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AN AMBIGUOUS SUCCESS

HOW FINLAND MAY HAVE GOTTEN TANGLED IN THE STRANDS OF INDUSTRIAL ORGANIZATION AND POLICY IT USED TO HOIST ITSELF TO PROSPERITY, AND WHAT TO DO ABOUT IT?

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Content

PREFACE

Finland's competitiveness until today has been based on innovation and strong research & development. This strategy has indeed been very successful. In many international comparisons the competitiveness and innovativeness of Finland has been ranked among the top countries. However, our business environment is changing rapidly and radically. Value is quickly migrating from products to services, and new centers of innovation – particularly in Asia – are rising as we speak. The worldwide competition for innovation is dramatically intensifying. This calls for new approaches to innovation as well as great renewal capability from companies and nations.

Incremental improvement and innovation does not suffice anymore. Instead, competitiveness is increasingly based on radical innovation, which is often achieved by combining different knowledge sources in a unique manner. In this new competitive game collaboration with multiple stakeholders is a must. As a result, the so called open innovation seems to be gaining ground over the traditional closed, in-house innovation. Traditionally, Finnish companies have been good at generating new knowledge and innovations by using their internal resources like own R&D – but how good are they in addressing the new innovation paradigm? This in mind, Sitra started in 2006 the Global Knowledge Transfer study with the title "clusters in transition". The starting point of the study was to analyze whether and how the new innovation paradigm challenges the traditional strong industrial clusters of Finland? The study was conducted by Professor AnnaLee Saxenian from UC Berkeley and Professor Charles Sabel from the Columbia Law School. Two clusters were selected as a focus, forest and ICT clusters because of their importance to Finnish economy. The study was based on interviews of representatives of these industries and available literature.

According to the authors Finland is quickly becoming a victim of its own success. Efficiency improvement and incremental innovations along current business trajectory will gradually lead these industries into a dead end unless they use innovation as a vehicle for transforming themselves to new higher value businesses. The crucial question for Finland is: are forest and telecom industries capable to transform their strategy and ways of working to meet the challenges of continuous renewal and "radical innovation". Saxenian and Sabel raise some serious concerns about the readiness of these industries and the Finnish innovation system as a whole for the needed transformation.

As always with external analysis, there is place for critique and different views. However, as always in times of change, it is healthy – after so many glorifying reports – to listen to critical but constructive and well-grounded view from outside, in this case from two eminent researches. The timing of their contribution is ideal in terms of implementation of the new national innovation strategy. The report is also useful material for those who will evaluate the Finnish innovation system and its agencies.

On the behalf of the Finnish Innovation Fund I would like to congratulate professors Saxenian and Sabel for their excellent report. We are grateful for their interests in Finland's competitiveness. I would like also to thank director Antti Hautamäki for his initiative to conduct this study and for his help during the process.

Helsinki 1.9.2008

Mikko Kosonen
Executive president
Sitra

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Finns talk to each incessantly—so often, and with such intensity, that it can be hard for outsiders to join the conversation, no matter how welcome they are made to feel. We are therefore indebted to Petri Vasara and his team at Pöyry Forest Industry Consulting Oy for connecting us to key actors in the forest products and ICT sectors, and especially appreciative of Petri's efforts to keep us aware of what we might be misunderstanding. In the end we disagreed about how best to characterize Finland's economic prospects. But Petri found a way to reconcile justifiable pride in his own judgment with respect for our dedication and integrity, and we are grateful to him for that as well. Kari Lilia was not officially part of our research team. Yet his influence and that of his collaborators in Finland and the wider group of the Nordic Translearn Project is so evident throughout that in some ways he might as well have been. We can't thank them enough for their generosity, intellectual and personal. Mikko Kosonen—late of Nokia, now the Executive President of Sitra, and author, with Yves Doz of an important, very recent book and article on the strategic difficulties of platform leadership—was our last-minute sparring partner. The more detailed disagreements became, the more quickly we found our way past differences of language and nuance of conceptualization to agree on fundamentals—on characterize the strengths and weaknesses of the current situation, and how to frame further questions to answer the ones that must remain open for now. Last, but not least, we are most grateful to Director Antti Hautamaki at Sitra for his many contributions to a project that involved more cross-cultural coordination than any of us anticipated.

1 INTRODUCTION

Finland is at risk of becoming a victim of its economic success. In the last decades Finnish firms in the forest products and telecommunications industries have become world leaders. Together they account for 40 percent of the country's exports and 8 percent of its GDP. They have achieved this by relentlessly refining the core technologies in their respective domains, and introducing them into successful products with the help of supply chains and marketing organizations whose discipline, flexibility, and efficiency are widely admired by their competitors. The development of the technologies central to this success has been supported by an ensemble of public research facilities which are equally widely admired.

But the kinds of discipline that made possible this success, and the public policies that furthered them, are unlikely to secure it in the future. The core products of both industries—pulp, paper and packaging for the one, cell phones for the other—have become commodities in the fast growing markets in the rapidly expanding economies of the developing world. For now and some time to come those markets will demand lower prices, not sophisticated products—and thus rationalization of current skills rather than radical innovation. To continue to succeed in the advanced countries, however, firms in both industries will indeed have to innovate radically, transforming their products from articles valued for themselves into platforms that afford users a wide range of new and changing possibilities. Thus in sophisticated markets the cell phone is already on the way to becoming a mobile portal to the internet, and the constantly evolving set of services it provides, while paper is becoming a medium for embedding information or information-management devices ranging from (literally) printed circuits, to radio frequency identification tags for locating merchandise on store shelves or containers in transit, to anti-microbials protecting hospital patients against infection. Developing and commercializing these platforms requires combining knowledge from domains where Finnish firms are acknowledged masters with knowledge from domains where they are not. The skills needed to identify possibly rewarding combinations, and organize the collaboration they require with, among others, external research partners, and customers and suppliers along novel supply chains differ from those honed in the firms' tenacious and improbably successful scramble for leadership. Awareness of this mismatch and the dangers it poses for leading firms and the economy as a whole grows as we write. But awareness has not entailed action. There are many projects to advance along current trajectories, and many plans to address the need for substantial long-term change. But the connection between projects and plans—between improvement and continuing transformation—are tenuous. So far as we can see, both in the leading firms and in the public institutions which support and surround them, the efforts at reorganization needed to bridge the gap between the kinds of collaboration that make for success today and the kinds needed to flourish tomorrow are hesitant and uncertain.

The forest products industry is more overtly at risk. Profits and return to capital are low as sales in advanced markets stagnate. Markets are expanding rapidly in the developing world, particularly China and Latin America; but growth puts the industry's long-term future in commodity production at substantial risk. China alone accounts for half of the paper and paperboard capacity increase since 2000 (Pöyry databases). Finnish firms have installed much of the new paper machine capacity in the world in the last few years. As the Chinese market grows local machine producers are likely to begin developing equipment from cheap, abundant straw-like fibers in place of traditional wood inputs, adapting Finnish equipment or developing their own as circumstances suggest. In addition some Chinese machine builders will likely license (or pirate) Finnish designs and then improve them by applying them in next-generation, higher volume configurations—outrunning the Finns just as the Finns, as we will see, outran the Americans. In either case—or worse yet in both—the price of current sales and success is long-term marginality. Italian machine builders in the shoe and ceramic-tile industries, once as dominant in their domains as the Finnish capital goods firms in the forest product industry are today, have gone down that road and can already see its dead end. Much of the capital needed for the risky bets to develop new paper platforms has already been invested in drive into developing markets and failed efforts establish a strong presence in North America. Low profitability makes it hard for the industry to raise more.

Nokia, the flagship of the country's telecommunications industry, is, in contrast, highly profitable, and its returns on capital are widely envied. But this continued success in mobile phones obscures challenges similar to those facing the forest products sector. Since its growth depends increasingly on gaining market share in emerging economies like China and India, Nokia, like the forest products industry, must cut costs and optimize the production of basic models. But in the advanced countries it must compete by developing innovative high-value added services and software for mobile devices. However decades of investment in manufacturing optimization, and the related organizational skills and routines, hamper this innovation. The firms' recent missteps in the market (late with email, clamshell model, and Bluetooth, failure of N-Gage gaming device, etc.) illustrate the difficulties. The entry of Apple and Google as direct competitors in the market for mobile internet platforms compounds the challenge. The example of the forest products industry shows how easily missteps can occur, and how daunting their consequences can be.

And even if Nokia manages its current balancing act for another decade, the Finnish economy is not likely to benefit. Nokia's growth through the 1990s was rooted in national institutions and the domestic talent pool. By 2000 the firm had "outgrown" Finland. Not only did Nokia begin to aggressively recruiting foreign skill and locate production and research in other parts of the world, it also withdrew from local collaborations and began to emphasize intellectual property protection and trade secrets. As the firm relocates production to lower cost locations such as India and Hungary, its subcontractors have followed, often abandoning Finland altogether. As a result electronics manufacturing employment in Finland fell 11.5% during 2006 compared to a decline in overall industrial output of only 1.1%.

Shocks to major companies in both sectors, moreover, are unlikely to be buffered by or (at least in the short and medium terms) contribute to the vitality of domestic small firms in general, or start ups in particular. In part because of the centralization of national research and development in Helsinki, and in part because of the closure of the large firms themselves—manifest in their dealings with major subcontractors and their indifference, if not hostility to spin outs and start ups—there is simply not much of a small firm or start-up sector to talk about. As the sense of crisis mounts it is becoming clear that it is necessary to reorient national support for research and development away from familiar interlocutors in large firms and research institutes and towards a more varied "ecology" of potential users. The paucity of small, innovative firms will surely hinder that reorientation, at least for a time.

And yet the idea that the Finnish economy could be advancing towards a crisis will seem implausible, even irresponsibly alarmist, given the extraordinary vitality Finland demonstrated in the 90s. The country's rapid recovery from the deep recession connected to the disruption of its traditional Eastern European markets, and the emergence in same decade of Nokia as a leading maker of cell phones seemed to mark a definitive transition from an economy based on a commodity natural resource—trees—to an economy based on cognition. To many observers, foreign and domestic, Finland has become a "knowledge" economy: Its actors, connected by networks almost as plastic as the mind itself, can literally think their way into new markets when old ones are exhausted. More precisely, in the closing decades of the last century the accomplishments of Finnish firms and the public sector created endowments or preconditions which seem to sharply reduce the risk of crisis even if they do not completely assure success. Among the salient items on this list of accomplishments are these:

- Firms in key sectors—mechanical engineering and machine building no less than forest products and mobile phones—reached the world technological frontier: As of, say, 2000, the core capacities of Finnish firms matched those of the most capable of their then current competitors.
- The country's national innovation system—the ensemble of university and industry laboratories and other institutions supporting the firms' efforts at research and development—was and is seen as one of the most effective in

the world. It is taken to be a key contributor to the firms' rapid advances, and a foundation of continuing success

- The country is a leader in the development of the EU innovation system, which aims to pool the efforts of member states so as overcome the limits of each.
- Financial markets were reformed, breaking the traditional hold of bank and family groups on industrial firms and putting corporate governance in the hands of investors whose interests as shareholders are, in theory, best served when company assets are put to their highest value, most productive use.
- The country's K-12 public school system was recognized as one of, if not the best in the world—reliably producing the largest share of all countries of top performers *and* the smallest share of low performers in international benchmark tests in reading and mathematics.
- Finland also regularly scores at the top of the World Economic Forum's Global Competitiveness Index, which attests the prudence of its macro-economic management, the independence of its judiciary, and the general efficiency and incorruptibility of its public institutions.

But seen from the perspective of the development of key sectors such as forest products and ICT, these achievements are subject to question and qualification. Taken together the qualifications undercut the suggestion—explicit in the "knowledge economy" characterization of the country and assumed in praise of its governance, innovation system, public education and competitiveness—that Finland is as robust and adaptive as a modern economy can and need be.

Take first the plausible claim that Finland reached the technological frontier. Reaching the frontier at any moment improves an industry's prospects only if subsequent development indeed proceeds from what then counts as the most advanced point. But a general result of what is loosely called the information revolution—the widespread diffusion of powerful computers and telecommunications networks—is increased unpredictably in the direction of technological development. The easier it becomes to explore the frontier of each line of technological development, and to survey results across frontiers, the greater the chances of multiple, competing solutions emerging to any given problem—each solution better on some dimensions than the others, but none dominant on all. Moreover, dimensions of a solution that are particularly important in one round of innovation may be less so in the next. Hence the progress of technology becomes unpredictable insofar as there can be no expectation that one good solution will lead by a natural progression to another. Counter intuitively, the more knowable the world as a whole becomes, the less confident we can be about the kind of knowledge that will prove useful in engaging its parts. By the same token, the more development depends on applying knowledge from domains traditionally unrelated to the industry's core activities, the less meaningful the idea of a technological frontier—it is everywhere and nowhere—and the less confident we can be that leadership today assures leadership tomorrow. In these circumstances it may well be more important to be able to search effectively across domains than to dominate the generation of ideas and technologies within any one of them. The decline of the centralized corporate research laboratory, where stable project groups could pursue a line of research for a decade or more and the ad hoc research consortia, connecting expertise from what once seemed disjoint domains is one widely remarked reflection of this transformation.

Long traditions of informal inter-firm cooperation among professionals notwithstanding, Finnish companies have only begun to build the kind of organizational networks that make such transverse searching possible. On the contrary: They continue to focus chiefly on optimizing the performance of the technologies and processes on which their recent success depended. In this regard it is the similarities, not the differences, between the forest products and ICT industries—between the traditional industry of the past and the knowledge economy of the future—that stand out. The forest products firms continue to improve the performance of paper making machines, yet struggle to commercialize new ways of making paper based on recycled inputs or nano-scale chemistry, even as they proclaim the necessity of doing both. In the same way Nokia continues to hone its mastery of complex supply chains and of antennae technology, but struggles to give commercial meaning to the idea—as compelling to it as to Apple or Google—of the cell phone as mobile portal to the internet. At the same time success in emerging markets entails relentless attention to lowering the costs of high-volume products, and so increases the pressures for and rewards to optimization--making the re-direction of the organization, or even of some of its key parts, that much the harder. To repeat: central actors in Finnish industry are well aware of the shift in the meaning of the technological frontier and the corresponding risks of proceeding along current trajectories, optimizing what is already done extremely well, rather than exploring alternatives or complements. But so far as we can tell their firms and sectors have yet to develop a compelling response to this recognition.

Nor, it seems, have policy makers fully acknowledged the significance of this change for public institutions. Ideally Finland's justly vaunted national system of innovation should play an important role in addressing the shift from optimization to transverse exploration. But so far it has not. National systems of innovation, Finland's included, were often designed with the idea of closing the gap between a country's capabilities in particular areas and the respective world technological frontier. Such systems become less useful as the "boundary" begins to wander. In the worst case the national system of innovation can actually impede progress by focusing attention, and fixing resources, on the problems that would have been central to an industry's domain if unanticipated connections to other bodies of knowledge had not rendered them irrelevant. There is some risk of this perverse outcome in Finland. For example, the country's university based research in the forest products area, though indisputably the best in the world, is largely dedicated to investigating the leading edge of current production technologies, even as the technology's manifold limits as the basis for an industry in an advanced county become clear. An analogue in ICT is a research focus on radio-related cell-phone technologies or on optimization of current network software to the neglect of the technological foundations of the applications that will give distinctive value to cell-phone platforms.

Recent efforts to re-configure EU technology policy around general purpose “technology platforms” derived from and encouraging wide-ranging search, and active Finnish participation in these projects attest that policy actors, no less than their counterparts in firms, recognize a deep change in the challenges they face. But here too we will see a gap between the recognition of the problem and the articulation of an effective solution. In the main the policy response, like the response in the private sector, has been to do more of what has worked in the past, sometimes under a new name, rather than to make the kinds of (corrigible) commitments that signal renewal. Indeed, in part no doubt because declarations of the need for a new course have gone hand in hand with the hesitation to systematically question past practices, there are already striking indications that the new EU research programs have inherited some of the limitations of their predecessors; worse yet, EU programs, old and new, may have transmitted some of their most obstructive practices to their Finnish counterparts, and vice versa. There is thus the danger that the EU, instead of providing a field on which to rally the forces of renewal, will become another wall in the fortifications holding the Finish economy prisoner to its own success.

1.1 Good Governance as a Backstop?

But what of the possibility that the institutions of good governance—capital markets that properly align the interests of investors and firms, a public administration that plainly aims to serve the public good rather than aggrandize itself, an independent judiciary—will allow the Finnish economy, and the larger society, to correct mistakes of strategy and execution before they have serious and enduring consequences? Confidence in good governance or market-making institutions as providing necessary and even sufficient conditions for economic growth at all stages of development was, after all, particularly pronounced in the 1990s; and the World Economic Forum's competitiveness rankings are but one expression of its persistence today. If, by properly allocating property rights and protecting their elaboration from political distortion, a polity creates effective incentives for long-term growth, perhaps it need not, and should not, meddle with the decisions of the economic actors, however sincere the intention of helping them?

Much historical and contemporary evidence—and especially Finland's own experience over the last century—counsel skepticism. In fact, Finland's success in catching up with the most advanced economies in the 20th century, and doing so while building a social welfare state is more easily understood as contradicting, rather than confirming the rules of good governance. The conformity of some, but only some, of the country's current institutions with the rules is surely more the late fruit of the earlier, deviant success than a deep cause or guarantee of the country's prosperity. Indeed, in some areas, such as the configuration of the national innovation system, the partial conformity may have been the partial result of policy makers' (now) passing infatuation with the idea that Finland, having become a knowledge economy, could and should apply the latest lessons of institutional design. Those efforts, we will argue, have hurt the economy more than they have helped. In general we see little evidence that Finland, having made a virtue of judicious disregard of some of the rules of good governance can benefit by scrupulous regard for them.

Recall that in the context of developing countries (Finland as it was until well into the last century), the idea of good governance was translated into the Washington Consensus program emphasizing liberalization (and eventually abolition) of tariffs and other restrictions on trade, privatization of state firms (as a step towards refocusing state intervention on making few but fair rules for competition) and stabilization of domestic prices and exchange rates with foreign currency by limits to public spending. The last thing a politically vulnerable and economically uniformed state in a developing country should do in this view is try to speed development by picking winners—favoring one sector or firm over another. Recall further that with regard to advanced countries (what Finland indisputably is now), good governance suggested that "state" failures in the provision of services or rules were very often worse than the market failures they were meant to remedy. This translated generally into a preference for hiring private firms to provide public goods such as schooling, health care or even old-age pensions. The social welfare state was a special target of this general criticism. The welfare state was seen as undercutting the work ethic of the poor by subsidizing indolence and both the work ethic of high earners as well as the investment incentives of the wealthy by taxing income and capital gains to finance redistribution and ample public services.

These views certainly identify important potential limits on development—no one invests if the returns are expropriated and certain types of subsidies can certainly reinforce the recipients' sense of dependency. But in both variants they proceed from an extremely general diagnosis of possible problems to a misleadingly narrow, and often simply incorrect specification of remedies. While it is true, for example, that developing economies must compete in world markets to acquire the capabilities needed for sustained growth, it does not follow that elimination of tariffs is the only or best method for securing the necessary opening to the outside. On the contrary, export processing zones—which exempt qualified firms within their jurisdiction, but only those, from import and export duties—or industrial policies—which provide subsidies and public inputs (research facilities, certification services, infrastructure) to firms in particular, export oriented lines of business—have often been found to be more effective. Thus, while countries such as Bolivia and El Salvador lowered tariffs and otherwise complied with the requirements of the Washington Consensus, they did not grow, while countries such as China, and India used "heterodox" methods to open to the world, and did. Finnish success in forest products, we will see, was crucially dependent on such complex industrial policies, especially before and after World War I, and they have played an important role in the development of Finnish telecommunications industry as well.

Similarly the criticism of the welfare state has proven overly broad, sweeping into a single, suspect category institutional constellations with strikingly different effects on growth. Welfare states cluster into different “families.” The Nordic or folkehjem model affords individual citizens and families a rich array of public services (now frequently tailored to individual circumstance) over their entire life course, while the Continental or Bismarkian model traditionally emphasized not services but transfer payments linked to occupational history. Aspects of the latter welfare family have contributed to some labor market rigidities of the kind singled out by the good governance criticism. But the Nordic welfare states have, if anything, increased labor mobility by assuring employees and their families’ access to a broad range of necessary services regardless off their attachments to particular workplaces or even the active labor market. Indeed some scholars have argued (though without reference to the micro mechanisms shaping various markets) that Finland in the 1990s was *the* model of this mix of welfare, educational expansion, and economic growth. According to Castells and Himanen (2002), for instance: “Finland has uniquely created a ‘virtuous cycle’ out of the information society and the welfare state: the successful information society makes the continued financing of the welfare state possible and the welfare state generates well-educated people in good shape for the information society’s continued success.”

Mainstream economists now recognize that high marginal tax rates and a high ratio of government spending to GDP are under some conditions indeed compatible with high growth rates and low rates of unemployment, as well as a reduction of income disparities. This is particularly true of the Danish “flexicurity” version of the Nordic welfare state. In the flexicurity model unions do not protect existing jobs, but do insist on an effective system of continuing education—thereby allowing employees at all skill levels regularly to increase their employability by learning to take on more and more demanding tasks. At the limit this leads to a specific and apparently successful variant of the virtuous circle at which the knowledge-society view gestured: Employers have to compete for the best employees by offering the most highly skilled and high value-added jobs, and employees compete for desirable places by upgrading their skills and adding value. In this way the same institutions that underpin the flexibility of the labor market and economy ensure the security of the workforce. With regard to welfare policy, as with economic development, Finland is therefore a clear example of "heterodox" success—its welfare model is firmly rooted in the Nordic tradition, even if, the strength of its K-12 public school system notwithstanding, it lags, as we shall see, Denmark in the development of the continuing system of vocational system on which the flexicurity model depends.

So too with financial markets. Fine-grained versions of the good governance idea point to possible distortions in financial markets. The most widely discussed is the supposedly inadequate protection of minority shareholders in the bank-based credit systems that were or are still common to almost all the world's economies outside the Anglo-Saxon countries. This inadequate legal protection, it is argued, allows the holder of the dominant block of stock to enjoy "private rights of control:" to divert the firm's resources to selfish purposes, thereby deterring other investors and harming the economy as a whole by making the capital market a club of the privileged. But devilish details again defeat the sweeping good government argument. A recent study demonstrates, for example, that the control premium—the amount in excess of the current market value of a company's shares paid in order to acquire a controlling interest—is no higher in Sweden than in the US, although Sweden's system of corporate governance and equity rights is not based on the common law (Gilson, 2006). Thus, measured by the value of their control rights, owners in Sweden are at no more liberty to pursue their own interests at the expense of other stakeholders than are owners in the US. Debate of course will continue. But the implication of this finding, and others like it, is that in advanced countries no less than in developing economies efficient outcomes can be reached by different institutional paths. Conversely, as the missteps of firms in recent years in the US auto, banking and telecommunications industries remind us, in financial markets as elsewhere in the economy, the "right" governance institutions can permit or even encourage the wrong results. One upshot for Finland is that it's "unreformed," bank-based markets may not have been terribly inefficient after all. A second is that much the move away from bank finance may indeed have loosened encrusted power relations and facilitated the re-organization of production, the move in the direction of US-style credit markets does not in itself assure that firms will be efficiently structured.

1.2 Two Views of Growth and Innovation

Beyond the reassuring view of Finnish economic prospects suggested by a survey of governance institutions and the alarming one that emerges from the briefest canvass of company and sectoral prospects, as well as heterodox exceptions to the "rules" of good governance, lie two, contrary ways of thinking about economic growth and innovation. The first, endowment or production function view, associated with the Washington Consensus and good governance, assumes that economies grow if they are endowed with the proper market-making institutions. The list of crucial institutions typically starts with clearly defined property rights that assign the returns on investments to those who incurred the risk of making them. These rights are in turn protected by a government whose own powers of expropriation are limited, most directly by an independent judiciary attentive to the customs and practices of market participants. Rights, government and judiciary are finally underpinned by a culture of the rule of law. If, but only if, these basic endowments are in place does it pay to invest in improving the quality of the inputs to the economy, such as the skills of the work force or the sophistication of national research capacities.

Sophisticated current versions of the endowment—called "neo-Schumpetarian" because of their emphasis on the role of innovation and entrepreneurship—recognize that these institutions must be supplemented by polices that reflect changes in an economy's context, especially its relation to sources of key technical and organizational knowledge: the technological frontier. For example, competition policy can, in this updated view, be more tolerant of oligopolies and other forms of concertation when an economy is catching up (and incumbent firms will invest more in applying proven technologies when rents are assured) than when the gap has been closed (when powerful incumbents will be tempted to crush the vulnerable innovators on whose success further progress depends). But while this view assumes that an economy's distance from the frontier can vary, it holds tight to the idea that the notion of a frontier is itself invariant, and thus that the chief problem for development is always getting from "here" to "there" as quickly as possible, wherever "here" happens to be.

The second, process or constraints view takes this first and limited step towards contextualization of institutions and policy much further. This view generalizes the episodes of heterodox success in the history of industrialization and in current experience, and the equally heterodox success of (some forms) of the welfare state. It assumes that there are nearly always opportunities for development in a given economy, and that some actors, private and public, begin to take advantage of them. But while development on this view is not hard to start, neither is it self perpetuating. On the contrary, the continuation of growth is always threatened by a sequence of constraints, many, perhaps most of them particular to the firm, its sector, or the region in which it operates. The problem of development is correspondingly to build institutions that can identify and relax these constraints on growth. Economies that create (a succession of) such problem-solving mechanisms grow, (as Finland did) and ultimately "endow" themselves with institutions whose function is equivalent to, but whose mode of operation may little resemble those on the Washington Consensus list of preconditions to growth. Economies that start with the listed institutions but lack the constraint-relaxing mechanisms can score well in rankings of governance, but don't grow.

It is only a slight exaggeration to say that since the 1990s mainstream economists (including those focused on innovation, but with the increasingly vehement exception of those studying developing economies) have applied and elaborated the endowment view, while mainstream students of business strategy and corporate organization have elaborated the constraint or process alternative. The difference in perspective has yielded a striking difference in overall conclusions: The endowment school, particularly as articulated in current theories of economic growth, sees success leading to success, as good endowments lead to the accumulation of assets (including especially productive knowledge and the skills necessary to acquire it) which speeds further accumulation in a virtuous circle of positive returns. The constraints school sees success as a potential trap, creating incentives and cognitive dispositions that focus far too much attention on improving what already works rather than identifying and accommodating 'disruptive" alternatives to the current trajectory of development. The focus on perfecting the current trajectory of development blinds both companies and policymakers to solutions from unlikely domains which could ultimately prove superior to the currently dominant one.

To managers and other economic actors this increasing unpredictability and the risks associated with it are manifest as the pervasive fear of what Clayton Christensen (1997) calls "disruptive" technologies. A disruptive technology is a superior alternative to the currently dominant know how in a particular domain. But the most masterful producers and users of the dominant method are blind to its potential, and the threat it represents, precisely because their experience teaches how to improve on what they already know, and how to find flaws in upstart challengers. Disruptive technologies can, for example, get footholds in secondary or peripheral markets of no interest to the dominant players. Proven there by "outsider" firms, they are generalized to core domains of application, dislodging the incumbent producers. Examples include disruption of integrated steel making by electric-arc or mini-mill steel production; of wire-activated by hydraulically-activated earth-moving equipment; or, more recently, of magnetic-tape or CD-Rom based portable music players by devices based on semiconductor flash memories. Christensen argues—unchallenged, so far as we know—that all established technologies are in principle disrupt able in this way. For the endowment view and the related growth theories incumbency at the technological frontier was *the* goal, allowing firms to see over the horizon of development and providing, through the proceeds of economies of scale, the means to realize the possibilities they saw. In the constraints view incumbency is seen as a burden—(at least) as bad as the burden of backwardness because of the particularly insidious ways it obstructs the search for useful novelty. Where the winner takes all in the endowment school, the winner is cursed in the constraints view—and the key strategic problem for actor and observer alike is to devise mechanisms that can relax the constraints produced by success itself.

Despite their manifest and even contrary differences the two views are alike in disregarding the possibility or relevance of institutional innovation in the organization of firms or the public sector. In the endowments view, once incentives have been correctly aligned by the assignment of property rights and the panoply of institutions that support them, actors are motivated to define and construct the institutions that serve their ends. Policy, and theoretical reflection, properly focuses on establishing the incentive regime, not on the idiosyncratic—but uniformly efficient—use actors make of it. We saw that this inattention to the detail of institutional design let the endowment school to misleadingly general reform proposals, and a corresponding blindness to the utility of "heterodox" solutions. In the constraints view the cognitive disabilities of incumbency are presumed to nullify institutional responses of every kind. Even knowing that disruption is a pervasive risk, firms are presumed to be unable to design against it, as though efforts to search beyond the limits of their current routines necessarily blinded them in new ways. Given the predictable failures of the institutional responses to the predictable danger of disruption, the attention of decision makers and theoreticians is on finding ways of training emotions and senses to heighten awareness of the danger—maintaining a constant alert so as reduce the time needed to respond once a threat does materialize. But surely organizations can be, and are increasingly designed to encourage this kind of alertness, even if no organizational response in itself guarantees it. Indeed, firms such as Nokia manage changes in core technologies, and in the organization of supply chains, that would have been regarded as disruptive a decade ago. No one has seriously argued that there is an upper bound on the kind of change that institutions can accommodate. But the constraint view's fatalism about disruption leads it to neglect the innovations in adaptability that are occurring. If those adaptations grow from general and generalizable principles they reflect, the constraint school would not know it.

We undertook this study of leading sectors in the Finnish economy largely in hopes of countering this neglect. We assumed that the plasticity and vitality of Finnish firms, and the tradition of successful industrial policy in the Finnish state, would make the public and private sectors leaders in the innovation of adaptable institutions. We have seen a general recognition that this should occur and signs of a debate within firms and the public sector to expedite the occurrence. But we found too that the struggle against inertia has been harder than we or many others would have expected or desired.

The story we tell, therefore, is inconclusive. It is more about a history of frequent change and recent entrapment than about continuing plasticity. We have no reason to believe that the hesitations and blockages we see are other than transitional. In calling attention to them our hope is to aid the transition. Many actors in firms and the public sector already know how to talk as though they were living, or soon will live in a world where the legacies of the past are less constraining. What follows is a reminder that it is necessary to recognize that legacy and its subtle grip on the present, in order to escape it.

The presentation of the argument is straightforward. Chapter 2 traces the history of the forest products industry, underscoring the cascade of changes that led to success against the Swedes, and other competitors in the 1980s and 80s, and then on to a concentration of the industry and expansion into global markets, especially for commodities at just the time (it now seems in retrospect) that the industry should have been making paper into a platform. Chapter 3 tells an analogous story for telecommunications. Chapter 4 presents scenarios for the development of both industries, emphasizing the gap between short- to medium-term rationalization or optimization projects all too closely connected to current activities and transformative plans that do not seem connected, or easily connectable to current operations at all. A conclusion looks at recent trends in the Finnish innovation system and its EU counterpart, and finds worrisome signs, at least for the short run, as well as possible signs of change.

2 THE FOREST PRODUCTS INDUSTRY

The forest products industry has been, until now, Finland's most valuable and renewable resource. Learning to make successively more demanding products—from sawn lumber, to pulp, to paper and packaging by various processes, to coated papers and sophisticated packaging, radio frequency identification (RFID) labels and so on—has been indispensable in generating the capacities that allowed the economy to become a world leader in machine building, computer control of complex industrial processes, logistics and the information technologies on which such control systems are based. The speed and scope of the country's success in this domain are striking. Although Finland did not figure as a serious competitor in the most demanding segments of the world paper industry at the beginning of the 1950s, Finnish companies—UPM-Kymmene, Stora Enso, Metso and more specialized players — have a very strong position in technologically and commercially key sectors in the industry today. Sweden, which until the 1980s was more advanced in the production of forest products than Finland, is now the latter's junior partner.

This achievement was the work of what would today be called a developmental state or a vast public-private partnership: The State owned stakes in key firms and still has a strong stake in Stora Enso; regulation of savings and lending rates allowed banks to provide cheap capital to forest-sector firms,[1] and via state instruments such as the Bank of Finland helped finance the industry's push into higher value added products from the mid 1960s through the mid 1980s. Public institutions sometimes cooperated, sometimes competed with industry controlled ones in providing research. Until Finland joined the EU and adopted the Euro, the national currency was periodically devalued in order assure the competitiveness of the domestic forest products industry. Today the Finnish forest industry

[1] On the favorable conditions of finance, see Lilja, ed. 2005, p. 19.

accounts for about a fifth of national industrial production and a quarter of export earnings –equivalent to some €2,000 per capita. Two hundred thousand persons are employed directly and indirectly in the sector, accounting for about 8% of total employment. (Finnish Forest Industries Federation, 2006, Statistics Finland). And even these measures of success understate the industry's contribution to and dependence on national solidarity: A million Finns—one fifth of the population—together own 60 percent of the nation's forests, and the forest industry buys two-thirds of the wood raw material it uses from them. (Finnish Forest Industries Federation, 2006) No wonder developing countries focused on the "beneficiation" of their natural resources today look with admiration at Finland's ability to something as common as a tree into a kind of philosopher's stone yielding knowledge and prosperity.

But there was a price for this success—hidden at first, now more and more evident. Prodded by the determination to become a world leader in demanding products based on chemical manipulation of wood fibers—the coated papers used, for example, in mail order catalogues and glossy magazines—the Finnish forest industry also became, almost surely more by accident and inattention than by grand design, a volume producer serving a stagnating market with excess capacity in the EU and the USA. From the mid 90s on, profit margins decreased, and with them the propensity to invest. As the pace of modernization slows, and the focus shifts from building new plants to refurbishing existing ones, there is the real danger that in a decade or less Finnish paper plants will not be a technological match for the world's best. And even as the industry stagnates, much of its imposing research capacity remains focused on the process improvements that have made it technologically dominant, and vulnerable: of 36 professors at Finnish universities specializing in the paper-related disciplines, 31 are focused on the paper making process, only 5 on new uses for cellulose fibers in, for example, packaging and building materials. This inertia is punctuated by alarming signs of overcapacity: When a strike in Finnish paper plants reduced EU supply by one fifth in the summer of 2006, the price of paper didn't budge.

The recent, world-wide hunt for bio fuels to replace depleted reserves of oil, gas and coal only makes the situation worse by raising the cost of the industry's key raw material—cellulose fibers—and thereby negating the laborious and costly efforts to insure price competitiveness by increasing the efficiency of production.

To be sure, markets for quality papers and packaging are growing rapidly in developing countries such as China and India, and there is low-cost, fast growing fiber in the Southern Hemisphere, especially in Brazil and Argentina, Uruguay and Indonesia, as well as a vast supply of wood fiber in Russian forests, if political problems associated with securing reliable access can be solved. But given the complexity of the industry's logistics, this reshuffling of opportunities and resources has profound implications for the location of forestry products production. Pulp travels well, paper less so, tissue not at all; and certain grades of packaging are competitive only when produced close to their end users. Thus Finnish paper firms can, and in some measure already do, follow the growing markets and relocate paper and packing mills in developing countries, and supply them with pulp from advantageous locations worldwide. But just as the Finns were avid to learn from and outdo the Swedes, Americans and Germans in paper making, so the powerful developing countries with the fastest growing markets want to learn from and outdo the Finns. Proximity to the newest and most innovative plants will favor the pupils, not the masters. By itself the internationalization of the industry, or rather its dislocation from Finland, will most likely mean slow decline for the companies with little if any corresponding benefit for the country on whose determined support they until recently depended.

But this dead-end dislocation is far from the only path available to the Finnish forestry products industry. The creativity of teams at individual laboratories, engineering units, and production plants; the networks of engineers and managers that connect innovators across plants, and create possibilities for them to think through bold projects that would be unwelcome at their home institutions; the external consulting firms that challenge business as usual even as they sometimes re-enforce it; the pool of engineering talent constantly refreshed by students to premier Finnish programs from around the world—all the elements that contributed to the industry's remarkable ascent are still available for its regeneration—provided they can freed of the traps the industry has set for itself through consolidations and reconnected to each other, and the wider world in new ways. The story of the potential regeneration of the industry is reserved for chapter 3, where striking similarities to the possibilities—and perils—of the reorganization of Nokia can be explored. This chapter focuses on the slow rise, the unlikely success and the bewildering sudden discovery of the limits of what seemed an enduring triumph.

The story falls into four periods. The first, from the mid 19th century to the end of World War II covers formation of the Finnish forestry products and paper-machine industries under the aegis of the state. The second looks briefly at the forced-draft development of the industry after the War, when reparations obligations to Soviet Union led to a mobilization of the technical capacities of the paper making and related capital goods industry. This mobilization became the immediate foundation for commercial expansion, during the Korean War, and more importantly honed and linked the skills in workshops and design bureaus on which the succeeding decades of innovation would be built. This extended burst of innovation is at the center of the third part of the story, from the 1960s through the early 1990s. It is in this period that Finland decisively specializes in coated papers and other differentiated, high valued added products, becoming the world leader in these segments and surpassing Sweden, which casts its lot with the mass production of newsprint and related paper grades. To explain Finland's achievement—and thereby to help direct our search for the mechanisms of innovation that have been obstructed by success itself—we focus on the contrast with Sweden: differences in the investment opportunities and the system of financing; differences in the sourcing of raw materials and marketing methods (both, in the case of Finland, powerfully shaped by the choices made in the WWI period), and again—as a continuing theme—the unusual importance of the state in industrial development in Finland. The last section details the consolidations of the 90s, and documents the stagnation of the industry at home, and the pitfalls of simply transposing the strategies from Europe to the world the strategies that succeeded at the end of the last century.

2.1 The Beginnings to WWII

The Finnish forestry products industry originated in the 1800's with sawmills established with Western European technology and producing for the export market. The modern industry, based on the kraft or sulphate process for making pulp for paper products developed towards the end of the 19^{th} century, when Finland was still a Grand Duchy of the Russian Empire. By the turn of the century Finnish pulp and paper mills, operating behind tariff walls and with the benefit of favorable rail connections, had become competitive in the closed, "home" Russian market, towards which most production was directed until the First World War. (Reunala et al, 1998) Kraft or brown paper (used for bags and cartons) along with newsprint were the principal products. By the outbreak of the war, and after a round of consolidations, the industry was dominated by eight large companies which, in one form or another were to play an important role in the following decades: Gutzeit, Ahlström, Kajaani, Kaukas, Kymin, Wilh. Schauman, G.A. Serlachius and Yhtyneet paperitehtaat (UPM). Because the industry relied almost from the first on large, lumpy investments, and was subject to large swings in the demand for its output, the firms were in turn dependent on large banks and their patient capital: a variant of the German and Japanese "universal" or "main" financial systems, in which large banks pool funds from depositors and extend long-term loans to large industrial borrows, in whose enterprises the banks also own significant equity stakes.

The defeat of first Russia, then Germany in World War I; the establishment of Finland as an independent country in 1917; the victory the next year of the conservative Finnish Whites over the social democratic Reds in the civil war triggered by these events;—this violent cascade created the mutual and enduring dependency of the new state and the emerging industry. The state needed access to export earnings that only the paper industry of the day could plausibly provide: in fact, beginning in this period, and until the 1950s, 80 to 90 percent of all export earnings came from the forest industry. The industry in turn was dependent on the state because, cut off from the Russian market it had served before the war, firms needed the government to negotiate and otherwise smooth access to new markets in Western Europe, and do much else besides. (see Lilja, ed, 24-25)

The most direct expression of state concern for the industry was nationalization of forests and mills under foreign ownership. In this way the government created Enso and acquired the company Gutzeit Oy from its Norwegian owners. A third company, Veitsiluoto Oy, was founded to utilize forest reserves. (Reunala et al, 1998).

Less conspicuously, but not less consequentially, the state encouraged firms to collaborate with each other and the government in conducting their affairs and in formulating official policy. Sales cartels[2] were established to open the new, western markets, and to allow producers to export without having to invest in marketing organizations. A collective trade association, the Central Association of Wood Processing Industry, was established in 1918, and the heads of firms participated in all important government-business or corporatist decision-making bodies. Almost all paper industry firms in addition funded White parties in parliamentary elections. Perhaps most important, the managerial elite of the paper and pulp industry companies was so personally intertwined with the country's political and social elite that the line between government and business was blurred to invisibility in trade policy and related domains. (See case in Box.) Thus discussions between Finland and Soviet Union in the early 1920's

[2] This was not illegal or secret at that time.

produced guidelines for barter trade that become the cornerstone of bilateral relations for the next 70 years. Separate negotiations made it possible for Finland to export newsprint to demanding customers in Britain, the United States, and Argentina by the end of the 1920s.

CASE: Pattern Of Personal Influence In Business – And The Easy Movement From Industry To Government

The career of Hjalmar J. Procopé illustrates the fusion of industrial and political elites. He was the managing director of the association for joint paper sales (later Finnpap) 1931-38, Minister of Trade and Industry 1920, ´21, ´24, Minister of Foreign Affairs 1924-26, 1927-1931), and finally Finnish ambassador to the US in the critical WWII years (1938-1944).

Similarly, Rudolf Walden and Gösta Serlachius were key in the early development and cooperation of Finnish paper industry. They had served together in the Army Headquarters and later in the Civil War in 1918. Walden gained experience and new ideas while working as a manager at the Slovo printing company in St. Petersburg during the first years of 20^{th} century. He became the Russian market agent for all paper qualities of the Simpele mill and later bought the mill. Walden was in a key role to promote early exports of pulp and paper products. He acted as the first chairman for Finnish Paper Mills Association founded in 1918 (and later served as Minister of Defense – the juxtaposition of industry and government was next to nonexistent in many cases).

Gösta Serlachius acted as the Finnish Paper Mills Association representative to the Central Office of the Finnish Paper Industry and Chairman of the Central Office Supervisory Board. The Association was formed to meet the need for cooperation in the industry and centralize the sales. In its infancy, it comprised 23 companies and 63 paper machines.

WWI halted export activity which was well on its way. The paper mills association had a target to market paper in the Ukraine, where the Finnish paper industry had succeeded in sales for many years. There was an obstacle to the trip: the planned route via Berlin. Under the circumstances travel visas were granted only to government officials. Consequently positions were arranged for both gentlemen as Consuls in Kiev (Walden) and Odessa (Serlachius). Finland, of course, had to acknowledge the independence of Ukraine. The trip turned to be a success until political events turned the tide i.e. a ship load of paper was halted in Riga harbour due to fall of Germany. After the war, Serlachius convinced the Finnish government of the need to send a trade delegation to Western Europe and the United States. He was appointed the paper-industry representative and the Chairman of the Cellulose Association, Jacob von Julin, headed the delegation. (Finnpap, 1993)

A further upshot of the mutual dependence of state and industry, and the interpenetration of their respective elites were state policies that, beyond the influence exerted through trade policy and public companies, provided indispensable infrastructure and other public inputs to the forestry sector. River rapids were harnessed to provide hydroelectric power to pulp and paper mills. Railroads were extended to accommodate the industry's logistic needs. In 1922 and 1923 professorships were established in mechanical and chemical wood technology. National forest stocktaking (inventointi) was introduced in the 1920's. One of the first statistically rigorous sampling efforts of its kind, this inventory created the foundations for siviculture techniques that improved yields and would signal and thereby mitigate over-harvesting 40 years later. (Reunala et al, 1998)

But one of the most consequential of all public interventions in the forestry domain—a series of laws severely restricting corporate ownership of domestic forests—grew in this period out of the long-simmering problems of the tenant farmers (*Torpparit)*. Forced to bargain repeatedly under conditions of great legal uncertainty with more powerful and vastly wealthier parties—the owners of the lands they leased—the tenants suffered and protested the abuses typical of this combination of circumstances. The pulp and paper industries' increased demand for timber and for the forests lands on which it grew, created pressures that threatened to dispossess the tenants entirely. But the political turmoil of the War and its aftermath gave the tenants exceptional power as swing voters shamelessly courted by Reds, Whites, Russifiers and the Fennoman nationalists. First the tenants were granted the right to purchase the lands they worked on what proved to be extremely favorable terms. But the definitive foundation of an extensive system of state protection of forest smallholdings (that endured until the late 1990s) was the Lex Pulkkinen of 1925, which prevented forestry companies from purchasing agricultural farms and allowed the state to repossess forest lands that had been acquired by corporations. [3] It has been called "perhaps the most import event behind the creation of modern Finland," as "it forced major forestry companies to source their raw material from tens of thousands of peasant-owned forests, which meant that the success of the export industry flowed like a wide river across society". Further land reforms after the World Wars created incentives for farmers to maintain holdings in remote areas (Lilja, ed. 2005, p. 23) Thus was formed the enduring basis for dispersed private, ownership of the forest industry's raw materials in Finland. As we will see below, this was to have an important, perhaps decisive—but certainly unintended—effect on the industry's choice of strategy at the crucial turning point in the 1960s and 70s.

One aspect of the industry's development where state policy, in contrast, played little or no role was technology transfer. In the late 19th century Finland, as measured by income per capita, export earnings per capita or share of the workforce employed in industry was a backward country compared to its Nordic neighbors, let alone the rich, large economies such as Great Britain, Germany and France. Nonetheless, the country had ready access to the relevant foreign technology. In the 19th century paper machine were supplied mostly by German or English companies, which delivered spare parts and provided maintenance services. The Kraft process, first commercialized in Sweden in 1890, was introduced to Finland shortly thereafter, a reflection of the close ties between the economically dominant, Swedish-speaking minority in Finland and the industrial elite of Sweden that would act as an important conduit of new ideas in coming decades.

As the pace of development quickened, the long delivery times for new machines and replacement parts created demand for domestic machine makers.

[3] For analogous developments in Denmark, see Charles Sabel and Peer Hull Kristensen, 1997.

The main machine shops were Wärtsilä, Ahlström, and Tampereen Pellava ja Rautateollisuus. (Lammi, 1994, pp. 10-33; Nykänen, 2005) Their growth went hand in hand with the emergence of small engineering community connecting experts in different specialties. By the early 20th century machines were still imported, but maintenance was done domestically. Cooperation with demanding customers encouraged product development and the application of new technologies. The first Finnish paper machine was built in 1904 by Vyborg Machine using a design derived from older equipment. A sign of the growing technical sophistication of the forestry industry and its capital goods providers was the founding in 1916 of KCL (Keskuslaboratoriot), a research laboratory jointly owned by the pulp and paper industry companies. (Nykänen, Paulapuro, 2005, www.kcl.fi) (Reunala et al, 1998; Nykänen, 2005) KCL was the center of industry R&D for some 20 years: Only in 1942 was it thought necessary to complement it with the creation of the Technical Research Center of Finland (VTT), which did (and does) both contract and general research (Reunala et al, 1998) for the forest products industry and other sectors as well.

During the 1930s technology transfer continued by a flurry of licensing and joint ventures. The main forest industry engineering companies were, as in earlier decades, Ahlström and Wärtsilä, now joined by Tampella, which started as paper machine manufacturer and entered the industry in 1952 (Nykänen and Paulapuro, 2005). Ahlström, for example began fiber board production in the early 1930's in cooperation with Backus-Brooks, a US company. Other licenses were obtained from the German company Sulzer, deLaval in Sweden and Nash in the US. Ahlström also cooperated with the Swedish machine builder KMW, and this cooperation led to a joint venture—Kamyr—in Sweden involving Ahlström, KMW and Oslo-based Myren. (Nykänen, 2005; Reunala et al, 1998) For its part, Wärtsilä Oy worked as a licensee manufacturer of Minton pulp drying machines. It also used a license from the Kamyr joint venture to produce pulp and paper technology .[4] In the early 1930's Tampella represented KMW in Finland.

These three Finnish producers were self confident enough to be tempted by the idea of taking control of the domestic market by agreeing to restrict production to complementary specialties,[5] and to coordinate pricing. In 1935 Tampella and Wärtsilä actually reached an agreement to do just this, but Ahlström refused to join them. (Nykänen, 2005) But the idea of a specialization cartel would be revived, successfully, by these firms after WWII and the period of forced-draft reconstruction that followed.

Reconstruction and Opening

As an ally of Germany (but never a partner in the Nazi racial politics) Finland was obligated to pay onerous reparations: $300 million US dollars, at 1938 exchange rates, equivalent to 4 percent of country's total output (GDP) in the late 1940s. Some 20 percent of this debt was assigned to the entire industry, not counting $22 million worth of goods seized by the Russians as "restitution payments." As a result much of the revenue of the paper industry's output in the immediate postwar years went, directly or indirectly, to cover reparations obligations. As in the immediate aftermath of WWI, the result was to intensify cooperation between

[4] The major trend in the development of pulp and paper machinery technology is the development in automation since the 1950s. It has made it possible to increase the speed of paper machines from 800 m/min in the 1950s to 2000 m/min in the 2000s. The most significant technology innovation was the Kamyr continuous digester, which was patented very well and gave Kamyr a monopoly until 1989.

[5] Under the name of Rationalisierungskartelle or rationalization cartels such specialization agreements were common in Germany in this period among capital goods makers,. In order to respond to the specialized and changing demands of their customers, capital goods makers must use highly flexible production equipment. This flexibility makes it relatively easy for such firms to switch production from their distinctive specialty to other types of machinery when demand for their usual products falls off. In hard times many producers make such forays, underbidding each other and so depressing prices across the whole range of their activities. The Rationalisierungskartell avoids this problem by obligating firms to stay within their niche throughout the whole business cycle. The best way for a firm to increase the market for its products under this condition is to innovate, thereby rendering existing equipment in its line of business obsolete and obligating lead customers to replace it with the model. See Gary Herrigel, 1996.

government and industry to the point of fusion: The state allocated the compensation quotas mill by mill, and prices were fixed by the reparations commission—*Soteva*—after discussions with sales organizations. Paper was only freed from government control in 1949. Perhaps the deepest result of this collective exertion was to consolidate the ties among a generation of engineers and managers in machine makers and paper mills and give them confidence in their joint capacity to solve daunting problems: Ahlström, for example, constructed its first paper machine in 1948 for the Tervakoski paper mill by pooling the knowledge of customer and capital-good supplier.

As normalcy—punctuated by bouts of inflation, swings in the exchange rate and periodic international crises—returned in the 1950s, the paper industry resumed its pre-War growth. Production of paper products, largely newsprint and brown paper, grew, reaching 1 million tons per year by 1960. As in the 1930s, Finnish machine makers used foreign licenses to acquire the knowledge needed to develop their own technological capacities; and as in the 1930s as well domestic industry was far from being a technological leader, yet within hailing distance of the technological frontier, and with relatively easy access to it.

This combination of distance from but access to advanced technology is reflected in the career of Jaakko Pöyry, founder of the eponymous engineering and consulting firm, which is today the largest provider of both plant designs and strategic analysis to the forest products industry world wide. Pöyry's early interests were in combustion engines, and he focused on novel diesel designs at the Helsinki University of Technology, intending to emigrate to Great Britain to make a career at Leyland Bus. But during his studies a summer internship at the SCA sulphite pulp mill in Svartvik, Sweden, turned his enthusiasm to the paper industry, and upon graduation in 1948 he started work in Wärtsilä's pulp and paper machinery department—which, a year later, at age 25, he headed.

In 1953 Pöyry was sent on a tour of 60 US and Canadian pulp and paper factories to see first hand the most advanced machine technologies and plant layouts of the day. He returned with ideas for reorganizing the Nordic industry which proved prescient, but were also unacceptably radical for his employers and many of their peers. Rejected at Wärtsilä, Pöyry was soon hired by a small group of Swedish inventors and investors and by the Finnish subsidiary of a Swedish firm manufacturing cleaner-installation solutions for pulp and paper mills. Pöyry, working with a younger friend from student days, Matti Kankaanpää (See Box), quickly saturated the Finnish market with the new equipment. By 1958 Pöyry was so well known that Finnish Forest Owners' association asked him and Jaakko Murto, professor of paper technology at the Helsninki University of Technology, to design a new sulphate pulp mill in Änekoski in central Finland. So was created the engineering consultancy of Murto and Pöyry, from which over the next twenty years, the Pöyry Group would emerge: Where Murto proved to be the classic artist-engineer, almost incapable of extended collaboration, Pöyry was at home with the cosmopolitan elite of engineers and managers engaged in advanced investment projects in pulp and paper around the world. The firm rapidly consolidated its position in the Nordic countries. By the mid 1960s it was undertaking large projects in Portugal and Germany, and was recognized as a central node in the network of knowledge flows within the international pulp and paper industry. The Group today employs some 7,300 persons.

CASE Individuals as the vector of knowledge transfer: The Matti Kankaanpää story continues.

Matti Kankaanpää rejoined Pöyry in 1963, having worked at Beloit research from 1957 to 1963 and becoming a pioneer in components and section standardization in Finland. In 1970 Jaakko Pöyry Oy was responsible for the engineering and equipment choices of a MoDo mill project. Matti Kankaanpää of Jaakko Pöyry Oy proposed a new press section solution, which he had developed, to the customers. He developed consecutive new press section solutions starting from 1970. These were sold by Valmet. Matti Kankaanpää transferred to Valmet in 1971. He began to work on the press sections called Sym-Press in 1971. He also developed the first hybrid former, named the Sym-Former, which was implemented in a pilot machine in 1972. The pilot plant was renewed in 1977 and refurbished so that customers could gain confidence in the technology by seeing it at work. In 1975 a cooperation project with Nokia on tissue paper machines was begun. It gave Valmet the opportunity to study the class of machines and develop its own—the first of which was sold in the same year. A new complete wet end concept, called Sym-Concept was applied in 1973 to the UPM Simpele mill. It increased reliability and decisively decreased the amount of maintenance shutdowns. Since the mid-1970's the market was saturated and this resulted in a switch of focus to rebuilds. Valmet's key product, the former, was also developed for rebuilds. (Nykänen, 2005)

Thus, by around 1970, as domestic paper production exceeded 4 million tons per year, Finland, though not as wealthy as Sweden, and with a much shorter history of industrialization, could vaunt a pulp and paper sector in many ways comparable to that of the latter. Both used the same raw material: Northern spruce. Both produced the same range of products—pulp, newsprint and kraft paper. As evidenced by the success of Jaakko Pöyry both had access to the same gamut of technologies. And both faced, from the mid 1950s on, with increasing intensity, the same threat: US firms, drawing on recent innovations in the bleaching of brown sulphate pulp, had learned to use the long fibers of the abundant pine of the South and Southeast (mixed with some short fibers from deciduous trees) to make pulp and paper grades that until then could only be derived from spruce. Mechanical pulping from pine, rather than spruce, began in this area of the US as well, and with it the production of newsprint. To make matters worse, US firms began vertically integrating at home, securing a stable source of domestic pulp rather than importing supplies, and acquiring paper producers in Western Europe. Pulp, which before the War flowed mainly from the Nordic countries to North America began to flow, in large quantity, in the other direction as well, and along with it came pine-based newsprint in great quantities and low prices, and local subsidiaries of US firms to market it.

Faced with this threat Sweden attempted to beat the US at its own game and concentrated on high volume production of a few standard grades of paper, aiming for the greatest possible economies of scale. The results were not only commercially disappointing but also technologically self blocking—the Swedish investment strategy slowed the pace of technical advance. The Finns, in contrast, bet on a strategy of flexible production for more and more demanding markets. Avoiding head to head competition in volume production and serving (rapidly growing) niches, the Finnish industry prospered and surged ahead technically. What accounts for these contrary strategic choices?

2.2 Towards high-valued added products

An important, perhaps decisive factor, anticipated above, was the difference in accessibility of wood supplies in the two countries. More exactly, the Finnish paper producers faced what is called a hold-up by their wood suppliers, and therefore a major obstacle to pursuit of a high-volume strategy, while the Swedes did not. The potential for hold ups arises generally because of the mutual specialization intrinsic to mass or volume production: The particular input one party provides only has value when combined with a complementary, equally specialized input provided by another. For example, coal with a certain sulfur content mined in a given place will be very valuable to a nearby power plant optimized for coal of that composition, but not to distant plants burning other types of coal; by the same token the power plant is valuable so long as it has ready access to the nearby coal, but otherwise not. Hold-ups occur when one party to such a relation makes a specialized or asset-specific investment, and the other extorts greater returns to cooperation by threatening to withhold its complementary one: the mine owner sinks a shaft, but the power-plant owner delays construction until the agreement between them has been altered in his favor. If the parties to the transaction are independent firms, as in the classic hold-up case, the efficient solution is vertical integration, with the customer to acquiring the supplier to assure supply under fair and predictable terms, or, failing that, long-term supply contracts.

These solutions were available to the Swedes, but not the Finns. Firms own 25 percent of the Swedish forests and there were and are no legal impediments to acquiring more. Firms own less than 10 percent of the Finnish forests, and as we saw, the law of 1925, passed in connection with emancipation of the tenant farmers, prohibits further acquisitions. As of 1960, some 75 percent of timber consumed by the Finnish paper industry was supplied by 300,000 private owners, mainly farmers, while Swedish producers relied on private owners for only a small fraction of their supplies. (Peterson, 2001, p. 33) The difference in bargaining power of the firms was reflected in price differences between Finnish and Swedish spruce in this period. In the first half of the 1960s the stumpage price for spruce doubled in Finland, while in Sweden it increased by only 10 percent. (ibid) Finnish firms and investors were unlikely to be attracted to a high volume strategy that added little value to the wood it processed—and in the very act of expanding production to secure economies of scale increased the ability of the wood suppliers to claim an increasing share of whatever profits it generated. Conversely, strategies that focused on adding value to wood fibers by transforming them into papers coated with mixtures of minerals and chemicals for specialized needs both yielded higher margins and limited the power to wood suppliers to alter the terms of exchange.

There were, of course, additional factors channeling strategic choices in opposite directions. The Swedes already had begun to invest in large facilities and high-volume equipment. Consolidation in the paper industry was in some ways the continuation and intensification of then current ideas, not a break with them.[6] The decision in favor of mass production, moreover, was surely encouraged by the concurrent strategic discussions in the Swedish steel and shipping-building. Faced with analogous problems, they, too, placed large (and as it turned out losing) bets on mass production—re-enforcing, at leas for the critical moment, the impression that the choice was nearly self evident.

In Finland the channels ran the other way. As we will see in some detail below, alongside the large firms in the industry there existed a substantial cluster of smaller, family owned ones. Most of these used flexible, lower volume equipment

[6] The Swedes, as significant exporters of pulp, were concerned that volume production would put them in competition with their Western European pulp customers, who might retaliate by exclusionary measures. But this problem was to some extent finessed by choosing commodities to avoid competitive collisions.

to produce specialized products. Marketing was done jointly so smaller firms were not excluded by their limited resources from export markets or from a rich flow of information about changing customer needs. Specialization, not volume production, was arguably the "traditional" response. Moreover, since the paper industry was the country's largest, there was no herd to join in a rush to mass production. On the contrary—as early as the 1920s some of the most respected figures in the paper industry, such as Rudolf Walden, considered the quality of paper more important than quantity. Finally, awareness that the Swedes were likely to move aggressively in the direction of volume production of commodities must have focused the Finn's attention all the more firmly on exploring the possibilities of niches and high value added specialties.

But whatever the exact causal pathways, the difference in outcome in striking. While Sweden expanded its production of brown kraft papers and carton packaging roughly 5 times between 1960 and 1992, Finland was producing only 50 percent more of these products at the end of that period than at the beginning.

Figur 6.10. *Kraftpapper och kartong, exkl fluting; produktion i Sverige och Finland 1950–92, 1 000 ton*

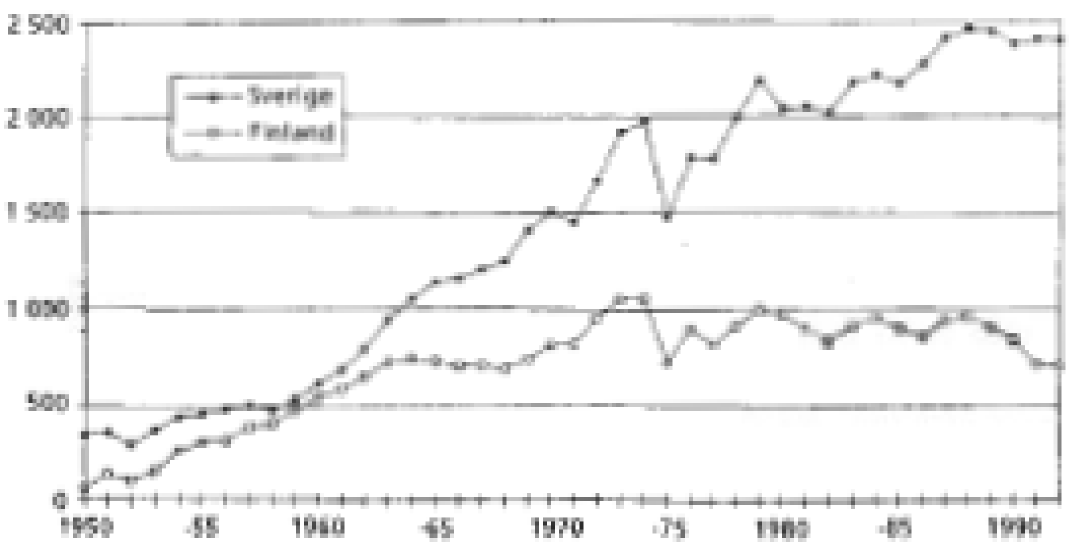


Figure 1. Kraft papers and carton production in Sweden and Finland 1950-1992 (Figure 6.10 in Peterson, 1996).

Conversely, as figure 2 shows, production of coated writing and printing papers soared in Finland and stagnated in Sweden.

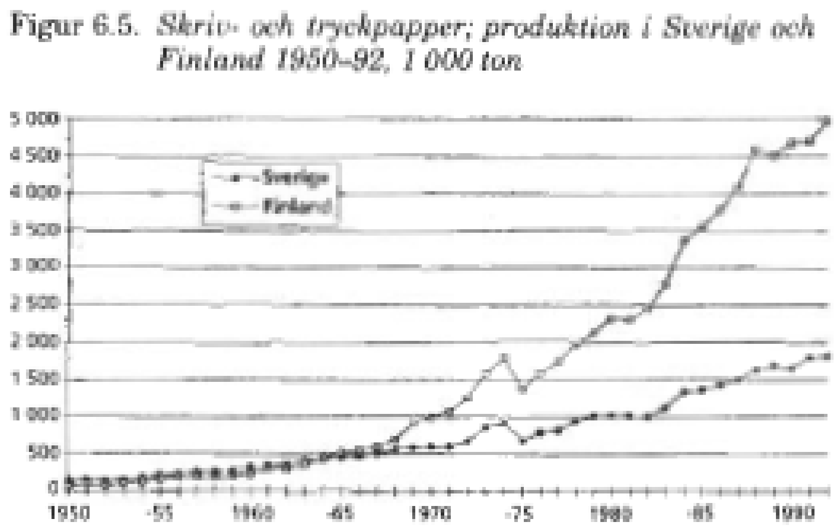


Figure 2. Production of coated writing and printing paper in Sweden and Finland (Peterson 1996, Figure 6.5).

This long-term shift in Finnish paper-making strategy was manifest in a dramatic shift in the context of firm and project-level decision making, as reflected in a careful “before” and “after” study of two large investments by Tampella, a leading paper producer and machine maker. The first project, in the early 1980s, regarded a pulp mill and a new newsprint machine at a facility with two older machines. The second involved the total rebuild of one of the mill’s paper machines. Both increased the firm’s paper production and deployed new machinery produced by Tampella itself. Both were carried out by essentially the same management. But beyond these commonalities the projects differed in ways that underscore the characteristics of the new strategy.

Thus the first project was for producing newsprint. The value added was low. The equipment built was conventional within the industry—and within the machine-building unit of Tampella and the mill for which it was destined as well. The project was financed by the firm's then house bank. Wary of low returns on the project, the bank refused to increase its equity in the firm and insisted instead on financing the project through a loan. Beyond the bank's distaste for risky projects Tampella was inhibited by an agreement (foreshadowed by the failed efforts at cartelization in the 1930s) with Wärtsilä and Ahlström to restrict itself to certain classes of machinery production.

The second project was directed to production of machine-finish coated (MFC) paper: a bright, film-coated, grade used with a particular type of web -offset printing machines. The value added was high. The equipment was advanced within the industry, and innovative within the company and the mill. In developing it Tampella was no longer restricted by the cartel arrangement, which had been abrogated in the intervening years. The project was financed by a new bank owner—who let the sitting managers know the innovations would be effected with or without them. (Laurila. 1997)

2.3 Consolidation and its Constraints

But success brought consolidation and consolidation inhibited the industry's innovative flexibility innovation—just as the rich country markets for a broad range of conventional products began to stagnate. Unable or unwilling to run the risks of trying to create new markets by innovation, Finnish firms have sought to redeploy updated versions of their standard know how to rapidly growing emerging economies. But, bedeviled by falling returns, they have also begun to disinvest, raising serious questions about the industry's long-term prospects.

Consolidation was made possible, and perhaps to some extent even propelled, both by radical changes in Finnish financial markets that put an end to the universal banking system, breaking the links between firms and house banks, and by the massive recession, and corresponding fall in asset prices in the early 1990s—a consequence of the dissolution of the Soviet Union and with it the disruption of markets on which the Finns had long relied. Without these permissive or facilitating conditions, consolidation might have been delayed or slowed long enough for some of the costs of proceeding pell mell might have become visible; in the event, with these conditions as accelerants, consolidation, with its jumble of ill considered constraints, appears to have become a reality before it was a fully deliberate strategy.

The breakdown of the universal bank system was the culmination of more than a decade of deregulation of the financial sector and growing capacity for self finance on the part of firms. By the 1990s, both EU directives and the Finnish banking law strictly limited risk allocations of the commercial banks and imposed reserve requirements that effectively required the banks to diversify their lending away from traditional core customers. These regulations set limits to lending for the flagship corporations and put pressure on their liquidity and solidity. At the same time, using financial de-regulation to their own advantage, the large firms in the paper and other industries created internal merchant banking units (often located abroad) to raise capital without having to rely on bank intermediaries. At the same time the firms' need for external financing of any kind was reduced by increases in free cash flow, and the greater possibilities for self financing of investments that it afforded.

Even as the firms distanced themselves from the banks, they became more attractive to, and more active participants in equity markets. Restrictions on foreign ownership of shares in Finnish companies were abolished in these years, and foreign holdings increased. By 1993, at the bottom of the long recession, the Finnish Mark was weak and domestic equities undervalued. The largest corporations were in play, buying each other partly for more or less well considered strategic reasons, partly to avoid themselves being taken over.

The effect on the organization of the industry was dramatic. As Figure 3 makes clear the list of the top 25 forestry products firms remained essentially constant from 1947 to 1985. Numerous and diverse, yet able to share information through professional associations and industry bodies, these firms as a group were well suited to engage in the parallel searches of niche markets that made the Finnish move into high value-added products a success. In the next decade the industry's structure changes dramatically, with 15 firms surviving until 1990 and 9 until 1996. Of these UPM-Kymmen Oy, Enso Oy and Metsä-Serla Oy are publicly held.

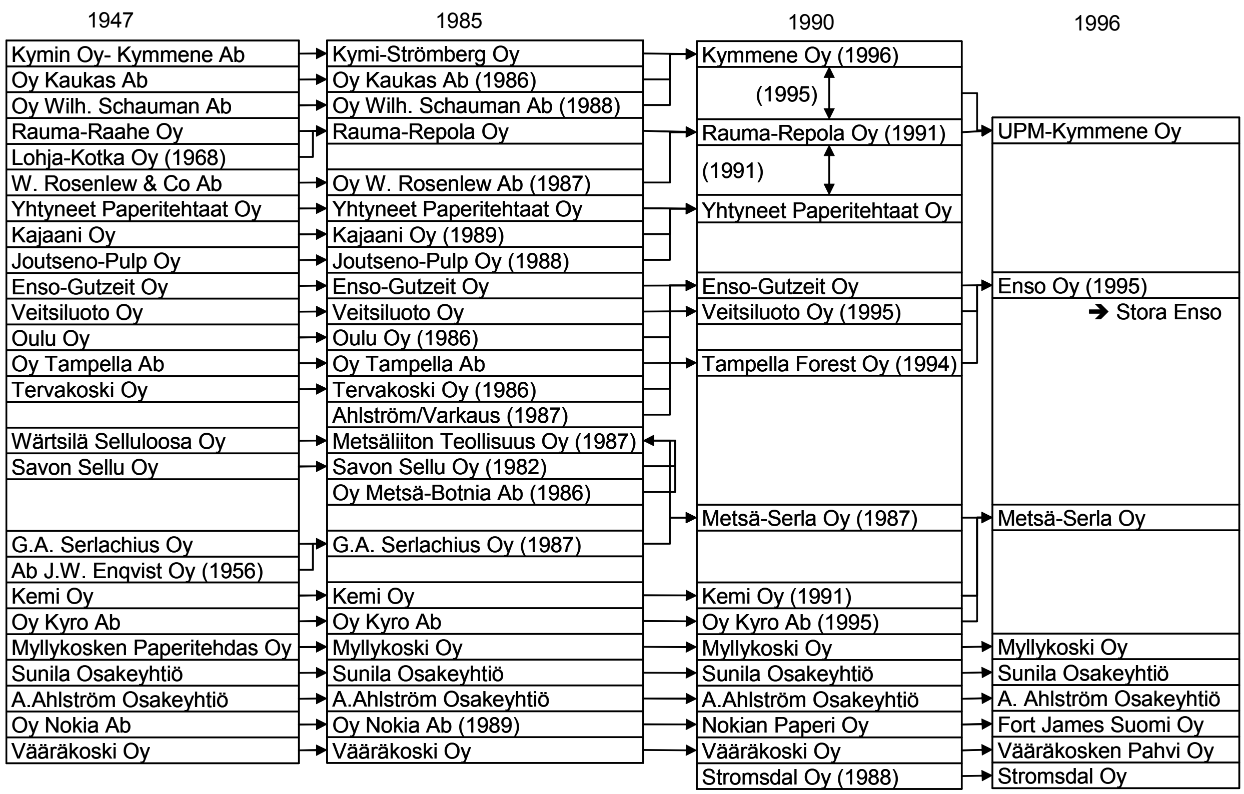


Figure 3. Organizational Development of Finnish Forest Industry after WWII until mid-90's

Of these survivors, 3—UPM Kymmene, StoraEnso and M-Real (Metsä-Serla's new name since 2001)—today dominate the market. Each is itself the hub of an international consortium of forestry products firms connecting the Nordic countries, Central and Southern Europe, North America (until recently) and emerging markets. The mergers and acquisitions of the most prominent players have are shown in Figure 4,.

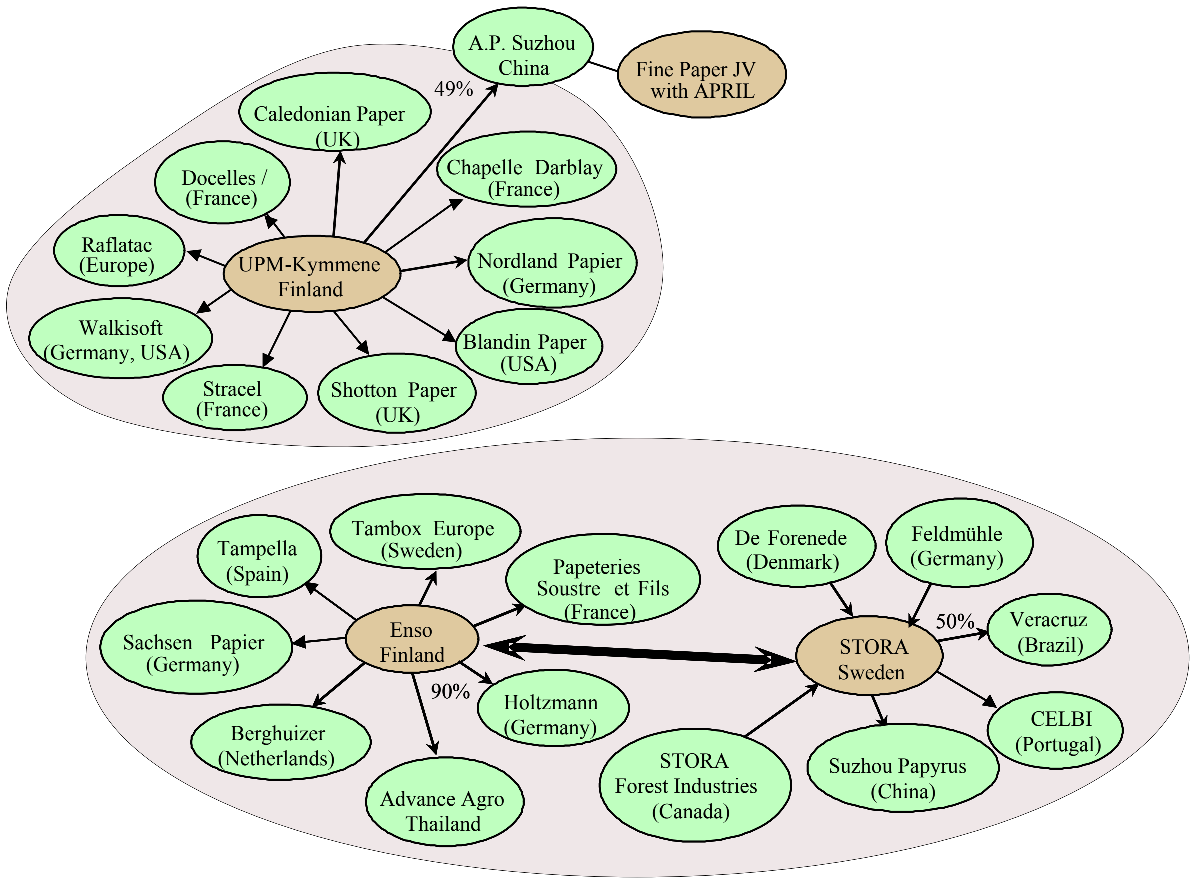


Figure 4. International mergers and acquisitions of UPM-Kymmene and Stora Enso up to 2006/2007. Source: Pöyry

But dominance has not brought prosperity to the industry. The most immediate reason is that paper, in almost any form recognizably derived from the traditional products of the industry, proves to be an inferior good. An inferior good is one whose consumption increases with increasing income up to some threshold level, but stagnates as income levels rise still further. A commonplace example is canned peaches: per capital consumption of canned peaches rises as incomes rise in mid-income country such as Russia, but growth in consumption slows as incomes levels there begin to reach those in the rich countries. So, recently, with paper. For much of the post-World War II period paper consumption increased at least as fast as growth in GDP. This historical relation is captured in the scatter plot of GDP per capita and per capita paper consumption per capita for a range of countries in Figure 5 as of 2005.

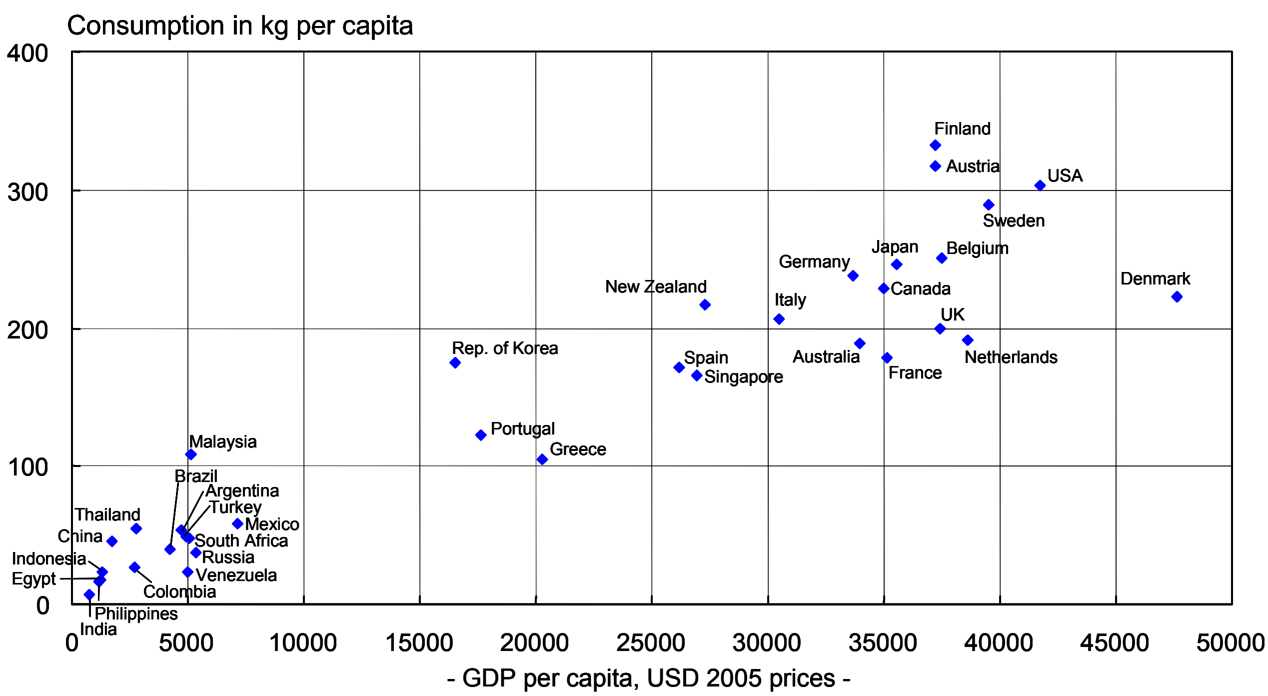


Figure 5. Relation between GDP/capita and Paper consumption/capita in several countries

But finer grained analysis reveals a different picture, as shown in the next Figure 6. Starting in the mid 1980s, just as the Finns were consolidating their position in the world paper industry, rising incomes (associated perhaps with changes in information and communications technologies, broke the link in countries at the income level of the US and richer EU member states between increasing purchasing power and increasing consumption of paper.

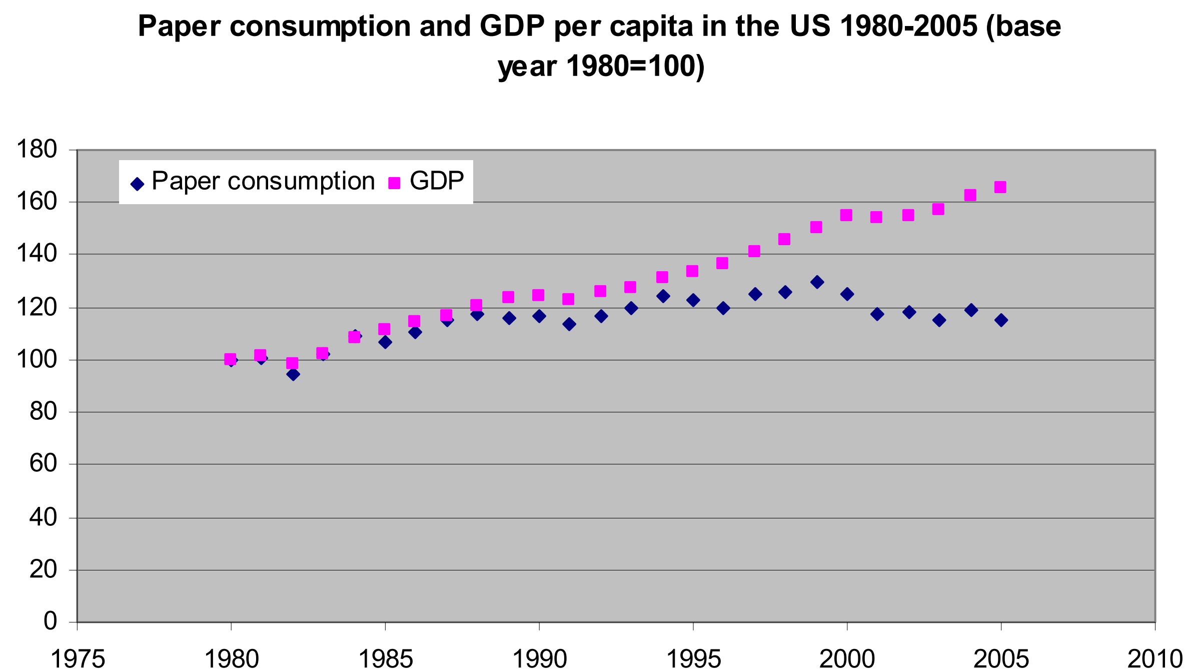


Figure 6. Paper consumption and GDP per capita

The response to this stagnation of markets, as noted above, has been rationalization of facilities in core countries and a drive to locate production pulp production near cheap sources of fiber and paper-making in fast-growing, emerging markets. Much of this involves the application, with appropriate updates, of existing technology rather than innovation. Indeed, in the case of pulp production the strategy is a return to the road not taken: Finnish firms are building, especially in Latin America, precisely the kinds of integrated facilities which the Swedes were building at the high noon of their failed venture in mass production.

In Uruguay, for instance, Metsä-Botnia began building a pulp mill in the city of Fray Bentos in 2006. The mill will eventually produce one million ton per year of high-quality bleached hardwood pulp for export to Europe, Asia and North America. To supply a substantial part of the 3.5 million cubic meters of pulpwood that the mill will require annually Metsä-Botnia acquired plantations from Royal Dutch/Shell and a Uruguayan wood trading company. Stora Enso has likewise been buying land and plantations in Uruguay. It aims to plant about 100,000 hectares with eucalyptus and pine, so as to feed a pulp mill to be built near the Baigorria Dam, with an annual production capacity of about one million tons. (Snoek et al, 2007, p. 71) So far, at least, this and related returns to familiar strategies have not produced the desired results. The Finnish paper companies' return on capital has been declining in recent years (see Figure 7)

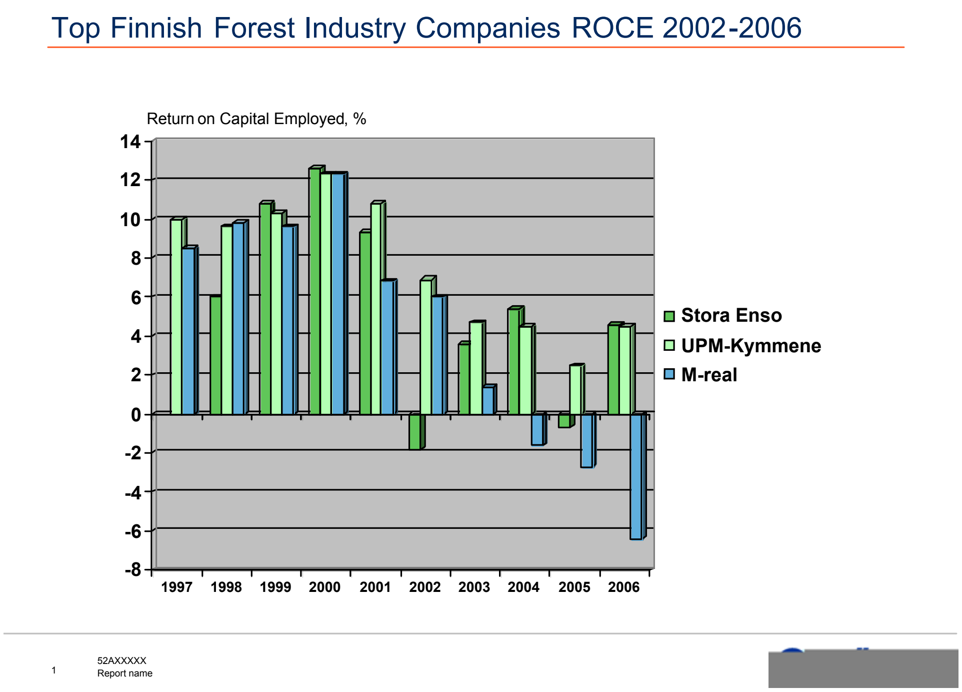


Figure 7. Top Finnish Forest Industry Companies

And its results show no better in comparison with the returns to major international competitors, see Figure 8.[7]

[7] The pulp and paper industry gets bad financial press. Noting that the industry had underperformed in 20 of the past 31 years, the Financial Times quipped that one way to beat the market was simply to avoid the sector entirely. See FT, May 30 2005.

Return on Capital Employed (ROCE) of Major Forest Industry Companies 1997-2006

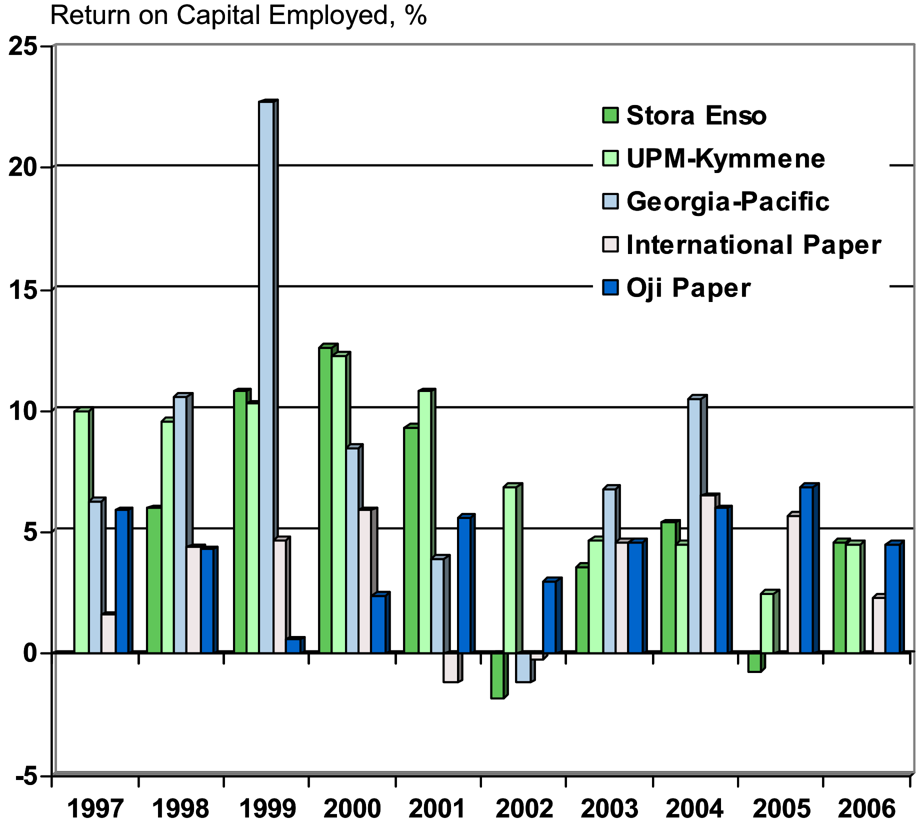


Figure 8. Return on Capital Employed of Major Forest Industry Companies 1997-2006.

Not surprisingly, investment levels have fallen. Indeed capital expenditures in the pulp and paper industry have fallen below the level needed to offset depreciation, and the gap has been growing at an increasing rate since 1998 (see Figure 9).

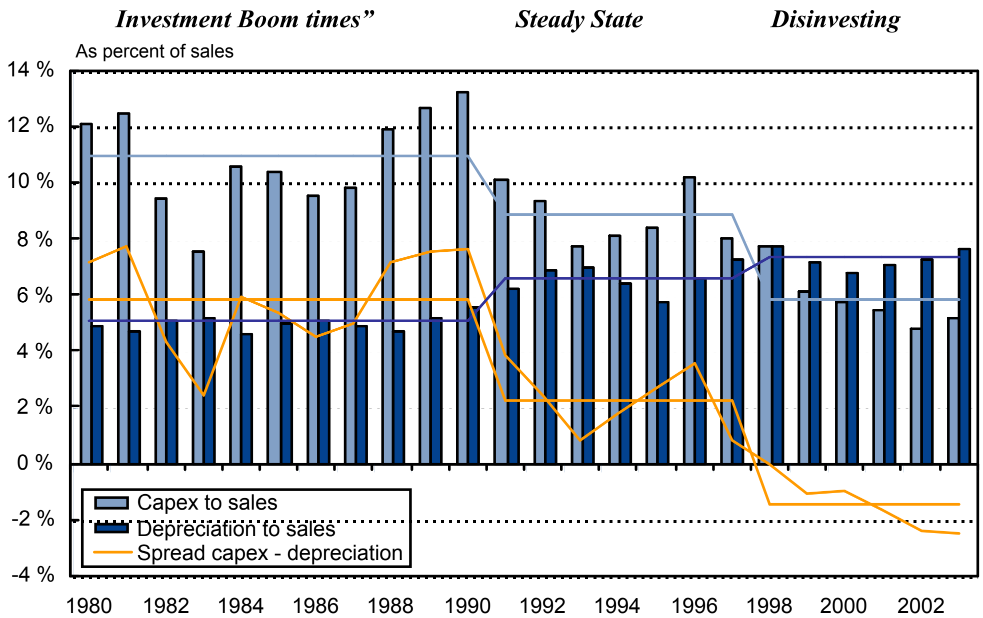


Figure 9. Capital Expenditure Falls as Investment Needs Rise in the Pulp and Paper Industry after 1998

Hence the paradox of the current situation: The world's leading pulp and paper industry seems unable to outpace its competitors—indeed unable to find a strategy that will amount to more, in time, than a graceful exit from the sector it dominates. But this can't possibly be the whole story. The innovative capacity and sheer know how built up over a century can't have been dissipated by a decade of success. It is only common sense to suspect that somewhere within the industry those who made it what it is, or their heirs, must have projects that put the industry's extraordinary capacities to productive use. But, assuming that common sense is, this time, right, what are those projects? And how, crucially, can their advocates be connected in ways that allow them to test their ideas and learn enough from their failures to produce a new generation of successes? In chapter 4 we begin to explore these questions. But first we show how Nokia, the other pillar of the Finnish economy, starting from different conditions, and enjoying, for now, more florid times than the forestry products industry, nonetheless is likely to face similar problems.

3 THE INFORMATION AND COMMUNICATION TECHNOLOGY SECTOR

The information and communications technology (ICT) sector led Finland's transition during the 1990s from a resource based-economy that relied on exports of forest products and machinery into a wealthier and more globally integrated information economy. As recently as 1980 the Finnish economy depended primarily on forest products; by 2005 ICT-related industries accounted for close to 10% of GDP and over 20% of exports; domestic companies were international leaders in mobile phones, telecommunications equipment, and web-based media and services. Its best know brands, Nokia and Linux, were recognized worldwide as innovators in product design and organization. Indeed while the forest products industry faced immediate challenges, Finland's ICT cluster appeared invulnerable.

Nokia is the flagship of the Finnish ICT sector, which boasts some 6,000 firms, a majority of which are focused on telecommunication markets. Finland's, and Nokia's, leadership of the world mobile phone industry is remarkable. In less than a decade, Nokia transformed itself from a paper, rubber, and cable conglomerate into an extremely efficient producer of handsets and equipment for wireless communications. The firm's user-friendly designs and logistical excellence have contributed to a steadily growing share of global mobile communications markets, which reached 40% in 2008.

The early history of Finland's telecommunications industry is distinctive in two ways. First, the industry grew out of telephony, and later radio engineering rather than equipment manufacturing. Second, its trajectory was shaped by a highly decentralized and competitive market for most of the 20th century. Like the forest products industry, the sector benefited from extensive financial support from the state as well as from horizontal collaboration, both formal and informal, between public research institutes, state technology agencies, universities and colleges, and private firms. At the same time, Nordic collaboration in development of a mobile telephone network during the 1970s and 1980s helped move Finland to the leading edge of mobile communication technologies.

Also like the forest products industry, however, Nokia and the ICT sector demonstrate vulnerabilities. Nokia's success in world markets, celebrated in the late 1990s and early 2000s, is viewed with growing anxiety today. Not only does the firm dominate the domestic ICT sector, but today it also dominates the national economy, accounting for 21% of exports and up to 60% of the market valuation of the Helsinki stock exchange. With a handful of exceptions (the operator Elisa and a couple of smaller software and service companies) other domestic ICT firms are struggling. While Nokia's margins and market share continue to increase, virtually all of its new investments are located outside of Finland. In 2006 63% of the company's 65,324 employees worldwide were outside of Finland; in 2002 more than one-third of total R&D spending was outside the country; and lead suppliers continued to closed or down-size domestic operations in favor of lower cost locations. At the same time, the level of entrepreneurial or corporate spin-off activity in Finland remains below that in most advanced economies, leaving few external sources of new growth or innovation.

This trend is likely to continue as long as Nokia remains committed to the strategy that brought it immense success in the past: expanding scale and optimizing manufacturing efficiencies to cut costs. The firm's current focus on growing market share and ramping up production capabilities in emerging economies like India and China extends this model on an international scale; however it coexists uneasily with a simultaneous commitment to serving all segments of the mobile device market, including exploration of innovative opportunities for high-value added services and software as the mobile phone becomes a platform for sophisticated computing and web applications, as well as communication.

The following figures illustrate Nokia's geographical shift from 2000-2006. The total net sales of the company have grown by over 30% within five years: from 31 billion EUR in 2001 to 41 billion EUR in 2006. At the same time new markets in Asia-Pacific and in the Middle East and Africa have gained importance as can be seen in Figure 10.

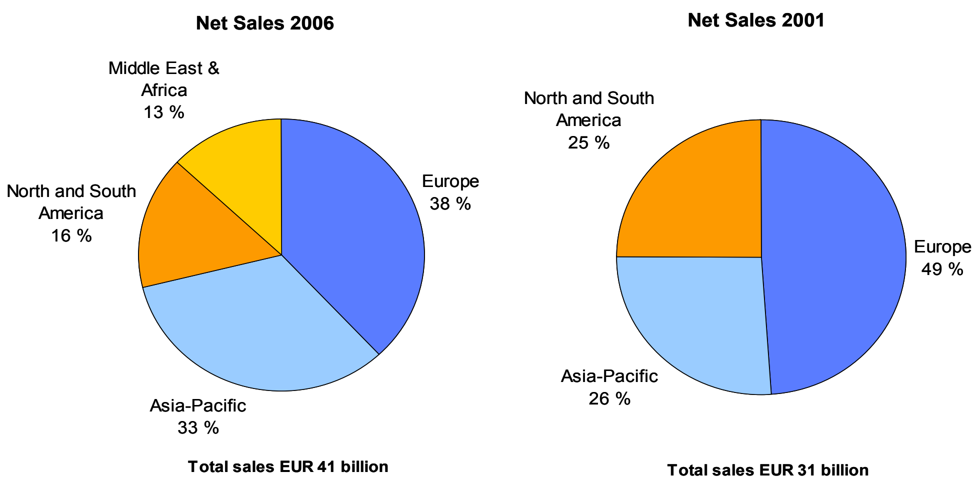


Figure 10. Geographical Distribution of Nokia Net Sales in 2001 and 2006

The development of net sales from 2002 to 2006 is shown in Figure 11. China and India are the largest and the fastest growing markets, while the US market continued to decline.

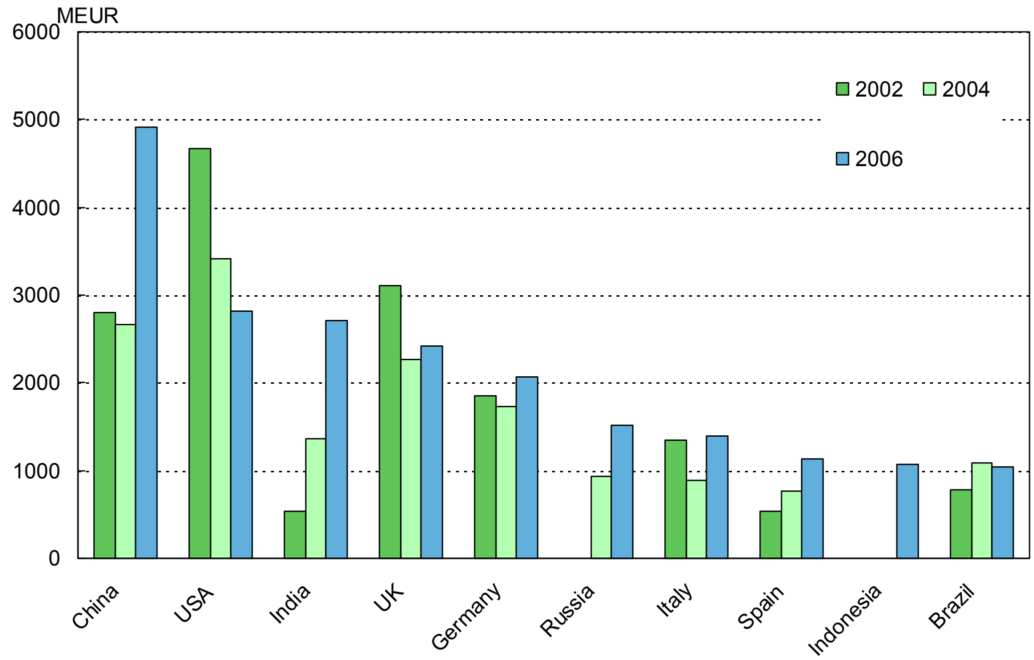


Figure 11. Nokia net sales in main markets 2002, 2004 and 2006 (millions of euros)

Figure 12 shows the growth of Nokia's employment outside of Finland. Employment growth in this period was concentrated in low cost locations which were also its fastest growing markets. By 2006 China and India were the largest centers of Nokia employment outside of Finland. Figure 13 illustrates the shift of employment to locations outside of Finland since 2000.

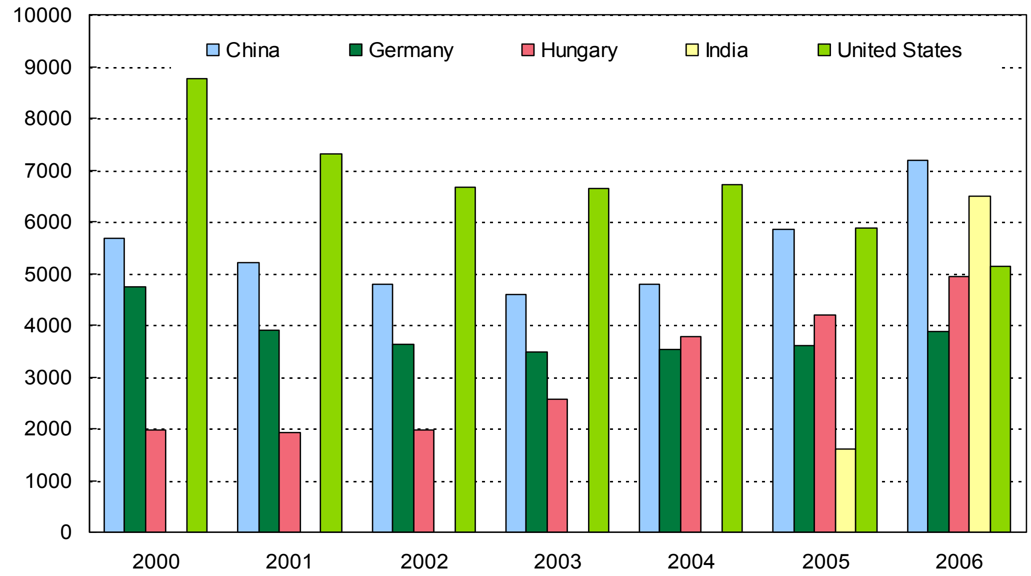


Figure 12. Number of employees of Nokia main countries (Top 5 in 2006) outside Finland 2000-2006

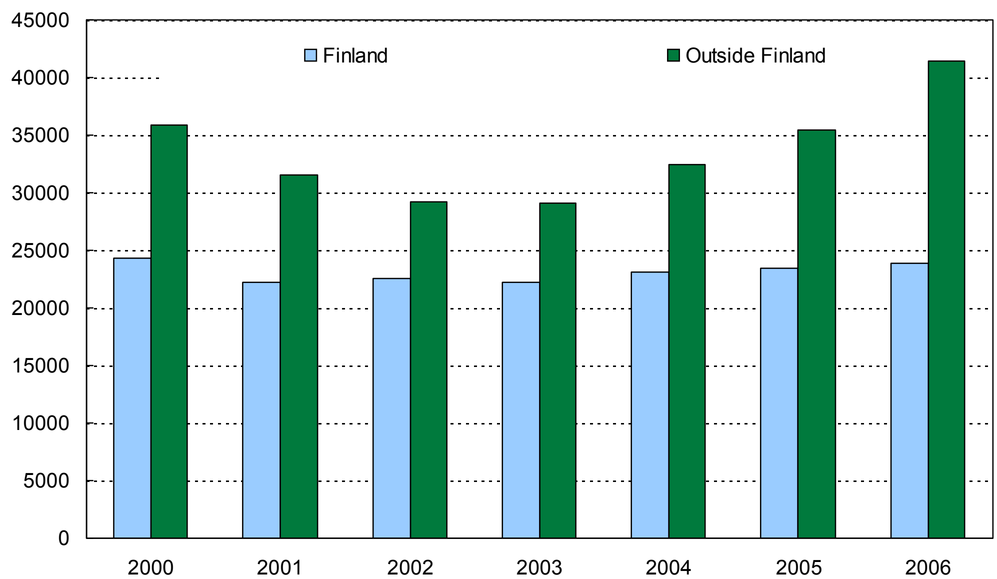


Figure 13. Number of employees of Nokia: Finland vs. the rest of the world

The technological capabilities and infrastructure for Finland's current success in wireless communications, and ICT more broadly, originated to the 19th century. The sector's development divides into four major periods. During the first phase (section 1.1), which lasted through the 1960s, Finland accumulated technical expertise and skills in radio and telephony through an uncoordinated but informally linked activities of public agencies, private firms, research institutes, and universities, as well as enthusiastic hobbyists.

In the second phase (section 1.2), the 1970s and 1980s, the Finnish state invested heavily in development of domestic technology and production capabilities in mobile and digital communications by funding collaborative research among private enterprises, public agencies, and universities, in areas such as digital switching; by targeting technologically-demanding government procurement to domestic firms; and by expanding university degree programs in electronics and information technology to meet the fast growing demand. Finnish firms, particularly Nokia, benefited from this capability building as well from the collaboration among Scandinavian post and telegraph administrators in pioneering cross-border Nordic mobile telephone (NMT) network, and later the GSM standard for telecommunications.

The third era (section 1.3) began with the collapse of the Soviet Union in the early 1990s and recession in Europe, which triggered a national economic crisis in Finland. National political and economic institutions were transformed as the old state-bank led industrial policy system collapsed. The influential new Science and Technology Policy Council (STPC), an elite group of business leaders, university administrators, top policy makers, and union representatives, set the agenda for ICT-led growth and a "national innovation system." In addition to financial and trade liberalization and the deregulation of telecommunications, the STPC authorized substantial increases in funding of national R&D and higher education institutions. While crisis was particularly severe for Nokia, which in 1992 began divesting all of its other businesses in order to focus on mobile communications, by the end of the decade, Finland--with Nokia in the lead—emerged as the world's leading center for wireless communications equipment and handset manufacturing.

In the fourth and most recent period (section 1.4), Nokia's dominance of the Finnish economy has grown, but its connections to local firms and institutions also diminished. Ramping up manufacturing on a scale previously unknown in Finnish industry, and developing a sophisticated planning and logistics system made Nokia the most cost-effective mobile phone producer in the world. The firm now dominates markets not only in the advanced world but also in emerging markets such as India. However a focus on manufacturing scale and optimization has undermined the domestic ecosystem for ICT-related experimentation; it also fits uneasily with the company's need to monitor and anticipate potentially disruptive external technological and market changes in a dynamic industry.
The final section (1.5) engages the work of Nokia insiders, Yves Doz and Mikko Kosonen. We compare our own, less optimistic, account of Nokia's current situation to their view of the firm's ability to adapt successfully through the strategic agility of the core team of top managers.

3.1 Early Capability Building: Pre-1970

Communication was central to Finland's military efforts in the 18th and 19th centuries because the nation had been dominated for centuries, first by the King of Sweden, and then by the Russian Empire. This may help explain why Finland established domestic telephone service in 1877 just a year after Alexander Graham Bell patented the device.

3.1.1 Decentralized telephone networks

The structure of Finland's telephone network was, from its origins, highly decentralized. In 1886 the Senate, seeking to prevent strict controls of the sort that imperial Russian had established over the telegraph industry, passed a statute mandating that the telephone network remain locally owned and controlled. The state granted these licenses so liberally that by 1900 there were 50 private telephone operators in Finland, in 1910 there were 250, and by 1938 there were 815—with each operator typically exercising a local monopoly.

The Finnish market for telephone equipment was also kept open to foreign manufacturers, in contrast with the protected national monopolies in France, German, and Sweden at the time. By the late 1880s there were already four competing telephone manufacturers in Finland, including Bell, Ericsson, and Siemens. This insured that while local equipment manufacturing was still weak, local operators had access to the most advanced technologies. It also created competitive pressure for the emerging domestic manufacturers and insured that their customers (the operators) remained technically demanding and were capable of integrating competing suppliers' equipment into their systems.

Following Finnish independence, a public telephone operator (PTO) was established and there were several efforts to nationalize the communications network. However the small private telephone operators retained ownership and control over local networks, in part by mobilizing the Association of Telephone Companies (ATC) in 1921 to protect their interests. The ATC became a powerful opponent to the public carrier.

The structure of the Finnish telephone industry thus remained unique in Europe, with a large number of private firms operating local networks, and a monopoly carrier only in the national trunk and long distance networks. This multi-operator market structure, and the 'creative' tension between the PTO and the ATC, shaped the pace and direction of development of the Finnish telecommunications industries.

The PTO used its regulatory authority in the early decades of network building to acquire poorly performing private operators. This threat stimulated competition and technical upgrading of the private network, even though there was no direct competition because each operator held a local monopoly. The PTO acquired the equipment of some 170 telephone companies between 1920 and 1949; it also invested heavily in repair and reconstruction of the communications infrastructure in the aftermath of WWII. The private firm, Finnish Cable Works (later the cable division of Nokia) expanded and began its early diversification into electronics in this era.

Although the PTO was the largest and most powerful network operator in Finland it was forced to be entrepreneurial and technically competent in order to work with the hundreds of independent private operators and to manage ongoing conflicts over interconnections and tariffs. The private operators closely monitored local users' needs and regularly demanded new and upgraded services and technology. At the same time, the PTO, as the lead procurer, encouraged competition among the equipment manufacturers, thus helping to keep equipment costs low.[8]

In 1932 the PTO established an R&D laboratory and invested in research on switching and transmission technologies. The lab gradually expanded its activities from pure research into the development and testing of switching systems—and eventually would facilitate the transition in the 1960s from electromechanical to electronic switches. Investments in research on automation of long distance traffic starting in the 1950s were aimed at improving the

[8] Palmberg (2002) refers to the PTO as a "competent technology procurer" and "lead user" which identified the most competitive technology pathways and invested accordingly. He attributes Nokia's subsequent innovative capabilities and global success to earlier interactions with, and R&D investments by, the PTO.

technical quality of local networks by setting increasingly stringent requirements. This triggered another wave of investment and consolidation, with the PTO and some of the largest operators purchasing networks of smaller companies. By the mid-1960s there were only 88 telephone companies in Finland (and the number fell to 61 in the 1980s.)

3.1.2 An entrepreneurial radio-telephone industry

Radio technology remained a relatively marginal activity in Finland and received little support from the research establishment until the 1960s. Nevertheless, a university professorship was established in radio engineering at Helsinki University of Technology in 1924 and the Ministry of Defence established a Radio Laboratory in 1925.[9] There were also groups of radio engineers in the State Railways and the General Military Staff, as well as in the PTO's radio department. These groups ultimately provided the basis for an entrepreneurial "radio telephone" industry, fuelled in part by a large army contract for radio phones in 1963, with two leading firms: Salora (est.1945, a consumer electronics firm) and Finnish Cable Works (est. 1917, focused on cables but starting to diversify into electronics.)

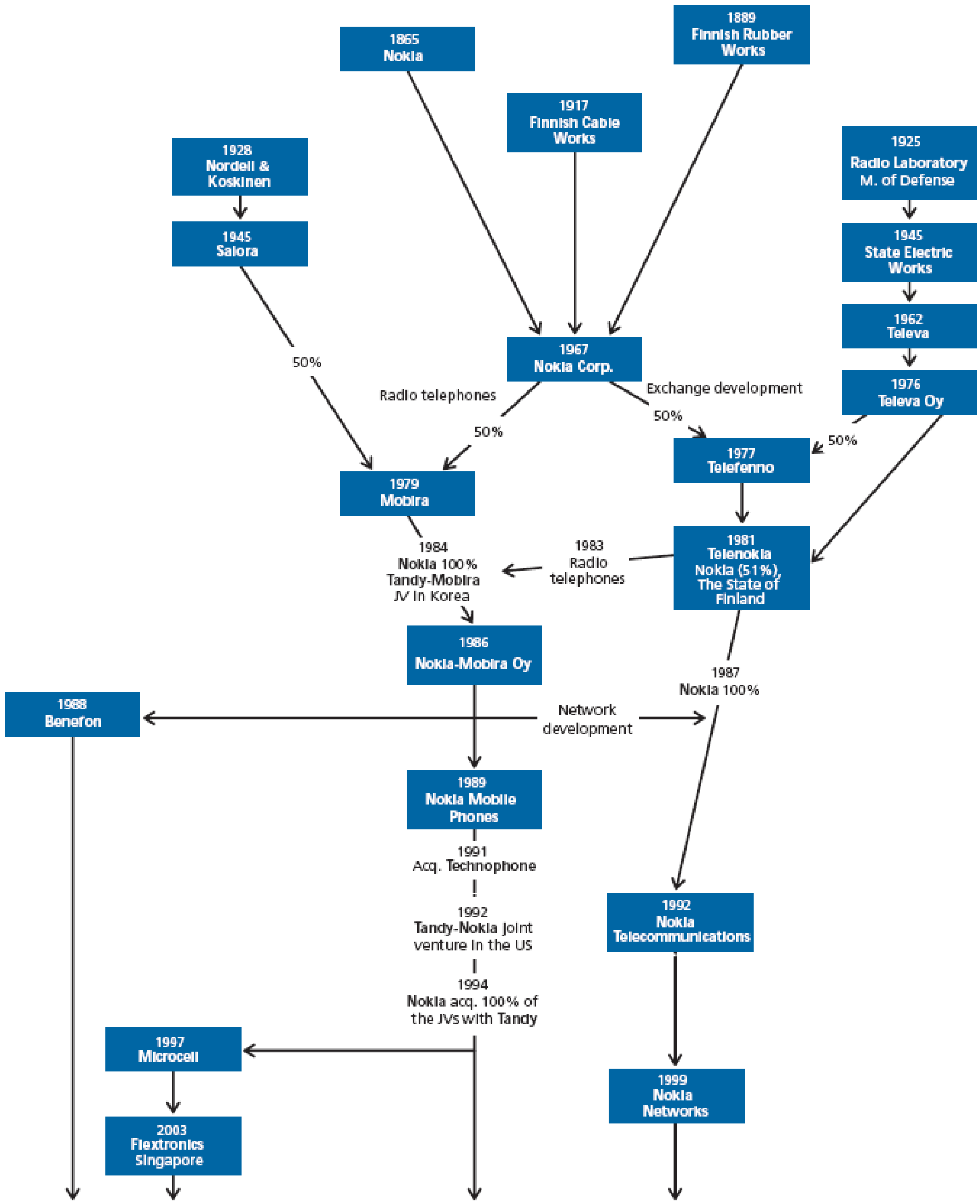
Finland also introduced a nation-wide radiotelephone service, the Auto Radio Puhelin network (Car Radio Telephone) in 1971, a forerunner to the Nordic Mobile Telephone network. The ARP relied on soon-to-be outdated analogue switching, but provided experience with customer interfaces for the main suppliers of terminals and network equipment in Finland, including Nokia, Salora, and Televa. As forerunners of mobile phones, radiotelephones also demonstrated the commercial potential for mobile services.

[9] The Radio Laboratory was absorbed by the State Electric Works in 1945, and in 1962 it was renamed Televa—but remained state-owned. Televa, with its roots in military research, was to become a key source of digital switching technology in the 1980s.

By the end of the 1960s an informal scientific and engineering community was emerging in Finland that would lead the development of digital communications technology. This network included radio engineers (from the military and the railroads), the early radio telephone entrepreneurs, engineers working for the telcos and other private enterprises, and researchers from Finnish technical universities and government labs—the PTO R&D lab as well as the Technical Research Center of Finland (VTT), which was founded in 1941 to undertake research commissioned by public or private sector groups.

The Nokia Corporation was formed in 1967 through the merger of Finnish Cableworks, Finnish Rubberworks (est.1889), and Nokia (a forest products company, est.1865.) See Figure 14. While it was an unwieldy conglomerate, this marked the firm's entry into telecommunications. In subsequent decades Nokia would build on the core knowledge from the cable company's electronics department. The electronics group thus began research on digital transmission and pulse code modulation (PCM) in the 1960s and, in 1969, delivered its first PCM-based digital data transmission system to the PTO—the first of its kind in the world. Nokia also worked with Helsinki telephone operator and the State Railways to develop systems for their uses. Nokia's first exports of digital transmission systems were to the Soviet Union, which quickly became an important market for the firm.

The relationship between the leaders of the emerging telecommunications industry and the political elite of Finland was extremely close in this era. The CEO of Nokia at the time of the merger, Bjorn Westerlund, actively cultivated his ties to President Kekkonen. Not only did Nokia need state approval for its consolidation of the electronics industry, but the firm was still dependent upon the state-owned banks, KOP and SYP. The President also oversaw trade with the Soviet Union, which was an importer of both cables and electronics. In the words of CEO Westerlund: "First one must take care of politics, and only then industrial matters" (Jakobson, 2001b.)



Source: Derived by the authors from an earlier version by Palja (2001, p. 25).

Figure 14. Evolution of the Finnish Mobile Communications Industry 1865-2003; Source: Rouvinen and Yla Anttila, 2004, p. 95.

3.2 State-Supported Resource Mobilization: 1970s and 1980s

Nokia emerged as a player in the telecommunications industry in 1991 when it supplied the equipment for the first digital cellular mobile system, and a year later commercialized the first fully specified GSM mobile phone. The transition from a national forest-products conglomerate to a global telecom equipment firm was enabled by the technological discontinuity that accompanied the transition from the 1st generation analogue cellular telecom standard (NMT) to the 2nd generation GSM digital cellular standard—a transition which Nokia both contributed to and benefitted from. The technological competences for this shift were mobilized in Finland during the 1970s and 1980s through a series of loosely connected publicly as well as privately-funded research initiatives involving Finnish technical universities, state-owned and private radiotelephone and electronics-related firms, public research institutes, local telecom operators and the PTT.

The convergence of computing and telephony in the late 1960s intensified tensions between the PTO and the private operators, with both claiming data communications as their domain: private companies saw data as a telephone service because it was transmitted on telephone networks, while the PTO argued that data communication was an advanced form of telegraphy and hence subject to telegraph legislation. The conflict was resolved in 1970 with a compromise that gave both the PTO and the private operators the right to compete in data communication. This rapid resolution opened the way for progress in the development of data communication services; it also foreshadowed Finland's early liberalization of telecommunications.

The threat of nationalization of the electronics industry remained a real concern for Nokia into the 1970s. The firm began collaborating with the state-owned radio-phone company, Televa (formerly the State Electrical Works) in the early 1970s to build a national digital telephone network, but at the same time the

Social Democratic Prime Minister Kalevi Sorsa led the formation of a new, state-owned cathode-ray tube plant, Valco, with the goal of mass-producing television screens. Nokia's fears were only eliminated for good when the venture went bankrupt in competition with Japan, and Sorsa was exposed for taking bribes in the "Valco scandal."

3.2.1 Public investment and capability building

The public sector invested actively in building domestic capabilities during the 1970s and 1980s. The Ministry of Trade and Industry funded a variety of pre-competitive collaborative research initiatives, the PTO stimulated demand through procurement of leading edge telecom products, and the Department of Education expanded university-level education and research activities in electronics and information technology.

These public activities were not part of a coordinated plan, nor were they particularly large in scale. The value of public R&D funding was, according to participating, mainly in legitimating, leveraging, and complementing private sector activities. The dominance of private over public R&D funding is clear in data from 1975, which finds that the equipment firms—Siemens, Ericsson, and Alcatel along with Nokia—accounted for 60 percent of total R&D conducted in the Finnish telecom sector, compared to 20 percent from the PTT, 8 percent from universities, 6 percent from private telecom operators, and 6 percent from the VTT, 6%. [10]

Perhaps most significant, the state contributed to the mobilization of a domestic network of skill and knowledge with expertise in the range of technical challenges associated with the shift from analogue to digital communication. These included development of digital signal processing hardware and software, mobility and

[10] Cited in Palmberg and Marikainen, 2003.

roaming capabilities, integration of voice and data services, digital switching systems, and (extremely complex) software for the operations support system (OSS) as well as for digital signaling, control, application and user interfaces, etc. Participants in these activities came from Nokia Electronics, the public research labs (PTO and VTT), the state-owned electronics firm, Televa, the technical universities, and some of the larger operators (such as Helsinki and Tampere.) The PTO played the critical early role of transferring digital technology to Finland; and the later participation of the PTO and local firms in Nordic collaborations developing the NMT mobile system further enhanced Finnish capabilities.

Nokia, recognizing that longer term growth with cables and tires was limited, diversified into electronics and telecommunications in this period. They were well positioned to tap Finland's rich infrastructure of radio and telephone as well as digital switching expertise. In 1977 Nokia Electronics and the state-owned Televa created a 50-50 R&D joint venture called Telefonno to focus on applications of digital technology and the ISDN standard in switching systems. In 1979 Nokia brought its knowledge of switching technology and data modems to a collaborative venture with Salora, the leading supplier of radiotelephones for ARP. Nokia Electronics and Salora eventually formed an entrepreneurial company called Mobira (also a 50-50 joint venture) that was charged with development of mobile terminals and base stations for the NMT. Mobira already had a strong market position in the Nordic radiotelephone market that allowed it to play a central role in identifying new business opportunities and initiating R&D projects with Nokia as well as with the VTT and technical universities.

The PTO's importance as a technologically sophisticated lead user was evident in this period. It had the financial ability that the smaller operators lacked to support risky and pricey projects like development of a large-scale digital telephone switching system; it also had competence in this area through participation in research consortia as well as close ties to the main suppliers of these systems, Televa and Nokia. The PTO also became a carrier of the competences related to NMT and later GSM specifications for cellular systems, as well as disseminating the business opportunities related to these standards.

Televa developed a first generation completely digital switching system for fixed networks, the DX200, in the 1970s—at a time when the leading equipment manufacturers, Siemens and Ericsson, were producing only analogue systems.[11] By 1980, more than one-third of PTO operated networks in Finland used DX200 equipment from Televa and Nokia (compared to only 2% of the networks operated by the private telcos.) The PTT's large-scale equipment orders provided an important opportunity for the firms in this new, fringe market to interact with customers and to continue improving the system. No doubt the PTT also sought to avoid dependence on the oligopoly of foreign incumbent equipment suppliers.

3.2.2 The rise of Nordic collaboration

The Nordic Telecommunications Conference (NTC) initiated research collaborations on a cross-border mobile telephone system, the Nordiska Mobil Telefongruppen (NMT) in 1969. The NMT was designed by the national telecom operators as a fully automatic, cellular system with equipment compatibility between Nordic countries, the capacity for mobile-to-mobile calls, reliability and durability, low cost infrastructure and handsets, privacy protection, and open standard specifications. Success in the initial collaborations led the Nordic Conference to recommend in 1975 that member countries commit to building the new network. The project consolidated the competences related to cellular networks on a Nordic level, facilitating knowledge sharing between the region's equipment firms (including Nokia) and the national PTOs.

[11] The idea of digital switching systems met resistance within these firms as well. In the 1960s when Televa was still making analog switches, an engineer began experimenting with microprocessor-based switches, but faced significant opposition and had difficulty getting funding internally until 1973 when he got a contract for delivery in 1979 of a digital system to a very small Finnish community with only 100 subscribers. Televa subsequently committed resources to the project and it was delivered on time. The DX200 remains a key component in Nokia's networks.

Sweden and Finland were the first commercial service providers for the NMT when it was completed in 1981. The 450MHz system was estimated to provide triple the capacity of a manual system. As the first and largest cross-national cellular network in the world, the NMT established the first-generation cellular standard, and provided Nordic nations with an important first-mover advantage. (The early diffusion of US cellular network standards was hampered by the Federal Communications Commission, which sought to assign radio-frequencies to television.) Commercial introduction of the NMT triggered a wave of industry growth, with the NTC promoting technical compatibility and competition between manufacturers in order to reduce costs. The service proved popular and quickly diffused internationally, creating a large and growing market—and significant business opportunities for industry leaders, Nokia and Ericsson.[12]

In 1982, led by the Nordic countries and the Netherlands, the European Conference of Postal and Telecommunications Administrations formed the Group Special Mobile (GSM) to serve as a standards group for Europe's digital radio and telephone systems. The Nordic Telecom Conference, with Nokia and Finland's PTO as major actors, played a leading role both in establishing the GSM standards group and in designing the pan-European mobile network that would emerge in the early 1990s.

3.2.3 Commercialization of technology

The Finnish Technology Agency, Tekes, was formed in 1983 to finance research and technological development, taking responsibility for public funding of R&D over from the Ministry of Trade and Industry. Tekes provided funds directly to Finnish research institutes, universities, and firms; and it also provided incentives

[12] The GSM standard allowed mass production of equipment which drove down the cost of handsets as well as network infrastructure. Use of the same technical standard on neighbouring frequencies (licensed by different operators) also reduced the chance of interference, as the standard incorporates limits on broadcast power as well as interference-avoidance techniques.

for research collaboration between private and public sector organizations. The formation of Tekes thus marked the start of an era of continuous growth of R&D as share of GDP in Finland: in 1984 the Tekes budget was less than 50 million Euros; by 2004 it had increased to over 400 million Euros, and accounted for about 28 percent of the government's total R&D budget. Total R&D expenditures in Finland increased more than five-fold between 1984 and 2004 (Figure 15.)

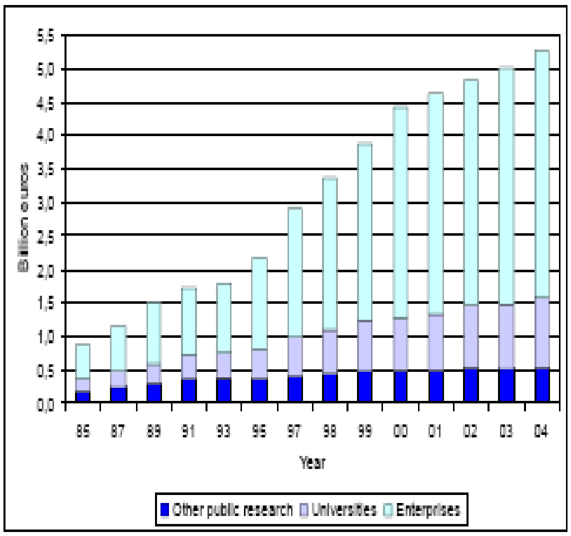


Figure 15. Total domestic R&D expenditure in Finland, 1985-2004 (billion Euro)

Tekes funding was central to the transformation of research on digital technology into industrial applications in this period. In 1984, for example, Tekes funded FINPRIT, a large scale four-year project aimed at raising competence levels in hardware and software applications, and integrating different subsystems' data content and communication capabilities. While FINPRIT was primarily funded by Tekes, about 30 percent of the financing came from research institutes like VTT, technical universities, as well as private industry (including Nokia.) Nokia in turn actively recruited the top university and VTT researchers from projects like FINPRIT to work in their research lab.

Finland’s telecommunications industry, and Nokia in particular, benefited directly from the establishment of Tekes. An average of 40% of research expenditure in Finland during the 1980s and 1990s was directed to ICT and mobile technology related projects (Lesser, 2008, p. 21). Tekes funds alone accounted on average for 8 percent of Nokia’s total R&D expenditures between 1980 and 1995, however this proportion ranged from a high of 26.3% in 1980 and 14.5% in 1981 to 1.8% in 1985 (Ali-Yrkko and Hermans, 2002.) And while government funding did not amount to a large proportion of Nokia’s total R&D spending over the long term, many of the largest Tekes projects in these years were tailored to Nokia’s needs, including the development of the digital call center system, GSM technology, and software tools and protocols. This suggests that public funding had strategic and long-term impacts on Nokia’s growth. Tekes financing also contributed to insuring the continuity of research activities at Nokia Research Center during the most economically difficult recession years of the early 1990s (Haikio 2001, p. 96).

In essence, Tekes became the source of national technology policy for Finland, and Nokia was a (if not the) leading beneficiary. The close connection between the two is reflected in the decision by the first Tekes director, Dr. Juhani Kuusi, to become head of the Nokia Research Center in 1995. The close relationship also benefitted the domestic economy in this period. The rapid growth in private R&D spending in the 1980s and 1990s was attributable primarily to Nokia’s investments (Dahlman, et. al. 2005.) By 2003 Nokia accounted for one-third of Finland’s gross expenditures on R&D and 47 percent of total private sector R&D spending (Lesser, 2008, p. 21)

The technical universities in Finland, such as Helsinki University of Technology and the University of Oulu, were major participants in the digitization and software development research and education in this period—and became core clusters of specialized technical skill, know how, and research activity in this period. Helsinki University of Technology, which already had programs in transmission and radio technology from the 1960s, began work on cellular and digital radio technology in the late 1970s, and later introduced research in compiler theory, protocol design languages and concurrency models. Located in Espoo, in the immediate suburbs of Helsinki, HUT was conveniently located near Nokia's research headquarters.

The University of Oulu in turn anchored a cluster of embedded and DSP-software competences that were critical to the subsequent success of GSM-related projects. Oulu University began electronics education and research in the late 1960s, introducing microprocessor technology and system software development methodologies. In 1971 the VTT Electronics Lab was also founded in the city of Oulu to strengthen the local education and research milieu. Over time the lab specialized in embedded computer control and software design; it also contracted projects to industry and provided training to local firms in topics such as low-power consumption microprocessor software. The Lab also established significant joint R&D programs, one in Computer Aided Design and printed circuit board design, and one on the Software Engineering Environment. In the late 1970s Mobira (the Salora-Nokia joint venture) located its R&D on base stations, embedded controls, and mobile switching software in proximity to Oulu University and VTT Lab. Mobira and later Nokia in turn actively recruited talented engineers from the VTT and Oulu University to their R&D lab.

3.2.4 Nokia's expansion

Nokia transformed itself into a technology conglomerate during the 1980s. The firm absorbed much of Finland's telecommunications know how, as well as several foreign consumer electronics firms, with an aggressive merger and acquisition strategy. In 1981 it acquired a majority share (51%) of Telefonno (the Nokia-Telera JV) leaving the state of Finland with 49% in the new firm, Telenokia. In the following year, 1982, Telenokia commercialized Europe's first fully digital telephone exchange based on the DX200 system. The main evolution was finished in 1986 when the system was adapted to support ISDN.

The development of the DX200 system was, according to Palmberg (2002) “one of the biggest R&D projects in Finnish history of technology, both in terms of R&D expenditures and man years.” In 1987 Nokia acquired the remaining 49% of Telenokia—forming the basis for the telecommunications network equipment side of Nokia, Nokia Cellular Systems. In 1986 the radio telephone knowledge from Telenokia as well as Mobira’s mobile telephone know-how were joined into Nokia-Mobira Oy, which in 1988 became Nokia Mobile Phones (NMP)—the core of its handset manufacturing side. Nokia Mobile Phones founded a new R&D unit in the city of Tampere, where it collaborated with the Tampere Technical University and the Nokia Research Center to apply, upgrade, and develop interoperability between the different tools (e.g. prototyping and simulation tools.)

The newly configured Nokia was, by the late 1980s, poised to supply a GSM cellular system. A final technical challenge involved achieving interoperability of between subsystems and components as well as finding ways to commercialize the system in export markets. In an alliance with Alcatel and AEG (the ECR900) Nokia developed a GSM simulator that finalized the software and insured inter-operability, hence timely commercialization. Perhaps more importantly, since Nokia already had the requisite technology, the alliance insured access to European markets that were controlled by protectionist domestic PTTs and dominated by a handful of large oligopolistic equipment firms.

Finland exploited the first-mover advantages created by domestic and Nordic investments of the 1970s and 1980s to build the world’s first digital cellular networks. A critical turning point came when Radiolinja Oy, a Finnish consortium of private operators and their main corporate customers, gained a license to develop and service a GSM system. The private operators had been repeatedly rejected in their applications for licenses because the PTO believed that it was a natural monopoly. With the support of lead customers, however, the consortium finally prevailed, and Radiolinja launched the world's first commercial GSM network in 1991. The PTO introduced a competing GSM network in 1992.

The Radiolinja network, which was built with Nokia equipment, served as an important early reference for Nokia in the global GSM market. The success of the Radiolinja's private GSM license application also helped stimulate the subsequent deregulation and liberalization of the Finnish telecommunications market.

3.3 Consolidation and Expansion: 1990-2000

The collapse of Finland's main trading partner, the Soviet Union, along with weak demand in Western markets, resulted in severe recession and very high unemployment in the early 1990s. Nokia, already financially overextended as a result of its foreign acquisitions of the 1980s, almost collapsed as its old-line businesses stopped making money and its TV and computer businesses struggled. Even Nokia Mobile Phones, the industry leader in 1987, lost market share to competitors like Motorola that had more mass production experience. In 1990 the firm had eleven business areas with over thirty separate businesses, yet its market capitalization was under US $1 billion. Nokia's largest shareholder, a bank, tried to sell its stake to Ericsson in 1991, but Ericsson refused.

The Ministry of Transport and Communications continued deregulating the telecoms sector in the early 1990s, reducing its ownership share of the PTO/Telecom Finland. By 1994 Finland boasted one of the most liberalized telecom markets in the world. This was reflected in the world's lowest prices for mobile services, which further accelerated the adoption of mobile telecoms. Four years later Telecom Finland was fully privatized and renamed Sonera, leaving two dominant operators in the market, both private entities: Sonera and Finnet (a consortium of private operators.) Finland's rapid liberalization provided a competitive advantage to domestic firms over their Nordic competitors, whose home markets remained regulated for significantly longer.

3.3.1 The rise of the national system of innovation

The crisis also triggered a shift away from Finland's post-war national policy regime, with its extensive state-ownership and bank-group-based financial and governance system. The new post-1990 regime committed the state to supporting a "national innovation system" through a horizontal, public-private-university collaboration and dialog at the national level. The Science and Technology Policy Council (STPC), which had been formed in 1987 to develop long term goals and systematic coordination of science, technology and innovation policy for Finnish industry, was at the apex of the new national policy-making system.[13]

The prestige of the STPC in this system was reflected in its membership and its position: it was headed by the Prime Minister and given power and status parallel to that of the Cabinet. The STPC included a mixture of private and public sectors members, including eight ministers, ten high-ranking representatives from universities, industry, the Academy of Finland, Tekes, and representatives of peak employee and employers associations. Nokia's managing director typically served as an industry representative on the STPC. The council's role was critical in creating a national consensus on technology policy goals and strategies, and ensuring coordination between the relevant ministries and other actors and stakeholders.

The STPC presided over significant increases in public funding of R&D and continued investment in public education, particularly the university system.

[13] The STPC grew out of the Science Policy Council of the 1960s that focused solely on science policy. The STPC recognized a need for coordination of science and technology policy, thus overcoming the gap between science and industry. Today it even addresses "social" innovation.

Between 1985 and 2004 R&D spending increased by close to 14 percent annually in Finland, compared to an EU average of under 4 percent, with total public and private R&D expenditure as a proportion of GDP reaching 3.5 percent in 2004 (see Figure 16). Finland thus ranks as the OECD country that has spent the highest share of its GDP on R&D after Sweden in the 1990s and 200s. The share of public funding of R&D out of GDP was also very high: 1.01 percent, second only to France, and well above the EU mean of 0.75 percent.

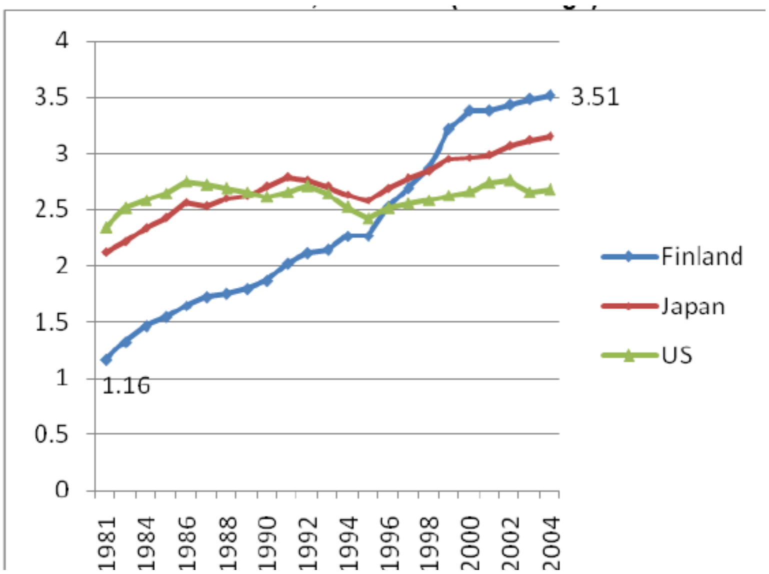


Figure 16. Gross domestic R&D expenditure as share of GDP, 1981-2004 (%)
Source: OECD Main Science and Technology Indicators, 2007.

Higher education (including universities and the newer polytechnics) was expanded dramatically during the 1990s as well. Between 1993 and 1998, the total intake in Finnish universities increased nearly two-fold and in polytechnics nearly three-fold. Programs were also started to focus on information technology-related fields. Total graduates from the top 5 engineering programs at Finnish universities more than doubled between 1986 and 2006, from 1,394 to 2,948, with the top two (Helsinki and Tampere) alone accounting for 73% of total graduates in 2006.[14]

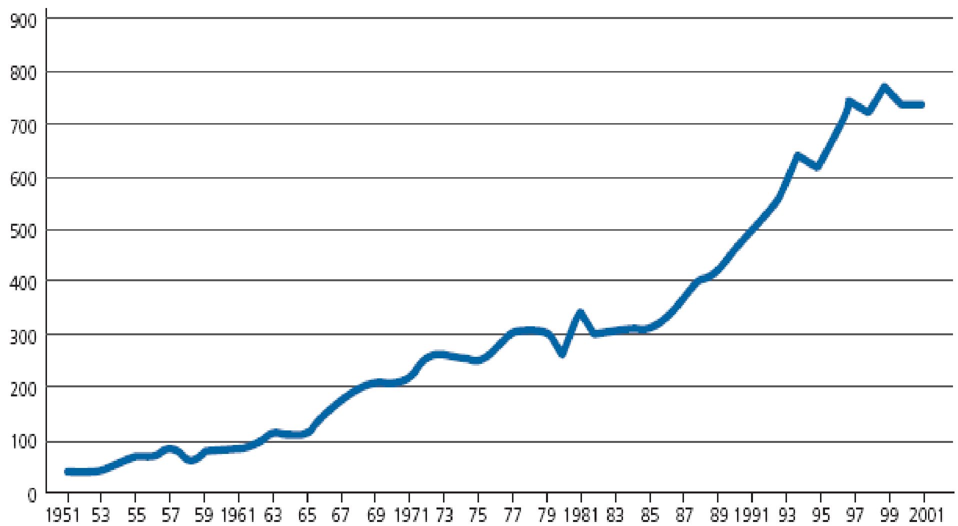


Figure 17. Post-graduate degrees in natural sciences and engineering, Finland, 1951-2001. Source: Rouvinen and Yla-Anttila, 2004, p. 91

The expansion of the public education system in Finland, particularly in scientific and technical areas, along with high levels of unemployment in the 1990s insured that Nokia and the other Finnish ICT firms benefited from ample supplies of relatively low cost, well-educated engineers, scientists, and design talent. Professional (such as engineers) salaries were one-third those in Silicon Valley in the 1990s, in part due to the egalitarian tradition of incomes policy that dictated low national increases in wages and salaries, and in part due to the recession and devaluation of the Finnish currency.

The STPC also encouraged collaboration between public and private sectors, particularly between companies and research institutions at the "cluster" level. The forest industry sector had long relied on horizontal cooperation between

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[14] The top 5 universities include Helsinki Institute of Technology, Tampere University of Technology, Lappeenranta University of Technology, University of Oulu, and Abo Akademi.

companies, their suppliers, research institutes, and universities. In the 1990s the policy was directed toward growing the ICT sector. Close interactions between industry and technical universities contributed to both product and process development, with the boundaries between scientific and industrial R&D blurred by personal relationships and enthusiasm about advancing technology. The public research unit, VTT, with over 3000 employees, pursued projects commissioned by both public and private organizations, and developed and applied its deep expertise in electronics, IT, and automation.

Universities and industry worked closely to define skill requirements and relevant curriculum for training and education, including direct knowledge transfers from industry. Tekes also provided substantial funding for collaboration between universities and polytechnics and Finnish industry in commercializing the results of domestic R&D. These programs encouraging industry-university research collaboration appear to have succeeded: Finland regularly ranks top in the world for technological and research cooperation (Moen & Lilja, 2005.)

By the late 1990s, in part due to early deregulation, Finland boasted the world's highest relative penetration in mobile cellular and internet services, and the Finns were early adopters of technological innovations like data services, chat rooms, short messaging, and so forth. The Finnish mobile, telecommunications, and ICT sector employed some 75,000 workers, and was characterized by rivalry among foreign as well as domestic competitors, rapid new product development, and a sizable number of independent operators. The cluster included equipment manufacturers (Nokia, Ericsson, Benefon), electronics contract manufacturers and component subcontractors (Elcoteq, Perlos, Eimo, JOT Automation), software and new media firms (F-Secure, Satama Interactive), telecom operators (Sonera, Telia, Elisa) and hundreds of others.

3.3.2 Nokia's recovery and breakthrough

Nokia survived the crisis of the early 1990s with an aggressive dismantling and disinvestment of many business sectors—including its forest related activities such as rubber boots, tissue paper, and cable manufacturing, as well as consumer electronics—leaving only telecommunications. This focus on mobile communications may have seemed bold in the early 1990s, but it proved fortuitous. Nokia recognized the potential of the handset as a consumer product earlier than its competitors and in 1992 launched the first mass-produced GSM phone, the Nokia 1011. The speedy diffusion of the second-generation GSM standard further enhanced Nokia's global market advantage in cellular mobile technology.

In the early 1990s Nokia CEO Ollila focused on raising money to support the unprofitable firm's growth in a troubled market. Developing the corporate vision as "telecom-oriented, focused, global, value added" he aggressively shed the remaining cable, paper and rubber divisions, as well as the overextended consumer electronics businesses. Nokia Mobile Phones accounted for a growing share of the Nokia Group sales, rising from 5 percent in 1988 to 43 percent in 1995 and 74 percent in 2001 (Haikio, 2001.) Ollila also raised money (US $3.5 billion) in the US—listing on the NYSE in 1994—which was unheard of in Finland at the time and market the final break with the old domestic system of bank finance and control. It also provided an important international presence for the company.

Nokia's breakthrough insight was to transform the handset into an affordable, mass produced, consumer product. By radically redesigning and reengineering the GSM digital phone Nokia turned the clunky 450 gram Nokia 1011 model into a smaller smooth, rounded device of under 200 grams with a large screen, software based text menu system.[15] The introduction of the 2100 series of phones in late 1993 started Nokia's turnaround. While the goal was to sell

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[15] The old analog models were only barely "mobile"–the Mobira Cityman CD60 (1986) weighed close to 800 grams, and the Mobira Cityman 100 (1990) weighed 450 grams (Häikiö, 2002.)

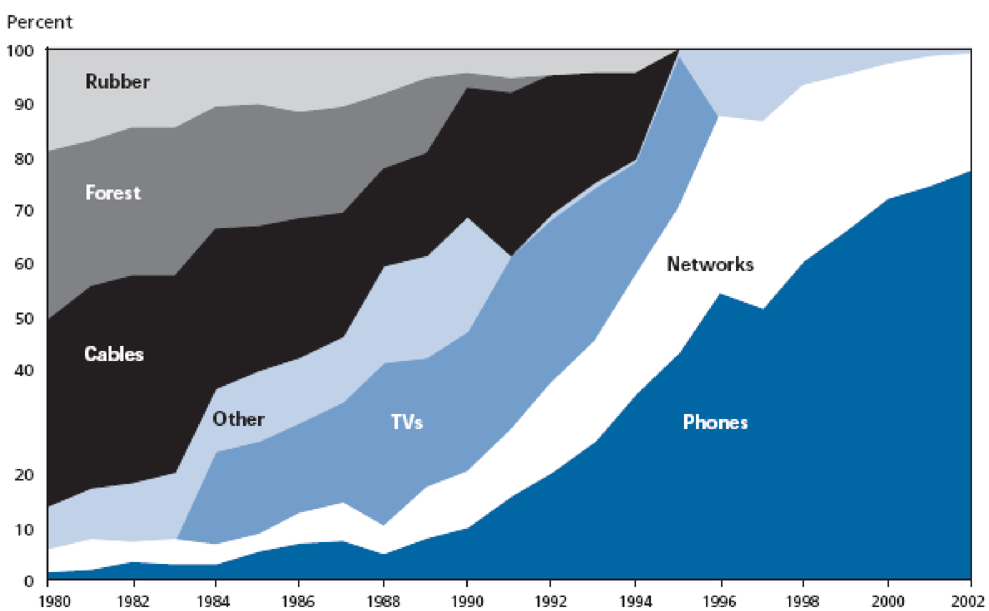
400,000, the firm sold 20 million. Nokia's operating profit went from negative in 1991 to $1 billion in 1995 to almost $4 billion in 1999 (Fox, 2000.)

Recognizing the opportunity to make mobile phones still more customer-friendly, in 1998 Nokia developed the user-friendly interface and design that (re) established its leadership in global mobile phone production. Ollila also focused on developing the Nokia brand by hiring a marketing executive from 3M. By 2000 Nokia was ranked as one of the top ten most valuable brands in the world along with Coca-Cola, Microsoft, IBM, GE, Intel, and Disney—and accounted for close to 30% of world cellular phone market.

Nokia's profits were restored and its share price skyrocketed, but the rapid growth of the 1990s created severe challenges for production and logistics. The output of Nokia Mobile Phones grew from 500,000 units in 1990 to 2.5 million in 1993, then doubled to 5 million in 1994, and doubled again to 11 million in 1995. NMP output reached 128 million units in 2000. While Nokia is unusually secretive and closed to outsiders, it is clear that the firm invested heavily during the 1990s in strong process management, including improving large-scale logistics and production efficiencies to create a highly orchestrated and tightly controlled system of internal planning and production. As a result, productivity, measured by Added Value/Total Wages and Salaries, grew rapidly, from under 1.5 in 1990 to 3.5 in 2000.

The production changes introduced at NMP in the 1990s included significant reductions in inventory, a shrinking of the inventory cycle from 154 to 68 days, reduction of the raw material cycle from 86 to 26 days, and a halving of inventory costs per handset. New production goals included reducing the number of parts from 900 to 400 and below 200, cutting production time from 40 minutes to 4 minutes, shrinking production start-up time from 6 months (in early 1990s) to one month, improvement of production yield from 30 percent (in early 1990s) to 90 percent for latest products, improvement of line efficiency from 35 percent to 92 percent, increasing the hourly performance of surface mount pick-and-place machine from 15,000 to 40,000, increase line capacity from 35,000 units (1992) to 110,000 units in 1997, reducing testing time by 30-50 percent using new equipment, and reducing the number of mechanical parts by 20-30 percent (Häikiä, 2002).

By the late 1990s Nokia had emerged as a growth engine for the Finnish ICT cluster, which included firms in equipment, networks and related services (44,000 employees), telecommunications services (17,000 employees), and components and contract manufacturing (10,000 employees.) Nokia's supply chain included an estimated 15,000 Finnish subcontractors—including contract manufacturers, component suppliers, software and product development companies, production equipment suppliers, and service companies—many of which were dependent upon Nokia (Steinbock, 2001.)



Sources: Derived by the authors from an earlier version by Palja (2001, p. 27) with additional data from Häikiö (2001b) and Nokia's annual reports.

Figure 18. Nokia's transformation from a conglomerate to a mobile handset company: sales by industry, 1980-2002. Source: Rouvinen and Yla-Anttila, 2004: 96

The new Nokia was a product not only of the state-led investments of the 1980s, but also of the reconfigured Finnish national innovation system of the 1990s—particularly the research funding, strong educational system, and the technology collaborations with public research and universities. The domestic pool of low cost high quality technical talent and research supported the firm's accelerated growth for most of the 1990s; Nokia in turn contributed directly to the nation's economy recovery. One estimate attributes to Nokia one percentage point of Finland's GDP growth in the late 1990s. By 1999 Nokia accounted for 4 percent of national GDP.

The structure of the Finnish telecommunications industry changed substantially as well: two private operators, Sonera and Elisa (Telia) had replaced the hundreds of local operators and the public operator (PTO), and Nokia had absorbed the dispersed capabilities of scores of independent equipment manufacturers to dominate the domestic, and increasingly the global, network and handset industries. Nokia and Sonera jointly accounted for 83% of Finland's total ICT revenues.

Nokia pursued international expansion aggressively in the 1990s: it raised capital, established production and technology partnerships, and recruited talent globally. By 2000, only 40 percent of Nokia's more than 60,000 employees were located in Finland. The firm entered China early and, from a base exporting cable machinery and telecom networks, became the first producer of large-scale GSM mobile phones, networks and systems in China. Only a few years later, Nokia had its own production facilities in 10 different countries. Other Finnish firms, particularly its subcontractors, benefited from Nokia's reputation and global presence and followed it to China and elsewhere overseas.

Nokia also emerged from the 1990s as one of the world's most valuable companies (by market capitalization.) Its ownership became more international as well, as older Finnish institutional owners (such as Merita Bank, UPM-Kymmene, and the Pohjola group) were replaced with foreign, particularly American institutional investors. By 2002 Nokia's sales volume reached $31 billion—surpassing the annual budget of Finland and ten times its (nominal) sales a decade earlier. Nokia was increasingly a "multinational giant in a small country" (Lilja, ed., 2005).

3.4 A New Global and Competitive Era, 2000-2008

Nokia's success in mobile communications remains striking: the firm increased its share of the world market for handsets steadily from 30 to 40 percent in one decade, from 1998-2008, in spite of intense competition—not only from traditional rivals like Motorola, but also from aggressive Asian competitors like Samsung, Sony-Ericsson, and LG, that put severe downward pressure on price. In 2007 the Chinese telecom producer, ZTE, became one of the world's top ten mobile phone makers by producing ultra low-cost phones for emerging markets. Nokia's profit margins remained solid in spite of continued downward pressure on prices, largely because of its intense focus on gaining scale economies and cost-efficiencies and its early presence and distribution networks in emerging markets like India and China.

At the same time there are growing signs of Nokia's vulnerability to external innovation—whether new designs, like Motorola's RAZR clamshell design, or the integration of new capabilities such as an email client or new browser, into the handset. The introduction of Apple's iPhone, Google's Android platform, and the entry of other non-telecom competitors with distinctive applications and software highlight the unpredictability of innovation and competition in this market. Meanwhile the company's Enterprise Solutions division struggled to make a profit, facing ongoing turf wars with the Multimedia division before the 2008 reorganization folded both into the new Devices unit.

Even if Nokia continues to gain market share in mobile devices, the company's success will not protect the Finnish economy from the loss of telecom and electronics-related manufacturing jobs. While overall industrial output in Finland declined 1.1 percent from 2006 to 2007, electronics manufacturing output fell 11.5 percent. This reflects the growing number of plant closures and decisions to move production to lower cost locations overseas: in the past year Elocteq, Aspocomp, Perlos, Salcomp, Benefon, BenQ, and Foxconn (all Nokia subcontractors) announced plant closures and/ or significant layoffs in Finland while expanding in locations like Romania, Hungary, China, and India (12/28/07, NewsRoom Finland.)

3.4.1 Manufacturing mastery

Nokia's competitive advantage today lies in a highly optimized manufacturing system that combines logistical excellence with the efficiencies of large-scale production. In addition to its brand recognition and established distribution channels, Nokia's unparalleled purchasing power and manufacturing mastery allow it to produce handsets phones more efficiently than even the lowest-cost Asian makers. Nokia, for example, claimed some 35 percent of the Chinese market for mobile handsets in 2006, compared to the domestic Lenovo Mobile with only 6.2 percent. The ability to make a profit even at the extreme low-end of the handset market has allowed Nokia to continue growing its share of emerging markets like China and India. In fact, the low end (sub-50 Euro budget models) accounted 42 percent of sales and virtually all of Nokia's shipment growth in 2006.[16]

Nokia has historically viewed manufacturing as its key asset and maintained tight control over a highly integrated process. A comparison of the production strategies of Ericsson and Nokia in the telecom equipment business in the early

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[16] Andrew Orlowski "High-flying Nokia now dependent on cheapies" *The Register* June 5, 2007. Mike Clendenin, "Tale of two cell phone markets: India and China" *EE Times*, June 4, 2007.

2000s highlights the integrated nature of Nokia's manufacturing system. In their study of the firms' mobile network system businesses (production of radio base stations) Berggren and Bengtsson (2004) contrast Ericsson's "radical outsourcing" with Nokia's more limited sourcing model.[17] Ericsson left all high volume production to contract manufacturers and focused internally on new product design and development, including the design and prototyping of strategic components.

Nokia, by contrast, treated manufacturing as a core competency and competitive advantage, and maintained strategic components and processes in house along with the majority of assembly and testing.[18] Non-strategic components were sourced from selected suppliers (normally one or a few per component) that were closely monitored, often even co-located physically. Nokia used its scale as a buyer (coordinating purchasing across the network and mobile phone divisions) to negotiate the lowest possible purchasing prices; and prided itself on being the most cost-efficient producer in the industry.

There is substantial evidence that Nokia Mobile Phones has followed the same strategy, and likely has maintained tighter integration than the network group. According to Häikiö (2002) only 15-20 percent of Nokia's mobile phone manufacturing was outsourced in the 1990s so that the firm could closely integrate product design, process engineering, and manufacturing to improve productivity. This strategy involved the commitment to "platforms:" the use of standardized design, technical, and commercial specifications so that common components and technical solutions form the basis for evolving product models and lines. It also facilitates outsourcing of standard subsystems, streamlining and

[17] Note that this is a comparison with Nokia Networks, which makes the radio base stations, not with Nokia Mobile Phones. While Nokia has impressive scale economies in phone manufacturing which might justify internal production, it did not have scale advantage in radio stations, but still chose to maintain production in-house.
[18] Nokia maintained "capacity suppliers" to absorb excess orders, thus insuring flexibility and high levels of capacity utilization in its own plants.

rationalization of the supply chain, strong process controls, and relocation of production to low cost locations.

The platform strategy serves Nokia very well, allowing the firm to introduce some 40-50 new products a year, with an average life cycle of 12 to 24 months, while remaining more cost-effective than its competitors. However it leaves the firm vulnerable to unanticipated changes in technology, markets, and customer preferences. Nokia has repeatedly played "catch-up" when new features or designs, such as cameras or color displays or GPS, are introduced by competitors. The firm was at least six months late with Bluetooth technology. This, along with poor relationships with US network operators, likely helps account for Nokia's falling share of the North American market (the largest market for mobile devices): its share was only 7% in the first half of 2008, down from 20% in 2006.

Nokia's move to India exemplifies its manufacturing process mastery. Expecting India to be its second largest market in the world by 2010, after only China where it already has two factories, in 2006 Nokia invested $150 million in a dedicated mobile phone production facility near Chennai. This was the fastest ramp up by any Nokia factory worldwide; the plant produced 25 million mobile handsets in its first year of operation. The plant now employs some 6,000 workers at the Chennai plant and in 2007 Nokia announced another $75 million investment to expand the plant's capacity. Seven other long term Nokia subcontractors—Salcomp, Aspocomp, Jabil, Laird, Perlos, Wintek, and Foxconn—have also located in close proximity to the factory to insure logistical efficiency. Other foreign investors, like Samsung and Motorola, are planning to make a range of consumer electronics products in India; Nokia's factory is devoted to handsets, which allows full optimization, but also carries potential risks.

The firm's global manufacturing strategy is consistent with this focus on cost-minimization and process optimization. In early 2008, Nokia announced closure of its manufacturing plant in Bochum Germany (resulting in 2300 jobs lost directly and another 1700 at local suppliers) and the shift of its capacity to a plant in Romania where wages are 1/10 those in Germany. This plant will assemble five mobile phones per second. By comparison: in the early 1990s it took Nokia 40 minutes to assemble one mobile phone; by the end of the decade the company had lowered this time to 4 minutes per phone.

3.4.2 Back to Finland

Nokia's commitment to optimizing its manufacturing process and remaining the lowest cost provider comes at a price for Finland and for the workers at many of its subcontractors. After long resisting the trend to use contract manufacturers, in 2002 Nokia began to forge closer ties with Asian assemblers and sub-system makers who are able to design and build a larger proportion of the mobile phones at lower cost and more efficiently than their Finnish counterparts. Electronic Manufacturing Service (EMS) providers such as Taiwan-based Foxconn now serve as intermediaries coordinating Nokia's global mobile phone supply chains, coordinating and assembling the hundreds of components into a final handset typically from a base in China, which now boasts a complete mobile phone supply chain.[19]

Nokia's subcontracting fuelled the growth of the Finnish ICT sector during the 1990s. Two of its leading subcontractors, for example, Elcoteq (contract manufacturing) and Perlos (manufacturer of precision plastic parts) literally "grew up" in Helsinki alongside Nokia. They served competitors like Ericsson as well, but Nokia remained their largest customer and 80-90% of their revenues came from mobile phone-related products. Other subcontractors in the Nokia network included JOT Automation, Eimo, Elektrobit. Nokia's dominance as lead customer led most of these firms to develop as dependent subcontractors, lacking in

[19] China is the world's largest mobile phone manufacturing base, accounting for 46.9 percent of total output in 2006.

strategic flexibility or independent innovative capacity. For example, Nokia required its suppliers to adapt their business models to its requirements, forcing them to focus on cost reduction, decrease delivery time, and improve efficiency, and flexibility, rather than developing independent market positions. They also internationalized with Nokia during the 1990s, following their lead customer to China and later to Hungary and India.

While Nokia is very secretive about the size and nature of its subcontracting network, and the subcontractors, in turn, are rarely forthcoming with information about their business with the mobile phone manufacturer, it is apparent that since the mid-2000s they have felt the consequences of increasingly fierce price competition among the leading handset manufacturers. Nokia's shift to EMS companies has simultaneously reduced their need for external suppliers, thus further intensifying the competition.

The CEO of Savcor (which produces decorative coatings and RF/EDS interference shields for cell phones) reports: "Nokia is much, much more price-critical and cost-aware than it was a few years ago. . . Prices are negotiated constantly, and we are always trying to find ways to lower the price of our products." He goes on: "We are operating entirely on our own risk. We wish that Nokia could make some commitments now and then." (Suominen, 2006) In addition to pricing pressure, delivery times have dropped dramatically as well.

The CEO of Perlos reports that five years ago they had a few weeks notice to ship handset covers to Nokia. "Today, we have one-tenth of the time we had then. From the time when we know what to deliver, we sometimes have as little as two hours to complete the delivery, sometimes as much as a week." (Suominen, 2006) Intensifying cost and time pressure also means that subcontractors have no alternative but to locate close to their customers' main operations. According to Perlos CEO, Hantila, their move was motivated less by India's low costs than by the need to be near the market: "The logistics cycle is so frenetically fast that we do not have time to import products or components to India from abroad."

The proliferation of phone models, as well as the shorter life span of these models, further exacerbates these challenges. Hantil reports: "We have some sort of window of visibility a week ahead. We make our production plans for one week at a time. .. Our strength is that we can do this." One way that Perlos manages the uncertainty is to rely on temporary workers: 40 percent of its global labor force is on fixed-term contracts or recruited from a temp agency. Perlos has also sought to move up the manufacturing value chain from making moulded plastic covers to delivering entire electromechanical modules; and it is seeking to diversify into the medical devices industry to reduce its dependence on Nokia and mobile phones.

Some subcontractors don't survive the competitive pressure. Plastic components and housing maker, Eimo, failed to invest enough in a new model of covers and as it grew weaker was acquired by Foxconn, which shut down Eimo's plant in Hollola Finland in 2005. Others like the circuit board supplier Aspocomp are struggling as well. Several prominent suppliers have simply closed their operations in Finland altogether in favor of lower cost locations. Elcoteq closed its last Finnish plant in Lohja during 2007, as Nokia shifted more and more of its handset orders to Asian competitors. Perlos and Aspocomp also closed Finnish plants in 2007.

In short, over time the domestic ICT ecosystem specialized in serving the needs of one firm— while in the interest of cost-competitiveness, Nokia has expanded its cooperation with Asian subcontractors and to grow its R&D investments outside, rather than inside, of Finland.

This is not to suggest that Nokia is unaware of the need to combine exploration with exploitation. In the late 1990s, it appears that Nokia sought to open up to external innovation by collaborating more with its suppliers and subcontractors, and seeking to develop long term strategic relationships with some. A 2001 report on Nokia's network (Ali-Yrkkö, 2001) describes a "new form of R&D cooperation" with specialized software development firms, and anticipates the emergence of long term R&D partnerships in which both partners share the risks and the rewards of cooperation. However the report also makes it clear that even long term software development was being billed by the hour, rather than the results (pp. 46-47.)

Similarly while there is much discussion of the cooperation between Nokia and universities, a report on the Finnish innovation system (Ali-Yrkkö, 2002) suggests that many of the projects were more like contract work than true research partnerships: "What came up in many interviews is that representatives of universities and research institutions felt that they did almost all the work related to the projects. Financing organizations take part in executive meetings but not in the actual substance of most of the projects. Many interviewees brought up the issue that business partners could play a more active role. The next quote describes these wishes:

> We would really greatly welcome more active company partners. That is the opportunity of the Tekes projects. That a company, which assigns a person there, who has the right competence, skill, background, commitment, time and who would stay on there. Not only become familiar with the material and come to the meetings prepared and so, but would maybe go and talk to the people there and work on a paper together and participate. This is extremely rare. (Professor, University/research institution)"

3.4.3 Back to Nokia

The vulnerabilities of Nokia's optimization-driven business model are also becoming clear internally, particularly in an intensely competitive and technological fast changing market. Nokia has invested heavily in maintaining a presence in the high-end of the device market, and increasingly in software and services, at the same time that seeks to preserve its dominance as the low-cost manufacturer.

The Nokia New Ventures Organization (NVO) represented an early effort to seed new ideas and to avoid the cognitive lock-in that often undermines once successful companies. NVO was created in 1997 and tasked with creating a "third leg" or business for Nokia, beyond network infrastructure and handsets. After this approach failed, NVO director Pekka Ala-Pietila relocated to Silicon Valley in 2001-2002 to actively scout for new opportunities. While some opportunities were identified the group was unable to connect them to the core business units, struggled to show tangible benefit to the company, and never made a profit. NVO was disbanded and it was not until 2006 that Nokia established a research laboratory in Silicon Valley. Nokia had started to scan the external research environment in the late 1990s, establishing research centers outside of Finland and university-oriented "lablets" in Cambridge, UK and MIT, Massachusetts. However its presence in Silicon Valley, where the leading Internet technologies were developing, dates to the early 2000s.

The most recent reorganization, in January 2008, was promoted as a strategic shift to focus more on "mobile internet" and an opening of the organization to new ideas and innovations. The creation of a new unit dedicated to 'Mobile Software and Service' alongside 'Device' and 'Markets' units is the key to the new structure. The high-end multimedia internet (N-series) and enterprise (E-series) groups have been merged into 'Devices' in order to integrate the characteristics of those models quickly into mid-range model that can be produced in high volume for affluent sectors of emerging markets.

While the new structure places software and services at the core of Nokia's research and strategic direction, it does not clearly resolve the challenge of managing an organization that simultaneously pioneers innovative, break-through high end services and software, while also reaping the benefits of economies of scale in “emerging markets, multimedia and enterprise-featured phones.” These goals demand different organizational incentives and business models: the former requires open exploration and search for innovative partners and opportunities, and assumes that the technological future is likely to look very different from the past and the present; the latter assumes that the trajectory of technology is sufficiently established that an inward focus on optimization can accommodate incremental integration of new features into the existing platform (video recorder, MP3 player, bigger display, high resolution color screens, GPS.) Senior leaders at Nokia are aware of these challenges company, as we will see in a moment.

If the recent introductions from Apple and Google underscore the challenges that Nokia faces in staying in touch with external innovation, its recent efforts at the high end of the market suggest continued distance from customers. Even its original strengths in design are less apparent today. Other examples:

- In 2003, after the firm invested tens of millions in development and $100 million in promotion, Nokia introduced a new mobile gaming device, the N-Gage (which combined mobile phone, games console, FM radio, and digital music player—it was aimed at Sony and Nintendo, but it was priced high and lacked games) that was poorly received in the market.
- The 2007 introduction of the portal Ovi (“the door” in Finnish) for games, music, information, and “social” interaction –going “beyond the phone.” This was a direct threat to network operators who refused to carry their music phones, and reminiscent of the earlier Club Nokia portal which never got off the ground.
- Insiders report that Nokia has made progress in freeing itself from the operators and creating its own brand and alternative channels; however commentators question the viability of the business model for its recent “Comes with Music” which offers unlimited downloads. By contrast,

> Apple's iPhone is highly profitable, making money not just on the hardware but also the subscription revenue service.

The dominance of process perfection and manufacturing optimization over search and exploratory innovation has limited Nokia's ability to see where the market or technology is going. Historically the firm has not been open, especially in R&D, in part because of a tradition of close integration. Rather than creating external partnerships, it appears that Nokia is now using acquisitions as a means of monitoring and accessing external innovation, particularly in the mobile internet space. Examples in 2007: Loudeye, digital music ($60 million), Twango, social networking ($100 million), Enpocket, mobile marketing (undisclosed), and Navteq, digital mapping ($8.1 billion in cash!)

3.5 The Big Picture: Competing Interpretations

Recent experience of incumbent technology firms that have attempted to achieve economies of scope internally—by essentially creating two different firms within one organization—are sobering: both IBM's attempt to innovate in PCs while maintaining a its traditional strengths in mainframes, and Microsoft's attempts to create an open, internet-based business alongside its closed, proprietary software model, are judged failures.

Though it is informed by numerous, open discussions with high Nokia managers, the account so far remains a view from the outside. We simply did not have the ongoing interchange with the company that allows for anything approaching an insider's comprehension of strategic (re-) orientation: an evaluation of what is being learned, rather than what has been accomplished. Nor could we benefit in this regard from the cooperative guidance of a team of industry experts, as we could in the case of forest products. There is the risk, therefore, that in focusing on outcomes and ignoring the lessons Nokia has drawn from reverses and partial successes, we are understating the company's actual or potential for renewal.

To complement our account, therefore, we turn to recent writing about Nokia's situation and strategy co-authored by an insider, Mikko Kosonen—CIO of the firm from 1997 until his departure in 2005—and Yves Doz—a professor of business strategy. Their work converges with and confirms ours in that they too find that Nokia has been constrained by its successes in high-volume production and even more fundamentally by the needs to integrate numerous, complex and rapidly changing technologies that form its mobile phone platform. But they also make a compelling case that the company is well aware of the dangers of entrapment, and has at least in some cases succeeded in relaxing the constraints—even if the outcome is still manifestly inconclusive.

Doz and Kosonen see Nokia as having come, by the mid 1990s, to believe both the trajectory of product development was foreseeable, and that they already had in place, or were on the way to installing, business processes sufficiently flexible to handle the needs of this predictable market. The result was a lapse of the "strategic sensitivity" that had allowed the company to take advantage of the open situation at the end of the 1980s, and an increase of "strategic rigidity" or self-blocking entrenchment. The first and perhaps more binding constraints on flexibility came from the bottom up, in the form of solutions to operations problems provoked or revealed by rapid growth. This was especially so with regard to process disciplines put in place in response to a tangle of supply-chain problems that Nokia called collectively the "logistics crisis" of 1995.

> The response to the logistics crisis provided greater resource fluidity in principle, but only for mass-produced products, and memories of the crisis led to greater care, but also to rigidity, in planning. Nokia was threatened with an early onset of strategic rigidity. This tension between strategic planning and opportunistic strategy emergence has persisted at Nokia ever since. (Doz and Kosonen, 2008b, p. 102.)

A sense of assurance about the direction of technical development reinforced these constraints from the top down in the following years:

> Strategic sensitivity was weakened by a growing sense that third-generation (3G) telephony was *the* answer to the emergence of the Internet and the growing importance of data communication. This belief was reinforced by Nokia's growing dependence on fewer bigger customers, who themselves were making huge commitments to buying 3G licenses, as the mobile service industry started to consolidate and integrate internationally, and as major telecom incumbents realized the importance of mobile communication. Major customers were starting to hijack Nokia's strategy process. The growing autonomy of the business groups threatened leadership unity. (ibid.)

And even as Nokia's freedom of action was thus being subtly restricted, market conditions, as we have seen, became ever more demanding:

> The fast increasing pace of new model introduction and price erosion, on the one hand, and the voice-data digital convergence (blurring industry boundaries) on the other hand, have forced Nokia to keep putting a high emphasis on both disciplined execution and experimentation at the same time in the same core business. Nokia cannot sustain its margin leadership without flawless execution (to reap scale advantages) and a continuous flow of bold innovations (for new high-end devices and services). New experiments have to be immediately globally tested and, if promising, quickly scaled up to high volume. The innovative use of mobile phones makes conventional market research particularly ineffective and the success or failure of specific application unpredictable. Yet, the

> dependence on global (often teenage) fashion trends and technologies called for fast global product introductions. (ibid)

Since the late 1990s, Doz and Kosonen show, Nokia has deliberately struggled to relax the constraints on its decision making in order to respond to the increasingly market pressures. The first efforts were tied to the creation of NVO in 1998. They key contribution of NVO, they argue, was to introduce a setting and process for decision making that was tied neither to Nokia's annual planning cycle, nor directly to the firm's core businesses, and was therefore able to identify and elaborate projects that would have been excluded by the new routines. But despite the formation of NVO, and potentially convergent attempts to institutionalize experimentation in NMP, the new forms of decision making, as we saw above, remained peripheral to the firm. The motor of change remained the external environment:

> Despite all the activities undertaken to address renewal from different strategic perspectives (venturing in NVO and NMP's own efforts) and operational perspectives (common business infrastructure development), very little core business renewal actually happened in Nokia until mid-2001. Beyond the cognitive seeds the ventures provided, and the more organizationally embedded strategic sensitivity the venturing process fostered, once again necessity had to be the mother of invention. It took another disruption (the stalling of growth in the mobile phones market in May 2001) and the fast-evolving commoditization of the mobile communications industry to trigger action. (ibid, p. 105)

In response to the threat of commoditization Nokia took (successful) steps to meet immediate challenges to its hardware and software platforms, reorganized business units to give truly new ventures linked to the mobile internet a better chance of succeeding, and continued refinement of the modularization of business processes that would make subsequent reorganization of business units (and perhaps even business models) easier. But while this series of changes was less plainly two-edged than the earlier response to the logistics crisis—which increased operational flexibility while restricting the range of strategic maneuver—it was not free of a similar ambiguity. On the one hand Nokia was committed to searching more broadly than before for new (kinds of) products. This created the potential for a new opening. But on the other hand, picking projects from the enlarged and continuously refreshed set of possibilities required a new, complex and unfamiliar kind of "matrix dialogue" among managers with deep knowledge of particular market domains, managers with functional knowledge of platforms, and managers in control of budgets. This created the potential for a new closure in that the need for increased internal coordination and coherence might make it difficult or impossible to make use of the new possibilities uncovered by broader search.

In the short term many incumbent managers viewed the changes as more a constraint than an opportunity:

> Having led autonomous business groups and units through a period of exhilarating growth, the more seasoned Nokia executives found it less motivating to operate in the newly interdependent matrix. Many resigned in 2004-2005 and moved on. (ibid, p. 107)

Doz and Kosonen see these departures as clearing the way for renewal at the top, which is in turn, in their view, the precondition for the decisive transition from a device-based to a service-based company. The

> new, more-integrated Nokia organization further increased the need for good collaboration within the top team. Its members could no longer run their own "fiefdoms" but were now each responsible for one key dimension in the overall success of Nokia. Secondly, they

> had to manage contradictory goals on a continuous basis. Maximizing the success of a device business called for subordinating services and making them proprietary. Conversely, maximizing the growth of the new services business called for open platforms and selling services and software to all, including device competitors. When managed well this healthy tension benefits the whole company as it leads to deeper dialogue between the two units. (ibid, pp. 107-108)

Indeed, several managers with experience of the current division of labor at Nokia, Doze and Kosonen suggest that the new organization, in creating the devices anad software/services units, may well be regularizing the exploration of alternatives—challenges to existing routines—in ways that were intended, but impracticable before. As the two units have become much more nearly equals now than under the old regime—when software/services was subordinated to devices—each can make demands on the other that would have been previously impermissible, so bringing to the surfacee, and making actionable fundamental questions about the future direction and organization of the firm. To take only one, crucial example: Is Symbian the optimal platform for delivering services, as long assumed?

Responding to such questions will require reexamination not only of the relation of the big internal units to each other, but of their respective connections to collaborators on the outside. It may be that in taking these steps Nokia succeeds both in opening its organizational borders and in increasing the strategic agility of its top team. Or it may be that its latest reorganization—the creation of two internal businesses which both complement and compete with each other--will prove to be a first and decisive step towards the reconstitution of the firm as a series of linked but independent entities—an opening of another kind. But whatever the outcome, if this latest and still tentative interpretation of developments at Nokia is correct, fundamental questions are being put on the table in a way could well lead to a redrawing of the boundaries of the firm.

4 TWO ROADS TO THE FUTURE?

This chapter looks ahead to the future of the Finnish forest products and ICT industries—and by extension to the prospects of the entire economy. For this we employ the convenient and conventional device of the scenario, the fact-based extrapolation of some aspect of the present into the future. But for reasons that will shortly become clear, we are so unsure of what lies ahead for Finnish industry that we consider its future from the vantage of two different kinds of scenarios. In the first and most familiar we simply imagine how, given current capacities and strategies, the sectors will respond to opportunities open to them—keeping in mind that the opportunities will become threats if competitors respond more effectively. Successful responses in these scenarios will depend on a series of anticipatory changes, and success will itself entail further, perhaps radical change. The fact that these changes will occur amidst success will of course make them easier to bear, but they will likely be disruptive nonetheless.

From the preceding chapters it should be clear that we do not have a great deal of confidence that Finnish industry will respond—is responding—with sure footed ease to the multiple challenges it faces. We have, to our surprise, encountered forms of instructional lock-in where we expected to find openness and fluidity. Lock-in is especially dangerous in a very volatile world. Put another way, we have not seen promising anticipatory changes, neither at the level of (re)-organization, nor at the level of (re)-conceptualization of strategy as embodied in a series of concrete projects—as opposed to imagined as a series of power point slides.

For this reason we look briefly at a second kind of scenario that takes as its starting point the failure to adjust in a timely way: What happens, that is, if Finnish industry doesn't adjust as fast as the competition? We can say something about this possibility because in some Finnish locales, like the mill town of Varkaus in central Finland, something like this has already come to pass. In light of that experience the short answer to the question 'what happens?' is: certainly nothing as catastrophic as might be feared, and a good deal that is more promising than might casually be imagined. Indeed, we will see that the road to success may just as well, perhaps more easily, begin in "failure," as in what, in the best of cases, proves to be the zigzag march of progress.

4. Scenarios for Finland: Assuming the Actors Stay the Same, Even If Their Actions Change Significantly

4.1 Forest Products

In part, perhaps large part, the future and well being of the Finnish forest products industry depends on competitive contests whose outcome only the immediate participants can assess and influence: Will Chinese paper-machine makers displace Finnish suppliers sooner, later, or not at all? Who will control paper making technology in Latin America in 15 years? But in part too the future of the industry depends on its capacity to re-invent itself, using its indisputable technological prowess to transform what paper is—the things paper products can do---and they way it is made so as to remain competitive in today's rapidly evolving markets. This section looks briefly at a range of scenarios for such technological re-invention. The scenarios are a curious mixture of self-evident and elusive: self evident because there is a consensus in the industry, and among academic observers, regarding promising developmental paths; elusive because, this consensus notwithstanding, the industry has yet to advance far enough along any of the trajectories to test its long-term potential. Some of the lack of progress no doubt reflects the sheer technical difficulty of the challenges, and the familiar, but burdensome problems of learning what potential customers want, and teaching them to make use of what they could have. But some of the delay in progress also reflects strategic choices by the industry: the move into emerging markets and North America, and the consequent de-emphasis, at least for the last decade, of bold exploration of alternatives to the industry as conventionally conceived. As we write attention is shifting back to these possibilities, and the scenarios presented here where the industry will go as it aggressively explores this domain of its future. We make no pretense of completeness or precision. In some cases, such as the application of nano-scale technology to the enlargement of the “feature space” of paper—a redefinition of the properties we associate with it—research is barely underway and speculation about results would be truly idle. In other cases—particularly the production of synthetic fuels forest raw materials—there is a flood of detail, yet it is so incomplete and contradictory that even the most expert observers are guarded in their predictions.

4.1.1 Urban Mini Mills

Urban mini-mills—low tonnage paper mills, using new equipment, located in urban areas that supply raw materials and provide markets for the finished products—are an idea whose time came, and went, in the 1990s, but may be coming back again. In theory, mini mills processing recycled paper form the “urban forest” should require less capital investment and have lower operating costs than mills processing virgin fiber, at least at relatively low production volumes. A mini-mill sited in an existing industrial park, for instance, saves the huge costs of support and service facilities (access roads, railroad sidings, electric substations, storm sewers) incurred by a stand-alone mill in a remote forest. Similarly, the urban mini-mill might share a cogeneration facility with other industries in the park, eliminating the need for a boiler of its own; it could discharge effluent into a publicly owned treatment works, eliminating the need for an expensive, dedicated treatment facility. (Kinstrey, 1992).

A mini-mill of this type came close to being in New York City in the 1990s. The plan was developed by the former CEO of UPM (then Yhtyneet), Niilo Hakkarainen. It called for a plant producing 220,000 metric tons of newsprint annually, using recycled fiber from old newspapers and other sources, all from New York City. The mill was to have been located at the abandoned Harlem River Rail Yard in South Bronx; it would have used treated wastewater, rather than freshwater, in papermaking.[20]

But despite letters of intent from major newspaper publishers such as Gannett Co., Advance Publications Inc./ Newhouse Newspapers, New York Times Co., and News Corp, and a pledge of financial support from the State of New York in the form of a promise to issue tax-free bonds, the mill was never built. There were, for one thing, issues of environmental justice: the mostly Hispanic residents of the South Bronx neighborhood feared that the truck traffic to and from the plant would be a significant source of pollution, and that the presence of the mill would make it easier for other industrial polluters to establish themselves nearby. The result would be that they would bear a disproportionate share of the burden of pollution produced by the urban economy—a form of discrimination. For another, there were fundamental questions about the business model: Even with reduced capital costs the mill would only be profitable if there was a sufficiently large spread between the purchase price of old newsprint and the sale price of new paper. But the prices of both were gyrating wildly even as efforts were made to finance the project.

In the end the combination of problems proved, at least temporarily, overwhelming—in the Bronx and elsewhere. Despite the promise of the low-capital/low tonnage urban forest model of paper making, nothing came of these early initiatives.[21] But the underlying logic of the model has, if anything, become more compelling with time. First, increasing population densities and spreading habits of recycling have increased the availability of feed stocks and the attractiveness of large urban markets. Second, and more importantly, advances in the capacity to recover energy from biomass—any organic matter derived from

[20] "Bronx Newsprint Project Rolling," Pulp & Paper, Aug. 1996.

[21] Capital-saving mini-mills charged with scrap and using electric-arc furnaces did succeed in the steel industry, particularly in the US and it is tempting to speculate on the mix of cultural and industry specific reasons that explain the difference. We resist.

renewable sources, including dedicated energy crops and trees, food and feed crops, wastes and residues, wood wastes and residues, aquatic plants, and so on—mean that mini-mills might become economically viable when integrated with systems for producing electricity for the mill itself, for the local energy grid or supplying green fuels to national market. So a part of energy/paper producing complexes urban mini-mills may have a future after all—especially if it is possible to develop "miser" mills that radically economize on energy and water, or "omnivores" that can sort and "eat" poorer quality fiber, even waste. But energy production from bio-mass will have a large, if still indeterminate effect on the economics of the forest products industry even if it does not rescue the urban mini-mill, and it is to this we turn next.

4.1.2 Bio-Energy and Bio-refining

The forest products industry, in Finland and worldwide, is already a leader in the recovery of energy from the biomass that it uses as feedstocks. The forest products industry derives more of its energy requirements from biomass than any other industry– more than 50 percent in OECD countries, compared to about 10 percent for food and tobacco and negligible amounts for all others.[22] In Scandinavia advanced mills already produce more energy than they consume, and technology currently available, or soon to be, will increase the energy surplus.[23] As the production of bioenergy draws on more and more sophisticated and diverse technologies, it shades into biorefining: the use of distillation, cracking or chemical separation to export energy from a facility fed by biomass. It is in biorefining that the possibilities for real breakthroughs are proliferating—so much so that it is hard to know which bets to place, let alone confidently assess the odds that currently attractive choices will prevail in long term competition with other strategies.

To give only the roughest idea of the span of possibilities, and hence the risks of

[22] "Biofuel Outlook for the Forest Industry," Asko Hyttinen, Senior Vice President, Corporate Finance & Strategy, StoraEnso, SYNBIOS II Conference, Stockholm, 24 May 2007.
[23] Markku Karlsson, UPM-Kymmene Corporation, "The Integrated Forest Biorefinery," European Conference on Biorefinery Research, Helsinki, Oct. 19-20, 2006.

choice under extreme uncertainty, consider that one eminent analyst, limiting himself to “hardware on the ground” and “proposed commercial facilities,” identifies 12 different pathways for extracting energy from biomass in forest products production—and confidently predicts that there will be more in the future.[24] The simplest pathways start with gasification: a process that converts carbonaceous materials, such as coal, petroleum, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen. This produces synthesis gas or syngas, which is itself a fuel. Syngas can be turned into synthetic fuel, or synfuel, by the Fischer-Tropsch process—a conversion method first developed in Germany in the 1920's and further developed by Sasol in South Africa to produce oil and gasoline from coal when that country was cut off from world energy markets during the anti-apartheid boycott. The Fischer-Tropsch process is catalyzed by iron or cobalt; the temperature, pressure and catalyst used determine whether a light or heavy syncrude is produced: at 330C the output is mostly gasoline and olefins, at 180 to 250C mostly diesel and waxes. Stora Enso, Neste Oil—a Finnish company specializing in refining and marketing advanced, clean traffic fuels—and VTT are building a demonstration plant at Stora Enso’s Varkaus mill to gasify forest chip raw materials, purify the syngas, and transform it by the Fischer Tropsch process into especially clean diesel fuel. Varkaus was chosen because it is surrounded by essentially unlimited supplies of forest biomass and is already served by the extensive infrastructure needed to move the bulky raw materials. If the pilot plant proves the process to be economically viable, commercialization will follow.

And this is a (relatively) easy pathway/process. More complex ones involve still greater technical risks. But they often have the compensating advantage of integrating bio-refining more directly into pulp and paper making—thereby benefiting from the logistics, automation and heat balances of existing installations in a way stand-alone bio-refineries may not. Of these more demanding processes one of particular interest involves gasification of black

[24] Ben Thorp, “The Compelling Case for Integrated Biorefineries.”

liquor, also called spent pulping liquor: the dark, lignin-rich solution left after the cellulose fibers used in making paper have been extracted by chemical means from the ligno-cellulosic biomass that constitutes trees. Today black liquor is usually concentrated to a solution of about 80% solids and burned in Tomlinson recovery boilers developed in the 1930s. Steam from these boilers is used to help power the pulp mill; sometimes the steam is passed through a turbine to generate electricity. The Tomlinson boiler also helps recover pulping chemicals for re-use.

The emerging technology of black liquor gasification, in contrast, removes the biomass materials from black liquor in a high temperature chamber and converts the complex hydrocarbon mixture into simpler gaseous molecules, primarily hydrogen, carbon monoxide, carbon dioxide, and methane. The inorganic pulping chemicals in the black liquor are recovered for re-use in pulping. A Swedish consortium, lead by Chemrec—a pioneer in black liquor gasification—is pursuing this strategy. Chemrec's proprietary black liquor gasification technology for producing low-carbon chemicals and fuels is already deployed in plants in Piteå, Sweden and at Weyerhaeuser New Bern, North Carolina.

But the results so far have been daunting. After a decade of cooperation with Chemrec, Weyerhaeuser's high-temperature gasifier operates only 80 percent of the theoretically available time, and its output when operating is only 68 percent of the design target. Replacement of refractory materials shuts the plant 21 days per year; higher-than anticipated operating temperatures cause severe metallurgy problems as well. The Piteå pilot plant started burning liquor in October, 2005, and after four months had burned black liquor a total of 63 hours, typically at 30-50 percent of design load.[25]

In noting this we do not mean to be expressing more or less confidence in one or another bio-refining pathway or technology. Our purpose, rather, is simply to underscore how thorny the technical issues in essentially all the biorefining

[25] Forest Biorefining: Industrial Perspective, May 18, 2006, www.cnr.ncsu.edu/wps/documents/Phillips.pdf .

pathways are—and have in some cases remained even after years of experimentation. And putting aside persistent and refractory technical problems, there remain vast, nearly overwhelming economic uncertainties associated with this scenario, even assuming that the price of synthetic fuels will remain attractively high, and the regulatory environment will further encourage their introduction. So far as the forest products industry is concerned the most significant of these uncertainties is the prospect that non-forest biomass will prove easier to convert into synfuel on a commercial basis than the biomass generated by or easily available to makers of pulp and paper. Cultivation and of oil-rich algae varieties could prove a superior alternative, as could the production of cellulosic ethanol from switch-grass and other cellulose rich plants by fermentation, assisted by genetically modify bacteria. In a decade or two we will know which pathways work. In the meantime it is hard to say what effect the coming growth of bio-refining will have on the forest products industry, in Finland and elsewhere.

4.1.3 Integrating forward from Capital Goods to Services

Just as IBM shifting from making computer hardware to selling maintenance and consulting services to customers who had installed that hardware, or machines like it, so Metso Paper—the worlds' largest paper-and board-machine manufacturer—wants to provide more and more services to its customers. The reasons are the same: Once the hardware base is installed, the hardware maker's growth slows, unless it can rebuild the existing machines, using the knowledge thus gained both to improve the successor product and to expand into business areas—once the customers' exclusive preserve—otherwise closed to it. Moreover, sales of expensive capital goods tend to be lumpy or cyclical, in response to the rise and fall of industry prospects, while the demand for services is more nearly predictable.

Metso's capacity to provide sophisticated services to its clients was an extension of the modernization of its internal design process in the 1990s. In order to accelerate design and delivery of increasingly sophisticated machines—the speed of paper making machines was increasing at three percent a year—from 1,200-1,300 to 1,600-1,700 meter/minute, or from about 75 kilometer/hour to 100 kilometer/hour—Metso introduced sophisticated email and e-document management systems and related tools, such as ERP. Once information was flowing internally, it was easier to make it available across organizational boundaries, and to integrate outside information into internal discussion. By the 1990s about 40 percent of order value came from rebuilds, ranging from 80 to 15 percent annually. (Applegate et al. 2004, p. 7.)

On key challenge involved in the provision of demanding services was collection and analysis of the real-time performance of various types and vintages of its paper-making machines in order to establish benchmarks for rebuilds and improvements. A second was the integration of customers into the knowledge management system in order to facilitate training and the diffusion of best practices. (ibid, p. 12)

Building on these developments Metso Paper today offers extensive rebuilding and optimization services. These are addressed especially to the North American market, where, the company notes in its advertising, "mills run older, or even obsolete, paper machines. Harsh market conditions have forced some of these North American companies to shut down," and—given the lack of appetite for investing in new technology—rebuilds of key components can plausibility be seen as the only alternative to shuttering plants.[26]

In theory of course the kind of information pooling, analysis and application on which the growth of services is based should also help protect the firm's competitive advantage in the development of new machinery—and thereby help ensure the future of Finland as the leading capital goods supplier to the forest products industry. But here too there is an imponderable—the extent to which sophisticated knowledge of paper machine making is diffusing to developing

[26] "Metso Mechanical Roll Service," www.metsopaper.com/paper/MPwUpRunning.nsf/WebWID/WTB-060712-2256F-7F54F

markets—for example, through Valmet-Xian, Metso's joint venture in China, and its rapidly expanding service facilities, or contact between the users' of Metso machines and machine makers in their home markets. Or it could be that increases in the price for wood fibers will accelerate the search for cheap fiber alternatives in emerging markets—and thus a shift towards less sophisticated but cost-effective technology that does not require either the equipment Metso makes or the new services it is learning to provide.

4.1.4 Service Platform of Publisher and Packagers

Even as the capital goods sector is beginning to offer sophisticated services to mill owners, and by degrees attempting to co-manage mill operations, so the mill operators are trying to cooperate with their clients—users of paper and board—to develop new products. Kimberly-Clark, at the cutting edge of the tissue/consumer products segment of the paper market—and know for brands such as Kleenex, Scott, and Huggies—has been the leader in this. The expectation is that others, in very different segments, will follow.

Kimberly-Clark's efforts in effect to move, if not integrate, forward into retailing and marketing are well illustrated by a virtual-reality facility it opened in Wisconsin in 2007. The design studio, as it is called, is built around a high-tech kiosk that simulates a shopper's experience. Its purpose is to allow the company to test new store-organization and product concepts without spending the time and money to physically construct mock-ups. By partnering with retail customers, or conducting its own research, Kimberly-Clark claims to be able to create "real" store settings, down to retailer-specific color palettes, graphics and layouts—allowing exploration of hypothetical in-store design and merchandising concepts without having to move an actual package.

By co-designing retail space in this way Kimberly-Clark moves at least half a step from supplying retailers with consumer products towards becoming a retailer itself. The example is promising, especially in an industry whose core products are commodities. But it remains an exception, and a recent one at that.

4.1.5 Blurring the Distinction between New Media and Old: Radio Frequency Identification Tags (RFID), for Example

The profound changes in the organization of production—capital goods makers becoming co-operators of the manufacturing plants they equip, manufacturers co-designing the products of the retails they supply—are also reflected in changes in supply chains, logistics, and—naturally—the packaging that flow through them and the labels that help direct that flow. These changes in packaging and labels in turn open both invite and compel innovation in areas that have long been the province of the forest products industry. We discuss one such innovation—RFID—to illustrate the opportunities and risks along this path to renewal.

RFID or "smart tags" are essentially microchips with transmitters and antennas that broadcast electronic product codes (EPCs) to other devices over radio frequency waves. EPCs are the successors to the familiar line-of-sight bar or universal product codes (UPCs) used to track the movement of everything from freight cars to cartons of toothpaste or individual garments from point of origin to destination. As bar codes before them, smart tags can be embedded in the product itself, or its plastic or paper package, becoming an inseparable part of product labeling.

To economize on expensive memory capacity, smart tags used as labels will initially store only about as much information as currently contained on UPCs. The decisive advantage of the EPC over the UPC is in affording automatic, instantaneous access to that information without requiring physical access to the tagged object. Standard smart tags can broadcast to readers 6 to 9 feet away with high resolution: RFID tags can identify individual items in multiple-pack boxes. Retailers using shelf-mounted readers can do inventory without removing products from cartons or moving pallets; shippers can track containers, their contents and the trucks or trains hauling them as they circulate through depots. Password protection can make the broadcast information secure.
But as in any effort to create near universal standards of this kind, cutting across

the boundaries between firms, industries and positions in supply chains, there are substantial coordination problems. Retailers get the benefits of RFID by making a one-time investment in readers and information systems: For them decreasing the risk of stock-outs—losing a sale because the merchandise is unavailable in the precise variant demanded—is itself of great value. Manufactures, on the other hand, have to buy tags for every item them ship. How will the costs and benefits be shared between retailers and manufactures? Large freight forwarders anticipate substantial gains to themselves from better knowledge of where their equipment is. This knowledge leads to higher rates of capital utilization—more goods moved with less or the same equipment—and lower risk of the fleet manager's equivalent of a stock out—not having a truck or container to move goods when schedules must be met. But the value of the locational information is directly related to its completeness: If all terminals have readers, every shipper gains from using RFID tags, but if readers are spotty, none is eager to be the first to invest in tagging the fleet and containers. Is there a way to ensure that all act together, rather than all hold back because each fears acting alone?[27]

For natural problems there are, in part, natural answers: Some retailers are so large that they can in effect command their lead suppliers to switch to the new technology. Wal Mart has already done this for RFID. Some manufacturers are so large that they can benefit themselves from the superior information that RFID affords about internal logistics, and even more from what they learn about how their products are actually displayed in large retail outlets. Proctor and Gamble is in this category—or at least is convincing itself that it should be.[28] Some large shippers, such as DHL or UPS, have door-to-door control over the goods they carry, and customers so intent on knowing the moment to moment location of their shipments, that conventional, or nearly conventional calculations of return

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[27] Robert Hadow, "The Math Behind RFID in Logistics," RFID Journal, Jan. 31, 2005.
[28] Dan Gilmore, Procter and Gamble "Unplugged" on RFID, Supply Chain Digest, June 7, 2007, http://www.scdigest.com/assets/FirstThoughts/07-06-07.php?cid=1078&ctype=content

on investment favor introduction of RFID. (Noha Tohamy, Forrester Research, "The Present and Future of RFID in Logistics," November 16th, 2005)

In the end, though, RFID is likely to have a bright future, and Finish firms will be part of it. UPM Raflatac, a unit UPM, is already a world leader in the manufacture of RFID tags and inlays. In 2007 it doubled RFID tag and inlay production capacity at its Jyväskylä plant in central Finland to meet rapidly growing demand. The firm also has a plant in North Carolina. Its RFID tags can embedded in plastic containers or packaging and withstand the frequent hot water and aggressive chemical washes to which many returnable plastic containers are subject. The firm is testing its technology in supermarket meat trays in Europe and says trials in North America are expected to start shortly and in advanced retail settings such as those of J. Crew.[29] Perhaps most suggestively, the firm is co-designing its products with others—readers with Tyco Security, quality assurance protocols with a Spanish specialist—in a way that the fluid and rapidly changing context of competition would seem to require—but which is, as we have repeatedly stressed, not the rule in Finland.[30]

4.2 ICT Scenarios

The future of the Finnish ICT industry depends first and foremost on the success of its dominant producer, Nokia, and the surrounding ecosystem of smaller, less well known domestic producers, in global battles to define and meet customer needs for ICT-based products and services. But as with the Finnish forest products industry and its competitors, we cannot realistically assess the outcomes of this competition, nor can we see farther ahead than others into longer-term futures in an unpredictable and rapidly changing technological and competitive environment. Least of all can we explore possibilities that exist only in concept, such as nanotechnology-based phones that can change states—a

[29] "Thirty RFID Case Studies in Retail: J Crew: Apparel, Item Level, USA," http://server2.idtechex.com/pdfs/en/T7248J7940.pdf
[30] TYCO Fire & Security and RAFSEC to Deliver EPC-Compliant RFID Tag Reader Systems, http://www.sensormatic.com/WhoWeAre/prDetail.aspx?id=110

real concept, but too far from reality to be conceptually interesting. What we can do instead is illuminate near-term opportunities open to the industry, suggesting possible elements a healthy economic future for Finland. Even here there is a caveat: While most of these opportunities will be described as technological scenarios, the pace of change in the sector quickly renders scenarios obsolete. Three years ago, for example, few would have listed Apple among Nokia's leading competitors. Who can say what Google's relation to Nokia will be three years from now?

By establishing itself as a leading producer of mobile phones, Nokia fuelled the recovery and growth of the Finnish economy in the 1990s through the development of a dynamic ICT industry. The positive links between Nokia, the ICT industry, and the domestic economy were self-evident. However, as this account has demonstrated, Nokia succeeded in part by absorbing and/or reorienting the activities of local suppliers, producers, and researchers towards its own needs, unwittingly undermining the regime of decentralized technological experimentation that was a key source of the industry's earlier successes. As Nokia outgrew the Finnish skill and knowledge base in 2000s, the link between its own success and domestic employment and technological capabilities began to weaken. Today, mobile device sales growth is concentrated heavily in low-end emerging markets, accelerating the movement of production to lower cost locations. At the same time R&D investments are growing in leading clusters of technological expertise like Silicon Valley, rather than Finland. As a result, Nokia's success is no longer sufficient to insure growth of the domestic ICT industry or economy, yet a significant weakening of Nokia's competitive position could seriously damage both the ICT sector and the domestic economy.

The following sections describe emerging technology pathways. Success in these scenarios will likely require both reinvention of existing enterprises like Nokia and the revitalization of the domestic environment for entrepreneurial experimentation. Dynamic new firm formation and ICT growth in Finland during the 1970s and 1980s was rooted in open, horizontal collaborations between university researchers, private firms, and public research institutes in a variety of localized clusters. However the vibrant connections and competitive pressures that characterized these regional ecosystems have attenuated in recent decades. Initiatives like the Tekes program for financing innovative startups launched in April 2008 (http://www.Tekes.fi/eng/) signal recognition of the problem, but the available funds may well be too small, and the bureaucratic project-management process too cumbersome and slow to make a significant difference. Nokia's history of successful reinvention, from paper pulp and rubber boots to electronics, telecommunications, and mobile phones, is a constant reminder not to underestimate the plasticity and determination of the company. But the history is an inspiration and a legacy, not an amulet protecting the firm and sector from a world of competitive threats.

4.2.1 Mobile software and services

There is widespread recognition today that the mobile handset has become a commodity, with falling prices and margins. Increasingly value will therefore be added in the sector by providing software and content, rather than by simply manufacturing mobile devices. Likewise it is not difficult today to identify services and content appropriate for mobile delivery, ranging from music and games to photos and video. The challenge is to gain sufficient scale of adoption to make money providing the services.

Location-based services are among the most frequently mentioned emerging mobile services. The prices of sophisticated GPS devices for navigation are falling, and mapping capabilities are increasingly available. The salience of location-based service helps explain Nokia's acquisition of NAVTEQ, the largest Geographic Information System (GIS) mapping data provider, for $8.1 billion. Multiple possible opportunities lie in helping people identify where they are located, where friends and services and other opportunities are located, and how to get from one to another. There are also potentially unlimited opportunities for mobile delivery of software and services in domains ranging from health care (patient monitoring, information provision and exchange) to finance (personal banking, microcredit, etc.) to environmental monitoring (using sensors.) Some researchers see mobile devices as the primary mode of software and service delivery in emerging economies, where personal computers are not widely available.

But while there is no shortage of ideas for mobile applications (or of competitors in this space), there are few examples of mobile services that have definitively succeeded in the market. Aside from the mobile phone itself, the clear successes can be counted on the finger of one hand: the BlackBerry (sophisticated email and communications management), the GameBoy, the PSP (or Play Station, portable, if you don't use one), the iPod, and the iPod Touch. Finnish firms appear to be ideally placed to develop mobile solutions with their experience in developing phones and qualifying them on networks. However the experience of Nokia's original N-Gage gaming device, which was clunky and (over)loaded with features, none of which worked very well, and which lacked sufficient games, underscores the importance of designing solutions rather than products. The success of firms like Sony and Apple suggests that producing mobile solutions may require an understanding of customer needs and a focus on the integration of hardware, software, and services that differs from the understanding and focus needed for making commodity phones.

4.2.2 Mobile computing and mobile internet services

A related opportunity lies in extending mobile telephony into what is alternately referred to as the "mobile internet" or "mobile computing." This means moving beyond phones as mobile communication devices to transforming the phone handset into a mobile computer and a means of accessing the internet. It promises to serves three distinct but overlapping markets for mobile data: those for entertainment (games and media, esp. music and video), those for information services (business services, info management), and those for communication services (email, SMS, tele- and video- conferencing.) The competition in this space is already strong and coming from many directions, as illustrated below, the Microsoft Zune, Sony's PSP and GameBoy, and Apple's iPod and iPod Touch in the entertainment-centric space, Nokia's N800 Internet tablet, the ASUS Eee PC Asus, and PDAs in the information management space, and the RIM BlackBerry, Windows SmartPhone, Nokia 9500, and Palm Treo in the communication services. Even Google, with no hardware or manufacturing experience, is moving in this direction from its strengths in software and internet services (see Figure 19).

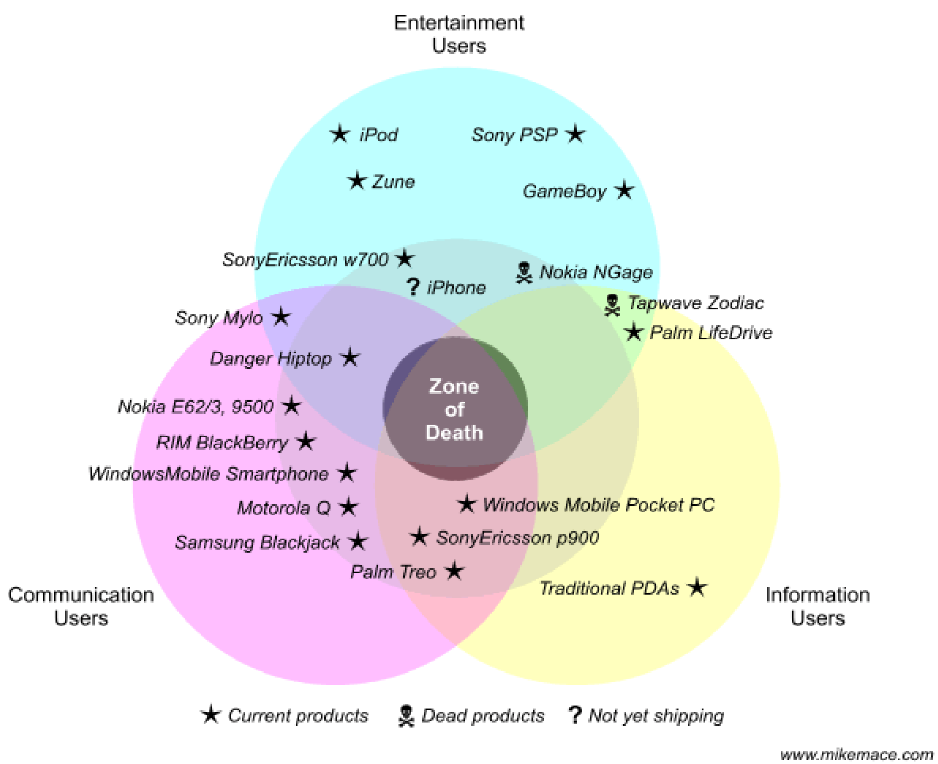

Figure 19. The mobile data market, January 2007 [31]

Competing in the mobile internet-based service business requires diverse expertise and relationships: not only telephony experience and device

[31] http://mobileopportunity.blogspot.com/2007/01/shape-of-smartphone-and-mobile-data.html/

manufacturing capabilities, but also web technologies such as the browser and internet-related software, the system design skill required to produce an integrated and well-functioning solution, relationships with telecommunications operators (carriers), the content providers (music studios, game makers, publishers,) and increasingly even interface and product design skills to insure an attractive product.

In 2007 Nokia publicly signaled its intention to become a developer and publisher of internet content and services with the announcement of several new game and music-capable phones, an online music store and a mobile game store (an updated N-Gage offering). The firm's new website (ovi.com) provides access to all of its mobile services, including games, music, video, maps, photo sharing, etc. This put Nokia in direct competition with Apple and its iPod, iPhone, iTunes, and iPhone video offerings in the mobile computing space. While both have strong brands, Nokia and Apple have very different strengths as companies. Nokia has vast financial resources, logistical excellence, and experience with designing and qualifying phones, as well as tremendous breadth. Apple has deeper skill and experience in system design, user-interface design, and industrial design. Meanwhile the accelerating pace of change makes it increasingly difficult for other producers to enter this space, with the possible exception of SonyEriccson or Microsoft.[32]

4.2.3 Mobile Service Platforms

We have thus far described competition in mobile computing as parallel to that in PC-based computing: producers competing to develop the best mobile software applications, services, or solutions. However the parallels were limited until recently by the fragmentation of the market and the proliferation of incompatible and mostly closed and proprietary operating systems (Windows Mobile, Palm

[32] See Michael Mace "The War Between Nokia and Apple" http://mobileopportunity.blogspot.com/2007/09/war-between-nokia-and-apple.html.

OS, Psion, Symbian, etc.) No producer had established a dominant mobile platform that would enable a proliferation of applications, in turn accelerating the growth of the overall market for devices, as Windows did in PC world.

However competition to define and dominate mobile standards has intensified. Google's announcement of the free, open source Android mobile operating system signaled an effort to enter the mobile space from the internet industry, and to challenge the "walled gardens" of the proprietary mobile operating systems, e.g. Windows and Symbian. The creation of the open mobile OS appears to be an attempt to trigger rapid development of compelling mobile applications, generate demand for Android-based handsets, and potentially establish it as a de facto standard.

Nokia, which also seeks to provide the dominant mobile platform, significantly increased its ability to support multiple platforms and development options through the acquisition of Trolltech, a Norwegian company that makes development tools for applications that run across multiple operating systems and Linux software, and its subsequent announcement that it would make Microsoft Silverlight (a web application graphics and interface layer that competes with Flash) available for all of its mobile platforms. This may be motivated by the desire to mount its own open source OS, and/or to prevent any other single platform from dominating mobile applications. However the proliferation of platforms discourages developers from designing mobile applications altogether (because they need to keep recreating the wheel by building versions for multiple operating systems, browsers and platforms) and leads them to focus instead on designing web-based services that can be accessed with a browser.[33]

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[33] See Michael Mace "Nokia and Microsoft, sittin' in a tree…" http://mobileopportunity.blogspot.com/2008/03/nokia-and-microsoft-sittin-in-tree.html and "Mobile Applications- RIP" http://mobileopportunity.blogspot.com/2008/02/mobile-applications-rip.html.

The most significant event in the fast-paced and accelerating competition to dominate mobile service platforms is Apple's recent, uncharacteristic, decision to open up its operating system to outside developers. Many observers view the release of the iPhone software developer kit (SDK) as a "game changer" because it has created, for the first time, the opportunity for a community of third-party developers to design and certify mobile applications relatively profitably, and without burdensome constraints,. The venture capital firm, Kleiner Perkins, simultaneously created a $100m fund for iPhone developers (dwarfing Google's $10m contest for Android applications.) The expectation is that this will fuel rapid growth of applications—in all arenas, ranging from games and business to media and location-based services—and will make the iPhone more attractive to customers, which will in turn attract more developers, bringing in more users, and so forth in a virtuous cycle. In the words of one analyst: "The rest of the industry is still trying to figure out how to respond to the system design of the iPhone, and now they need to also figure out how to run an ecosystem as well. Right now Apple is changing the terms of competition faster than the other guys can react."[34]

Apple has, in short, greatly raised the competitive pressure for any firm that seeks to have a thriving mobile applications portfolio. Nokia still had more developers (150,000 in all) than Apple, but will need to quickly develop software developers kits for its different devices (the S60, S40, N*** series) and establish a viable music-video-applications store (which depends on negotiating deals with studios for videos, and so forth.) Nokia has already faced resistance from its operators (carriers) who don't want to cede their control over services and content, and it remains to be seen how they will overcome this challenge. While Apple lacks Nokia's breadth of product offerings, the advantage of a single device and OS is clear in developing an ecosystem.[35]

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[34] Michael Mace "The iPhone SDK- Apple gets it right" http://mobileopportunity.blogspot.com/2008/03/iphone-sdk-apple-gets-it-right.html.
[35] CounterNotions "Who can beat iPhone 2.0?" http://counternotions.com/2008/03/10/iphone2-competitors.

4.2.4 Platforms for Ubiquitous Computing

There remain opportunities to define platforms that extend the reach of mobile and digital devices into other product and service areas. The vision of a ubiquitous computing future has been widely discussed but is only in initial stages of being implemented. Nokia's Wibree, an energy saving wireless standard for short-range radio communication between mobile devices, personal computers, and small power devices (located in shoes or watches) offers a warning: the technology was never clearly differentiated, it offered little of new value to consumers, and was introduced in 2006 before it was completely defined. A year later, Wibree, under development since 2001, was quietly folded back into the Bluetooth standard.[36]

The opportunity to provide the standards for connecting a range of digital household entertainment, communication, and information management devices remains significant. The challenge will be to develop technology that can efficiently transfer digital content between mobile phones, personal and desktop computers, and other devices such as TV/video players, music players, and even electronic books; and to insure that there is sufficient adoption of the standard to insure widespread inter-operability.

If there is a broader lesson for Finnish ICT from the scenarios presented here, it is the importance of working closely with and learning from customers, as well as continually refreshing internal knowledge of what is feasible by monitoring distant technologies and business models. Finland's ICT industry mobilized resources to capitalize on an emerging technological and market opportunity in mobile telephony, and has maintained leadership through scale and optimization. The

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[36] See Bill Ray "Why, why, Wibree? http://www.theregister.co.uk/2006/10/06/wibree_analysis/ and Tony Smith "Nokia Folds Wibree into Bluetooth" http://www.reghardware.co.uk/2007/06/12/nokia_folds_wibree_into_bluetooth/.

industry has flourished in a world of managed competition in which operators, handset vendors, and governments set shared standards for mobile communications, allowing vendors to time the introduction of new features in a relatively protected and slow-changing context. This environment shaped the routines of domestic institutions like universities and public research institutes as well.

The computing and internet worlds, into which the mobile phone industry is quickly being absorbed, is more open, more competitive, and faster-paced: barriers to entry are low and innovation can come from almost anywhere, including smallest firms. The challenge is no longer to simply design new features or technologies into a device; the challenge is to design complete solutions that integrate the hardware, software, and services to meet customers' needs. This requires changing internal processes and culture, altering relationships with operators and customers, and redefining partnerships with both private and public sector collaborators.

4.3 The "Varkaus" Scenario

The scenarios just presented have in common the assumption that Finish firms will continue to lead their sectors: They will define and in that sense "own" the technology platforms which integrate, and thereby make usefully accessible, a rapidly changing series of subsystems or applications, each adding functionality itself and increasing the value of the functionality of the others. But suppose, as the foregoing may suggest, that there is a chance that platform leadership passes, at least for a time, to firms outside of Finland. The kind of industrial leadership Finland enjoys in ICT and forest products was arduously acquired. Its loss would be an affront to national pride. But the loss of leadership would not completely devalue the skills and prowess that Finns have worked so hard to accumulate. Suitably reconfigured, we would expect that Finnish firms could quickly redeploy the skills they contain to produce applications or subsystems for the new platform leaders. Indeed, we might even speculate that a period of collaborative "followership" of this kind could be an expeditious, perhaps even necessary step towards regaining leadership—or discovering that in today's world of co-design and co-production the difference between leading and following is itself fugitive.

Our expectation that Finnish firms could well survive the loss of leadership and prosper as applications makers is based on two kinds of considerations. First, and very generally, even a brief canvass of the vicissitudes of platform providers suggests just how vulnerable platform "leaders" are to coordination failures—failures, that is, of their own ability to coordinate all the different sides of the markets in innovative products that they are aiming to develop. It is far from clear that the most desirable position in an industry is that of hegemon, connecting all the others and determining by the form of connection the development—at least and perhaps only—in the short to intermediate term. As the economics of multi-sided markets plainly demonstrates, platform leaders do not enjoy natural, self-reinforcing monopolies. [37] As a general matter leadership is a strategic choice, to be weighed against its costs, not the sine qua non of success, to be pursued by all means.

The second kind of consideration is empirical, rather than theoretical. The re-organization and sale of large plants or even divisions of Nordic multinational firms in the last decade or so has created many situations where operating units which were long units of de facto platform leaders became formally subordinate suppliers or branch plants to foreign multinationals with their own platforms. These situations approximate natural experiments allowing us to see whether,

[37] See Annabelle Gawer & Michael A. Cusumano, Platform Leadership: How Intel, Microsoft and Cisco Drive Industry Leadership (2002); Evans, David S. & Richard Schmalensee, *Some Economic Aspects of Antitrust Analysis in Dynamically Competitive Industries*, 2 Innovation Policy and the Economy, Vol. 2, A 1-50 (J. Lerner Jaffe & S. Stern eds., 2001); Rochet, Jean- Charles & Jean Tirole, *Two-sided Markets: An Overview, (*IDEI Working Paper, 2004) available at *http://www.frbatlanta.org/filelegacydocs/ep_rochetover.pdf*. David S. Evans et al., *A Survey of the Economic Role of Software Platforms in Computer-Based Industries*, (CESIFO Working Paper No. 1314, October 2004).

and in what measure, the capacities developed in particular units of an integrated platform maker can be redeployed in compete successfully against internal units and external suppliers of the headquarters with analogous competences. All else being equal, to the extent that the former units of “vanquished” multinational flourish in the new setting we can conclude that they had, or could easily develop generally valuable capacities, not tied to the specifics of their previous platform, and we have reason to be optimistic that even large changes in ownership—of the kind that could result from the loss of industry leadership—could be much less disruptive to the operating units of the former leader than its own headquarters apex.

For present purposes the most relevant experience is that of an industrial town in the center of Finland—Varkaus—where an involutary “experiment” of this kind is in progress, and under close observation by Lilja, Laurila, Lovio and Jääskeläinen (2008). Varkaus was long a mill town of the family owned Ahlström Corporation. By the mid 1980s, Ahlström was a diversified and international company, and one of the largest manufacturing firms in Finland. Until the mid 1980s, Varkaus was the largest of its production sites in Finland (Lilja and Laurila 2003). But starting in the mid 1980s, family owners of paper industry companies in both Europe and the US came to doubt that they could meet the rapidly growing capital needs of their firms. Ahlström was soon involved in these deliberations (Kosonen 1994). In 1987, the firm sold its pulp and paper manufacturing facilities in Varkaus to Enso Gutzeit, a state-owned forest industry company. This was a start of the transformation of traditional industry in Varkaus, as a series of multinationals—including Honeywell (industrial controls) and Foster Wheeler (energy technology) from the US, Andritz (pulping technology) from Austria, Hartmann (egg cartons) from Denmark, Stora Enso (pulp, paper and saw-mill products), co-ownded by the Finnish State and the Swedish Wallenberg family, and CAE-AFT (screen plates) from Canada—soon bought former Ahlström units.

From the late 1980s, when the round of acquisitions began, to roughly 2000, the new subsidiaries flourished. Foster Wheeler prospered on the basis of its innovative boiler technology. After some difficulties, the Honeywell subsidiary demonstrated to headquarters that its process controls for the pulp and paper industry were more competetive in Finland and world-wide than the firm’s other products. The Varkaus unit was recognized as the corporation’s leader in the sector as Honeywell as a whole, and partly influenced by the Finnish experience, moved towards a more sector-specific form of organization in the late 1990s.

The period since 2000 has been more turbulent, but the adaptive capacity of local units, and beneficial, higher-order effects on regional—though not necessarily particular municipal—economies continue to be in evidence. Thus StoraEnso closed one fine-paper machine mill—PM 1—to reduce capacity, putting 155 jobs at risk. The firm and the paper workers’ union carefully registered the skills of the threatened workers and matched them to the extent possible to open jobs elsewhere in StorEnso’s Varkaus operations. In the end only 38 permanent blue-collar workers and 12 white-collar employees were actually fired. Of the 38 only 12 were still unemployed after six months. At the same time exhaustive benchmarking of current and potential productivity gains revealed attractive possibilities for expanded production at the firm’s other fine paper mill in Varkaus—MP 3—and beyond that the broader reallocation of operations within Finland. The firm’s Varkaus pulping plant was upgraded, increasing the competitiveness of the whole site; and efforts were made to apply the lessons learned from the skill-matching and benchmarking exercises to the routine evaluation, deployment and development of employee competences. Another upshot of the extensive negotiations triggered by the plant closing was the joint venture, mentioned above, between StoraEnso and Neste Oil to build a pilot bio-fuel pilot plant in Varkaus. (ibid, pp 20-23)

The Foster Wheeler subsidiary faltered after 2000 when it tried to become a turn-key supplier of complete power plants, only to experience expensive delays with several key projects. Confusion at corporate headquarters, and corresponding vacillations in the appointment of managers to oversee the subsidiary, made the situation even more difficult. But in the end corporate headquarters reaffirmed the strategy of making the Varkaus unit a technologically sophisticated supplier of boilers to power-generating utilities. The subsidiary has become a profitable leader in the design of next generation, high-pressure or super-critical boilers that increase efficiency while reducing environmentally burdensome CO_2 emissions. The design benefited from collaboration with the EU's 5th Framework High Performance Boiler (HIPE) Program, VTT, Energoprojekt Katowice in Poland and Siemens AG in Germany (Lundquist, 2003). In orchestrating the construction of the designs the subsidiary licenses and makes available to its suppliers' 3-D computer-aided design and communications software, so the subsidiary becomes in effect a manufacturing hub as well as a design center. Given the ferment in international energy markets and this combination of capacities, it is unsurprising that employment in Forster Wheeler Oy has been growing: In 2006 there were 460 employees, 90 percent of whom had a university education. The goal was to increase employment by 20 percent in 2007, but only 60 places were filled, leaving some 20 open. Partly as a result, and partly to anticipate long-term needs, the unit is increasing its internal skill development capacities, building on traditions that existed when it was under the direction of Ahlström. (pp. 23-25)

For the Honeywell subsidiary too the turn of the millennium was turbulent, as the parent company fused with Allied Signal Corporation and in 1999 and attempted a merger with General Electric Corporation. Nonetheless, by 2002 features of the Varkaus control system became standard for all Honeywell forest-industry products, and the subsidiary was officially designated the leader of its segment. In recognition of this role the unit was accorded a new R&D development center which was soon employing more than 50 researchers on projects linking a variety of sensors and data-mining software in innovative process controls.

At the same time the subsidiary developed a new service model based on iterated, joint problem solving with customers—a model related to several of the scenarios above. The core idea is that Honeywell and the customer agree to pool the information needed to indentify the root causes of problems, and to share the gains from doing so. (cf. Sabel 2005: 114-117). The new model was crystallized in a project involving the re-organization of a specialty pulp mill, Savon Sellu, in the neighbouring town of Kuopio. Dermot Smurfit–former chairman of the board of Jefferson Smurfit Group, a leading board manufacturer—acquired the mill in 2006. Using his own and his family's expertise, he quickly rationalized production, reducing employment from 252 to 180 while increasing production by more than 10 percent. The reorganization depended in part on outsourcing core activities, which gave Honeywell the opportunity to demonstrate the effectiveness of its new service business model in practice. Honeywell Finland soon thereafter entered a similar agreement with Valio, a producer of dairy products also located near Kuopio. Together the agreements put the subsidiary in the forefront of experiments in the new service area of collaborative problems solving.[38]

As these last examples suggest, the benefits of divestment and local reorganization do not necessarily accrue exclusively, or even primarily to a single localty, as opposed to some larger geographic unit such as a region. In fact, Honeywll not only collaborated with firms in Kuopio, but in 2006 uprooted its subsidiary from Varkaus and moved it to the neighboring town. There were many reasons for the move: The University of Kuopio had already started collaboration with Honeywell in the kinds of projects of concern to the new R &D unit, and was interested in extending it further. Kuopio had persuaded the VTT to establish a unit in the field of process automation to Kuopio. A local polytechnic located on the university campus offered laboratory facilities Honeywell could use. Kuopio could match the real estate subsides Vakaus offered. The Kuopio economy was more diversified, so it was easier to find subcontractors, and for

[38] For other examples see http://hpsweb.honeywell.com/Cultures/en-US/NewsEvents/SuccessStories/default.htm)http://www.honeywell.com/.

the spouses of Honeywell employees to find local jobs. The greater economic vitality was reflected in better air connections to the rest of Finland, which was especially attractive given the needs for customer contact that could be expected to grow from the new service model. All of these considerations point to issues of concern for decentralized development policy, but they do not call into question the potential for regional benefits of divestment and reorganization of parts of platform leaders.

A second strand of supporting empirical evidence comes from a recent study by Eliasson of the effect on the regional economy of shocks to large Swedish firms headquartered in the greater Stockholm or Lake Mälar area, including Uppsala, Södertälje and Västerås. Although the study comes to inconclusive econometric results regarding the benefits to new firm formation of shake ups in the large corporate sector, it is useful nonetheless as a reminder, first, that these shake up do occur, even to firms with long and deserved reputations for being well managed, and, second, that such are not obviously disastrous, even if it is hard to demonstrate clear benefits.

Eliasson argues that large Swedish manufacturing firms were able to compensate for domestic stagnation from the 1980s on by opting for "global mass production and distribution of mature products, choosing rationalization of existing production lines rather than reorganization and moving up the value chain to focus on sophisticated technological competition from a domestic high cost base. (Eliasson, p. 216) The continued dominance of large firms was re-enforced by de facto subsidies to that sector (and corresponding disincentives to start-ups) that were implicit in the Rehn-Meidner model of development, which favored the high-wage, mass production sector. By the early 1990s, however, this strategy had reached its limits, and many leading firms went into decline, making manifest at the corporate level a long term deterioration in economic performance reflected in a steady drop in GNP per capita from 5th in the world in

1970 to 17th in 2002. Among the firms affected include ABB, Ericsson, Alfa Laval, Atlas Copco and Pharmacia, to give only a few examples.

As in the case of Varkaus, however, the reverses of one or another large firm in the Lake Lake Mälar region appear to have released resources that can be rapidly recombined to productive ends. For instance, the division of the bio-tech firm Pharmacia in the 1990s into a part owned by General Electric (as of 2004), and a part owned by Pfizer (as of 2002)—to greatly simplify a very tangled corporate history—has given rise to a "host of new start-ups, many of which are based on the competences of Pharmacia, all of them, except Pfizer, with a considerable presence in Uppsala"—where the original firm has been headquartered since 1951 (Eliasson, p. 252.) We say "appears to" because, as noted, econometric tests of the effect of the withdrawal of Pharmacia on firm creation and employment generation are, even 10 years after the first shock, still only suggestive: As Eliasson puts it: "It was not possible to reject the null hypothesis that the Pharmacia withdrawal had a positive or zero effect on biotech employment in the Uppsala region. In other words, for the time being we conclude that the Pharmacia shakeout has not had a negative impact on local biotech employment." (ibid, p. 263)

In sum, even in policy regimes such as those in Finland and Sweden that have in subtle ways favored large, incumbent firms over start ups—the existence of many supports for new ventures notwithstanding—the outcome of scenarios in which actors as well as actions change is certainly not discouraging. On the contrary—the limited successes of (still) marginal cases such as Varkaus/ Kuopio raises the question of how the policy agenda might need to change in order to make the most of opportunities that could be thrust upon the Finnish economy. The next chapter takes some first steps towards addressing that question.

5 THE END OF THE NATIONAL INNOVATION SYSTEM: A CONCLUSION AND THE FURTHER THOUGHTS ON A NEW BEGINNING

The standard story of the Finnish miracle is one of sectoral succession, the shift from a resource-intensive manufacturing economy to a new, knowledge-based economy. In this account Finland led the world, along with Silicon Valley, in the transition to the "information society" as domestic telecommunications and ICT-based industries replaced the forest products and paper machinery industries as the economic base. Our case histories demonstrate, however, that the Finnish paper-making and mobile phone industries have more common with one another than the standard accounts suggest; and that the focus on their output hides the deeper similarities--and vulnerabilities--of the two sectors. Both were not long ago paragons of flexibility. Both achieved global success through—and came to understand that success as depending on—-competitive strategies based on process optimization. In part deliberately, in part not, both adopted corporate and managerial structures that maximize exploitation of the existing technology trajectory, rather than systematic exploration of alternatives. The success of this strategy, we have seen, has created new obstacles to search and flexibility in an environment when disruptive innovation is likely to emerge from unanticipated sources. By way of conclusion we here quickly show how the national innovation system came to be centralized in various, overlapping ways, and how Finnish policy makers—sensing the end of the era of national innovation systems—have recently begun to shift course. We think they are right to do so, provided that in their haste they do not forget that they are likely to be wrong this time too, and will need to catch and correct errors more quickly than before.

Finland's forest product and telecommunication industries were shaped by their origins in the pre-independence 19th and 20th centuries, and by the extensive state investment in infrastructure and industrial capacity-building in the post WWII decades, including support for horizontal collaboration among researchers in private industry, public institutes, and universities. The close ties between the new state and these emerging industries, and frequently even the interpenetration of industrial and political elites, supported rapid accumulations of technological know-how and talent that allowed the leading firms in both industries to innovate and achieve the global technological frontier quickly.

Because public investments in the post-war period were guided in part by a commitment to regional equity, these decades were characterized by the decentralization of innovative capacity and a diversity of potential technological alternatives. The location of the VTT electronics lab in Oulu in the 1970s, and its collaborations with both Oulu University and local firms created a cluster of skill in embedded computer control, digital signal processing and software design. Similarly the collaborations between Helsinki University of Technology and the Nokia R&D Center in Espoo during the same period created leading-edge knowledge and capabilities in cellular and digital radio technologies.

The financial deregulation and restructuring following the recession of the early 1990s reduced direct state ownership and intervention in the economy, resulting in a more market-oriented system with a technocratic elite making policy decisions to enhance the institutions of the "national system of innovation." For most, the success of this policy regime in fuelling Nokia's rise to global leadership in mobile devices has ratified the classic endowment-based approach to economic policy. This view sees the economy as a giant production function with policymakers investing in increasingly sophisticated inputs, such as highly educated workers, support for basic and applied R&D, etc. On this view, as long as basic market protections are in place, these investments alone will fuel technological innovation. Tekes, along with Finland's universities and polytechnics, were the key institutional foundations for this national innovation system.

The limits of this strategy became visible in forest products in the late 1990s, when profit margins and investments by the leading companies (UPM-Kymmene, Stora Enso, and Metso) began to decline. Today it is clear that continued focus on process improvements in paper-making and paper–related disciplines is a dead-end strategy in a global market characterized by overcapacity and the rise of aggressive new competitors in developing countries with far lower costs. However domestic producers appear to be trapped by their own mindsets and organizational investments and, even when recognizing that more radical change is needed, continue perfecting the existing technology pathway rather than develop alternatives that allow them to search more broadly for technology. And while Nokia's remains profitable, it too faces fierce competition from producers in both emerging and advanced markets. The closed, organizational model that allows it to remain the lowest-cost producer of mobile devices significantly constrains its ability to innovate along alternative technological pathways. Finnish policymakers, who appear similarly blinded by their past successes, have only recently acknowledged the significance of the changed competitive environment for domestic institutions.

The prospects for longer term growth in Finland will require rethinking domestic institutions and policy in light of the new environment in which there is no fixed technology frontier but rather multiple possible ideas and technologies opportunities in diverse, and often unrelated, domains. The Finnish "national system of innovation" –with its institutions for public funding of education and research as well as horizontal collaborations between researchers in private industry, universities, and research institutes—fuelled successful innovation in both forest products and ICT industries during the 1990s, but appears to have become self-limiting in the global environment of the 2000s.

5.1 The Political Economy of the National Innovation System

By the turn of the millennium, when Finland emerged as a global model of the networked, information economy, the innovation policy regime was dominated by the Ministry of Trade and Industry and the Ministry of Education, which implemented national visions and strategies defined created by the STSC, with its elite leaders from business, universities, unions, and policymakers. The Ministry of Education focused on basic research, through the Academy of Finland; the Ministry of Trade and Industry on applied R&D through Tekes. Traditional industrial policy instruments—including regional and sector-specific institutions—were dismantled to make way for the “national innovation system.” Policy at the local and regional level remained the domain of the Ministry of the Interior, which used its limited resources to create a network of Centres of Expertise, typically linked to science parks, universities, and polytechnics (Goddard, 2007). However, the overwhelming orientation of policy and resources was towards national, rather than regional, institution building.

Finland’s investments in this “national system of innovation” have grown rapidly. Tekes total funding for R&D projects, for example, increased 30% between 1998 and 2007, from 361m to 469m Euros, at the same time that the number of projects it financed steadily decreased. Tekes reports that it financed 2,454 projects in1998 and only 2,120 projects in 2007. The average project size thus grew 50% in less than a decade: from 147,106 Euros in1998 to 221,226 Euros in 2007. It appears that Tekes, which in the 1980s and 1990s provided a flexible source of funding for collaboration and experimentation by researchers in public and private institutions, has become increasingly powerful, but also less relevant to local industrial innovation.

Corporate researchers report that the growing scale of Tekes projects has significantly increased the administrative overhead while also reducing the agency’s responsiveness. Projects funded by Tekes (like its EU-level counterparts) now require long lead times, multiple layers of approval, and detailed hourly bookkeeping that frustrate private sector researchers to the point that some say they are no longer worth the money that they generate. The long funding cycle, often up to three years from an initial application to a financed project, cannot match the pace of innovation in the private sector, where product life cycles are often under a year. Top Finnish corporate researchers increasingly consider both national and EU R&D public sector funding agencies irrelevant. The Nokia Research Center, for example, which received substantial Tekes funding in the past, is discontinuing its reliance on public R&D funding—not least for fear that by accepting support it will be obligated to dedicate resources to projects for years after their futility has been demonstrated.

Since Tekes oversees virtually all programs for financing domestic applied R&D, it has in turn shaped the behavior of a wider network of institutions. University researchers, for example, have become adept at applying for and managing grants from Tekes and EU research agencies; likewise Finland's public research institute VTT, the Polytechnic universities, and the Science Parks have followed this lead. Without richer exchanges with diverse private sector collaborators, however, these institutions are destined to fall behind in fast-changing markets.

The growth of investments in the national innovation system has been associated with a geographic and institutional concentration of innovative inputs. The critical components of the Finnish innovation system are located in the nation's leading urban areas. More than 40 percent of Finland's R&D activity is located in the Greater Helsinki region, and over 60 percent is in just four regions (Helsinki, Tampere, Oulu, and Turku—each home to a Nokia research lab.) Likewise just two universities, Helsinki University of Technology and Tampere University of Technology, along with the Technical Research Centre of Finland (VTT), receive a sizable majority of the public research funding from Tekes, even though the country is home to some 20 universities and 28 polytechnics. A map of the share of Finnish regions receiving R&D funding from Tekes would likewise show the same dominance of the Helsinki region (44% in 2003) along with Oulu, Tampere, and Turku (81% in these four regions alone.)

One scholar observes that by the early 2000s the institutions of the "national innovation system" were, for all practical purposes, concentrated in central Helsinki, which Steinbock (2006) calls

> . . .the command and control center of the Finnish innovation system . . . (and home to) the headquarters of the half-dozen world-class corporations and their R&D activities, and the public sector players including the STPC and the key government organizations (Ministry of Trade and Industry, Ministry of Education, and other Ministries as well as Parliament), the implementer-financiers, particularly the Finnish Funding Agency for Technology and Innovation (Tekes), the National Fund for Research and Development (Sitra), and the Academy of Sciences.

The few programs that sought to decentralize administration and achieve greater regional balance have thus far encountered in “resistance and tradeoffs.”

Nokia’s dominance in all measures of Finnish innovative capacity is also striking. While this began in the 1980s and 1990s, it continued into the 2000s. Nokia was responsible for some 40 percent of total R&D spending in Finland in 2002 and held title to 70 percent of Finnish patents issued in the US, up from 40 percent in 1997 (Daveri and Silva, 2004.) The spatial distribution of employment reflects Nokia’s role as well. Figure 16 displays the development of employment within production of electro-technical components (including mobile phones and parts) and confirms the concentration of electronics-related activity, as well as its relationship to Nokia. The main cities in the regions are Helsinki (Nokia Research HQ)/Espoo (Nokia HQ and Network products), Turku, Tampere (Nokia Research Center units) and Oulu (Nokia Network products) respectively.

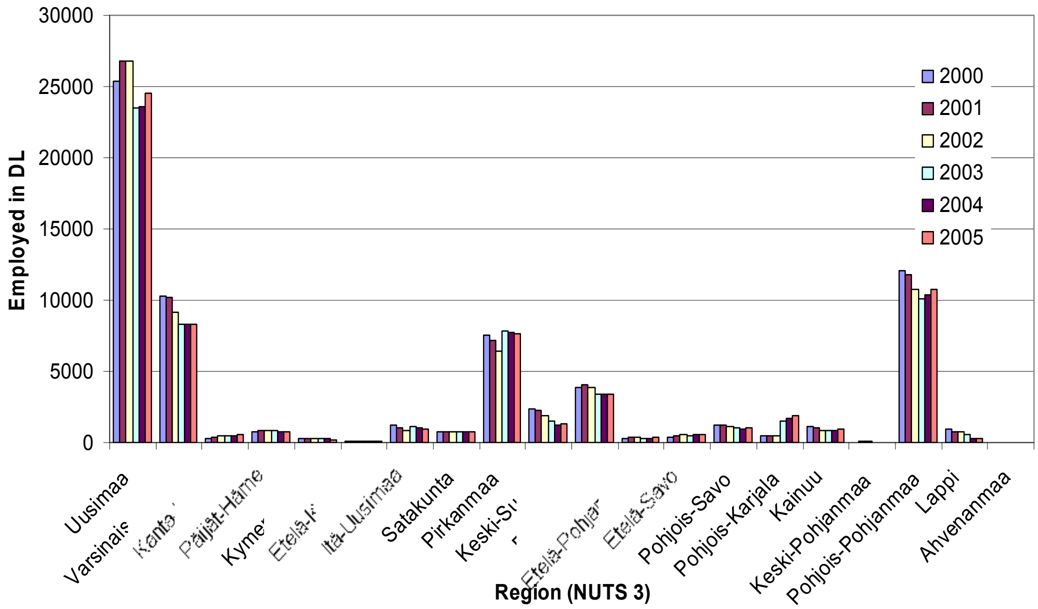

Figure 20. People employed in production of electro-technical components in 2000-2005 by NUTS 3 region in Finland

The dominance of a single firm might not be a problem if it was collaborating with other local firms and institutions. However an analysis of the Finnish economy in the 1990s found little evidence of technological spillovers from Nokia. The national input-output tables show minimal inter-industry linkages between the firm and the rest of the economy.[39] Daveri and Silva (2004) observe that while Nokia "directly and substantially contributed to enhancing productivity growth" in the country, productivity gains outside Nokia and a few other IT-related service industries were "small, temporary, or non-existent at all." They conclude that the productivity gains recorded in a few other fast-growing service industries were not related to Nokia's boom, but rather to the decline in the world price of computing power.

[39] Both forward linkages and backward linkages are thin. Aside from the transactions taking place within Nokia, the company's only quantitatively significant linkage is with 'business services.' The scale is still small: for a 10% increase in Nokia output raises the demand for intermediate inputs from Nokia itself by 2% and from business services by 0.5%. Daveri and Silva, 2004.

Finland's ICT industry is now characterized by a relative dearth of small and medium-sized enterprises: the amount of entrepreneurial activity and corporate spin-offs ranks among the lowest in the OECD. The Global Entrepreneurship Monitor (GEM, 2000) describes the "Finnish Paradox:" in spite of many favorable conditions, only 4.9% of the Finnish working age population was involved in new or emerging firms, compared to 12% in the leading countries for total entrepreneurial activity; Finland thus ranked 15 among 21 high-income GEM countries surveyed. By 2007 this proportion had risen to 6.9% and Finland's ranking rose to 8th out of 23 high-income countries (GEM, 2007). Yet Finland still performed poorly in the prevalence of "high-growth expectation early-stage entrepreneurship" (as opposed to total early-stage entrepreneurial activity) in the adult population for 2000-2006, ranking 18th, with under 0.4% compared to over 1% for other high-income nations such as Iceland, Australia, Canada, New Zealand and the US.

A comparison of early-stage entrepreneurial activity in metropolitan areas based on the GEM data for 2001-2006 shows Helsinki in the bottom quartile (and on par with Brussels, Rotterdam, and Paris) with 4.7% of the adult population involved with startups, compared to Chicago with 14%, New York 11%, London 7%, and Copenhagen 6%.[40] Performance reviews by the European Commission regularly identify the large-scale and relatively undiversified industrial base as a weakness of the Finnish economy. (European Comission 2004: 63; Orsten and Rehn, 2006.)

While Finland shifted decisively from a bank controlled and debt-financed economy toward a stock market-centered financial system in the 1990s, it still appears to lack the financial infrastructure and services (particularly venture capital) that have supported dynamic new firm formation elsewhere in Europe and North America. A comparative analysis of the venture capital industries in Nordic countries found that in 1998-2000, Finland ranked 8th out of 15 European

[40] Acs, Bosma, and Sternberg (2008) details at www.gemconsortium.org.

nations (and behind the Netherlands, Belgium, Ireland, Norway, Sweden and France, as well as the UK) in private equity investments in ICT-related sectors as a share of GDP; and it ranked 9th in terms of private equity investments in ICT related sectors as a share of the total value of investments. The authors suggest that the private equity industries in the Nordic countries lag the rest of Europe in part because they lack the exit opportunities needed for risk-taking investments and in part because the institutions for corporate governance and shareholder protection are not well developed (Hyytinen and Pajarinen, 2001).

We have seen that the Finland's early leadership in telecoms-related technologies grew out of the competitive pressures of a decentralized industrial structure, which was reflected in part in dispersed spatial concentrations of expertise. Finland has not entirely abandoned its policies to address regional uneven development. The Centre of Expertise (CoE) Programme, for example, was launched in 1994 by the Ministry of the Interior and targeted eight regional centers of expertise located near leading universities with the goal of encouraging collaboration between local firms, universities and research institutes. In 1998 the number of regional centers was expanded to fourteen in 1998, along with two national networked centers of expertise; and in 2003 the government added six more centres of expertise.[41] The Finnish Science Park Association, TEKEL, similarly has 33 science parks and technology centres that distributed across the country and closely aligned with the centers of expertise.

There is little evidence, however, that these programs have stimulated local entrepreneurial activity or innovation. Surveys in the early 2000s found that a majority of firms in the Science Parks mainly provided IT services for larger Finnish companies.[42] This is consistent with the findings cited earlier on Nokia's

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[41] See http://www.oske.net/en/what _is_oske/history/.

[42] Sadowski, Dittrich and Duysters (2003) describe a substantive partnership between Nokia and Seiren Solutions, a Finnish developer of software for WAP applications. This appears to be the exception that proves the rule.

relations with its domestic suppliers which appears to be little more than standard subcontracting or software development billed by the hour, while its relations with universities involved primarily contract research (Yrkko 2001, 2002). Nokia's most significant technology partnerships since the mid-1990s have been primarily with international firms, as have those of its larger Finnish counterparts such as the operator Sonera (Sadowski, Dittrich & Duysters, 2003.) And less than 1% of Tekes R&D funding annually goes toward start-up loans to help new technology companies (amounting to 3 million Euros in 2007).

Disaggregation of the Finnish ICT sector confirms these conclusions. The largest share of enterprises in 2004 by far was in ICT Consultancy (4192) and these enterprises had the smallest average size (4.77 employees per enterprise); the next largest share was ICT Wholesale (881 enterprises) with an average 5.40 employees per enterprise. ICT Manufacturing had 662 enterprises and they were significantly larger, averaging 60.07 employees per enterprise, and Telecommunications had only 269 enterprises and 65.45 employees per enterprise. (Nordic Information Society Statistics, 2005) If we eliminate the numerous but small wholesalers and consultancies, Finland had only 931 manufacturing and telecommunications enterprises in the ICT sector.

The weaknesses of the domestic environment for entrepreneurship is evident in a survey in 2000-02 of Finnish companies that were "born global" (they entered international markets in their first couple of years, compared with conventional companies that often took ten times as long to globalize). The researchers characterize many of these 89 companies as fragile, and "desperately" in need of help in planning their businesses, even though they were already supported by either Tekes or venture capital (which is how they were identified) and even though they were the "winners" as they had succeeded in globalizing. Nevertheless, the bankruptcy rate was 10 percent per year, and the companies were struggling with "tremendous entrepreneurial and managerial challenges" (Luostarinen and Gabrielsson, 2006, p. 796).

5.2 Rethinking the National Innovation System?

A series of changes in governmental structure and policy in 2007 and 2008 reflect a rethinking of innovation policy in Finland. It is too early to judge the results of the new initiatives, but two departures are worth noting: first, a new focus on industrial sectors, or clusters, and second, increased attention to the development of regional capabilities. In addition, a powerful new Ministry of Employment and the Economy (MEE) was created in 2008 with responsibility for employment, regional development, industrial policy, innovation and technology policy, energy policy, and competition policy.[43] While these changes indicate recognition of the need for change, and some movement toward decentralization, we do not believe they are sufficient to forestall the economic shocks to the large established Finnish corporations in forest products and ICT in the coming years.

In 2007 Tekes announced the launch of Forest Cluster, Ltd—the first Strategic Centre of Excellence in Science, Technology and Innovation (STI.) Forest Cluster Ltd. is a consortium aimed at coordinating top-level, longer term research programs that combine funds and expertise from private enterprises, universities, and research institutes, with public support--primarily from Tekes and the Academy of Finland, as well as from the EU under the Seventh Framework Program. The Strategic Centers of Excellence are aimed enhancing the national research capacity by creating "internationally visible and attractive research units as well as research, development and innovation clusters and programs. . . [that are] globally competitive and significant for the future of the business sector and society." The Science and Technology Policy Council authorized the formation of centres in the five areas: energy and environment, metal products and mechanical engineering, forest cluster, health and well-being, and information

[43] The MEE assumed the functions of the Ministry of Trade and Industry, the Ministry of Labour, and the Department for the Development of Regions of the Ministry of the Interior.

and communication industry and services. The ICT and metals sector clusters are expected to launch in 2008.

The Strategic Centers of Excellence engage the same actors as earlier Finnish innovation policies, but the model diverges in three ways: (1.) it identifies a set of strategic sectors (clusters) in advance for research coordination, (2.) it authorizes creation of an administrative unit to coordinate the joint definition of research plans, and (3.) it envisions investments in longer-term (5-10 years), larger, and higher-profile projects than previously possible. This approach has the potential to exacerbate the existing concentration of resources in a network of established companies, universities, and locations—while also potentially creating new divisions between clusters at a time when they might especially benefit from cross-fertilization. It also assumes that the participants in these "clusters" are sufficiently foresighted to anticipate the technological trajectory 5-10 years in advance—rather than having to continually search and experiment to identify and exploit opportunities for innovation.

The other significant change is a public recommitment to local and regional level economies and innovation systems—a move toward decentralization. The Centre of Expertise Programme (OSKE), which dates to 1994, was renewed in 2007 for a six year period in order to "improve regional competitiveness in line with national and European policies." The program traditionally provided small amounts of funding and high-level status in the Finnish innovation strategy to encourage cooperation among universities, research institutes, companies, and municipal actors in 21 regional Centres of Expertise. The 2007 program created 13 new Clusters of Expertise—or Competence Clusters—selected through a competitive process to represent the top expertise in their fields, which range from Food Development, Clean Tech, Energy Technology and Health and Wellbeing to Ubiquitous Computing, Nanotechnology, and Tourism and Experience Management.

These Competence clusters are organized to draw up a strategic plan that encourages cross-regional cooperation among the actors in the differently specialized concentrations of expertise, while also increasing the “critical mass” needed to insure international competitiveness in these areas. The program is coordinated at the national level by a committee of experts that includes representative of the Ministry of Employment and Economy, the Ministry of Education, and Tekes. It is difficult to predict whether these competence clusters will help reinvigorate local experimentation and innovation. The process of defining joint projects should ideally encourage participation by new actors in cross-cluster collaborations of the sort that didn’t exist previously; but much will depend on the incentives for different actors to participate across regions and domains. Since the funding and implementation of both cluster-based R&D policies—the Competence Clusters and the Strategic Centers of Excellence—potentially involves many of the same of actors, it is also worth asking who participates in each of the programs, and whether their research agendas compete with, complement, or otherwise relate to one another—if at all.

Similar problems to those we seen in the national innovation system have emerged at the EU level. The 7th Framework Program introduced the Technology Platform as a policy mechanism to integrate the innovation systems of its members, by encouraging long term R&D cooperation within sectors. A study of the Forest Based Sector Technology Platform suggests that while this initiative has brought together representatives from 30 different countries, participation is quite uneven (Finland and Sweden are over-represented), and even within those countries there are conflicts among the representatives of different actors within the national innovation system (Lilja, Moen and Peterson, 2008). For example KCL and VTT, Finland’s the two largest R&D organizations for forest–based industries, have very different operating modes and research agendas: KCL is more closed and hesitant to participate in pre-competitive innovation collaborations because it is owned by 4 forest industry companies, whereas VTT, which is fully owned by the state, is far more open. It is striking as well that while

Sweden has 7 representatives in the Value Chain Working Groups, none of them are from the private sector, and six are from research institutes. Neither Finland nor Sweden has university representatives participating. In short, problems that confound the Finnish national system of innovation are also appearing (not surprisingly) in EU efforts to coordinate R&D collaboration at the platform, or sectoral, level.

The recent initiatives do not mean that Finland is abandoning its focus on the national innovation system. In 2007 the Ministry of Employment and the Economy began work on a new National Innovation Strategy: they sought input from the many actors in the innovation system by organizing open consultations, expert workshops, and finally a high profile conference. The resulting proposal for Finland's National Innovation Strategy (currently under review by the Government) recognizes that the policies that supported Finnish industrial success in the past are no longer sufficient in an increasingly competitive, global environment. It calls for economic renewal by moving beyond the sector-based and technology-oriented innovation strategies of the past to strategies that support broader, more diversified sources of innovative capability, including addition of "demand-based" innovation policy.

In the absence of more specific analysis of the challenges facing Finnish firms and industries, the recognition of the limits of traditional "supply-based" strategy has led to a far more ambitious, "broad-based" approach to innovation: "Instead of partial solutions, comprehensive renewal and structural development of entire systems is called for." The report refers to ten key sets of measures--including strategic and regional centers of innovation, provision of finance and services for entrepreneurs, public procurement programs to support innovation, incentives for demand- and user-oriented innovation, learning-oriented educational reform, increased scale of higher education and research institutions to become internationally competitive, reforms of tax policy and immigration policy to support competitiveness, and development of management training programs. As this will require the cooperation of multiple actors and institutions, the core of the policy proposal remains "the central government's corporate steering" exercised through a Cabinet Committee on Economic and Innovation Policy (replacing the current Cabinet Committee on Economic Policy) and a high-level Research and Innovation Council (to replace the Science and Technology Policy Council.) Much will depend upon the flexibility and responsiveness of these groups.

It remains to be seen whether this redefinition of Finnish national innovation strategy will allow domestic firms and their partners to open themselves up to entirely new sources of knowledge and expertise, and to redefine themselves and their relationships sufficiently to exploring domains well beyond their current technological expertise.

5.3 What Comes Next?

Finland's public and private institutions face a choice. They can continue to invest in the national innovation system as currently configured, and support optimization along the existing technological pathways (or platforms.) This, we believe, will insure that the crisis now facing the forest products industry will shortly spread to the telecommunications and ICT sectors as well. There would be a silver lining: crisis and breakup of the largest firms will free up skill and expertise that can be redeployed into projects that, over time, could support the regeneration of local innovative capacity and renewed industrial opportunities. But the costs would be high in the interim.

The new innovation policies, particularly the regional centers of expertise and competence clusters, have the potential to stimulate greater cross-sector, cross-domain experimentation and new collaborations in projects that could ultimately redefine the sectors themselves. Much depends upon the incentives for participation and the weight of this more open and decentralized approach, relative to the sector or platform-based Strategic Centers of Excellence model that will likely reinforce the existing concentrations of resources.

If the national system of innovation, along with its counterpart at the EU level, is in crisis, as we believe it is, then the task for scholars, policymakers, and companies, is to develop institutions that encourage adaptation and learning instead of inertia and entrapment. In this way they can support firms in more open searches for customers, partners, and suppliers that can help define innovative and unanticipated new technologies, products, and industries. One crucial step towards doing this is surely for Finland to go beyond the current flurry of program creation and take the lead in exploring what a post-national system of innovation could be. At a minimum that would require monitoring the successes and failures of the new institutions in order to catch missteps early and to prevent the kinds of lock-in that hampered the last generation of policy innovations. As Finnish policy makers know, forward looking action is better by far than recrimination. But as the surprising rigidities of the forest products and ICT sectors show, action can be blinding. In today's uncertain world even the best institutions can not avoid mistakes. They can, however, respond to them quickly. Building such institutions is the challenge for Finnish innovation policy on the cusp of a new era.

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