Innovations in the background of the Nokia success story

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  - External co-operation in Finnish ICT
- 1980-1991 creating competences
  - Sonera (codification of innovative team products)
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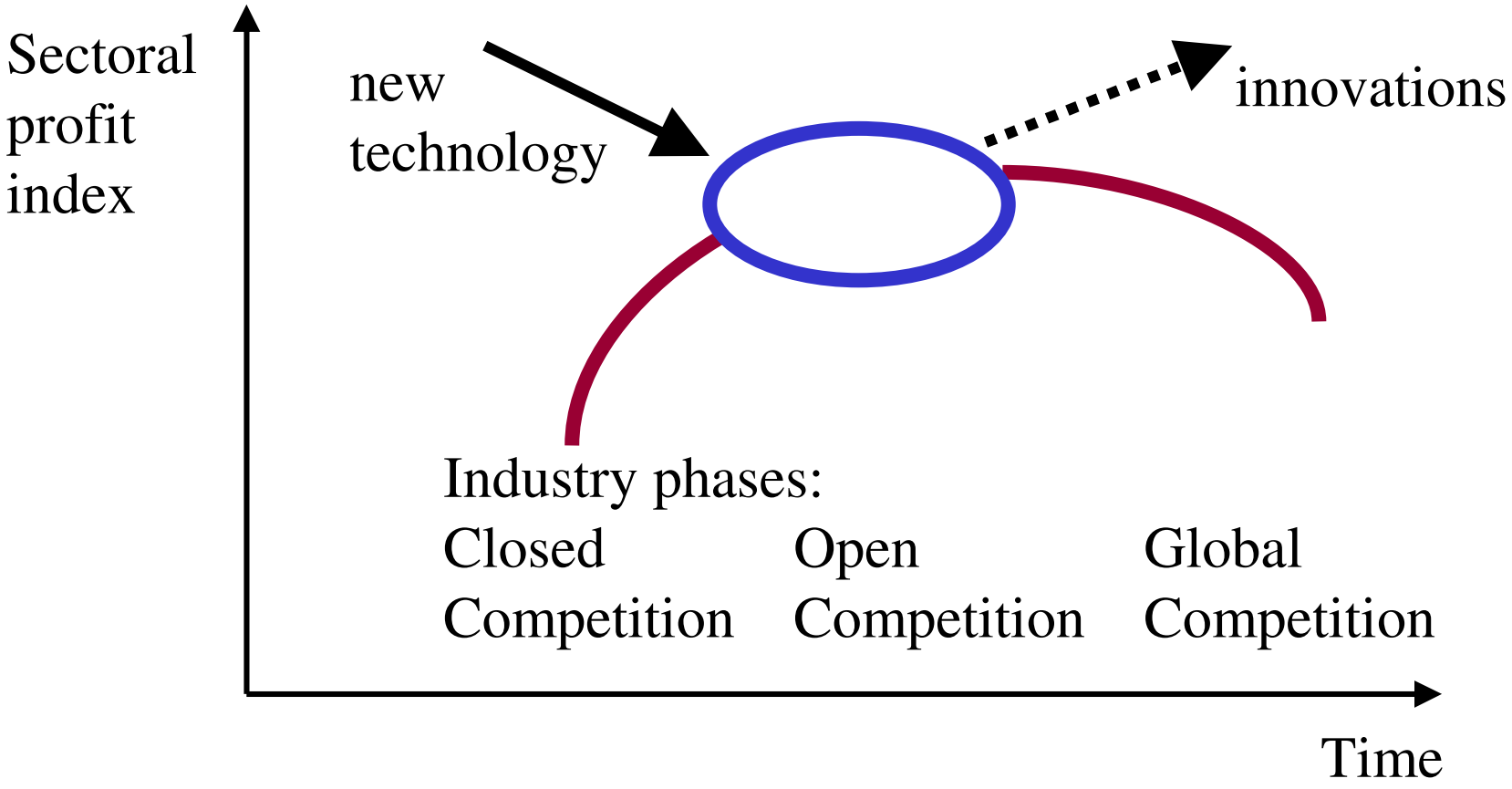
- 1991-2000 reaping the fruits
  - Nokia's role (growth of R&D activities)
  - Leading mobile penetration growth
  - Conclusions

1970 - 1991

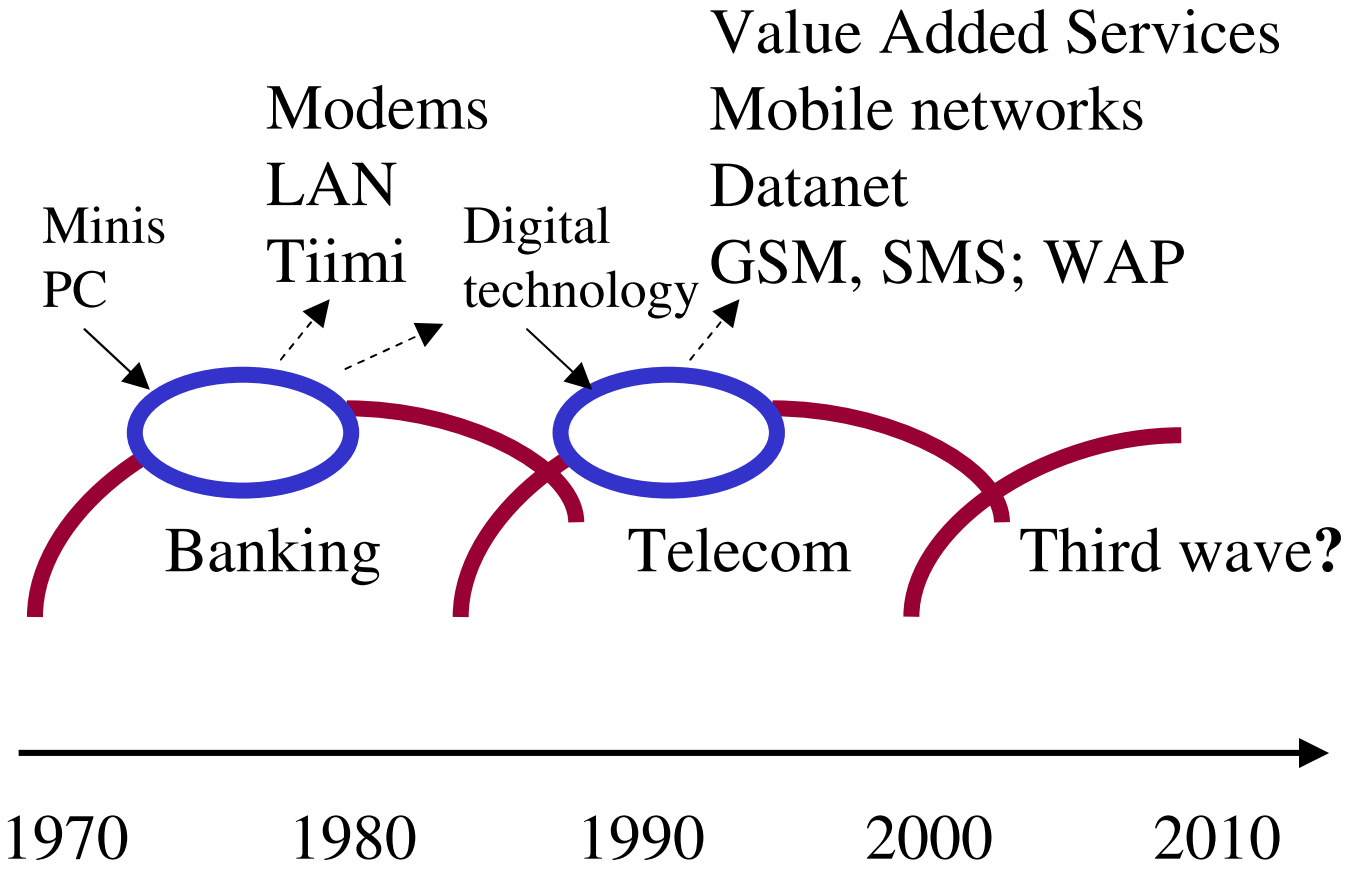
How innovations were born?

- In 1970-1991 -the ICT core of Finland was created
- The Banking sector competed with investing in new offices and new services
  - Digital modems
  - Mikromikko and Netnet
- Telecom sector competed with new services
  - Value added data and voice
  - Mobile services
  - Router networks - Datanet
  - GSM, SMS and WAP
- Both sectors used part of the profit for developing new services in the opening competition

How innovations were born?



How innovations were born?



1970's learning by doing

- New infrastructure investments created ICT competence
  - 1920's - telephone network automatization (Siemens, Ericsson)
  - 1960's - 1980's network digitalization (Siemens, Ericsson, Nokia)
  - 1970's - 1980's investments in banking created modem industry (Nokia)
- Government investments supported Finnish telecom industry
  - 1960's - 1970's Salora → Mobira, Televa, Telefenno, Nokia
  - 1980's digital and NMT network investments by Finnish Telcos
- Establishment of the National Technology Agency in 1983
  - New technology R&D-programs created complementary competences in microelectronics and systems/embedded software (Nokia and GSM)
- Deregulation and global mobile market growth threw Finnish telecom and software industry into fast growth in 1990's

1980-1991 creating competencies

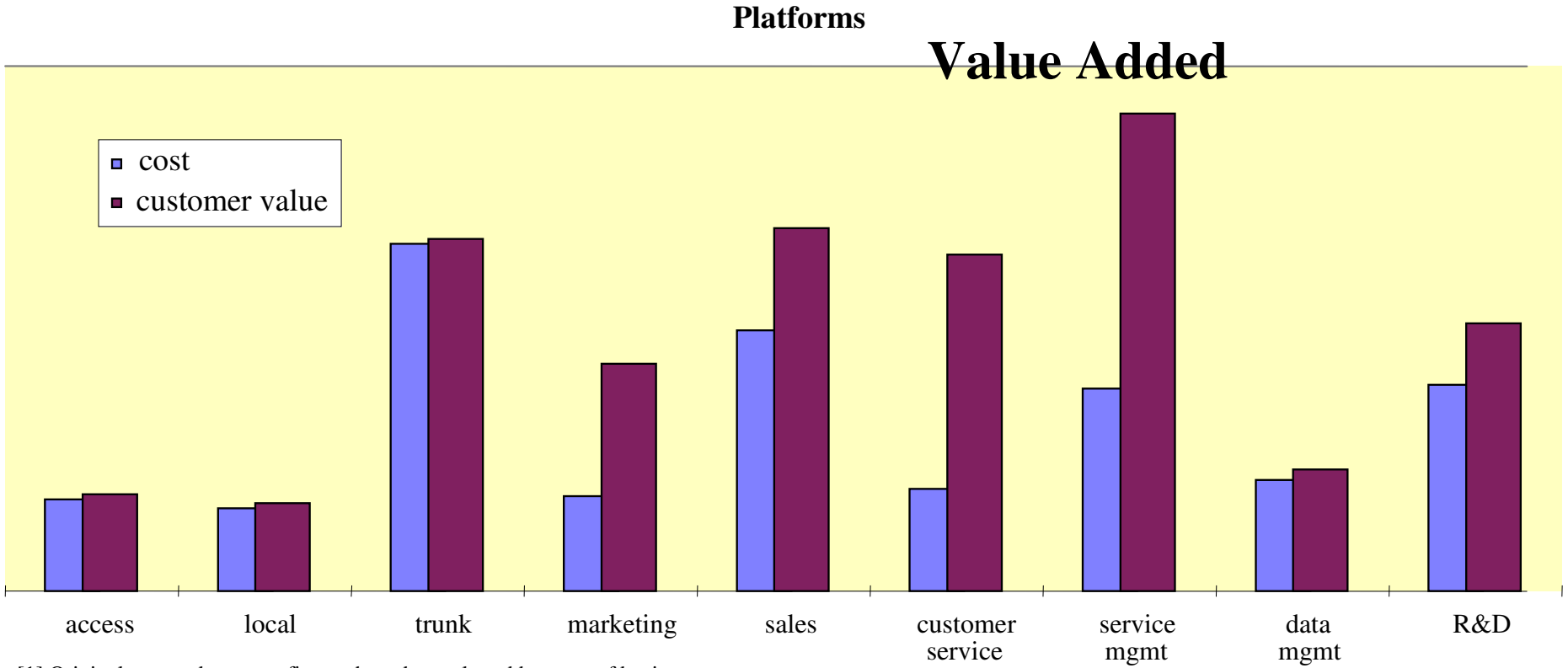
- Banking sector connected local offices to mainframes using digital modems from Nokia - Nokia modems became the largest in Europe 1983
- Nokia providing PCs and LANs to the banking sector
- Sonera as a demanding customer for DX200 and NMT and an importer of new services and technology from USA
- Nordic Mobile Telephone (NMT) – Mobile phones from Mobira and switches later from Telenokia – Mobira became the largest NMT phone supplier in 1985
- Nokia GSM development started 1986

Sonera (Telecom Finland)

- Freephone and Premium Rate Voice (1986-)
  - Splitting Bell Systems to RBOC and AT&T as a US anti-trust operation created fierce competition
  - Finland as a fast applier of Voice and IN services
- Datanet and Finnish router networks (1988-)
  - US corporate model changed to public telco service
  - Became the data services core for more than decade
- NMT and GSM (1981-, 1991-)
  - Scandinavians as early movers in mobile radio

Sonera 9700-Service

Service element cost and value as perceived by third party service providers



[1] Original cost and revenue figures have been altered because of business secrecy.

Source: Olli Martikainen et al

Nokia

- The case of Nokia and GSM by Palmberg & Martikainen 2003:
- Which were the crucial GSM-related technologies and competences enabling Finnish telecom/Nokia to enter, and achieve a strong position in the GSM market?
- Could these technologies be characterised as discontinuous, when, where and how were the related competences developed?
- Lessons learnt and implications to be drawn in light of present developments transition from 2G to 3G/4G/11.5G?
- Contributes on firm adaptation to standardisation/ discontinuity in a crucial period in the history of this firm.

Nokia market shares in cellular switching systems and mobile phone markets globally in 1G and GSM

Nokia market share	**1 G** **1986**	**GSM** **1996**
Cellular switching systems	0%	14%
Mobile phones	15%	24%

(Source: Häikiö 2001; Bekkers and Smits 1997)

Questions addressed

1. Identification of the nature of GSM-related technological discontinuities
2. How and why did Nokia/Finland manage to master discontinuities, enter a new market and succeed?
3. Which lessons might be drawn from viewpoint of ’stylised facts’ and policies vis-á-vis future standards/discontinuities?

A note on the methdology

- Based on longer version: Palmberg & Martikainen (2003)
- Data consists of extensive literature review and 21 semi-structure interviews
- Major effort to identify extent and nature of GSM discontinuity – ’discontinuity chart’
- Research triangulation through multidisciplianry team

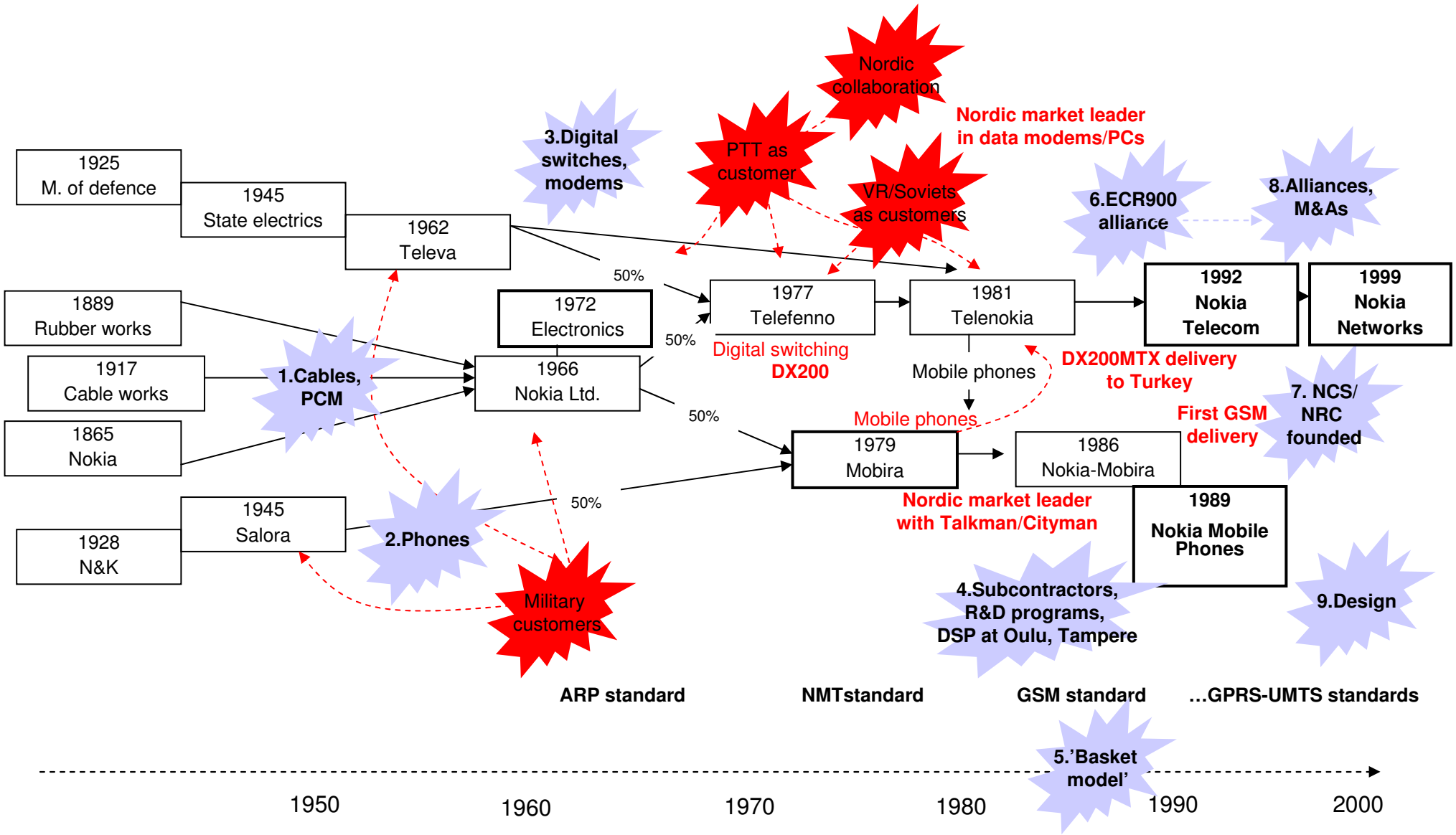
Analytical framework I

- Schumpeterian concept of technological discontinuity (Anderson & Tushman 1986 etc.)
- Distinction between competence-enhancing vs. competence-destroying, relationships with industrial dynamics
- 'Stylised fact': discontinuities mastered by new entrants, while incumbents are on the defensive (Abernarhy & Utterback 1978; Anderson & Tushman 1997 etc.)
- Resemblence between dominant designs and standards, especially in ICT

Analytical framework II

- In dynamic framework entrants are gradually overtaken by incumbents once dominant design emerges
- Undefined continuum between incremental and radical/discontinuous innovation – integrative capabilities matter (e.g. Henderson & Clark 1990)
- Rate of diffusion as an intermediating factor – entrants can gain volume-related advantages at fringes of markets (Christensen 1997)
- 'Symbiotic co-existence' of entrants and incumbents, divison of labour in R&D, sales, marketing (e.g. Rothaermel 2000; Dunning and Boyd 2003). Biotech as a good example!

Historical highlights…



Source: C. Palmberg

Nordic market shares amongst main suppliers of microcomputers, 1986

Main suppliers	**Nordic market share 1986**
Nokia Information Systems	*16%*
IBM	22%
Commodore	10%
Apple	5%
Olivetti	5%
Others	42
	100%

(Source: Häikiö 2001)

Market shares in analogue mobile phone market, 1985

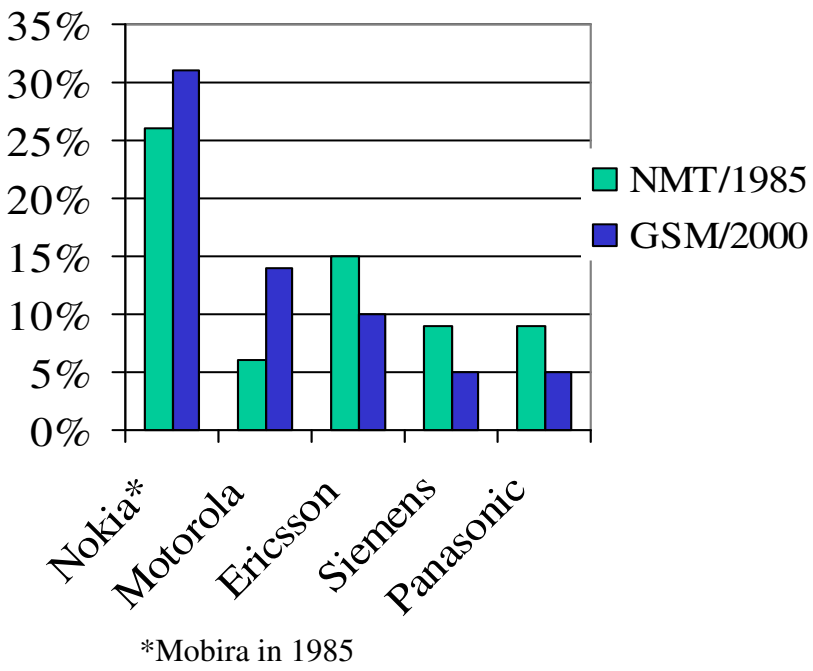
Main suppliers	**Market share in 1985**
Motorola	22%
Mobira (Nokia)	*13%*
Mitsubishi	5%
NEC	16%
Panasonic	10%
AP-Phillips	5%
OKI	15%
Ericsson	6%
Siemens	3%
Others	6%

(Source: Koivusalo 1995)

GSM Introduction

- Standardisation as a source of discontinuous change (Tushman & Anderson 1986):
  - complements/substitutes technologies
  - extend technical limits, improve price/performance ratios
  - scope for differentiation…restructures industry
- The GSM is interesting because…
  - the worlds widely diffused telecom standard
  - restructured industry – new firms entered, others exited
  - underlies Finnish entry into digital technology, laid foundations of UMTS
- Discontinuous by the face of it…

Market shares of significant firms in NMT and GSM mobile phone markets



*Mobira in 1985

(Source: Häikiö 2001b, www.3g-generation.com)

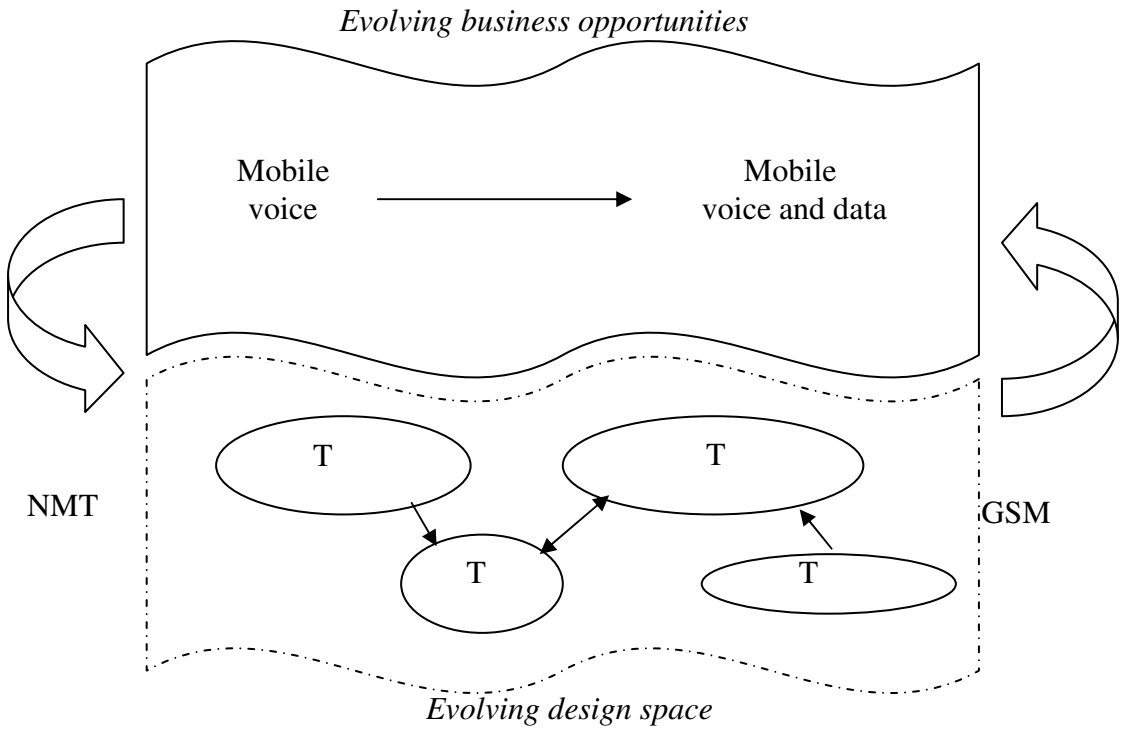
Source: Palmberg and Martikainen 2003

The standardization process – A brief chronicle of the GSM

- First discussions held at the World Radio Conference in 1979 prior to NMT
- French PTT's initiative in 1980 – collaboration institutionalised as GSM group in 1981 under the CEPT
- Early comitments specified in standard by 1985:
  - based on ISDN – digitalisation
  - integration of the OSI model to cellular systems
- Technological compromise in 1987 through political mitigation – **the 'basket model'** (see Bach 2000)
  - opening up standardisation to equipmnent suppliers, non-exclusive compulsory licensing of IPRs through ETSI procedure
  - 'entry ticket' to new entrants - used through formation of three competing alliances
  - …but software complexity/ uncertainty increased manifold
- Pan-European commercialisation deadline set to Summer of 1991…which failed

Source: Palmberg and Martikainen 2003

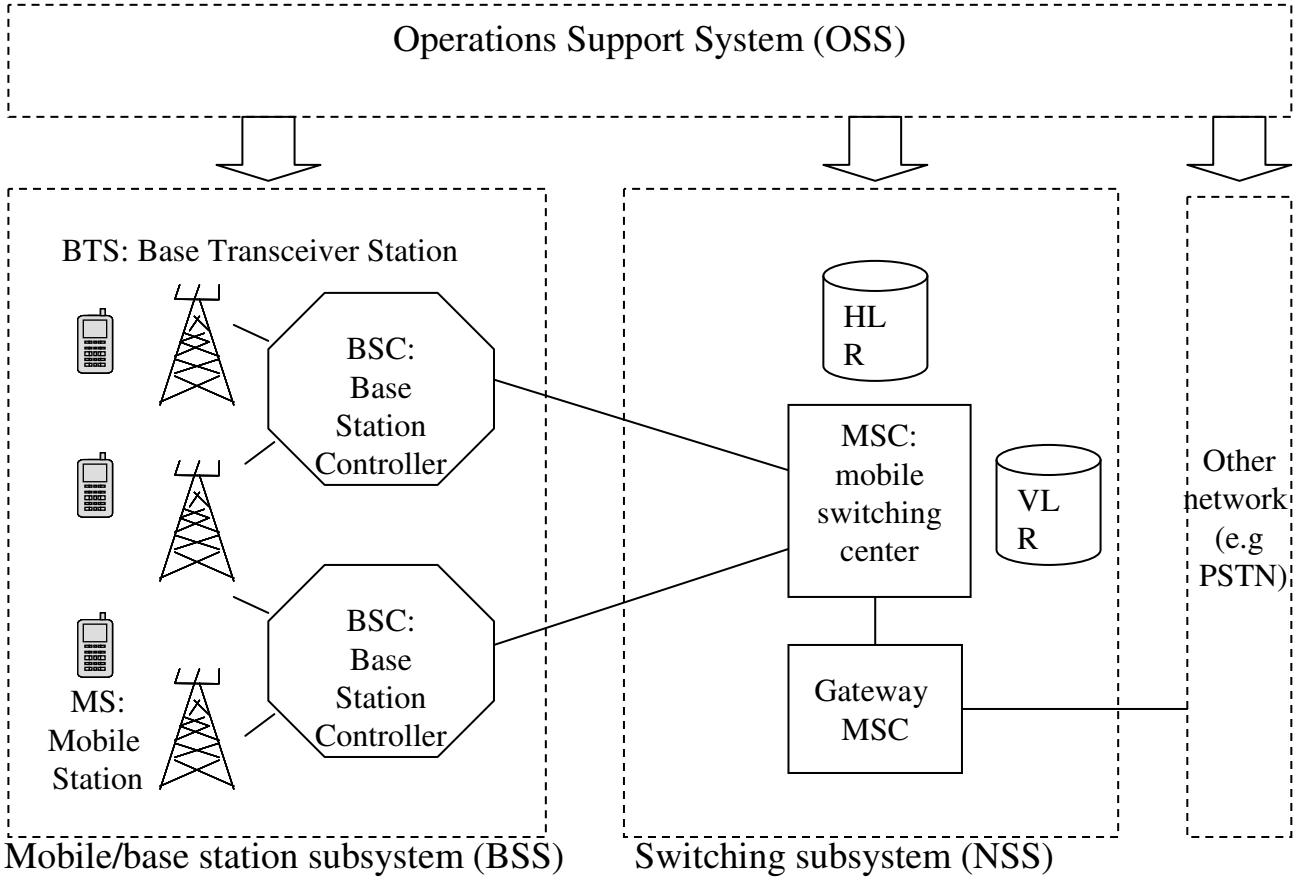
The co-evolution of business opportunities and design spaces



T=clusters of complementary technologies

Carlsson & Eliasson 2001
Palmberg & Martikainen 2003

Defining the cellular system design space



Source: Palmberg and Martikainen 2003

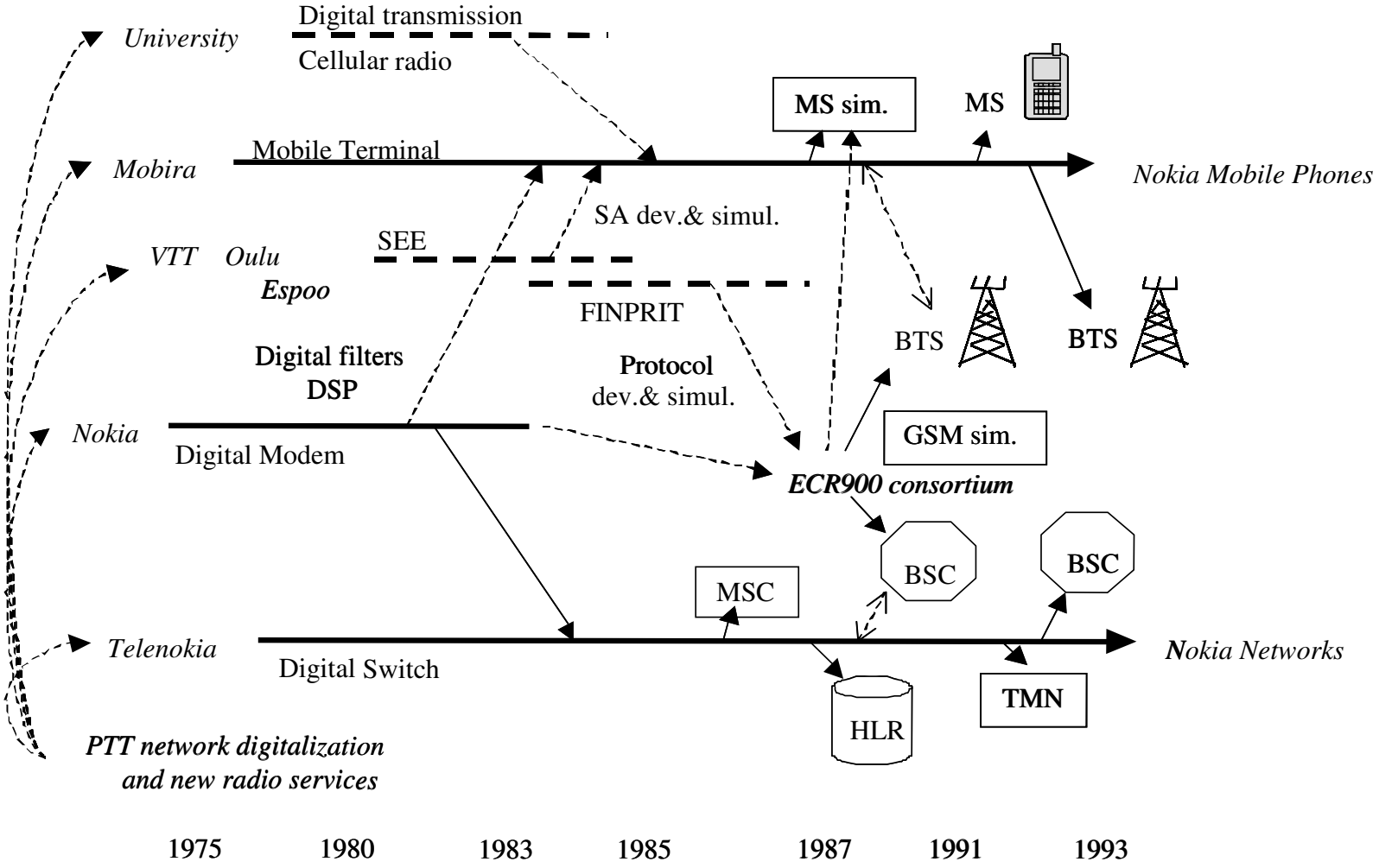
Discontinuity chart

	Competence-enhancing	Competence-destroying
Mobile and base station subsystem (BSS)		
MS (Mobile Station)		
Digital RF filters, A/D and D/A converters		
• DSP and software		√
Signalling and control software		
• Application/user interface software	√	
Integration of voice and data services		
• Digital signalling stacks		√
• Signalling software complexity		√
BTS (Base Transceiver Station)		
Digital RF filters		
• DSP and software		√
Signalling and control software		
Integration of voice and data services		
• Digital signalling stacks		√
• Signalling software complexity		√
BSC (Base Station Controller)		
Mobility and roaming functionalities		
• Location area roaming and mobility		√
ISDN for integration of voice and data		
• Digital signalling stacks		√
• Signalling software complexity		√

Discontinuity chart

	Competence-enhancing	Competence-destroying
Switching subsystem (NSS)		
MSC (Mobile Service Switching Centre)		
Mobility and roaming functionalities		
• Pan European roaming and mobility	√	
• Service software	√	
ISDN for integration of voice and data		
• Digital signaling stacks (SS#7 and OSI)	√	
• Signaling software complexity	√	
HLR/VLR (Home/Visitor Location Register)		
Location data	√	
ISDN for integration of voice and data		
• Digital signaling stacks (SS#7 and OSI)		√
• Signaling software complexity		√
Operations Support System (OSS)		
Centralized operation and maintenance		
• Operations and Management Centre (OMC)	√	
• Protocol stacks and databases (TMN)		√
• Authentication Centre (AUC)		√
• Equipment Identity Register (EIR)		√

Nokia case chronology



Source: Palmberg and Martikainen 2003

Nokia

- The Mobile Station (MS) software development was based on Structured Analysis SA/DT methodology developed in VTT Oulu Software Engineering Environment (SEE) project.
- ”The formal SEE approach based on specifications of several abstraction levels developed in parallel, verification of specifications by simulation, or formally, and then automated code generation, created a software process that was applied by Nokia.”
- “The software development process was the most important thing we learnt from the SEE program. In Mobira we created our own software architecture and tools closely tied to the software process. We were able to simulate all developed MS software modules against each other in our VAX minicomputer.”

Source: Palmberg and Martikainen 2003

Nokia

- The ECR900 consortium GSM simulator was developed using development and simulation tools from VTT Espoo Finprit program. The software was also used in Nokia's own GSM simulator in Oulu.
- “We had learnt to use prototype and simulation tools at VTT. As a result, we managed to harness these tools efficiently during the simulation of the GSM NSS subsystem even though our team was small at the time *[…]*. Similar in-house tools were reused in subsequent projects.”
- Starting from 1986, the CVOPS tool was taken into use at the Nokia Research Center, whereby a first priority was to secure the compatibility between the specifications of the BSS and NSS interfaces in the GSM standard. Starting from the early 1990s, during the further specification of the GSM standard during Phase 1, Phase 2, and Phase 2+, the CVOPS was complemented with GPRS and 3G protocol stacks (Inside Mita 2002).

Source: Palmberg and Martikainen 2003

Nokia discussion

Overcoming the discontinuities

- Confirmation of casual observation – the GSM introduced discontinuities ála Tushman & Anderson (1986):
  - digital signal processing (DSP)
  - manifold increase in system and component software (e.g. NMT-phone 20 kLOC, GSM 500 kLOC)

  …the GSM as the 'Global Software Monster'

- Nokia and related firms new entrants in cellular system market, although 'accidental incumbents' in the underlying technolgies/design space:
  - digital roots in Pulse Code Modulation (PCM) techniques in the 1960s and 1970s
  - amongst the European market leaders in DSP-based datamodems in the 1970s and 1980s

- Mobira as the entrepreneur and intermediator, realising business opportunities:
  - an early mover in the 'wireless fringe' market (early mobile phones)
  - the role played by the PTT as a competent customer (same story in NMT, see Palmberg 1998)

…overcoming the discontinuities

- Intertwined emergence of GSM related competences and public research infrastructure – fortunate timing above all…:
  - from small to large – critical mass achieved at the right time (NCS, NRC, NMP)
  - VTT showed well timed interest in embedded software, IC and DSP applications
  - SEE program at Oulu – Oulu as a success story in it's own right
  - Tekes FINPRIT program – the importance of systematic process innovations!
  - density rather than size of networks – spillovers through technological gatekeepers (Allen 1977)

- Serendipity should not be ignored:
  - standardization process took many turns favourable to Nokia
    - choice of narrowband TDMA favoured the 'Nordic camp'
    - the 1987 basket model and the ECR900 consortia as Nokia's 'entry ticket' to the global telecom scene
  - critical moments of GSM coincided with collapse of Soviet trade – resources freed
  - a guardian angle at managerial level during times of crises in early 1990s (…or pure ignorance)?

Source: Palmberg and Martikainen 2003

Reflections on present developments

- GSM represented a break in the regulatory regime (also 'regulatory discontinuity'):
  - founding of ETSI in 1988 – political coordination
  - *basket model* compromise introduce the equipment suppliers to standardisation/alliance game
  - essential patents procedure set up at ETSI – non-exclusive compulsory licensing

- Transition to 3G? – lessons learnt:
  - UMTS, through GPRS and EDGE, essentially a continuation of technological and regulatry regime of GSM
  - present uncertainties related to UMTS resemble those related to GSM in early 1990s – is it too early to doom UMTS?
    - gross underestimation of popularity of service (also the case in NMT)
    - slow diffusion of major application – the SMS service
    - technological risks also inherent in GSM – presently discontinuities in application domain
  - …but now competition from 4G or 11.5G as 'wireless fringe markets', financial debacles, lack of political will and uncoordinated launch, multiple IPRs

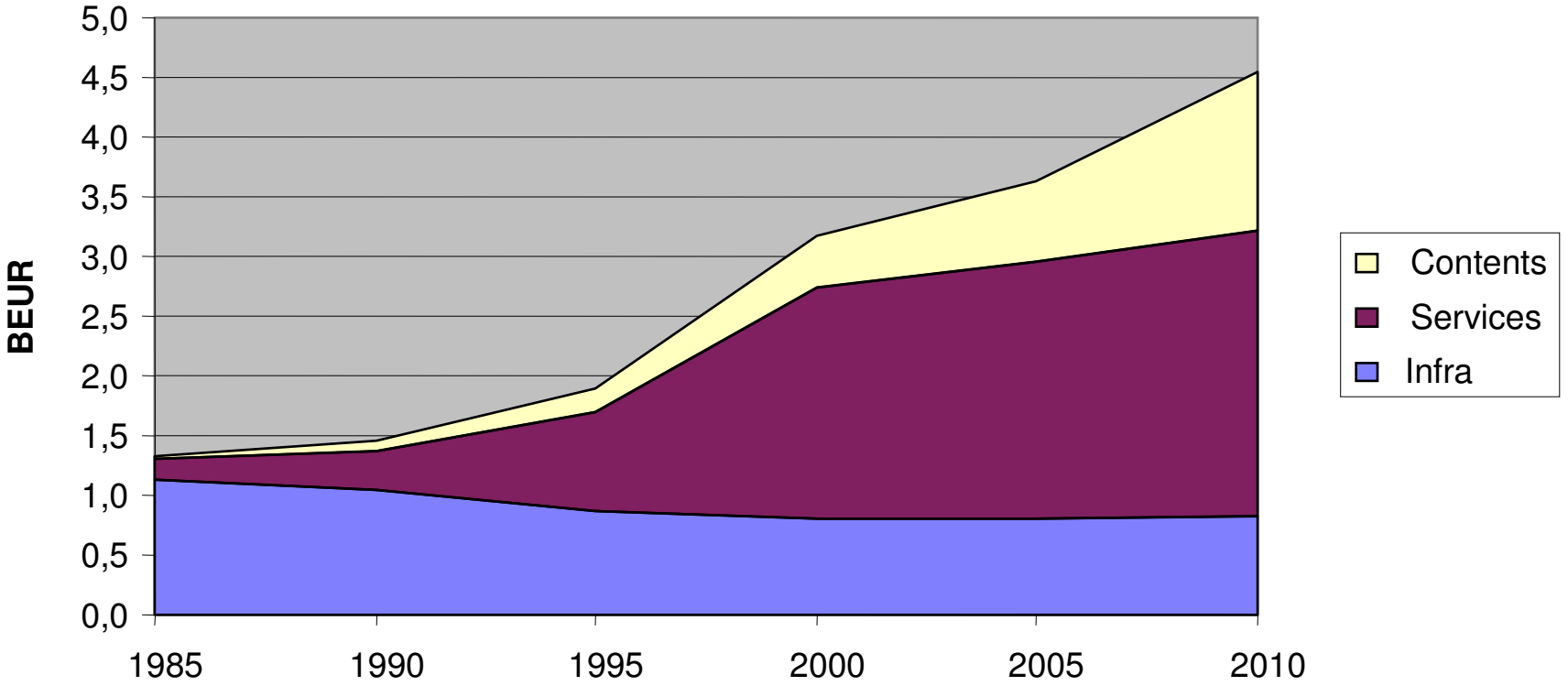
Source: Palmberg and Martikainen 2003

1991 - 2004

1991-2000 reaping the fruits

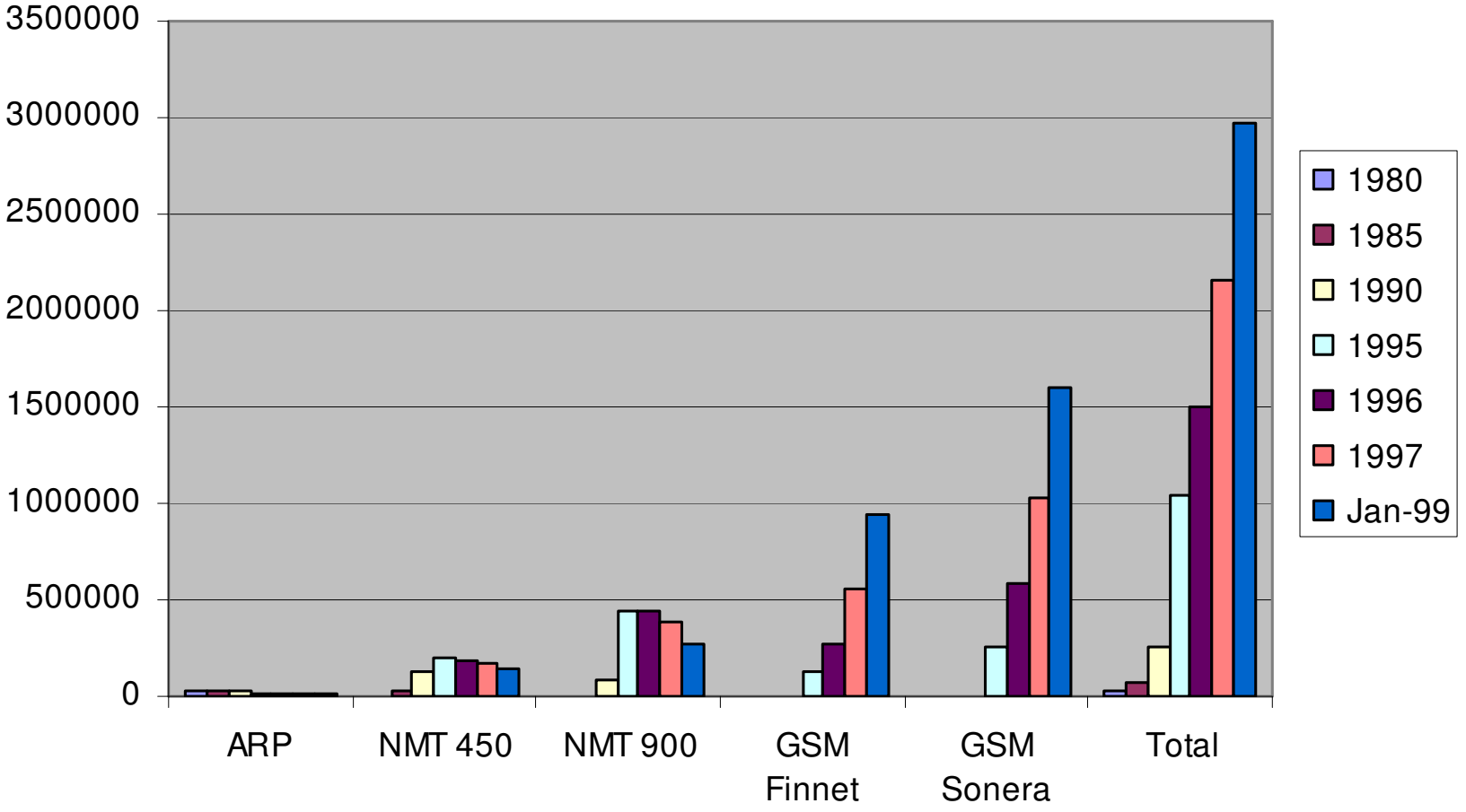
- Nokia's growth
- Sonera and Radiolinja as first GSM operators
- R&D funding growth
- Electronics became as the leading export industry in Finland

Telecom Services in Finland



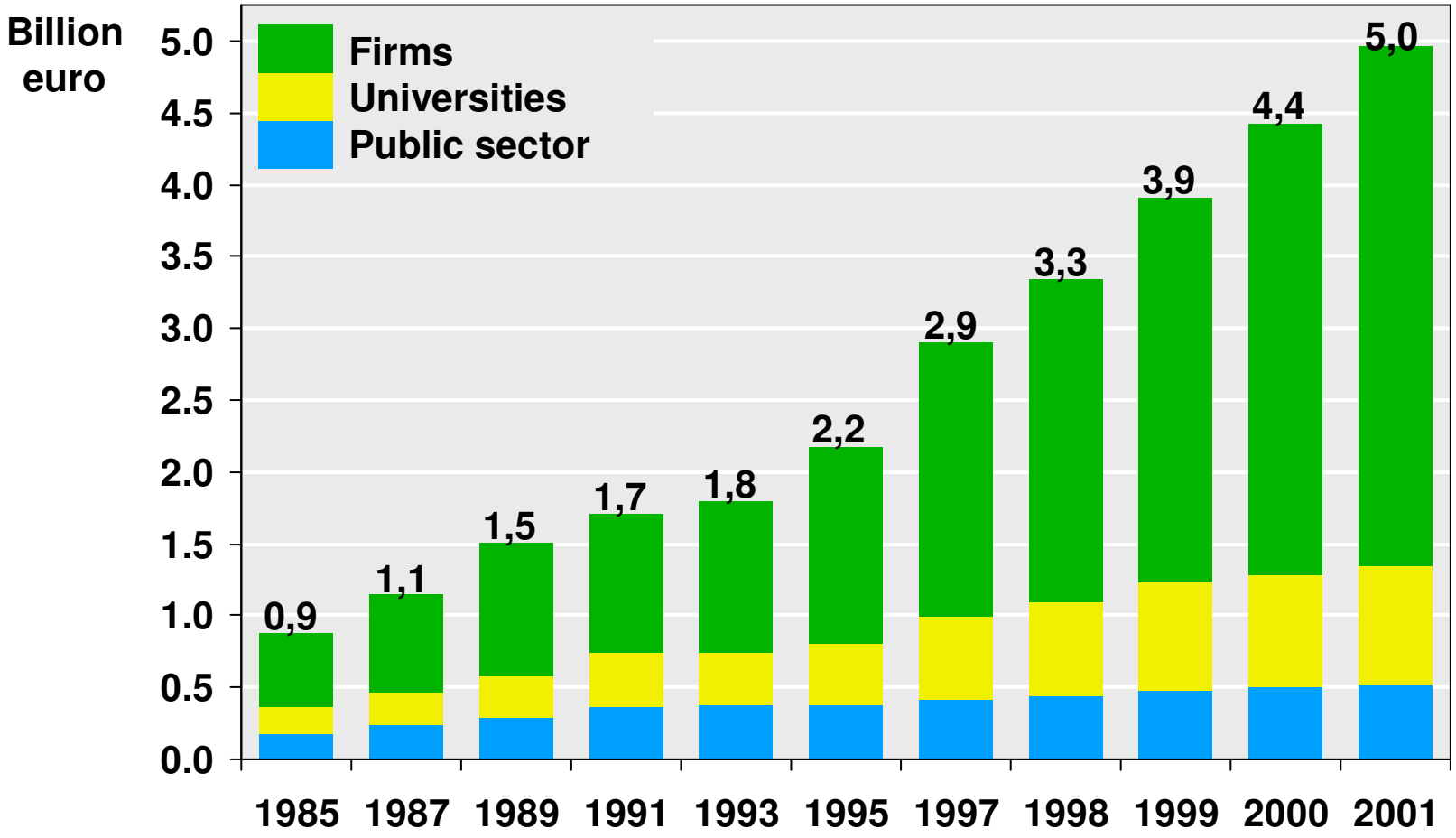
Data from industrual sources, forecast by OM

Installed Base of Cellular Connections in Finland



Source: Ministry of Communications, Finland

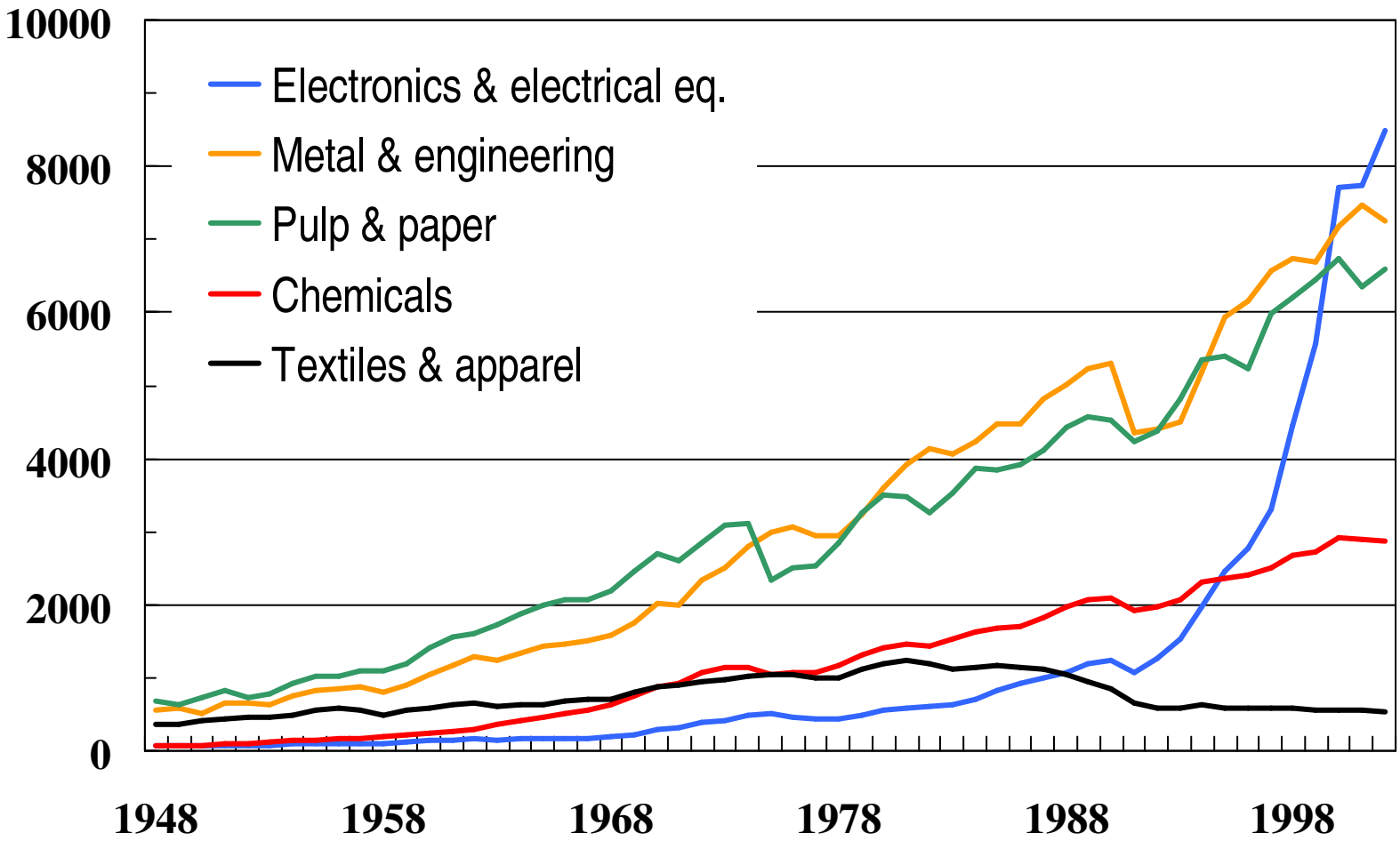
R&D funding in Finland 1985-2001



Lähde: Tilastokeskus

Manufacturing output in Finland by industries

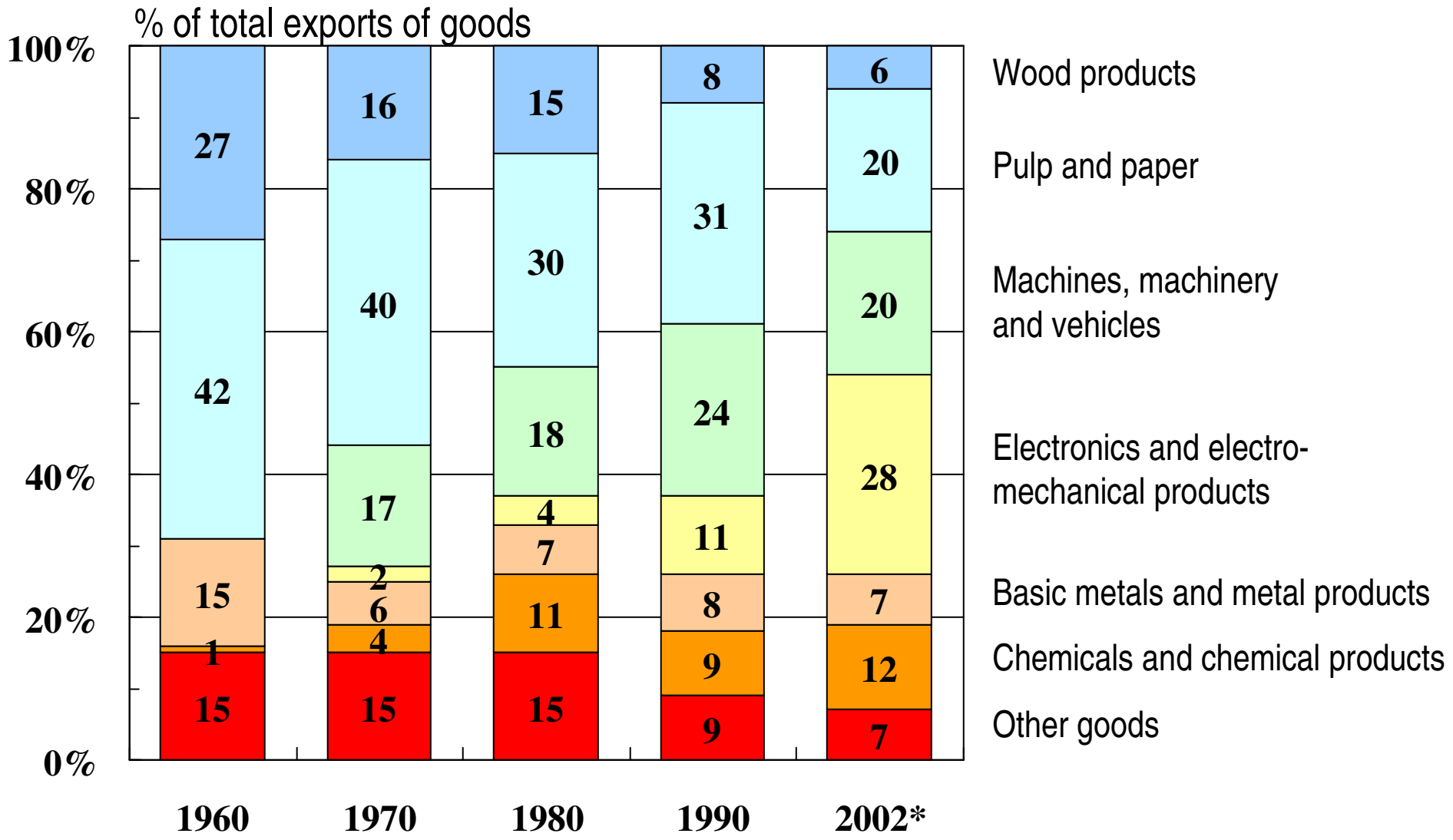
(at 2002 prices)



Sources: Hjerppe-Hjerppe-Mannermaa-Niitamo-Siltari (1976), Statistics Finland, ETLA.

Author: pekka_ya/esitelmä15092003/k02

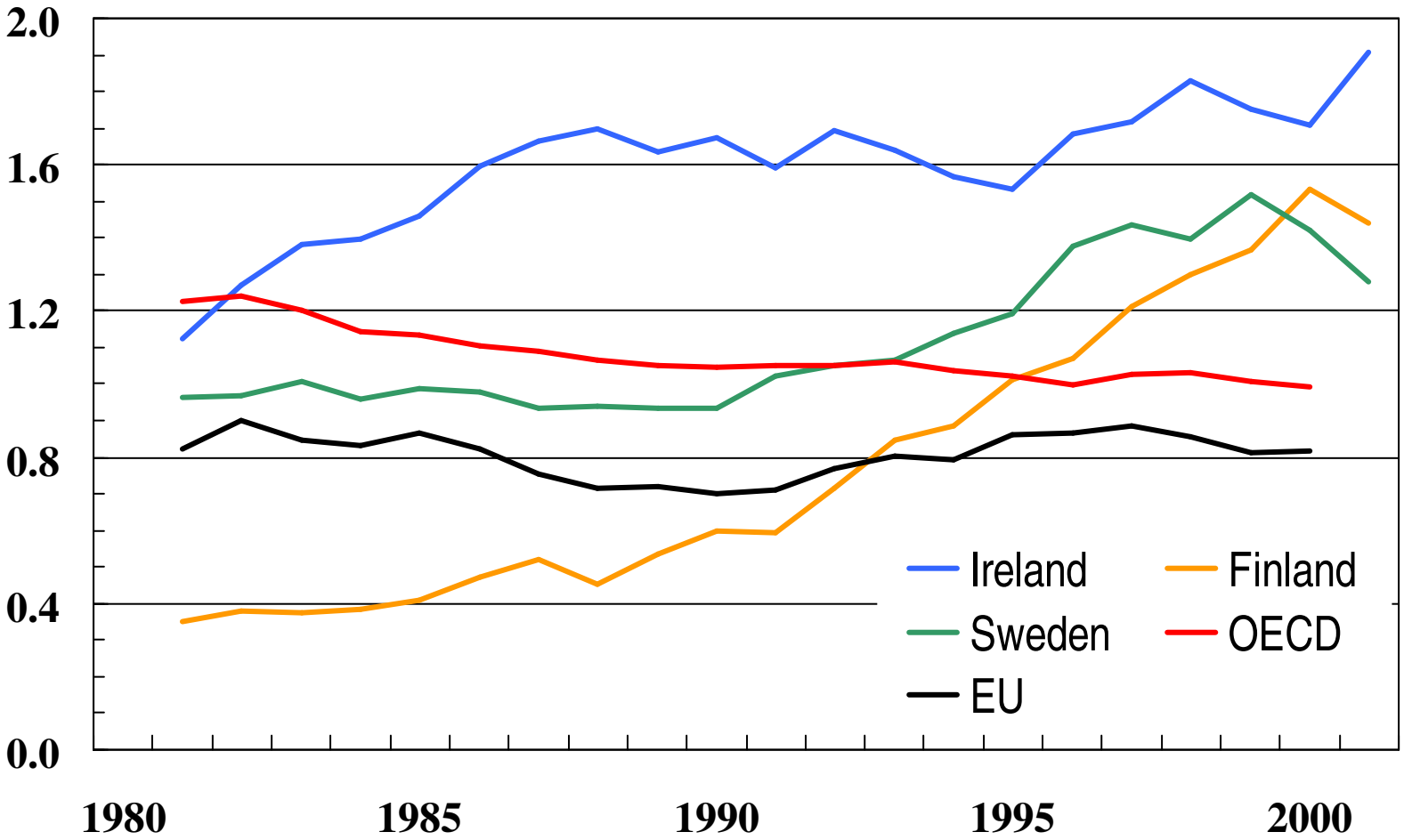
Finnish exports of goods by industry 1960-2002 (%)



Source: National Board of Customs.

Author: pekka_ya/esitelmä15092003/k29

Export/import ratio of high-tech products



Source: OECD.

Authro: pekka_ya/esitelmä15092003/k26

Summary of the Finnish ICT history

- Old structure –> competition, investments –> globalization, consolidation
- Competition and investment phase created high demand for local product and service industries:
  - Banking -> Nokia Data, Modems, Mikromikko, Datacommunications ->..
  - Telecom -> Mobira, Nokia, Comptel, Sonera ->..
  - What next?
  - *Public sector* -> Process development and consolidation, Service industries .. (to be seen)
  - *Globalization* -> Global corporate, Productivity and process development KISA and KIBS .. (tbs)

Learnings from early successes

- In 1981-1987 industry consortia made large R&D investments to bring in latest research, create methods and tools and apply them in local industries
- The goals set for the Tekes Finprit program were collected *from industry* in 1983, Oulu and Espoo leading the R&D
- The new methods and tools were combined by Nokia into its existing technology core and applied in *early GSM development*
- The *US corporate router network technology* was applied by Tele (Sonera) and made as first public router service (Datanet)
- *Similar actions would be needed again in the development of New Services, Business Processes and IP-applications*

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