, 2007).

The last step of establishing geographical network trajectories is variation, or innovation in the network structure. The search for innovation in networks is constant and it will answer to the needs and strategies of firms at a particular moment in time. When looking to innovate, firms can try to connect with non-traditional partners in different locations or between different sectors in the same geographical area.

2.4.2 Network Centralities and Power Structure

Within the discipline of World City studies, there are two schools with fundamental conceptual differences: one is that of Alderson and Beckfield which postulates that MNC networks, regardless of their industrial sectors, is the primary force linking cities into a world system; the alternative school is the GaWC research method which follows Sassen's lead in focusing on the 'advanced producer services' (APS) sector since APS represents the cutting-edge global economic activity and leads the way of world city formation. (r)

The two schools also differ in their data analysis methodologies. Alderson and Beckfield used data from the Fortune 500 firms and their direct subsidiaries worldwide; whereas the GaWC method analyzed data from 100 APS firms and their offices in 315 cities with different levels of corporate connections. Alderson and Beckfield used social network analysis techniques to measure centrality and network structure; while GaWC method used what's called 'total interlock connectivity' to derive three distinct levels of an inter-locking city network: global, dominant and sub-ordinate. (Taylor, 2001; R. Wall & Knaap, 2011)

The empirical study of Wall & Knaap (2011) bridges between these two schools by using the data similar to Alderson and Beckfield's (Fortune 100 MNCs), but classified into 5 levels of corporate ownership following the GaWC approach. Social Network Analysis techniques was used to measure the four aspects of centrality: indegree, outdegree, diagonal and betweenness. By using one single data set, the study shows the nodal centralities and linkage structures within the 'all industrial sector' network and the 'producer service network'; also it shows strong correlation between the two, 'especially towards the apex of the economic systems'.

By using a more elaborate classification method for the firms and exploring the deeper ownership structures, the study also shows the co-existence of both hierarchical and heterarchical city network structures. Between global cities, the corporate ownership network is essentially heterachical as '84% of the MNC network occurs among cities, not within them'; however the network structure between headquarter cities and subsidiary cities shows clear hierarchical hub-and-spoke structures.

2.4.3 Network Cohesion and Emerging Market Dynamics

Hatani & McGaughey (2013)examined the evolutionary dynamics of interfirm networks especially in entering emerging markets in a rapidly changing world. They found that increasingly, competitive advantage does not reside in a single firm's capabilities or resources, but in interfirm networks that compete with other networks.

They identified that in emerging markets, network members will confront uncertainty across heterogenous business conditions, and need to coordinate a network based division of labor and learning internationally. Maintaining network cohesion is essential in global expansion, and international competitive advantage.

2.5 Evolution of Global Agro Food Systems

2.5.1 Historical Evolution Perspective

In his influential book entitled *Guns, Germs and Steel*, Diamond (1999) explains the various important aspects of the consequences of the interaction between ‘geography’ and ‘economics’ by covering an extensive period of 13,000 years. From a historical perspective, Diamond explained how human societies interacted with their physical environment and with other societies and how the innovation and economic accumulation process evolved.

The key theories of relevance to understand historical network trajectories are:

- All developments of economically complex, socially stratified, politically centralized societies were based on food production

- Societies that engaged in intense exchanges of crops, livestock, and technologies related to food production were more likely to become involved in other exchanges as well

- Geographical connectedness has exerted both positive and negative effects on the evolution of technology/innovation.

2.5.2 International Food Security

Morgan & Sonnino (2010) identified five 'profoundly disquieting trends' to point out that food security is no longer an issued confined to the global south, but is becoming a major challenge for the global north as well. These trends include food price surges, population growth coupled with dietary changes, surge of national security outcries, climate change and land conflicts.

Economists and agricultural scientists carried out modeling to study the production and consumption dynamics in responding to the global challenges and their results differ. Schneider et al., (2011) find that the per capita food levels increase will have minor impact on food prices, as the effects of population growth will be counterbalanced by technological adaptations. Study by Rask & Rask (2011), on the other hands, point to 'critical food supply' issues due the compounding effect of income growth on dietary change alone, even before considering population growth.

Henkdrickson & Heffernan (2002) contribute to the debate on production and consumption dynamics by taking a contrary view and analyzing global food chain clusters. They analyzed the structure of the global food systems through the rise of food chain clusters and their extension into retail to understand how power is negotiated in the chain.

2.5.3 Global Agro-food Systems

Their analysis showed that food chain clusters are networks of relationships where relatively few decision-makers control vast amounts of resources. This is as a result of the "trans-nationalization' in the food and agriculture sector, which is a process that reflects broader societal transformation. In the global food system, power rests with those who can structure this system by 'spanning distance and decreasing time between production and consumption'.

From firm study perspectives, transnational companies (TNCs) achieve this power by several strategies, like TNC in other sectors. First is to horizontally integrate by expanding their business in the same stage of the commodity system. Firms can also vertically integrate by expand upstream or downstream in the agriculture and commodity chains. Finally firms globalize to reduce uncertainty or to expand business. All these strategies result in increasing

and concentrating ownership and control in the food system and they depend highly on the formation and sustaining of relationships and networks.

The authors study the emerging clusters of firms that control many of the decisions in the food system from gene to supermarket shelf. A dozen of global oligopolies possessed formidable economic power and fundamentally restructuring the global supply and distribution networks. Powerful processors and retailers have to 'negotiate' their respective power in the chain.

While the strengths of this global system include mass production for mass consumption, access to capital and business viability, the challenges to the large firms is their ability to be flexible and to meet the niche, often high end markets. For developed western economies, trust from consumers is increasingly a big issue.

Therefore, the global domination is not the end story. More likely scenario is the 'global competitiveness, local resilience' with two farm systems: one system is made of several large farmers engaged in commodity production who depend on technology and economies of scale to survive on razon-thin margins; the other system will focus on product-oriented, consumer driven, end-user approach to agriculture and production.

The main conclusion from Henkdrickson and Heffernan is that the global food systems is a very dynamic system and hard to predict how it will evolve. Technologies and outside changes can greatly disrupt the organizational structure.

2.6 Evolution of Beer

The history of beer brewery has been closely associated with the history of agriculture and food, and hence the history of civilization and urbanization (Diamond, 1999). The dynamics forces that shaped the beer industry in the last century and the emerging trends reflect the wider societal transformations as well, such as: trans-nationalization & industry consolidation, globalization vs. localization, emerging market dynamics and transition towards a 'green' model. Therefore, the beer industry is a strategic 'lens' through which to view the interplay of the globalization and urbanization forces shaping the global agro food systems.

The dynamics forces and trends that impact the development and future of the beer industry that reflect the wider societal transformations are the following:

Trans-nationalization: Dramatic consolidation and concentration in the beer industry at the international level since 1990s marked by large takeovers. Currently, the global beer market is dominated by a few multinational players (Swinnen & Vandemoortele, 2011)(Tremblay & Tremblay, 2011). Global branding and marketing play a key role in the global beer sector.

Emerging market dynamics: Beer consumption in the traditional 'beer' countries has stagnated in recent years. Asia has seen strong growth of trade and direct investments and was involved in 31 percent of all the Mergers and Acquisitions (M&A) transactions that took place in the beer sector between 1998 and

2010. However, Africa will likely take over Asia as the fastest-growing market in the future (Rabobank, 2014)

Rise of 'local' – the craft beer sector: countermovement to global consolidation is the rise of microbrewery sector in mature markets as Belgium and US (Tremblay & Tremblay, 2011). Increasing consumer income has created a larger demand for variety, prestige, and local products—characteristics which craft beers offer.

Sustainable supply chain (in new markets): Shortage of inputs such as malt of required quality and consistency means foreign investors need to set up own supply chains to secure these inputs in China, India and so on (McCluskey & Shreay, 2011). Therefore, supply chain, logistics and vertical integration are important considerations for companies to invest in new emerging markets.

History and networks: The history of beer has been closely associated with the history of food, and hence the history of civilization and urbanization(Diamond, 1999). Beer is a product that is often consumed within a social group. History, culture and peer influence have strong impact on beer consumption and preferences (McCluskey & Shreay, 2011)).

2.7 Conceptual Framework

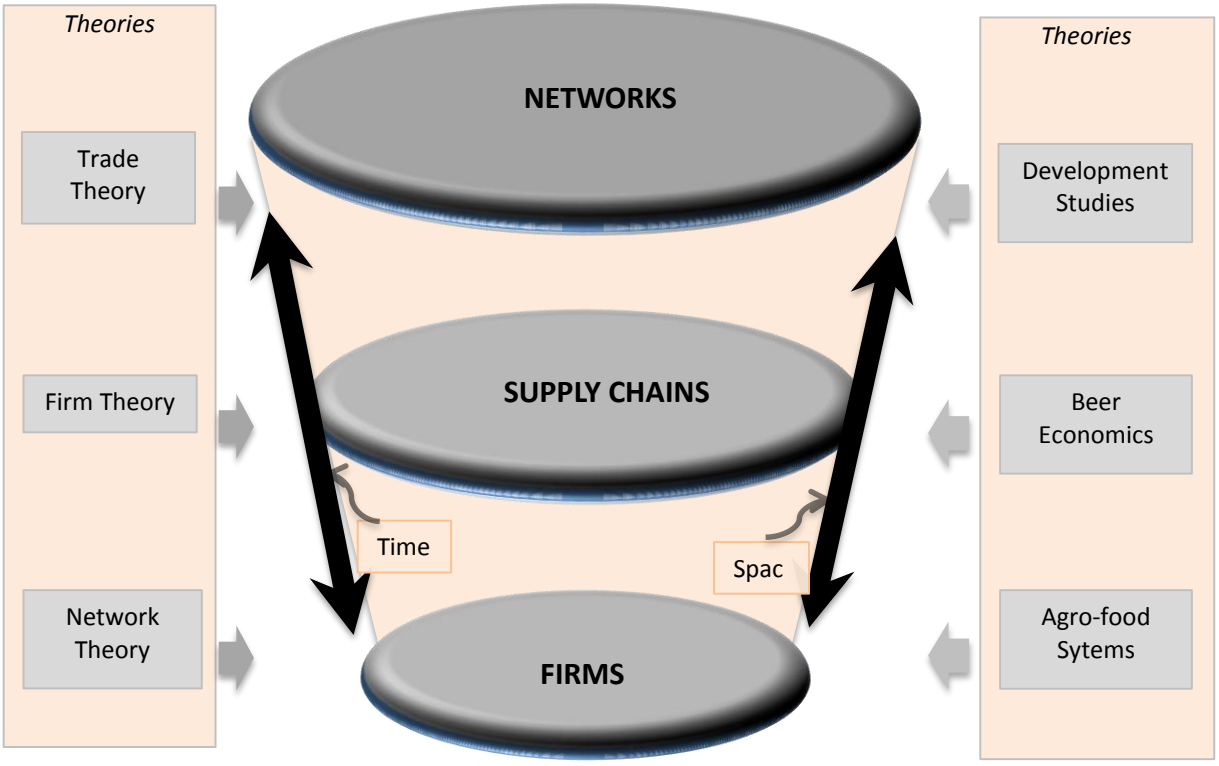

Figure 2 Conceptua Framework

Chapter 3. Research Design and Methods

3.1 Revised Research Questions

What are the network dynamics both within and between the trading network of beer and the investment network in the food sector in response to endogenous network structures and exogenous environment?

- what are the respective typology, dynamics and evolution of the trade network in beer and the F&B investment network regarding network structure and country positions?
- Which endogenous and exogenous factors are important for the network dynamics for the two networks respectively?
- How do the two networks inter-relate to each other?

3.2 Operationalization: Variables and Indicators

Dependent Variables: Network evolution of the trade network and the investment network

Explanatory Variables:

- structural variables that depend on the network only including reciprocity, transitivity

Country Characteristics:

- known effects documented important to trade including the *income effect* as measured by GDP per capita; *regionalism* as measured by the geographical regions the countries are located; *openness* as measured by percentage of export value in total GDP. For the regional effect, the *same*-ness effect is used instead of the *similarity* effect to measure tendencies for countries to establish and maintain ties with partners in the same region.

- infrastructure. 3 indicators from the World Development Indicators (WDI) were chosen including internet users (per 100 people), road density and water productivity which is measured in the value of GDP produced with each cubic meter of fresh water extraction. Road density and internet uses try to capture the 'flow'and exchange enabled by infrastructure and technology; and water is included due to its importance as a production factor for beer and for the food industry.

- capture the dynamics and 'flow' of people effect. Three variables were tested: *urban growth* in percentage that indicates the movement of people from rural to urban; *urban population* in large agglomerations of more than 1 million people; and effect of *international tourism* which indicates the 'flow' of people around the world.

- the Logistics Performance Index (LPI). The LPI index is measured by World Bank and only available for the years of 2007 and 2010. Other than the overall effect, the sub-indexes on *Trade and Transport Infrastructure, Logistics Performance, Efficiency of customs clearance process, Efficiency to Arrange Competitively Priced shipments* were tested as well.

- Global Competitiveness Index. Other than the overall effect, several indexes were tested including: Infrastructure, Goods Market Efficiency, Macro Environment and Market Size. Yearly data for GCI index is available from 2006.

3.3 Research Strategy and Methodology

3.3.1 Complex Network Analysis

We live in an increasingly **interconnected** and **interdependent** world characterized by intertwined networks of trade in goods, services, cross- border investment and the international movement of workers. Trade linkages are one of the most important channels of interaction between world countries. For example, they can help to explain how economic policies affect foreign markets; how economic shocks are transmitted among countries; and how economic crises spread internationally. However, direct bilateral-trade relationships can only explain a small fraction of the systematic influences of today's global system. Therefore, a **complex-network analysis** of the trade and investment networks, by characterizing in detail the topological structure of the network, can nicely complement the standard international-trade analysis and indicators, which instead only account for bilateral-trade direct linkages.

A **Complex-Network Analysis** uses social network analysis methodology and visualization techniques to understand the position of each country in the trade network and focus on the **structural** dimension of trade relations and on the **interdependence** among countries. This approach can be used to address issues where systematic effects can be relevant, such as transmission mechanisms of international shocks, the relationship between multilateralism and regionalism, and the impact of new emerging countries in the World Trade Network.

3.3.2 Stochastic Actor Oriented Models (SAOMs)

With the growing interest on network dynamics, the availability of longitudinal relational data, and more powerful computers, applications of Stochastic Actor Oriented Models (SAOMs) have started to recently emerge in economic geography.

In contrast to the previously presented approaches, SAOMs are a class of statistical models that have been specifically developed for the analysis of network dynamics. The most well-known SAO models have been proposed by Snijders (2001) in order to provide a statistical model able to analyse empirically the evolution of complex network structures. By combining random utility models, Markov processes and simulation (Bunt and Groenewegen 2007), the SAOM has permitted to study the dynamic of networks and thus to provide recently new results in many fields of social science.

The main objective of this class of models is to explain observed changes in the global network structure by modeling choices of actors at a micro-level. More precisely, this statistical model simulates network evolution between observations and estimates parameters for underlying mechanisms of network dynamics by combining discrete choice models, Markov processes, and simulation (Snijders et al. 2010b). SAOMs not only account for statistical dependence of observations, but also explicitly model structural dependencies, like triadic closure.

Endogeneity of network structures, i.e., the fact that networks reproduce themselves over time is not perceived as an econometric issue that needs to be corrected, but as a rich source of information used to model the complex evolution of network structures. Broekel et.al., (2014) believe that SAOM are probably the most promising class of models allowing for statistical inference of network dynamics.

3.4 Network Selection

A total of 178 countries are included in the network studies representing the complete global network (see Annex 1 for complete listing).

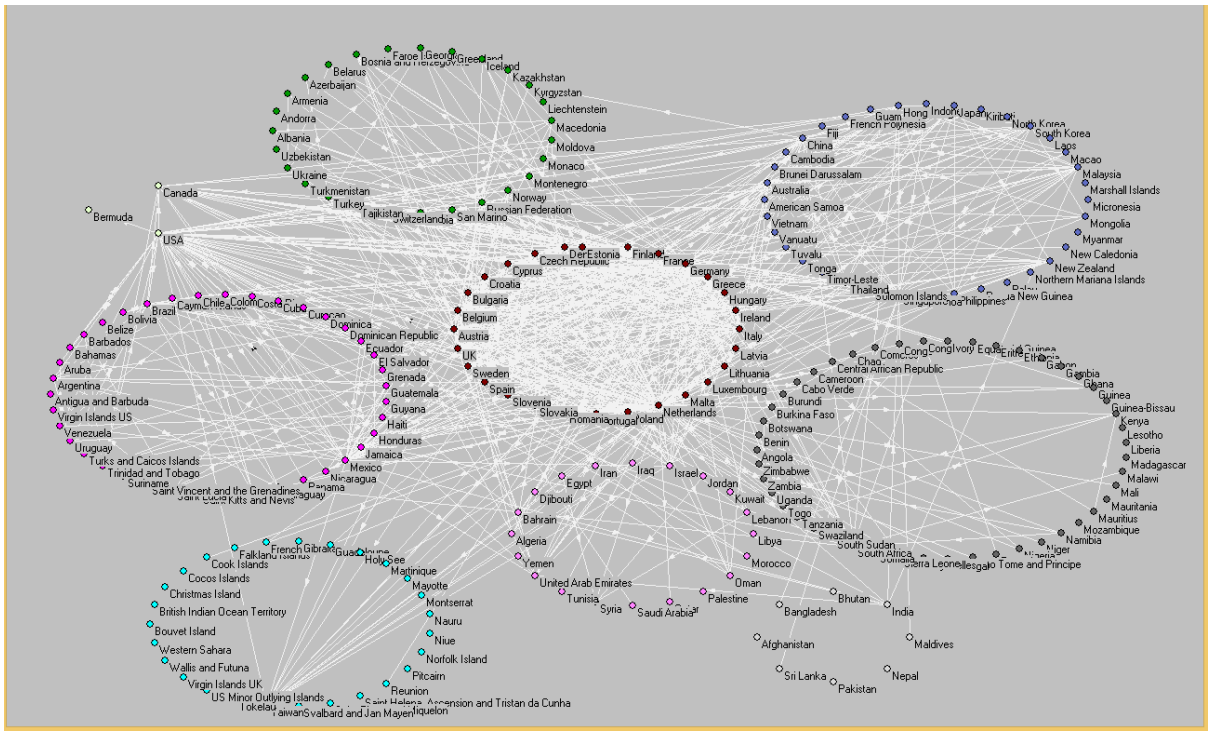

Figure 3 Countries Invovled in Trading of Beer between 1992 to 2011 (data source: FAOSTAT)

3.5 Validity and Reliability

The convergence of the statistical models are tested to confirm that the simulated network converges with the observed network therefore providing meaningful parameter estimates.

Covariance between variables are tested for multi-collinearity.

3.6 Data collection methods

Longitudinal: panel data with 10 years, at each point all ties on the predetermined node set

Node set: 178 countries

Networks are dependent as well as independent variables

The data to be collected and analyzed consist mainly of two kinds of data: network data on trade, firms and foreign direct investment, and locational and competitiveness data on nations

and main cities.

Longitudinal network data on trade and foreign direct investments

Time series data for the last 10-20 years will be collected from the following sources:

- FAOSTAT (Global trade data)
- EUROSTAT (Regional trade data)
- fDi Markets (covers global greenfield investments and includes information on firm, destination city, firm activity, year of investment for the last 10 years)

Country Specific Indicators

Indicators were collected from various international organizations including the World Bank, World Economic Forum to measure the following:

- World Development Indicators
- Logistic Performance Index (LPI)
- Global Competitiveness Index (GCI)

3.7 Data analysis methods / or techniques

3.7.1 Descriptive research

Descriptive research of the typology, evolution and trends in beer trade and FDI flows using social network analysis techniques and tools

Centrality measures are network indicators that represent how each single country is relatively positioned in the overall network. Several studies (De Benedictis et al., 2013; Fagiolo, Reyes, & Schiavo, 2008) have explored the suitable network indicators for analysing world trade which can be classified into four main groups:

1) Degree centrality that measures how a node is connected to others (and related strength centrality for the weighted network);
2) Closeness centrality that measures how easily a node can be reached by others;
3) Betweeness centrality that measures how important a node is in terms of connecting other nodes;
4) Eigenvector centrality that associates a node's centrality to the node neighbor's characteristics. In another words, it takes into account whether a country is connected to central players or to peripheral ones. It is not the country's centrality itself that matters, but rather the centrality of the countries linked to him.

Degree and strength centrality are regarded as 'local' centrality measures as they consider only the direct links of a node, regardless of the position of the node in the network's structure. However, the topological map above shows that the position of a country does depend on the position of others: all the countries have the same out degree, i.e. 2 representing the top 2 trade partners, but they attain very different position in the network. Turkey is linked with central countries, whereas Egypt with peripheral countries. The indicators that measure the 'effect of others' are hence regarded as 'global' centrality measures (De Benedictis et al. 2013).

3.7.2 Explanatory Research and Statistical Inference

Modeling of the longitudinal network data is done using SIENA model (Simulation Investigation for Empirical Network Analysis) which is computer program that carries out the statistical estimation of models for the evolution of social networks according to the SAOM methodology.

3.7.2.1 Structural effects

According to the SAOM methodology, the ties in a social network are evolving 'states' rather than 'events'. Actors have inertia to keep their current states. The changes are made by actors who send the tie, on the basis of their and others' attributes, their position in the network, and their perceptions about the rest of the network(Snijders et al., 2010). Therefore the actors do not change the ties at will, rather they choose the 'moves' that maximizes their utility in the objective function. Hence SAOM is referred to as the 'actor-based model'.

The objective function below is a linear combination of a set of components called *effects*. $f_i(\beta, x)$ is the value of the objection function for actor *i* depending on the state x of the network. The functions $S_{ki}(x)$ are the effects that contribute to the tendency of network changes; and β_k is the statistical parameter (Ripley et al., 2014). If β_k equals 0, the corresponding effect plays no role in the network dynamics; if β_k is positive, then there will be higher probability of moving into directions where the corresponding effects are higher, and the converse if β_k is negative.

$$f_i(\beta, x) = \sum_k \quad \beta_k S_{ki}(x) \qquad \textbf{(1)}$$

The distributions of the parameters β_k are 'approximately normally distributed' (Snijders et al., 2010). Therefore the parameters can be tested by the t-ratio, defined as parameter estimate divided by standard error, to a standard normal distribution.

The structural effects are 'endogenous' effects since they depend only on the network. The main structural effects included in the models for the trade and investment networks are described below.

Basic Effects

Two basic effects that should always be included in all models (Ripley et al., 2014) are the *outdegree* and *reciprocity* effects. Outdegree represents the basic tendency to have ties at all. In most cases a negative parameter is obtained for the outdegree effect since in a sparse network, the cost of extending an arbitrary tie will usually outweigh the benefits. Putting it in the context of firms making trade or investment decisions, firms need indeed always weigh the benefits and costs associated to justify the transaction costs associated with establishing (or terminating) ties with partners. Reciprocity is another basic feature in social networks, represented by the number of reciprocated ties of actor i.

Network Closure Effects

Network closure effects are also called triadic effects, which measures the tendency for two paths to become closed (Snijders et al., 2010). The two triadic effects modelled are represented by the following diagrams. *Transitive triplets* represent the tendency towards transitivity or clustering (here the path of $i \rightarrow h \rightarrow j$ is closed by $i \rightarrow j$). *Three cycles* represents generalized reciprocity or the opposite of hierarchy. A positive parameter for transitivity and a negative for *three-cycles* can be interpreted as a tendency towards local hierarchy (Ripley et al., 2014).

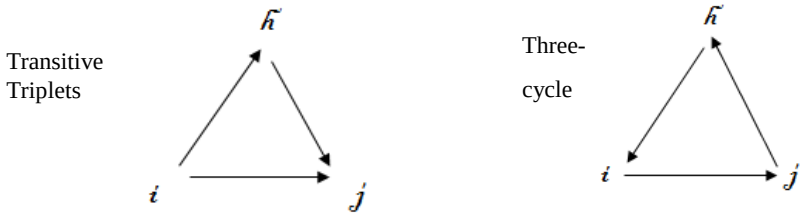

Figure 4: Transitive Triplets and Three-Cycle

Degree – related effects

Degree related effects are important measures for the trade and investment networks which are characterized by high heterogeneity. The main effects modelled are: *in-degree popularity* effect that controls the tendencies actors with high in-degrees to attract extra incoming ties 'because' of their current high in-degrees; *out-degree activity* effect to account for the tendencies that actors with high out-degrees to send out extra outgoing ties. The *in-degree popularity* and *out-degree activity* are self-reinforcing effects and can be referred to as 'cumulative advantage' or 'preferential attachment'(Ripley et al., 2014). The *in-degree activity* or *out-degree popularity* controls the correlation between in-degree and out-degree.

3.7.3 Univariate network Dynamics: Covariate effects

Covariate effects are effects that depend on externally given attributes, hence they are also referred to as the "exogenous" variables. For a country specific variable V, there are three basic effects: the *ego* effect that measures whether countries with high V values tend to send out more ties; the *alter* effect measures whether countries with high V values will be more popular for others to establish ties with and hence have higher in-degrees; and the *similarity* effect that measures whether ties tend to occur more often between countries with similar value on V. This is also referred to as the 'homophily effect' in social network literatures.

3.7.4 Multivariate network dynamics: co-evolution of the trade and investment networks

After investigating the dynamics in within each network separately, the last step is to investigate the dynamics across the two networks.

A multiple or multivariate network is defined as a set of *n* social actors, on which R relations are defined (Snijders, Lomi, & Torló, 2013). In the trade and investment networks, both contain 178 countries as the 'actors'. SIENA algorithm is used to test cross-network dependencies between the two relations.

The results of the joint analysis of the trade and investment networks in 2010 and 2011 are summarized in the table below. The within-network parameters are structural effects for each network individually as control effects and they have been presented in the earlier sections. For the interaction between the two networks, only the basic cross network dependency effects were explored and summarized as below: (Snijders et al., 2013):

1) **Trade network as dependent variable, investment network as explanatory variable**
   In the case of direct association, the hypothesis is that an investment tie in the F&B sector will have positive influence on the formation of a tie in the trade of beer. For mixed reciprocity, the hypothesis is the investment tie will increase the probability of a reciprocal trade tie.
2) **Invest network as dependent variable, trade network as explanatory variable**

In the case of direct association, the hypothesis is that a tie in the trade of beer will have positive influence on the formation of investment tie in the F&B sector. For mixed reciprocity, the hypothesis is that the trade tie will increase the probability of a reciprocal investment tie.

3.7.5 Functions of Tested Effects

The objective function $f_i(\beta, x)$ is the weighted sum of effects $S_{ki}(x)$, as given by the formula (2) below:

$$f_i(\beta, x) = \sum_k \beta_k S_{ki}(x)$$

The estimated parameters β_k which represent the 'weight' are 'unstandardized' coefficient of the statistical functions$S_{ki}(x)$. The parameters can be interpreted in two ways in subsequent sections. The mathematical formulas for the main effects tested are listed as below:

Structural effects:

1. Out-degree or density effect, defined by the out-degree

   $$S_{i1}(x) = \sum_j x_{ij} \quad \textbf{(2)}$$

   where x_{ij} = 1 indicates presence of a tie from i to j while x_{ij} = 0 indicates absence of this tie;

2. Reciprocity effect, defined by the number of reciprocated ties

   $$S_{i2}(x) = \sum_j x_{ij}\, x_{ji} \quad \textbf{(3)}$$

3. Transitive triplets, defined by the number of transitive patterns in i's relations.

   $$S_{i3}(x) = \sum_{j,h} x_{ij}\, x_{ih} x_{jh} \quad \textbf{(4)}$$

4. Number of three-cycles

$$S_{i4}(x) = \sum_{j,h} x_{ij}\, x_{jh} x_{hi} \quad \textbf{(5)}$$

5. In-degree popularity (sqrt) effect, defined by the sum of the square roots of the in-degrees of the others to whom i is tied,

$$S_{i5}(x) = \sum_{j} x_{ij} \sqrt{x_{+j}} = \sum_{j} x_{ij} \sqrt{\sum_{h} x_{hj}} \quad \textbf{(6)}$$

where $_{+}j$ denotes total in-degree of j.

6. Out-degree activity (sqrt) effect

$$S_{i6}(x) = x_{i+}^{1.5} = x_{i+}\sqrt{x_{i+}} \quad \textbf{(7)}$$

where i_{+} denotes total out-degree of i

Note: the square root version is used instead of raw effects for 5) and 6) as suggested by Ripley et al. (2014)

Covariate Effects as denoted by v_i:

7. Covariate-ego or covariate-related activity, defined by i's out-degree weighted by his covariate value

$$S_{i7}(x) = v_i x_{i+} \quad \textbf{(8)}$$

8. Covariate-alter or covariate-related popularity, defined by the sum of the covariate over all actors to whom i has a tie

$$S_{i8}(x) = \sum_{j} x_{ij}\, v_j \quad \textbf{(9)}$$

9. Covariate-related similarity, defined by the sum of centered similarity scores sim_{ij}^{v} between i and the other actors j to whom he is tied,

$$S_{i9}(x) = \sum_{j} x_{ij}(\, sim_{ij}^{v} - \widehat{sim}^{v}) \quad \textbf{(10)}$$

where the similarity score is

$$sim_{ij}^{v} = 1 - \frac{|v_{i-}\, v_j|}{\Delta_V},$$

with $\Delta_V = \max|v_{i-}\, v_j|$ being the observed range of v and where $\widehat{sim}^{v}$ is the mean of all similarity scores.

Multiple Network Effects

For the cross-network effects, one network has the role of the dependent variable, while the other network has the role of the explanatory variable. In the following functions the network in the role of dependent variable is denoted by the tie variables x_{ij}, while the tie variables w_{ij} denote the network that is the explanatory variable. Since the co-evolution of the networks is modelled, effects for reversing X and W are also included:

1. Effect of W on X (direct association):

$$S_{i1}(x) = \sum_{j} x_{ij}\, w_{ij} \quad \textbf{(11)}$$

$i \xrightarrow{W} j$ leads to $i \xrightarrow{X} j$

2. Effect of incoming W on X (mixed reciprocity)

$$S_{i2}(x) = \sum_j x_{ij}\, w_{ji} \quad \textbf{(12)}$$

$j \xrightarrow{W} i$ leads to $i \xrightarrow{X} j$

Chapter 4. Research Findings

4.1 Descriptive Research of Trade Network in Beer

4.1.1 General

The brewing sector is of significant global economic importance. In Europe, which is home to around 4500 breweries and to the headquarters of the world's largest brewing companies, the brewing sector is estimated to be responsible for 2 million jobs, 51.5 billion Euro in value added in the supply chain, and 53 billion Euro in government revenues.

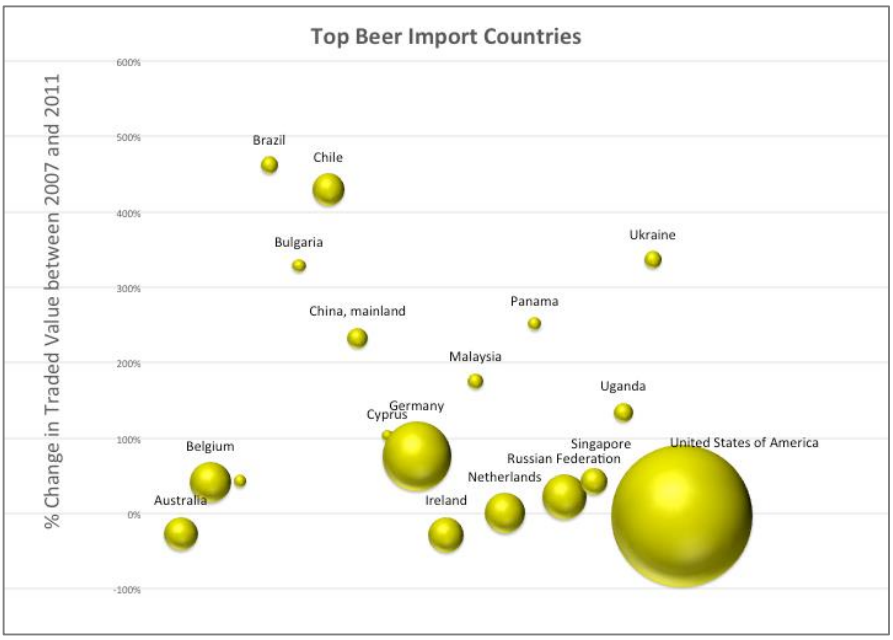

Figure 5 Export volumes for traditional beer countries have stagnated from 2007 – 2011 (Data Source: FAOSTAT)

In 1991, there were about 70 exporting and importing countries involved in the beer trade; the numbers had peaked to around 140 at 2007, and stabilizing at 120 in recent years. (Data Source: FAOSTAT). The traditional top export countries, as depicted in the figure below, are mostly European nations. In recent years, the emerging economies including Brazil, China have seen the most rapid growth in import.

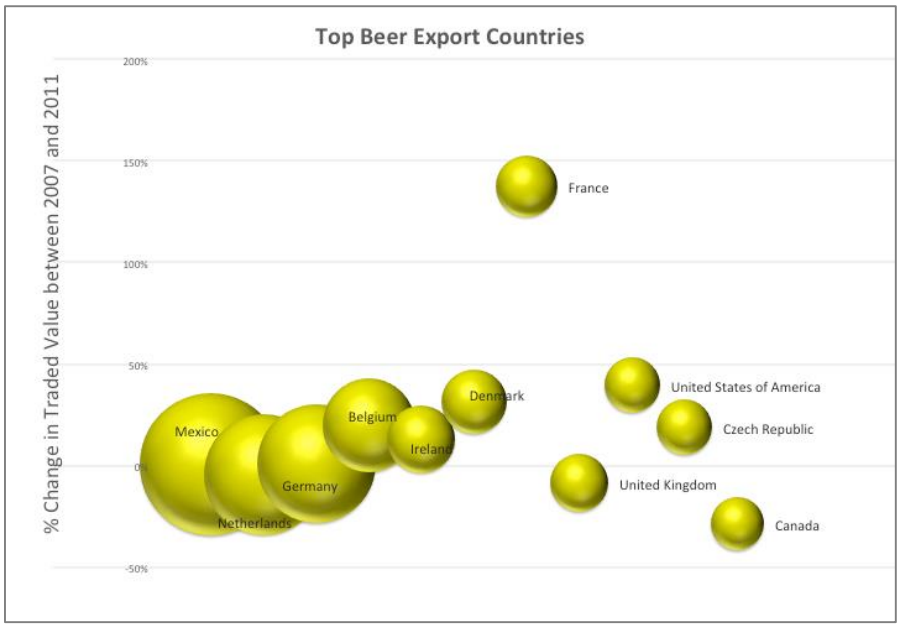

Figure 6: Emerging countries in Asia and Latin America have shown the highest potential for growth from 2007 – 2011 (Data Source: FAOSTAT)

4.1.2 Geographical and Topological Analysis of the Beer Network

The network of beer trade can be visualized as a geographical network as shown below. Size of the circles represents represent number of trading partners; thickness of the lines represents the import/export values. Only trade values of more than 300,000 USD are shown. Main trading activities are between Europe and US; with increasing trend with the BRIC countries; Africa remains largely untapped.

Figure 7: Map of World Trade for Beer as a Geographical Network

The network is drawn using ArcGIS (Data source: FAOSTAT 2011)

The geographical representation of the trade network does not allow to visualize the effect of 'interdependence' on each country since the position of the countries are fixed by physical space. Removal of trade ties would affect the sizes of the nodes representing the countries, but will have no impact on the 'structure' of the network. In order to represent the relative position of each country in the whole trading system, a 'topological' representation is required (De Benedictis et al. 2013).

Figure XX is obtained by accounting for just the two major export markets for each country. The width of the links represent the traded values, hence it depicts a directed weighted network. With this construction there is no countries or group of countries that are isolated from the network. The width of the circle corresponds to the import ties whereas the height corresponds to the export ties. In another words, the 'tall' circles mean that the countries have more export partners than import partners; and vice versa for the 'flat' circles. The layout of the graph is obtained by applying what is called the ***force-directed algorithm***(De Benedictis, Nenci, Santoni, Tajoli, & Vicarelli, 2013). The algorithm acts as a balanced spring system that minimizes the energy in the system. As a result, highly connected countries are generally placed at the center of the network (i.e. West European countries, UK, US and China), while less connected countries are placed at the hedges of the figure. The position of the countries are

determined by its bilateral links as well as by the ***indirect effect*** of others. It shows the position of each country ***relative*** to all the other countries and depending on the ***entire*** trading system.

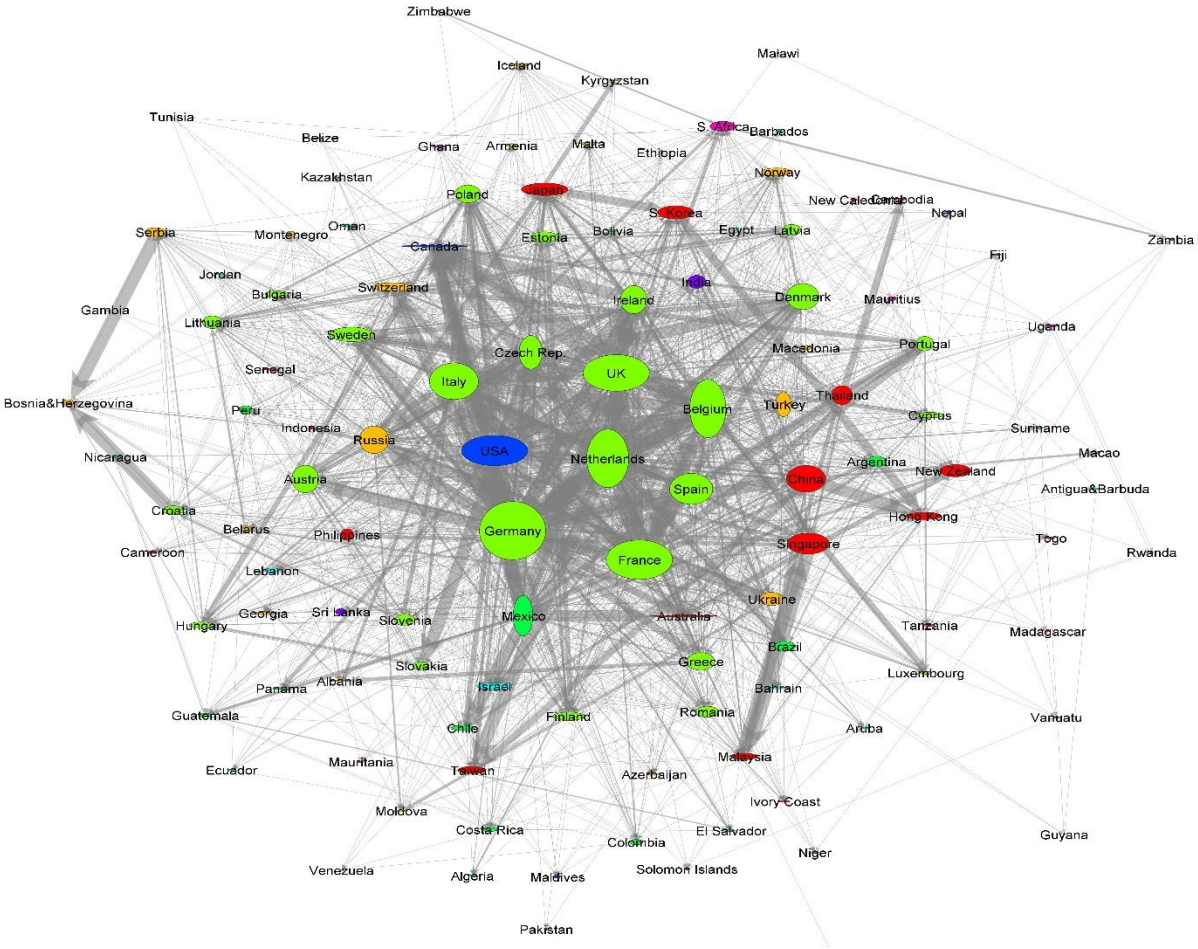

Figure 8: Topological Network of Trade in Beer 2011 (major two export partners)

(Drawn with Visone using Embedded Spring Algorithm)

4.1.3 Local and global centrality measures and relative countries' position

Centrality measures are network indicators that represent how each single country is relatively positioned in the overall network. Several studies (De Benedictis et al., 2013; Fagiolo, Reyes, & Schiavo, 2008) have explored the suitable network indicators for analysing world trade which can be classified into four main groups:

5) Degree centrality that measures how a node is connected to others (and related strength centrality for the weighted network);
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Degree and strength centrality are regarded as 'local' centrality measures as they consider only the direct links of a node, regardless of the position of the node in the network's structure. However, the topological map above shows that the position of a country does depend on the position of others: all the countries have the same out degree, i.e. 2 representing the top 2 trade partners, but they attain very different position in the network. Turkey is linked with central countries, whereas Egypt with peripheral countries. The indicators that measure the 'effect of others' are hence regarded as 'global' centrality measures (De Benedictis et al. 2013).

The network indicators were calculated based on the whole set of 178 countries. The table below report the main countries which are selected based on the EU 27 member countries and their respective top 2 partners from the seven regional groupings (see appendix for the complete listings).

Table 1: Centrality Measures for Trade Network in Beer

ISO	Name	Indegree_p	outdegree_p	In-strength_p	Out-strength_p	Degree_p	closeness_p	eigenvector
AL	Albania	0.7837	0.1045	0.2888	0.0005	0.4441	0.9112	0.0576
DZ	Algeria	0.3657	0.0000	0.0802	0.0000	0.1829	0.0000	0.0404
AR	Argentina	0.8882	0.9927	0.1441	0.1552	0.9404	1.0976	0.0897
AW	Aruba	0.4180	0.0000	0.0794	0.0000	0.2090	0.0000	0.0342
US	Australia	3.1348	0.0000	2.0321	0.0000	1.5674	0.0000	0.2298
AT	Austria	1.2017	2.6123	0.6848	0.6348	1.9070	1.3053	0.1070
BH	Bahrain	0.9404	0.0000	0.1621	0.0000	0.4702	0.0000	0.0937
BY	Belarus	0.4180	0.5747	0.0874	0.0947	0.4963	1.0020	0.0379
BE	Belgium	1.6196	4.1797	2.0204	9.8471	2.8997	1.5680	0.1423
BA	Bosnia& Herzegovina	0.5225	0.6270	0.9539	0.0309	0.5747	1.0408	0.0382
BR	Brazil	0.9404	0.9404	0.3717	0.1408	0.9404	1.0877	0.0968
...								
SE	Sweden	1.9854	1.3584	1.1342	0.4561	1.6719	1.1337	0.1662
CH	Switzerland	1.8286	0.8359	1.0831	0.0648	1.3323	1.0926	0.1457
TW	Taiwan	1.2539	0.6792	1.3660	0.0364	0.9666	1.0364	0.1223
TZ	Tanzania	0.4702	0.2090	0.0292	0.0018	0.3396	0.9659	0.0353
TH	Thailand	0.9404	1.7764	0.1886	0.5942	1.3584	1.2014	0.0974
TR	Turkey	0.6792	2.3511	0.0810	0.2357	1.5152	1.2709	0.0713
GB	UK	2.5601	3.4483	6.6257	6.3309	3.0042	1.4373	0.2014

UA	Ukraine	1.0449	1.2539	0.3014	0.8706	1.1494	1.0926	0.0892
US	USA	3.3438	2.8736	33.5449	3.0523	3.1087	1.3415	0.2333

Table 2: Ranking by Centrality Measures for Trade Network in Beer

ISO	Name	In-degree Rank	Out-degree Rank	In-Strength Rank	Out-Strength Rank	Degree Rank	Closeness Rank	Eigenvector Rank
AL	Albania	50	81	38	90	67	69	63
DZ	Algeria	83	108	68	103	98	108	75
AR	Argentina	44	34	55	37	41	32	41
AW	Aruba	77	106	69	104	95	106	87
US	Australia	2	99	10	99	19	99	2
AT	Austria	27	13	21	21	16	12	30
BH	Bahrain	39	100	53	101	65	100	38
BY	Belarus	78	52	63	44	61	57	80
BE	Belgium	15	3	11	4	6	3	16
BA	Bosnia& Herzegovina	69	49	18	55	54	47	79
BR	Brazil	40	36	32	39	42	35	35
…								
SE	Sweden	9	21	15	25	17	22	10
CH	Switzerland	13	37	16	49	25	33	14
TW	Taiwan	26	45	13	54	40	48	23
TZ	Tanzania	75	73	93	85	72	65	85
TH	Thailand	43	18	49	22	24	18	34
TR	Turkey	61	16	66	31	20	16	53
GB	UK	3	6	3	5	5	6	3
UA	Ukraine	38	24	37	15	28	34	42
US	USA	1	10	1	9	4	10	1

The centrality rankings show that countries differ in their structural position when local and global centrality measures are considered respectively. For instance, Mexico ranks first in out-strength due to its large export volume to the US. It is also among the top countries in terms of closeness due to the importance of US centrality in the trade network. However, its eigenvector position is 44 which shows the vulnerability of relying on few partners.

The scatterplot of degree centrality versus eigenvector centrality shows the dispersion of countries' position with different centrality measures. The colours depict geographical regions. Countries above the diagonal increase their ranking position when centrality includes the 'effect of others', or the structural component influencing their position in the network. European countries are mostly found above the diagonal line which means they are more structurally connected at the global level; whereas the countries with large dispersion below the diagonal line means that these important local players become less important when the 'effect of others' is taken into account.

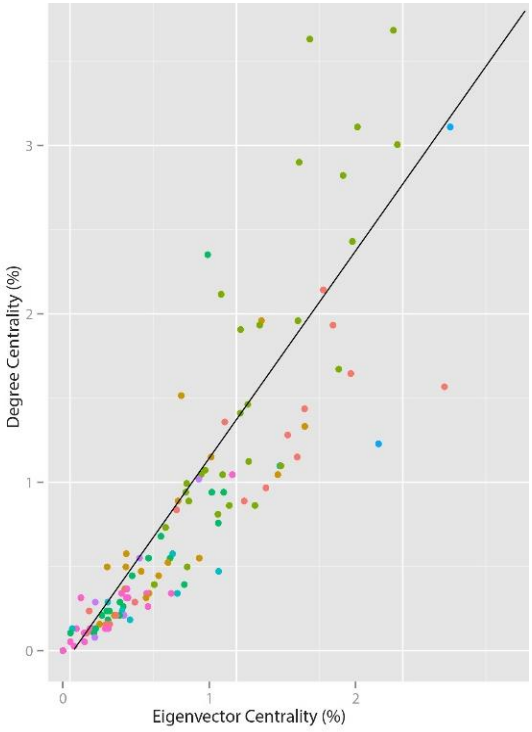


Figure 9: Scatterplot of Degree Centrality vs. Eigenvector Centrality for Trade Network of Beer

4.2 Descriptive Research of Investment Network in Food & Beverages

4.2.1 General

Between the years of 2003 and 2012, there were altogether 5641 counts of greenfield investment in the food and beverages sector with estimated value of about 200 million US dollars. The diagrams below give a breakdown of the investments by sectors and by activity.

Beverages takes up 19% of the total, and majority of the investment is in manufacturing. Investment in logistics, R&D, education and training takes up only small percentage of the total.

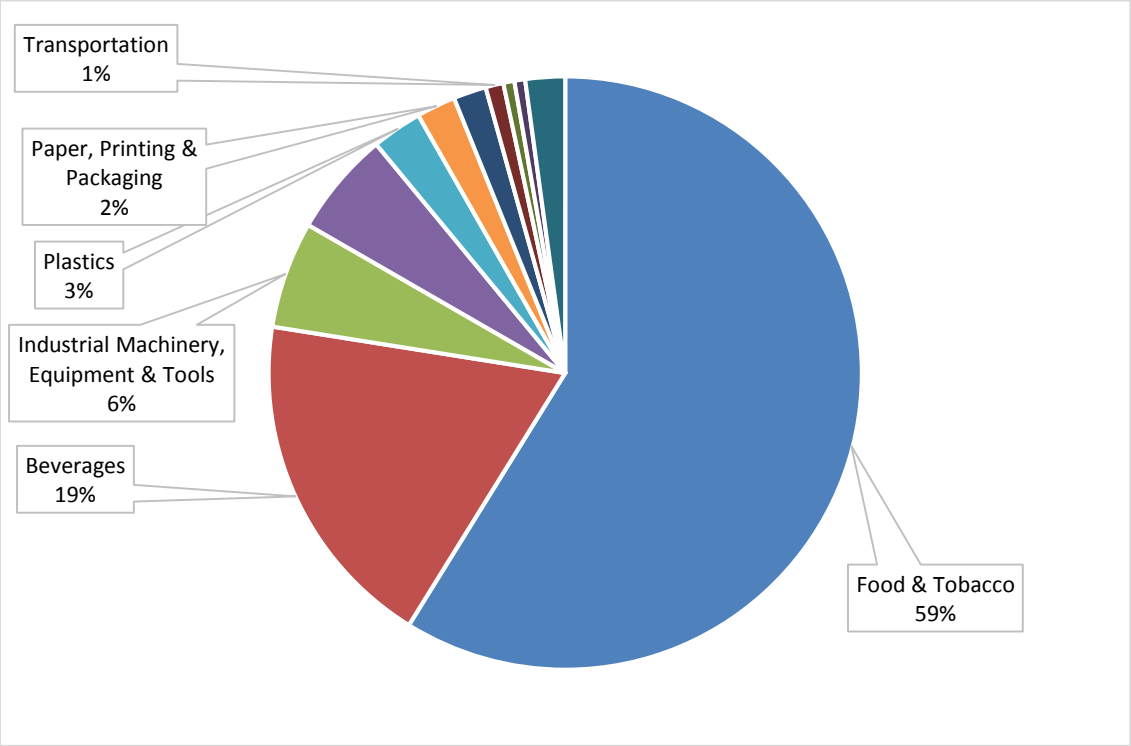


Figure 10 Breakdown of F&B Investment (2003-2012) by Sector

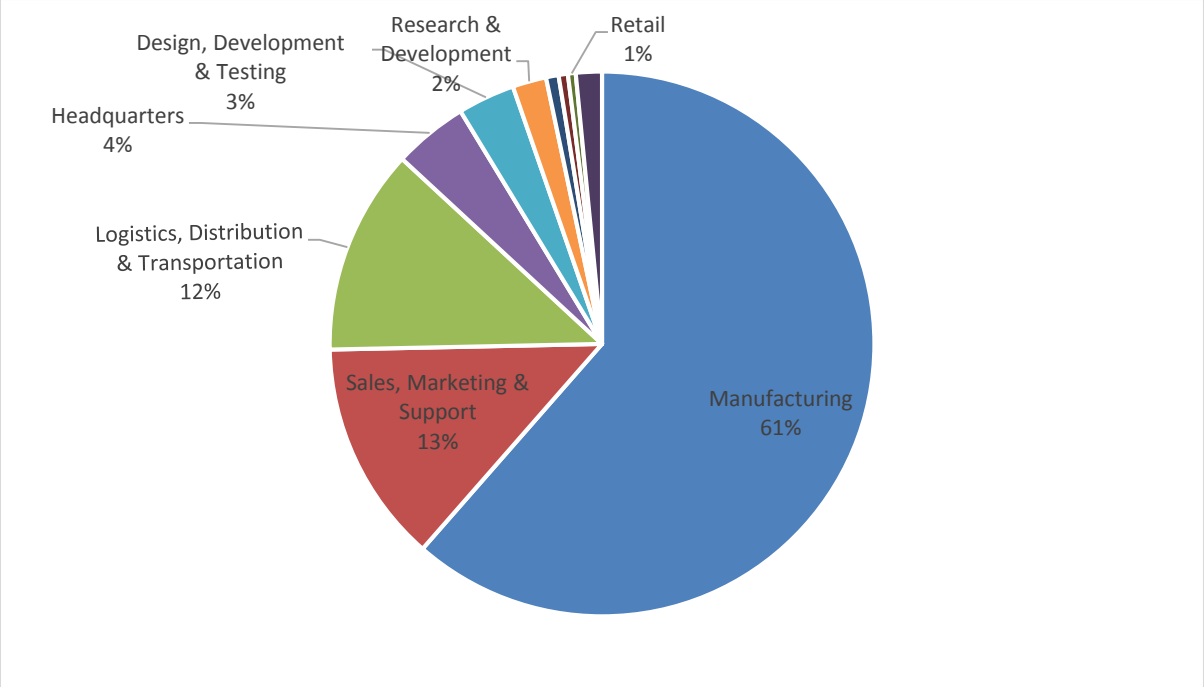


Figure 11: Breakdown of F&B Investment (2003-2012) by Activities

4.2.2 Network Typology

Today's global agro food system is increasingly characterized by interconnected and inter-dependent networks of trade, investment and firms, which is currently dominated by the transnational powers in the developed countries. An geographical overview of the flows of foreign direct investment in the food sector in the last 10 years shows that the power to invest (in other countries) largely dominated by the powers across the Atlantics. (Data Source: fDi Markets)

Figure 12: Map of World Investment for the Food Sector as a Geographical Network.

The topological representation of the F&B investment network in 2011 puts a handful of main countries in the center including the US, the Netherlands, France and UK. The line width in the map reprensents the number of investment counts. Most of the countries are linked by one count.

With emerging countries such as China, India, and African nations are fast becoming the biggest consumers for food, one of the fundamental challenges is that the development of the agricultural economy severely lags behind that of the economic growth. Global investment in the food and agro sector must step up rapidly to help developing nations to improve logistics and accessibility. In search of sustainable solutions for the common global challenges, the global value chains of the agro food industry need to be better integrated between the developed and developing countries to capitalize on technology, finance and markets.

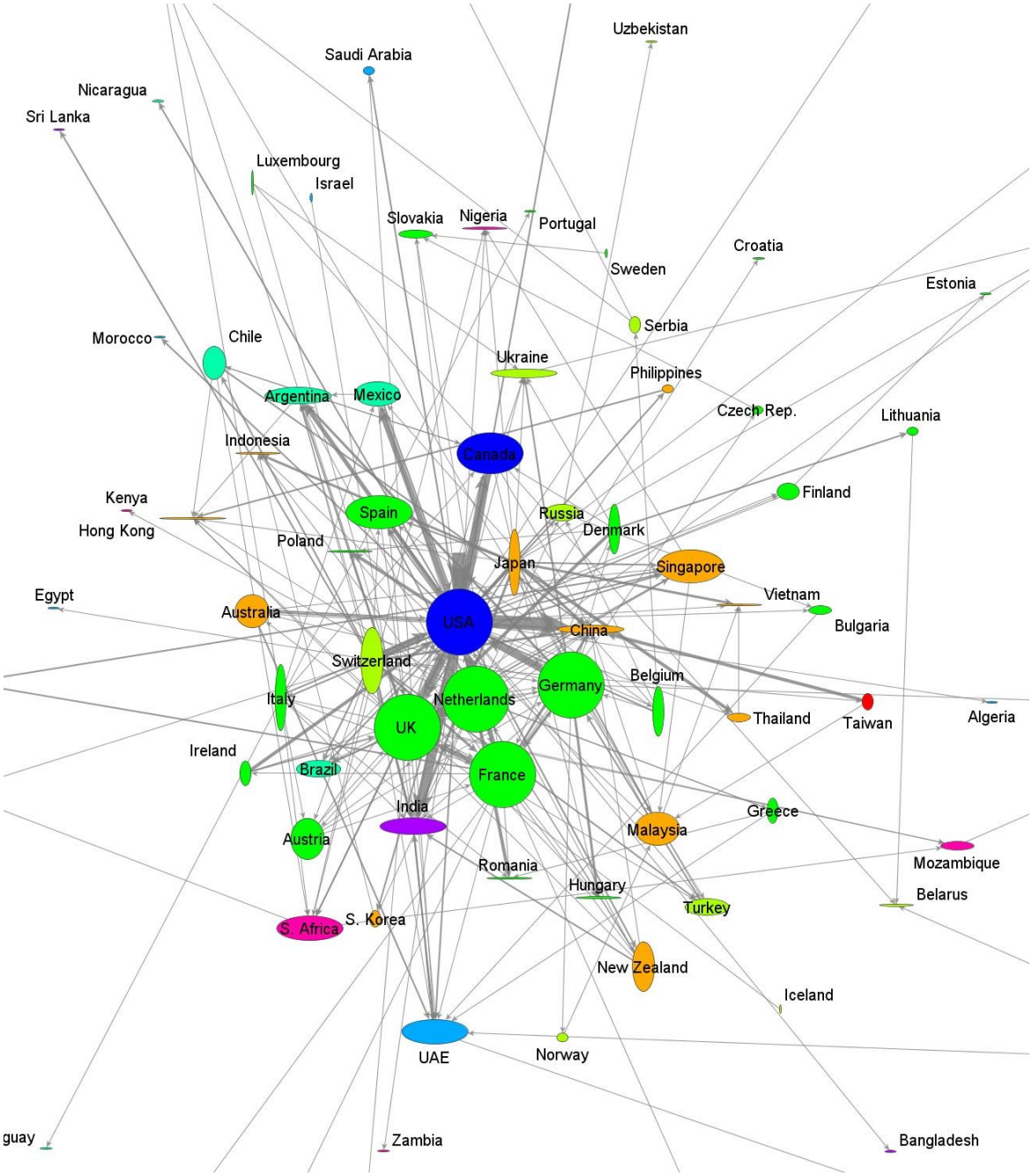


Figure 13: Topological map of world investment for the F&B Sector using force directed algorithm

Just a few main countries dominate the center being the main source and destination for investment ties. Most other countries are located at the periphery.

4.3 Explanatory Research of Trade and Investment Networks

In section 4.1 and 4.2 the network analysis have shown the inter-dependency and inter-connectedness of the networks. The next step is to find the influential factors that have most likely contributed to the current network state. The explanatory research was carried out in 3 stages. In stage 1 the structural effects on the trade and investment networks were tested respectively to control the 'inter-dependency' effects inherent in the networks, so that the hypothesis for the country specific characteristics can be tested more completely. In stage 2 the covariates were tested in groups to explore individual impacts. Variables that are more supported in trade theories such as income effects and regionalism were entered first as the base model for subsequent models. The same set of country specific covariates were tested for both the trade and investment network to compare their results. In stage 3, the co-evolution dynamics between the two networks are tested to understand how ties in one network influence ties in another.

4.3.1 Dependent Variable – Network Evolution

The diagram shows the evolution of the network densities for the two networks in recent years.

Network density is defined by the number of ties in a network divided by the number of possible ties. In the defined two networks each with 178 actors, the number of possible directed (i.e. import and export) ties is 178 x (178-1) = 31506. For instance, in 2011, there were a total of 1913 trade ties of beer among the countries, therefore the network density of 2011 is 1913/31506 = 0.06.

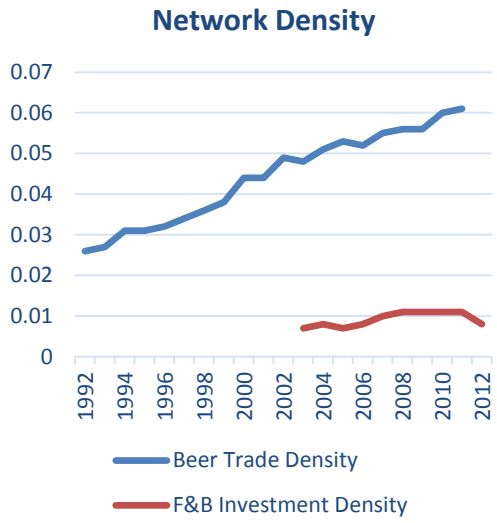


Chart 1: Network Densities

The F&B investment network is more 'sparse' than the beer trade network signifying that the global (greenfield) investment in the food sector in the past decade is still at a relatively low level.

Within the SIENA algorithm, the "evaluation" function is used in the following analysis to model the odds of presence of ties (either created or maintained) versus no tie (either terminated or maintained). The estimated parameters for each effect should be interpreted as **log-odds ratios**(Ripley, Snijders, Boda, Voros, & Preciado, 2014)**.**

The tables show the evolution of ties changes in the periods to be modelled by SIENA. Due to the large number of nodes, the strategy of modeling 'periods' each containing two successive 'waves' (i.e. years) is adopted. As shown by the tables below, within each period, ties were either created (0=>1), terminated (1=>0), or maintained (0=>0, 1=>1). The 'distance' mentioned in the tables measure the number of tie variables that differ between successively observed network while the related Jaccard index measures stability. The Jaccard index measures the amount of changes between two waves by

$$\frac{N_{11}}{N_{11}+ N_{01}+N_{10}} \quad \textbf{(13)}$$

Where N_{11} is the number of ties present at both waves, N_{11} is the number of ties newly created, and N_{11} is the number of ties terminated. Take the period of year 2010 to 2011 for the trade network as example, the Jaccard index is therefore calculated as

$$\frac{1580}{1580+333+303} = 0.713$$

Jaccard values of .3 and higher indicates that the network is stable and evolving and therefore more suitable for the SIENA method(Snijders, Bunt, & Steglich, 2010). The tables below show that the beer trade network is more stable with gradual changes; whereas the food and investment network has a rather low Jaccard value reflecting high dynamics.

Table 3: Network Tie Changes Trade Network Beer

Period			0 => 0	0 => 1	1 => 0	1 => 1	Distance	Jaccard
2003	==>	2004	29633	359	255	1259	614	0.672
2004	==>	2005	29536	352	299	1319	651	0.67
2005	==>	2006	29584	251	284	1387	535	0.722
2006	==>	2007	29522	346	253	1385	599	0.698
2007	==>	2008	29460	315	282	1449	597	0.708
2008	==>	2009	29417	325	328	1436	653	0.687
2009	==>	2010	29375	370	248	1513	618	0.71
2010	==>	2011	29290	333	303	1580	636	0.713

Table 4: Network Tie Changes F&B Investment

Period			0 => 0	0 => 1	1 => 0	1 => 1	Distance	Jaccard
2003	==>	2004	31143	158	122	83	280	0.229
2004	==>	2005	31124	141	154	87	295	0.228
2005	==>	2006	31127	151	137	91	288	0.24
2006	==>	2007	31059	205	144	98	349	0.219
2007	==>	2008	30984	219	165	138	384	0.264
2008	==>	2009	30953	196	202	155	398	0.28
2009	==>	2010	30956	199	212	139	411	0.253
2010	==>	2011	30958	210	196	142	406	0.259

The density and Q-Q plots for the in- and out-degrees of the beer trade and F&B investment networks confirm the highly heterogeneous nature of the two networks.

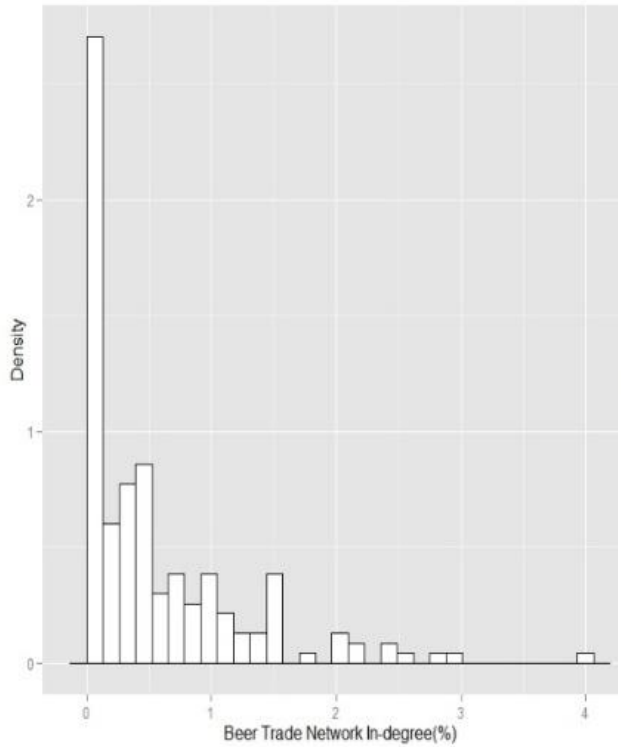


Chart 5: Beer Trade Network In-degree (%) Density

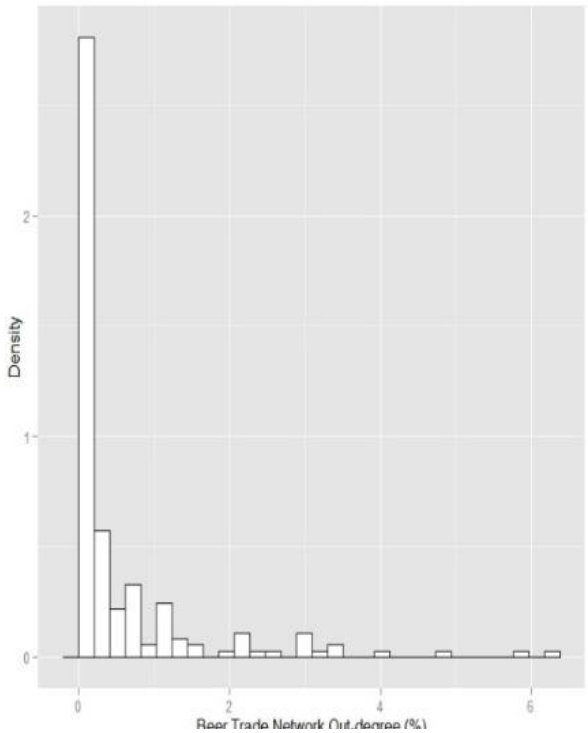


Chart 5: Beer Trade Network Out-degree Density

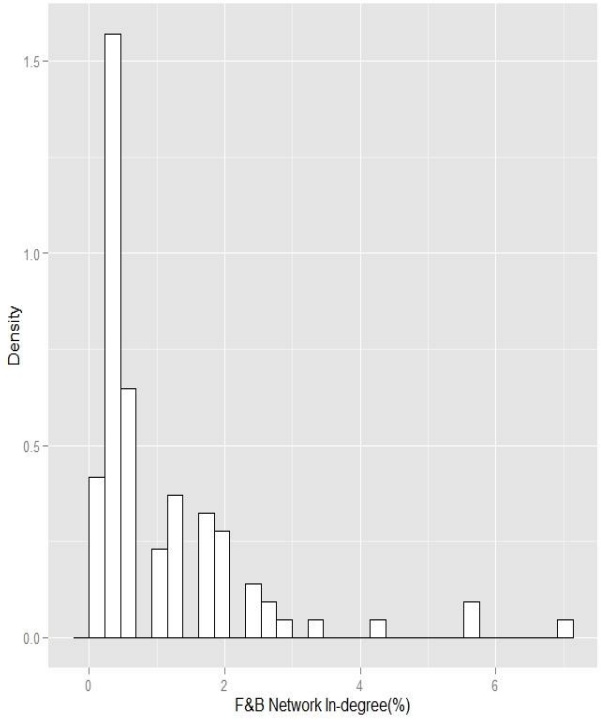


Chart 3: F&B Investment Network In-degree Density

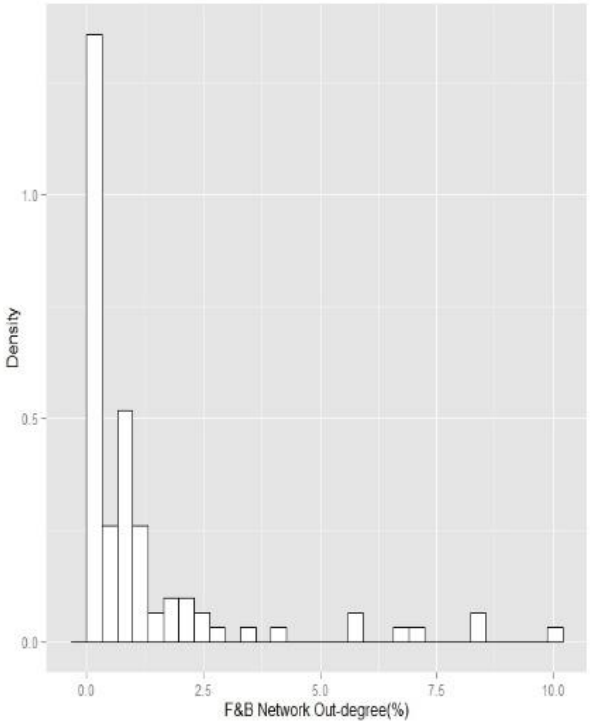


Chart 3: F&B Investment Network Out-degree Density

4.3.1.1 Results

The results of the structural effects are summarized in the following tables. For viewing purpose, the standard errors are not shown but the significance of t-test statistics.

The parameters for the rate function are defined as the expected frequencies, between successive waves, with which actors get the opportunity to change a network tie (Snijders et al., 2010). The high value of the rate parameter for the F&B investment network implies high network dynamics. For both networks the amount of changes are particularly low in the period of 2005 to 2006. Both networks have negative out-degree parameters showing the 'costs' for actors to establish ties. The trade network has a significant strong reciprocal tendency over the years while the effect is much weaker for the investment network. Both networks show the effects of cumulative advantages in in-degree and out-degree. The effect is especially strong for countries with high incoming investment ties to be even more popular, though it seems to reduce in strength over the years. Lastly, the investment network has a strong significant transitive tendency to form local clusters. The negative parameter for the three cycles effect shows the tendency for local hierarchy. The overall observed structural trends are rather stable over the years of 2003 – 2011.

Table 5: Structural effects on the beer trade network

Model 1 Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
Rate parameter	8.79		9.40		6.82		8.44		7.75		7.73		8.20		8.57	
outdegree (density)	-4.55	***	-4.49	***	-4.30	***	-4.50	***	-4.47	***	-4.48	***	-4.33	***	-4.40	***
reciprocity	1.39	***	1.12	***	1.30	***	1.43	***	1.36	***	1.36	***	1.16	***	1.21	***
transitive triplets	0.08	***	0.07	***	0.10	***	0.06	***	0.08	***	0.08	***	0.09	***	0.07	***
3-cycles	-0.05	*	-0.04	*	-0.06	**	-0.04	ns	-0.04	ns	-0.04	ns	-0.05	*	-0.05	~
indegree - popularity	**0.47**	***	**0.41**	***	**0.33**	***	**0.41**	***	**0.44**	***	**0.44**	***	**0.33**	***	**0.37**	***
outdegree - popularity	-0.14	**	-0.12	*	-0.10	ns	-0.15	*	-0.18	ns	-0.17	*	-0.05	ns	-0.10	ns
outdegree - activity	**0.20**	***	**0.22**	***	**0.16**	***	**0.24**	***	**0.20**	***	**0.20**	***	**0.19**	***	**0.19**	***

Table 6: Structural effects on the F&B investment network

Model 1: Structural Effect Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
Rate parameter	17.57		20.20		15.21		18.96		20.71		20.71		22.87		24.08	
outdegree (density)	-5.94	***	-5.84	***	-5.58	***	-4.92	***	-5.36	***	-5.40	***	-5.00	***	-5.24	***
reciprocity	0.02	ns	0.75	~	0.57	ns	0.22	ns	0.83	***	0.83	**	0.25	ns	0.64	*
transitive triplets	0.59	***	0.31	***	0.33	***	0.44	***	0.28	***	0.27	***	0.29	***	0.29	***
3-cycles	-0.46	~	-0.66	*	-0.01	ns	-0.36	*	-0.35	***	-0.34	**	-0.22	*	-0.30	***
indegree - popularity	**0.74**	***	**0.72**	***	**0.65**	***	**0.36**	***	**0.54**	***	**0.55**	***	**0.44**	***	**0.57**	***
outdegree - popularity	0.07	ns	0.07	ns	0.03	ns	0.15	**	0.08	ns	0.08	ns	0.12	*	0.04	ns
outdegree - activity	**0.46**	***	**0.44**	***	**0.44**	***	**0.39**	***	**0.42**	***	**0.43**	***	**0.33**	***	**0.36**	***

ns: not significant; ~ $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

4.3.2 Univariate network Dynamics: Covariate effects

Covariate effects are effects that depend on externally given attributes, hence they are also referred to as the "exogenous" variables. For a country specific variable V, there are three basic effects: the *ego* effect that measures whether countries with high V values tend to send out more ties; the *alter* effect measures whether countries with high V values will be more popular for others to establish ties with and hence have higher in-degrees; and the *similarity* effect that measures whether ties tend to occur more often between countries with similar value on V. This is also referred to as the 'homophily effect' in social network literatures.

4.3.2.1 Model Specifications

The covariates are first tested in the following exploratory models. Model 2 and 3 are base models to control for known effects that are important for trade and are included in all subsequent models. Other variables are tested in separate groups to see their interaction, significance as well as trends on connecting good and people over the years. Overall the focus is to test for variables that influence the 'flow' of goods and people. A final model can then be decided based on the significant effects.

- Model 2 and 3: known effects documented important to trade including the *income effect* as measured by GDP per capita; *regionalism* as measured by the geographical regions the countries are located; *openness* as measured by percentage of export value in total GDP. For the regional effect, the *same*-ness effect is used instead of the *similarity* effect to measure tendencies for countries to establish and maintain ties with partners in the same region.

- Model 4: infrastructure. 3 indicators from the World Development Indicators (WDI) were chosen including internet users (per 100 people), road density and water productivity which is measured in the value of GDP produced with each cubic meter of fresh water extraction. Road density and internet uses try to capture the 'flow'and exchange enabled by infrastructure and technology; and water is included due to its importance as a production factor for beer and for the food industry.

- Model 5: Model 5 tries to capture the dynamics and 'flow' of people effect. Three variables were tested: *urban growth* in percentage that indicates the movement of people from rural to urban; *urban population* in large agglomerations of more than 1 million people; and effect of *international tourism* which indicates the 'flow' of people around the world.

- Model 6: the Logistics Performance Index (LPI). The LPI index is measured by World Bank and only available for the years of 2007 and 2010. Other than the overall effect, the sub-indexes on *Trade and Transport Infrastructure*, *Logistics Performance*, *Efficiency of customs clearance process*, *Efficiency to Arrange Competitively Priced shipments* were tested as well.

- Model 7: the Global Competitiveness Index. Other than the overall effect, several indexes were tested including: Infrastructure, Goods Market Efficiency, Macro Environment and Market Size. Yearly data for GCI index is available from 2006.

For models 2,3, 4 and 5, data are available from the WDI databases so they can be tested on all years (water productivity is measured every 5 years). Due to data availability, Model 6 is only tested on the periods between 2007 and 2011 (4 periods) and the data for 2007 is used for the periods of 2007-2008, 2008-2009, 2009 – 2010 and the data for 2010 for 2010-2011. Similarly model 7 is tested for the periods between 2006 to 2011 using respective yearly data.

The plots below shows the trends of some of the covariates over the years. The means of the variables for each region is plotted. The colours represent the different regions.

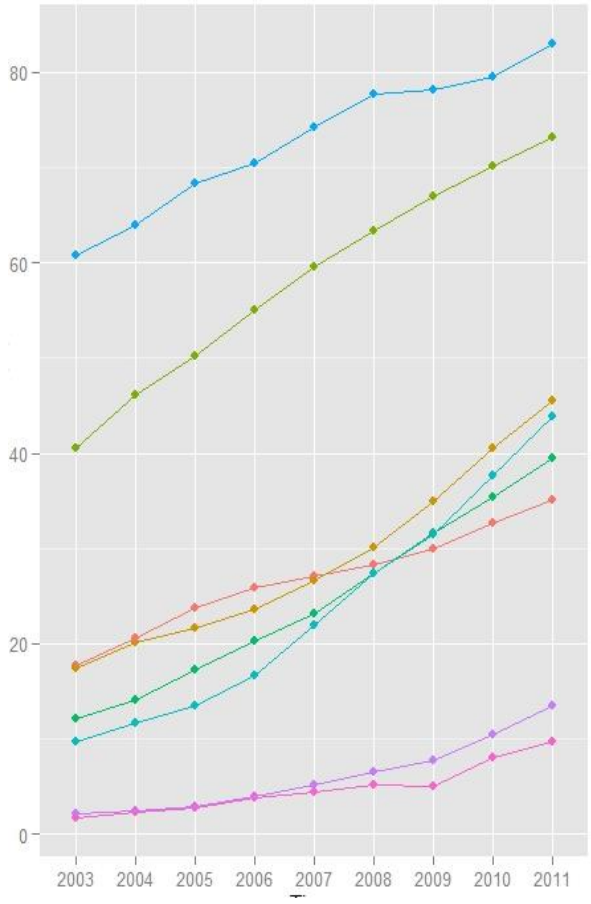


Chart 6: Internet User (per 100 people)

North America is the most connected region in terms of internet usage; followed by Europe. South Asian and Africa has very low levels but picking up growth

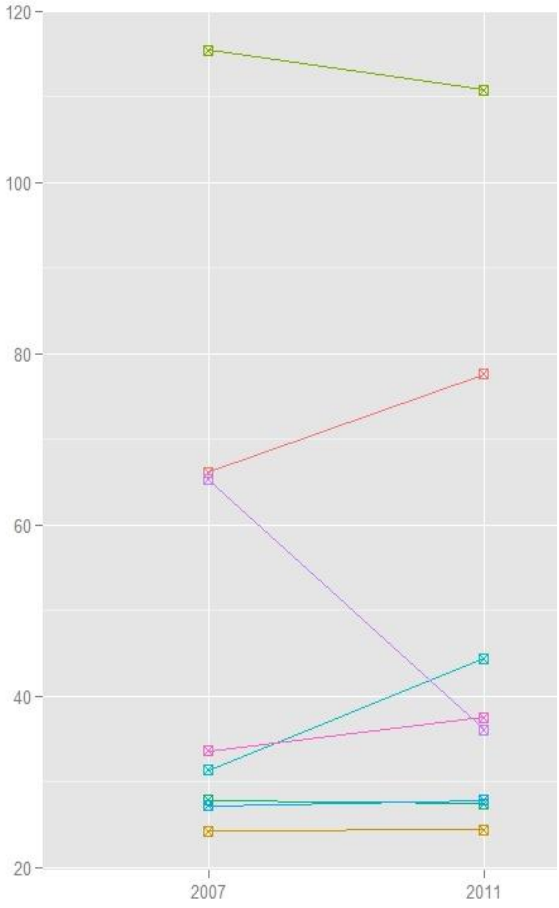


Chart 7: Water Productivity

Europe is by far the most leading region in terms of water productivity. East Asia is improving while South Asia saw dramatic decrease. Most of the world have much to improve with efficient usage of fresh water resources

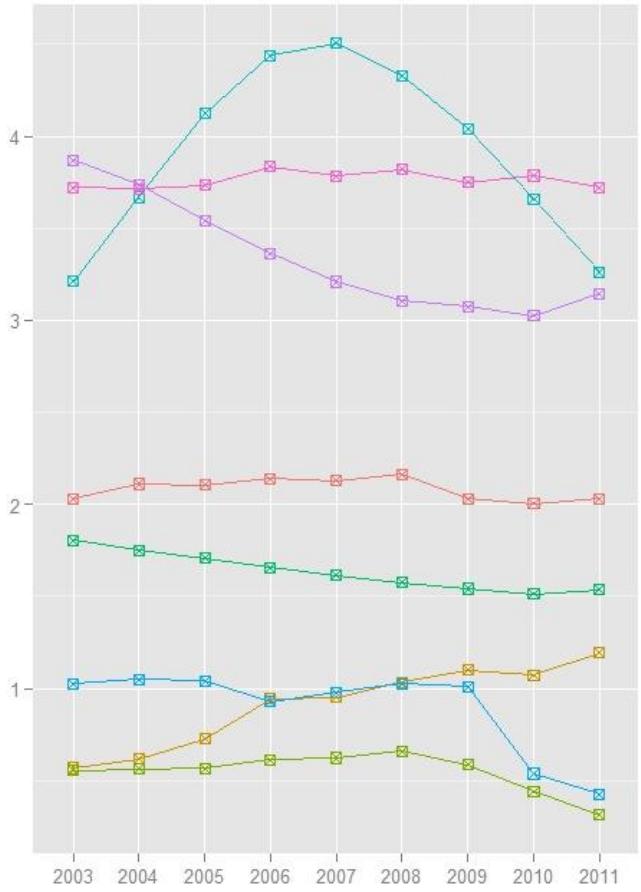


Chart 9: Urban Growth (%)

South Asia and Africa has the highest urban growth. There is a dramatic turn for Middle East and North Africa around the year 2007. In the rest of Europe and Central Asia there is upward trend while the developed nations in North America and EU naturally see decline due to the already high levels of urbanization.

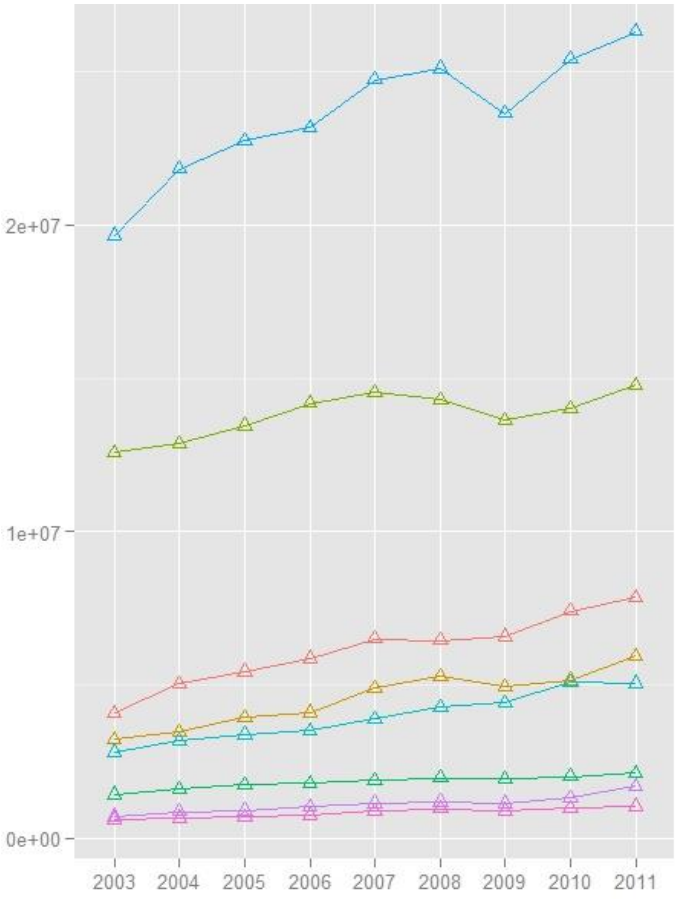


Chart 8: International tourism measured by arrival numbers

North America is by far the most popular tourist destinations by absolute numbers, followed by Europe. In the models the natural log of the tourism arrival numbers is used due to the large dispersion of the numbers.

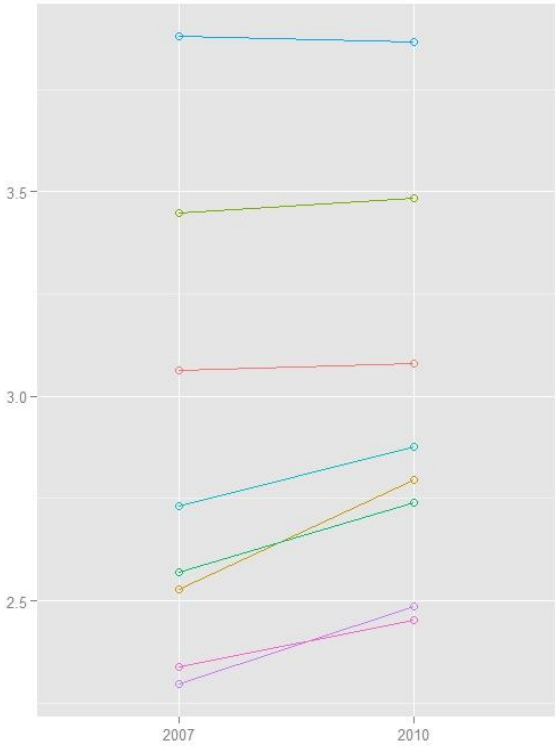


Chart 11: LPI Index

North America is the best logistically performing region, followed by EU then by East Asia. In general countries improve their ranking slightly over the years.

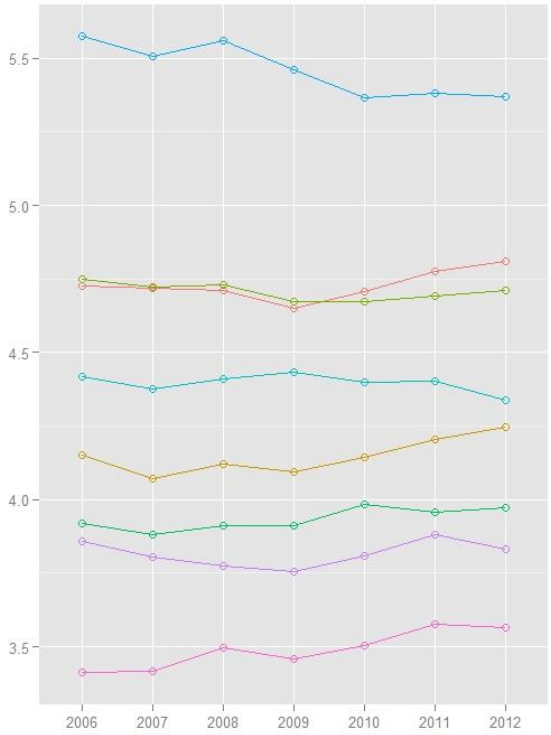


Chart 10: GCI Index

North America is also the most competitive region, followed by East Asia surpassing EU in recent years. Other regions remain similarly ranked across the years. The overall order of rankings are similar to the LPI index

4.3.2.2 Covariate Model Results and Trends

The results of the 7 models for each of the 9 periods for the two networks are presented in the tables below. The significant observed trends with the data tested individually are summarized below:

- Model 2 and 3: Regionalism as expected plays a significant role for both trade investment in all the periods due to geographical distances and regional trade agreements. However, the influence shows a decreasing trend. The income effect, i.e. similarity in GDP per capita, is consistently significant for the trade network but is not the case for investment. Rather surprisingly that the openness of a country as measured by the percentage of export in total GDP has mostly insignificant influence on both networks.

- Model 4: infrastructure. All the three indicators: road, internet users, and water productivity show overall no significant influence on both networks, with the exception of internet users in recent years. Considering the data is only available until 2011 and that the explosion of social networks and mobile users only in the last few years, more recent data on ICT usage may reveal a different picture.

- Model 5: Model 5 gives the most significant important results. Above all is the influence of international tourism (log), or maybe the enabling factors that attracts international people flow to a country and the converging effect brought forth, have consistently significant strong influence in all the periods for both networks. For the trade network, the similarity effect are significantly strong, showing that countries that attracts high number of incoming tourist tend to have more trade ties in beer with other highly attractive countries. This supports that the brewing industry is strongly associated with the leisure and entertainment sectors. What is interesting is that for the F&B network, not only the tourism similarity effect is even more pronounced, but also the influence of ego and alter are significant. This implies that countries with high incoming tourist tends to send out more investment ties; and also tends to be more popular as investment destinations. As shown in the plotting of the tourism trend, this in part has to do with that the countries with most incoming tourists are also the main investor countries in North America and EU; however, it also points to the need to understand more the dynamics of connecting people together.

  For urban growth, the similarity effect is equally significantly strong for both networks with a general increasing trend. This is consistent with the observation of world growth in terms of urbanization in recent years. Also the alter effect is significant for both networks, that countries with high urban growth tends to receive more incoming trade and investment ties.

  The **similarity** effect for urban agglomeration is significant and strong for the beer network for certain periods. This shows that large cities tend to trade more with similarly large cities, but the size of the cities alone is not influential all the times.

- Model 6: the Logistics Performance Index (LPI). The recently available indexes of LPI and GCI have no significant influence on the ties in the trade network, except for one or two periods when one of the sub-indexes such as logistics show positive similarity effect but overall inconclusive. However, for the F&B investment network there is strong significant ego effect for the overall LPI performance indicator throughout the years, showing that countries with high LPI rankings are the ones to send out more investment ties with others. The *similarity* effect is significant for 2 of the 4 periods tested. This may be explained by that the trade network in beer has a long history and 'inertia' between the partners; whereas for investment in recent years, the overall logistic and competitiveness performance as measured by the indexes have more important influence for the formation of investment ties.

- Model 7: The GCI index has similar patterns as the LPI index when tested separately, i.e. in general not significant for the trade network, but has significant ego effect for the F&B network in all periods, and strong similarity effect for half of the time. There are overlaps between these indexes so when testing for overall effects the differences between the two can hardly be discerned. For the sub-pillars, the results are similar to the LPI sub-indexes and therefore inconclusive.

4.3.3 Final models and Results

Based on the above exploratory studies, a final model is compiled and tested with the most significant variables from previous analyses. The results are shown in the tables below.

The final significant effects for the Trade Network includes

1. Structural effect
    - Reciprocity
    - In-degree popularity
    - Out-degree activity

2. Covariates effect
    - GDP per Capita similarity
    - Same region
    - International tourism, including the ego, alter and similarity effect
    - Urban Growth, including the alter and similarity effect

The final significant effects for the Investment Network includes

1. Structural effect
    - Reciprocity
    - In-degree popularity
    - Out-degree activity

2. Covariates effect
    - Same region
    - International tourism, including the ego, alter and similarity effect
    - Urban Growth, including the alter and similarity effect
    - The ego effect of LPI index

All the variables that were tested significant in the separate groupings remain similarly significant when put together in the final model. The covariance matrix shows no significant multi-collinearity among the parameters. The trade and investment networks share certain similar trends in in-degree popularity, out-degree activity, regional effect, tourism and urban growth but also differ in several aspects. The income effect which is influential for the trade in beer is not significant for the investment network. The regional effect appears to be consistently reducing in strength over the years for investment network. This shows that trade in beer is very much influenced by the geographical distance due to its bulkiness while investment activities are diversifying beyond the regional scope. The reciprocity effect starts to take significance only in recent years for the investment network which may point to the time for partners to establish mutual exchange relationship. Also interesting to note the more pronounced effect of tourism on investment. Not only the homophily effect is evident, but the strong ego effect that countries with high incoming tourists also tends to send out more investing ties. Overall the homophily effect is strong in terms of regionalism, similarity in tourism and urban growth. Lastly, the LPI index is a strong indicator for countries with high scores to send out more investment ties. This represents an important opportunity for emerging nations to benefit from the exchange and improve its own logistics performance.

Table 7: Final Model for the Trade Network in Beer for Consecutive Periods

Model 8 – Final Model for Trade Network																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
outdegree (density)	-6.21	***	-6.04	***	-6.35	***	-6.14	***	-6.17	***	-6.07	***	-5.99	***	-6.55	***
reciprocity	**0.57**	***	**0.50**	***	**0.62**	***	**0.80**	***	**0.65**	***	**0.64**	***	**0.72**	***	**0.62**	***
transitive triplets	0.01	ns	0.02	*	0.03	***	0.02	**	0.02	***	0.02	***	0.04	***	0.01	*
indegree - popularity	**0.61**	***	**0.57**	***	**0.54**	***	**0.59**	***	**0.59**	***	**0.56**	***	**0.57**	***	**0.58**	***
outdegree - activity	**0.30**	***	**0.33**	***	**0.33**	***	**0.33**	***	**0.31**	***	**0.31**	***	**0.26**	***	**0.34**	***
GNPCap similarity	**0.48**	~	**0.62**	**	**0.89**	***	**0.82**	***	**0.75**	**	**0.60**	*	0.14	ns	**1.12**	***
same regionID	**1.14**	***	**1.02**	***	**1.18**	***	**0.83**	***	**0.80**	***	**0.80**	***	**0.90**	***	**0.99**	***
Tourism alter	-0.05	ns	-0.08	*	-0.88	~	-0.10	**	-0.11	***	-0.10	***	-0.12	***	-0.07	*
Tourism ego	0.04	ns	0.01	ns	-0.04	ns	0.00	ns	0.03	ns	0.02	ns	0.08	~	-0.03	ns
Tourism similarity	**0.56**	*	**1.17**	***	**1.15**	***	**1.26**	***	**0.93**	***	**0.93**	***	**0.52**	~	**0.74**	*
UrbGrowth alter	0.03	ns	0.06	*	0.10	***	0.15	***	0.06	*	0.07	*	0.19	***	0.14	***
UrbGrowth ego	-0.13	***	0.02	ns	-0.02	ns	0.04	ns	0.03	ns	0.02	ns	-0.01	ns	-0.08	~
UrbGrowth similarity	**1.73**	***	-0.40	ns	**0.95**	*	0.44	ns	**1.64**	**	**1.61**	**	**1.19**	***	**2.35**	***
UrbAgglo alter	0.00	ns	0.00	ns	-0.01	*	0.01	*	0.01	*	0.01	*	0.01	**	0.01	**
UrbAgglo ego	-0.01	ns	0.00	ns	0.01	ns	0.01	**	0.00	ns	0.01	ns	0.01	~	0.01	*
UrbAgglo similarity	-0.33	ns	-0.24	ns	0.27	ns	**1.34**	**	0.68	ns	0.65	ns	**1.37**	*	0.57	ns

Table 8: Final Model for the F&B Investment Network for Consecutive Periods

Model 8: Final Model for F&B Investment Network																
Effect	2003-04 Est.		2004-05 Est.		2005_06 Est.		2006_07 Est.		2007_08 Est.		2008_09 Est.		2009_10 Est.		2010_11 Est.	
outdegree (density)	-7.47	***	-7.16	***	-6.90	***	-6.89	***	-6.93	***	-6.83	***	-6.56	***	-7.11	***
reciprocity	0.08	ns	0.50	~	0.40	ns	0.15	ns	**0.64**	**	**0.65**	***	**0.37**	~	**0.48**	*
indegree - popularity	**0.81**	***	**0.65**	***	**0.69**	***	**0.70**	***	**0.73**	***	**0.72**	***	**0.71**	***	**0.72**	***
outdegree - activity	**0.41**	***	**0.40**	***	**0.35**	***	**0.32**	***	**0.24**	***	**0.23**	***	**0.18**	***	**0.17**	***
same region	**0.89**	***	**0.71**	***	**0.68**	***	**0.91**	***	**0.52**	***	**0.50**	***	**0.45**	***	**0.43**	***
Tourism alter	**0.18**	***	**0.26**	***	**2.33**	***	**0.13**	**	**0.09**	~	**0.10**	*	**0.09**	*	**0.14**	**
Tourism ego	**0.56**	***	**0.46**	***	**7.33**	***	**0.65**	***	**0.45**	***	**0.44**	***	**0.38**	***	**0.48**	***
Tourism similarity	**2.07**	**	**2.23**	***	**1.27**	*	**1.91**	***	**1.59**	***	**1.53**	***	**1.36**	**	**0.84**	~
UrbGrowth ego	-0.07	ns	**-0.21**	**	**-0.12**	~	**-0.16**	**	**-0.02**	ns	**-0.01**	ns	**-0.13**	***	**0.01**	ns
UrbGrowth alter	**0.07**	ns	**0.11**	*	**0.11**	*	**0.09**	**	**0.13**	***	**0.13**	***	**0.08**	*	**0.10**	*
UrbGrowth similarity	**1.80**	**	**1.47**	*	**1.72**	**	1.06	ns	**2.39**	**	**2.44**	**	**0.86**	~	**1.76**	*
LPI_Overall ego									**1.19**	***	**1.21**	***	**1.06**	***	**1.86**	***

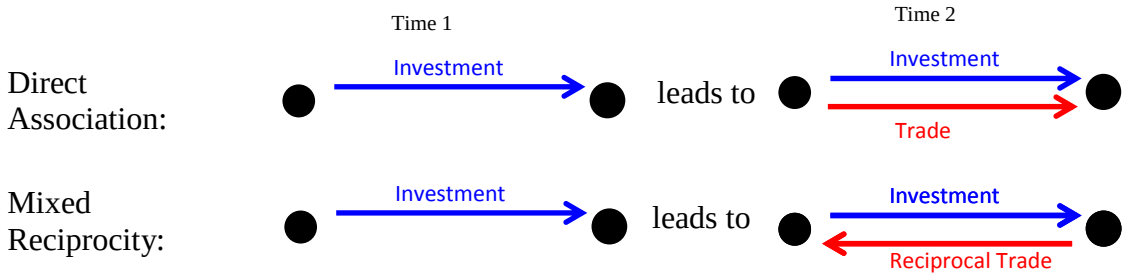
4.3.4 Multivariate network dynamics: co-evolution of the trade and investment networks

After investigating the dynamics in within each network separately, the last step is to investigate the dynamics across the two networks.

A multiple or multivariate network is defined as a set of *n* social actors, on which R relations are defined (Snijders, Lomi, & Torló, 2013). In the trade and investment networks, both contain 178 countries as the 'actors'. SIENA algorithm is used to test cross-network dependencies between the two relations.

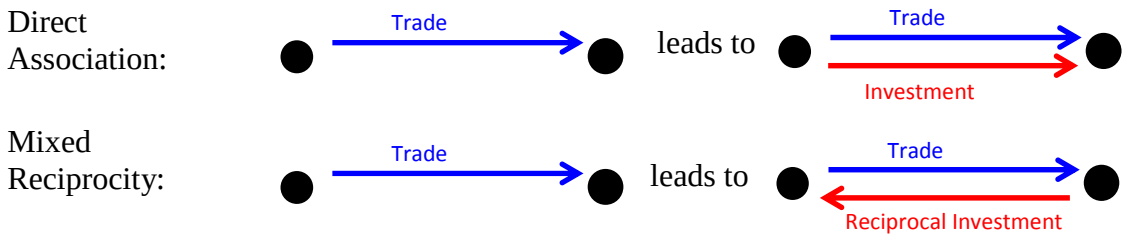
The results of the joint analysis of the trade and investment networks in 2010 and 2011 are summarized in the table below. The within-network parameters are structural effects for each network individually as control effects and they have been presented in the earlier sections. For the interaction between the two networks, only the basic cross network dependency effects were explored and summarized as below: (Snijders et al., 2013):

3) Trade network as dependent variable, investment network as explanatory variable



In the case of direct association, the hypothesis is that an investment tie in the F&B sector will have positive influence on the formation of a tie in the trade of beer. For mixed reciprocity, the hypothesis is the investment tie will increase the probability of a reciprocal trade tie.

4) Invest network as dependent variable, trade network as explanatory variable



In the case of direct association, the hypothesis is that a tie in the trade of beer will have positive influence on the formation of investment tie in the F&B sector. For mixed reciprocity, the hypothesis is that the trade tie will increase the probability of a reciprocal investment tie.

Table 9: Cross Network Model Results

Effect	Trade in Beer 2010-2011			Investment in F&B 2010-2011		
	par.	s.e.		par.	s.e.	
Within-Network						
Basic rate parameter BeerTrade10_11	8.02	(0.78)	***	23.80	(3.22)	***
Outdegree (density)	-4.33	(0.32)	***	-5.29	(0.27)	***
Reciprocity	1.18	(0.17)	***	0.33	(0.34)	*ns*
Transitive triplets	0.08	(0.01)	***	0.17	(0.04)	***
3-cycles	-0.07	(0.02)	***	-0.24	(0.15)	~
Indegree - popularity	0.30	(0.05)	***	0.52	(0.06)	***
Outdegree - activity	0.25	(0.06)	***	0.32	(0.17)	~
Between-Network						
Effect of investment on trade	-			0.57	(0.93)	*ns*
Effect of investment on reciprocal trade	-			-0.74	(0.62)	*ns*
Effect of trade on Investment	**0.46**	(0.15)	**	-		
Effect of trade on reciprocal investment	**0.77**	(0.18)	***	-		

The results confirmed the second hypothesis that there is significant positive influence of the presence of beer trade tie on the formation of investment tie in the F&B sector. Moreover, presence of trade tie in beer will also significantly increase the probability of a reciprocal investment tie. The effects on the opposite direction are not significant. This direct association effect is logical in that countries engage in trade first before investment. The significant mixed reciprocity effect shows the importance of exchange in goods on the exchange of investment which will bring technology and know-how.

4.3.5 Parameter Interpretations

4.3.5.1 Interpretation I: 'attractiveness' of the network

One interpretation of the objective function is to compare the 'attractiveness' of the network for a given actor. For example, in the final model for the uni-variate networks, the ego, alter and similarity effects of urban growth were modelled. The estimated parameters are denoted as β_e, β_a, and β_s respectively for the following illustrations. According to the functions in 7), 8), and 9) above, the joint contribution of these urban growth related effects to the objective function is

$$\beta_e v_i x_{i+} + \beta_a \sum_j x_{ij} v_j + \beta_s \sum_j x_{ij} (sim_{ij}^v - \widehat{sim}^v) \quad \textbf{(14)}$$

The contribution of the single tie from i to j, represented by the single tie variable x_{ij}, is the difference between the values for the above function for x_{ij} = 1 and x_{ij} = 0. It should be noted that all variables are centered by SIENA (p. 26, Ripley et al., 2014) on the variable mean. The above equation can be rewritten as the following to more explicitly represent the contribution of the urban growth variable to the network evaluation function by one single tie x_{ij}:

$$\beta_e(v_i - \bar{v}) + \beta_a(v_j - \bar{v}) + \beta_s (sim_{ij}^v - \widehat{sim}^v)$$
$$= \beta_e(v_i - \bar{v}) + \beta_a(v_j - \bar{v}) + \beta_s (1 - \frac{|v_{i-} v_j|}{\Delta_V} - \widehat{sim}^v) \quad \textbf{(15)}$$

Taking the model outputs for the period 2010 to 2011 as an example, the urban growth variable in 2010 (in percentage) has a range from -3.8 to 11.5, with overall mean $\bar{v}$ equals to 2.137, and the mean of the similarity variable $\widehat{sim}^v$ = 0.8688 (calculation by SIENA). From the final model output for the beer trade network in the period of 2010 to 2011, the estimated parametersβ_e, β_a, and β_s are for the urban growth effect are -0.08, 0.14 and 2.35 respectively. Substituting these value into the equation (15) yields the following:

$$\text{-0.08}(v_i - 2.137) + 0.14(v_j - 2.137) + 2.35(1 - \frac{|v_{i-} v_j|}{11.5-(-3.8)} - 0.8688)$$

Using the above equation a table can be made that gives the outcome for some values of the urban growth variable v_i and v_j :

$v_i \setminus v_j$	-3	0	3	6	9	11
-3	0.00	-0.04	-0.08	-0.12	-0.16	-0.19
0	-0.70	0.18	0.14	0.10	0.06	0.03
3	-1.40	-0.52	0.36	0.32	0.28	0.25
6	-2.10	-1.22	-0.34	0.54	0.50	0.47
9	-2.80	-1.92	-1.04	-0.16	0.72	0.69
11	-3.27	-2.39	-1.51	-0.63	0.25	0.84

Table 10: Alter-Ego Selection Table For Urban Growth - Trade Network

Table 10 shows the preference for similar alters: in all rows, the highest value is at the diagonal ($v_i = v_j$). The ego and alter parameters are close to 0, therefore the similarity effect is dominant. However, the formula uses raw values for v_i and v_j but divides the values for the absolute

difference $|v_{i-}\ v_j|$ by Δ_V which is 11.5 – (-3.8) = 15.3. Therefore the weight of 0.14 for the alter effect become significant at high v_j values. The positive alter effect leads to preference for ties to countries with high urban growth which goes against the similarity effect for $v_i = -3$, but strengthens the similarity effect for $v_i = 11$. For countries with low urban growth but not less than 0 (e.g. 1-3% for the developed countries in EU), there are strong preferences to develop ties with other countries with higher urban growth. For countries experiencing negative urban growth (e.g. Russia, Latvia), it is 'unattractive' therefore unlikely for these countries to develop outgoing ties.

Similarly, for the F&B investment network in the period of 2010 to 2011, the estimated parametersβ_e, β_a, and β_s for the urban growth effect are 0.01, 0.10 and 1.76 respectively. Substituting these value into the objective equation (15) yields the following:

$$0.01(v_i - 2.137) + 0.1(v_j - 2.137) + 1.76(1 - \frac{|v_{i-}\ v_j|}{11.5-(-3.8)} - 0.8688)$$

Using the above equation a table can be made that gives the outcome for some values of the urban growth variable v_i and v_j :

$v_i \setminus v_j$	-3	0	3	6	9	11
-3	-0.33	-0.38	-0.42	-0.47	-0.51	-0.54
0	-0.65	0.00	-0.05	-0.09	-0.14	-0.17
3	-0.96	-0.32	0.33	0.28	0.24	0.21
6	-1.28	-0.63	0.01	0.66	0.61	0.58
9	-1.59	-0.95	-0.30	0.34	0.99	0.96
11	-1.80	-1.16	-0.51	0.13	0.78	1.21

Table 11: Alter-Ego Selection Table For Urban Growth - F&B Network

The result shows a similar pattern that the highest value is at the diagonal. For countries with negative urban growth, there is strong ***negative*** tendency for such countries to extend investment ties with any others. The positive alter effect leads to preference for ties to countries with high urban growth which goes against the similarity effect for $v_i = -3$, but strengthens the similarity effect for $v_i = 11$.

4.3.5.2 Interpretation II: ratio of probability for changes in tie

An alternative interpretation of the parameters in the objective function is that when actor i has the opportunity to make a change in her outgoing ties (where no change is also an option), and x_a and x_b are two possible results of this change, then $f_i(\beta, x_b)$ - $f_i(\beta, x_a)$ is the log adds ratio for choosing these two alternatives, so the ratio of the probability of x_a and x_b as next states is

$$\mathbf{exp}(f_i(\boldsymbol{\beta}, x_b) - f_i(\boldsymbol{\beta}, x_a) = \frac{\exp(f_i(\beta, x_b))}{\exp(f_i(\beta, x_a))} \qquad \textbf{(16)}$$

For example, using the results from the cross-network parameters from above, let the investment network be the dependent network X, the beer trade network as the explanatory network W. Suppose countries j and h, both potential investment partners for country i, have

exactly the same network position and the same values on all variables included in the model, except that for country h, there is a trade tie from i to h, that is: w_{ih} = 1 while w_{ij} = 0. From formula 12, the effect of trade on investment is defined as

$$S_{i1}(x) = \sum_j x_{ij}\, w_{ij} \quad (11)$$

The contribution to this formula made by a single tie variable, i.e. the difference made by filling in x_{ij} = 1 or $x_{ij} = 0$, is just w_{ij}. Therefore the difference between extending an investment tie to h or j for the direct association effect of W on X is: $\beta \times (w_{ih} - w_{ij}) = \beta \times 1 = \beta$. From the table above, the estimated parameter, β, is 0.46.

Thus, in this situation, β is the log odds ratio of the probability that h is chosen compared to the probability of j is chosen. The ratio of probability must then be calculated as the exponential transformations of the log odds ratio. **In another words, when all else being equal, and *i* currently has an investment tie neither to *j* nor *h*, then the probability for *i* to extend a new investment tie to *h* is $e^{0.46} = 1.58$ times as high as the probability for *i* to extend a new investment tie to *j* as a result of the presence of the beer trade tie from *i* to *h*.**

A similar calculation can be done on the mixed reciprocity effect. In this case, suppose j and h have exactly the same network position and the same values on all variables included in the model, except that for country h, there is an incoming trade tie from h to i, that is: w_{hi} = 1 while w_{ji} = 0. According to formular 13, the effect of incoming W on X is defined as

$$S_{i2}(x) = \sum_j x_{ij}\, w_{ji} \quad (12)$$

The estimated β is 0.77. Following similar calculations as above, the conclusion is that **when all else being equal, and *i* currently has an investment tie neither to *j* nor *h*, then the probability for *i* to extend a new investment tie to *h* is $e^{0.77} = 2.15$ times as high as the probability for *i* to extend a new investment tie to *j* as a result of the presence of the beer trade tie from *h* to *i*.**

Chapter 5. Conclusions and recommendations

5.1 Inter-dependency, inter-connectedness and resilience

We live in an increasingly **interconnected** and **interdependent** world characterized by intertwined networks of individuals, supply chains, cities and countries spanning large geographical distances. Trade and investment linkages are one of the most important channels of interaction between world countries. For example, they can help to explain how economic policies aff ect foreign markets; how economic shocks are transmitted among countries; and how economic crises spread internationally. However, direct bilateral-trade relationships can only explain a small fraction of the impact that an economic shock originating in a given country can have on another one, which is not among its direct-trade partners. Similarly, the global agro-food systems is composed of different and interrelated chains and systems crossing different sectors and facing enormous challenges and uncertainties in the coming decade. As a result of this complexity, fundamental and trans-disciplinary research is needed to develop theories and methods with which complex chains and systems can be understood and analysed. By combining statistics inference and network analysis methodology and tools to study a 'traditional' trading network in beer and an emerging investment network in the food sector, this paper aims to systematically analyse the 'inter-dependency' and 'inter-connectedness' within and between networks and to shed light on policy and research implications.

5.2 In retrospect: Research Objectives

The fundamental research objective of this paper stems from some basic questions: what does "inter-dependency" mean for complex social network and systems? Does the past predict the future? The choice of the beer trade network and the food investment network stems from the interest in the long history of beer and the dire needs of investment in the agro-food sector globally. The availability of advanced computer programs and modelling techniques allow this research to embark on an exploratory journey to discover the 'scientific' meaning of 'connectedness' and the discovery points to exciting further studies.

5.3 Conclusions and discussions

5.3.1 Typology, dynamics and evolution of the two networks

Both networks are characterized by high heterogeneity with a strong core-periphery structure. The focus on the study on the networks is the **relations** between countries, but not on the relations between country *i* and *j* in isolation, rather taken into account the 'effect of others' or the structural dimension of the networks. Therefore the characteristics of *inter-dependence* is the hinge of networks.

By applying network visualization techniques and algorithms, the inter-dependency between countries can be intuitively shown. A topographical representation of the networks shows clearly the core-periphery structure of the trade and investment networks of the chosen sector. US and EU countries dominate both the incoming and outgoing ties for trading and investment.

5.3.2 Position of specific countries in the network and its relations to others at both regional and global level

Centrality measures are network indicators that represent how each single country is relatively positioned in the overall network. Centrality indicators representing local and global positions were calculated for both networks: *degree* centrality that measures how a node is connected to others (and related strength centrality for the weighted network); *Closeness* centrality that measures how easily a node can be reached by others; *Eigenvector* centrality that associates a node's centrality to the node neighbor's characteristics.

The centrality indicators allow the ranking of countries according to different measures. The centrality rankings show that countries differ in their structural position when local and global centrality measures are considered respectively. For instance, Mexico ranks first in out-strength due to its large export volume to the US. It is also among the top countries in terms of closeness due to the importance of US centrality in the trade network. However, its eigenvector position is 44 which shows the vulnerability of relying on few partners.

The dispersion of a country's rankings shows their structurally embedded they are at the global and local level respectively. European countries are more structurally connected at the global level for the beer trading network; whereas the countries with large dispersion means that these important local players become less important when the 'effect of others' is taken into account. The different degree of 'connectedness' have important implications to a country's economic development and resilience towards shocks in the system.

5.3.3 Important endogenous and exogenous explanatory variables and their trends

A total of more than 200 simulation runs were carried out in SIENA to simulate how each network 'evolve' between two successive years and to determine the most influential factors that have 'most likely' brought the network to its current state. By controlling the endogenous variables which represent the inherent 'inter-dependency' in network structure, the effect of other variables of interest can be tested more completely. Contrary to the standard regression techniques where the inter-dependency between variables are considered a violation of statistical assumptions, the SAOM model implemented in SIENA can use these inter-dependencies as valuable information. The trends and the interactions between the variables are compared and be the basis for the final model. The choice of the variables are based as much as possible on literature and theories. However there are very limited literature on the application of the network dynamics inference algorithms on large networks between countries, hence the modeling approach has an exploratory and data driven nature.

All the variables that were tested significant in the separate groupings remain similarly significant when put together in the final model. The trade and investment networks share certain similar trends in in-degree popularity, out-degree activity, regional effect, tourism and urban growth but also differ in several aspects. The income effect which is influential for the trade in beer is not significant for the investment network. The regional effect appears to be consistently reducing in strength over the years for investment network. This shows that trade in beer is very much influenced by the geographical distance due to its bulkiness while investment activities are diversifying beyond the regional scope. The reciprocity effect starts

to take significance only in recent years for the investment network which may point to the time for partners to establish mutual exchange relationship. Also interesting to note the more pronounced effect of tourism on investment. Not only the homophily effect is evident, but the strong ego effect that countries with high incoming tourists also tends to send out more investing ties. Overall the homophily effect is strong in terms of regionalism, similarity in tourism and urban growth. Lastly, the LPI index is a strong indicator for countries with high scores to send out more investment ties. This represents an important opportunity for emerging nations to benefit from the exchange and improve its own logistics performance.

5.3.4 Cross-network dynamics

Does countries with more trade in beer tends to have more investment ties in the food and beverages sector? This hypothesis is tested and confirmed by running the multi-network algorithm to test the direct association and mixed reciprocity effect. The results are statistically significant and support that **there is significant positive influence of the presence of beer trade tie on the formation of investment tie in the F&B sector. Moreover, presence of trade tie in beer will also significantly increase the probability of a reciprocal investment tie.** This result points to that when everything is connected to everything, we can discover connections in unexpected places. When the general indexes provided by world organizations fail to explain certain specific phenomenon in a rapidly changing world, it is maybe more worthwhile to study the real flow and connections by people, goods and knowledge with the help of the advent in computer technology and large amount of available recent data.

5.3.5 Based on these trends, how can the developed world and the developing world benefit from each other with new growth opportunities and development paradigms?

Connectivity is important for a country's economic development. These connectivity can be trade and commodity ties, investment ties, but also in tourism, social media and culture. Establishment of investment ties with partners with advanced knowhow in logistics management, water management can bring valuable knowhow and developmental benefits to the emerging countries and to build more sustainable and robust supply chains. The importance of tourism points that there are important enabling factors that attracts international people flow such as: good environment, good urban facilities and infrastructure. Such factors are beyond the scope of this research but the important conclusion may be that the 'soft' factors are equally important to a city or country's competitiveness.

5.4 An addition to the existing body of knowledge

The application of statistical inference with network analysis is a fast emerging and exciting field. This research adds to the empirical experience of modelling large networks involving countries. Further research can be extended in more detail into city and organization level.

5.5 Policy Recommendations

International trade and investment are of critical importance to EU and its global partners. EU is not only the biggest importer and exporter, but also the biggest investor and recipient of foreign direct investments(European Economic and Social Committee, 2013). International

trade and investment flows had experienced significant growth during the last round of internationalization and trade liberalization, contributing to global welfare gains and development. It is strongly recognized by the EU Commission that continuing trade liberalization and opening new markets will remain top policy agenda for maintaining EU block's global competitiveness in the future.

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Chapter 7.

Annex 1 Country Listing

ID	ISO 2	Short Name	Region	ID	ISO 2	Short Name	Region
1	AF	Afghanistan	South Asia	90	LY	Libya	Middle East & North Africa
2	AL	Albania	Europe & Central Asia	91	LT	Lithuania	European Union
3	DZ	Algeria	Middle East & North Africa	92	LU	Luxembourg	European Union
4	AO	Angola	Sub-Saharan Africa	93	MO	Macao	East Asia & Pacific
5	AG	Antigua&Barbuda	Latin America & Caribbean	94	MK	Macedonia	Europe & Central Asia
6	AR	Argentina	Latin America & Caribbean	95	MG	Madagascar	Sub-Saharan Africa
7	AM	Armenia	Europe & Central Asia	96	MW	Malawi	Sub-Saharan Africa
8	AW	Aruba	Latin America & Caribbean	97	MY	Malaysia	East Asia & Pacific
9	AU	Australia	East Asia & Pacific	98	MV	Maldives	South Asia
10	AT	Austria	European Union	99	ML	Mali	Sub-Saharan Africa
11	AZ	Azerbaijan	Europe & Central Asia	100	MT	Malta	European Union
12	BH	Bahrain	Middle East & North Africa	101	MH	Marshall Islands	East Asia & Pacific
13	BD	Bangladesh	South Asia	102	MR	Mauritania	Sub-Saharan Africa
14	BB	Barbados	Latin America & Caribbean	103	MU	Mauritius	Sub-Saharan Africa
15	BY	Belarus	Europe & Central Asia	104	MX	Mexico	Latin America & Caribbean
16	BE	Belgium	European Union	105	FM	Micronesia	East Asia & Pacific
17	BZ	Belize	Latin America & Caribbean	106	MD	Moldova	Europe & Central Asia
18	BJ	Benin	Sub-Saharan Africa	107	MN	Mongolia	East Asia & Pacific
19	BM	Bermuda	North America	108	ME	Montenegro	Europe & Central Asia
20	BT	Bhutan	South Asia	109	MA	Morocco	Middle East & North Africa
21	BO	Bolivia	Latin America & Caribbean	110	MZ	Mozambique	Sub-Saharan Africa
22	BA	Bosnia&Herzegovina	Europe & Central Asia	111	MM	Myanmar	East Asia & Pacific
23	BR	Brazil	Latin America & Caribbean	112	KP	N. Korea	East Asia & Pacific
24	BN	Brunei Darussalam	East Asia & Pacific	113	NP	Nepal	South Asia
25	BG	Bulgaria	European Union	114	NL	Netherlands	European Union
26	BF	Burkina Faso	Sub-Saharan Africa	115	NC	New Caledonia	East Asia & Pacific
27	BI	Burundi	Sub-Saharan Africa	116	NZ	New Zealand	East Asia & Pacific
28	KH	Cambodia	East Asia & Pacific	117	NI	Nicaragua	Latin America & Caribbean
29	CM	Cameroon	Sub-Saharan Africa	118	NE	Niger	Sub-Saharan Africa
30	CA	Canada	North America	119	NG	Nigeria	Sub-Saharan Africa
31	KY	Cayman Islands	Latin America & Caribbean	120	NO	Norway	Europe & Central Asia
32	CF	Central African Rep.	Sub-Saharan Africa	121	OM	Oman	Middle East & North Africa
33	TD	Chad	Sub-Saharan Africa	122	PK	Pakistan	South Asia
34	CL	Chile	Latin America & Caribbean	123	PA	Panama	Latin America & Caribbean
35	CN	China	East Asia & Pacific	124	PG	Papua N. Guinea	East Asia & Pacific
36	CO	Colombia	Latin America & Caribbean	125	PY	Paraguay	Latin America & Caribbean
37	CG	Congo	Sub-Saharan Africa	126	PE	Peru	Latin America & Caribbean
38	CD	Congo DRC	Sub-Saharan Africa	127	PH	Philippines	East Asia & Pacific
39	CR	Costa Rica	Latin America & Caribbean	128	PL	Poland	European Union
40	HR	Croatia	European Union	129	PT	Portugal	European Union
41	CU	Cuba	Latin America & Caribbean	130	QA	Qatar	Middle East & North Africa
42	CY	Cyprus	European Union	131	RO	Romania	European Union
43	CZ	Czech Rep.	European Union	132	RU	Russia	Europe & Central Asia
44	DK	Denmark	European Union	133	RW	Rwanda	Sub-Saharan Africa
45	DM	Dominica	Latin America & Caribbean	134	ZA	S. Africa	Sub-Saharan Africa
46	DO	Dominican Rep.	Latin America & Caribbean	135	KR	S. Korea	East Asia & Pacific
47	EC	Ecuador	Latin America & Caribbean	136	WS	Samoa	East Asia & Pacific
48	EG	Egypt	Middle East & North Africa	137	SA	Saudi Arabia	Middle East & North Africa
49	SV	El Salvador	Latin America & Caribbean	138	SN	Senegal	Sub-Saharan Africa

50	GQ	Equa. Guinea	Sub-Saharan Africa	139	RS	Serbia	Europe & Central Asia
51	EE	Estonia	European Union	140	SC	Seychelles	Sub-Saharan Africa
52	ET	Ethiopia	Sub-Saharan Africa	141	SL	Sierra Leone	Sub-Saharan Africa
53	FJ	Fiji	East Asia & Pacific	142	SG	Singapore	East Asia & Pacific
54	FI	Finland	European Union	143	SK	Slovakia	European Union
55	FR	France	European Union	144	SI	Slovenia	European Union
56	GA	Gabon	Sub-Saharan Africa	145	SB	Solomon Islands	East Asia & Pacific
57	GM	Gambia	Sub-Saharan Africa	146	SO	Somalia	Sub-Saharan Africa
58	GE	Georgia	Europe & Central Asia	147	ES	Spain	European Union
59	DE	Germany	European Union	148	LK	Sri Lanka	South Asia
60	GH	Ghana	Sub-Saharan Africa	149	KN	St. Kitts	Latin America & Caribbean
61	GR	Greece	European Union	150	LC	St. Lucia	Latin America & Caribbean
62	GT	Guatemala	Latin America & Caribbean	151	VC	St. Vincent	Latin America & Caribbean
63	GN	Guinea	Sub-Saharan Africa	152	SD	Sudan	Sub-Saharan Africa
64	GW	Guinea-Bissau	Sub-Saharan Africa	153	SR	Suriname	Latin America & Caribbean
65	GY	Guyana	Latin America & Caribbean	154	SE	Sweden	European Union
66	HT	Haiti	Latin America & Caribbean	155	CH	Switzerland	Europe & Central Asia
67	HN	Honduras	Latin America & Caribbean	156	SY	Syria	Middle East & North Africa
68	HK	Hong Kong	East Asia & Pacific	157	TW	Taiwan	
69	HU	Hungary	European Union	158	TJ	Tajikistan	Europe & Central Asia
70	IS	Iceland	Europe & Central Asia	159	TZ	Tanzania	Sub-Saharan Africa
71	IN	India	South Asia	160	TH	Thailand	East Asia & Pacific
72	ID	Indonesia	East Asia & Pacific	161	TG	Togo	Sub-Saharan Africa
73	IR	Iran	Middle East & North Africa	162	TT	Trinidad&Tobago	Latin America & Caribbean
74	IQ	Iraq	Middle East & North Africa	163	TN	Tunisia	Middle East & North Africa
75	IE	Ireland	European Union	164	TR	Turkey	Europe & Central Asia
76	IL	Israel	Middle East & North Africa	165	TM	Turkmenistan	Europe & Central Asia
77	IT	Italy	European Union	166	AE	UAE	Middle East & North Africa
78	CI	Ivory Coast	Sub-Saharan Africa	167	UG	Uganda	Sub-Saharan Africa
79	JM	Jamaica	Latin America & Caribbean	168	GB	UK	European Union
80	JP	Japan	East Asia & Pacific	169	UA	Ukraine	Europe & Central Asia
81	JO	Jordan	Middle East & North Africa	170	UY	Uruguay	Latin America & Caribbean
82	KZ	Kazakhstan	Europe & Central Asia	171	US	USA	North America
83	KE	Kenya	Sub-Saharan Africa	172	UZ	Uzbekistan	Europe & Central Asia
84	KW	Kuwait	Middle East & North Africa	173	VU	Vanuatu	East Asia & Pacific
85	KG	Kyrgyzstan	Europe & Central Asia	174	VE	Venezuela	Latin America & Caribbean
86	LA	Laos	East Asia & Pacific	175	VN	Vietnam	East Asia & Pacific
87	LV	Latvia	European Union	176	YE	Yemen	Middle East & North Africa
88	LB	Lebanon	Middle East & North Africa	177	ZM	Zambia	Sub-Saharan Africa
89	LR	Liberia	Sub-Saharan Africa	178	ZW	Zimbabwe	Sub-Saharan Africa

Annex 2: Results of Intermediate Models

Table: Results of Covariates Impact on Beer Trading Network

Model 2 Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	4.43		5.34		3.95		3.86		3.94		3.93		4.08		4.19	
outdegree effect on rate BeerTrade03_04	0.02	***	0.02	***	0.02	***	0.03	***	0.02	***	0.02	***	0.02	***	0.02	***
outdegree (density)	-5.94	***	-5.20	***	-5.49	***	-4.98	***	-5.14	***	-5.14	***	-5.03	***	-5.48	***
reciprocity	0.52	***	0.45	***	0.66	***	0.68	***	0.59	***	0.58	***	0.71	***	0.54	***
transitive triplets	0.02	***	0.03	***	0.04	***	0.03	***	0.04	***	0.04	***	0.04	***	0.03	***
indegree - popularity	**0.54**	***	**0.44**	***	**0.41**	***	**0.39**	***	**0.42**	***	**0.42**	***	**0.40**	***	**0.44**	***
outdegree - activity	**0.30**	***	**0.28**	***	**0.30**	***	**0.27**	***	**0.27**	***	**0.27**	***	**0.25**	***	**0.29**	***
same regionID	**1.27**	***	**0.99**	***	**1.71**	***	**0.79**	***	**0.62**	***	**0.63**	***	**0.77**	***	**1.36**	***
GNPCap similarity	**0.44**	~	**0.62**	**	**0.76**	**	**0.58**	*	**0.72**	*	**0.57**	*	0.25	ns	**0.89**	***

Model 3 Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	4.44		5.37		3.92		3.91		3.97		3.98		4.13		4.12	
outdegree effect on rate BeerTrade03_04	0.02	***	0.02	***	0.02	***	0.03	***	0.02	***	0.02	***	0.02	***	0.02	***
outdegree (density)	-6.03	***	-5.23	***	-5.60	***	-5.17	***	-5.14	***	-5.27	***	-5.34	***	-5.51	***
reciprocity	0.51	***	0.36	***	0.53	***	0.61	***	0.47	***	0.47	***	0.61	***	0.44	***
transitive triplets	0.02	***	0.03	***	0.04	***	0.03	***	0.04	***	0.04	***	0.04	***	0.03	***
indegree - popularity	**0.55**	***	**0.41**	***	**0.40**	***	**0.40**	***	**0.39**	***	**0.41**	***	**0.42**	***	**0.42**	***
outdegree - activity	**0.31**	***	**0.27**	***	**0.29**	***	**0.28**	***	**0.26**	***	**0.27**	***	**0.26**	***	**0.28**	***
GNPCap similarity	**0.44**	~	**0.53**	*	**0.77**	**	**0.63**	*	**0.52**	*	**0.45**	ns	**0.24**	ns	**0.99**	***
same regionID	**1.32**	***	**0.82**	***	**1.11**	***	**0.70**	***	**0.73**	***	**0.75**	***	**0.85**	***	**0.93**	***
ExpGDP similarity	0.52	~	-0.04	ns	0.13	ns	-0.15	ns	0.03	ns	0.06	ns	0.24	ns	-0.37	ns

Model 4 Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	4.40		5.38		3.88		3.96		3.97		3.95		3.91		4.18	
outdegree effect on rate	0.02	***	0.02	***	0.02	***	0.03	***	0.02	***	0.02	***	0.02	***	0.02	***

outdegree (density)	-6.26	***	-5.58	***	-6.02	***	-5.26	***	-5.65	***	-5.88	***	-5.70	***	-6.11	***
reciprocity	0.61	***	0.45	***	0.55	***	0.62	***	0.52	***	0.53	***	0.57	***	0.49	***
transitive triplets	0.03	***	0.03	***	0.03	***	0.03	***	0.03	***	0.03	***	0.04	***	0.02	***
indegree - popularity (s	0.60	***	0.44	***	0.49	***	0.41	***	0.51	***	0.56	***	0.53	***	0.52	***
outdegree - activity (sq	0.33	***	0.32	***	0.32	***	0.29	***	0.29	***	0.30	***	0.25	***	0.32	***
GNPCap similarity	0.18	ns	0.38	ns	0.57	ns	0.42	ns	0.28	ns	-0.02	ns	1.24	**	1.04	***
same regionID	1.32	***	0.88	***	1.20	***	0.71	***	0.77	***	0.80	***	0.90	***	0.97	***
Internet alter	-0.01	~	0.00	~	0.00	ns	0.00	ns	-0.01	~	-0.01	***	-0.01	~	0.00	ns
Internet ego	-0.01	*	-0.01	*	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.01	*	0.00	ns
Internet similarity	0.11	ns	0.27	ns	**0.52**	~	0.20	ns	0.41	ns	**0.59**	*	-0.38	ns	0.35	ns
Road alter	0.00	ns	0.00	*	0.00	**	0.00	ns	0.00	**	0.00	**	0.00	ns	0.00	ns
Road ego	0.00	ns	0.00	ns	0.00	**	0.00	ns	0.00	~	0.00	~	0.00	ns	0.00	ns
Road similarity	0.54	ns	-1.06	ns	-3.92	***	-0.20	ns	-2.38	*	-2.55	*	0.41	ns	-1.21	ns
Water_07 alter	0.00	~	0.00	*	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	~
Water_07 ego	0.00	*	0.00	*	0.00	ns	0.00	ns	0.00	~	0.00	*	0.00	ns	0.00	*
Water_07 similarity	**-2.02**	*	**1.83**	**	0.42	ns	0.20	ns	-1.49	ns	-1.35	ns	-1.10	ns	**-1.93**	*

Model 5																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	4.48		5.44		3.98		3.91		4.07		4.07		4.08		4.25	
outdegree effect on rate	0.02	***	0.02	***	0.02	***	0.03	***	0.02	***	0.02	***	0.02	***	0.02	***
outdegree (density)	-6.21	***	-6.04	***	-6.35	***	-6.14	***	-6.17	***	-6.07	***	-5.99	***	-6.55	***
reciprocity	**0.57**	***	**0.50**	***	**0.62**	***	**0.80**	***	**0.65**	***	**0.64**	***	**0.72**	***	**0.62**	***
transitive triplets	0.01	ns	0.02	*	0.03	***	0.02	**	0.02	***	0.02	***	0.04	***	0.01	*
indegree - popularity	**0.61**	***	**0.57**	***	**0.54**	***	**0.59**	***	**0.59**	***	**0.56**	***	**0.57**	***	**0.58**	***
outdegree - activity	**0.30**	***	**0.33**	***	**0.33**	***	**0.33**	***	**0.31**	***	**0.31**	***	**0.26**	***	**0.34**	***
GNPCap similarity	**0.48**	~	**0.62**	**	**0.89**	***	**0.82**	***	**0.75**	**	**0.60**	*	0.14	ns	**1.12**	***
same regionID	**1.14**	***	**1.02**	***	**1.18**	***	**0.83**	***	**0.80**	***	**0.80**	***	**0.90**	***	**0.99**	***
Tourism alter	-0.05	ns	-0.08	*	-0.88	~	-0.10	**	-0.11	***	-0.10	***	-0.12	***	-0.07	*
Tourism ego	0.04	ns	0.01	ns	-0.04	ns	0.00	ns	0.03	ns	0.02	ns	0.08	~	-0.03	ns
Tourism similarity	**0.56**	*	**1.17**	***	**1.15**	***	**1.26**	***	**0.93**	***	**0.93**	***	**0.52**	~	**0.74**	*
UrbGrowth alter	0.03	ns	0.06	*	0.10	***	0.15	***	0.06	*	0.07	*	0.19	***	0.14	***
UrbGrowth ego	-0.13	***	0.02	ns	-0.02	ns	0.04	ns	0.03	ns	0.02	ns	-0.01	ns	-0.08	~
UrbGrowth similarity	**1.73**	***	-0.40	ns	**0.95**	*	0.44	ns	**1.64**	**	**1.61**	**	**1.19**	***	**2.35**	***
UrbAgglo alter	0.00	ns	0.00	ns	-0.01	*	0.01	*	0.01	*	0.01	*	0.01	**	0.01	**
UrbAgglo ego	-0.01	ns	0.00	ns	0.01	ns	0.01	**	0.00	ns	0.01	ns	0.01	~	0.01	*

UrbAgglo similarity	-0.33	ns	-0.24	ns	0.27	ns	**1.34**	**	0.68	ns	0.65	ns	**1.37**	*	0.57	ns
Model 6																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter									3.96		3.95		3.99		4.15	
outdegree effect on rate BeerTrade07_08									0.02	***	0.02	***	0.02	***	0.02	***
outdegree (density)									-5.46	***	-5.47	***	-5.54	***	-5.94	***
reciprocity									0.48	***	0.47	***	0.60	***	0.47	***
transitive triplets									0.04	***	0.04	***	0.04	***	0.02	***
indegree - popularity									**0.47**	***	**0.47**	***	**0.48**	***	**0.47**	***
outdegree - activity									**0.27**	***	**0.27**	***	**0.24**	***	**0.32**	***
GNPCap similarity									0.49	ns	0.15	ns	**0.95**	*	**0.85**	*
same regionID									**0.75**	***	**0.76**	***	**0.89**	***	**1.01**	***
LPI_TradeInfra alter									-0.04	ns	-0.08	ns	0.18	ns	-0.07	ns
LPI_TradeInfra ego									0.01	ns	0.03	ns	0.15	ns	-0.11	ns
LPI_TradeInfra similarity									0.03	ns	0.18	ns	-0.43	ns	-1.14	~
LPI_Logistics alter									0.35	ns	0.46	~	-0.31	ns	0.09	ns
LPI_Logistics ego									-0.09	ns	0.14	ns	-0.93	**	0.10	ns
LPI_Logistics similarity									0.27	ns	-0.04	ns	0.27	ns	**1.97**	***
LPI_Custom alter									-0.38	~	-0.48	*	0.05	ns	0.08	ns
LPI_Custom ego									-0.12	ns	-0.31	ns	**1.28**	***	0.08	ns
LPI_Custom similarity									-0.24	ns	0.07	ns	-1.26	*	0.31	ns
LPI_Shipment alter									-0.19	ns	-0.17	ns	-0.02	ns	-0.04	ns
LPI_Shipment ego									0.18	ns	0.09	ns	0.02	ns	-0.22	ns
LPI_Shipment similarity									-0.17	ns	-0.16	ns	**1.72**	*	-0.94	*
Model 7																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter							3.87		3.98		3.95		4.06		4.16	
outdegree effect on rate BeerTrade06_07							0.03	***	0.02	***	0.02	***	0.02	***	0.02	***
outdegree (density)							-5.22	***	-5.65	***	-5.77	***	-5.55	***	-5.91	***
reciprocity							0.63	***	0.50	***	0.51	***	0.58	***	0.49	***
transitive triplets							0.04	***	0.04	***	0.03	***	0.04	***	0.02	***
indegree - popularity							**0.43**	***	**0.48**	***	**0.52**	***	**0.48**	***	**0.48**	***
outdegree - activity							**0.27**	***	**0.28**	***	**0.28**	***	**0.26**	***	**0.31**	***

GNPCap similarity			**0.65**	*	0.46	ns	0.36	ns	0.49	ns	**1.27**	***
same regionID			**0.67**	***	**0.77**	***	**0.77**	***	**0.88**	***	**0.95**	***
GCI_2_Infra alter			0.09	ns	0.10	ns	0.07	ns	-0.07	ns	-0.06	ns
GCI_2_Infra ego			-0.01	ns	-0.04	ns	-0.02	ns	0.08	ns	0.00	ns
GCI_2_Infra similarity			0.51	ns	-0.40	ns	-0.38	ns	-0.11	ns	-0.17	ns
GCI_6_Goods alter			-0.19	ns	-0.20	ns	-0.17	ns	0.17	ns	0.09	ns
GCI_6_Goods ego			0.26	ns	0.18	ns	0.16	ns	0.24	ns	-0.01	ns
GCI_6_Goods similarity			-0.34	ns	0.53	ns	0.73	~	0.62	ns	-0.18	ns
GCI_3_Macro alter			0.02	ns	-0.20	**	-0.19	*	-0.06	ns	0.10	ns
GCI_3_Macro ego			-0.20	*	-0.40	***	-0.34	***	-0.01	ns	0.07	ns
GCI_3_Macro similarity			-0.10	ns	0.43	ns	-0.05	ns	-0.79	*	0.55	ns
GCI_10_Markt alter			-0.12	*	-0.07	ns	-0.08	ns	-0.09	~	-0.03	ns
GCI_10_Markt ego			-0.08	ns	0.00	ns	0.05	ns	-0.09	ns	-0.05	ns
GCI_10_Markt similarity			-0.64	*	0.64	*	0.74	*	-0.33	ns	0.09	ns

Table: Results of Covariates Impact on F&B Investment Network

Model 2 and 3: GDP per Cap, Region, Export Openess																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	19.95		21.58		16.76		22.34		21.57		20.76		24.33		23.67	
outdegree (density)	-7.03	***	-6.41	***	-6.51	***	-5.78	***	-5.63	***	-5.52	***	-5.32	***	-5.41	***
reciprocity	0.36	ns	1.18	***	0.55	ns	0.46	ns	0.99	***	0.87	***	0.38	ns	0.66	*
transitive triplets	0.41	***	0.19	***	0.24	***	0.26	***	0.23	***	0.22	***	0.23	***	0.26	***
3-cycles	-0.27	ns	-0.43	*	0.03	ns	-0.16	ns	-0.32	**	-0.26	**	-0.14	~	-0.28	***
indegree - popularit	**0.85**	***	**0.79**	***	**0.72**	***	**0.66**	***	**0.62**	***	**0.61**	***	**0.56**	***	**0.58**	***
outdegree - activity	**0.52**	***	**0.46**	***	**0.51**	***	**0.43**	***	**0.42**	***	**0.42**	***	**0.32**	***	**0.36**	***
GNPCap_04 similarity	-1.22	***	-0.47	ns	-0.60	ns	-0.40	ns	-0.22	ns	-0.20	ns	-0.62	*	-0.18	ns
same regionID	**1.44**	***	**1.07**	***	**1.14**	***	**0.98**	***	**0.65**	***	**0.63**	***	**0.71**	***	**0.70**	***
ExpGDP_04 alter	0.00	ns	0.00	ns	-0.01	**	0.00	ns	0.00	~	0.00	ns	0.00	~	-0.01	*
ExpGDP_04 ego	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	ns	0.00	ns
ExpGDP_04 similarity	0.14	ns	-0.96	ns	-1.44	~	0.03	ns	-1.49	**	-1.48	**	-0.86	~	-1.43	*

Model 4: Infrastructure																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	19.97		22.96		18.65						22.95		25.88		25.45	

outdegree (density)	-7.15	***	-6.71	***	-6.47	***			-5.97	***	-5.41	***	-5.68	***		
reciprocity	0.33	ns	1.02	**	0.83	*			1.03	**	0.62	*	0.94	**		
transitive triplets	0.31	***	0.12	~	0.17	**			0.17	***	0.20	***	0.18	***		
3-cycles	-0.09	ns	-0.25	ns	0.13	ns			-0.16	ns	-0.04	ns	-0.17	ns		
indegree - popularity	**0.89**	***	**0.81**	***	**0.79**	***			**0.68**	***	**0.63**	***	**0.64**	***		
outdegree - activity	**0.40**	***	**0.34**	***	**0.36**	***			**0.36**	***	**0.26**	***	**0.28**	***		
GNPCap similarity	-1.44	*	-0.14	ns	-0.57	ns			0.03	ns	-0.35	ns	0.32	ns		
same regionID	**1.24**	***	**0.78**	***	**0.77**	***			**0.55**	***	**0.61**	***	**0.46**	***		
Internet alter	0.00	ns	0.00	ns	0.00	ns			0.00	ns	0.00	~	-0.01	~		
Internet ego	0.03	***	0.03	***	0.03	***			0.02	***	0.01	***	0.03	***		
Internet similarity	0.52	ns	0.51	ns	0.52	ns			0.35	ns	-0.16	ns	**0.52**	~		
Road alter	0.00	ns	0.00	ns	0.00	ns			0.00	ns	0.00	ns	0.00	ns		
Road ego	0.00	~	0.00	ns	0.00	ns			0.00	ns	0.00	ns	0.00	ns		
Road similarity	1.97	ns	-1.04	ns	0.64	ns			1.21	ns	-0.41	ns	-1.59	ns		
Water_07 alter	0.00	ns	0.00	ns	0.00	ns			0.00	ns	0.00	ns	0.00	ns		
Water_07 ego	0.00	ns	0.00	ns	0.00	ns			0.00	~	0.00	ns	0.00	ns		
Water_07 similarity	0.31	ns	0.41	ns	-0.65	ns			-1.50	ns	-0.77	ns	-1.06	ns		

Model 5: Tourism, Urban Growth																
Effect	2003-04		2004-05		2005_06		2006_07		2007_08		2008_09		2009_10		2010_11	
	Est.		Est.		Est.		Est.		Est.		Est.		Est.		Est.	
parameter	18.94		21.97	***	18.85	***	25.33		23.72		24.26		27.16		26.03	
outdegree (density)	-7.38	***	-7.10	***	-6.76	***	-6.55	***	-6.14	***	-6.14	***	-5.76	***	-5.86	***
reciprocity	0.06	ns	0.50	~	0.37	ns	0.13	ns	0.60	**	0.63	*	0.32	ns	0.41	~
transitive triplets	0.09	ns	0.01	ns	0.06	ns	0.06	ns	0.09	*	0.09	*	0.12	***	0.10	**
3-cycles	-0.13	ns	-0.22	*	-0.03	ns	-0.10	ns	-0.23	***	-0.23	***	-0.13	*	-0.20	**
indegree - popularity	0.80	***	0.67	***	0.68	***	0.57	***	0.61	***	0.61	***	0.62	***	0.57	***
outdegree - activity	0.38	***	0.38	***	0.33	***	0.29	***	0.31	***	0.32	***	0.26	***	0.25	***
GNPCap similarity	-1.20	***	-0.88	**	-0.81	*	-0.80	*	-0.88	***	-0.77	**	-0.89	***	-0.89	***
same regionID	**0.90**	***	**0.68**	***	**0.68**	***	**0.92**	***	**0.49**	***	**0.49**	***	**0.43**	***	**0.46**	***
Tourism alter	**0.15**	*	**0.23**	***	**1.92**	*	**0.08**	~	**0.12**	~	**0.14**	*	**0.09**	*	**0.14**	*
Tourism ego	**0.52**	***	**0.43**	***	**6.69**	***	**0.59**	***	**0.45**	***	**0.44**	***	**0.32**	***	**0.50**	***
Tourism similarity	**2.13**	***	**2.40**	***	**1.47**	*	**1.73**	***	**1.97**	***	**1.96**	***	**1.88**	***	**1.24**	**
UrbGrowth alter	0.07	ns	**0.11**	*	**0.12**	**	0.06	ns	**0.14**	***	**0.13**	***	**0.09**	**	**0.09**	*
UrbGrowth ego	-0.07	ns	-0.21	**	-0.12	~	-0.16	**	-0.02	ns	-0.01	ns	-0.13	***	0.01	ns
UrbGrowth similarity	**1.65**	*	**1.48**	~	**1.74**	**	0.34	ns	**2.52**	***	**2.22**	***	0.70	ns	**1.95**	*

Model 6: LPI index

Effect	2003-04	2004-05	2005_06	2006_07	2007_08		2008_09		2009_10		2010_11	
	Est.	Est.	Est.	Est.	Est.		Est.		Est.		Est.	
parameter					25.10	***	24.61	***	29.51		29.66	
outdegree (density)					-5.99	***	-6.28	***	-6.39	***	-6.27	***
reciprocity					0.93	***	0.91	***	0.44	ns	0.70	*
transitive triplets					0.11	**	0.10	*	0.11	***	0.11	***
3-cycles					-0.18	*	-0.14	ns	-0.02	ns	-0.14	~
indegree - popularity					0.72	***	0.73	***	0.76	***	0.70	***
outdegree - activity					0.30	***	0.30	***	0.20	***	0.23	***
GNPCap_10 similarity					-0.39	ns	0.02	ns	-0.64	~	0.41	ns
same regionID					0.42	***	0.50	***	0.51	***	0.42	***
LPI_Overall alter					-0.14	ns	-0.08	ns	-0.13	ns	-0.02	ns
LPI_Overall ego					**1.24**	***	**1.58**	***	**1.64**	***	**2.19**	***
LPI_Overall similarity					**1.16**	*	**0.83**	~	0.30	ns	0.60	ns

Model 7: GCI Index

Effect	2003-04	2004-05	2005_06	2006_07		2007_08		2008_09	2009_10		2010_11	
	Est.	Est.	Est.	Est.		Est.		Est.	Est.		Est.	
Rate parameter				27.12		24.36			29.56		27.30	
outdegree (density)				-6.13	***	-6.14	***		-6.02	***	-5.94	***
reciprocity				0.44	ns	1.17	***		0.66	*	0.93	***
transitive triplets				0.15	**	0.12	**		0.14	***	0.15	***
3-cycles				0.00	ns	-0.14	ns		-0.03	ns	-0.13	ns
indegree - popularity				0.73	***	0.74	***		0.75	***	0.73	***
outdegree - activity				0.24	***	0.31	***		0.26	***	0.20	***
GNPCap similarity				-0.44	ns	-0.67	~		-0.72	~	0.12	ns
same regionID				0.92	***	0.51	***		0.62	***	0.54	***
GCI_Overall alter				-0.14	ns	-0.34	*		-0.23	*	-0.26	*
GCI_Overall ego				**1.42**	***	**1.22**	***		**1.00**	***	**1.56**	***
GCI_Overall similarity				1.11	ns	**1.77**	***		0.69	ns	0.46	ns