ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS

Timo Seppälä

CONTEMPORARY DETERMINANTS AND GEOGRAPHICAL ECONOMY OF ADDED VALUE, COST OF INPUTS, AND PROFITS IN GLOBAL SUPPLY CHAINS

An Empirical Analysis

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Author:	Timo Seppälä
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Supervisor:	Professor Eero Eloranta, Aalto University
Instructor:	Professor Martin Kenney, University of California, Davis
Instructor:	Doctor Jyrki Ali-Yrkkö, The Research Institute of the Finnish Economy

Abstract

The structures of industries, the economic geography of multinational enterprises (MNEs) and the global configurations of supply chains can be considered to be the three key factors essential to understanding contemporary globalization on a micro-level. In practice, the competitive position of a single nation as a geographic location of value-adding activity and its ability to attract new foreign direct investment (FDI) is a consequence of these behaviors. Hence, it is essential to understand how MNEs plan, implement, position, and execute their strategies in global supply chains and production networks and how these MNEs create value and capture profits in their respective industries and geographies.

This PhD dissertation is composed of five papers, each of which addresses a specific topic in the research domain of global value chains. Each of the dissertation's papers analyzes a selected micro-level problem from an industry, MNE, supply chain and/or national economy perspective. That said each of the papers focus on specific case study to explain the relation to the same contemporary phenomenon of globalization to provide a bridge between rich empirical narratives and mainstream research and public policy.

The five separate papers that constitute this dissertation use qualitative research methods combined with case studies; hence, qualitative research methods and case studies have seldom been used in economics research. It should be recognized that qualitative research methods and case studies have been used to develop theories on diverse topics. Furthermore it should also be emphasized that the methodology and the datasets for these case studies in this PhD dissertation are unique.

The dissertation, including all the specific papers, make a contribution in its academic, business and public policy domain, by addressing factors that have received limited attention in the existing research and contemporary public policy. Furthermore, it is notable that the extant literature is largely silent on interactions between these micro-level mechanisms of contemporary globalization perspectives.

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Tiivistelmä

Nykyistä globalisaatiota voidaan kuvata ja ymmärtää mikrotasolla tarkastelemalla kolmea avaintekijää: teollisuuden rakenteiden muutosta, monikansallisten yritysten talousmaantiedettä ja tuotteiden maailmanlaajuisia toimitusketjuja. Eri valtioiden rooli lisäarvon tuottajana ja niiden kyky houkutella ulkomaisia suoria investointeja (FDI) on seurausta näistä kolmesta avaintekijästä. Siksi on tärkeää ymmärtää, miten monikansallinen yritys suunnittelee ja toteuttaa strategiaansa osana globaaleja toimitusketjuja ja tuotannon verkostoja. Näistä strategioista seuraa, miten monikansalliset yritykset luovat arvoa ja saavat voittoa eri toimialoilla ja maantieteellisillä alueilla.

Tämä väitöskirjatutkimus koostuu viidestä artikkelista, joista kukin artikkeli käsittelee tiettyä aihealuetta maailmanlaajuisten arvoketjujen näkökulmasta. Kukin väitöskirjan artikkeli analysoi valittua mikrotason ongelmaa joko teollisuuden, monikansallisen toimitusketjun ja / tai kansantalouden kannalta. Lisäksi jokainen artikkeli tarkastelee tapauskohtaisesti nyky-globalisaatiota ja tarjoaa sillan rikkaan empiirisen kertomuksen ja valtavirtatutkimuksen välille huomioiden julkisen politiikan näkökulman.

Väitöskirjan viisi erillistä artikkelia hyödyntävät laadullisia tutkimusmenetelmiä yhdistettyinä tapaustutkimuksiin. Laadullisia tutkimusmenetelmiä ja tapaustutkimusta on käytetty harvemmin talouden ilmiöiden tutkimisessa, mutta toisaalta niihin perustuen on kehitetty monia elinkelpoisia teorioita. Tässä tutkimuksessa ja sen yksittäisissä artikkeleissa kerätyt yritystasoiset empiiriset aineistot sekä niiden pohjalta luodut mallit ovat uusia ja ainutlaatuisia.

Väitöskirja, mukaan lukien kaikki sen artikkelit, tuo uutta tietämystä akateemiseen, liiketoiminnalliseen ja julkisen politiikan tutkimukseen nyky-globalisaation syistä, vaikutuksista ja seurauksista. Lisäksi on huomattava, että viimeaikaisessa tutkimuksessa on nyky-globalisaatiota tarkasteltu vain vähän yritysten arvoketjujen ja sisäisen päätöksenteon mekanismien näkökulmasta.

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Preface

Timo came to academe through a long circuitous route that took him through a business career followed by consulting at ETLA. In each new world he has had to learn new rules, while drawing upon his previous experiences. Now, with the completion of his PhD dissertation, he gets to start again in the academic world. The chapters in this dissertation are informed by his previous experiences, but offer new evidence-based studies of contemporary globalization. Most previous case studies of supply chains/value chains/production networks are based on interview data or commercial teardowns of various electronic gadgets. These are excellent first approximations, but tell us very little about key issues such as profits, transfer pricing, and cost of logistics. Timo's work takes us to the far granular level of invoices and cost accounting, where the real managerial decisions are made.

Timo's PhD dissertation unpacks the organization of global value creation by MNEs at three different levels of analysis: 1) the competitive dynamics of global industries; 2) the dynamics of existing configurations of global supply chains; and 3) the dynamics of where value is added and profits are accounted for across different national economies and between different supply chain participants. He addresses the above issues in his PhD dissertation using sophisticated and original methods, unique data sets, and interviews with practitioners. With these new empirics and their respective findings and descriptions, he makes a number of significant and novel contributions to the dynamics of global value chains and international trade literature. Moreover, many of his case studies and datasets are more applicable to the European industries, such as precision machinery, than the U.S.-centric studies of personal computers and iPhones.

This book is Timo's PhD dissertation at Aalto University, Department of Industrial Engineering and Management Espoo. Its findings will have valuable insights for researchers, policy-makers, and corporate managers. For the reasons stated above, I strongly recommend it to practitioners and academics alike. As I see it, the methodologies and datasets that Timo has developed promise new empirical insights to enrich our theories of how firms operate their global supply chains and the implications to this for key firms, their suppliers, and the nations within which they operate.

Davis, CA, 12th May, 2014

Professor Martin Kenney

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Second, I would like to thank my closest colleagues at ETLA, The Research Institute of Finnish Economy, Jyrki Ali-Yrkkö, Petri Rouvinen and Pekka Ylä-Anttila, for their encouraging support and participation in numerous discussions. If I had not met Jyrki in April, 2009 while I was walking away from a company board meeting, just having been fired from my CEO position, I would not be here right now! I am also indebted to all of them for providing me with this learning opportunity and co-authoring three papers that support this dissertation.

Third, I would like to thank my supervisor, Professor Eero Eloranta, of Aalto University, for making all this possible. It has been one of my childhood dreams to graduate from the most distinguished university and department in Finland: old TKK, Industrial Management.

Forth, I also thank Professor Gary Gereffi, DUKE University, and Professor Torben Pedersen, Bocconi University for providing excellent comments on the strengths and weaknesses of this PhD dissertation in their role as pre-examiners.

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For their financial support, I would like to thank the Foundation for Economic Education, the Emil Aaltonen foundation, and the Finnish Society of Electronics Engineers. Without their support, the finalization of this dissertation would not have been possible.

Finally, I would like to thank my family: my wife Minna, my son Kim-Kristian, and my daughter Karolina for their enduring support during these past three years! I would also like to thank my father Juhani, my mother Katriina and my two sisters Titta and Tiia for their encouraging support during these 46 years of my life. I love you all from the bottom of my heart.

Helsinki, 12th May, 2014

Timo Seppälä

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Other articles, papers and editorials that underlie this dissertation

List of publications

This dissertation consists of a summary article and the following papers:

1. Seppälä, T. & Kenney, M. (2012). "Building Complementary Assets in a Unified TCP/IP World", Berkeley Roundtable on the International Economy (BRIE) Working Paper Series No. 204, University of California, Berkeley.

   Contributions: Based on the original concept of Seppälä and Kenney. Seppälä was mainly responsible for building the analytical framework, conducting the empirical analyses, managing the data and reporting.

2. Seppälä, T., Kenney, M. & Ali-Yrkkö, J. (2014) (forthcoming). "Global Supply Chains and Transfer Pricing: Insights from a Case Study", Supply Chain Management: An International Journal, Volume 19, issue 4.

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3. Seppälä, T. & Ali-Yrkkö, J. (under review). "Changing Geographies of Value Creation in Global Supply Chains: Evidence from Mobile Telecommunications".

   Contributions: Based on the original concept of Seppälä and Ali-Yrkkö. Seppälä was mainly responsible for building the analytical framework, conducting the empirical analyses and reporting.

4. Ali-Yrkkö, J., Rouvinen, P., Seppälä, T. & Ylä-Anttila, P. (2011). "Who Captures Value in Global Supply Chains? Case Nokia N95 Smartphone", Journal of Industry, Competition and Trade, Issue 11, pp. 263–278.

   Contributions: Based on the original concept of Ali-Yrkkö, Rouvinen, Seppälä and Ylä-Anttila. Seppälä was mainly responsible for conducting the empirical analyses and reporting.

5. Seppälä, T. (2013). Tracking Offshoring and Outsourcing Strategies in Global Supply Chains. In Offshoring Challenge: Strategic Design and Innovation for Tomorrow's Organization; Pedersen, T., Bals, L., Ørberg Jensen, P. D., Møller Larsen, M. (Eds.), pp. 57–76, Springer-Verlag London.

INTRODUCTION TO THE DISSERTATION

1 Background

Analyses related to industry dynamics and the concept of the global value chain have been my particular topics of interest for the last four years as contemporary globalization persistently progresses. Furthermore, analyses of global value chains link research to international trade-related policy making and the internationalization of multinational enterprises, which constitute two facets of the same phenomenon. Moreover, the catch-up effect to balance the inequalities between advanced and emerging economies represents another facet of this discussion. Hence, all three facets, international trade policies, the internationalization of multinational enterprises, and economic inequality are essential to creating a greater understanding of contemporary globalization.

As globalization persistently progresses, many economists are calling for more active and modern policies because many advocates of state intervention often point to the fact that there is innovation and higher knowledge in technology but not in manufacturing (Sperling, 2012; Marzinotto, 2012, Baldwin & Evenett, 2012). Hence, future manufacturing will require a fundamentally different approach to government support and changes to policies (Zysman et al., 2012; Baldwin & Evenett, 2012). As Baldwin and Evenett (2012) note, policy makers still view the world from the perspective of trade theory based on the first unbundling. The first unbundling refers to viewing globalization through the eyes of the trade theory that was designed to understand the effects of the industry clusters where firms were located at close proximity to one another (Baldwin, 2006, 2009, 2011; Baldwin & Evenett, 2012). This calls for the systematic understanding of the causes and effects of contemporary industry dynamics and the economic geography of refined global value chains and production networks.

Fewer barriers in international trade allow for the greater relocation of different product life cycle processes related to technology, design and manufacturing (Baldwin & Venables, 2010; Baldwin & Evenett, 2012). These organizational decisions made by multinational enterprises have not been sudden; relocation to lower the costs of research, design and manufacturing locations has been gradually occurring over the last decades (Vernon, 1966, 1971; Quinn, 1969, Teece, 1977, Seppälä, 2010, 2013). Lower coordination and contracting costs and new information and communication technology has enabled this separation in time and space to occur in a controlled manner. Baldwin (2006) calls this current stage of a globalization a second unbundling.

Industry dynamics and the economic geography of the global value chains and production networks of multinational enterprises are key elements to understanding contemporary globalization (Buckley & Ghauri, 2004; Picard et al., 2004). For a more detailed understanding of these changes, this PhD dissertation addresses factors related to the micro-level involvement of multinational enterprises in global trade and discusses the economic geography of global value chains and the subsequent offshoring and outsourcing of different processes and tasks. The perspectives of both industries and multinational enterprises are highlighted to identify the elements that should be considered when creating a new international trade theory.

The aim of this dissertation is to shed light on the specific components of industrial dynamics, as well as global value chains and their respective industrial networks, with a particular emphasis on the importance of all these aspects, while considering the value creation and value capture mechanisms in the world of the second unbundling: *i)* the usefulness of complementary assets in the case of macro-level innovation or, in Schumpeter's terms, the opening of a "new economic space" (Appendix 1); *ii)* the importance of separating the input costs and profits of multinational enterprise as two distinct measures while considering international trade theory, trade statistics, the second unbundling and the economic geography of added value (Appendix 2); *iii)* the relationship between the changes in economic geography, the geographical dispersion of added value, and the changes in the locations of research-, design- and manufacturing-related tasks (Appendix 3); *iv)* the significance of services while considering international trade theory, trade statistics and the second unbundling (Appendix 4); and *v)* the connection between changes in a leading firm's business environment and the strategy and responses of its global supply chains and industrial networks (Appendix 5).

The context for the empirical analyses in this PhD dissertation is the global mobile telecommunication industry, which consists of larger established multinational enterprises and their respective industrial networks and supply chains (Appendices 1, 2, 3, and 5). Furthermore, the context for the empirical analyses in article 4 is the global precision machinery industry because empirical details related to global supply chains were unavailable for the multinational enterprises in the global mobile telecommunication industry. These two communities are well-established and recognized globally. To provide more insights into the context of this PhD dissertation, it is worthwhile to briefly describe these two industries.

The mobile telecommunications industry is engaged in the technological application of both hardware and software (e.g., networks, mobile devices, services, content, and the respective service and network systems) that wirelessly transmit information through electromagnetic signals. Mobile telecommunications emerged in the early 1980s in the USA, when telephone services were deregulated and liberalized (Li & Whalley, 2002). It then became a global phenomenon with the continuing deregulation and liberalization of telecommunications (Li & Whalley, 2002). However, the mobile telecommunications industry has changed somewhat in recent years in that it has become a mobile Internet industry (West & Mace, 2010; Kenney & Seppälä, 2012; Seppälä & Kenney, 2012).

The precision machinery industry is associated with a diversified manufacturing base that produces highly engineered machine components to customer specifications using a variety of materials (e.g., steel, stainless steel, aluminum), parts, complete assemblies and capital goods to be incorporated into finished goods such as automobiles, aircraft, heavy trucks, medical devices, and appliances, among others. The precision machinery industry is a significant exporter in many advanced economies (Masao, 2011; Kenney, 2012). Due to fewer barriers to international trade, the precision machinery industry has followed the example of the mobile telecommunications industry by relocating its industrial networks to emerging economies.

The remainder of this introduction is structured as follows. Section 1.1 introduces all five papers of this PhD dissertation in short. Section 2 discusses the research questions put forth in each of the 5 dissertation papers. Section 3 introduces the key results of the individual papers and positions the papers in relation to the extant research by indicating their contributions to the existing body of knowledge. Section 4 addresses the study's implications for research, public policy and practice. Section 5 discusses the limitations of this dissertation. Finally, in Section 6, conclusions are drawn and directions for future research are presented.

1.1 Introduction to the papers

The first paper in this dissertation discusses why the contemporary competition in the smartphone industry is an ideal setting for studying Schumpeterian creative destruction. This current creative destruction is particularly interesting because the convergence of previously separate industries is pitting firms with differing business models from the old telecommunications world against the operating system winners of the old personal computer world and competitors from the new internet world. This paper utilizes insights from the literature on complementary assets and technology platforms to understand the competition in smartphone industry. This paper contributes to a broadened understanding of the contemporary industry convergence that is has the Internet and cloud computing at its unifying center, and intelligent communications devices at its edges. Furthermore, this paper extends the current academic discussion of the changes in the mobile telecommunications industry to consider the possibility that cloud computing will integrate a plethora of new devices that will include personal computers, smartphones, Internet-enabled televisions, and a nearly infinite number of other devices that will provide data to the cloud.

The second paper in this dissertation elaborates on and identifies the importance of understanding the unique characteristics of transfer pricing and cost accounting as part of the economic geography of value generation and profit capture in MNEs. In the extant literature, transfer pricing is considered to be the key determinant of an MNE's profits, but the question of how MNEs capture profits from global supply chains remains unanswered. This paper contributes to the existing literature on international trade theory and trade statistics by explaining the economic consequences of the increasing dispersion of added value, input costs and profits in global supply chains. The empirical evidence suggests that MNEs have many choices regarding where to geographically allocate their profits. Furthermore, translating this into concrete policy and trade statistics measures is of great relevance to understanding the contemporary phenomenon of globalization.

The third paper in this dissertation emphasizes the changes and transformation in the geographical distribution of value creation and the transition of business services from advanced economies to emerging economies in global supply chains during the last ten years. The existing research on global value chains at the industry and MNE levels primarily consists of single-point-of-time type studies, whereas this paper takes a longitudinal study approach. This paper contributes to the existing literature by describing how emerging economies are gaining from global competition, global supply chains and the associated manufacturing and services that have moved from advanced economies to emerging economies. Hence, advanced economies continue to manage the most valuable intangible assets.

The fourth paper in this dissertation identifies and elaborates on the links between international trade and firm-level data for trade in goods and trade in services. To investigate the issue, we perform grass-roots investigative work to uncover the geography of added value for a smartphone circa 2007. The smartphone was assembled both in Finland and China. When the smartphone was assembled and distributed in Europe, the value-added share of Europe rose dramatically. Even when the smartphone was assembled in China and distributed in the United States, Europe captured more than half of the added value because most of the service functions and intangible assets of the case company were geographically located in Europe. Our analysis illustrates that international trade statistics can be misleading; the capture of added value is largely detached from the flow of physical goods. Instead, services and other intangible aspects of the supply chain are dominant. Although final assembly – which commands two percent of the added value in our case – has increasingly moved offshore, developed countries continue to capture most of the added value generated by global supply chains.

The fifth paper in this dissertation tracks and describes the linkages between changes in a MNE's business environment and changes in its strategic offshoring and outsourcing actions and decisions in terms of its global supply chain. The case firm is one of the market leaders in mobile telecommunications network equipment. Furthermore, the paper explains how these transformations reflect the strategy and respective offshoring decisions of suppliers. The increasing amount of highly skilled labor in emerging markets enables industrial business networks to rearrange themselves along shorter life cycles. Furthermore, I find that different firms typically react to their customers' strategies with the same approach but implement and schedule their implementation in different ways. These differences in offshoring and outsourcing execution and implementation patterns also differ among industries.

2 Research questions

The key objectives of all five papers introduce new perspectives into the existing body of literature and empirical evidence on creative destruction, economic geography, global value chains, and strategic thinking related to MNEs. For these purposes, in the following subsections, the research questions of each of the five papers are introduced, explained, and discussed. All five papers draw on integral and related but diverse streams of literature, thus providing brief theoretical and empirical background for each of the four topics of creative destruction, economic geography, global value chains, and the strategic thinking of MNEs.

The first paper focuses on the role of complementary assets in dynamic business environments facing creative destruction, the next three papers focus on the economic geography and global value chain perspectives, and the fifth paper focuses on the role of strategic thinking in MNEs. All of the papers provide empirical findings for the current understanding of the contemporary determinants and geographical economy of added value, cost of inputs, and profits in global supply chains. Papers two, three, and four especially provide micro-level evidence and contributions to the existing literature by exploring the linkages between international trade theory, global trade statistics, national economies and global MNE supply chains through several cases and descriptive analysis.

Research question 1:
What are the strategies of the most powerful entrants and platform providers in the mobile Internet industry and what implications do their platform models have for a key group of partners, the mobile phone operators, which are the firms that actually provide connectivity to the mobile internet?

The first study is motivated by the lack of empirical evidence on current creative destruction, the role of complementary assets, and technology platforms in the contemporary mobile internet context. In particular, these three aspects are being ignored in the existing literature and current academic discussion. This current creative destruction is particularly interesting because current industry convergence is pitting firms and paradigms for the old telecommunications world against the operating system winners of the old personal computer and competitors from the new internet world (for an introduction to this topic, see Schumpeter, 1947; West & Mace, 2010; Kenney & Pon, 2011; Kenney & Seppälä, 2012).

This study sheds light on the usefulness of complementary assets and technology platforms in a situation in which macro-level innovation, or, in Schumpeter's words, a "new economic space", is opening, within which there can be many innovations. However, the entering firms are incumbents and therefore, by definition, have legal protection, scale and scope, and complementary assets. In the literature, complementary assets, technology platforms and the ability to combine these assets have been associated with firm performance and success (for reviews, see Teece, 1986; Tushman & Anderson, 1996; Cusumano & Yoffie, 1998; Cusumano & Gawer, 2002; Cusumano, 2010).

The contribution of this paper broadens the understanding of the currently occurring industry convergence that centers around the Internet and cloud computing and incorporates intelligent communication devices at its edges (for comparison, see Armbrust et al., 2009; Murray & Zysman, 2011). Furthermore, this paper extends the current academic discussion on the mobile telecommunications industry, which used to be controlled by incumbent telecommunications networks, mobile device makers, and carriers. Due to recent changes in industry dynamics, the contemporary mobile internet is now controlled by the multinational enterprises in the computer and Internet sectors; i.e., multinational enterprises from North America (for comparison, see West & Mace, 2010; Funk, 2012). Moreover, this paper contributes to the existing literature on competitive dynamics and the role of complementary assets in global value chains (for comparison, see Teece, 1986; Cusumano, 2010) by taking all these arguments into account when discussing the outcomes of the paper and their respective analyses.

Research question 2:
Where do multinational enterprises locate their costs and profits in global production networks?

The second paper is motivated by the fact that globalization is causing the disaggregation of production networks and investigates how these segregated rents of added value are geographically distributed among different national economies. The division of added value into input costs and profits, and how these two elements of added value are geographically distributed, is predominantly disregarded in the existing literature and theoretical discussion. The division of added value into input costs and profit is noteworthy because many national economies are trying to attract multinational enterprises to relocate their tangible and intangible resources to their national economies (for introductions on this topic, see Baldwin, 2006, 2009, 2011; Baldwin & Venables, 2010; Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011; Baldwin & Evenett, 2012).

This paper highlights the value of understanding the structures of multinational enterprises under specific global value chain governance models and transfer pricing mechanisms. In the literature, the global value chain governance models and transfer pricing mechanisms and the aptitude of using these associated theories creates a moderated way to capture the logic behind how multinational enterprises operate in disaggregated production networks (for reviews, see Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et al., 2005 for global value chains, and Kaplan & Atkinson, 1989; Edlin & Reichelstein, 1995, and Shelanski, 2004 for transfer pricing mechanisms).

The available trade statistics reveal little about the economic consequences of the increasing dispersion of input costs and profits because a multinational enterprise can distribute profits between all its business units or intangible assets or allocate the profits to one single business unit or intangible asset. The contribution of this paper broadens the existing literature on international trade theory and trade statistics by explaining the importance of separating the geographical distribution of input cost and profit analyses while considering the value added reporting of international trade (for comparison, see Baldwin & Evenett, 2012). In this paper, this separation of costs of inputs and profits is taken into account when discussing the outcomes for public policy.

Research question 3:
How have globalization and the disaggregation of value chains occurred in the mobile telecommunications industry between 2000 and 2007?

The continuation of geographical dispersion and the distribution of added value in global supply chains are correlated with increasing knowledge in emerging economies. The third article explores how multinational enterprises have responded to this change. This transformation in the transfer of knowledge was recognized several decades ago, and as knowledge flows to new economies, the added value of entire industries and single products or services is increasingly created in numerous countries instead of within single national economies. Furthermore, these developments impact where different technological and product development, prototyping, component manufacturing and final assembly activities take place. However, most of the technological and product development, prototyping and market-related knowledge have historically been located in advanced economies (for introductions on this topic, see Vernon, 1966, 1971; Quinn, 1969; Teece, 1977; Döring & Schnellenbach, 2005; Antràs & Rossi-Hansberg, 2009).

This article conceptualizes the dynamics of globalization, the changes in the geographical distribution of added value, and the transfer of knowledge from advanced economies to emerging economies through three distinct cases. For the specific literature related to international trade, global value chains, and knowledge transfer, it creates a modern way to capture the logic behind how multinational enterprises have systematically transferred their value-adding activities and knowledge from advanced economies to emerging economies. Furthermore, the article offers the opportunity to consider the commoditization of technology, task-level globalization, and the organizational level of value creation over multiple years (for reviews, see Gereffi, 1999; Pyndt & Pedersen, 2006; Mudambi, 2008; Linden et al., 2009; Dedrick et al., 2009, 2011).

Emerging economies already execute most of the tasks related to certain technologies, including product design and manufacturing. Advanced economies therefore continue to manage the most valuable intangible assets (for comparisons, see Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö et al., 2011). This paper broadens the existing literature and current academic discussion on the relocation of value chains and industrial networks, the offshoring and outsourcing strategies of firms, and agglomeration in the global economy (for comparisons, see Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö et al., 2011). In this paper, these arguments are taken into account when discussing the outcomes of a transformation within a single multinational enterprise.

Research question 4:
Who captures value in global supply chains?

The economic consequences of the increasing disaggregation of multinational enterprise processes, activities and tasks are not clearly visible in trade statistics. The fourth paper investigates how the geography of added value for goods and services plays out for a single product in global supply chains in the era of the second unbundling (for an introduction, see Baldwin, 2006). Furthermore, the paper demonstrates that the capture of value, the ultimate variable for multinational enterprises and nations, is less dispersed among global supply chains than processes, activities, and tasks. Moreover, as Grossman and Rossi-Hansberg (2008) argue, recent developments in transportation and communication technologies have weakened the relationship between labor and geographic location.

This paper conceptualizes the approach and methodology to analyze added value in a complete global supply chain of a multinational enterprise from the perspective of a single product. Furthermore, the paper conceptualizes how to calculate the geographical distribution of added value, not only based on multinational enterprise headquarters, but allowing for the generation of each component of added value created and captured by multiple locations and functions. Moreover, the paper offers an opportunity to compare macro-level international good and service trade statistics data to micro-level data on the product level and to analyze the differences in measures (for reviews, see Linden et al., 2009; Ali-Yrkkö, 2010).

Available trade statistics reveal little about the economic consequences of the increasing dispersion of added value; i.e., trade of goods and services (for comparison see Baldwin 2006; Ali-Yrkkö, 2010; Baldwin & Venables, 2010; Baldwin & Evenett, 2012). This paper extends the existing literature on international trade theory and trade statistics by explaining the importance of separating reporting on the trade in goods from that on the trade in services to capture the contemporary role of services in each economy (for comparison, see Baldwin & Evenett, 2012). This is only visible in minor details in current trade statistics reporting. In this paper, this separation of trade in goods and trade in services is taken into account when discussing the outcomes for public policy.

Research question 5:
How have offshoring and outsourcing advanced in global high tech business networks and supply chains from 2000 to 2010?

The fifth study is motivated by the accelerated pace of the disaggregation of multinational enterprise value and supply chains and how this disaggregation causes different phases of product life cycles to shift from advanced economies to emerging economies. The characteristics linked to changes in the leading multinational enterprises' business environments, offshoring and outsourcing strategies and operational structures, and how these changes are then reflected in the strategies and operational structures of industrial supplier networks, motivate this study. However, each industry, global supply chain, and industry supplier network evolves at its own rate (for introductions on this topic, see Blinder, 2007a, 2007b; Mudambi, 2008; Dunning, 1993, 1998; Pyndt & Pedersen, 2006, Seppälä, 2010, 2013).

This research tracks the industry dynamics and transformations of entire industry networks through multiple cases in which systematic knowledge transfer and catch-up effects to balance the inequalities between advanced economies and emerging economies play an important role. Tracking these strategies in global supply chains is therefore often a complex task. Furthermore, this study facilitates the discussion related to the shift from transferring knowledge related to tangible assets to intangible knowledge. Moreover, the research confirms the observation of Grossman and Rossi-Hansberg (2008) that a decline in labor costs has effects such as factor-augmenting technological progress (for reviews, see Mudambi, 2008; Ali-Yrkkö & Tahvanainen, 2009; Seppälä, 2010, 2013).

Disaggregation has and continues to play an important role in the strategic decisions of firms. New industrial networks are being transferred from advanced economies and rebuilt in emerging economies because of new market opportunities and lower costs (for comparison, see Mudambi, 2008; Baldwin & Venables, 2010). This paper extends the existing literature and current academic discussion on the relocation of value chains and industrial networks, the offshoring and outsourcing strategies of firms, and agglomeration in the global economy (for comparisons, see Pyndt & Pedersen, 2006, Sturgeon et al., 2008; Seppälä, 2010, 2013). In this paper, these arguments are taken into account when discussing the outcomes of multinational enterprises for multinational enterprise interaction.

3 Methodological aspects and research material

Qualitative research methods in general and case studies in particular have a long and distinguished history in management research; hence, research case studies have seldom been used in economics (Gummesson, 2000). Case studies have been used to develop theories on diverse topics (Yin, 1989, 1994, 2009; Eisenhardt & Greabner, 2008). However, theory built from case studies can sometimes be incomprehensive. As Eisenhardt and Greabner (2008) explain, building theory from case studies involves a rich empirical narrative of a specific phenomenon. A general limitation of case studies is related to the fact that there are no generally accepted guidelines for case assessments (Yin, 1989, 1994, 2009).

In this PhD dissertation, the discussion focuses on five different case studies in relation to the same contemporary phenomenon of globalization to provide a bridge between rich empirical narratives and mainstream research. Furthermore, all the case studies in the different papers focus on the same phenomenon but from different perspectives. It should be emphasized that the dataset for these case studies is unique. However, the dataset focuses only on two industries: mobile telecommunications and precision machinery. Nevertheless, the total number of 17 local and multinational enterprises are covered in the research program.

Inductive case studies in this particular PhD dissertation facilitate an understanding of a complex issue, extend experience and strengthen findings from previous research. Inductive case studies primarily generate new empirical findings on current contemporary globalization and help to set respective new theories. In management research, case studies are typically concerned with understanding the current status of a firm and serve as a starting point for improving its performance. The different papers of this dissertation use different types of research designs, data and levels of analysis; Table 1 summarizes these aspects.

Table 1
Summary of the research questions, research designs, key results, and contributions of the papers

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Title	Building Complementary Assets in a Unified TCP/IP World	Global Supply Chains and Transfer Pricing: Insights from a Case Study	Changing Geographies of Value Creation in Global Supply Chains: Evidence from Mobile Tele-communications	Who Captures Value in Global Supply Chains? Case of the Nokia N95 Smartphone	Tracking Offshoring and Outsourcing Strategies in Global Supply Chains
Research objective	To shed light on specific components of international trade theory and contemporary industrial dynamics in mobile telecommunications through the analysis of global value chains with a particular emphasis on the significance of these aspects in the context of the second unbundling.				
Research question	What different strategies are employed in the current mobile internet market?	How do multinational enterprises operate in contemporary global production networks?	How are the operational structures of multinational enterprises being transformed?	How do multinational enterprises operate in contemporary global supply chains?	How are the operational structures of global supply chains being transformed?
Specific research question	What are the strategies of the three most powerful entrants in the mobile Internet market?	Where do multinational enterprises locate their costs and profits in global production networks?	How have globalization and the disaggregation of value chains occurred in the mobile tele-communications industry between 2000 and 2007?	Who captures value in global supply chains?	How have off-shoring and outsourcing advanced in global high-tech business networks and supply chains between 2000 and 2010?
Level of analysis	Industry-level analysis	Multinational enterprise-level analysis	Multinational enterprise-level analysis	Multinational enterprise-level analysis	Industry and industry-network-level analysis
Research design and methodolo gy	Empirical, qualitative	Empirical, quantitative, case analyses	Empirical, quantitative, case analyses	Empirical, quantitative, case analyses	Empirical, qualitative
Data sources	Public data from eight firms; Qualitative interviews;	Case firm; Public data; ORBIS database (from Bureau van Dijk Electronic Publishing)	Public Data; Qualitative interviews; ORBIS database (from Bureau van Dijk Electronic Publishing)	Public data; Qualitative interviews; ORBIS database (from Bureau van Dijk Electronic Publishing)	Public data; Qualitative interviews; ORBIS database (from Bureau van Dijk Electronic Publishing)

Key results and insights	Inclusion of the geographical turnaround of industrial power through radical interventions Inclusion of two different technology platforms inside the mobile internet market	Identification and inclusion of different measures of trade in the era of the second unbundling: trade in added value, trade in cost of input, and trade in profits Identification and inclusion of the role of transfer pricing in dividing added value into cost of inputs and profits, between the different stages of global manufacturing networks, and by economic geography	Inclusion of the changes in the distribution of added value and in economic geography and inclusion of geographical dispersion of the different product life-cycle tasks, both in a longitudinal study Inclusion of the geographical dispersion of the value added by participants and economic areas in a longitudinal study Inclusion of the dynamics of the geographical dispersion of the different product life-cycle tasks between advanced and emerging economies in a longitudinal study	Identification and inclusion of different measures of trade in the era of the second unbundling: trade in goods and trade in services; identification of the new endogenous role of multinational enterprises in international trade. Identification and inclusion of the geographical dispersion of the value added by participants and by economic geography and the role of business services in trade and value creation and capture	Inclusion of the geographical dispersion of a supply chain Inclusion of the dynamics of the geographical dispersion of the supply chain in a longitudinal study

All of the papers of this PhD dissertation produce results of general interest, but their conclusions can be either general or specific regarding the number of case studies in each paper. The key results and contributions are presented in the next section of the introduction.

4 Key results and contributions

The overriding result and contribution of this PhD dissertation is to clarify the separation of added value into two distinct processes, the cost of inputs and profits, and how they are linked to international trade theory and trade statistics. Understanding these two processes and their respective economic geographies in light of two aspects of the contemporary phenomenon of globalization, the second unbundling and global value chains, is critical. Other results of this PhD dissertation contribute to contemporary research on industry dynamics and the global disaggregation of clusters.

4.1 Creative destruction in the mobile internet market

We are witnessing Schumpeterian creative destruction on an unprecedented scale in the mobile internet market Only 10 years ago, the mobile telecommunications industry was a controlled telecommunications network consisting of mobile device makers such as Ericsson and Nokia and incumbent carriers such as AT&T and Verizon. In 2012, the power of these players has declined and Silicon Valley is now at the center of competitive events in the mobile internet market The first paper of this PhD dissertation (Appendix 1) sets the scene for contemporary events in the mobile Internet market in which multinational enterprises from the Internet, computer and mobile telecommunications industries are merging into n-dimensional competition.

The first paper of the PhD dissertation (Appendix 1) contributes to the literature on industry dynamics, complementary assets and technology platforms by addressing research from a contemporary Schumpeterian creative destruction perspective. Complementary assets and technology platforms have so far been absent from the current literature and academic discussion related to the mobile internet market In existing research and literature on industry dynamics, complementary assets are well established; however, research and literature on technology platforms has focused mostly on a single-firm perspective, not an ecosystem perspective, as discussed in this paper.

To answer the research questions "*what are the strategies of the three most powerful entrants and platform providers in the mobile Internet industry?* and *"what implications will their platform models have for a key group of partners, the mobile phone operators, which are the firms that actually provide the connectivity in mobile internet?"*, this paper focuses on understanding symbiotic and context-driven relationships between the different multinational enterprises operating in a single mobile Internet ecosystem. Hence, many multinational enterprises drive their relationships in two mobile Internet ecosystems.

The first paper of this dissertation (Appendix 1) collected data from two sources: First, public data, such as press reports, blogs and other similar sources of information were studied; second, F-21 reports, financial reports, and press releases of eight multinational enterprises involved in mobile ecosystems and their direct competitors were assessed. This data set is essential for a dynamic analysis of contemporary events in the mobile internet market. Furthermore, the data allowed for the consideration of the strategies employed by multinational enterprises from the internet, computer, and mobile telecommunication industries.

The first paper makes an empirical contribution to the literature on industry dynamics (Seppälä & Martikainen, 2011; West & Mace, 2010; Kenney & Seppälä, 2012; Funk, 2012; Seppälä & Kenney, 2012), complementary assets (Teece, 1986; Tushman & Anderson, 1996), and technology platforms (Cusumano & Yoffie, 1998; Cusumano & Gawer, 2002; Cusumano, 2010; Kenney & Pon, 2011).

The general results of the analyses of the first paper of the dissertation (Appendix 1) indicate that we are witnessing a geographical shift of industrial power caused by the radical innovations represented by Apple's and Google's business models, especially Google's, in the current mobile Internet market. Empirical evidence indicates that Google's revolutionary business model in particular appears to be the current winning model in the race for competitive and positional advantage in the mobile internet market. However, the future role of the operating system in the mobile internet market remains unclear if the main functions of the operating system and their respective technological architecture are transferred to the cloud with its respective technological architecture. This development then causes the separation into two different technology platforms inside the mobile internet market: device and cloud. This observation is particularly interesting when considering the future dynamics in the mobile internet market in relation to n-dimensional competition.

The key result of the analyses of the first paper of the dissertation (Appendix 1) is related to the complementarity of Google's technologies and service platforms, which take generic, specialized, and non-specialized complementary assets into account. Google provides technologies and service platforms such as Google Play, the Android operating system, cloud services and other technologies and service platforms free of charge to different stakeholders in its mobile internet ecosystem as well as to consumers. This may impede, however, the other ecosystem members from capturing monopolistic rents because they constantly compete with other firms using the platform. Finally, as we have shown, because of Google's weak lock-in, it must protect itself by having positions in the largest number of spots in the value chain/stack.

4.2 Economic geography of added value, cost of inputs, and profits

The so-called "new trade theory" and, more recently, the literature on economic geography and global value chains have enriched the economic understanding of international trade. However, anyone who has sought to understand the shift in international trade between the first and second unbundlings over the past years has faced the problem of low quality trade statistics. The second paper of this PhD dissertation (Appendix 2) contributes to the extant literature by focusing on the specifics of global value chain analytics from the perspective of international trade theory and the economic geography of added value, cost of inputs, and profits; in contrast, earlier literature and empirics have focused on the first type of unbundling in international trade theory and trade statistics.

To answer the research question "*where do multinational firms locate their costs and profits?*", the paper highlights the fact that multinational enterprises can distribute profits between all their business units or intangible assets or allocate the profits to one single business unit or intangible asset. Hence, trade statistics on added value, cost of inputs and profit levels would reveal the change from the first unbundling to the second unbundling. Furthermore, new trade statistics would expose the contemporary role of multinational enterprises and national economies in modern international trade.

The second paper of this PhD dissertation (Appendix 2) uses data collected from a multinational Finnish precision machinery enterprise. The data focuses on the individual aspects of "simple economics," i.e., invoice-level data based on the cost accounting and transfer pricing data for a single precision machinery product manufactured by a multinational enterprise with assembly facilities in three macro regions – Northern Europe (Finland), Asia (China), and North America (USA). The product is produced internally in six separate modules and then assembled in one of the three regions for final delivery to the customer.

The paper makes methodological (Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011; Baldwin & Evenett, 2012) and empirical (Baldwin, 2006, 2009, 2011; Baldwin & Venables, 2010; Baldwin & Evenett, 2012) contributions to the discussion of the new international trade theory and the respective academic discussion on the second unbundling and global value chains (for global value chain literature, see Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et al., 2005; Sturgeon et al., 2008).

The results of the analyses of the second paper of the dissertation (Appendix 2) indicate that we have witnessed a new industrial revolution. However, multinational enterprises appear to be ahead of the game, and international trade statistics are lagging behind. In this paper, we have identified and illustrated new measures of trade statistics in the industrial era of the second unbundling: trade in added value, trade in cost of inputs, and trade in profits. Furthermore, we have identified and illustrated the role of transfer pricing in dividing added value into cost of inputs and profits between different stages of global manufacturing networks, and by economic geography. Moreover for nation-states, as value and supply chains become more international and complex, critical measures such as gross domestic product, worker productivity etc. are becoming ever more imprecise.

The single most surprising observation to emerge from the case analyses is that MNE's accounting system and the transfer pricing mechanism do not necessarily represent where the most valuable assets of the MNE are geographically located. This could be because the case firm used to manufacture its products mainly in one single economy and has recently distributed its operations and supply chain on a global scale; the accounting system and transfer pricing mechanisms are simply lagging behind.

4.3 Tracking transformations in global value chains

The rising share of offshoring in global economies highlights the crucial role of tracking transformations in global value chains in detail. Furthermore, anyone who has attempted to understand these transformations and the respective disaggregation of the supply chain between advanced economies and emerging economies over the last decades has been faced with deficient empirics. The third paper of this PhD dissertation (Appendix 3) contributes to the extant literature and empirics by focusing on the specifics of global value chain analysis from the perspective of the changes in economic geography and knowledge transfer in a longitudinal study; in contrast, earlier literature and empirics have focused on single-point-of-time studies.

To answer the research question "*how have globalization and the disaggregation of the value chain occurred in the mobile telecommunications industry between 2000 and 2007?*", the paper focuses on understanding how added value is distributed among the different participants of global supply chains, the geographical distribution of added value, in which geographical economy major tasks related to the product are actually performed, and how these developments have changed from the late 1990s until today. Furthermore, the third paper of the PhD dissertation (Appendix 3) sheds light on the progress of the geographical dispersion of supply chains and how this dispersion correlates to the increasing volume of knowledge in emerging economies.

The third paper of this PhD dissertation (Appendix 3) uses data collected from a multinational Finnish telecommunications enterprise. The data focus on the details of three products with similar functionalities but differences in industrial design. This is ideal for a dynamic examination of value creation at the product level. Furthermore, the data allow for the consideration of the commoditization of the technology, globalization at the task level, and geographical and organizational value creation at the product level. The product is produced internally in several different manufacturing locations for final delivery to the customer.

The third paper makes an empirical contribution to the discussion on the new international trade theory and the respective academic discussion on the second unbundling (Baldwin, 2006, 2011; Baldwin & Venables, 2010; Baldwin & Evenett, 2012). Furthermore, the paper makes another empirical contribution to the literature on geographic economy and global value chains (Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et al., 2005; Sturgeon et al., 2008; Mudambi, 2008).

The results of the analyses of the third paper of the dissertation (Appendix 3) indicate changes in the distribution of added value, economic geography, and the geographical dispersion of the different product life-cycle tasks in a longitudinal study. Three key results of the analyses were found: *First*, the emerging economies execute most tasks related to technology and product development, prototyping, component manufacturing and final assembly. Furthermore, market knowledge is located in emerging economies (in reference, see Mudambi, 2008). *Second*, because the emerging economies execute most of the tasks, the created added value has increased. Third, an increase in more demanding tasks in developing countries has required a competence transfer from developed countries. Rather than occurring suddenly, this process has taken place gradually over several years. Overall, our study provides product-level insight into task-level globalization and how it impacts value creation in different regions. Developing countries such as China are no longer just manufacturing locations; increasingly, they are undertaking tasks with greater added value, including management and R&D tasks.

4.4 Economic geography of added value by supply chain participants

The new models to construct the economic geography based on global value chain analyses are models in which multinational enterprises arise endogenously. Hence, investigating the role of services in international trade and in manufacturing in general during the time of the second unbundling has been limited by scarce trade statistics. The fourth paper of this PhD dissertation (Appendix

4) contributes to the extant literature and empirics by focusing on the specifics of global value chain analytics from the perspective of the international trade theory and the economic geography of added value; in contrast, earlier literature and empirics have focused on the first type of unbundling in international trade theory and on trade statistics.

To answer the research question "*who captures value in global supply chains?*" the paper highlights the fact that current trade statistics can be highly misleading in economic analyses because they continue to measure the gross value of cross-border trade instead of added value. Hence, trade statistics on added value would partly reveal the change from the first to the second unbundling. Furthermore, new added value trade statistics would expose the contemporary roles of multinational enterprises and national economies in current international trade. Moreover, the value added in different manufacturing stages could be properly measured.

The fourth paper of this PhD dissertation (Appendix 4) uses data collected from five different sources in relation to a product that is designed and manufactured by a multinational Finnish telecommunications enterprise. The data focus on individual aspects of public information and on further qualitative and quantitative information collected via interviews with sixteen industry experts who are currently working or have previously worked in various roles in the telecommunications supply chain.

The paper makes methodological (Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö, 2010) and empirical (Baldwin, 2006, 2009, 2011; Baldwin & Venables, 2010) contributions to the discussion on the new international trade theory and the respective academic discussion on the second unbundling and global value chains (for global value chain literature, see Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et al., 2005; Sturgeon et al., 2008).

The results of the analyses of the fourth paper of the dissertation (Appendix 4) indicate that we have witnessed an appropriately industrial revolution. However, multinational enterprises appear to be ahead of the game, and international trade statistics are lagging behind. In this paper, we have identified and illustrated the importance of differentiating between trade in goods and trade in services in trade statistics in the industrial era of the second unbundling. Furthermore, we have identified and illustrated the geographical dispersion of added value by participants and by economic geography and the role of business services in trade and the creation and capture of value.

The results of our analyses have three broad implications. *First*, our results highlight the irrelevance of the lingering manufacturing vs. services discussion.

Second, international commodity trade statistics that continue to record the gross values of cross-border flows of goods can be highly misleading. *Third*, in many countries, national policy makers appear to have an obsession with attaining a certain national final assembly capacity. Hence, the objective of the national economy should be to capture as much added value as possible. For example, while China is determined not to remain a "2%" assembly location and is rapidly extending its higher value adding functions, Europe and the USA retain many advantages in providing globally differentiated inputs.

4.5 Tracking transformations in industry networks

The geographical dispersion of value and supply chains has recently begun to play an increasingly important role in the analyses of offshoring and outsourcing. Anyone who has been interested in offshoring and outsourcing has been faced with an abundance of empirical data on value and supply chains but a lack of data on single multinational enterprises. The fifth paper of this PhD dissertation (Appendix 5) contributes to extant literature and empirics on offshoring and outsourcing by focusing on the specifics of tracking the transformation of a complete supply chain. Furthermore, the paper focuses on describing the transformation in terms of economic geography and the respective knowledge transfer process among the different multinational enterprises participating in the supply chain over a certain period of time.

To answer the research question "*how have offshoring and outsourcing advanced in global high-tech business networks and supply chains between 2000 and 2010?*", the paper focuses on understanding the changes in the business environment and strategies of leading firms and how these changes affect the different participants in a leading firm's supply chain. However, industry dynamics appear to differ from those in the mobile devices industry (Seppälä, 2010, 2013). Furthermore, the fifth paper of the PhD dissertation (Appendix 5) sheds light on the progress of the geographical dispersion of supply chains and how this dispersion correlates to the increasing volume of knowledge in emerging economies.

The fifth paper of this dissertation (Appendix 5) used data collected from two sources. First, between August 2010 and May 2011, 14 semi-structured qualitative interviews were conducted. Second, public data, such as F-21 reports, financial reports, and press releases of the involved multinational enterprises and their direct competitors were assessed. This data collection is essential for a dynamic analysis of offshoring and outsourcing in global supply chains. Furthermore, the data allowed for the consideration of the role of technology commoditization in the offshoring and outsourcing decisions of a multinational enterprise.

The fifth paper makes an empirical contribution to the literature on geographic economy and global value chains (Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et al., 2005; Sturgeon et al., 2008; Mudambi, 2008). The results of the analyses of the fifth paper of the dissertation (Appendix 5) demonstrate the changes in and the dynamics of the geographical dispersion of a supply chain in a longitudinal study.

The results of the analyses of the fifth paper of the dissertation (Appendix 5) indicate that the dynamics of industrial networks that cause the disaggregation of global supply chains continue to be one of the key operational strategies implemented by MNEs. This implies that the knowledge transfer – catch-up effect continues to close the skilled labor gap between advanced and emerging market economies. Furthermore, shortages in the labor supply and technology commoditization seem to be other key drivers for firms to relocate their global supply chains from advanced to emerging market economies.

4.6 Synthesis

To illustrate the contributions of the different papers (Appendixes 1, 2, 3, 4, and 5) to the literature on international trade theory, economic geography, global value chains, industry dynamics and the global disaggregation of clusters, Table 2 classifies extant literature and analyses on global value chains and provides the main references. The contributions of the different papers were discussed in greater detail in section 4.1–4.5, above.

The key results and contributions of this PhD dissertation (Appendixes 1, 2, 3, 4 and 5) are aligned with the discussion of the linkages between international trade theory and its respective trade statistics as well as how value chain analytics that employ “simple economics” are used to analyze the behaviors of multinational enterprises in global production networks and supply chains (for a comparison, see Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö, 2010; Baldwin & Venables, 2010; Baldwin & Evenett, 2012). Furthermore, using “simple economics,” i.e., transfer pricing mechanisms and the cost accounting of multinational enterprises, the added value can be divided into two different types of trade, cost of inputs, profits, and the respective economic geography. The implications for research, public policy and practice are presented in the next section of the introduction.

Table 2
The existing body of knowledge on global value chains

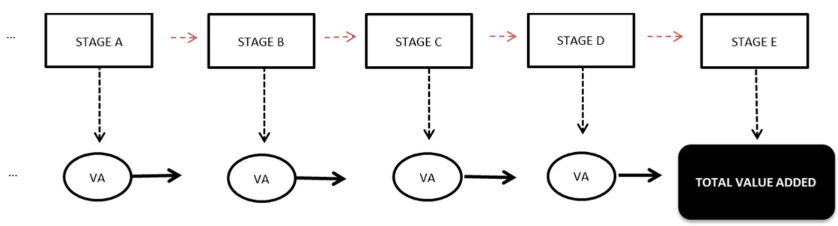
Elements of global value chains	Extant research and literature	Contribution of papers and the dissertation
International trade theory and second unbundling	Vernon, 1966; Helpman, 1984; Markusen, 1995; Markusen & Venables, 1998, 2007; Baldwin, 2006, 2009, 2011; Baldwin & Evenett, 2012	Paper 2. Identification and inclusion of different measures of trade in the era of the second unbundling: trade in added value, trade in cost of inputs, and trade in profits Paper 4. Identification and inclusion of different measures of trade in the era of the second unbundling: trade in goods and trade in services; identification of the new endogenous role of multinational enterprises in international trade.
Global value chains and analytics	Eccles, 1985; Kogut, 1985; Porter, 1986, 1990; Hopkins & Wallerstein, 1986; Gereffi, 1994, 1999; Gereffi et. al., 2005; Hanson et. al., 2005; Sturgeon et. al., 2008; Linden et. al., 2009; Dedrick et. al., 2009, 2011; Ali-Yrkkö, 2010; Baldwin & Venables, 2010;	Paper 2. Identification and inclusion of the role of transfer pricing in separating added value into cost of inputs and profits, between the different stages of global manufacturing networks, and by economic geography Paper 3. Inclusion of changes in the distribution of added value and economic geography and the inclusion of the geographical dispersion of different product life-cycle tasks, both in a longitudinal study Paper 4. Identification and inclusion of the geographical dispersion of added value by participants and by economic geography and the role of business services in trade and the creation and capture of value
Off-shoring and geographical dispersion of added value	Vernon, 1966, 1971; Quinn, 1969; Teece, 1977; Döring & Schnellenbach, 2005; Grossman & Helpman, 2005; Pyndt & Pedersen, 2006; Antràs & Rossi-Hansberg, 2009; Grossman & Rossi-Hansberg, 2008; Mudambi, 2008; Seppälä, 2010, 2013	Paper 1. Inclusion of geographical changes in industrial power through radical innovations Paper 3. Inclusion of geographical dispersion of added value by participants and economic areas in a longitudinal study Paper 5. Inclusion of the geographical dispersion of a supply chain
Industry dynamics, complementary assets, and technology platforms	Teece, 1986; Tushman & Anderson, 1996; Cusumano & Yoffie, 1998; Cusumano & Gawer, 2002; Cusumano, 2010; Seppälä & Martikainen, 2011; West & Mace, 2010; Kenney & Pon, 2011; Kenney & Seppälä, 2012; Funk, 2012; Seppälä & Kenney, 2012	Paper 1. Inclusion of the two different technology platforms in the mobile Internet industry Paper 3. Inclusion of the dynamics of geographical dispersion of different product life-cycle tasks between advanced and emerging economies in a longitudinal study Paper 5. Inclusion of the dynamics of geographical dispersion of a supply chain in a longitudinal study

5 Implications for research, public policy and practice

This PhD dissertation investigates the contemporary phenomenon of globalization from the perspective of the second unbundling. Furthermore, this PhD dissertation explores three micro-level determinants of globalization: the dynamics of industries, the economic geography of multinational enterprises (MNEs) and the global configurations of value chains and their respective industrial networks. Each paper of this PhD dissertation identifies areas in the extant literature in which there are empirical gaps and makes related contributions. The contemporary phenomenon of globalization is broad. We would therefore like to emphasize the discussion of the implications of the PhD dissertation papers.

The spatial disaggregation of global value chains continues (Baldwin & Evenett, 2012). Furthermore, there are numerous stages of added value in global supply chains (see Figure 1 for illustration). In each stage of a global supply chain, value added is created, either positive or negative.

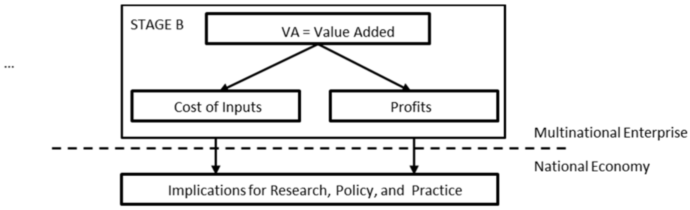
Figure 1
Each stage/participant in a global supply chain creates value added



The value added created at each stage of the supply chain can be further divided into inputs of cost of inputs and profits based on "simple economics": the transfer pricing mechanisms and cost accounting of a multinational enterprise. This approach then allows for the calculations of how the added value, cost of inputs and profits are distributed among different national economies as separate measures of trade in added value (see Figure 2 for illustration).

These contemporary organizational choices of multinational enterprises impact national policy makers and change their respective policies. Figures 1 and 2 illustrate how each stage of the global supply chain has implications for research, policy, and practice. These implications are presented in the next sections.

Figure 2
The division of added value into cost of inputs and profits at each stage in a global supply chain and the respective policy implications



5.1 Implications for research

As a contribution to contemporary research, this PhD dissertation and its respective papers demonstrate that the global value chain literature lacks an appropriate methodology to evaluate and understand the contemporary phenomenon of globalization. However, the methodology and literature provide a set of criteria and tools to be developed. As Sturgeon et al. (2008) and Baldwin and Evenett (2012) note, the research is in a nascent stage because we lack empirical evidence. To date, a few empirical analyses have been conducted, but with major limitations due to a lack of understanding of the contemporary behaviors of multinational enterprises in global supply chains. This PhD dissertation shows that there is a great opportunity to confront assertions about globalization with facts from multinational enterprises and a reasonably good methodology.

- **The relevance of contemporary public policies should be evaluated from the perspective of the second unbundling**

This PhD dissertation and its respective papers serve as a useful foundation to empirically challenge the assertions that have been made in relation to global value chains. The first encouraging avenue for future research is to continue extending the current methodology to new areas of analyses, including social and educational policies, and especially job creation policy, and to measure the efficiency of these policies in longitudinal studies. As Tahvanainen (2011) notes in his PhD dissertation, to improve the efficiency of public policies, we need to understand geographical economics and how the geography of multinational enterprises affects the evolution of national economies; we also need to understand the distribution of added value in global supply chains, their respective industry networks and the role of the public sector. Such an understanding would first require several research teams to benchmark the developed methodology and its usage for global value chain analysis. Furthermore, a theory for global value chains could be created.

- **Measures on the trade of cost of inputs and trade of profits should be evaluated and calculated from the perspective of a national economy**

The second encouraging avenue for research is related to international trade theory and new measures of trade because the results from paper two (Appendix 2) show that the geographies of added value, cost of inputs and profits differ significantly from one another. Measuring only trade in added value leads to different conclusions than separately measuring cost of inputs and profits. Such a new study could test the validity and implementation of the new measures of trade. Furthermore, such new measures of trade could lead us to understand the contemporary phenomena of globalization through different means. In particular, understanding the geographies of cost of inputs and profits could lead to small adjustments in the principles of comparative advantages and the respective theories of national economies.

- **Value capture through the different phases of product and innovation life cycles should be analyzed more thoroughly using the basic methodology from paper four of the dissertation**

The third promising pathway for research is in the area of innovation profits (for introduction, see Teece, 1986; Dedrick et al., 2009). Such research would be interesting because Teece (1986) offers a framework in which he identifies the factors that determine who captures profits from innovation. However, specific empirical evidence is missing. Dedrick et al. (2009) take a step in the right direction because their empirics are based on a single point in time. Furthermore, Dedrick et al. (2009) do not consider innovation profits over the product life cycle and do not explain the amount of market access. Identifying the outcomes of innovation profits from a product life cycle is a great opportunity for future studies.

Finally, future studies could investigate the efficiencies of different designs and manufacturing locations for a product or a service of a multinational enterprise by using the same global value chain methodology and analyses. This study would be especially interesting when considering the transfer of knowledge between advanced and emerging economies and its respective advantages and disadvantages for national economies and multinational enterprises. The implications for public policy and practice are presented next.

5.2 Implications for public policy

Offshoring and outsourcing have distributed different tasks and stages of global value and supply chains across the world. Furthermore, technological changes in products and services and changes in organizational structures continue because multinational enterprises continue to search for new markets and new positioning and competitive cost advantages. These changes could lead to increased national employment and investment losses in most advanced economies but also in emerging economies if markets mature, costs rise and investments decline. The contributions of this PhD dissertation and the five papers have the three following potential implications for public policy.

- **Micro-level units of control for national policies should be considered**

Based on economics thinking, the national economy continues to be the unit of control for national policies. The first implication for public policy is two-dimensional: first, the implication relates to micro-level units of control inside and between national economies; second, the implication relates to the larger unit of control for policies that are not decided by a single national economy but a larger consortium of national economies. All five papers indicate that policy makers are still lacking behind in comparison to multinational enterprises (Appendix, 1, 2, 3, 4 and 5). This finding confirms the observation by Baldwin and Evenett (2012) that national policies are still considered through the eyes of the first unbundling.

- **In mature industries, the changes in technological lifecycles, organizational structures and global supply chains continue to be longitudinal**

One of the key implications for public policy relates to the role of longitudinal policies. In terms of the contemporary phenomenon of globalization through the eyes of the second unbundling, longitudinal policies continue to be the backbone for mature industries and industrial networks. As indicated in papers three and five (Appendixes 3 and 5), changes in industry structures require long-term strategic planning and implementation; however, if sudden changes occur in the business environment, there might be a need for supporting short-term policies

- **Employment structures in national economies continue to be multi-level – manufacturing jobs continue to be of importance**

Another key implication for public policy relates to employment structures in national economies. Typically, employment structures include primary (e.g., mining), secondary (e.g., manufacturing), tertiary (e.g., teaching) and quaternary (e.g., research & development) jobs. Regarding second unbundling and the disaggregation of tasks and stages of global value and supply chains, secondary jobs should be treated equal to quaternary jobs. As noted in papers three, four, and five (Appendix 3, 4, and 5), especially in paper three, the connection between manufacturing job losses and business service job losses continues to be high, especially in the area of commoditized technologies. However, the relationship to research & development is indistinguishable. The implications for practice are presented next.

5.3 Implications for practice

The change from the first to the second unbundling has been a long-term, multi-year process for multinational enterprises. The spatial reorganization of global value chains during the past fifteen years has been partly caused by the possibility of coordinating the tasks of product life cycles and stages of global supply chains from a distance and partly due to the developments in information and communication technologies, especially in the area of distributed team management tools and enterprise resource management systems. The earlier architecture of such tools and systems were designed and built to manage single tasks and operations such as during the first unbundling. However, the architecture of tools and systems started to change in early 2000, enabling the geographic disaggregation of the tasks and stages of global supply chains in a coordinated manner.

- **The role of management systems and information and communications technology platforms should not be underestimated**

It could be argued that many multinational enterprises do not consider management systems and information and communication technology platforms as enablers for the management of teams and the coordination of he globally dispersed stages of supply chains and industrial networks. Papers three and five (Appendix 3, and 5) explicitly explain the role of disciplined management systems while managing planned knowledge transfers between different geographical locations but also while managing agreed transformations in global supply chains between multinational enterprises. Furthermore, there is a great opportunity for multinational enterprises to enhance their performance though the effective use of different distributed team management tools and enterprise resource management systems.

- **The optimization of the cost of inputs , profits and taxation performance of multinational enterprises on the task and product levels should be further investigated**

The second unbundling offers a great opportunity for multinational enterprises to plan and implement optimized task- and stage-level input cost, profits and taxation processes. In particular, paper two (Appendix 2) provides temporal and spatial distinctions of these three different processes of the multinational enterprise from the perspective of economic geography. Moreover, this level of planning and implementation represents an opportunity for multinational enterprises to further enhance their financial performance. However, additional resources might be needed for planning and implementation.

6 Limitations

The most noteworthy limitations of this PhD dissertation relate to the broad phenomenon of contemporary globalization under investigation and the case studies and respective data sets used in papers two, three, and four (Appendix 2, 3 and 4). Contemporary globalization includes various components and theories that provide a variety of different empirical perspectives. The discussion in this PhD dissertation is focused on the time of the second unbundling, and the emphasis is more on the methodology used to analyze the geographic distribution of added value, input costs and profits than on actual changes within the economic geography between advanced and emerging economies. This focus then allows for the provision of empirical evidence about the transformation from the first to the second unbundling. It should be noted that the methodology is used only for five product analyses in three papers (Appendix 2, 3, and 4). Nevertheless, a total of 39 product case studies were conducted in research program. For the sake of clarity, all the limitations of the five different papers will be addressed in this introduction chapter.

In addition to one general limitation, this dissertation is subject to several paper-specific limitations. I first explain the limitations of papers two, three and four (Appendix, 2, 3, and 4) because the limitations of paper four build on the limitation of papers two and three.

In the fourth paper of the PhD dissertation, the global value chain analysis methodology is used for the first time. However, a similar methodology has been used by Linden et al. (2009) for analyzing Apple's iPod. Hence, our analyses focus on the added value created by different participants in a global supply chain rather than on gross margins. Furthermore, the theoretical approaches differ because our approach relies on economic rather than management theories. To our knowledge, this paper is the first to use this methodology. The other limitations of the fourth paper of the PhD dissertation are related to the data. Most significantly, we did not have access to either the internal cost accounting or transfer pricing data of multinational enterprises; we only had access to external sources of information and public information.

In the third paper of the PhD dissertation, the global value chain analysis methodology is used for a dynamic approach to analyze transformations of shares of added value between different economies in a longitudinal study. To our knowledge, this paper is the first to empirically demonstrate such systematic added value and knowledge transformations between advanced and emerging economies. Furthermore, the same limitations that apply to paper four also apply to this paper.

Additionally, a second limitation of the second paper of the PhD dissertation is that the global value chain methodology is further developed to analyze not only added value but also two different measures of added value; cost of inputs and profit. Furthermore, the economic geography is calculated separately for the three measures. To our knowledge, this paper is the first to use such an approach to calculate the differences in economic geography. Moreover, the limitations that apply to papers three and four also apply to this paper, with the exception that, in this case, we had access to the cost accounting and invoice-level transfer pricing data of multinational enterprises.

In addition to the limitations in papers two, three and four, papers one and five are subject to specific limitations as well. In the first paper of this PhD dissertation (Appendix 1), the complexity of the researched phenomenon is a limiting factor. Furthermore, in the fifth paper of this PhD dissertation, the complexity of understanding complex transformations in global supply chains is a limitation. However, this is the second such study on the topic of "Transformations of Mobile Telecommunications Supplier Networks" (see Seppälä, 2010, 2013).

7 Conclusions and future research

The purpose of the introduction of this PhD dissertation is to describe how all five papers of the dissertation are integrated as a whole. Furthermore, the other rationale behind the introduction is to illustrate how the different papers and respective case studies with rich empirical narratives serve as a bridge between the mainstream research on the second unbundling and international trade theory. With these empirically rich case studies, the theory building research should result in new insights on contemporary globalization. Moreover, the replication of similar case studies is important if the ultimate goal is to develop a new theory.

This PhD dissertation has addressed the contemporary phenomenon of globalization by concentrating on providing specific empirical evidence on creative destruction, economic geography, global value chains, and the strategic thinking of MNEs. For these purposes, each of the five papers focuses on a different aspect of a theory and empirics. Furthermore, the PhD dissertation highlights areas where there are gaps in theory, literature, methodology, and empirics and discusses possible contributions to shed light on these areas and their respective approaches.

The first paper (Appendix 1) of the PhD dissertation explained the Schumpeterian creative destruction that is taking place in the contemporary mobile internet market The second paper (Appendix 2) discussed the specifics of global value chain analytics from new empirical perspectives of the economic geography of added value, cost of inputs, and profits and the respective contributions to international trade theory and trade statistics. The third paper (Appendix 3) focused on the specifics of global value chain analytics from two new empirical perspectives, economic geography and knowledge transfer, in a longitudinal study. The fourth paper (Appendix 4) concentrated on the specifics of global value chain analytics from two perspectives: the international trade theory perspective and the economic geography perspective of value added. The fifth paper (Appendix 5) explained the essence of tracking transformations in a complete supply chain and especially focused on describing the transformation in economic geography and the respective knowledge transferring process between the different multinational enterprises participating in global supply chains. All papers of this PhD dissertation contribute to the contemporary phenomenon of globalization from the perspective of the second unbundling.

There are several potential directions for future research. The first potential direction for future research is related to the methodology used in papers 2, 3, and 4 (Appendix 2, 3, and 4), extending the methodology to the areas of social, education and especially job creation policy. The second promising direction of future research relates to the area of international trade theory and new trade measures. In particular, the results related to the geographical distribution of inputs of cost and profits are interesting. The third promising area for future research is the analysis of innovation profits from two specific perspectives: first, the product and innovation life cycle perspective, and second, the transformative economic geography perspective. Finally, future research could investigate the efficiencies of different innovations, designs and manufacturing locations of a product or a service from multi-industry and enterprises viewpoints.

All future research should focuses on further understanding the contemporary phenomenon of globalization and developing a methodology for understanding global value chains and the respective changes in economic geography. Furthermore, it enables us to understand the second unbundling and possible future transformations.

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Appendix 1

Building on Complementary Assets in a Unified TCP/IP World

Timo Seppälä & Martin Kenney

"... the whole world had one language – one common speech for all people. The people of the earth became skilled in construction and decided to build a city with a tower that would reach to heaven. By building the tower they wanted to make a name for themselves and also prevent their city from being scattered. God came to see their city and the tower they were building. He perceived their intentions, and in His infinite wisdom, He knew this "stairway to heaven" would only lead the people away from God. He noted the powerful force within their unity of purpose. As a result, God confused their language, causing them to speak different languages so they would not understand each other. By doing this, God thwarted their plans. He also scattered the people of the city all over the face of the earth..."

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Abstract

The contemporary competition in the smartphone industry is an ideal setting for studying Schumpeterian creative destruction, the role of the complementary assets, and the strategic use of technology platforms. This current creative destruction is particularly interesting because the current convergence from previously separate industries is pitting firms with differing business models from the old telecommunications world against the operating system winners of the old personal computer, and competitors from the new internet world. This paper utilizes insights from the literature on complementary assets and technology platforms to understand the completion in smartphones. This paper contributes a broadened understanding of the contemporary industry convergence occurring with Internet and cloud computing at its unifying center, and with intelligent communications devices at its edges. Furthermore, this paper extends the current academic discussion of the changes in the mobile telecommunications industry to consider the possibility that cloud computing will integrate a plethora of new devices that will include personal computers, smartphones, the internet-enabled television, and a nearly infinite number of other devices that will provide data to the cloud.

INTRODUCTION

The long discussed digital convergence appears to be finally occurring with the Internet and cloud computing at its unifying center, and with intelligent communications devices at its edges (Kushida et al., 2011).[1] Convergences are particularly interesting periods; these are moments when incumbents and their ecosystems are threatened with becoming irrelevant. Theory suggests that complementary assets can be used by incumbents to deflect attacks by new entrants (Teece, 1986) intent upon overcoming the incumbent's competences (Tushman and Anderson, 1986). As these firms come into competition with each other to navigate the convergence, firms must understand and/or build their advantages. The current convergence is driven by the mobile phone becoming a smart phone, which is essentially a hand-held computer. This is a fascinating setting for exploring firm strategy, not only for its own sake, but because the smartphone and tablets are becoming the key edge devices for the entire ICT industry.

For firms in emerging new industries or those being transformed by new technologies, firms must identify the correct business model and occupy the key strategic position to ensure survival and an ability to capture out-size rents. Much of the recent analysis in the ICT industry has focused upon the position that Microsoft, Intel, Cisco, Qualcomm and others have achieved by controlling key technologies that would become industrial platforms (see Cusumano and Gawer, 2002; Gawer and Cusumano, 2002; Gawer and Henderson, 2007; Gawer and Cusumano, 2008; Gawer, 2009; Cusumano, 2010). In the PC industry, Intel and Microsoft occupied the key positions and their duopoly was termed Wintel (Borrus and Zysman, 1997). The general gist of the platform literature has been to suggest firms can occupy a favorable business position by encouraging the growth of a third-party provider ecosystem on their platform. To illustrate, in an examination of handheld computing operating systems Boudreau & Hagiu (2009) found that "granting access to complementors accelerated the introduction of new devices by a factor of roughly five," while giving up control over the platform completely only increased the introduction rate by roughly 20%"[2] Thus, the general advice in the platform literature is to develop a platform, allow its use by complementors, but retain control over the platform.

The mobile Internet is particularly interesting, because the current convergence is pitting firms and paradigms from the old telecommunications world

[1] For a useful description of what cloud computing is, see, for example, Armbrust et al. (2009).

[2] One oddity about this study was that many of the entrants had no complementary assets, while those granting access like Microsoft had enormous existing power, so the playing field was hardly level.

against the operating system winners of the old PC world and entrants from the new Internet world. This strategic competition is a complicated, many-sided struggle, not only because these are multiple-sided markets (Hagiu and Wright 2011), but also because of the significant variety of business models, a variety of technologies and the layered nature of the computer-telephony industry. This article sheds light on the usefulness of these complementary assets in a case within which the macro-level innovation, or in Schumpeter's terms a "new economic space," is opening and there can be many innovations, but the firms entering are incumbents from adjacent industries and so by definition have assets in terms of legal protections, scale and scope, and complementary assets.

This convergence and business model competition can best be seen in the current rivalry in the emerging mobile internet ecosystem. Three competitors, each with their own strategy, technology, platforms, and complements are trying to define the new space even as they continue to eye personal computers and televisions. Their decisions, strategies, and success are likely to frame the ecosystem for all of the other ICT constituents, not only of the mobile communications industry, but for the entire information and telecommunications sector. To illustrate, Apple, which has a small personal computing business (when compared to Wintel), is using the iPhone platform-based iPad to threaten the personal computing industry. It is further extending its control with iCloud and considering entry into the television industry. Google's strategy could be similarly disruptive but would operate through quite different mechanisms. Finally, Microsoft's strategy is, in many respects, the least disruptive as its goal appears to be only to extend its control of the PC to the mobile phone and tablets. In this paper, we examine the competitive weapons that each of the firms is deploying to extend their business model into the newly opening business spaces.

The internet as a technology platform

Competition in the ICT industries has very often been used to understand the creation, adoption and exploitation of technical standards (for an introduction to this literature, see Shapiro and Varian, 1999). In the ICT space new technological standards can become "platforms," though platforms need not be based on standards. The key point is that third parties can build their products and services upon the platform. Conversely, a platform has relatively little value without complementary products and services, thus platform providers are motivated to find the third-party complementors (Teece, 1986; Cusumano, 2010).

In cases in which there are multiple firms proffering different platforms, market success is often determined by which platform can recruit the greatest number of complementors. The stakes in such contests are enormous, because in ICT, where interoperability is predicated upon complete interface standardization, owning and controlling the platform upon which other firms build their businesses provides enormous power and can be a lever for capturing value from the entire ecosystem. This was the core of the Microsoft business model in the PC and is now driving Apple's success.

Most discussions of platforms assume ownership by a single firm, but this need not be the case. To illustrate, the Internet protocols are not owned and yet they are a platform. This is one reason that the Internet ecosystem differs markedly from that of the PC ecosystem where Microsoft's ownership of the operating system allowed it to become the dominant force and capture outsize profits. Microsoft accomplished this by creating a mutually reinforcing linkage between the operating system and personal productivity software. These mutually reinforcing positions enabled it to become, with Intel, the dominant firm in the PC ecosystem. This position was challenged when the Internet emerged in the 1990s, and the browser, a new PC application, was introduced by Netscape. Netscape had hoped to use the browser to dislodge Microsoft's dominant position. However, Microsoft, though late in understanding the implications of the Internet,[3] used its control of the operating system and office application parts of the PC platform to directly embed Explorer into the MS Office package. With the widespread adoption of Microsoft's Internet Explorer browser application, the competitive environment fundamentally shifted against Netscape (Cusumano and Yoffie, 1998). The most important browser competition, until Google's recent release of Chrome, was the open source Mozilla Firefox.

With Microsoft's initial success and, as long as Internet access was limited to the PC, Microsoft could benefit even as the Internet grew and new corporate giants such as eBay, Amazon, Yahoo!, and Google emerged. Beginning in the decade of 2000, the Internet, through its "cloud" manifestation, threatened a fundamental reorganization of the entire ICT world. The technological changes encouraging the reorganization are the following: At the chip level, according to Moore's Law, increased computing and communication power became available in smaller and smaller devices, i.e., computers are becoming smaller and smaller, even while prices are decreasing. The current manifestation of this is that today's cell phone is an increasingly powerful computer. However, televi-

[3] Microsoft's official and fundamental recognition of the importance came on May 26, 1995 with Bill Gates' release of his "Internet Tidal Wave" memorandum.

sions and nearly every other electronic device are receiving increased computing power. For example, in televisions "set-top" boxes are superfluous as its functions and dedicated Wi-Fi are integrated at a trivial cost. Previously, the three main connectivity devices, telephones (wireless and wire line), televisions, and personal computers (desk top and notebook), were connected to central delivery backbones by not fully compatible networks. Today all are built with sufficient computational and communication capability to be connected through a single network, i.e., the Internet. Moreover, this "Big Three" is being joined by a myriad of other devices such as mobile computing "pads," and other computation and communication capability-endowed devices such as automobiles, refrigerators, appliances, cameras, sensors, and nearly every other electronic gadget.

While each of these computational and communication-enabled devices outwardly appears similar to their previous "dumb" manifestations, they now are being connected to a single network using Internet protocols. To illustrate, the smart phone will remain a small individual communication device, the personal computer may remain in the office and be optimized for such activities, while the television with its large screen remains in the familial personal spaces. The interfaces with human actors are different, but they all will "speak" the same digital language. With this unification, what is at stake is the ability to provide services and capture value in this new network.

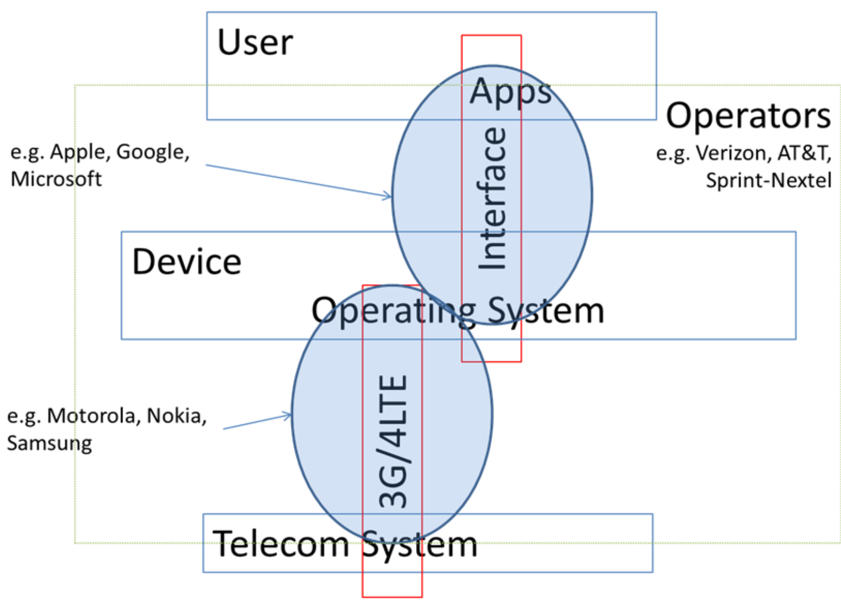
Fundamental in this struggle for control will be a strategy for developing, recruiting or controlling complementary assets in determining the outcome. Competition in this converged network world is likely to be asymmetric, because the three most salient competitors, Apple, Google, and Microsoft have differing business models, strategies, and potential complementary assets. While it is necessary to recruit actors with complementary assets into their ecosystem, the firm wielding platform may also threaten or attack firms providing complementary assets. In this paper, we examine the strategies of the three most powerful entrants and platform providers in the mobile Internet industry and examine what the implications of their platform models have for their key partners, the mobile phone operators – the firms that actually provide the connectivity. In the remainder of the paper we examine the interplay between firm missions, strategy and operating behaviors, their product and service platforms, and their efforts to strengthen their position in the converging sectors.

Industry setting

The setting for this paper is the current digital information delivery system, which consists of mobile devices, personal computers, and televisions. The objective is to understand how different actors in an ecosystem react to the opportunities and threats presented when a technological discontinuity creates an industrial convergence. This is particularly interesting when considering the three most successful new entrants, Apple, Google, and Microsoft have not traditionally been significant in mobile phones as they come from the world of personal computers and, in the case of Google, the Internet. The mobile Internet is changing the arena of competition, and complementary assets are one of the key weapons used by firms to shape the future.

The competition is played out across three layers: 1) the world of devices, their operating systems, and related complementary assets, e.g. applications and 2) the telecommunications systems and respective complementary assets, and 3) the world of operators. This is illustrated in Figure 1, as the world of operating systems meets the telecom systems and operators for mobile internet.

Figure 1
The relationship between smartphone user, device operating system, and telecommunications system



Previous research

In this newly emerging ecosystem where it is likely that all activities will be united by the Internet, control of the mobile devices is increasingly viewed as vital for any firm seeking to become dominant in the information technology world. This particular moment is quite interesting, because during periods of convergence and turbulence it may be difficult for firms determine what the critical complementary assets necessary to achieve dominance are [on the interrelatedness of a major elements of the firms – strategy, organizational structure, employees, and technology, see the seminal work of Chandler (1962) and Leavitt (1967); on complementary assets, the seminal work is Teece (1986; 1988)]. In another study, Rothaermel and Hill (2005) examined the effects of a technological discontinuity upon industry incumbents and found that an incumbent's financial strength had a stronger positive impact on firm performance after the discontinuity if the new technology could be commercialized through generic complementary assets, while R&D capability had a stronger positive impact on firm performance after the discontinuity if specialized complementary assets were required. Tushman and Anderson (1986) examined technological discontinuities from the perspective of whether they were competence enhancing or competence destroying. These studies concentrate upon industries that have relatively clear boundaries and recognizable trajectories. However, an increasing number of firms now operate in recombinant or converging industries where boundaries are uncertain or subject to redefinition. In information and communication industries, the underlying technologies are "stacked" upon each other and no firm controls the entire stack. Firms in different layers of the stack must cooperate sufficiently for the product to operate, but at times may also come into competition. These markets can be further complicated by the fact that firms may be involved in ecosystem or stack competitions, where groups of firms based on different platforms may be competing. In such markets, complementary assets and the implications of technology discontinuities may not be clear at the outset.

Previous research has focused on understanding the existing value creation and value capture mechanisms, and existing innovations, technology and service platforms in the current mobile telecommunications industry (see Funk, 2007; West and Mace, 2010; Ali-Yrkkö et al., 2011; Kenney & Pon, 2011; Seppälä and Martikainen, 2011; Dedrick et al., 2011; Funk, 2001, 2007; Seppälä and Kenney, 2012). Since the current mobile platform leaders and mobile internet ecosystems have different industrial trajectories, examining their strategies and operating behaviors can provide insight into how firms leverage complementary assets to extend their current business strategies and models.

Setting the scene

In the pre-Cloud computing era, each of the currently converging industries had a relatively clear industry structure. In mobile phones, personal computers, and televisions, there were firms that produced the gadget, which were connected by various operators to sources of content. Initially, mobile phones were "dumb" handsets, but gradually other services normally provided by the mobile operator were incorporated into the device. And yet, the operator's control gradually loosened. Similarly, personal computers initially had limited connection to networks. This began to change most significantly with the introduction of email. However, the creation of the World Wide Web made the Internet an increasingly important personal computer application and gradually came to rival the Microsoft Office application's monopoly. Televisions were one-way content "push" devices (and, in some cases, gaming monitors) with content delivered by cable TV firms. The final set of competitors were the Internet-only firms, such as Amazon, Yahoo!, Salesforce.com, and slightly later Google, that began life in what came to be known as the Cloud.

In this world, the operators controlled the voice and data "pipelines" to the consumer, while Microsoft controlled the personal computer. The operators were treated and regulated as utilities, with the benefit of guaranteed rates of returns and significant barriers to entry, but also had to make large capital investments to stay abreast of the increasing volume of voice and data flows. The operators aimed to increase their returns by controlling the content provided to their "captive" customers. These arrangements were termed "walled gardens" within which the owner would be able to extract the bulk of the profits – effectively, these were invitation-only platforms (for a vigorous praise of these operator controlled environments, see Hazlett et al., 2011; for a discussion of the case of Japan, see Funk, 2001, 2007; Kushida, 2008).

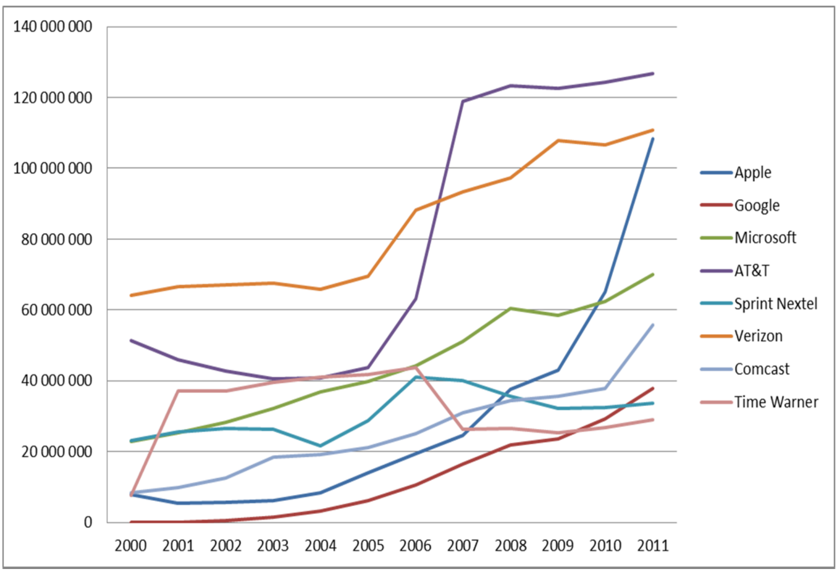
The access device makers, operators, and content providers in the earlier model had a rough symbiosis within which each of them could capture a return. The move to the smartphone threatened the operators, but, at least initially, it appeared as though there would be another walled garden promoted and controlled by the device makers, as Apple migrated its music-downloading iTunes Store from the iPod to the iPhone and renamed it as the "Apps Store." Nokia and other mobile handset access device makers responded with their own much less successful stores. The tremendous market power that Apple demonstrated in their negotiations with the operator broke their power to control the smart phone as a platform.

Despite the success of the Apple App Store with applications such as Rovio's Angry Birds, the true killer application was direct access to the Internet (West and Mace, 2010). This can be proven by the latest survey results that found that smart phone users spent 128 minutes per day on their smart phones of which 19 percent was surfing the Internet, 14 percent checking social networks, 11 percent listening to music, 12 percent playing games, 9 percent making phone calls, 10 percent text messaging, 7 percent using email, 7 percent watching TV/films, 7 percent reading books, and 3 taking photographs (O2, 2012).

Internet access destroyed the operator strategy of confining customers within their network's boundaries. The new smartphone device/operating system makers were repositioned to be able to provide a semi-walled garden. While the device must provide access to the Internet, the operating system provider could create a "store" where users could purchase applications made either by the owner of the operating system or third-party vendors. For the operators this was an unwelcome development as they were threatened with relegation to utility service providers even as they were forced to invest more to keep up with traffic growth.

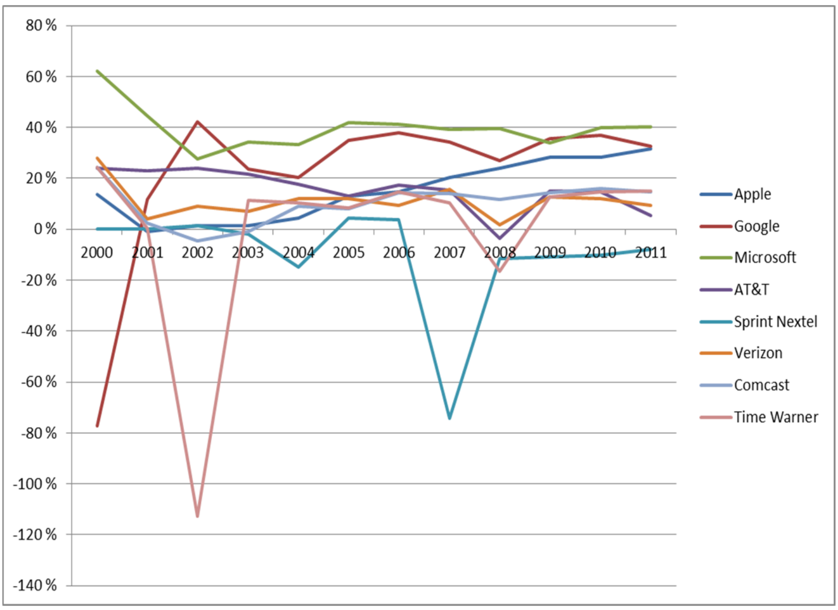
With any platform or ecosystem, the issue is which firm(s) can capture the greatest profits as that is likely to indicate where the locus of power resides. While admittedly crude indicators, growth in revenues and profits are one substantial

Figure 2
Operating revenue data 2000–2011 (various sources)



indicator of relative success. During the recent years the operating revenues and the profit and loss before taxes of the mobile internet ecosystem operating system providers seems to have increased hand in hand, but the profit before taxes has declined in what appears to be an accelerating pace. This can be seen in Figure 2, which presents operating revenue data for a selected peer group of firms, Apple, Google, Microsoft, AT&T, Sprint Nextel, Verizon, Comcast and Time Warner from 2000 through 2011. Clearly, since entering the mobile space in 2007, Apple has had remarkable success. Google, whose main revenue source is advertising, has continued to grow and appears to be gaining success in the mobile space. Microsoft is still in the middle of its attempted extension from computer to mobile internet and the vast preponderance of its revenues is derived from its personal computer monopoly. The operators, whether they are the mobile carriers, such as Verizon, AT&T and Sprint/Nextel,[4] or the cable carriers for the landline have experienced operating revenue increases, but profitability remains weak.

Figure 3
Profit & loss before taxes (various sources)



[4] Three biggest mobile carriers in US based on number of subscribers (source Pyramid Research, 2011).

In long term the mobile carriers may face difficulties in maintaining the current operating revenue levels due to fierce price competition in data products. However, the operating revenue levels seem not to be the main problem of mobile carriers in the short term, but rather the problem is to fulfill the increasing data carriage demand while coping with weak profitability. According to industry estimates the capacity requirement for mobile data has been doubling annually.[5] In Figure 3 we examine how profit and loss before taxes has evolved for the same peer group of firms from 2000 to 2011. What this indicates is that the OS providers, in particular Apple, are capturing the preponderance of the industry profits.

For the mobile operators, the situation is difficult, but the cable operators that do not have the benefit of subscriber and carriage growth appear even more stressed as they have low profit margins. Moreover, they are threatened by the mobile carriers that also have land pipelines to the home. However, in the US market thus far the carriers have been able to maintain their profit margins due to their relative monopoly. As long as this monopoly is protected, their positions do not become untenable. However, particularly for Google, lowering the cost of access to the Internet, which ultimately is its platform, would be a desirable development.

For the carriers, it is the strategies of new entrant operating system providers that are of critical importance because the operators stand in the way of their direct access to their customers. To illustrate, Apple is considering adding a software subscriber identity module (Software SIM) to all of its next generation devices.[6] The change from current SIM-card to software SIM would be a direct attack on the mobile operators, as it would enable Apple to directly interface with its access device owners through their Apps store. This would mean that a consumer accessing the Apps store chooses its carrier via an App Store download i.e. the connectivity in devices becomes an application instead of a SIM-card as today.

In contrast to Apple's investment in applications to disintermediate the operator's SIM-card dominance, Google has invested heavily in long-distance fiber capacity. More recently, it has been experimenting with various last-mile technologies to achieve access to the user's devices. For example, in Kansas City, Google is experimenting with extending optical fiber to the home. It also invested $500 million in a failed Wi-max project – again, to achieve access to the home. In 2012, Google is one of the largest data carriers in the world. Interestingly, Microsoft has not announced any significant technologies and investments that

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[5] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html (accessed July 3, 2012).

[6] http://www.bloomberg.com/news/2010-11-18/gsma-explores-software-based-replacement-for-mobile-sim-cards.html (accessed 6.3.2012)

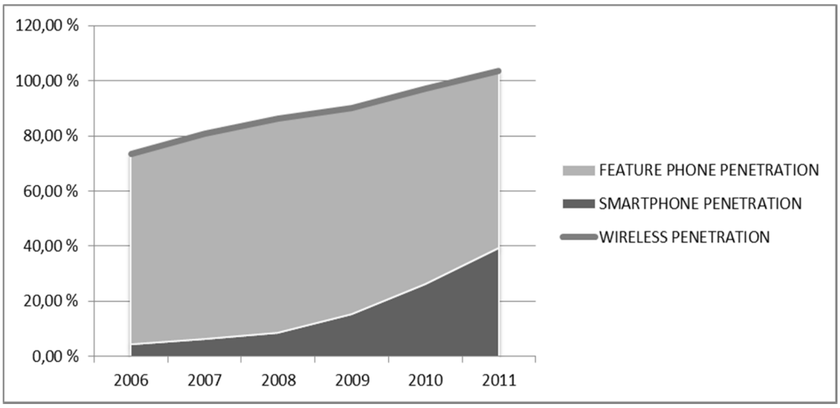
could be interpreted as a threat to mobile operators. In this respect, Microsoft's initiative appears to preserve the current roles of the ecosystem members and this may explain why Nokia, the leading cell phone incumbent, which was under severe threat from both Apple and Google's Android OS, agreed to join with Microsoft.

The common denominator for all three mobile internet ecosystems is the Internet cloud as the technology platform. The Internet cloud as a technology platform, together with new technology innovations such as software SIM, threatens to displace or subordinate the current mobile operator infrastructure with new technologies, infrastructure, and data centers. These new Internet cloud based technology platform enables mobile internet ecosystems to provide global access for an infinite variety of devices, services, and applications. These could be provided without roaming fees and the other charges that make the carriers greatly disliked by consumers. For the cloud providers location is largely irrelevant from a cost of service perspective. For the mobile operators this extremely profitable part of their business could decline driving their profitability even lower.

The entrants in the new ecosystem – positioning for value capture

Prior to the emergence of mobile internet, the mobile value chain was relatively stable for many years. The mobile carriers in each country delivered service to the consumer at a standard price, the media providers supplied the content, and network equipment and handset manufacturers interacted with the mobile carriers to provide new phones (Sabat, 2002; see West and Mace 2010 on initial efforts to create mobile internet). West and Mace (2010) explain how after June 2007 the introduction of the Apple iPhone revolutionized the mobile telecommunications industry. Figure 4 illustrates the change from the perspective of the increase in wireless penetration in the United States from 75.5% in 2006 to 103.5% in 2011. Furthermore Figure 1 explains the shares of feature phones and smartphones of total wireless penetration during the same period of time. While the total wireless penetration has grown 30.0%, smartphones represent 116.5% of total wireless penetration growth and respective feature phones represent -16.5% in comparison. That said, the growing share of smartphones from 4.4% in 2006 to 39.3% in 2011 has not significantly decreased the share of the feature phones. However the feature phone penetration has continued to stay almost

Figure 4
Wireless market penetration in United States versus feature phone and smartphone penetration



at the same level in 2011 as in 2006. Moreover, it is important to recognize that wireless penetration is calculated from the total number of all wireless subscriber connections.

The iPhone was the outcome of a trajectory that drew upon the enormous success with the iPod and its experience and skill at integrating operating systems and hardware. However, the overwhelming advantage was the iPhone's ease of use for surfing the Internet. This introduction was further strengthened because Apple already had its iTunes store for downloading music which became a powerful complementary asset for the iPhone and soon evolved into the App Store, which was opened to third-party application developers (West and Mace, 2010).

The key to the iPhone was its introduction of a rich user experience, but it was also protected from other competitors by a strong technology patent portfolio (Seppälä and Martikainen, 2011). This allowed Apple to leverage the touch-based screen of the iPod and continued a migration away from the keyboard-based systems that the other vendors had introduced from the PC world. While the App Store and music downloads were significant complementary assets and are usually cited as the key to Apple's success, the application that catalyzed the transformation of that smartphone into the mobile internet was the provision of an excellent web surfing experience, which became possible due to the touch-based screen. With this, Apple shifted the competition from "feature phones to "smart phones" and further to the "mobile Internet" and catalyzed the integration of the cell phone into the Internet. With this transformation, the most used internet access device was destined to become the mobile phone. Parenthetically, with the later introduction of the iPad, the PC itself, or, at least some of its functions, were threatened, and by extension the personal computing industry platform owner, Microsoft.[7]

The significance of the iPhone can be seen in the US market by the impact it had on AT&T, on whose network it was first introduced. AT&T's exclusive US distribution rights were limited to 3 years and 7 months, until Verizon received the iPhone 4 in February 2011.

The operators had always feared becoming utility-like access providers, as had been the case with their landline operation. Already prior to the emergence of the smartphone, operators particularly in Japan and Korea, but also globally were trying to provide value-added services to their customers. The problem for consumers is that the operator made the choices and there were no alternatives. Walled gardens, by virtue of being within one operator's purview and optimized for cell phones, were, by definition, small business ecosystems, especially when compared to the World Wide Web. The strategy was adequate as long as the device was the cell phone with limited Internet capability. However, technology was evolving.

When Apple introduced the iPhone with its excellent web surfing capabilities, the immediate result was that the worldwide web became the new ecosystem. The iPhone allowed customers to escape the walled garden and they proceeded to do just that. The benefit for the initial operator, AT&T, was an enormous increase in the profitable download traffic, but in return it had to handsomely pay Apple for the privilege and it lost the ability to monetize its customers with value-added services. In fact, with Skype and other Internet-based voice services, voice traffic itself was threatened.

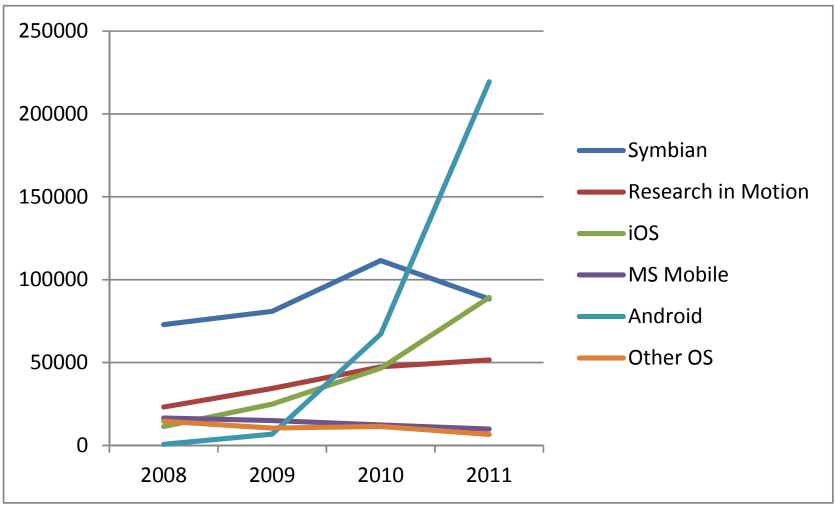
With Apple providing a single operator, AT&T, an exclusive opportunity to sell the iPhone its enormous success placed the other operators at a serious disadvantage. The other operators needed a phone with mobile internet access and similar user experience. Nokia was not an answer with the Symbian operating system, and Meego, another operating system platform offered by Nokia, was still on the drawing board. To meet this demand, different operators, software companies, commercialization companies, semiconductor companies, and phone manufactures established an Open Handset Alliance (OHA) in 2007. At the heart of OHA was Google's Android operating system as a free, relatively Open Source offering, fully integrated with a specific hardware, i.e. Qualcomm hardware plat-

[7] Interestingly, though Microsoft's partner, Intel, was not as directly threatened, its weakness in mobile integrated circuits may prove to be a long-run threat.

form. For both the operators and various mobile phone producers that could see they had to transition from feature phone to smartphone, this was an attractive platform. With Google's brand, the relatively high-quality of the software, and the fact that it was free, adoption soared (see Figure 5). Google's strategy was to attract mobile phone users to Android so other potential competitors such as Apple, Microsoft, or others could not prevent or shunt users to other search services. For the operators, however Android also permitted their customers to leave the walled garden – it also destroyed the operators hold on customers.

While Apple was a device maker and did not directly threaten Microsoft, Google was different. Google was essentially a server of data, so it was interested in moving applications from the end-user device to its data center. More significant, was the other side of Google – the enormous data centers (the Cloud) that could store and serve data to anywhere with cell phone access (increasingly, everywhere). With this, now applications such as those in the Office suite could be hosted in the cloud and used locally. For Microsoft, recognition of this trajectory meant that while its dominance on the desk top might be threatened, mobile phone operating systems, especially those on pad-like devices, could become a potent rival to the immensely profitable Windows franchise.[8] The arrival of the

Figure 5
Global smartphone sales by operating system 2008–2011
(Source: Gartner Press)



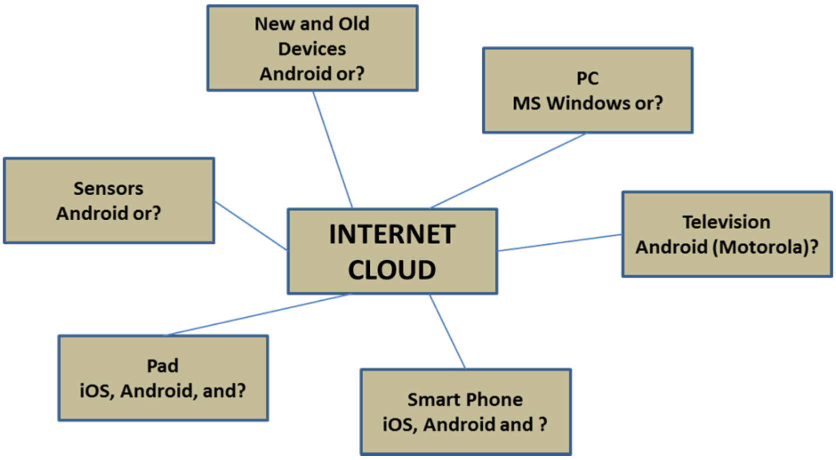
[8] Parenthetically, this would also threaten the Intel monopoly as ARM-based processors on mobile devices threatened the Intel franchise.

mobile Internet meant that Google, which had become the dominant Internet franchise, could possibly erode the Microsoft business. New classes of devices/users were arriving and this promised Google a tremendous opportunity to expand its market. Of course, with this opportunity came a threat, if the new users did not use Google instead adopting a different search engine on their mobile devices, it might lead to the replacement of their PC search engine and, of course, it was obvious that soon more people would be accessing the Internet from mobile devices than from PCs. The mobile Internet ecosystem could be a lever to penetrate Google's position as the dominant search engine for personal computer users. The owners of the mobile internet device operating system might be able use it in the same way as MS had used its Windows platform to disadvantage and eventually overwhelm its applications' competitors, as was the case with the Netscape browser (Cusumano and Yoffie, 1998).

While the incumbents of the PC world were discomfited, so were the leaders in mobile telephony. Apple demonstrated with the iPhone that there would be one Internet and that access was the killer application for all devices. For Nokia, the dominant mobile phone firm, the competitive situation worsened dramatically. For all incumbents including Google, the threat was existential. The iPhone showed that the new economic space in the mobile world was the Internet. The mobile Internet also proved that all devices with a microprocessor/controller would ultimately and possibly quite soon, be connected to the Internet through a variety of networks. All of these devices would need an operating system and possibly one could unite them all. If all devices were to be connected to the Internet, then the heart of the convergence would be the cloud data center, where the data going to and coming from the plethora of different devices would be served from and stored at (Kushida et al., 2011). This new configuration is displayed graphically in Figure 6. The Internet cloud would become the platform. This new Internet would serve multiple devices and thus a PC-centric perspective could not be sustained. It would take time for the implications of these changes to become manifest, however.

Just as the operators are being thrust toward being commodity providers, the increasing centrality of the cloud required them to increase the capacity of their networks. The current capacity of the legacy telecommunications networks that had to be expanded to handle the increasing data consumption from the first Internet wave would once again be placed under strain from the new data communication wave. Moreover, while the dot.com bubble offered carriers the ability to raise enormous amounts of capital from the public markets, in the current environment public markets were unwilling to provide capital to operators. New radio frequencies were required to support the increased demand as cell

Figure 6
Internet cloud – The heart of industry convergence (Source: Authors)



phones became data-intensive end-use devices. As the locus of economic power shifted to content providers, the operators experienced profit declines, even as their networks experienced greater traffic (see Figure 2).

Industry convergence, architecture, and the Internet value chain/stack

In a technology convergence, as is the case when an industry is formed, the industry architecture is uncertain. For example, when the personal computer industry was formed the industry architecture was uncertain and, in fact, two architectures emerged. The dominant one was the IBM-initiated personal computer whose core firms would be Microsoft, Intel, and the computer assemblers such as Dell and HP. The other architecture belonged to Apple, which controlled the brand and the operating system. These two architectures co-existed until the present time. Considering the industry architecture is important, because, as Pisano and Teece (2007) theorize, it shapes the distribution of returns from innovation. In the formative period, competitors experiment with creating the architecture. One of the vital strategic decisions firms must make is what portion of the entire value chain must be controlled. In the case of information and communication technology industries, this includes the stack. So, for example, Microsoft decided that it could secure its position by owning the operating systems and the major office productivity applications. With the advent of the Internet, Bill Gates, then CEO, recognized that it was vital to extend its competitive scope and it did so by introducing the Internet browser (Internet Explorer), a portal (MSN), and purchasing an email firm (Hotmail). Later, it would introduce a search engine (Bing), a mapping application, and other applications in an effort to match Google.

There are two technological developments driving this industrial convergence. The first technological development is that the mobile phone is completing its evolution from a phone to a computer. In the process, it went from a phone with some other applications to a computer with the Internet being its most important application. The second development is that applications are increasingly moving to data centers serving data to the end user using any number of devices. The convergence is not in the user-interface device, but rather the network/data center that is serving the bits. The epicenter of this convergence is the mobile device, which requires an operating system. The number of mobile Internet devices globally will be a far larger market than the personal computer, and mobile devices such as pads may replace, at a minimum, notebook computers including those using the Microsoft operating system. For this reason, the stakes are enormous. For the incumbent mobile phone-makers the stakes are also enormous because any firm controlling the operating system will be able to determine the success of the phone maker.

Industry architectures are also affected by the strategies used for monetizing the good or service provided. This "commoditization" of such technology platforms has enabled firms such as Google to enter the market space with new business models and value propositions or those that extend their current business model to new users. In the case of Google, this is the provision of free-of-charge technology platforms integrated to its existing advertising-based revenue model. The ability to shape the industry structure, as Apple and Google appear to be doing, may allow them to become leaders as their technology and service platforms become the core of the new ecosystems.

As compared to both Microsoft and Apple, as Cusumano (2005) recognized, the Google business model has no technical or market lock-in. If a better search, email, or mapping application appears, users can quickly migrate; though there may be a high switching cost to migration. This may be similar to other Internet technologies. For example, Mozilla Firefox has experienced a significant decline in browser market share, particularly in the face of competition from Chrome. Internet market share can drop extremely rapidly, i.e. the clock speed is extremely fast (on clock speed see Fine, 1988). This fundamental fact forces Google (and all firms within the Internet ecosystem) to constantly experiment, innovate, and find new ways of retaining existing users and attracting new ones. This is best illustrated by the difficulties Yahoo! is experiencing, as it also was unable to create a platform with lock-in. The strongest lock-ins may be for firms, such as eBay and Amazon that have created widely used marketplaces.

In contrast to traditional software firms that can and do introduce new features only quite slowly, Google does not have natural lock-ins, but it can constantly introduce new features and modify existing features. So their strategy, as was the case with Yahoo!, is to continually introduce new and upgrade old services for which it can introduce advertisements.

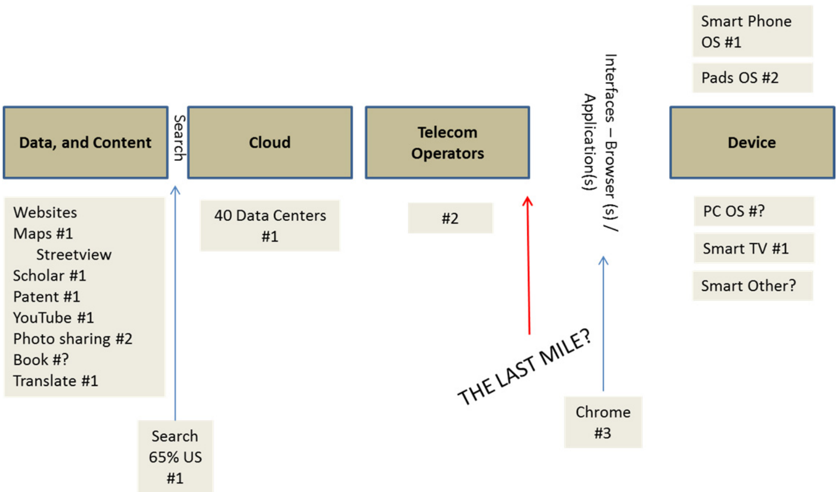
Google

Like so many Internet firms, the core of Google's activity search offers little lock-in. Gmail and Calendar offer stronger lock-in possibilities, but again their strength is debatable. In addition to the user-friendly interfaces Google has enormous amounts of organized data – that is what YouTube, Images, Maps, Street view, Earth, Scholar, News, Books, Patent, Translate, etc. are. For example, in 2008 Google processed 20 petabytes of data per day (Dean and Ghemawat, 2008). Hosting and organizing all of this data also provides Google with powerful economies of scope and scale. Ultimately, it is access to data that attracts users and ensures that they use Google. As long as Google can remain best or near-best in class for all of these functions, it can retain users and leverage this advantage to new connectivity devices, of which mobile is the most important.

Google has demonstrated that they understand the two different levels of network effects by separating their value capture from value creation, i.e. separating advertising profits from technology platform investments makes it is possible for it to capture the benefits of network effects. In other words, the Google business model uses a commoditized technology platform, i.e. the Internet including carriers/networks and also commoditizes different types of hardware and software technology platforms while establishing an advertising-driven revenue model (Venkatraman & Henderson, 2008).

In contrast to earlier models where the stack layers are controlled by separate firms, Google appears to be integrating many layers. Figure 7 demonstrates the variety of initiatives Google uses in various stack layers. What is interesting is that normally an ecosystem or platform leader acts as a complementor in the

Figure 7
Google's value chain/stack integration strategy (Source: Authors)



industry value chain/stack, not a stack integrator (Gawer & Cusumano 2008). Such an end-to-end strategy would appear to violate the normal platform or ecosystem strategies, but, if Google does not believe it has a lock-in platform, then controlling increasing large portions of the stack could be an effective defensive strategy.

Google's offerings do experience network effects, but they are not as tightly coupled as those of Microsoft or, those of the closed system provider, Apple. Google also captures some network effects, as it can tightly link its various offerings and follow users through the many services it offers.

In the US Google has already purchased sufficient long haul fiber access to make it the second largest data carrier in the world.[9] Because Google is estimated to generate 12% of the total US data traffic, having this capacity prevents other carriers from blocking or slowing its traffic. It also allows it to participate in decisions regarding data carriage where it inevitably argues for net-neutrality. The seriousness of its bandwidth initiative can be seen by the announcement that it was considering bringing fiber to Europe, though no concrete plans have been announced (Telecommunicator, 2011).

9 Stu Feldman 7.2.2012 in Cloud Computing: Key questions for Economic Policy, and How to address Them, A Roundtable Workshop; The Berkeley Roundtable on the International Economy (BRIE), University of California, Berkeley.

The Android operating system, in contrast to other Google products, could develop powerful network externalities if it enables the introduction of new devices, applications, and related services thereby expanding the market. Prior to the shift into the mobile Internet field, Google's business was based on the open and unowned Internet protocols – they were the platform. In certain respects, this changed when it released the Android operating system. Conceived as relatively open and free, Android threatened not only incumbent cell phone firms but also Microsoft, which was endeavoring to extend its operating system monopoly from PCs to mobile phones and Apple with its closed garden approach. As Google expanded from the relatively open and uncontrolled Internet world to other technology areas, such as operating systems, it entered domains within which intellectual property can be used to bar competition. While Google spends over 10% of revenue on R&D, it had not been active in patenting. Because in the mobile communications industry patents can be extremely important, Google has been forced to strengthen its patent portfolio.

While Android is a platform, its openness allows all vendors to build their own brand, and provides them with some protection against commodification. In this respect, the Samsung Galaxy brand is the most significant and most successful illustration.

Google's experimentation with various strategies for circumventing the operators' control of the last mile opens the potential to circumvent the operators completely. The strategic reasons for this are unclear, and could be merely the creation of a credible threat to prevent operators from creating environments excluding Google's search engine. Also, the experimentation may operate as an implicit threat to encourage the operators to upgrade their last-mile networks, as Google wants to encourage increasingly fast and cheaper access to the Internet so that it can deliver still more advertising. Finally, securing direct access to users' homes would eliminate the ability of the cable and landline operators to block access to televisions and other devices in the home.[10]

Google's interest in securing access has taken a number of forms. For example, in 2008 Google invested $500 million in a 4G WiMAX scheme that was meant to develop a wireless last mile link to the home. This scheme failed and in 2012 it sold its stake at an enormous loss (Priyo, 2012). Google is also undertaking a project to provide high-speed fiber for television and other services to Kansas City homes. This would place it into direct competition with the landline telephone and cable firms for the last mile. Even if Google does

[10] In February Google announced that they were an Internet provider of "ultra-high-speed broadband" for up to 500,000 customers in a US city. http://www.google.com/appserve/fiberrfi/public/overview (information retrieved 26th September, 2011).

not proceed with a large-scale last mile effort, the creation of a credible threat may be sufficient.

Another area within which Google appears to be making headway is in office productivity applications delivered from the Cloud – this will lead it into directly confronting Microsoft. The scale of adoption of Google Apps by enterprises is difficult to measure. For example, a 2011 estimate is that it generated approximately $400 million in revenues (or 1% of total Google revenue). Increasingly, enterprises appear to be accepting certain apps such as email, internal search, browsers and other communication applications. Further, an ecosystem may be forming around Google Apps (Walsh, 2011) that, if it continues to expand, will threaten the core of the Microsoft business, Office. The question for Microsoft is whether Apps adoption proceeds from the Internet-linked applications such as email and browsing to office productivity.

Google is intriguing because it constantly intrudes into the markets of other firms across the entire IT industry. With its huge cash flow from advertising, it can fund large-scale experiments, any one of which might provide new demand for data that can be served with those advertisements. Threatened firms cannot predict Google's intentions in advance, thereby making them vulnerable to coercion. Its leverage is that it can offer, at least some, services for "free" because its monetization is through advertising – a situation that makes it even more vexing to conventional competitors that require direct compensation for products and services.

Currently, Google's threats are most salient in the mobile space where it has an opportunity to participate in the definition of a new ecosystem. In certain respects, this is similar to what Microsoft was able to do in the early days of the PC industry. An alternative explanation of Google's initiatives is that the emerging market is still unformed, and each initiative is simply exploratory. This may be explained by the fact that when Google was formed it was not initially obvious how it would monetize search. It only gradually came to understand that advertising was the proper business model. The emergent nature of Google's strategy is particularly obvious when compared to Apple and Microsoft. Apple progressed from iPod through iPhone and iPad to the iCloud. Microsoft's goal is to protect and extend the Windows-Office monopoly/synergy in the movement to the cloud. Google, in many respects, appears less consciously directed and, perhaps, like the Internet itself depends more upon the emergence of new opportunities.

Conclusions and discussion

Google is disrupting the business models for many ICT firms as the Internet threatens devices, network equipment providers, and network operators with commoditization and using advertising to monetize providing data (in its myriad forms – images, sounds, maps, written content, etc.). Were Google's Android to become the operating system leader for the mobile internet, it would not directly compete with other industry participants, device makers or operators, as it offers Android as a complementary asset for its mobile internet ecosystem members that enables them to commercialize their innovations, but for Google it would allow them to control the platform to sell more advertising. Other ecosystem members would have to differentiate themselves by product offering.

Google's technology and service platform is a complementary asset that takes into account all different forms of complementary assets: generic, specialized, and non-specialized. To illustrate Google provides technologies and service platforms such as Google Play, operating system Android, Internet cloud and other technology and service platforms freely to different stakeholders of its mobile internet ecosystem members, but also to consumers. It may impede, however, the other ecosystem members from capturing monopoly rents as they are constantly in competition with other firms using the platform. Finally, as we have shown, because of Google's weak lock-in it must protect itself by having positions in the largest number of spots in the value chain/stack.

Google's, as well as several other firms, mobile internet strategy aligns with the current network neutrality rules particularly for Internet delivery. The goal of network neutrality is to treat all content, sites, and platforms equally in the Internet. This is opposite to carriers' aspirations. The carriers' current strategy is to accept Internet-based neutrality for long-haul and possibly the wire into the home, but for the mobile Internet they would like to control and channel the data flow. Because this is a fundamental threat, Google is experimenting with building its own optical fiber networks with a last mile access.

According to network neutrality rules in mobile Internet the carriers have an opportunity to limit the network traffic, e.g. in the networks equipment there are several algorithms available to manage available bandwidth, in both ends of the networks, provided to individuals, both, firms and consumers. Furthermore, these algorithms can be used to manage the traffic between networks, e.g. from the Google network to the Verizon network and vice versa. In the Internet, and due to Internet neutrality rules, these limitations are not possible.

Carriers' future may be determined by the regulators if the network neutrality rules of the Internet are extended fully to the wireless world. The carriers will be relegated to being commodity service providers as even voice is carried through programs such as Skype (owned by Microsoft), which could significantly depress their income even while they must build out more bandwidth. If network neutrality rules are not extended to the mobile Internet, then it may be possible for the carriers to reestablish their control, though this is by no means certain because Microsoft, Google and Apple have sufficient financial resources to purchase the carriers.

It can be also argued that the competition in mobile Internet is becoming N-dimensional. N-dimensional refers to a space of competition rather than actually specifying a certain number of dimensions of competition, because any part of a business model can attract a competition. By analyzing the N-dimensional competition several areas can be considered: 1) Feature-by-feature; 2) Application-by-application; 3) Operating systems; 4) Device-by-device; 5) Intra- and/or inter-stack layer competition; 6) Data center management and 7) Ecosystem recruitment to mention a few of the most salient. Business model unification comes in the Internet cloud, which creates a common platform for data and content, while users access the data and content through multiple devices. The Internet may be becoming more than a platform for data and content – it may be the technology platform upon which all new ICT business models and related services, device and application platforms are implemented. It is becoming the nervous system for a multi-device environment and as such a new digital tower of Babel is being rebuilt. The firm or firms that can achieve centrality in this new world will be in a position to extract value from the largest business ecosystem ever created.

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Appendix 2

Global Supply Chains and Transfer Pricing: Insights from a Case Study

Timo Seppälä, Martin Kenney & Jyrki Ali-Yrkkö

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Abstract

Purpose – Supply chains are central to understanding wealth creation and capture in an increasingly globalized production system. The increasing disaggregation and dispersal of supply chains is profoundly affecting the geographical distribution of value added, input costs and profits of multinational firms. This suggests that understanding supply chains and where the activities and accounting for these activities takes place is crucial for understanding the causes and consequences of contemporary globalization. By using invoice-level data for a single globally-sourced product of a multinational firm, our paper integrates the issue of transfer pricing and logistics costs to understanding trade statistics and the operation of supply chains.

Design/methodology/approach – By using a case study of a single product and invoice-level data, it was possible to capture the actual costs incurred by a firm using a relatively simple global supply chain. We show how corporate intra-firm transfer pricing determines which business unit and location captures profits. A single firm provided the core data in this paper including product- and firm-level information on intermediate product prices and input costs for all internal transfers.

Findings – This paper advances interesting insights into trade in value added and shows that, though not often considered significant, transfer pricing is a critical issue for understanding the geographical distribution of value added. We conclude with some observations about the nature of global supply chains, the value of international trade statistics, and a hidden advantage of an integrated firm operating on a global-scale: the ability to somewhat arbitrarily select the activities to which profits should be allocated. For nation-states, as supply chains become more international and complex, critical measures such as gross domestic product, worker productivity etc. are becoming ever more imprecise. The economic geography of cost of inputs and profits continue to separate as multinational enterprises drive the disaggregation of value creation and value capture.

Research limitations/implications – Our case study facilitates an understanding of complex supply chain issues, thereby extending and deepening findings from previous research. This case study of transfer pricing in supply chains will assist other scholars in better formulating testable propositions for their studies and sensitize them to the internal complexities corporate managers face when making operational siting decisions.

Originality/value – Our case study suggests that understanding the configuration of and accounting in supply chains is vital for accurately measuring any national economic statistics. This case study provides some bottom-up evidence that national accounts and international trade economics undertaken without a deep understanding of supply chain organization is likely to generate misleading results. Our methodology of using invoice-level data can provide a more granular understanding of how supply chains are organized and where the value is added and captured. For practitioners, our data suggest that firms should think very carefully about, which of their activities generate the most value and value those accordingly.

Keywords – Global Supply Chain Management, Value-Added, Transfer Pricing, Global Division of Labor

Paper type – Research Paper

Introduction

Less expensive transportation, real-time communications, and reduced trade barriers have loosened the 'coordination glue' anchoring many job tasks in close proximity (Baldwin & Venables, 2010; Baldwin, 2011). This development has meant the dispersion of job tasks and presumably value-adding and supply chain activities and their resultant profits internationally and across firm boundaries (Ernst & Kim, 2002; Kenney & Florida, 2003; Mudambi, 2008; Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011). While international trade traditionally consisted mainly of the trade of finished goods and extracted raw materials, trade is increasingly a trade of goods-in-process (Grossman & Rossi-Hansberg, 2008). There has been a concomitant increase in international trade of goods-in-process internal to individual firms (Clausing, 2000).

Stages of supply chains are increasingly distributed internationally as activities are situated according to a complex set of decision variables, including labor availability and cost, transportation and inventory costs, quality considerations, and proximity to appropriate suppliers and end customers (see, for example, Tan et al., 2002; Kenney & Florida, 2003; Buckley & Ghauri, 2004; Gereffi et al., 2005; Creazza et al., 2010). And yet, aside from a few electronics products, such as mobile phones and personal computers (see, for example, Dedrick et al., 2009, 2011; Ali-Yrkkö et al., 2011), little is known about how accounting decisions determine where single firms capture their profits along the supply chain.[1]

The foundation of this paper is that the accounting decisions, supply chain designs, and respective transfer pricing mechanisms of a multinational enterprise (MNE) play a role when considering international trade in value added and the geographical distribution of the value added in global supply chains. Hence, our key motivation is to discuss and to address the differences in the economic geography of input costs and profits by answering the research question "How important is profit as a variable that can be used to measure value added?"

To address the general lack of knowledge about where value is created and where profits are captured, we report, on an invoice level, a global supply chain analysis for a single precision machinery product. This product is manufactured internally in six separate modules and is then assembled for final delivery to the customer by an enterprise with assembly facilities and customers in three macro regions: Northern Europe (Finland), Asia (China), and North America (USA).

[1] For example, it is common knowledge that many U.S. firms have booked enormous amounts of profit offshore to avoid U.S. taxes; however, there is little known about the internal accounting that makes this possible (U.S. Senate 2012).

Because this analysis is based on invoice-level internal data, it contributes to a new understanding of transfer pricing and the location of profits in global value and supply chains. In this context, how multinational firms implement their transfer pricing plays a significant role. Recently, bottom-up methodologies based on an examination of the costs and geographical sources of specific products have received increasing attention (see Linden et al., 2009; Dedrick et al., 2009, 2011; Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011; Shin et al., 2012). This study follows this tradition by focusing on a single product. Our research extends previous studies in four ways: First, our data, which are based on the actual invoices for inputs, allow for the division of a firm's value added into two parts, input costs (labor cost and supplies, both tangible and intangible) and profits. Using the MNE's cost, accounting, and transfer pricing data, the firm's value added, input costs, and profits at each step of the global value and supply chain are calculated. Second, with these data, it is possible to establish the geographical location of both the inputs and the profits. Third, due to the granularity of the data, it is possible to understand how transfer pricing is manifested. Finally, we conclude that MNEs have multiple ways of accounting for the activities that generate their profits, which can result in a wide variety of transfer-pricing schemes. This fact inherently limits the generalizability of this case study; however, in exchange for the lack of generalizability, we provide insights resulting from the granularity of the data and the methodology.

The paper proceeds as follows. Section 2 examines previous research on global value and supply chain design and transfer pricing in multinational enterprises. Section 3 describes the industrial setting, and Section 4 describes the data. In Section 5, we analyze the data and present the empirical analysis. The concluding section discusses the results and suggests further research opportunities.

Intra-firm trade, transfer pricing, and supply chain design

Global supply chains are composed of trade in goods and trade in tasks because flows of content, knowledge-intensive work are separate from the flows of physical components, intermediates, and final goods (Baldwin, 2006, 2009; Grossman & Rossi-Hansberg, 2008). Value added is important because the condition of a national economy is measured by the gross domestic product (GDP), which is the sum of the value added by all organizations in a national economy. And yet, the nature of global supply chains is making GDP ever more difficult to measure because value added is defined as gross output minus intermediate consumption; therefore, it is important to know where the value-added is created. Value added is divided into the input costs and profits for both intangible and tangible assets (Mudambi, 2008). However, the dynamics of goods and task dispersion and their impact on value added and profit disaggregation vary between industries and even multinational enterprises (Hirchleifer, 1956; Christopher & Ryals, 1999; Vidal & Goetschalckx, 1999).

When considering the geography of production and the respective supply chains, it is possible to distinguish between vertical production networks, in which a firm exports inputs from its home nation to be assembled in an affiliate factory abroad and then re-exported to multiple destinations, and horizontal production networks, in which a firm establishes a plant in a nation to produce and process inputs for that nation. In the traditional vertical production network, a common corporate strategy has been to build capital-intensive inputs in the home country and perform the labor-intensive work in the host nation (Hanson et al., 2005). Using aggregate U.S. government data, Hanson et al. found that the "demand for imported inputs is higher when affiliates face lower trade costs, lower wages for less-skilled labor (both in absolute terms and relative to wages for more-skilled labor), and lower corporate income tax rates." These results are intuitive, but at an aggregate level, and cannot provide insight into issues such as the role of transfer pricing that can shape multinational firms' supply chain decisions and where value added, input costs, and profits occur. Analyzing not only where activities are undertaken but also where the firm accounts for costs and profits, facilitates a more complete picture of the strategies firms use in managing their supply chains. Shedding light on this issue is important because firms have considerable freedom, within certain limits (such as having a presence to which the profit can be attributed), in choosing where to book profits (Vidal & Goetschalckx, 1999; Shelanski, 2004).

The supply chain literature has focused more on at the operationalization aspects of supply chains (for supply chain management literature see e.g. Mentzer, et al., 2001; Sacham & Datta, 2005; Frankel et al., 2008; Mentzer et al., 2008; Stock et al., 2010). Another parallel literature that we draw upon conceptualizes the supply chain as a "value chain. These scholars use the terminology of value added (which is the sum of the input costs and profits at any node in the value chain) and value capture (which is profits at any node in the value chain) rather than costs (all input costs) and profits (which are the sales price minus all costs), because they have been concerned with determining which nations undertake which activities (for global value chain literature, see Gereffi, 1994; Gereffi, 1999; Henderson et al., 2002; Gereffi et al., 2005; Gibbon et al., 2008; Dedrick et al., 2009; Gereffi & Lee, 2012). For firms, the issue is supply-chain design and profits, which can only be realized when the good or service being produced is sold to a customer. Value is added at different stages in the process by different firms and in different nations; however, the profits of all internal activities are only realized upon final sale. If all the steps in a supply chain were entirely separate entities, transfer pricing would not be feasible because a payment would be made at each step. To explore these issues, we use input costs, including transfer prices, and overall profits. More importantly, we shed light upon how a firm actually creates value and exerts power in the supply chain.

An MNE transfer-pricing mechanism is typically determined by the headquarters and actualized in accounting (see Eccles, 1985; Kaplan & Atkinson, 1989; Edlin & Reichelstein, 1995; Shelanski, 2004). As Shelanski (2004) indicates, transfer pricing is one of the key components of how MNEs manage and structure all intra-firm transactions and how the costs of resources and profits are allocated among different business units and different geographies. Classically, the transfer price set by the headquarters reflects a globally agreed upon standard cost of the specific activity related to the product at that step. The transfer price, based on the standard cost, can express either profits or losses in a particular node in the overall internal supply chain. Typically, if the transfer price is determined by the profit center, it includes profits. Cost-based supply chain analyses cannot capture transfer pricing and are unable to determine where firm profits are generated and/or allocated. Ultimately, the transfer price mechanism is dependent on an MNE's strategy and structure. For MNEs, value-added and profit mechanisms are planned and executed under the rules and regulations set by the OECD and a local nation's taxation authorities.[2] In practice, the execution of these rules and regulations offers enormous scope for interpretation. By understanding the global supply chain and MNEs' transfer pricing mechanisms (i.e., the way multinationals control and execute their business operations and organize their supplier relationships and the locations of production and where profits are captured), it is possible to better understand the inner workings of corporate supply chains.

The exact amount of value added is determined at every point of sales, both internal and external, in a global supply chain (Shelanski, 2004; Lepak et al., 2007). Utilizing transfer pricing mechanisms, Bowman and Ambrosini (2000) and Shelanski (2004) explain how the value-added and profit processes, respectively, are organized in global supply chains. However, the previous mainstream

2 See, for example, the OECD Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations (22 July 2010).

literature[3] in supply chains, as indicated by Power, (2005), Sacham & Datta (2005), and Joyce (2006), does not use these types of concepts, definitions, theories, rules, and principles from other research disciplines. In contrast, the supply chain management literature extensively discusses transfer pricing (see Hirchleifer, 1956; Stevens, 1989; Christopher & Ryals, 1999; Vidal & Goetschalckx, 1999; Sacham & Datta, 2005). This paper contributes to the extant literature on global supply chains by focusing on the specifics of value-added analytics from the perspective of transfer pricing in supply chain management. Moreover, this paper defines the economic geographies of added value, input costs, and profits; in contrast, earlier literature and empirics have focused on the international trade in value added and the corresponding statistics.

Industrial setting – the precision machinery industry

The global value and supply chain literatures have examined a wide variety of industries, ranging from textiles and electronics to food processing (Gereffi, 1994; Bridge, 2008; Kenney, 2012). Far less attention has been given to producers' goods such as precision machinery, which includes a wide variety of capital goods. As a capital good, precision machinery is not generally mass-produced in enormous quantities and technologically it evolves more slowly than products such as garments and electronics (see Fine, 1998, 2000; Sturgeon et al., 2008). Typically, precision machinery reflects deep technological expertise in terms of hardware, embedded software and other product-specific knowledge that comes from different individuals including engineers, technicians and, frequently, skilled crafts persons.

Geographically, developed nations are the most significant exporters of precision machinery, while developing nations such as China typically have been large importers of precision machinery (Kenney, 2012). More recently, due to cost pressures and the enormous size of the Chinese market, precision machinery firms have begun manufacturing in China, although their Chinese factories usually produce lower-end, mass production machines that are sold in price-competitive market segments or lower value-added modules. In contrast, newer higher value-added machines and key modules containing significant intellectual property and know-how continue to be designed and produced in

[3] On the supply chain management literature, see Ellram & Cooper, 1990; Cooper & Ellram, 1993; Harland, 1996; Houlihan, 1987, 1988; Mentzer, et al., 2001; Tan, 2001; Burgess et al., 2006; Kanda & Deshmukh, 2008; Christopher et al., 2006; Christopher, 2010; Creazza et al., 2010.

Finland. In this way, the highest value-added activities are retained in advanced economies. In this case study, while the highest value-added activities are retained in the advanced economy, the profits are not attributed to this particular segment of the supply chain.

Historically, precision machinery firms such as ours operated from and manufactured their products within a single nation, though sales were often global. Further, most suppliers were located in close proximity to their national manufacturing units. More recently, the globalization of markets has pressured firms in this sector to globalize their production. In this particular case, while production globalized, the firm's accounting system did not change and no longer reflects where the value added and respective key intellectual property are created.[4]

Data description

The core data in this study were provided by the firm and included product- and firm-level information on intermediate product prices when transferred within the firm. The data were collected during six in-depth interviews at the firm headquarters between January 2011 and December 2011. Each interview/workshop lasted two to five hours and included one to six participants and two research team members. The interviews were followed up with telephone calls and emails to complete the data collection. The primary sources of financial information were the chief financial officer and the business unit controller; however, purchasing directors and managers also participated in the majority of the interview sessions. These semi-structured interviews were used to gather product-specific financial data, including 1) sales pricing and intra-firm transfer pricing data (e.g., invoicing data between corporate headquarters and manufacturing units and invoicing data between different manufacturing units), 2) the firm- and plant-level income statements and balance sheets and 3) the bill of materials, including each component's price, the name of the supplier, and the country of design, manufacture, and distribution. In contrast to nearly all other studies, the firm also provided transportation and inventory carrying costs. In return for the firm's participation, both the firm and the respondents were granted anonymity.

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[4] Until the early 2000s, this firm undertook all production in Finland and then exported the finished product.

The firm also provided information on the costs of all inputs purchased from its external suppliers, distributors and retailers as well as material breakdown estimates of all components. Because the firm had limited information concerning upstream suppliers and their suppliers and components, the research team used the suppliers' financial statement data and balance sheets, as reported in the ORBIS database by Bureau van Dijk Electronic Publishing (BvDEP). All financial statements, balance sheets, and press releases available for each firm that was identified as a direct supplier or direct competitor were examined.

Table 1
Firm overview

	The case firm
Headquarters	Finland
Founded	Early 1900s
Industry classification	Industrial machinery
Annual revenues	> 1,000 M€
Offshoring activity	High and internal
Manufacturing locations	Finland, China, USA; each handles regional distribution Finnish and Chinese factories are equal in size, USA factory is smaller
Internal and external supply chain	Asia-centric supply chain
Production capacity	10 per day. Within each factory, this product represents a medium share of the total factory production capacity
Price per item	10,000€ (indexed)
Outsourcing activity	Purchased inputs are a low percentage of the total cost and are governed by manufacturing partnerships

These data allow calculation of the value added, input costs and firm profits for the product (for the calculation methodology, see the Appendix1). This particular product is composed of six separate modules that are produced internally. There is a distinct division of labor, with five of these modules produced exclusively in China and one produced exclusively in Finland. The modules are shipped to assembly facilities located in Finland, the USA, and China. The total number of components for the entire product is approximately 500.

The firm is approximately 100 years old (see Table 1 for a summary of the firm's characteristics) and produces multiple products that are sold globally. For each product, the firm has manufacturing units on at least two continents. Each plant has local and international customers. Using Gereffi et al. (2005)'s model of supplier relationships, our firm operates using hierarchical (internal), relational, and market relationships.

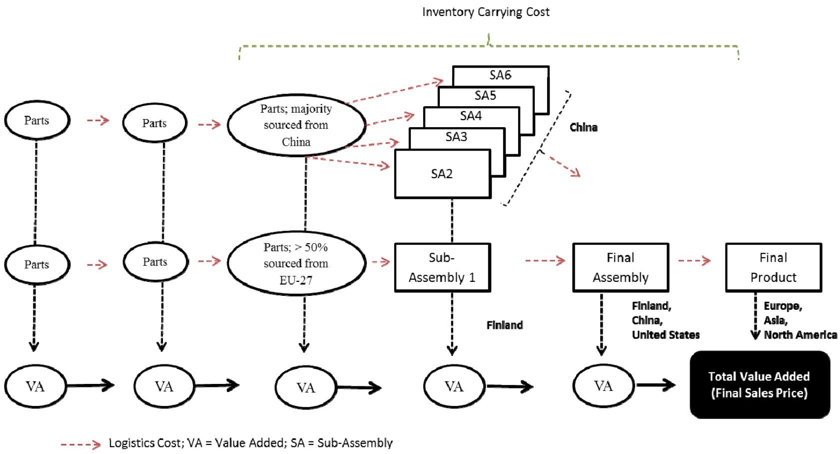
Empirical analysis and results

Our detailed product-level and firm-level data enable us to analyze value added, input costs and profits for a significant portion of the supply chain and to examine how the value added is divided between different participants and locations in the global supply chains. First, we examine how the value added in the global supply chain is divided between input costs and profits for each manufacturing location. Second, we illustrate how the value added, input costs, and profits differ among manufacturing locations. Third, we present the geographical distribution of the value added, the input costs and the profits in each of the three nations within which the firm operates.

Input costs versus value capture

The product is standardized, and a significant part of its production and other activities are located outside of Finland. The final customer price is the same in Europe, Asia, and the United States. The suppliers are mainly located in China, from where they serve Finnish-, Chinese- and USA-based manufacturing units. As mentioned earlier, the final product consists of six sub-assemblies that are assembled at a factory in each of the three global macro regions. Figure 1 demonstrates that there is a simple division of labor, with five sub-assemblies produced solely in China and one sub-assembly produced solely in Finland. These two factories supply the three regional final assembly facilities.

Figure 1
Supply chain with final assembly



Final assembly Finland

In Table 2, the total sum of the value added equals the product sales price of the firm (e.g., 10.000€ (indexed) = 100% of value added). The final product sales price is without taxes. The sales price of the product is then divided between the different participants in a global supply chain according to the data received from the focal firm and data inferred regarding suppliers (see value-added column in Table 2). In the case of the firm, when the product is manufactured in Finland and distributed to the European market, manufacturing is the largest contributor of value added. There are two separate operations: the production of sub-assembly 1 (sourced in Finland) and the final assembly. In this case, the five other sub-assemblies are imported from the firm's Chinese factories, as are the parts necessary for the final assembly. Nearly all of the Asian-sourced components are low-technology standard inputs.

As Table 2 indicates, when the product is manufactured in Finland and distributed to European markets, the inputs are 65% (6.500€ indexed) of the total cost of the finished product, while profits comprise 35% (3.500€ indexed) of the total cost. The actual input costs and profits are then distributed among the global supply chain participants according to the data received from the case companies (see input costs and profit columns in Table 2). In the accounting system, because the final assembly is treated as the profit center, it appears to produce the bulk of the profits. Because all of these operations are internal,

Table 2
Distribution of input costs and operating profit in Finland

	Total Cost (in percent) (10.000€)	Input Costs (in percent) (6.500€)	Profits (in percent) (3.500€)
Sales and Distribution	10	16	-1
Outbound Logistics	4	6	1
Headquarters	3	5	0
Manufacturing (Module and Final Assembly)	49	26	90
Inventory Carrying Cost	1	1	0
Inbound Logistics	7	9	1
Tier One Suppliers	9	12	5
Lower-Tier Suppliers	17	24	4

through using invoices that attribute profits to various operations, we cannot ascertain the location of the highest value-added activities. Because there is no market for the various sub-assemblies, there is no external market comparison.

Final assembly – China

The firm's operations in China differ from those in Finland. China produces five of the modules and undertakes the final assembly for the Asian market (depicted in Table 3). Sub-assembly 1 is exported from Finland to China to be included in the final product. When the product is manufactured in China and distributed to the Asian market, manufacturing is the largest contributor of value added, at 54% (see Table 3). The actual share of the input costs is 42% (4.200€ indexed) of the total value added, and profits are 58% (5.800€ indexed) of the total value added. Manufacturing continues to be the largest input cost. Given its low input costs and the ability to sell the product for roughly the same price in Asia as elsewhere in the world, the Chinese assembly operation appears to have excellent profits.

Table 3
Distribution of input costs and operating profit in China

	Value added (in percent) (10.000€)	Input costs (in percent) (4.200€)	Profits (in percent) (5.800€)
Sales and Distribution	14	8	19
Outbound Logistics	3	7	0
Headquarters	3	6	0
Manufacturing (excl. HQ)	54	23	77
Inventory Carrying Cost	3	7	0
Inbound Logistics	2	5	0
First-Tier Suppliers	7	16	2
Lower-Tier Suppliers	12	28	2

Final assembly – north america

The U.S. operation differs from those in Finland and China in that it only undertakes the final assembly. Five modules are imported from China, and the remaining one is imported from Finland. When the product is final-assembled in the USA and distributed to the North American market, manufacturing contributes the greatest proportion of value added, at 35% (see Table 4). The actual share of the input costs is 82% (8,200€ indexed) of the total value added, and profits are 18% (1,800€ indexed) of the total value added. Manufacturing and inbound logistics are the largest input costs. The USA assembly operation has higher logistics and inventory carrying costs compared with Finnish and Chinese assembly operations, because all subassemblies and components are imported, and therefore, it reports far lower profits.

Table 4
Distribution of input costs and operating profit in the USA

	Value Added (in percent) (10.000€)	Input Costs (in percent) (8.200€)	Profits (in percent) (1.800€)
Sales and Distribution	8	13	-14
Outbound Logistics	3	3	1
Headquarters	3	4	0
Manufacturing (excl. HQ)	35	24	84
Inventory Carrying Cost	3	3	0
Inbound Logistics	13	14	6
First-Tier Suppliers	12	14	12
Lower-Tier Suppliers	22	26	11

National distribution of value added and input costs

When we shift our perspective from that of the firm to that of the nation, a different pattern is observed (see Table 5). If the final assembly is undertaken in Finland, then 64% of the total value added occurs there. In the case of final assembly in China, 77% of the total value added occurs there, and if final assembly occurs in the USA, 50% of the value added occurs there. Because suppliers are small and, for the most part, provide standardized parts and because profits are allocated to the assembly factory, the location of the final assembly has a significant impact on the perceived location of the value added. To illustrate this point, the Finnish share of value added drops from 64% to 15% if the location of the final assembly is China and to 18% when the final assembly is in the USA. In China, this result is due of the large number of modules and other components sourced from China. In the case of the USA assembly, this result is due to the fact that there are few local suppliers. From this perspective, Finland and China have a similar share of the total value added: 18%. This result is paradoxical because the assembly factory undertakes the simplest functions and requires fewer trained personnel, particularly when compared with the Finnish sub-assembly factory.

Table 5
Geographical distribution of value added (Finland versus China versus USA)

	Value Added – Finland (in percent) (10.000€)	Value Added – China (in percent) (10.000€)	Value Added – USA (in percent) (10.000€)
Finland	64	15	18
China	11	77	18
Americas	2	0	50
EU-27	19	6	8
Other	4	3	5

From an overall perspective, the high value added attributed to Chinese operations is the result of two processes. First, the transfer of sub-assembly manufacturing operations to China means that an increasing portion of the entire product is produced there. Second, because the profits are assigned to the final assembly facility, it appears as though China has high value added. While the USA operation appears to have high value added, a significant portion of this value added consists of logistics and inventory costs, which, of course, are not value-added in the normal sense of the term (for a discussion of the costs of logistics, see, for example, Lorentz et al., 2012) . In summation, if the product is assembled in Finland, the product's value added is 65% of its total inputs and 35% of its value capture. When the product is manufactured in China, the product's value added is 42% of its total cost of resources and 58% of its value capture. Finally, if the product is assembled in the USA, the value added of the product consists of 82% of its total cost of resources and 18% of its value capture.

The differences between the three final assembly locations and how the input costs are distributed internationally are shown in Table 6. If the final assembly is located in Finland, then 48% of the total input costs are derived from Finland. In the case of China, 48% of the total input costs are national. For the USA, this percentage declines to 47%. This result indicates that the location of the final assembly has a significant impact on input costs, which is most evident in the case of the final assembly in the USA, where inventory carrying and logistics costs are significant.

Table 6
Geographical distribution of input costs (Finland versus China versus USA)

For product assembled in:	Costs of inputs from Finland (in percent) (6.500€)	Costs of inputs from China (in percent) (4.200€)	Costs of inputs from the USA. (in percent) (8.200€)
Finland	48	32	20
China	14	48	19
Americas	3	0	47
EU-27	28	13	8
Other	6	6	6

The geographical distribution of the profits reflects the firm's decision to allocate profits to the final assembly. This fact is illustrated in Table 7. For example, if the final assembly occurs in Finland, then Finland appears to generate 92% of total profits. When the assembly occurs in China, China appears as though 98% of the total profits are generated in China, despite the fact that the single most valuable module is produced in Finland. In many respects, the most remarkable result is the case of the USA assembly, which is shown to be responsible for 63% of the profits even though it only performs the final assembly. The details of the geographical distribution of the profits are explained in Table 7. The operation's

Table 7
Geographical distribution of profits (Finland versus China versus USA)

	Profits – Finland (in percent) (3.500€)	Profits – China (in percent) (5.800€)	Profits – USA (in percent) (1.800€)
Finland	92	2	12
China	5	98	17
Americas	0	0	63
EU-27	2	1	7
Other	1	0	1

USA profits appear high even though its logistics and inventory costs are large and USA performs only simple assembly. This example is an artifact of the firm's decision to account for profits at the assembly operation.

Discussion

In this paper, we have identified and illustrated the need for new measures of trade statistics in the industrial era of the second unbundling: trade-in-added-value measures can be further subdivided into trade in input costs and trade in profits in order to understand the manner in which MNEs actually operate in global supply chains. Furthermore, we have identified and illustrated the role of transfer pricing by parsing added value into input costs and profits in the different stages of global manufacturing networks and their locations. By examining the ways in which a corporation accounts for and reports its costs and profit, we contribute to both supply chain analysis and international trade theory. By considering added value, input costs, and profits, a more realistic picture of the operation and accounting in a global supply chain emerges. For those analyzing global supply chains, we show that it is important to identify and include the effect of transfer pricing in separating added value into input costs and profits among the different nodes in a global manufacturing network.

The single most surprising finding is that the MNE's accounting system and transfer pricing mechanism do not necessarily represent where the most valuable assets of the MNE are located. This is due to the fact that our firm previously had manufactured its products in one single nation and had only recently globalized its operations and supply chain. One explanation for this finding would be that the firm's accounting system and transfer pricing mechanisms are simply lagging behind reality. However, this suggests that, given the significant number of firms that have built global supply chains and the many more that will do so in the future, today's trade statistics may be seriously misleading and in the future they may become even more misleading. One bold assumption by top-down trade economists might assert that this is not a problem because, given the variety of firms, the discrepancies will cancel each other out. However, it may be equally true that the data are skewed in significant ways. Moreover, such data skewing could be industry specific, thereby further disturbing analyses and leading to erroneous conclusions.

As a case study, our results have significant limitations. First, this is a case study of a single product built in multi-product factories; thus, in these factories, managers may have more and less profitable products. However, in our case, this product was one of their most profitable. While this firm allocates nearly all profits to the final assembly, other firms may have entirely different strategies such as allocating profits to headquarters and R&D, to offshore tax havens, or to the marketing and distribution functions. Therefore, the generalizability of our results may be quite limited. Yet, the results show that the share of profits is a significant variable when considering value added; therefore, the current methods of measuring trade in value added can easily mislead decision and policy makers.

Based on the interviews and invoice-level component data, we know that the Finnish module has the highest value-added components and software and is the focus of corporate R&D. This finding suggests that the allocation of the "profits" to the assembly facilities provides an unrealistic impression of where the greatest value is added and where the firm's profits are generated. This fact disguises the true role of the Finnish module not only in generating the overall profit but also in ensuring that the firm retains control over the supply chain. Further, from the perspective of the supply base, the production of the key module in Finland provides markets for European suppliers.

There are also national and regional implications. First, while some scholars suggest that developed nations should be the location of higher value-added activities, the U.S. factory is a kit assembly operation that shows high profits. With the low-cost modules produced in China and the high-cost module built in Finland, the U.S. factory appears to have little potential for upgrading. This finding suggests that industrial recruitment campaigns to increase "manufacturing" employment should be careful in regards to what specific nodes in the supply chain are being courted. With regard to China, the Chinese operations appear to have a limited ability to upgrade their production due to the centralization of the value added in the Finnish module.

The appearance of profitability is interesting in its own right. Due to transfer pricing, the Chinese operations appear to be the most profitable ones because five modules are produced domestically and thus have small inventory and shipping costs. From an accounting perspective, China appears to be the most successful and important operation. This result is a creation of the accounting system, not the reality of where the true value is created.

Supply chain managers have long known that inventory and logistics costs are real and have a significant impact on overall profitability. Despite this fact, in nearly all previous studies, these costs have been either imputed or simply included in residual costs. Locational decisions affect these costs. At risk of repetition, the USA assembly operation was the most dramatic example. Because it received all modules from China and Finland, this operation had the highest input costs. Most striking were its inventory and logistics costs of €2,050; in comparison, these costs were nearly half those in Finland (€1,040) and less than half those in China (€798).

This firm, as we believe is the case with many other firms in the producer goods' industries, took a quite different road than firms in electronics and garments that long ago outsourced a large part or nearly all of their assembly activities. While our firm has relocated the production of the five less technically sophisticated modules to China, it continues to produce them in a subsidiary. Despite retaining the most important module in Finland, the accounting system and transfer-pricing mechanisms have not allocated profits to Finland, where the firm's most valuable assets and greatest apparent value addition are located. Interestingly, the firm did not choose to create a tax haven subsidiary in a nation such as Singapore for tax-reduction purposes. Because our firm has globalized relatively recently, our paper suggests that its accounting systems may lag or misrepresent where value is created and where value is recognized. This fact may not have been important when both the assembly and the key module assembly were centralized in Europe; however, with global operations, this decision may be causing a greater mismatch with reality. This case study suggests that top-down national income accountants or international trade economists that do not consider the learnings from supply chain researchers are likely to mis-specify their models and misunderstand the reality of the global economics. With global supply chains becoming ever more complex and dispersed, transfer pricing will only become more important for firms and nations.

APPENDIX 1

Value Added, Input Costs, and Profit Calculation Methodology

At each value-adding step *c*, an organization *i* purchases inputs, conducts its own value-adding activities (Y_c^i), and sells its output to the next node in the supply chain. The value added of each step (equation 1) is the combination of the step's input costs E_c^i and its operating profits π_c^i:

$$Y_c^i = E_c^i + \pi_c^i . \tag{1}$$

The sum of all value-adding steps equals the final price (Y) before any applicable taxes (equation 2):

$$Y = \sum_{i=1}^{J} \sum_{c=1}^{N} Y_c^i . \tag{2}$$

For each firm in the supply chain, we calculate the value added, which is the difference between the input costs (i.e., the costs of inputs purchased by an organization) and the price for which it sells the output (for suppliers, this cost is imputed). For the case product, we are able to calculate accurate product-level value added (Y_c^i) as well as its two components (E_c^i) and (π_c^i). For suppliers, our data allow USA to impute the product-level value added (Y_c^i), but not its division into (E_c^i) and (π_c^i). To approximate these product-level figures, we use firm-level data as follows. First, we calculate the operating margin at the firm level (equation 3):

$$\pi\_MARGIN^i = \frac{operating\_profit^i}{Net\_sales^i} . \tag{3}$$

Second, we approximate the component-level operating profit (π_c^i) by multiplying the firm-level operating margin (π_MARGIN^i) by the component price ($PRICE_c^i$) at which our focal firm purchases the input:

$$\pi_c^i = \pi\_MARGIN^i x PRICE_c^i . \quad . \tag{4}$$

Then, we subtract this product-level profit from the component-level value added to obtain the internal expenses at the component level (equation 5):

$$E_c^i = Y_c^i - \pi_c^i . \quad . \tag{5}$$

To estimate the geographical breakdown of the product's value, we allocate the value added, internal expenses, and profits in step Y_c to each region (equation 6):

$$Y_c^i = Y_{c,D}^i + Y_{c,E}^i + Y_{c,N}^i + Y_{c,A}^i + Y_{c,O}^i \quad , \tag{6}$$

where

D = Finland

E = Other EU-27

N = North America

A = Asia

O = Others.

The data include invoice information concerning the firm's generated value added in its manufacturing, sales, and other support functions in each region and the transfer price for all intra-firm transactions. The data also includes the manufacturing and R&D locations for nearly every component used in the final assembly and locational information for the majority of the parts used in the sub-assemblies. The great majority of these components are simple metal components, such as flanges and metal plates. Thus, their allocation to various regions is straightforward. In cases without detailed locational information, we allocate the inputs and profits of that component or value-adding step equally to a region where the component manufacturer's headquarters and manufacturing units are located.

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Appendix 3

Changing Geographies of Value Creation in Global Supply Chains: Evidence from Mobile Telecommunications

Timo Seppälä & Jyrki Ali-Yrkkö

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1 Abstract

This article analyses the distribution value added of three mobile telecommunications products launched in 1999, 2003 and 2007, in addition to analysing the respective changes of value added and the tasks – such as research & development, industrialisation, and manufacturing – related to disaggregation between advanced and emerging economies and knowledge diffusion. Our study finds that the distribution of value added and the locations of different tasks have dramatically changed among the different participants in global value and supply chains. Furthermore, we find that the geography of value added has shifted from being driven by the EU-27 to being driven by Asia. We also show how the smile-shaped value chain disaggregation has become a bathtub-shaped value chain disaggregation.

2 Introduction

Globalising value networks means that certain stages of value and supply chains that were formerly performed by the same company in the same geographical location are dispersed globally and typically to numerous companies. This shift in value and supply chains covers different stages and tasks, including research, technology and product development, prototyping, component manufacturing and final assembly. One key difference from earlier periods is that current globalisation is at a much finer level of disaggregation (Baldwin 2006, 2009). Furthermore, companies based in advanced economies are increasingly investing in low-cost nations by creating new units and expanding existing affiliations. Simultaneously, countries such as China and India have undertaken efforts to make themselves more attractive to the sourcing organisations of multinational enterprises (MNE's), which has led to increases in outsourcing and other forms of purchases from local firms.

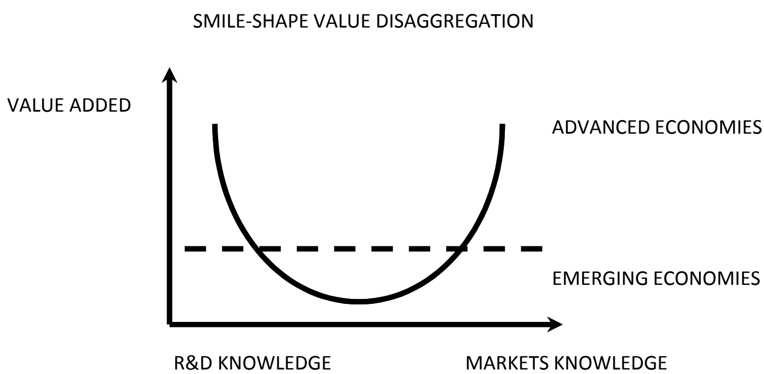
The progress of the geographical dispersion of supply chains correlates to the increasing volume of knowledge in low-cost countries. Without a sufficient level of knowledge, local companies or local branches of MNE's could not execute their research, technology and product development, prototyping, component manufacturing or final assembly operations. MNE's have responded in several ways to the challenge of imparting knowledge. A theoretical paper by Antràs et al. (2008) emphasised the role of skills in the host country and the need for intermediaries to transfer knowledge while minimising communication costs.

In their model, hierarchical structures and costs related to these structures are an important determinant of MNE's productivity and profitability of offshoring. However, it can generally be argued that the role of organisational hierarchies as transferors of knowledge is not new (see, e.g., Döring & Schnellenbach, 2006).

The role of multinationals as major institutions for transferring knowledge internationally was recognised over 40 years ago (e.g., Vernon, 1966; Quinn 1969; Teece, 1977). As knowledge flows to new regions, companies utilise such regions as locations for their in-house affiliates or suppliers, which indicates that the value added of a single product or service is increasingly created in numerous countries. Because GDP (Gross Domestic Product) is measured as the sum of the value added by all organisations in a national economy, it is important to know where value added – defined as gross output minus intermediate consumption – is created.

One way of conceptualising globalisation and knowledge acquisition is the "smiling" curve proposed by Stan Shih, the founder of Acer (See Figure 2.1), which illustrates when value added in manufacturing operations is decreasing and becoming increasingly concentrated in upstream and downstream functions in value chains. This development affects the geography of where different tasks related to technology and product development, prototyping, component manufacturing and final assembly are undertaken. Recently, manufacturing operations have been relocated to emerging countries (Gereffi, 1994, 1999; Pyndt & Pedersen, 2006; Mudambi, 2008). However, most of the technology and product development, prototyping and market-related knowledge has historically been located in developed economies.

Figure 2.1
Smile-shaped value chain disaggregation
(adopted from Everatt, 1999; Tsai & Everatt, 2006; Mudambi, 2008)



To our knowledge, there are only a few studies that examine the effects of this movement toward trade-in tasks on value creation and its geographical distribution. For example, Linden et al. (2009) examined Apple's iPod to understand how value is distributed across supply chain participants. In particular, they studied the ability of the lead firm to profit from innovation from a product perspective (see Porter, 1980; Teece, 1986). Linden et al. (2009) also estimated the geographical distribution of the value capture. Based on headquarters' locations, they concluded that firms in the U.S. capture most of the value. However, a shortcoming of this study is that it was not able to measure value added. As the authors themselves noted, "Gross profit does not equal the full value added, since it excludes direct labor". Ali-Yrkkö (2010) and Ali-Yrkkö et al. contributed to the literature by using an approach similar to Linden et al. (2009) and Dedrick et al. (2009, 2011) to analyse the geography of value creation in a Nokia N95 smartphone but employed value added instead of gross profit in the analysis. Ali-Yrkkö et al. (2011) also used Nokia's N95 smartphone as a case product in measuring the geographical location of value-added capture. Instead of allocating 100% of the component's value added to the location of the supplier's headquarters, this study allowed for the generation of each component's value added in multiple locations. The results suggested that even when the final assembly was located in China and the final sales occurred in the U.S., Finland captured 39% of the value added.

In this paper, we continue with detailed granular research to determine how globalisation, disaggregation of a value chain and respective knowledge diffusion occur regarding the basic three entry-level Nokia phones launched between 2000 and 2007. Our findings show that the results concerning the Apple iPod and Nokia N95 do not apply for the three products that are the subject of our analysis because the value creation across these models shows a rapid shift away from advanced economies to being captured in the emerging economies in which manufacturing occurs. This shift in value creation includes tangibles and manufacturing, in addition to a shift in intangibles and design knowledge.

In terms of methodology and approach, this study is similar to Ali-Yrkkö (2010), Ali-Yrkkö et al. (2011) and Seppälä & Kenney (2013). We extend the previous studies in three important ways. First, instead of using a single point in time, our examination of three models introduced at different times enables a dynamic approach that allows us to analyse how the location of value creation has changed as the technology inside products has been commoditised. Second, we analyse what types of tasks have been offshored to emerging economies and which types have been retained in advanced economies. Third, we show that knowledge has also been transferred as part of the relocation process. Our evidence shows that this transfer has proceeded on a step-by-step basis – beginning with manufacturing knowledge and ending with the transfer of system knowledge – that enables the products to be developed and manufactured for the global market. In our research, China has been the most important knowledge recipient.

The remainder of the paper proceeds as follows. Section 3 introduces the literature of global value chains and knowledge upgrading in offshore subsidiaries. Section 4 explains the data, data sources and methods. Section 5 provides an empirical analysis and the results, and section 6 concludes the paper.

3 Global value chains and knowledge upgrading in offshore subsidiaries

The operational environments of the value-adding activities of firms have been transformed through the processes of internationalisation. One of the most notable changes in this process has been the global dispersion of tasks – the stages of various value chains that were previously performed by the same organisation in the same geographical location are now dispersed globally and often to numerous companies (Fukao et al., 2003; Baldwin, 2006, 2009; Grossmann & Rossi-Hansberg, 2008). Furthermore, MNEs participating in the global dispersion of tasks have acted as catalysts for international knowledge diffusion and have contributed to creating new capabilities in these receiving economies (Rugman & Verbeke, 2001; Ernst & Kim, 2002; Buckley & Ghauri, 2004; Mudambi, 2008).

Gereffi (1994, 1999) uses a global commodity chains perspective to analyse the organisational dimensions of international trade networks and global industries. However, defining value derives from Porter (1980), which describes a vertical chain with three categories of players: suppliers, companies and buyers. Global production networks were conceptualised by Ernst & Kim (2002). In both approaches, by Porter (1980) and by Ernst & Kim (2002), the vertical chain concept is dispersed across the boundaries of the company and national borders to integrate it with global and local supplier and buyer networks that are, in turn, integrated with different supplier and customer relationship management mechanisms.

The geographical location of different tasks may vary with time. Furthermore, firms' strategic behaviour changes over time, and locational decisions are dependent on both internal and external drivers of the firm. The product cycle theory proposed by Vernon (1966) suggests that the location of production depends on the maturity of the subject product. When products standardise, the role of production costs as a determinant of location place becomes more important.

The product cycle theory strongly suggests that foreign affiliates mainly exploit innovations that are developed in the home country.

Notwithstanding that some offshore production and R&D sites continue to rely on the technological strengths of the firm's home country, an increasing number of MNEs have multiple locations in which innovations occur (Cantwell, 1995; Pearce, 1999; Cantwell & Mudambi, 2005). However, the term "R&D" covers a wide range of tasks from basic research to product customisation, and not all R&D sites located in different national economies – or regions – have equal roles (see, e.g., Kuemmerle, 1999; von Zedtwitz & Gassman, 2008).

The relationships of R&D roles with other sites are not static. When subsidiaries upgrade their competencies, their role and area of responsibility potentially change. The topic of competence building in MNE's multinational firms, with its focus on upgrading technological capabilities in offshore subsidiaries, is widely recognised (Cantwell, 1995; Rugman & Verbeke, 2001; Hobday and Rush 2007). According to Cantwell and Mudambi (2005), competence upgrading as part of subsidiary evolution is determined by several factors, including group-, subsidiary- and location-specific factors. Competence upgrading of subsidiaries should not, however, be understood as an ultimate goal of any subsidiary or parent company. Pananond (2013) argues that subsidiaries upgrade their capabilities because they strive to move up the value chain. If subsidiaries do not have certain capabilities, they are not able to undertake such moves (see also Rasiah et al., 2011). In general, when it upgrades its competence, a subsidiary is able to either better perform its current activities or extend its activities to new functions. Either result may lead to increased valued added, which is consistent with the definition of foreign subsidiary as a value adding entity, found in Birkinshaw and Hood (1998).

By contrast to previous studies, we study competence upgrading and value creation in a technology's life cycle. Our evidence will demonstrate that the accumulation of technological capabilities in subsidiaries is the result of a longitudinal process. Furthermore, it is not related to the particular activity, function or process over the technology's life; rather, it is a holistic transfer of knowledge.

4 Data and methods

Our detailed data allow us to examine value creation and the location of tasks at the product-level. We analyse three candy-bar-form factor handset models with small monochrome displays and no cameras that launched between 2000 and

2007: the Nokia 3310, the Nokia 1100, and the Nokia 1200[1]. These three models are among the world's bestselling handset models; the Nokia 3310 is the fifth bestselling mobile phone of all time, the Nokia 1100 is the bestselling mobile phone of all time, and the Nokia 1200 is the third bestselling mobile phone of all time. Each has sold over 100 million units[2]. All three handset models had similar functionalities but different industrial designs, i.e., the look and the mechanical design of the handset models were different. Furthermore, there were no significant designing efforts required among the different product models. Thus, we consider that these three mobile devices, the Nokia 3310, the Nokia 1100, and the Nokia 1200, are a representative sample of a larger portfolio of products and help explain what was occurring on a large scale inside a mobile device value and supply chain.

In particular, the 1100 and 1200 were basic models targeted at first-time users in entry markets and did not have any significant new features compared to older models, such as the Nokia 3310 and the Nokia 3210. This similarity among the handset models offers the opportunity to consider the commoditisation of technology, task-level knowledge transfer and globalisation, and geographical and organisational value creation at the product level. An ideal setting for a dynamic examination of product level value creation allows us to analyse the same product over multiple years; however, in the mobile phone industry, the life-cycles of single products are too short for this approach and, therefore, we used several comparable models.

4.1 Data description

Typically, companies will not provide information about the pricing of components or manufacturing costs, and the same holds for distributors and retailers. For this reason, we used four different information sources to estimate the distribution of the value added that was created by different participants and regions.

First, in October 2010, we physically disassembled the Nokia 3310, 1100 and 1200 phones and, in collaboration with electrical engineers, examined each of their hundreds of components. We also used "teardown" reports of the component compositions that are published by industry analysts. These reports (see, e.g., Portelligent, 2007) include estimates of factory prices and vendors. Next, using the knowledge gathered in the previous steps, we collected further qualitative and

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1 The Nokia 3310, 1100 and 1200 were launched in 2000, 2003 and 2007, respectively.

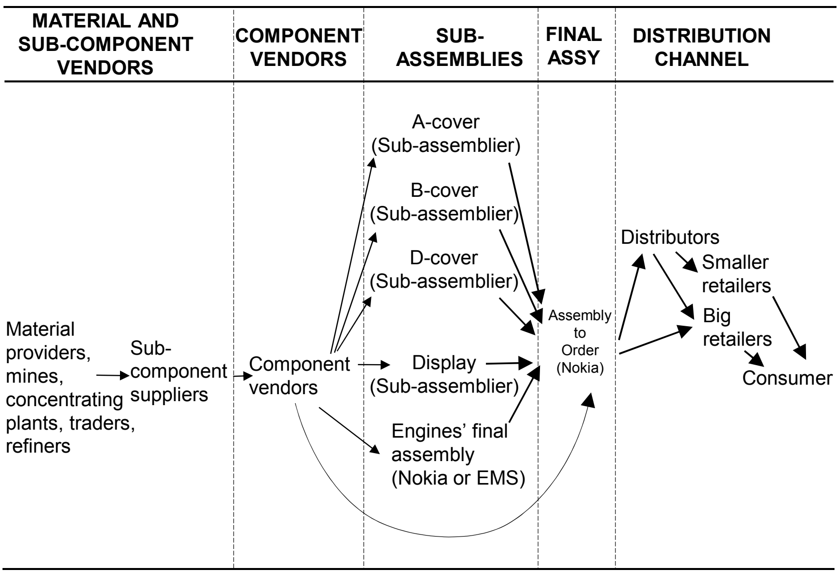
2 http://www.telegraph.co.uk/technology/picture-galleries/9818080/The-20-bestselling-mobile-phones-of-all-time.html?frame=2458860 (information retrieved 5.7.2013).

quantitative information by interviewing 12 industry experts either currently working or who had previously worked in various roles in the mobile handset supply chain. The interviews were conducted between April 2009 and May 2011[3]. Finally, we examined the financial reports and press releases of the companies involved and those of their direct competitors. In particular, we exploited the differences in reporting in various geographical locations and examined officially required additional information, such as Securities and Exchange Commission 20-F reports in the US.

4.2 Methods

A *supply chain* refers to the global flow of intermediate goods and services – including those provided in-house and those purchased from unaffiliated companies – that are involved in providing a good or service for final consumption (Figure 4.1).

Figure 4.1
The stylised supply chain of the Nokia 3310, 1100 and 1200 models[4]



[3] Because of the topic's sensitivity, we had to assure full anonymity to our interviewees. The interviews were semi-structured, and the questions varied among interviewees depending on their positions in the supply chain.

[4] Definitions: A-cover is the front cover of the mobile phone; B-cover is the bottom cover of the mobile phone; D-cover is the middle cover of the mobile phone; Engine is the printed circuit board assembly; Engine's final assembly is the assembly of display, D-cover and printed circuit board assembly; Assembly to order is the final assembly of A-cover, B-cover and an engine assembly, including software and sales packing.

Generally speaking, the flow in Figure 4.1 is as follows. The outputs of miners/refiners are turned into sheets of metal and other elementary processed goods that are traded to parts and components vendors. The 3310, 1100 and 1200 are composed of 250–400 components, and their vendors deliver the great majority of these components to sub-assemblers (who may, in turn, deliver the same components to other sub-assemblers). In the final assembly – the assembly-to-order phase (ATO) – Nokia itself combines these sub-assemblies and certain separate components. Some of the intangibles – to the extent they are not embedded in and bundled with physical components – are licensed. Standalone software is purchased from third parties as necessary. Furthermore, many of the intangibles are provided in-house or by vendors compensated at a billable hourly rate. Depending upon the market, in the case of mobile phones, Nokia's immediate customers are typically distributors (e.g., Brightpoint Inc.) who, in turn, supply wholesalers and retailers or operators (e.g., Vodafone).

In each step, each organisation conducts its own value-adding activities (Y_c) and sells its output, *c*, to the other participants in the supply chain. The sum of all value-adding activities equals the final retail price (Y) before any applicable taxes (equation 1).

$$Y = \sum_{c=1}^{N} Y_c \qquad (1)$$

For each company in the supply chain of the three phones, we calculated the value added, which is the difference between the cost of the inputs purchased by an organisation and the price for which it sells the output. For the retailer, the wholesaler, and Nokia, we were able to calculate accurate product-level value added. For most of the other companies, *i*, in the supply chain, we derived the ratio of the value added to net sales (what we call the value-added margin) at the firm level (equation 2)[5].

$$VA\_MARGIN^i = \frac{Operating\_profit^i + Depreciation^i + labor\_\cos ts^i}{Net\_sales^i} \qquad (2)$$

[5] For the companies that conform to US GAAP accounting principles, labour costs are unavailable. For these firms, we assume the value-added margin to be identical to its nearest competitor(s). For example, in the case of the charger included in the sales package of the Nokia 1200, the factory price of the charger is approximately €0.8, and Astec supplied a part of the chargers to this phone model. Astec (US) is a part of the *Emerson Network Power* group that adheres to US GAAP. Its direct competitor, *Salcomp Oy* (Finland), the leading global mobile phone charger vendor, follows IFRS. In its 2007 financial statement, *Salcomp's* value-added margin was 23.3%. Thus, we estimated *Astec's* value added to be approximately €0.19. Similarly, in the case of Texas Instruments (US), we employed the average of the value added margins of three competitors it identified in its 2007 Form 10-K report (pp. 3–4) required by the US Securities and Exchange Commission, i.e., *NXP* (the Netherlands), *Infineon Technologies AG* (Germany) and *STMicroelectronics* (Switzerland). For the other models, i.e., the Nokia 3310 and Nokia 1100, we use year 2003 and 2004 Form 10-K reports.

We then approximated the component-level value added (Y_c) by multiplying the firm-level value-added margin by the component price ($PRICE_c^i$):

$$Y_c = VA\_MARGIN^i xPRICE_c^i \tag{3}$$

In addition to the value added of each participant, we also analysed its geographical breakdown. It should be noted that companies themselves do not typically provide product-level information regarding their locations for manufacturing and other operations. With further research, we could nevertheless estimate this information fairly accurately, at least as far as broader regions are concerned.

The value capture of in-house indirect inputs, such as the role of general management, the corporate brand and image, and reusable tangible and intangible assets (including design and technical aspects copied from previous products or that contribute to future models), is difficult to allocate in general and is particularly difficult across geographical locations. Thus, we followed Ali-Yrkkö et al. (2011) and the estimation method developed therein (see Appendix 1). This method is briefly described as follows. In the case of each participant, 10% of the value capture occurs at the headquarter location, and 90% is attributed according to the actual location(s) of participants' production factors; however, there is an attempt to correct for regional productivity differences by using multi-factor productivity differences between regions (see equation (A6) in Appendix 1).

5 Results of an analysis

5.1 Who creates value? By types of actors

Let us first consider the direct costs of components, parts, sub-assemblies, software, and licenses with respect to the three phone models (Table 5.1). We begin by considering the actual sales prices (the gross value), and then we consider the first-tier suppliers on a value-added basis.

Based on our calculations, the direct bill-of-materials (BOM) is approximately € 31.2, € 23.7 and € 14.6 for the 3310, 1100 and 1200 models, respectively. Thus, between 2003 and 2007, the BOM's per phone was more than halved.

One of the main drivers behind price decline is technology commoditisation. As part of the process of technology commoditisation, the knowledge essential for producing components has spread to developing countries. In addition to

Table 5.1
The bill of materials (BOM) of the Nokia 3310 in 2003 prices, the Nokia 1100 in 2004 prices and the Nokia 1200 in 2007 prices

	2003 Nokia 3310		**2004 Nokia 1100**		**2007 Nokia 1200**	
Description	Eur	%	Eur	%	Eur	%
Processor(s)	2.2	7.0 %	2.2	9.3 %	1.8	12.5 %
Display	3.8	12.1 %	3.3	13.7 %	0.6	4.4 %
Memories	2.7	8.6 %	1.1	4.4 %	0.6	4.3 %
Battery pack	1.37	4.4 %	1.37	5.8 %	1.05	7.2 %
Other integrated circuits (excluding processors and memory)	8.46	27.1 %	6.74	28.4 %	2.86	19.6 %
Mechanics	3.79	12.2 %	3.05	12.9 %	1.85	12.6 %
All other hardware inputs	7.39	23.7 %	4.71	19.8 %	4.86	33.2 %
BOM (excluding supporting material, license fees and manufacturing)	29.7	95.2 %	22.4	94.3 %	13.7	93.8 %
Supporting material	0.95	3.1 %	0.93	3.9 %	0.70	4.8 %
BOM (excluding license fees and manufacturing)	30.6	98.2 %	23.3	98.2 %	14.4	98.5 %
License fees	0.56	1.8 %	0.43	1.8 %	0.22	1.5 %
BOM (excluding manufacturing)	31.2	100 %	23.7	100 %	14.6	100 %

Data source: Authors/ETLA database

Note A: For the Nokia 3310, 1100 and 1200 models, the values are presented in 2003 prices, in 2004 prices and in 2007 prices, respectively.

Note B: Costs related to warranty and outbound logistics are not included.

MNE's units in developing countries, local companies have also become suppliers. For instance, the displays of the 3310 and 1100 came from *Samsung* (South Korea), whereas the displays for the 1200 were provided by Taiwanese vendors, such as Wintek.

According to Seppälä (2010, 2013a, b), Nokia actively searched for and systematically developed local suppliers in developing countries during the 2000s. By lowering the unit cost of components and assembly, internally and externally, the company was able to lower sales prices, which in turn enabled low-income customers to purchase handsets. This development has indirectly served Nokia's strategy of increasing mobile phone penetration and its market share in developing countries.

We proceeded by analysing the value added by supply chain participants. The methodology for calculating these shares is presented in Section 4.2. In addition to the five participant categories presented in Figure 2.1, we also separated the value added that was created by logistics and warranty operations. Because Nokia used both its in-house facilities and unaffiliated companies' facilities to manufacture mobile phone engines, we also separated engine manufacturing into its own category[6].

Table 5.2 shows the value-added breakdown of the three models' pre-tax retail prices. The pre-tax retail prices for the Nokia 3310 is 79€ in 2003, for the Nokia 1100 is 63€ in 2004, and for the Nokia 1200 is 27€ in 2007, which represents a total drop of 66%.

For distributors, wholesalers, and retailers, the value-added margin and the sales margin were effectively identical. In the case of the 3310, 1100 and 1200 models, retailers' margins ranged from 10.2 to 13.6% of the final sales price[7],

Table 5.2
The value added breakdown in the supply chain by participant

	2003	**2004**	**2007**
	Nokia 3310	Nokia 1100	Nokia 1200
Vendors of vendors	22 %	21 %	34 %
Suppliers of material inputs	17 %	17 %	19 %
Licensors	0.5 %	0.5 %	0.8 %
Engine manufacturing	5 %	3 %	2 %
Nokia, excluding engine manufacturing	38 %	39 %	19 %
Logistics and warranty	2.5 %	4.9 %	6.4 %
Distributor	4.0 %	4.4 %	4.7 %
Retailer	10.6 %	10.2 %	13.6 %
Total	100 %	100 %	100 %

Source: Authors/ETLA database

6 The sum of the bill of materials related to the engine's final assembly for the Nokia 3310, the Nokia 1100, and the Nokia 1200 varies between 80% to 90% of the total bill of materials cost, depending on the phone model.

7 Mobile phone sales margins are difficult to estimate because of various types of tie-ins and bundlings with subscriptions and/or other services, in which case the initial transaction is often undertaken at a loss. We consider margins without any bundlings. However, retailers themselves decide how much to charge for the product or service; therefore, their sales margins vary.

whereas the margins for the distributors/wholesalers were between 4 and 4.7%. These portions also represent their share of the total product value.

In all these cases, Nokia generated a large share of the total value. However, in the case of the 1200, Nokia's contribution to the value added is substantially lower than in the previous models. In value terms, the estimated value added generated by Nokia for the 3310, 1100 and 1200 are €34, €26.7 and € 5.7, respectively, which is partly because Nokia's BOM decline was unable to keep up with the drop in pre-tax sales price for this technology. These amounts were allocated to direct and indirect in-house[8] labour costs, including final assembly (including the ATO phase), R&D, marketing, sales, sourcing, management, the depreciation of tangible and intangible assets, investments, and operating profit.

Careful study of industry sources and of the information contained in our interviews suggests that the final assembly/manufacturing costs, including both engine assembly and the ATO of the Nokia 3310, 1100 and 1200–€7.4, €5.6 and €1, respectively. These amounts account for 3.7 to 9.4% of the pre-tax final sales prices. Thus, although final assembly is an essential part of the supply chain, the value added (that final assembly supplied) declined and was surprisingly low.

With respect to the final assembly/manufacturing costs, first-tier hardware vendors were responsible for 17–19%, first-tier (external, non-cross-licensed) intangible vendors for 0.5–0.8%, and second- and higher-tier vendors (vendors-of-vendors) in both categories were responsible for 21–34% of this amount. These shares should not – as discussed above – be equated to profit.

5.2 Where has the value been created?

As discussed above, GDP (Gross Domestic Product) can be measured as the sum of the values added by all organisations in a particular country. The important part is *where* the value capture occurs.

It should be noted that the geographical allocations of the country of final sales and final assembly are case-specific. For instance, in the case of a Nokia 3310 assembled (engine and ATO assemblies) in Salo (Finland) for the UK market, an extra 9.4% accrues to Finland and an extra 14.5% to the UK (Other EU area) of total value added. In the case of an assembly in Beijing (China) for the US market, the accrual is different. In Table 5.3, we considered five potential combinations (see table 5.5 for details) and calculated the average of these results.

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[8] This includes some outsourced work that was purchased as billable hours. However, because of the lack of data, we were not able to allocate this to other companies.

Table 5.3
The value added breakdown by regions after taking into account the value added created in the country of final sales

	2003 Nokia 3310	2004 Nokia 1100	2007 Nokia 1200
Finland	33 %	30 %	15 %
Other EU area	23 %	26 %	21 %
North America	9 %	9 %	12 %
Asia	28 %	28 %	45 %
Other countries	7 %	7 %	7 %
	100 %	100 %	100 %

Source: Authors' calculations

Based on our estimates (Table 5.3), the geography of value added changed during the 2000s. In the case of the 3310, overall, 33% of the value added was captured in Finland, and when we consider the entire EU-27 area, the share was as high as 56%. These shares are quite different compared to those of the 1200 that was launched in 2007. In the case of the 1200, the corresponding shares for Finland and the entire EU area were 15% and 36%, respectively.

The data presented in Table 5.3 mask the impact of structural changes in manufacturing and sales locations. Although the Nokia 3310 was manufactured and sold in Finland, the Nokia 1200 was never manufactured in Finland, nor was it ever sold in Finland. Due to such differences among the models, the data presented in Table 5.3 must be used cautiously. To control for bias, we fixed locations and considered the case in which both manufacturing and final sales were located in Asia (Table 5.4). In Table 5.4, we considered all five potential combinations (see Table 5.6 for details) and calculated the averages of these results.

Table 5.4
The value added breakdown by region (manufacturing and final sales in Asia)

	2003 Nokia 3310	2004 Nokia 1100	2007 Nokia 1200
Finland	24 %	27 %	11 %
Other EU areas	10 %	12 %	10 %
North America	6 %	6 %	8 %
Asia	55 %	52 %	66 %
Other countries	4 %	4 %	6 %
	100 %	100 %	100 %

Source: Authors' calculations

While the exact data in Tables 5.3 and 5.4 differ, the overall trend is similar. The share of Asia increased, which correlates to an increased amount of value added.

In Tables 5.5 and 5.6, we consider the details of five alternatives in constructing the geographical breakdown similar to Ali-Yrkkö et al. (2011).

- Our baseline method, in Column A, allocates the value added to the headquarters location of each participant in the supply chain. This tends to over-estimate the role of developed countries and regions.
- Our second method, in Column B (see Eq. 4 in Appendix 1), assigns the value capture solely on the basis of the locations of the production factors (physical capital, labor, and R&D). This implicitly assumes that the general management or corporate brand has no specific role in the value capture and tends to under-estimate the role of developed countries and regions.
- The third alternative, in Column C, is an intermediate method between A and B in which it is assumed that, in the case of each participant, 10% of the value capture occurs at the headquarters location, and 90% occurs at the actual location(s) of the participant's factors of production.
- Individuals and organisations in various locations have different productivities. Thus, their abilities to capture value may vary. Column D replicates Column B, but it attempts to correct for this fact by using multifactor productivity differences among regions (see Eq. 6 in Appendix 1).
- Our preferred estimation method (Column E) combines Columns C and D. Thus, in the case of each participant, 10% of the productivity-adjusted value capture occurs at the headquarters location and 90% at the actual location of the production factors.

In both Tables 5.5 and 5.6, A and B constitute the lower and upper bounds for Europe, C and D refine certain aspects of the model, and E provides our preferred estimate of the geography of value capture (Ali-Yrkkö et al., 2011).

Table 5.5

The breakdown of value added by region (different combinations of manufacturing and sales locations)

Nokia 3310	(a) Based on head-quarters.	(b) Based on the locations of production factors.	(c) 10% to the headquarter country and 90% based on the locations of production factors.	(d) Based on the locations of the production factors, corrected for productivity.	(e) 10% to the headquarter. country and 90% based on the locations of production factors, corrected for productivity.
Finland	46.7 %	25.8 %	26.1 %	26.3 %	26.2 %
Other EU area	11.6 %	23.4 %	22.9 %	23.7 %	23.9 %
North America	13.4 %	18.7 %	18.8 %	19.1 %	14.5 %
Asia	18.4 %	26.4 %	26.1 %	25.3 %	31.3 %
Other countries	9.9 %	5.7 %	6.1 %	5.6 %	4.2 %
	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Nokia 1100	(a) Based on head-quarters.	(b) Based on the locations of production factors.	(c) 10% to the headquarter country and 90% based on the locations of production factors.	(d) Based on the locations of the production factors, corrected for productivity.	(e) 10% to the headquarter country and 90% based on the locations of production factors, corrected for productivity.
Finland	40.5 %	21.7 %	21.7 %	24.8 %	20.9 %
Other EU area	21.5 %	24.6 %	24.7 %	24.4 %	25.1 %
North America	13.4 %	19.0 %	19.0 %	19.1 %	14.6 %
Asia	15.8 %	29.3 %	28.8 %	26.4 %	35.5 %
Other countries	8.7 %	5.4 %	5.7 %	5.3 %	4.0 %
	40.5 %	21.7 %	21.7 %	24.8 %	100.0 %

Nokia 1200	(a) Based on head-quarters.	(b) Based on the locations of production factors.	(c) 10% to the headquarter country and 90% based on the locations of production factors.	(d) Based on the locations of the production factors, corrected for productivity.	(e) 10% to the headquarter country and 90% based on the locations of production factors, corrected for productivity.
Finland	21.0 %	8.1 %	8.1 %	10.5 %	8.1 %
Other EU area	22.1 %	23.0 %	23.3 %	23.0 %	24.2 %
North America	21.0 %	21.2 %	21.5 %	21.4 %	16.1 %
Asia	26.3 %	39.1 %	38.4 %	36.6 %	45.8 %
Other countries	9.6 %	8.6 %	8.7 %	8.5 %	5.8 %
	100.0 %	100.0 %	100.0 %	100.0 %	100.0 %

Note: Different models were manufactured and sold partly in various regions. For instance, the Nokia 3310 was manufactured and sold in Finland, but the Nokia 1200 has never been manufactured and sold in Finland. Because both the location of assembly and the country of final sale have consequences on the geographical distribution of value added, the above calculations reflect the arithmetic mean of the following four combinations (and are thus comparable across models/time): (1) Assembled and sold in the EU, (2) Assembled in Mexico and sold in the US, (3) Assembled and sold in Asia, and (4) Assembled in Asia and sold in the EU.

The majority of unaccounted inputs are low-cost inputs, such as resistors, capacitors and screws, which are mostly manufactured and designed in Asia. In the geographical breakdown, we assumed that 80% of the total value added of these inputs is created in Asia, 10% in EU-27 countries and 10% in the United States. Other countries: Based on our firm-level data, approximately 1/3 of this value is created in the new member states of the EU. Thus, we attribute this amount to EU-27 and the remaining 2/3 to other countries (i.e., countries outside EU-27, Asia and North-America). Vendors of vendors: We consider the vendors of material supplies and immaterial supplies separately. We divide the value added that is created by vendors of material suppliers to all regions equally (EU-27, North America, Asia and other countries). In terms of value added created by immaterial suppliers' vendors, we assume that 90% of the value added created by vendors of immaterial suppliers was created in these three regions and divide this 90% equally among EU-27, North America and Asia. The remaining 10% is attributed to other countries.

Table 5.6

Value added breakdown by regions (different combinations of manufacturing and sales locations)

3310	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia.	Manufactured in Asia and sold in EU (excluding Finland).
Finland	26.2 %	26.2 %	26.2 %	26.2 %	26.2 %
Other EU area	23.9 %	44.1 %	10.2 %	10.2 %	30.9 %
North America	14.5 %	6.0 %	39.9 %	6.0 %	6.0 %
Asia	31.3 %	19.5 %	19.5 %	53.4 %	32.7 %
Other countries	4.2 %	4.2 %	4.2 %	4.2 %	4.2 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

1100	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia.	Manufactured in Asia and sold in EU (excluding Finland).
Finland	20.9 %	20.9 %	20.9 %	20.9 %	20.9 %
Other EU area	25.1 %	47.3 %	11.2 %	11.2 %	30.8 %
North America	14.6 %	5.6 %	41.6 %	5.6 %	5.6 %
Asia	35.5 %	22.3 %	22.3 %	58.4 %	38.8 %
Other countries	4.0 %	4.0 %	4.0 %	4.0 %	4.0 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

1200	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia.	Manufactured in Asia and sold in EU (excluding Finland).
Finland	8.1 %	8.1 %	8.1 %	8.1 %	8.1 %
Other EU area	24.2 %	43.6 %	9.5 %	9.5 %	34.1 %
North America	16.1 %	7.6 %	41.6 %	7.6 %	7.6 %
Asia	45.8 %	34.9 %	34.9 %	69.0 %	44.4 %
Other countries	5.8 %	5.8 %	5.8 %	5.8 %	5.8 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

Note: 10% to the headquarters country and 90% based on the locations of production factors, corrected for productivity.

5.3 The location of tasks and knowledge transfer

The increased contribution from Asia indicates that an increasing number of value creating tasks are located in the region. During the 2000s, Nokia and its supplier network actively increased both affiliated and unaffiliated operations in Asia. As a part of this development, Nokia also transferred technology and other types of know-how from Europe and the U.S. to China. Instead of being a sudden change, this process was gradual and occurred over almost a decade (Table 5.7).

Table 5.7 considers the transformation and locations of the following functions: 1) concept design and product management; 2) hardware and software platforms design; 3) product-specific design tasks and prototyping; and 4) component, subassembly, and product manufacturing. The information in Table 5.7 enables us to understand the evolution of operational strategies of the firm and also helps us comprehend the intra- and cross-functional dependencies between different tasks from a longitudinal transformation perspective. Thus, the table considers that neither external drivers nor the physical co-location of different tasks is central to coordination.

The 3310 was one of Nokia's first global products. While the prototype manufacturing was located in Finland, the mass manufacturing was distributed across three continents. Nonetheless, the model was mainly developed and managed in Europe. Tasks such as product program management, hardware platform design, software platform design, concept design and product test design were all located in Europe. Nokia's R&D site in Denmark was a particularly important site for the 3310. Furthermore, Nokia's Finnish suppliers (such as Aspocomp, Perlos, Protopaja, and Elcoteq) played an important role in assembly, component design, industrialisation, and manufacturing (See Figure 5.1). Figure 5.1 describes the increasing involvement of local suppliers (such as Foxconn, BYD, and LiteOn) and shows how these suppliers absorbed technology from Nokia and also from the network of Finnish suppliers. To illustrate, in 1999 audited Foxconn and later on that same year Foxconn received their first plastics component orders from Nokia (Seppälä, 2010, 2013a). Later, Foxconn become the largest supplier of technology and electronics manufacturing services for Nokia.

In the case of the 1200, China had a substantially more important role as a location for parts of the production process; although the main responsibility of hardware platform design and software design remained in Denmark, Nokia's Beijing R&D site participated in development. As a part of this involvement, certain employees of Beijing's site visited Denmark to increase their knowledge about hardware platform design and product software design. It should be noted that knowledge also flowed in the other direction in certain cases. During the

Table 5.7
The location of major tasks related to the handsets

Product life cycle	**1999 - 2003**	**2003 – 2007**	**2006 -**
Product Model	Nokia 3310	Nokia 1100	Nokia 1200
	Including: 3310 (Europe), Chinese variant[9] (China), American variant [10] (USA)	Including: 1100 (Asia & Europe), American variant[11] (USA)	
Product management	Denmark	Denmark	Denmark
Hardware platform design and development	Denmark, Finland	Denmark, Japan	Denmark, China
Software platform design and development	Denmark	Denmark	Denmark
User interface design and development	Denmark	Denmark	Denmark
Product software design	Denmark, China (Asia's software variant)	Denmark, Finland (America's software variant)	Denmark, (active participation from China)
Concept mapping and design	Finland, Denmark	Finland, Denmark	Finland, Denmark, China
Product design (hardware)	Denmark (3310), Finland (American variant)	Denmark (1100), Finland, USA (American variant)	China
Product test design	Finland	Finland	China
Proto manufacturing	Finland, USA	Finland, USA	China
Assembly to order manufacturing (ATO) (Nokia)	USA, Finland, Germany, Hungary, China, South Korea	USA, Hungary, China, South Korea, Brazil	China, India, Romania, Hungary, Mexico, South Korea
Engine assembly, if not in ATO location (Nokia)		Mexico	
Engine assembly (outsourced)	Estonia, Hungary	Estonia, Hungary, Mexico	China
Mechanical component manufacturing and sub-assemblies	USA, Finland, Germany, Hungary, China, South Korea, Mexico, China, USA	USA, Hungary, China, South Korea, Hungary, China, Mexico	China, India
Electro mechanical component manufacturing and sub-assemblies	Japan, China	Japan, China	China, India

Source: ETLA database

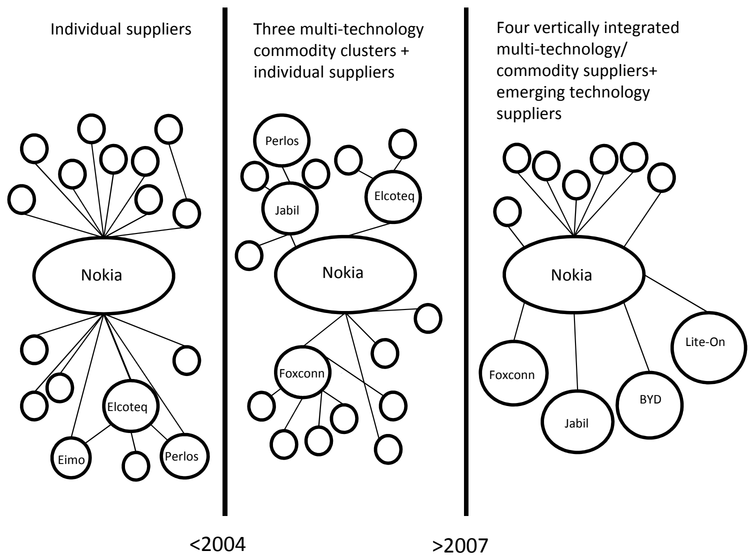
9 Software variant to Asian market.

10 American variant required a close collaboration with American operators (both hardware and software).

11 American variant required a close collaboration with American operators (both hardware and software).

2000s, Nokia's Denmark R&D increased its cooperation with Taiwanese-based Foxconn; soon, it became apparent that Foxconn was able to develop products faster than Nokia. Later, Nokia significantly reduced its product development time with knowledge gained from Foxconn (Larsen & Pedersen, 2011). Product test design and prototype manufacturing were also undertaken in China.

Figure 5.1
Changes in Nokia's supply chain network (Seppälä 2013a)



In summary, China's role substantially increased to encompass tasks other than pure mass manufacturing. Whereas Nokia's Beijing R&D site had previously localised products to the Chinese market, the Beijing operation today can design products for the global market. In addition to technical knowledge transfer, this process has included training programs to encourage initiatives by local R&D employees. However, the rise of China's role has required the systematic development of resources and knowledge transfers from advanced economies to emerging economies.

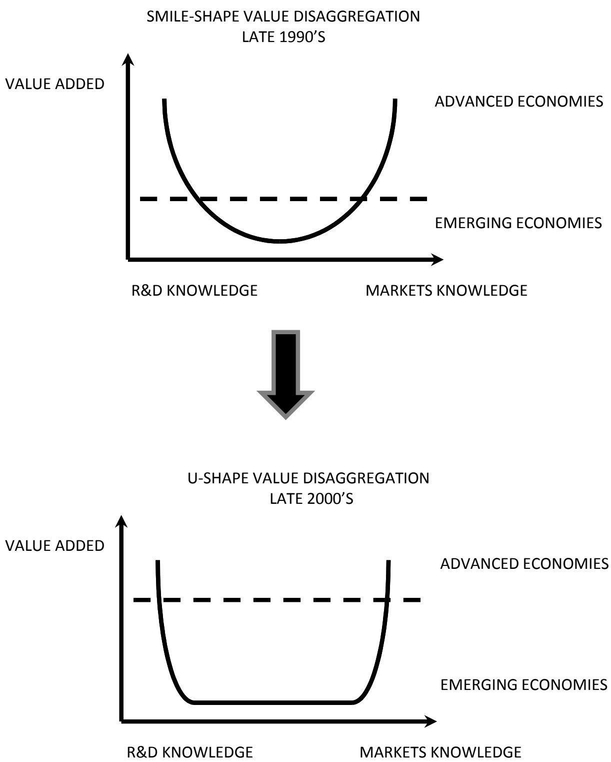
Our interviews revealed that this trend is continuing. For example, in the spring of 2011, Nokia decided to downsize its Danish R&D site. However, the downsizing of the Danish R&D site should not be considered representative of general trends in the industry because Nokia began having financial problems following 2007. Thus, all tasks previously located in Denmark are currently (or in the near future) being relocated to other sites. Because knowledge has been transferred to Beijing, it is evident that most of the tasks related to basic mobile phones will be relocated to China. Furthermore, Nokia's Finnish supplier network is being replaced by Taiwanese and Chinese multinationals capable of providing lower unit and assembly costs (Seppälä, 2010, 2013a).

6 Summary, conclusions and policy implications

In this paper, we examined the dynamics of global value chains in the context of a particular industry. Our results are based on bottom-up, product-level research in the mobile telecommunications industry for an individual firm's three basic mobile phones. There were three major findings, representing both theoretical and empirical contributions, that help explain the distribution of value creation and the geographies of dispersion in addition to helping describe the task level dynamics of global value chains in the mobile telecommunications industry between 1999 and 2007.

First, the "Smile"-shaped curve is transforming to a "bathtub-shaped" curve (see Figure 6.1 below; (for comparison see Mudambi, 2008, p. 207), and the

Figure 6.1
From a Smile-shaped value disaggregation to a U-shaped value disaggregation



emerging economies are now executing most tasks related to technology and product development, prototyping, component manufacturing and final assembly. Furthermore, market knowledge is located in the emerging economies. However, the management of most valuable intangibles – such as patents and similar intellectual property – continues to be located in advanced economies.

In practice, this finding indicates that an increasing number of tasks related to basic mobile phone development and production are being relocated to low-cost countries, particularly to China. Furthermore, higher-value-added tasks, such as research, are also being transferred. Moreover, the narrower slices of high-value-added tasks are conducted by advanced economies. Thus, the ownership of intangible assets (such as patents and branding) continue to be geographically located in advanced economies. In the case of the Nokia 3310, which was launched in 1999, tasks such as prototyping and printed circuit board manufacturing were located in Finland, and product hardware design was located in Denmark. In the case of the Nokia 1200, which launched 8 years later, all the aforementioned tasks and a number of others were located in China, but the product program management and other more demanding tasks remained in Denmark. However, Nokia's recent decision to completely close the Danish site suggests that the majority of these tasks will be relocated to China.

Second, as the emerging economies execute most of the tasks related to technology and product development, prototyping, component manufacturing, and final assembly, the share of value added attributable to the developing countries in which the value added was created have increased. In the case of the Nokia 3310, which was launched in 1999, Asia captured an average of 28% of the total value, and the EU-27 captured an average of 56% of the total value. These shares changed dramatically with the Nokia 1200, which was launched in 2007. In the case of the 1200, Asia captured an average of 45% of the total value, and the EU-27 captured an average of 37% of the total value.

Third, the increase in the number of demanding tasks in developing countries has required a transfer in competencies from developed countries. Instead of a sudden change, this process has occurred gradually over several years. Previously, product creation units in developing countries only localised products; today, some of these units – such as the Nokia Beijing product creation centre – are able to take full responsibility for developing products for global markets.

Overall, our study provides product-level insight into task globalisation and how it is affecting value and knowledge creation in different regions. Developing countries such as China are no longer merely manufacturing locations; increasingly, they are undertaking tasks with greater value added, including management and R&D tasks.

APPENDIX 1

To estimate the geographical breakdown of the product's value, we proceed as follows. The total value of the product Y is composed of the value added of all activities of the product's value chain or

$$Y = \sum_{c=1}^{N} Y_c \ , \qquad \text{(A1)}$$

where

Y = The total value of the product

Y_c = The value added of value chain's value-adding activity, *c*.

The value added of each activity (Y_c) can be created globally. We assume that this total value added of each activity is created in an area covering home country (Finland), other Europe, North America and Asia, thus

$$Y_c = Y_{c,D} + Y_{c,E} + Y_{c,N} + Y_{c,A} + Y_{c,O} \ , \qquad \text{(A2)}$$

where

D = Domestic (Finland)

E = Europe (Other EU-15)

N = North-America

A = Asia

0 = Others

Our data include the value added of each part (Y_c) but we do not have information about how this value added is created in different areas. To estimate the value added of activity *c* created in each region ($Y_{c,D}, Y_{c,E}, Y_{c,N}, Y_{c,A}, Y_{c,O}$), we have proceeded as follows.

We assume that the value added of activity *c* captured in each region is created by means of the factors of production. As is common in the economic literature, we consider three factors of production: physical capital stock (C), the size of the labour force (L) and knowledge capital stock (K). We assume the impact of each production factor is identical to their elasticities of output. The previous empirical literature (including a number of studies) has estimated a Cobb-Douglas style of production function:

$$Q = AC^{\alpha} L^{\beta} K^{\gamma} \quad , \tag{A3}$$

where A= multiplicative technology parameter

Equation (3) is typically estimated in logarithm form; thus, the parameters α, β and γ are the elasticities of output (Q) with respect to physical capital stock, labour and knowledge, respectively. In the majority of empirical studies, the estimated production function has included only two factors of production: physical capital and labour. Typically, the results of empirical studies show that the physical capital elasticity is approximately 0.4 and that the labour elasticity is approximately 0.6.

In studies in which knowledge capital is approximated by using R&D stock, the estimated knowledge capital elasticity varies typically between 0.05 and 0.25 (e.g., Hall 1993, Mairesse & Hall 1994, Harhoff 1998, Capron & Cincera 1998). Based on these studies, our calculations assume that this elasticity is 0.15. However, most studies have not taken into account the double counting related to R&D. R&D investment also consists of investment in physical capital and labour and these components are included in the regular production factors (see, e.g., Schankerman 1981, Hall & Mairesse 1996). Based on earlier literature, we know that approximately 50 per cent of R&D expenditure are labour costs (Hall 2009, NSF 1995). By taking this into account, we modify the capital elasticity (0.6) and labour elasticity (0.4) as follows.

$$\hat{\alpha} = \alpha - 0.5\gamma$$

$$\hat{\beta} = \beta - 0.5\gamma$$

Thus, our double-counting-corrected elasticities for capital, labour and R&D are 0.325, 0.525 and 0.15, respectively. We use these elasticities as the multipliers of production factors.

We continue by calculating the share of each production factor that is located in each region R and multiply each share by the elasticity of output. Next, we sum these values by region and obtain each region's share of value added (related to part c). Finally, we multiply this share by the value added of part c (Y_c). The value added of part c created in region R, is calculated as follows:

$$Y_{c,R} = \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right) Y_c, \tag{A4}$$

where

C_R is the firm's physical capital stock in region R,

C is the sum of the firm's physical capital in all regions,

L_R is the firm's employment in region R,

L is the sum of the firm's employment in all regions,

K_R is the firm's knowledge capital in region R, and

K is the sum of the firm's knowledge capital in all regions.

Thus, for instance, the domestically created value added is calculated as follows:

$$Y_{c,D} = \left(\frac{C_D}{C} \hat{\alpha} + \frac{L_D}{L} \hat{\beta} + \frac{K_D}{K} \gamma \right) Y_c \tag{A5}$$

The equations (A4) and (A5) implicitly assume that total productivity is equal in each region. To take regional productivity differences into account, we calculate the productivity corrected value added of part c that is created in region R as follows:

$$\hat{Y}_{c,R} = \frac{MFP_R \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right)}{\sum MFP_R \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right)} Y_c \qquad R \in (D, E, N, A, O), \tag{A6}$$

where MFP_R is multi-factor productivity in region *R*.

Thus, for instance, the domestically created value added is calculated as follows:

$$\hat{Y}_{c,D} = \frac{MFP_D\left(\frac{C_D}{C}\hat{\alpha}+\frac{L_D}{L}\hat{\beta}+\frac{K_D}{K}\gamma\right)}{\sum MFP_R\left(\frac{C_R}{C}\hat{\alpha}+\frac{L_R}{L}\hat{\beta}+\frac{K_R}{K}\gamma\right)}Y_c \qquad R\in(D,E,N,A,O) \qquad \text{(A7)}$$

Operationalisation of production factors

If component-level factors and factor shares are unavailable, we use firm-level information on the location of different factors. Firm-level data are based on the annual reports and web-sites of each vendor. We have operationalised variables as follows:

C = Non-current assets or long-lived assets, depending on which one was reported in 2007.

L = Number of employees (in 2007).

K = R&D expenditure. We are unable to calculate R&D stock for each region; thus, we used R&D expenditure in 2007.

In some cases, the reported regional breakdown of some factors is imperfect. In those cases, we read the entire annual report carefully and also searched necessary information on the Internet to approximate the regional breakdown. For instance, National Semiconductor (a US company) reports the regional breakdown of long-lived assets (annual report, p. 104) and employees (annual report, p. 12), but does not report exact geographical breakdown of their R&D expenditures. However, on p. 21, the company reports that their principal research facilities are located in Santa Clara (California, in the US) and that they also operate small design facilities in 13 different locations in the U.S. and 11 different locations outside the United States. Out of those 11 overseas R&D units, approximately half are located in Asia and half in the EU-15 area. Based on these facts and the number of facilities per region, we estimate that approximately 70% of R&D is conducted in the U.S., and we divide the rest of the 30% fifty-fifty for Europe (15%) and Asia (15%).

Operationalisation of multi-factor productivity (*MFP*):

We used value-added-based *MFP* figures of the electrical and optical equipment and postal and telecommunications industries reported by Inklaar & Timmer (2008). These data are downloadable at www.ggdc.net/databases/levels.htm. Based on this database, the regional MFPs used in our estimations are as follows:

MFP_D = 1.24 (Finland);

MFP_E = 0.81 (the average of EU-15 countries, excluding Finland);

MFP_N = 1 (United States);

MFP_A = 0.52 (the average of Japan, China, South-Korea and Taiwan). The *MFP*s of China, South-Korea and Taiwan are based on Motohashi (2008), which uses Japan as a reference country (Japan = 1.00); and

MFP_O = 0.37 (the average of Australia, the Czech Republic, Hungary, and Slovenia).

Appendix 2

Robustness test 1:

To test to what extent our results depend on our assumptions related to the value added created by material suppliers' vendors, we recalculate the geographical breakdown of value added by changing these assumptions. It might be argued that Asia's role in these upstream activities is more significant than we assumed in our basic calculations. Moreover, Australia, Russia and Africa are important raw material providers, and in this sense, our basic assumptions potentially under-estimate the role of these regions. Because of these two reasons, we raise the share of Asia to 50% and that of Other countries (including, e.g., Australia, Russia and Africa) to 30% of the value added created by vendors of vendors, and we lower the share of EU-27 to 10% and that of North-America to 10%. Next, we re-calculate all potential combinations related to the final assembly location and the countries of final sale. The results of this re-calculation show that our basic results hold (See Appendix 3).

Appendix 3

Robustness test 1 results by a value-added regional breakdown (different combinations of manufacturing and sales locations).

3310	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia	Manufactured in Asia and sold in EU (excluding Finland).
Finland	26.2 %	26.2 %	26.2 %	26.2 %	26.2 %
Other EU area	22.4 %	42.7 %	8.8 %	8.8 %	29.4 %
North America	13.0 %	4.5 %	38.4 %	4.5 %	4.5 %
Asia	31.3 %	19.5 %	19.5 %	53.4 %	32.7 %
Other countries	7.1 %	7.1 %	7.1 %	7.1 %	7.1 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

1100	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia.	Manufactured in Asia and sold in EU (excluding Finland).
Finland	20.9 %	20.9 %	20.9 %	20.9 %	20.9 %
Other EU area	23.7 %	45.9 %	9.9 %	9.9 %	29.4 %
North America	13.2 %	4.2 %	40.3 %	4.2 %	4.2 %
Asia	35.5 %	22.3 %	22.3 %	58.4 %	38.8 %
Other countries	6.7 %	6.7 %	6.7 %	6.7 %	6.7 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

1200	Average.	Manufactured in EU (excluding Finland) and sold in EU.	Manufactured in North America and sold in North America.	Manufactured in Asia and sold in Asia.	Manufactured in Asia and sold in EU (excluding Finland).
Finland	8.1 %	8.1 %	8.1 %	8.1 %	8.1 %
Other EU area	21.9 %	41.3 %	7.3 %	7.3 %	31.8 %
North America	13.8 %	5.3 %	39.3 %	5.3 %	5.3 %
Asia	45.8 %	34.9 %	34.9 %	69.0 %	44.4 %
Other countries	10.4 %	10.4 %	10.4 %	10.4 %	10.4 %
	100 %	**100 %**	**100 %**	**100 %**	**100 %**

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Appendix 4

Who Captures Value in Global Supply Chains? Case Nokia N95 Smartphones

Jyrki Ali-Yrkkö, Petri Rouvinen, Timo Seppälä & Pekka Ylä-Anttila

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Abstract
Available statistics reveal little about the economic consequences of the increasing global dispersion of production processes. To investigate the issue, we perform grass-roots investigative work to uncover the geography of the value added for a Nokia N95 smartphone circa 2007. The phone was assembled in Finland and China. When the device was assembled and sold in Europe, the value-added share of Europe (EU-27) rose to 68%. Even when it was assembled in China and sold in the United States, Europe captured as much as 51% of the value added, despite of the fact that it played little role in supplying the physical components. Our analysis illustrates that international trade statistics can be misleading; the capture of value added is largely detached from the flow of physical goods. Instead, services and other intangible aspects of the supply chain dominate. While final assembly – commanding 2% of the value added in our case – has increasingly moved offshore, the developed countries continue to capture most of the value added generated by global supply chains.

Key words: Global supply chains, international trade, value capture, Nokia, mobile phones

JEL: F 14, F 23, L 22, L 23

1 Introduction

In high-income countries, decision-makers and experts alike express their concern regarding production moving to lower-cost locations. Our illustration in this paper suggests that commonly employed measures exaggerate the issue to the extent that some aspects may even be illusory.

We agree with the theoretical argument of Grossman and Rossi-Hansberg (2008, p. 1978) that "Revolutionary advances in transportation and communications technology have weakened the link between labor specialization and geographic concentration, making it increasingly viable to separate tasks in time and space… The result has been a boom in "offshoring" of both manufacturing tasks and other business functions." We demonstrate, however, that value capture – the ultimate variable of interest for both businesses and countries – is considerably less dispersed than tasks within a supply chain.

Due to limitations regarding the available statistics, we resorted to grass-roots investigative work to uncover the geography of value added for the *Nokia N95* smartphone circa 2007. We find that value capture is increasingly detached from the flows of physical intermediate and final goods. Instead, in-house and market services and various forms of intangible assets command the lion's share of value added (and thus income and profits earned). Even if final assembly has largely moved offshore, the developed countries continue to capture most of the value added generated globally: even for a "made in China" smartphone exported for sale in the US, we find that Europe (EU-27) still captures half of the value added.

Linden, Kraemer, and Dedrick (2009), who study the supply chain of *Apple*'s *iPod* digital music player in 2005, is the most relevant predecessor of our work. They conclude that even though the *iPod* was assembled in Asia, *Apple*'s American workers and shareholders predominantly reaped the benefits. They also emphasize that innovation matters; the greatest value tends is owned by companies and locations providing critical differentiated inputs. Finally, they highlight the fact that international trade statistics can mislead as much as inform. All of these findings are echoed in our work.

Our approach and method closely resemble those of Linden *et al.* (2009). Besides obvious differences in terms of the industry, product, and point in time, our analysis is more detailed in several regards. Furthermore, our analysis focuses on value added (rather than gross margin). Our most important extension concerns the geographical breakdown of value added: we go beyond headquarters locations and allow for the generation of each component's value added in multiple locations and functions. To our knowledge, this is the first paper to examine global supply chains with regard to value added in such detail.

2 Context

The telecommunications industry typically consists of the following: network infrastructure equipment and its operation, end-user access (terminals, handsets, and portals), and digital content and services. Since the early 1990's, there has been a convergence of the telecommunications industry with closely related industries, particularly information technology (computers and their data networks, including the Internet) and content provision of various types, particularly radio, TV, and recorded audio and video.

Our case study of the *Nokia N95* smartphone addresses one aspect of the telecommunications industry; the primary function of a phone is to provide a physical end-user access point to wireless voice and data networks and their services. As the phone in question was introduced at a time when the convergence mentioned above had progressed substantially, it embeds dozens of non-communication functionalities.

Advances in information and communication technology (ICT) have had an important enabling role in the geographic dispersion of production processes. Furthermore, ICT industries are themselves among the most dispersed major industries globally, which relate to the exceptional modularity of basic designs, especially for personal computers. While the industry's internal division of labor and geographic dispersion has not progressed as far for mobile phones as it has for PCs, it should be noted that our case considers an industry that has progressed further in geographic dispersion than many others.

Upon its announcement in 26 September 2006, the *N95* was *Nokia*'s flagship product. It was one of the first "all-in-one multimedia computers" having the size and weight of a standard phone. The *N95* supported the latest high-speed mobile telephone protocols; it was also equipped with *WiFi* for long-range and *Bluetooth* for short-range data communications. It integrated GPS navigation, an MP3 player, an FM radio, and two video/still cameras, and it supported multiple email, messaging, and internet protocols. With its cameras, color display, and multiple speakers, the *N95* recorded and played back audio, video, and images with ease. Preinstalled software included a calculator, a calendar, and a dictionary, and – as with any computer – further software could be installed. The phone was actively marketed as an access point to the Internet services of *Yahoo!*, *Amazon*, and *Flickr*. The aforementioned convergence in industries would have been complete, if only the phone had supported the viewing of over-the-air television broadcasts. This omission was not, however, attributable to *Nokia*, but was rather related to the (still) lacking standards and unresolved intellectual property rights issues. Commercially, the *N95* was a success: some ten million, highly profitable copies were sold worldwide.

3 Sources

Our analysis is based on five sources. *First*, in August 2008, with the help of two engineering experts, we physically took apart a fully-functioning *N95* and examined each of its approximately 600 individual components. *Second*, we accessed public (particularly Internet searches) and private (direct contacts with various companies and individuals across the supply chain) information to obtain an idea of the direct (primarily coding for software and manufacturing/assembly for hardware) and indirect (R&D, design, and various supporting functions) value added of each component. *Third*, we purchased a standard "teardown" report of the component composition of the N95 (Portelligent, 2007), which also included estimates of factory prices and vendors by component.[1] *Fourth*, armed with the knowledge gathered in the previous steps, we collected further qualitative and quantitative information (and confirmed the validity of the rest of the data) via interviews with sixteen industry experts working currently or previously in various roles in the mobile handset supply chain.[2] *Fifth*, we examined financial reports and press releases of the companies involved and those of their direct competitors. We particularly exploited the differences in reporting in various geographies and officially required further information, such as 20-F reports in the United States.

4 The supply chain

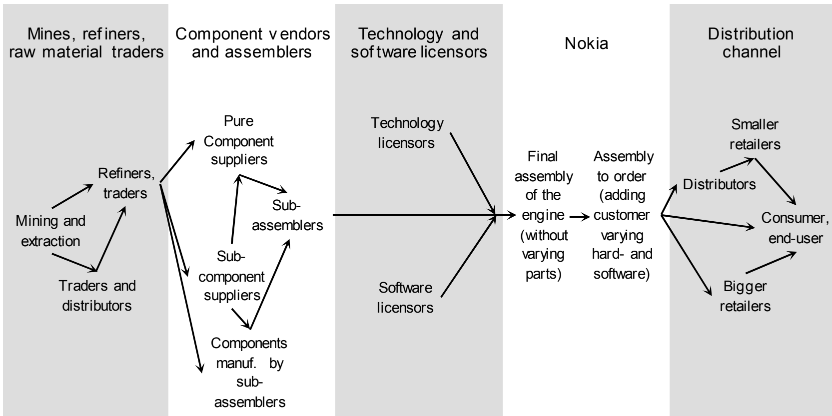
In our terminology, a supply chain refers to the global flows of intermediate goods and services (both those provided in-house and those purchased from outside vendors) involved in providing goods and services for final consumption. In each step, the vendor employs inputs, conducts its own value adding activities, and transfers its output to the other participants in the supply chain. The sum of all value adding activities equals the final retail price of the phone (before any applicable taxes are added).

Figure 1 represents a stylized supply chain for the *Nokia N95*. In the case of tangible components, typically four to eight layers exist between the assembly

1 The teardown report of *Portelligent* was acquired in September, 2008. We have also reviewed teardowns of other companies such as *iSuppli*.

2 Due to the sensitivity of the topic, we had to assure full anonymity of our interviewees. The interviews were conducted between January 2009 and March 2010 and were semi-structured with questions that varied between interviewees depending on their position in the supply chain.

Figure 1
A stylized supply chain of the *Nokia N95*



Source: ETLA.

and the extraction of metals and minerals from the earth's crust (Nokia 2009). All components embed intangible assets in some form and conform to one or more industry standards. In the case of licensed or purchased embedded and standalone software, the flows cannot be readily mapped in a similar manner, but typically, fewer intermediate layers exist.

In Figure 1, the actors in the supply chain of the *N95* are categorized into five groups: mines and refiners, component vendors and sub-assemblers, software and technology providers and licensors, final assembly by *Nokia*,[3] and wholesale and retail distribution by telecommunication network operators and/or general traders.

The flow in Figure 1 is as follows. The still raw but now purified outputs of miners/refiners are turned to sheets of metal and other elementary processed goods that are traded to parts and components vendors. These vendors in turn deliver to sub-assemblers (which may in turn deliver to other sub-assemblers) feeding the final assembler. Some of the intangibles, to the extent that they are not embedded in and bundled with physical components, are licensed in a "pooled" form as parts of industry standards. Standalone software is acquired

3 Unlike some of its competitors, *Nokia* maintains significant in-house manufacturing and assembly capacity; in 2007, *Nokia* outsourced 20% of the total assembly of its phones (SEC 2007, p. 36). All final assembly of the *N95* was done by *Nokia* itself.

as necessary. Depending on the market, *Nokia*'s direct customers are typically distributors (who in turn supply wholesalers and retailers) or operators. In both cases, the cooperation and support of the operators is vitally important in reaching the end-user.

5 Value added by actor

Let us first consider the direct components, parts, sub-assemblies, software, and licenses of the *N95* (the bill-of-materials). We first consider the actual sales prices (the gross value);[4] but in later sections, we consider the first-tier suppliers on a value-added basis.

As shown in Table 1, the direct *bill-of-materials* amounts to approximately €200. It should be noted, however, that *Nokia* is a major holder of intellectual property rights (IPRs) regarding GSM/WCDMA cellular communication standards, and it does not pay licensing fees to itself. Furthermore, cross-licensing is quite common within the industry, in which case fees paid do not reflect the full value of the employed IPRs. For a company without its own employable/tradable IPRs, licensing fees could, in our view, be more than double those presented in Table 1.[5] Apart from licensing fees, the most costly components of the phone are the processors, other integrated circuits, and the large color display.

The main integrated circuits of the N95 were provided by Nokia's long-time ally *Texas Instruments* (US). The display and the most expensive memory chips were obtained from *Samsung* (South Korea). On the semiconductor side, the main European companies involved were *NXP Semiconductor* (the Netherlands), *STMicroelectronics* (Switzerland), and *Cambridge Silicon Radio* (the UK).

As shown in Table 1, the licensing fee for the *Symbian* operating system was approximately €3. According to *Nokia*, the company paid less than 3% aggregate license fees on its WCDMA handset sales (based on Nokia's 12 April 2007 press

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4 Throughout the paper, we refer to the unbundled and unsubsidized official retail price without including any applicable taxes and excluding any additional products and services purchased. Mobile phones' sales margins vary considerably and are difficult to estimate in many markets due to various types of tie-ins with subscriptions and other services.

5 The *Economist* (28 Apr. 2007, p. 8) notes that "ABI research estimates that just four firms own almost 60% of the patents in 3G technology, pushing licensing rates as high as 28.5% of the cost of equipment." In this quote, it is somewhat unclear what is included in the licensing fees and what is the denominator, but even a conservative interpretation of this quote would suggest that, for an *a priori* industry outsider, licensing fees might have been manifold as compared to those listed in Table 1. In our view, the figure suggested in the *Economist* is somewhat exaggerated.

Table 1
The bill of materials (BOM) of the *Nokia N95* in 2007

Description	€	%
Processors	34.3	17.3%
Display	21.6	10.9%
Main camera module (5 million pixels)	16.5	8.3%
Memories	14.5	7.3%
Battery pack	3.0	1.5%
Video conference camera (VGA)	1.2	0.6%
Other integrated circuits (excl. processors and memories)	31.5	15.9%
Mechanics	18.7	9.4%
All other hardware inputs	21.1	10.6%
BOM (excl. supporting material, license fees and final assembly)	**162.4**	**81.8%**
Supporting material	15.5	7.8%
BOM (excl. license fees and final assembly)	**177.9**	**89.6%**
GSM/WCDMA license fees	13.5	6.8%
Symbian operating system	3.0	1.5%
Other license fees	4.2	2.1%
BOM (excluding final assembly)	**198.6**	**100.0%**

Source: ETLA.

release). On the basis of our interviews, we use 2.9% of *Nokia*'s €467 factory price of the N95, i.e., €13.5. Besides *Nokia*, *Qualcomm* (US), *Motorola* (US), and *Ericsson* (Sweden) are among the major WCDMA IPR holders. In addition to the operating system and the telecommunication air interface, *Nokia* paid fees for, *e.g.*, the inclusion of *Adobe Acrobat Reader*, *RealPlayer*, and *Zip Manager*. We estimate that in total, this software was responsible for 0.9% of *Nokia*'s sales price, i.e., €4.2. The total cost of separately licensed intangibles and software was €21.

The approximately €200 listed in the bill-of-materials accounts for the purchases of *Nokia* from upstream vendors as inputs for the final assembly of the *N95*. It reflects the total value added of all the first-tier vendors and their suppliers (the second- and subsequent-tier vendors). Below, we analyze the value added by *Nokia* and the distribution channel.

For each company in the supply chain of the *N95*, we derived the ratio of value added to net sales or the *value added margin* at the firm level. For the most part, we then equated this with the component-level value added margin.[6]

For the distributors, wholesalers, and retailers, the value added margin and the sales margin are almost identical. Retailers' sales margins on high-end mobile phones are somewhat lower than is usual in the electronics sector, 10–12% of the final sale price, leading to an estimated value added of €60.1 by the retailer. The distributors'/wholesalers' margins are 3.3–4.5%, suggesting an estimated value added of €19.1.

Subtracting all downstream costs from the price *Nokia* sells the phone to the distribution channel yields its own value added, €269. This value added is allocated to direct and indirect in-house labor costs (e.g., in its manufacturing/assembly, innovation, advertising, design, marketing, financial, legal, and management functions), depreciation of tangible and intangible assets, investments, and operating profit. It also includes some aspects of outsourcing, which we were unable to separate from Nokia's internal functions: purchases of "billable hours", some R&D and software sub-contracting, outbound logistics, and certain externally provided warranty and other services.

Careful studies of industry sources and our interviews suggest that the final assembly/manufacturing cost of the *N95* is €11.5, i.e., 2% of the pre-tax final sales price.[7] Thus, even if the final assembly is the essential part of the supply chain that meets the eyes of laymen (not least because of the *"Made in …"* labeling found on manufactured goods), the value added it commands is quite low.

Table 2 presents a value-added breakdown of the *N95*'s pre-tax retail price of €546: *Nokia* captures 50% of the value, first-tier hardware vendors 11%, first-tier (external, non-cross-licensed) software/intangible vendors 3%, second- and higher-tier vendors (vendors-of-vendors) 19%, distribution/wholesale 3.5%, and retail 11%.

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6 A company's value added is equal to the sum of its operating profit, depreciation, and labor costs. For the few companies that conform only to US GAAP accounting principles, labor costs are unavailable. For these firms, we assume the margins to be the same as for their nearest competitors. Thus, for example, in the case of the charger included in the sales package of the N95: the factory price of the charger is €1.1, and it is supplied by *Astec* (US), which is a part of the *Emerson Network Power* group using US GAAP. Its direct competitor *Salcomp Oy* (Finland) – globally the leading mobile phones' charger vendor – follows IFRS. In its 2007 financial statement, *Salcomp*'s value added margin was 23.3%. Thus, we estimate *Astec's* value added to be approximately €0.3. Similarly, in the case of *Texas Instruments* (US), we employ the average of the value added margins of the three competitors it identified in its 2007 Form 10-K report (pp. 3–4) required by the US Securities and Exchange Commission, *i.e.*, *NXP* (the Netherlands), *Infineon Technologies AG* (Germany) and *STMicroelectronics* (Switzerland).

7 In addition to direct labor costs, our estimate includes factory management and other indirect labor and capital costs.

Table 2
The value added breakdown of the *Nokia N95* listed by supply chain participant, %

Suppliers of material inputs	11%
Software and other companies selling licenses	3%
Nokia	50%
Distributors	3%
Retailers	11%
Unaccountable inputs	3%
Vendors of vendors	19%

Source: ETLA.

6 VALUE ADDED BY LOCATION

Table 2 provides a global breakdown of value added by the actors' major categories. Because the gross domestic product can be measured as the sum of the values added by all activities in a given country, national interest is based on where the value capture takes place.[8] Determining this is somewhat difficult, as companies are reluctant to reveal the geography of their operations even at the firm level (let alone at the level of a specific commercial offering). With some detective work, we can nevertheless make reasonably accurate estimates, at least as far as broader geographical regions are concerned.

The value capture of in-house indirect inputs, such as the role of general management and brand, and re-usable tangible and intangible assets (such as designs copied from previous or contributing to future models) are particularly tricky to allocate per phone and especially across geographies. Furthermore, we do not observe all actors and functions involved. Thus, In Table 3 we consider five alternatives in constructing the geographical breakdown:

- Our baseline method, in Column A, allocates the value added to the headquarters location of each participant in the supply chain. This tends to over-estimate the role of developed countries and regions.

8 Obviously employment is also of considerable national interest. We do not consider employment effects in this paper.

- Our second method, in Column B (see Equation 4 in Appendix 1), assigns the value capture solely on the basis of the locations of the production factors (physical capital, labor, and R&D). This does, for instance, implicitly assume that the general management or corporate brand has no specific role in the value capture tending to under-estimate the role of developed countries and regions.
- The third alternative, in Column C, is an intermediate method between A and B: it is assumed that, in the case of each participant, 10% of the value capture takes place at the headquarters location and 90% is based on to the actual location(s) of the participant's factors of production.
- Individuals and organizations in various locations have different productivities. Thus, their ability to capture value may vary. Column D replicates Column B, with the exception that it attempts to correct for this fact using multifactor productivity differences between regions (see Equation 6 in Appendix 1).
- Our preferred estimation method (Column E) combines Columns C and D. Thus, in the case of each participant, 10% of the productivity-adjusted value capture occurs at the headquarters location and 90% at the actual location of the production factors.

In a sense, A and B constitute the lower and upper bounds for Europe, C and D refine certain aspects, and E provides our preferred estimate of the geography of the value capture.

It should be noted that the first five rows in Table 3 (*Finland …Other countries*) do *not* fully reflect the value captured by each location simply because the next four rows (*Other countries … The country of final assembly*) have not been allocated accordingly. While we have a sense of the geography of vendors-of-vendors and we can make educated guesses regarding the inputs they provide the country, we cannot discriminate between unrecognized vendors (*Unaccounted inputs*), as the level of detail in our data is not comparable to our understanding of Nokia and its first-tier suppliers. With these caveats, we adopt our "rock-bottom" estimate E from Table 3 and split the value added of the unaccounted inputs and vendors-of-vendors to geographies with the assumptions discussed below (see also the notes to Table 3).

The geographical allocations of the country of final sales and final assembly depend on the specific case. For instance, for an *N95* assembled in Finland (Salo) for the German market, an extra 2.1% would go to Finland and an extra 14.5% to Germany (Other EU-27); for an *N95* assembled in China (Beijing) for final sale in the United States, the outcome would be different. We considered how the two cases (from Finland to Germany and from China to the United States) are

Table 3
The value added breakdown of *Nokia N95* by major region

	(a) Based on headquarters	(b) Based on the locations of production factors	(c) 10% to the headquarters country and 90 % based on the locations of production factors	(d) Based on the locations of the production factors, corrected for productivity	(e) 10% to the headquarters country and 90 % based on the locations of production factors, corrected for productivity
Finland	47.2 %	34.0 %	35.3 %	37.9 %	38.8 %
Other EU-27 countries	1.9 %	9.3 %	8.6 %	7.7 %	7.1 %
North America	6.6 %	9.1 %	8.9 %	9.1 %	8.9 %
Asia	4.7 %	8.3 %	8.0 %	6.6 %	6.4 %
Other countries	1.3 %	0.8 %	0.9 %	0.3 %	0.4 %
Unaccounted inputs	3.1 %	3.1 %	3.1 %	3.1 %	3.1 %
Vendors of vendors	18.7 %	18.7 %	18.7 %	18.7 %	18.7 %
The country of final sales	14.5 %	14.5 %	14.5 %	14.5 %	14.5 %
The country of final assembly (Finland or China)	2.1 %	2.1 %	2.1 %	2.1 %	2.1 %
	100%	100%	100%	100%	100%

Source: ETLA.

Notes: The majority of *unaccounted inputs* are low cost inputs, such as resistors, capacitors and screws, mostly manufac-tured and designed in Asia. In the geographical breakdown, we assumed that 80% of the total value added of these in-puts is created in Asia, 10% in EU-27 countries and 10% in the United States. *Other countries*: Based on our firm-level data, roughly 1/3 of this value is created in the new member states of the EU. Thus, we attribute this amount to EU-27 and the remaining 2/3 to other countries (*i.e.*, countries outside EU-27, Asia and North-America. *Vendors of vendors*: We consider the vendors of material supplies and immaterial supplies separately. We divide the value added created by vendors of material suppliers to all regions equally (EU-27, North America, Asia and other countries). In terms of value added created by immaterial suppliers' vendors, we assume that 90% of the value added created by vendors of immaterial suppliers was created in these three regions and divide this 90% equally among EU-27, North America and Asia. The remaining 10% is attributed to other countries.

recorded in international goods trade statistics on the basis of gross value, and how the value added on a geographical basis differs from that (Tables 4a and 4b).[9]

Table 4a
The geography of the gross value in two cases of the N95 as recorded in international goods trade statistics

	Exports from Finland to Germany	Exports from China to the US
Assembly in Finland, final sale in Germany	€467	
Assembly in China, final sale in the US		€467

Table 4b
The two cases of the N95 as recorded in international goods trade statistics (top), and the actual geography of value added in the two cases and across the product's life cycle (accounting for both assembly locations and all final sales markets)

	Finland	Other EU-27 countries	Asia	North-America	Rest of the world
Assembly in Finland, final sale in Germany	41 %	27 %	13 %	14 %	5 %
Assembly in China, final sale in the US	39 %	12 %	16 %	28 %	5 %
Both assembly locations, all markets	38 %	16 %	18 %	17 %	11 %

Source: ETLA.

6.1 Further considerations

Our best estimate is that over the life cycle of the *N95*, 55% of the value added was captured by EU-27 countries, taking into account both assembly locations and all countries of final sale (Table 5, bottom). Even when the final assembly occurred in China and the final sales occurred in the United States, EU-27 countries captured 51% of the value added (Table 5, middle), despite the fact that the phone was *Made in China*.

9 In 2007, the basic principle applied by Nokia was that smartphones intended for the European market were assembled in Europe, and smartphones intended for the Asian market were assembled in Asia. To our knowledge, smartphones intended for the US market were mainly assembled in Asia. Thus, using these three principles as our guidelines, the potential combinations are as follows: assembled in EU and sold in EU; assembled in EU and sold in other countries; assembled in Asia and sold in Asia; assembled in Asia and sold in North America; and assembled in Asia and sold in other countries. As a robustness check (Appendix 2), we changed the assumptions and re-calculated the geographical allocations.

Table 5
Breakdown of the phone's €546 (+tax) retail price circa 2007

Physical components	**€178**	**33%**
Processors	€34	6%
Other integrated circuits	€32	6%
Memories	€15	3%
Display	€22	4%
Main camera (5 mill. pixels)	€17	3%
Other physical components	€59	11%
Licenses and software	**€21**	**4%**
Nokia's value added	**€269**	**49%**
Internal support functions	€169	31%
Operating profit	€89	16%
Final assembly	€11	2%
Distrubution and retailing	**€79**	**14%**
Distribution	€19	4%
Retailing	€60	11%

Source: ETLA.

Notes: The phone's €546 retail price is the unbundled and unsubsidized official retail price without the inclusion of any applicable taxes; it also excludes other products and services possibly purchased at the time of initial sale or later. Licenses include protocols, the operating system, pre-installed software *etc. Nokia* is a major intellectual property (IP) holder in this domain and does not pay fees to itself. Thus, the value of its own IP is not included here. Furthermore, non-monetary payments (e.g., cross-licensing) are not included here. For a firm without its own IP, licensing fees could be manifold; see the text for discussion. In addition to operating profit and the final assembly, *Nokia's* value added covers its innovation, advertising, design, marketing, legal, and management costs, as well as depreciation and investments. It also includes some aspects of outsourcing we were unable to separate from *Nokia's* internal functions: purchases of "billable hours", some R&D and software sub-contracting, outbound logistics, and certain external warranty & other services. *Nokia's* operating profit has been estimated on the basis of the overall operating profits of *Nokia Multimedia* in 2006 and 2007 by assuming that the profitability of the *N95* was typical of a phone.

How is it possible that EU-27 countries capture so much of the value based on such an apparently minor role? This occurs simply because Finland and other EU-27 countries were dominant in the branding, development, design, and management.

Table 5 summarizes some of the above findings. While the final assembly is the main step in the physical incarnation of the product, this stage only commands 2% of the overall value added. However, the distribution channel, and its ultimate retail loop in particular, captures a large share of the value added – many times more than the final assembly.

We referred above to international goods trade statistics and ignored service trade statistics. On the basis of the supply chain's geography and the assembly volume of the *N95* in Nokia's Beijing plant, we estimate that service exports from Finland to China in 2007 were approximately €0.8 billion with respect to the N95. As recorded by Statistics Finland, however, the **total** service trade across **all** industries from Finland to China was €0.6 billion in 2007. Thus, the recorded overall figure does not account even for this one phone model, which in 2007 accounted for less than 1.5% of all sold *Nokia* phones and less than 7.5% of all *Nokia* phone sales.[10]

In the above calculations, we assigned *Nokia*'s operating profits to the headquarters location, which is consistent with prevailing national accounts practices. It does not suggest that Finns would "own" this part of the value added beyond their ownership of the company. Indeed, more than 90% of *Nokia*'s stock is held abroad and profits earned belong ultimately to the shareholders, in this case primarily to US-based institutions. Any dividends paid to foreigners are appropriately recorded in cross-border financial flows. It turns out, however, that companies' purchases of their own shares are not appropriately recorded, which in the case of Finland inflates its current account surplus. Savolainen and Forsman (2010) note that Nokia's purchases of its own shares amounted to €18.6 billion in 2003–2008. In 2005, they amounted to 2.3% of Finnish GDP.

Although our *N95* analysis is a single case study, it is, based on our understanding, a typical case in the electronics industry. Furthermore, automobiles, textiles, and some other traditional industries do not appear very different. Even in industries that feature less geographical dispersion, dispersion is nevertheless increasing. In our opinion, broader conclusions can be legitimately drawn from our analysis.

10 For a more general discussion on the globalization of trade in services, see Lejour & Smith (2008).

7 Conclusions

Even though the location of the final assembly earns the "made in …" label, the labeled country may command only a few percent of the supply chain's overall value added of an advanced industrial good. Unlike the apparent conclusions drawn from the cross-border flows of the related physical components and goods, developed countries continue to capture the lion's share of value added generated globally. Even for manufactured goods, most of the value added is captured by services (both in-house and those purchased from external vendors) and various forms of intangibles (including returns earned on various forms of intellectual property).

Our analysis has several broader implications. *First*, it highlights the irrelevance of the lingering manufacturing vs. services discussion. The recorded value added by manufacturing has a significant service component; most services need supporting physical infrastructure and complementing goods. The distinction between manufacturing and services is immaterial and should perhaps be laid to rest completely. *Second*, international commodity trade statistics that continue to record the gross values of cross-border goods flows can be highly misleading in economic analysis. Indeed, internationally concerted efforts should be taken to develop value added based trade statistics. While complementing the goods with service trade statistics and balance of payments information should help in principle, this does not currently appear to be the case in practice. Our crude estimates in the previous section suggest that service trade statistics and balance of payments information might be equally misleading, albeit for different reasons. *Third*, in many countries, national policy makers appear to have an obsession with having a certain national capacity of final assembly. This can hardly be justified by its role in national value added. This is *not* to say that final assembly has no importance, just that its national importance may relate more to its links with other functions in the supply chain.

Ultimately, nations compete for their citizens' high value adding roles in globally dispersed supply chains. For a given level of effort, the national objective is then to capture as much value and generate as much national wealth as possible. While China is determined *not* to remain a "2%" assembly location and is rapidly extending its higher value adding functions, Europe and the United States retain many advantages in providing globally differentiating inputs.

APPENDIX 1

To estimate the geographical breakdown of the value of the N95, we proceed as follows: The total value of the product Y is composed of the value added of all parts of the N95's value chain or

$$Y = \sum_{c=1}^{N} Y_c \ , \qquad (1)$$

where

Y = The total value of the N95

Y_c = The value added of part c of the value chain.

The value added of each part (Y_c) can be created globally. We assume that this total value added of each part is created in an area covering the home country (Finland), other European countries, North America and Asia, thus

$$Y_c = Y_{c,D} + Y_{c,E} + Y_{c,N} + Y_{c,A} + Y_{c,O}, \qquad (2)$$

where

D = Domestic (Finland)

E = Europe (Other EU-27 countries)

N = North America

A = Asia

O = Others

Our data includes the value added of each part (Y_c), but information regarding how this value added is created in different areas is not available. To estimate the value added of part c created in each region ($Y_{c,D}, Y_{c,E}, Y_{c,N}, Y_{c,A}, Y_{c,O}$), we proceed as follows:

We assume that the value added of part c captured in each region is created through factors of production. As is usual in the economic literature, we consider three factors of production: physical capital stock (C), the size of the labor force (L) and knowledge capital stock (K). We assume that the effect of each production factor is the same as that of their elasticities of output. The previous empirical literature (including a number of studies) has estimated a Cobb-Douglas type of production function:

$$Q = AC^{\alpha} L^{\beta} K^{\gamma}, \tag{3}$$

where A is the multiplicative technology parameter.

Equation (3) is typically estimated in logarithm form. Thus, the parameters α, β, and γ are the elasticities of output (Q) with respect to physical capital stock, labor and knowledge, respectively. In the majority of empirical studies, the estimated production function has included only two factors of production: physical capital and labor. Usually, the results of empirical studies show that the physical capital elasticity is approximately 0.4 and the labor elasticity is approximately 0.6.

In studies, where knowledge capital is approximated using R&D stock, the estimated knowledge capital elasticity typically varies between 0.05–0.25 (Hall 1993; Mairesse and Hall 1994; Harhoff 1998; Capron and Cincera 1998). In our calculations, based on these studies, we assume that this elasticity is 0.15. However, most studies have not takes the double counting related to R&D into account. R&D investment also consists of investment in physical capital and labor, and these components are included in the regular production factors (Schankerman 1981, Mairesse & Hall 1996). Based on earlier literature, we know that approximately 50 percent of R&D expenditures are labor costs (Hall 2009). Considering this, we modify the capital elasticity (0.6) and labor elasticity (0.4) as follows:

$$\hat{\alpha} = \alpha - 0.5\gamma$$

$$\hat{\beta} = \beta - 0.5\gamma$$

Thus, our our corrected elasticities for capital, labor and R&D are 0.325, 0.525 and 0.15, respectively. We use these elasticities as the multipliers of the production factors.

We continue by calculating what share of each production factor is located in each region *R* and then multiply each share by the elasticity of output. We then sum these values by region and obtain each region's share of value added (related to part *c*). Finally, we multiply this share by the value added of part *c* (Y_c). The value added of part c created in region *R*, is calculated as follows:

$$Y_{c,R} = \left(\frac{C_R}{C}\hat{\alpha} + \frac{L_R}{L}\hat{\beta} + \frac{K_R}{K}\gamma \right) Y_c, \tag{4}$$

where

C_R is the firm's physical capital stock in region *R*,

C is the sum of the firm's physical capital in all regions,

L_R is the firm's employment in region *R*,

L is the sum of the firm's employment in all regions,

K_R is the firm's knowledge capital in region *R*,

K is the sum of the firm's knowledge capital in all regions,

Thus, for instance, the domestically created value added is calculated as follows:

$$Y_{c,D} = \left(\frac{C_D}{C} \hat{\alpha} + \frac{L_D}{L} \hat{\beta} + \frac{K_D}{K} \gamma \right) Y_c . \qquad (5)$$

Equations (4) and (5) implicitly assume that the total productivity is equal in each region. To take the regional productivity differences into account, we calculate the productivity-corrected value added of part *c* created in region *R* as follows:

$$\hat{Y}_{c,R} = \frac{MFP_R \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right)}{\sum MFP_R \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right)} Y_c \qquad R \in (D, E, N, A, O), \qquad (6)$$

where MFP_R is the multi-factor productivity in region *R*.

Thus, for instance, the domestically created value added is calculated as follows:

$$\hat{Y}_{c,D} = \frac{MFP_D \left(\frac{C_D}{C} \hat{\alpha} + \frac{L_D}{L} \hat{\beta} + \frac{K_D}{K} \gamma \right)}{\sum MFP_R \left(\frac{C_R}{C} \hat{\alpha} + \frac{L_R}{L} \hat{\beta} + \frac{K_R}{K} \gamma \right)} Y_c \qquad R \in (D, E, N, A, O) \qquad (7)$$

Operationalization of production factors

If component-level factors and factor shares are unavailable, we use firm-level information regarding the location of different factors. Firm-level data is based on the annual reports and web-sites of each vendor. We have operationalized variables as follows:

C = Non-current assets or long-lived assets, depending on which was reported in 2007.

L = The number of employees (in 2007).

K = R&D expenditure. We are unable to calculate R&D-stock for each region. Therefore, we used R&D expenditure for 2007.

In some cases, the reported regional breakdown of some factor is imperfect. In these cases, we read the entire annual report carefully and researched necessary information on the Internet to approximate the regional breakdown. For example, *National Semiconductor* (US) reports the regional breakdown of long-lived assets (Annual Report, p. 104) and employees (Annual Report, p. 12), but do not report the exact geographical breakdown of their R&D expenditure. However, on page 21, the company reports that their principal research facilities are located in Santa Clara (US) and that they operate small design facilities in 13 other locations in the United States and 11 locations outside the US. Out of those 11 overseas R&D units, approximately half are located in Asia and half in the EU-15 area. Based on these facts, we estimate that approximately 70% of R&D is done in the U.S. and divide the remaining 30% fifty-fifty between Europe (15%) and Asia (15%).

Operationalization of multi-factor productivity (MFP):

We used value added-based *MFP* figures of the Electrical and Optical equipment and Post and Telecommunications industries reported by Inklaar and Timmer (2008).[11] Using this database, the regional *MFP*'s used in our estimations are as follows:

$MFP_D = 1.24$ (Finland)

$MFP_E = 0.81$ (the average of EU-15 countries excluding Finland)

$MFP_N = 1$ (United States)

$MFP_A = 0.52$ (the average of Japan, China, South-Korea and Taiwan). The *MFP*s of China, South Korea and Taiwan are based on Motohashi (2007) using Japan as a reference country (Japan=1.00).

$MFP_O = 0.37$ (the average of Australia, the Czech Republic, Hungary, and Slovenia)

[11] This data is downloadable at www.ggdc.net/databases/levels.htm

Appendix 2

To test to what extent our results depend on the assumptions we made related to the value added created by material suppliers' vendors, we recalculate the geographical breakdown of value added by changing these assumptions. One could argue that Asia's role in these upstream activities is greater than assumed in our basic calculations. Moreover, Australia, Russia and Africa are important raw material providers, and our basic assumptions potentially under-estimate the role of these regions in this regard. For these two reasons, we lower the share of the EU-27 countries to 10% and North America to 10% and raise the share of Asia to 50% and that of the other countries (including, e.g., Australia, Russia and Africa) to 30% of the value added created by vendors of vendors. We then re-calculate all potential combinations related to the final assembly location and the country of final sales. The results of this re-calculation show that our basic results are valid. On average, 52% of the total value added is captured in EU-27 countries, 14% in North America, 22% in Asia and 12% in the rest of the world.

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Appendix 5

Tracking Offshoring and Outsourcing Strategies in Global Supply Chains

Timo Seppälä

Globalisation is much more than simply moving employment and activities from developed nations into nations with lower-cost forces. Such a simple conclusion obscures the complicated skein of cross-border relationships that have evolved out of firm strategies seeking to balance the kaleidoscope of variable including labour and inventory costs, transportation, quality, concentration of valuable knowledge in clusters and temporal proximity to customers. Understanding firm strategies at the single moment in time is complicated enough, but unfortunately, these variables also fluctuate (Kenney and Florida 2004, p. 1).

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Abstract

The dynamics in industrial business networks, caused by the disaggregation of firms' value and supply chains, cause product life cycle phases and tasks to be transferred from advanced market economies to emerging market economies. In this chapter, I track the linkages between changes in a lead firm's business environment and changes in the lead firm's strategic offshoring and outsourcing actions; I also track how these changes in the lead firm's behaviour are then translated into a supplier firm's strategy and offshoring decisions. Additionally, I discuss offshoring and outsourcing strategies in global value chains. The increasing level of highly skilled labour in emerging market economies enables industrial business networks to rearrange themselves along with shorter life cycles. Furthermore, I find that different firms typically react to their customers' strategies with the same approach but implement and schedule their implementation in different ways. These differences in the execution and implementation patterns of offshoring and outsourcing also differ among industries.

Key words: Global value chains, Offshoring, Outsourcing, Industrial business networks

1 Introduction

The disaggregation of a firm's value and supply chains has accelerated in the past decade, especially among global high-tech firms. Other firms in other industries appear to be following this trend. This disaggregation of firms' value and supply chains has caused different product life cycle phases and tasks to be transferred away from advanced market economies to several different locations around the world and among emerging market economies (Blinder, 2007a; Mudambi, 2008). However, the product life cycle phases and tasks contributing most of the value and the control of global value and supply chains have continued to remain in advanced market economies (Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011). Nevertheless, there is increasing concern that these high-value product life cycle phases and tasks will be offshored as well. Offshoring entails the moving away of not only tangible assets but also intangible assets, especially those related to commoditised technologies.

Grossmann and Rossi-Hansberg (2008) approach this same disaggregation of firm value and supply chain from the international trade theory perspective by separating trade in tasks from trade in goods. Baldwin's approach (2006, 2009) moves to a finer resolution level and discusses unbundled value and supply chains. This division of international trade into trade in tasks and trade in goods and the unbundling of global value and supply chains mirrors the current working environments of any multinational enterprise, hereafter referred to as an MNE (Linden et al., 2009; Ali-Yrkkö et al., 2011). These two approaches represent the prevailing perspectives regarding global value and supply chains. However, there are many other perspectives (see Porter, 1995; Baldwin & Venables, 2010).

Managing offshoring and outsourcing strategies for global value and supply chains has been recognised by several authors (see Dunning, 1993, 1998; Pyndt & Pedersen, 2006). In this chapter, I extend the existing literature not by tracking a single firm's offshoring and outsourcing strategies and behaviour, a single moment of time; instead, I follow the causes and effects of a lead firm's behaviour in the context of disaggregated global supply chains in a longitudinal study. By tracking the offshoring and outsourcing strategies in high-tech global supply chains and their respective industrial supplier networks between 2000 and 2010, I am able to answer the following research question:

> How have offshoring and outsourcing advanced in global high-tech business networks and supply chains?

I track changes between 2000 and 2010 in the following characteristics of lead firms: (1) business environment; (2) offshoring and outsourcing strategies;

(3) operational structures and (4) industrial supplier networks. This approach enables me to analyse the linkages between changes in a lead firm's business environment and the lead firm's strategic offshoring and outsourcing decisions and then to observe how these changes in the lead firm's behaviour are translated into a supplier firm's strategy and corresponding decisions regarding offshoring and outsourcing contexts. Furthermore, I explain how different technology and service-based firms in industrial supplier networks have executed their offshoring and outsourcing strategies and relocated different product life cycle phases and tasks, such as research & development, production and after-sales services from advanced market economies to emerging market economies.

In this chapter, I use a case study methodology to examine the contemporary phenomenon of offshoring and outsourcing in high-tech business networks and supply chains, and I use the multi-case approach to capture differences in firms' behaviour (Eisenhardt, 1989; Yin, 1994). Furthermore, the multi-case approach is then supplemented with 14 interviews with industry experts, current and former representatives of mobile telecommunications industry. All interviews were conducted between August 2010 and May 2011.

The reminder of this chapter is structured as follows. The next section introduces the analytical framework, that is, industry dynamics, new emerging markets, global value chains and offshoring versus outsourcing, paying particular attention to ascendant definitions. The research context and the methodology are described in section three. The transformation of the mobile telecommunications industry business networks is then explained in detail in section four. The main results, a comparison to transformations in business networks within the mobile phone industry and conclusions, conclude the chapter.

2 Analytical framework

Each industry, each global supply chain and its respective industry supplier networks evolve at different rates of speed depending on changes in business environments, global operational structures and product life cycles (see Fine, 1998; Funk, 2004; Doz & Kosonen, 2008). High tech, for instance, is one of the fastest evolving industries today. Its products can have technology life cycles measured in tens of years. However, the most striking difference among all of the industries is the timeframe available for making decisions (Fine, 1998; Eisenhardt, 1989).

Fine (1998) argues that each firm has its own position in terms of industry dynamics; these positions typically vary between firms. In each firm, the status varies between being horizontally integrated and vertically integrated. By analysing its business environment, a firm can define its own and its competitors' positions. Along with the analyses of industry dynamics, a co-evolutionary model towards competitors' sharing of industrial supplier networks has emerged (Sturgeon & Lee, 2001; Möller & Rajala, 2007). Industrial supplier networks in Asia, especially in China and India, have been the dominant factor behind this change in industrial network structures (Seppälä 2010, 2013). This change among global value and supply chains has shifted from transferring only tangible assets to transferring intangibles as well (Mudambi, 2008).

The concept of global value chains is typically used to analyse the value added by a firm in a global industry and in its global value chain from "mines" to "consumers" (Ali-Yrkkö, 2010; Ali-Yrkkö et al., 2011). Furthermore, the concept of global value chains can be used to examine and analyse a firm's global strategy and position compared with others within its industry business network. Kogut and Kulatilaka (1984) and Porter (1995) originally designed the value chain framework to examine organisation-level or firm-level production and supporting value creation processes and the contributions of these towards developing a competitive advantage. Kogut and Kulatilaka (1984) argue the following:

> Global strategies succeed by creating certain economies along and between value added chains i.e., each firm creates its own value added chain, and by designing marketing programs that adapt products to national needs and yet exploit these in upstream economies.

However, both Kogut and Kulatilaka (1984) and Porter (1995) base their value chain frameworks and analyses on the notion that value as such is often created by activities within the firm, which then vary considerably between firms. Pyndt and Pedersen (2006) extend that by considering that the firm's ability to affect other companies in the value chain may constitute a critical source of competitive advantage. This finding confirms the importance of investigating entire value and supply chains rather than focusing on a single firm.

Mudambi (2008) offers a framework that combines several of the above contributions. He identifies three different global value chain management/business models; integrated, semi-integrated and low cost. An integrated global value chain management/business model represents cases in which an MNE controls the value throughout the product life cycle, including the intellectual property and technology (often customised) rights. A semi-integrated global value chain management/business model represents cases in which the MNE controls design and markets for the product, minimising outsourcing and its control of intellectual property and technology rights. The actual production processes are often offshored and outsourced as well, which means that under this global value chain management/business model, the intellectual property and other rights can also be contractually outsourced. The low cost business model is, in this case, regional not global. In many ways, this global value chain management/business model is very similar to an integrated way of thinking. Under this model, the component supplier tends to own the intellectual property and other similar rights. Often, these technologies are also mature technologies from a technology life cycle perspective.

In addition to discussion on industrial dynamics, global value chains and the disaggregation of global value chains, it is important to recognise the systematic knowledge transfer catch-up effect between advanced market economies and emerging market economies (Mudambi, 2008). This knowledge transfer – catch-up effect acts to balance inequalities between the economies. This knowledge transfer – catch-up behaviour can be identified from the decisions of Finnish MNEs in the period from early 2000 to 2011 (Ali-Yrkkö & Tahvanainen, 2009).

Dunning (1993, 1998) considers that there are four motivational factors behind strategic decisions of the firm while planning for offshoring and outsourcing strategies: is a firm (1) a market-seeking firm, supplying goods to that market; (2) a resource-seeking firm, looking for cost benefits; (3) an efficiency-seeking firm, looking for cost advantages or (4) exploring these options as a strategic consideration; for example, aiming to follow its customers and/or competitors? As mentioned earlier, these four motivational factors represent the key decision-making criteria of each firm.

Offshoring and outsourcing are typically treated as firms' strategies that need to be simultaneously understood (Contractor et al., 2010). Furthermore, Contractor et al. (2010) consider outsourcing and offshoring to be the two outcomes of the same strategic drivers that force firms to make new strategic decisions in terms of where to relocate research & development, industrialisation, production and after-sales service-related tasks. However, there exist opposing views as well. Therefore, the optimal position of each MNE in its disaggregated global value and supply chain is to be carefully analysed to understand firms' strategic decisions in this context while observing the role of transaction cost economics.

Contractor et al. (2010) consider that each firm has six different options for each value and supply chain task and/or activity. Firms typically operate domestically and/or externally in a foreign country. Simply put, offshoring entails moving jobs, task and/or activities out of a firm's home country (Blinder, 2007b). In contrast, outsourcing can happen in-house, cooperatively with another firm and/or through a market transaction through a partnership and/or any supplier. Today, in many cases, outsourcing occurs as offshoring. This elaborated view of offshoring and outsourcing builds on several studies such as those by Grossman and Helpman (2002) and Pyndt and Pedersen (2006).

Fill and Visser (2000) discuss about the principal factors and drivers associated with the decisions related to the outsourcing spectrum. The outsourcing spectrum offers a framework of outsourcing tasks from relieving capacity overload to a variety of strategic partnerships supplying predetermined, assembly, products or services. Drivers related to outsourcing occur more in the form of decision-making tools to support actual decision making and enabling the quantitative comparison of firms. Mudambi and Tallman (2010) describe the outsourcing spectrum as a make, buy or ally process occurring between firms that include the transfer of tangible assets, including some knowledge intensiveness related to production and innovations, that is, some degree of specific capabilities of the firm.

In the mobile telecommunications industry, outsourcing goes beyond Mudambi and Tallman's (2010) definition, especially when considering commoditised technologies (Seppälä, 2010). In relation to the above, Greenstein (2005) discusses different business models of outsourcing, such as contract manufacturing (CM), contract design and manufacturing (CDM) and original design and manufacturing (ODM), all of which are relevant to mobile infrastructure industry. The developments in mobile telecommunications industry continue to follow the development patterns of the personal computer industry, where a Taiwanese ODMs deliver most of the world's personal computers.

3 Research context

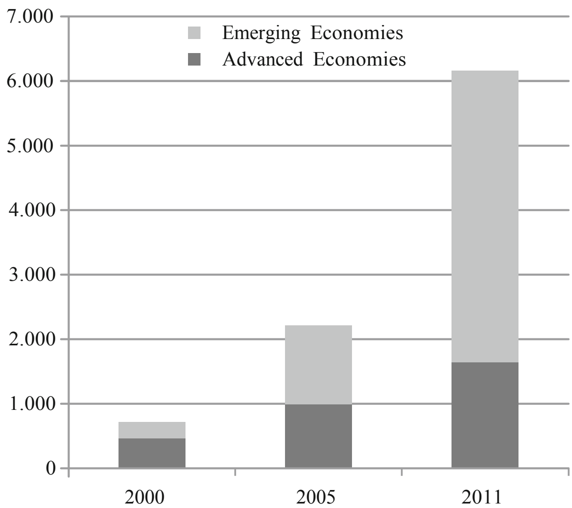
Developments in the mobile telecommunication industry can be divided into four distinct eras. The first-generation (1G) cellular systems, deployed in the 1980s, represented the simplest communication networks. The second-generation (2G) cellular systems were the first to apply digital transmission technologies for voice and data communication. To address the poor data transmission rates of the 2G network, technological enhancements called 2.5G technologies such as general packet radio service (GPRS) and 2.75G Enhanced Data Rates for GSM Evolution (EDGE) were developed. 3G networks are also referred to as universal mobile telecommunications systems (UMTS). However, China has developed its own standard, called time division synchronous code division multiple access (TD-SCDMA). As of today, the wireless networks are evolving from 3G to 4G architectures, which then provide a platform for the all-IP convergence of mobile and fixed networks, which in turn gradually leads to non-IP networks. These continual changes in technology have resulted in the increasing complexity of business environments as well as enhanced business and earning models of individual firms.

The increases in the number of mobile telecommunication infrastructure investments, especially in new market economies, have been another key factor behind recent developments in the mobile telecommunication industry and its technologies. These developments continue today. Figure 1 shows how the market focus has been shifting away from advanced economies to new market economies as well as the development in mobile subscriptions from 2000 to 2011. These two major developments have driven many companies to make decisions related to strategies and operations, especially those concerning the disaggregation of their value and supply chains to match market requirements.

3.1 Methodology

I use a case study methodology to examine the following question: How have offshoring and outsourcing advanced in global high-tech business networks and supply chains? I thus use the multi-case approach to capture differences

Figure 1
Mobile phone subscriptions – advanced economies versus emerging economies (Source ITU statistics)



in firm behaviour supplemented with 14 qualitative interviews (Eisenhardt, 1989; Yin, 1994). Interviews were conducted between August 2010 and May 2011 with industry experts and current and former representatives of the mobile telecommunications industry. Each interview lasted for two to four hours. The interviews focussed on four major topics: (1) tracking key changes in the business environment; (2) tracking changes in strategies and how they were communicated to the suppliers; (3) tracking changes in supplier networks and (4) tracking how different suppliers reacted to the changes. The interviews were followed by telephone calls and emails to ascertain and confirm case data. Furthermore, a multi-case approach, together with supplemented interviews, including a cross-case analysis, provides a richer and deeper understanding of micro-level processes of offshoring and outsourcing in the context of specific industry networks.

In my multi-case approach, I focus on describing changes in Nokia Networks, later nokia siemens networks (NSN), a Finnish telecommunications infrastructure business network, from 2000 to 2010 in terms of its (1) business environment; (2) offshoring and outsourcing strategies; (3) operational structures and (4) supplier network. The supplier networks perspective includes such firms as Efore, Alteams, Scanfil, Elcoteq and Incap. All of these firms have different and lengthy histories with NSN. The case firms were selected by direct contact with key personnel and requesting their participation. However, I wanted to ensure that there is a reasonable variance between the firms' strategic and operational processes. Therefore, I make reference to earlier studies and to recent changes in the industry networks' setting indicating that the emerging economies will continue to play an important role while considering new offshoring and outsourcing locations for research & development, production and after-sales services-related tasks.

4 Empirical analysis

4.1 Increasing complexity of the business environment

The competitive landscape of the mobile telecommunications infrastructure industry has been shifting away from a traditional hardware and software landscape to more of hardware, software and service landscape. This shift, together with technological changes within the mobile infrastructure industry, has rapidly altered the nature of competition and firms' strategies, moving the firms towards new unknown (Bettis and Hitt, 1995). Furthermore, new competition has emerged through new incremental technologies. It is meant to represent an increase in new competition for not only traditional hardware and software suppliers but also other players in a value chain, such as telecommunications operators.[1] Table 1 demonstrates change in the competitive landscape in the mobile infrastructure industry between 2000 and 2010 from the perspective of Nokia (Nokia Networks and Nokia Siemens Network), which can be considered one of the key players in the industry.

Therefore, the competitive landscape has been changing; for example, countries such as China have been offering incentives, such as tax incentives, for MNEs to continue to transfer operations from advanced economies to emerging economies. These initiatives, in addition to getting new business (i.e. new contracts), have been the main reason for MNEs' leading their supplier networks to move their operations as well.

This trend towards horizontal integration in the mobile infrastructure industry landscape seems to continue until the next disruptive technologies are launched. The next such disruptive technologies that could change the competitive landscape of the existing MNEs could be in the area of photonic switching

Table 1
The shift in competition in all Nokia Networks/Nokia Siemens Networks among all business areas

2000	2005	2010
Alcatel	Alcatel	Lucent-alcatel
Ericsson	Ericsson	Ericsson, Huawei
Motorola	Motorola	ZTE
Nortel	Nortel	NEC
Siemens	Siemens	Cisco
	Huawei	IBM
	Lucent	HP
	NEC	Accenture
	Cisco	Amdocs
	Juniper networks	Oracle
	IBM	
	HP	
	Accenture	

Source Nokia 20-F reports 2000–2010
Nokia Siemens Networks combines Nokia's Networks Business Group and the carrier-related businesses of Siemens Communications. In 2011, Nokia Siemens Networks completed the acquisition of certain parts of Motorola.

[1] Nokia Capital Markets Day – Simon Beresford-Wiley, 28.11.2006 (Source: www.nokia.com).

(see Reiley & Sasian, 1997) and/or quantum computing (see Williams, 2011) technologies. These technologies will be made publicly available in the next ten to fifty years.

4.2 Changes in global operational structures

MNEs engage in foreign direct investments (FDI) and own or in some way control value-added activities in more than one country (Dunning & Lundan, 2008). These value-added activities refer to value chain frameworks by Kogut and Kulatilaka (1984) and Porter (1995) as well as Baldwin and Venables (2010) created to examine organisation-, firm- and global supply chain-level value-added activities and their contributions towards developing greater value contribution by any advanced and/or emerging economy. Another consideration of value-added activities is made by Baldwin (2006, 2009), who divides international trade into two separate flows of trade: trade in goods and trade in tasks.

In the case of the Nokia Networks Business Group and later Nokia Siemens Networks, the firms' internal value-added activities, that is, different operations of the firm, have been distributed worldwide. Prior to the merger of Nokia Networks Business Group and carrier-related businesses of the Siemens Communications Nokia Networks Business group, research & development (R&D) operated in four countries in several geographical locations. Following the merger, R&D operations expanded to three new countries, Greece, Germany and Poland. Today, Nokia Siemens Networks has R&D operations in nine countries providing value-added services to the rest of the Nokia Siemens Networks operations around the world. The piloting and industrialisation of the products were separated from the main research and development activities.

The number of production facilities has varied significantly. Typically, these types of changes in numbers are related to their proximity to the final customer, to mergers and acquisitions activities and to outsourcing agreements. Table 2 presents the changes in numbers and also changes in geographical locations. According to Nokia's 20-F reports from 2006 to 2007, Nokia increased the number of its production facilities in China. This increase occurred because Siemens were forced to reclaim a plant in Shanghai, due to the Siemens earlier agreements with BenQ, a Taiwanese firm. The changes in a need of an additional capacity are visible in Table 2, which explains how much additional production capacity has been contracted to EMS. Typically, these same partners also manage after-sales services.

Table 2
Nokia Networks, Nokia Siemens Networks production and supply chain management from 2000 to 2010 (Source Nokia 20-F reports 2000–2010)

2000	2004	2007	2010
12 plants 5 in Finland 1 in United Kingdom 5 in China 1 in Malaysia	5 plants 3 in Finland; 2 in China	9 plants 2 in Finland; 3 in China; 1 in India; 3 in Germany	8 plants 1 in Finland; 3 in China; 2 in India; 2 in Germany
Outsourced > 60 %	Outsourced > 50 %	Outsourced > 20 %	Outsourced > 29 %

Indeed, strategic and operational agility become a necessity when these changes in the global business environment and respective operational structures are shared and communicated to the global supplier networks. Gaining a strong strategic and operational commitment from the global supplier networks is a must. Gained commitment then enables the whole supply chain to adapt changes in a more agile way as required by the business environment and global operational structures.

4.3 Communicating change to suppliers

Nokia Networks, currently Nokia Siemens Networks, typically communicated its new goals and respective performance targets related to changes in the business environment and in its global operational structures well in advance, so that the supplier had time to plan and execute these new goals and respective performance targets.

> Typically, Nokia Sourcing Organisation communicated the targets four years in advance. This means that 2004 targets were communicated in 2000; 2005 targets were communicated in 2001 etc. … a good example of such communication is that in 2006 low cost production targets were communicated meaning that 80% of production needs to be in low cost locations by 2010 (A former Elcoteq employee).

Sometimes, there was sufficient time to effect these requested changes, but sometimes, there was not.

> I remember an occasion in 2002 that they asked us to shift more production towards China in the area of PCBAs, but also provided us a target of localising 80% of the components value by 2005 … some such transfers were made only because of the target, but no real need. In some cases the production transfers

> from higher cost production location to lower-cost production location did not cause any cost benefits (A former Aspocomp employee).

According to Doz and Kosonen (2008), this systematic way of planning strategic and operational changed jointly with its supply chain, which began at Nokia during the period from 1993 to 1997. Later on, between 1998 and 2004, the systematic planning process was called strategic sensitivity and enhancing resource fluidity (Doz & Kosonen, 2008).

Nokia Networks' acquisition of Siemens brought some problems for Nokia Networks in that communication, as Siemens used different suppliers from those used by Nokia Networks. Unlike Nokia Networks' suppliers, Siemens' suppliers were more independent and owned all rights to their components and technologies.

> As a Siemens supplier we were selling the same components and technology to another customer, but in Nokia Networks' case we could not … also the consolidation of the Nokia Networks and Siemens supplier base caused some additional delays (A former Elcoteq employee).

Because of these differences, the merger between Nokia Networks and Siemens stopped the implementation of such communication of changes in the business environment and in global operations structures for two years. Two years later, following the merger, a similar communication strategy was employed.

4.4 Changes in supplier networks

During the period from 2000 to 2010, there have been five major disruptions to Nokia Networks and Nokia Siemens Networks' Finnish supplier network: (1) Global EMS companies, such as Flextronics and SCI-Sanmina, continued acquiring Nokia Networks' Finnish suppliers, such as Kyrel and Ojala; (2) Global technology companies, such as ADC, Remec and Powerwave, continued acquiring Nokia Networks' Finnish suppliers, such as Solitra and Filtronics; (3) the merger between Nokia Networks and Siemens; (4) the merger between Nokia Siemens Networks and Motorola and (5) the introduction of Asian suppliers, such as Fingu and Hon Hai.

> Flextronics and SCI-Sanmina acquired companies to gain access to Nokia Networks business, just as they did with buying ABB's and Ericsson's plants earlier … unfortunately, later on all the works from the Finnish plants were transferred away first to Western Europe and later to Asia (A former Scanfil employee).

The citation above describes the way in which large EMS and technology companies operated during that period. Later, in the mid 2000s, these EMS and technology companies encountered significant difficulties because they could not operationally or financially absorb the volume of assets they had bought. These companies have since made progress in this regard.

> Elcoteq faced a problem with NokiaSiemens Networks because NokiaSiemens Networks discontinued producing products that we were manufacturing. That was the end of that relationship … and at the same time Jabil bought Siemens' old plant with a load guarantee. It was then also disastrous for Flextronics and SCI-Sanmina (A former Elcoteq Employee).

In a business marked by constant, fierce competition, business deals such as mergers or contractual load guarantees can cause problems for suppliers. Furthermore, these changes are often so sudden that companies do not have enough time to adapt.

Similarly, in the mobile phone industry, Asian suppliers began to gain shares as parts of supplier networks. Surprisingly, in the mobile infrastructure industry, this gain began to happen much later, in 2006. Furthermore, during the same period, Nokia Siemens Network's Finnish suppliers began to operate at full speed even though they entered Asia much earlier, until suppliers ran on low loads. Since 2006, the move of operations from Finland to Asia has occurred at a much higher rate.

> Unfortunately, that is now the mode of operation in several Finnish electronics companies (A current Efore employee).

In parallel to these major changes in the business environment and global operational structures, there have been many minor changes, which are discussed in greater detail in the next sections of this chapter.

4.5 Tracking offshoring and outsourcing strategies

> The trend is obvious! With the financial support of emerging economy countries and because of the markets being moved to Asia and India we were moving our operations as well (A former Alteams employee).

Alteams, Efore, Elcoteq,[2] Incap and Scanfil are outstanding examples of this ongoing transformation. Initially, these firms' exploration of investing and operating offshore dates back to late 1990s. Efore is a firm that followed outsourced offshoring strategy, which then resulted as investing to own operations.

2 Elcoteq filed for bankruptcy in 2011.

Our offshoring strategy was based on a partnership with SCI (currently SCI-Sanmina). The collaboration was started in 2001 … Our outsourcing partner offered us a lower risk entry to China, but also to Brazil as well. Later on 2003 we started to expand our own production and we established our own production unit in China (A current Efore employee).

The others implemented offshoring strategies by investing to own offshoring operations from the start.

"Markets guide and markets force" Jorma Tenkanen.[3]
We were forced to follow our customer to be able to keep the business, even that there were no business; otherwise Nokia Networks would have chosen a local supplier … we were there only to gain from the tax benefits that were offered to Nokia Networks (A former Scanfil employee).

Elcoteq was in China and India namely because of other customers

Elcoteq was a supplier for both Nokia Networks and Siemens in the area of Electronic Manufacturing Services, but approximately one year later after the acquisition of Nokia Networks and Siemens Elcoteq delivered the final product from their manufacturing units (A former Elcoteq employee).
Incap NokiaSiemens network business was ramped down in 2007 (A current Incap employee).

The new offshoring strategy for all of these firms started to affect the manufacturing jobs in Finland quite rabidly. Already, in early 2000, hundreds of manufacturing jobs were cut. Later on, all the manufacturing jobs were transferred away to locations like China and India. As production started to shift quite rabidly in early 2000, a few years later, the research and development started to follow.

We started to consider offshoring of research and development already in 2002 … in 2005 it actually happened, and we established a research and development unit in Suzhou, China (A former Efore employee).

Efore's transfer of research and development operations to China cannot be considered very successful, as the employee turnover rate was initially high. The turnover rate was eventually normalised, encouraging Efore to establish another research and development unit in Shenzhen in 2010.

Only platform R&D is left here in Finland; all other work has been transferred away (A current Efore employee).

A complete transformation in research & development and production occurred between the late 1990s and 2010. Table 3 explains how the geography

[3] Jorma Tenkanen's presentation at KISA-MET seminar 19th May, 2005; http://www.sc-research.fi/fi/uutiset/030605.htm (information retrieved 14.11.2011).

of different activities has shifted away from Finland to lower-cost locations, primarily in China, but later in India as well. However, there are variations in strategies between the firms.

This move from Finland to China was also affected by the commoditisation of technologies. Commoditisation led to that the product architectures were shifted from single-product architectures to more modular product architectures. The move towards modularity has also led to additional cost reduction requirements. Because Efore has built its business on commoditised technology, Efore have had no other choice than to transfer its operations to lower-cost locations and to localise their supply network. This change was made to follow not only the industry-wide transformations but also their competitors. Furthermore, in commoditised technology business, product life cycles are typically short and feature many product modifications. It is often such that in Efore type of a business firms do not own significant intellectual property rights. This is the case with Efore, in that they do not own specific intellectual property rights in relation to their products, unlike their major competitors. Having no intellectual property rights can currently be considered a major risk to Efore's business, especially in China. Consequently, China has begun to renew their intellectual property rights strategy.

> Efore is a too small as a company to create IPR and fight back if somebody comes and sues us (A former Efore employee).

The two examples of Efore and Alteams, with their focus on technology, provide evidence of how NSN Finnish suppliers have been transferring their research and development, production and after-sales service operations from advanced economies towards emerging economies. Furthermore, the other three examples, Scanfil, Elcoteq and Incap, which have an electronic manufacturing service focus, provide evidence on how NSN Finnish suppliers have been transferring their production operations from advanced economies towards emerging economies,

Table 3
Changes in geographic locations

	2000–2004	2004–2008	2008–2012
Research & development	100 % Finland	50 % Finland 50 % Asia	Majority in Asia
Production	Finland 80 % Asia 20 %	Europe 50 % Asia 50 %	Europe 20 % Asia 70 %
Aftermarket services	Mostly in Finland	Mostly Europe	Europe 80 % Asia 20 %

but only one out of the three has survived. Today, Scanfil is considered to be vertically integrated from the production perspective, offering different types of services from prototyping to serial production. Closeness to Nokia Siemens Networks design in Oulu has definitely been one of the key assets of Scanfil to continue producing for Nokia Siemens Networks.

4.6 Measuring Success

The average employee cost can be treated as one of the key performance indicators to measure the success of firms' offshoring and outsourcing strategies. However, there exist other key performance indicators, for example, costs of employees per operating revenue and working capital per employee.

Table 4 presents Efore's and Scanfil's average employee cost figures.

In contrast to Efore, Alteams, another technology firm, has been able to lower its average employee cost from 39.714 to 14.219€ from 2001 to 2010 through its structural transformation. Furthermore, similar trends can be identified among firms in the service sector. Compared with Scanfil Elcoteq, another service firm, the average cost of an employee has continued at the same level over the last 10 years (17.020€ in 2001, 12.481€ in 2004, 11.548€ in 2007 and 13.471€ in 2010). Incap follows the same pattern. Among all firms, Nokia Siemens Networks, Efore, Alteams, Scanfil and Incap, wage inequality continues to be the driver of firms' relocation of their global operational structures. The average cost of an employee has reversed from decreasing to increasing, and China is no longer an attractive location featuring lower average employee costs. It seems that in the future, relocations will be in two directions west from China and south from Europe, if the average employee cost continues to be a performance indicator. The average cost of an employee has reversed from decreasing to increasing, and China is no longer an attractive location featuring lower average employee costs.

Table 4
Average cost of employees

	2001 (€)	2004 (€)	2007 (€)	2010 (€)
Efore	32,906	29,366	22,417	23,200
Scanfil	12,482	21,291	14,265	14,219

Source Bureau van Dijk Electronic Publishing (BvDEP), ORBIS database

5 Conclusions and discussion

In this chapter, I have examined the changes and challenges of the high-tech business environment of Nokia Siemens Networks and the firm's supplier net- works and supply chain. I have studied the changes in Nokia Siemens Networks: (1) business environment; (2) offshoring and outsourcing strategies; (3) operational structures and (4) supplier network. Furthermore, I have examined the integration and the causality, how these changes are translated into firms' offshoring and outsourcing decisions in global supply chains during the period ranging from 2000 to 2010 to answer my research question: How have offshoring and outsourcing advanced in global high-tech business networks and supply chains?

In reference to my earlier studies (Seppälä 2010, 2013), there were six major findings discussed in detail: (1) the changes in the business environment were not properly understood; (2) suppliers did not have a strategy and structure to manage their own strategic thinking; (3) there was no collaboration between suppliers; (4) suppliers were running out of the financial capital needed to further invest to meet customers' technology and service requirements; (5) suppliers lacked global brand recognition and (6) technology commoditisation occurred much more quickly than expected, causing extensive cost reduction requirements that suppliers could not fulfil.

Because changes in the business environment of Nokia Siemens Networks were much slower and the product life cycles longer in comparison with the case of Nokia Mobile Phones, the industrial business network had more time to adjust to any requirements set by the business environment and Nokia Siemens Networks. That said, and due to the dynamics in telecommunications infrastructure business networks, findings one, two, four and six seem to be irrelevant to this discussion. However, findings three and five continue to be relevant here.

Based on this examination, there are two new major findings. Furthermore, two other findings are discussed: (1) structural changes in global supply chains and (2) technology commoditisation; the two are reported in separate sections. First, offshoring research & development, industrialisation and production networks have not always benefitted firms, especially suppliers. However, to be able to continue to operate in global supply chains, suppliers were forced to follow their customers. The current supplier networks from advanced economies were used not only because of their knowledge but also to fulfil the localisation requirements set by authorities for the lead firm. Localisation of a supplier network was not possible with local supplier networks, as local suppliers did not have the technological knowledge required. Furthermore, the lead firm wanted to fulfil their contractual obligations to obtain agreed local tax benefits. Firms' average employee cost can be treated as one of the key measures to explain the success or failure of such changes in operational structures. By lowering their average employee costs, suppliers have been able to survive in a volatile market.

Second, outsourcing research & development, industrialisation and production networks have not dramatically changed. However, to be able to continue to compete in global supply chains, firms were adapting new business models alongside their customers. In the case of the Asian delivery model to customers, for example, the following characteristic was implemented: no extra premiums were charged for R&D efforts. This offer was partially why firms were investing in new services similar to their original strategies. These new services then enabled firms to continue to compete against their Asian competitors.

5.1 Structural changes in global supply chains

The dynamics in industrial networks that cause the disaggregation of global supply chains continue to be one of the key operational strategies that MNEs implement. This condition implies that the knowledge transfer – catch-up effect is continuing to close the skilled labour gap between advanced market economies and emerging market economies. Furthermore, the cost disparities between advanced market economies and emerging market economies, together with decreasing market unit prices, drive firms to offshore both routine and nonroutine tasks and both tacit and non-tacit knowledge-related tasks.

> It started, our production, as customer service operations only; products were actually manufactured elsewhere in the Americas and Finland and then transported to China … The main reason of doing so was just to fulfil the localisation requirements set by the local authorities (A current Efore employee).

To attract more foreign direct investments and to be able to maintain the current level of foreign investments, countries are setting new requirements for firms to localise parts of their research & development, industrialisation and production capabilities, that is, nonroutine and tacit knowledge-intensive tasks. Typically, these localisation requirements entailed the greater involvement of local firms.

> The average sales price decreased throughout 2000 to 2008 tens of percentages; together with weak Chinese currency it then forced us to transfer all our production to China to be able to compete against the local firms (A former Elcoteq employee).

> The transfer of the production has caused the transfer of R&D because with lower production margins in absolute money, you cannot continue to finance high-cost R&D operations in a higher cost country (A former Efore employee).

To be able to respond to local threats and increasing price competition, the firms continue to offshore routine and nonroutine, tacit and non-tacit knowledgerelated tasks. There appears not to be any force that can stop this shift of power from advanced market economies towards emerging market economies.

This finding confirms the observation by Grossmann and Rossi-Hansberg (2008) that a decline in a labour cost of task has effects much like factor-augmenting technological progress. This trend began with an industrial network in advanced economies and has now become an industrial network in emerging economies.

5.2 Technology commoditisation

Labour supply shortages, together with technology commoditisation, seem to be another key driver for firms to relocate their global supply chains from advanced market economies to emerging market economies. Simultaneously, with solving the problems in labour supply, tacit and non-tacit knowledge began to be relocated to emerging market economies.

> It all started with technology commoditisation; that was the reason why production was offshored (A former Elcoteq employee).
> We needed floor space for new products to be produced in our Finnish facilities (A former Scanfil employee).
> It continued as a must; you must offer it from a low cost location, otherwise we do not accept your offer (A former Elcoteq employee).

After transferring the production in relation to commoditised technologies, the firms then realised and remembered the facts in relation to physical contacts and geographic proximity between research & development and production units. Quite often, the transfer of production then caused the transfer of the research and development operations on commoditised technologies from advanced market economies to emerging market economies.

> It further evolved as a model that most of the research and development, industrialisation and production-related tasks and processes are nowadays done by industrial business networks in China and India (A current Efore employee).
> Nowadays we are left with small research units in Finland – let us see when that becomes a commodity! (A former Remec employee).

This confirms Blinder's (2007a, b) observation of a dichotomy between activities that require physical contacts and geographical proximity. This phenomenon began with labour shortage and technology commoditisation, causing the offshoring of production and related industrial supply networks. These events led to a condition 10 years later in which most of the product life cycle phases and tasks are carried out in Asian locations for both commoditised and emerging technologies. The process of transferring activities and tasks appears to evolve increasingly quickly.

5.3 Parting thoughts and conclusions

> The nature of international trade has changed.[4]

Recent findings have indicated that global supply chains continue to operate even in a finer distribution of labour (Baldwin & Venables, 2010). Furthermore, the increasing separation of tasks related to research & development, industrialisation and production-related tasks (i.e. disaggregation of firms' cost centres) from the headquarters activities (i.e. firm profit centres) are causing the separation of trade in tasks from trade in goods (Grossman & Rossi-Hansberg, 2008). However, the separation of value capture and value creation must also be considered.

> Offshoring continues (a former employee of Elcoteq).

The disaggregation of global supply chains continues to play an important role in firms' strategic decisions. New industrial networks are being transferred from advanced economies to be rebuilt into emerging economies. The current economic environment in advanced economies is accelerating firms' offshoring of activities. Firms continue to search for an optimal breakeven point and maximum financial returns on investments to be able to manage fluctuations in current and future economic environments.

Furthermore, firms are making strategic decisions in moving from emerging market economies back to advanced market economies. This change is due to increasing transaction costs in coordination and logistics. In doing so, firms are breaking up the Asian dominance and control of industrial business networks and in global value and supply chains, which then means that labour-intensive phases of product life cycle and respective tasks are transferred back to Europe and the US from Asia.

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4 Grossman and Rossi-Hansberg (2008).

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