Pathways to Innovation:
Policies, Products, and Processes
for Competitive Advantage in a Global Economy

20 – 21 May 2005, Tokyo

Impact of behavioral factors on innovation performance

An evolutionary approach with a simulation model for IT-companies in Japan and Germany

Dr. Monika Friedrich-Nishio

University of Karlsruhe (TH)
Institute for Economic Policy Research
Section System Dynamics and Innovation

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Aim and motivation

analysis of determinants of firms' innovation activity
- influence of behavioral factors
- "economy and culture cannot exist separately"

development of firms and branches through time
with inclusion of historical and cultural factors
here: selected firms in Japan und Germany in the IT sector

AIM: historically consistent trace (no forecast)
with **one** model for both countries
identifying the responsible parameters

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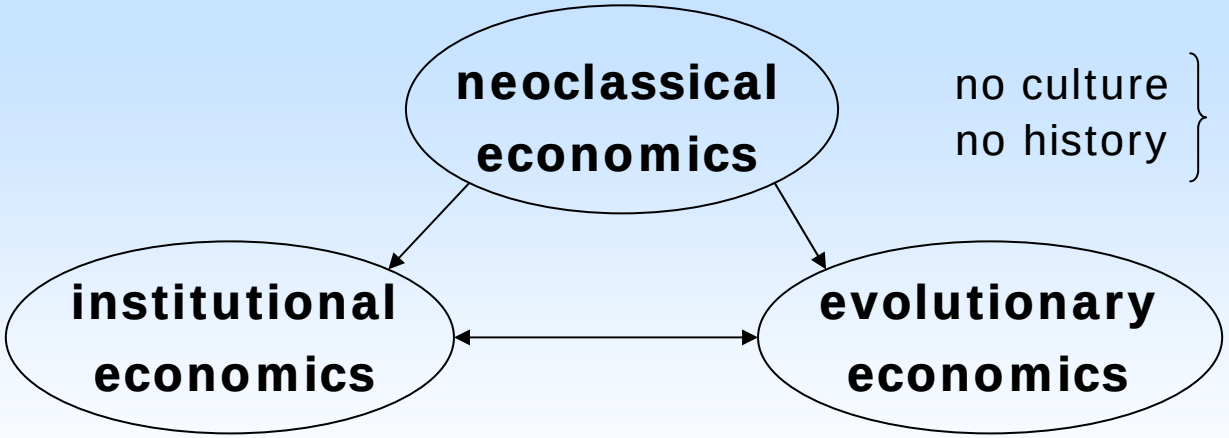

no culture
no history
} paths

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- Institutions = rules / systems of rules
- "Institutions and history have a decisive influence on the performance of innovation systems"
  ("*History matters* !" D. North)
- level of satisfaction
  (model of the "Satisficing Man", H. Simon, 1957)
- concept pf national innovation systems (NIS)

Top 3

- concept of the irreversible, historical time
- VSB-concept
- homo dissent

Top 4

- technological paradigms and path dependencies

Top 5

- focus: development under given **cultural, societal and political frameworks**

Top 6

→ theory of the firm

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Before modeling

Identifying the characteristics

1. IT sector

- consideration/analysis of several market members
- collection of empirical data
- whole market development (key figures)
- special incidents

2. Culture

Ethical value, tradition, religion:
Country's / sector's behavioral characteristics

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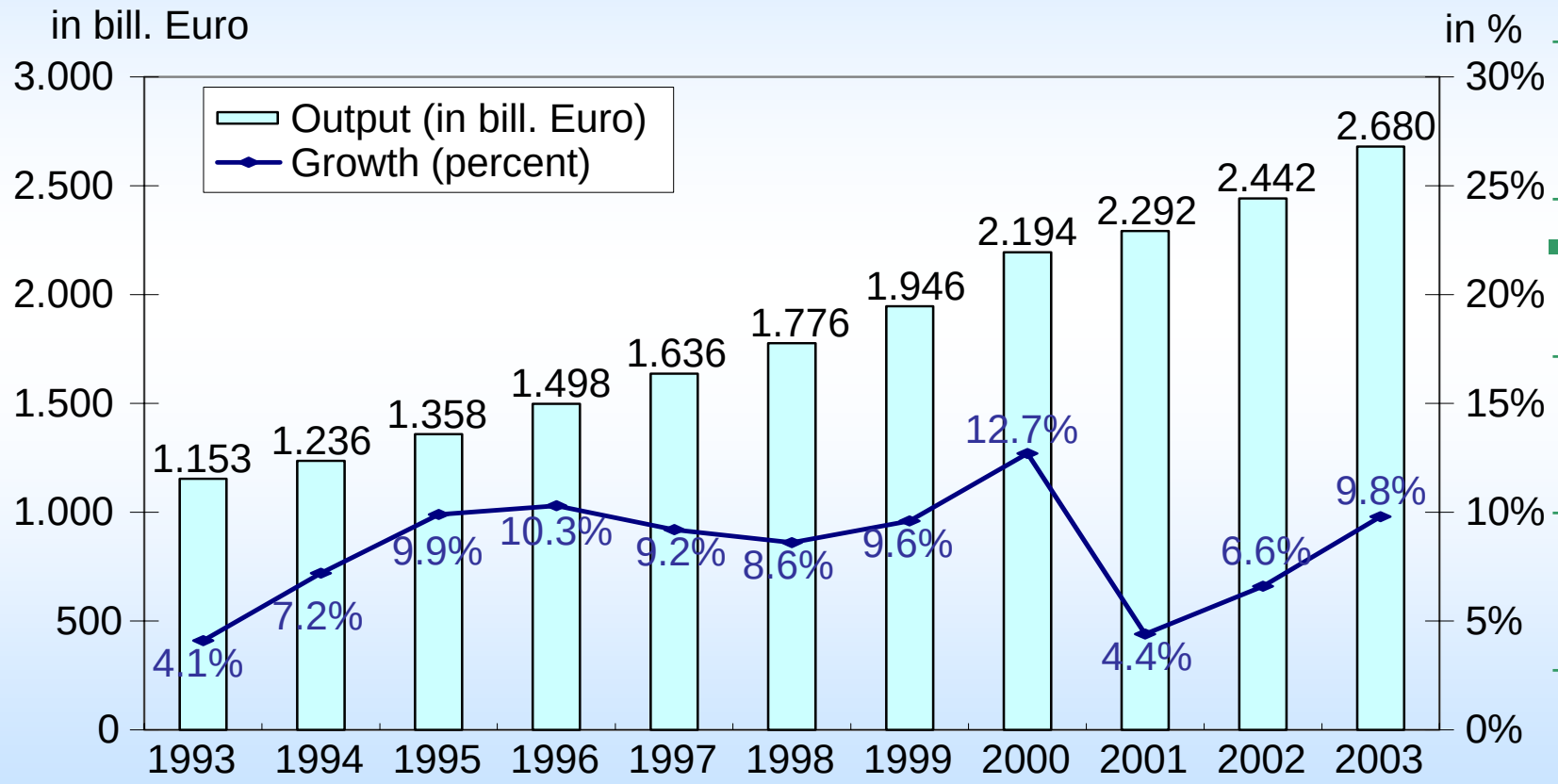
Growth of IT sector world-wide



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Source: EITO in cooperation with IDC

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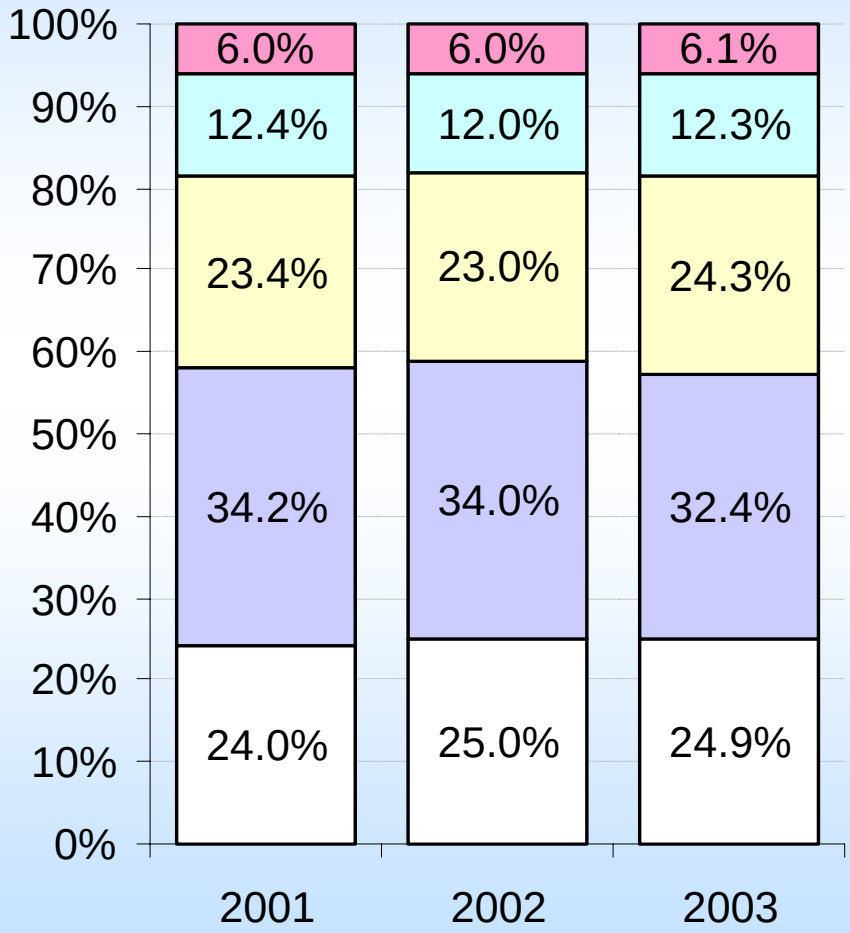
World-wide ICT market by region



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Source: EITO in cooperation with IDC

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IT sector: collecting empirical data

- **IT sector = hardware, software and telecommunication**
- data bases for firms, patents, publications etc.
- statistical key data from several different institutions
  (e.g. METI, MPT, NISTEP, Stifterverband, Stat.Bundesamt...)
- from firms of IT sector:
  - Fujitsu
  - Hitachi
  - NEC
  - NTT
  - Toshiba
  - Ahead
  - MAXDATA
  - Nixdorf
  - SAP
  - Siemens
  - VOBIS
  - IBM Deutschland

interviews and analysis of business reports

- number of employees
- R&D personnel
- R&D-expenditures
- array of products
- turnover/ benefit
- qualitative data (firm strategy, -philosophy)

period: 1960 until now: What are the characteristics?

→ development and change of **platforms**

1) mainframe systems
2) minicomputer / small und middle-sized systems
3) microcomputer / PC
4) client/server platform

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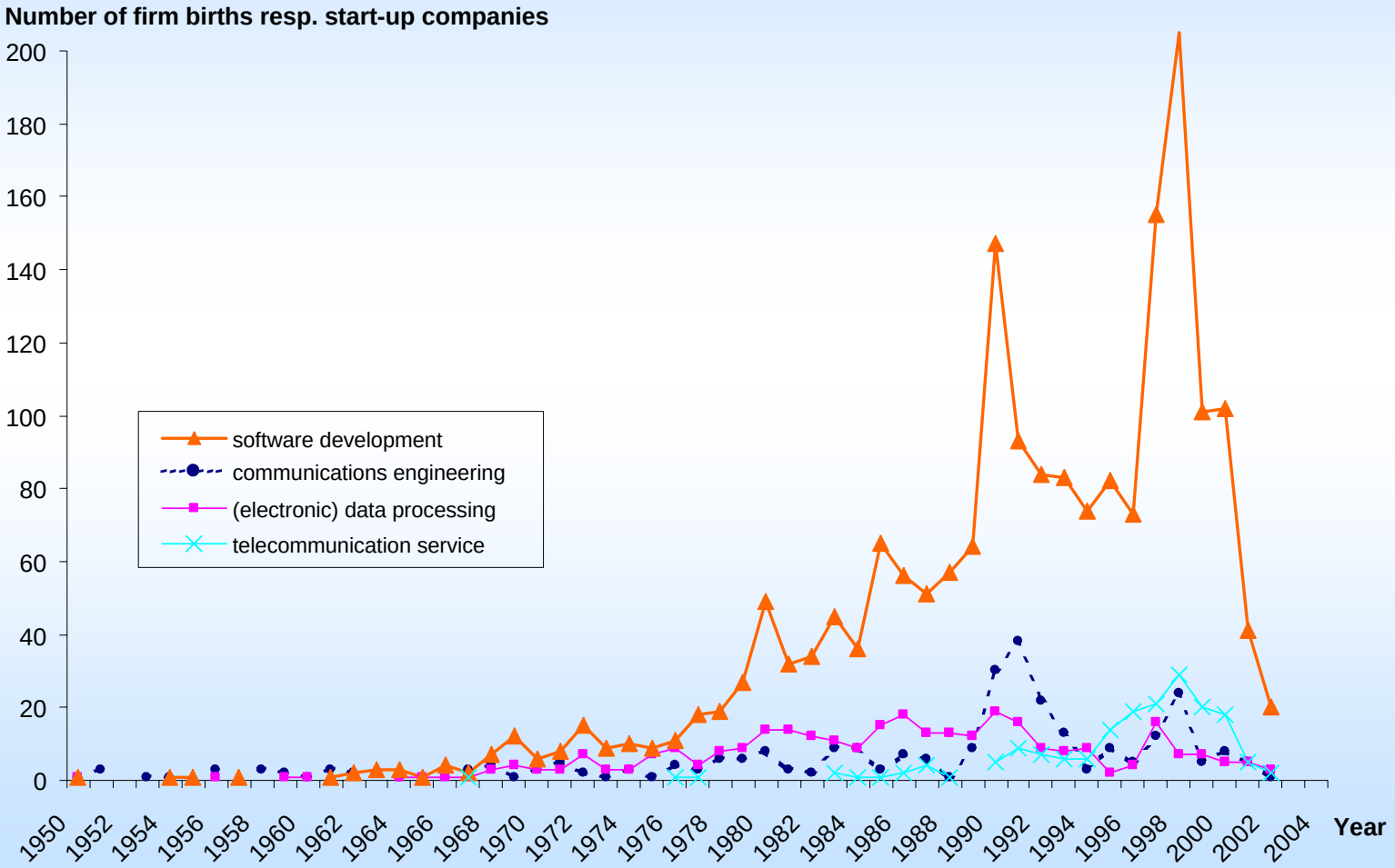
IT sector:

Boom of foundations in the IT sector



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IT sector:

Product cycles: Shape, length, number... Example: IBM vs. Nixdorf

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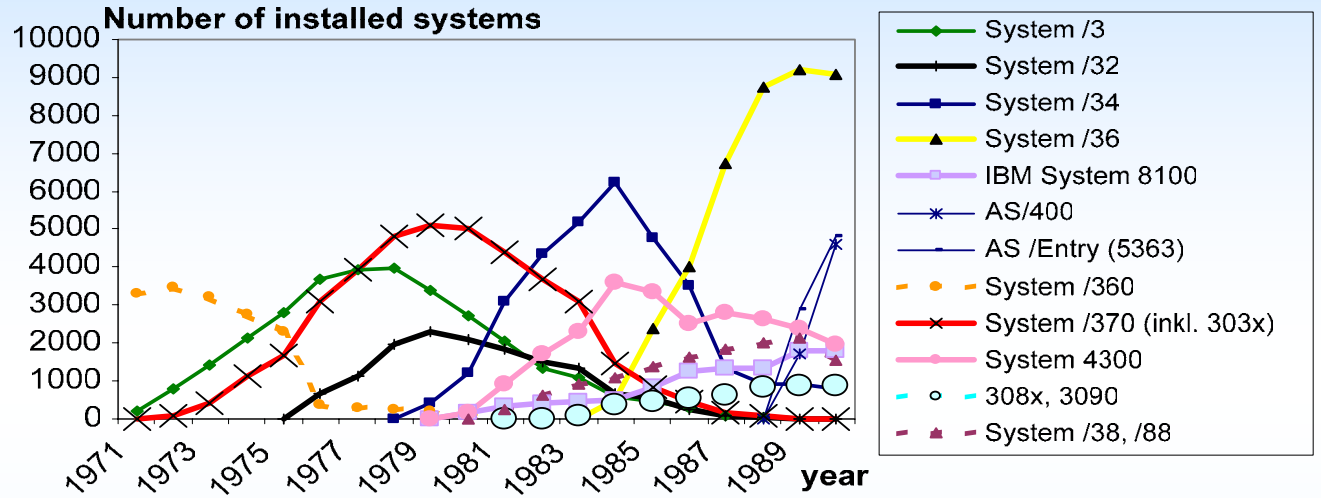

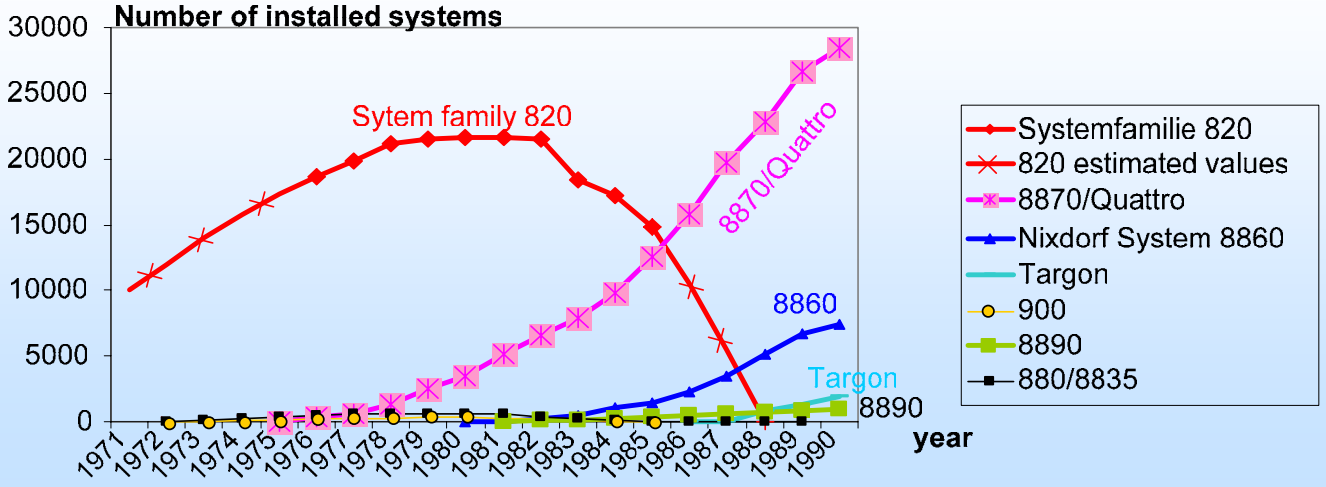

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Culture and Behavior

- religious influences
  Origins: religions (Shintoism, Konfuzianism, Buddhism, Christianity)
- historically developed influence factors
  (e.g. „Keiretsu“ 系列: fusion of firms to a “family“)
- differences in behavior and attitudes of employees and managers from different countries → Hofstede (1980)

  → no change over time (Adler 1997)
- Harmony vs. Individualism
- Status (in society, in firms)

  → meaning of contracts

  → hierarchy in firms
- business relationship and shareholding

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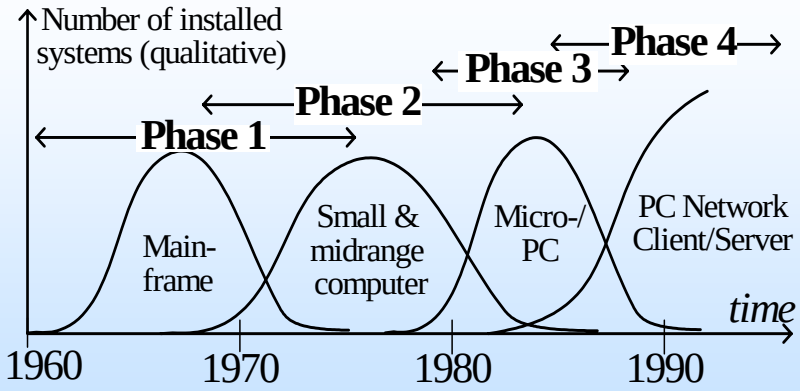
Idea of the evolutionary innovation model

- Theory of decision-making in firms
- Firm: active seek for **profit**
- **Strategy**: innovation, imitation or remaining, depends on:
  - own experiences and abilities
  - already used rules of decision making
  - known processes of problem solving
  - random incidences

→ ROUTINES

- **Market's selection process**: controls surviving / dying of firms
- Program in VENSIM
- (Model)-World
  with **exogenous conditions**:
  - ❖ **technology phases**
  - ❖ development of demand
  - ❖ political frame
  - ❖ exogenous "Shocks": Oil crisis, Bubble Economy (J), structural change, Globalisation,...



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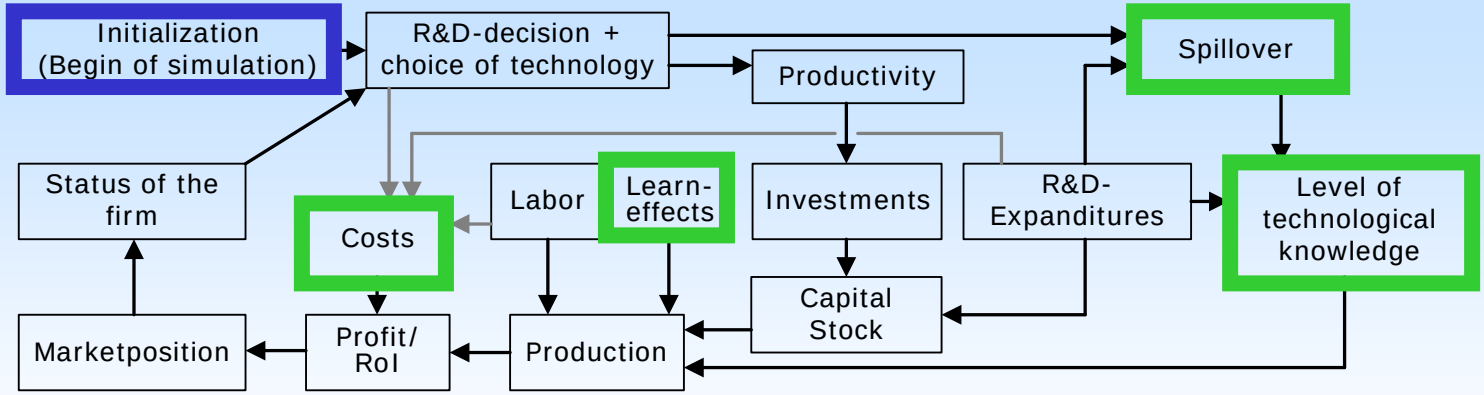

Initialization: Firm's equipment with:

Capital, labor, starting productivity: (*Kit, Lit, Ait*)

and ideas + behavior/attitude

→ individual

also cultural?

- learning behaviour
- risk attitude
- aims / image / expectations
- experience knowledge
- techn. knowledge (what kind? where from?)
- absorption (will, speed)

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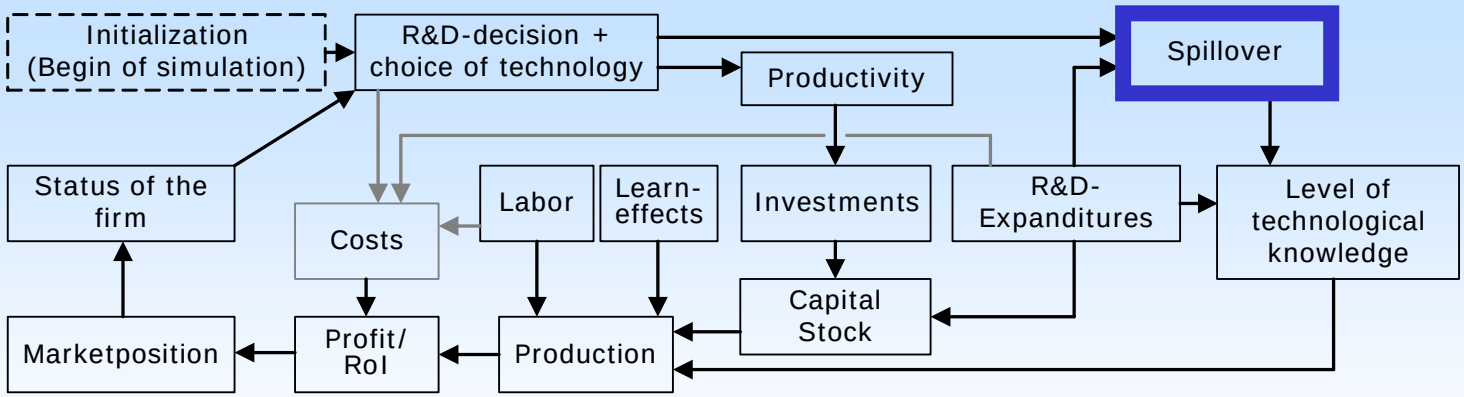

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Spillover-effects: Collective Know-How-potential

Top 3

$$S_{it} = \sum_{j=1,\, j \neq i}^{n} w_{jt} \cdot RCAP_{jt}$$

with

Top 4

$$RCAP_{it} = RCAP_{i,\,t-1} \cdot (g^{R\&D} - \delta_R) + R_{it} \cdot g^{R\&D}$$

Top 5

$RCAP_{it}$: R&D Capital of firm i at time t

δ_R: amortization rate of R&D-capital

R_{it}: R&D-expenditures of firm i at time t

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$g^{R\&D}$: expansion rate of R&D-capital

w_{jt}: weighting factor of firm j at t from view i

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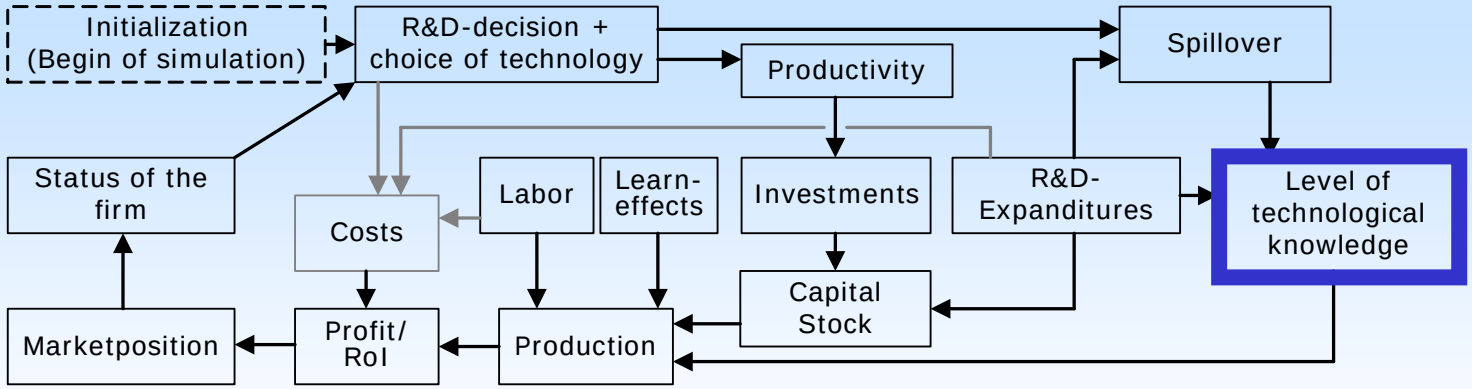

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Level of technological knowledge: T_{it}

Top 3

$$T_{it} = \sum_{j=1}^{\Lambda} \frac{1}{\Lambda!} \cdot (\Lambda - j + 1) \cdot R_{i,t-1} + (1 - \rho_T) \cdot T_{i,t-1} + S_{it}$$

Top 4

$$TL_{it} = \frac{T_{it}}{\sum_i T_{it}}$$

Top 5

S_{it} : spillover-effects, received by firm *i* at time *t*
R_{it} : R&D-expenditures of firma *i* at time *t*
ρ_T : obsolescence rate of a technology
Λ : "Lead Time" of R&D
TL_{it} : comparative level: technological level of knowledge of firm *i* at *t*

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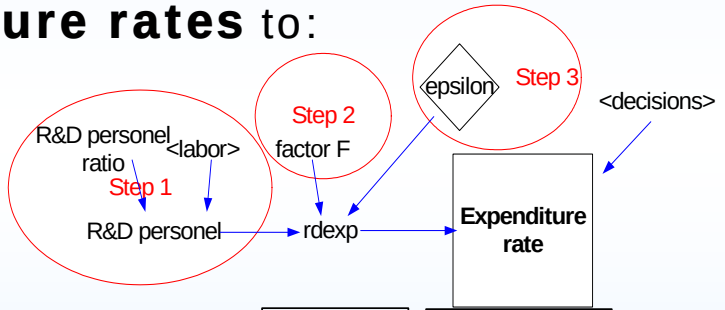
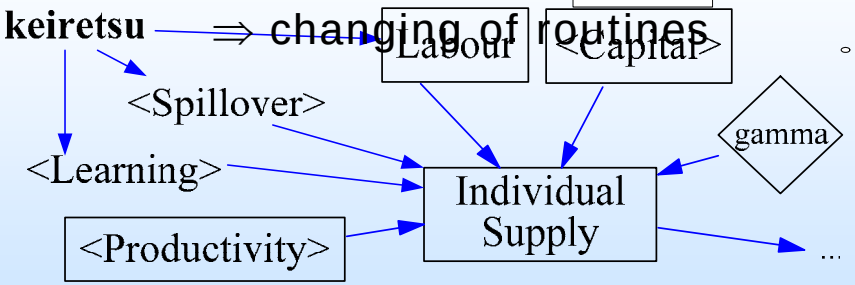
Place of influence of behavioral factors

- **imitation**: where do firms search for existing technology?
- **innovation**: depends on risk attitude, technological orientation etc.
- **level of satisfaction**: when are firms "satisfied"?
  duration of the searching process
- **adjustment of R&D-expenditure rates** to:
  1. (R&D-)personnel
  2. economical framework (factor F)
  3. innovative behavior of the previous period (factor ε)



- **"Keiretsu"-variable**
  - place of search for technology
  - learning speed
  - spillover + technological knowledge
  - pool of the resource "Human Capital"



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Selection

- performance-indicator
  (depends on innovation output of the firm: "patents" and "publications")
- market entry and market exit

Top 1

Top 2

Scenario

- scenario **A**: Japanese firms' data
- scenario **B**: German firms' data

Top 3

with 4 further scenarios:

- scenario 1: basic scenario ("reality" simulation)
- scenario 2: low innovation efficiency
- scenario 3: high innovation efficiency
- "what if"-scenario: equipment of several firm parameter with other firms' ones

Top 4

Top 5

→ Model calibration, optimization and specific questions

Top 6

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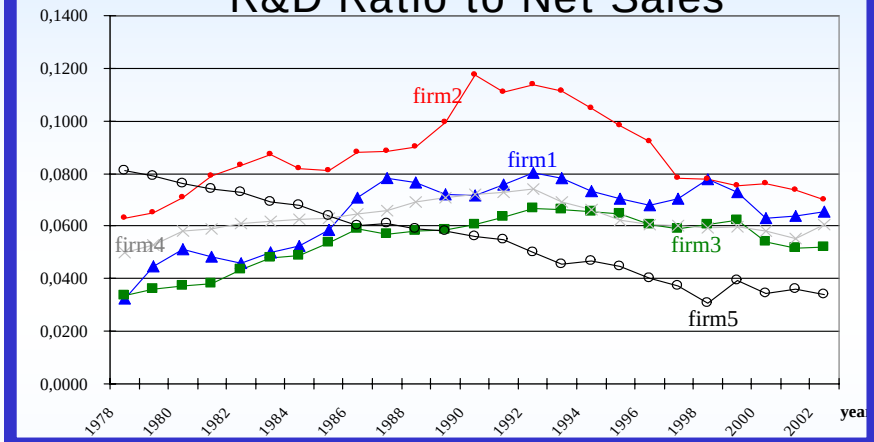
Result 1: Tracing the real historical development: Basic scenario

Scenario A: Variable “R&D share in exchange“ and “capital“

Top 1



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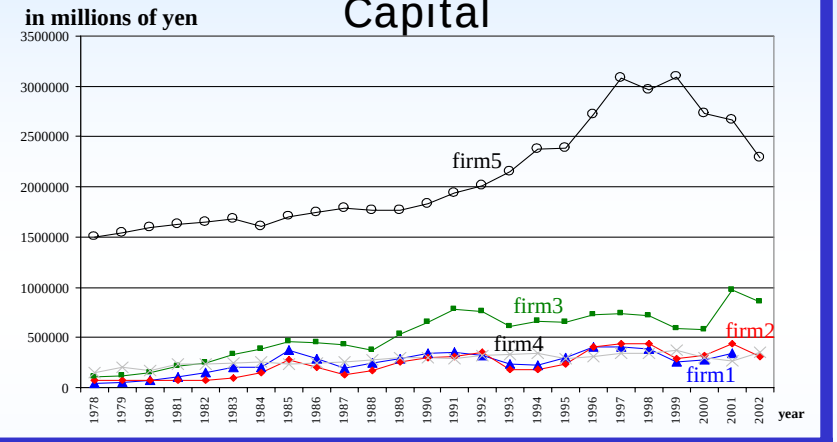

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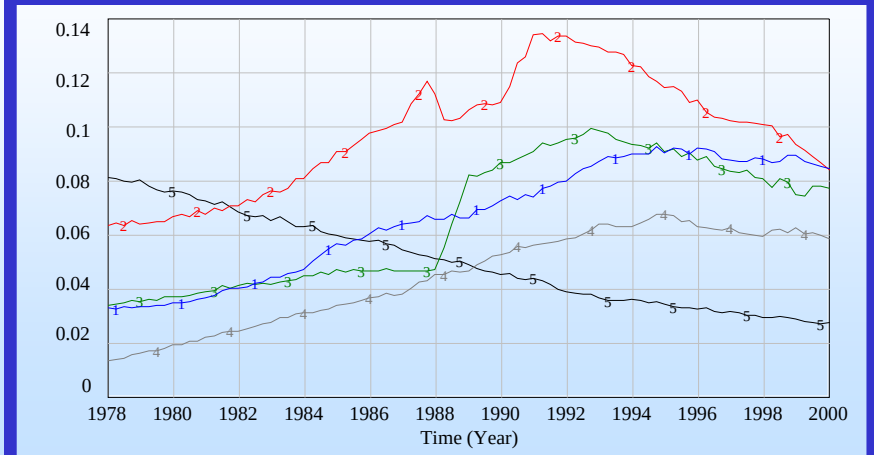

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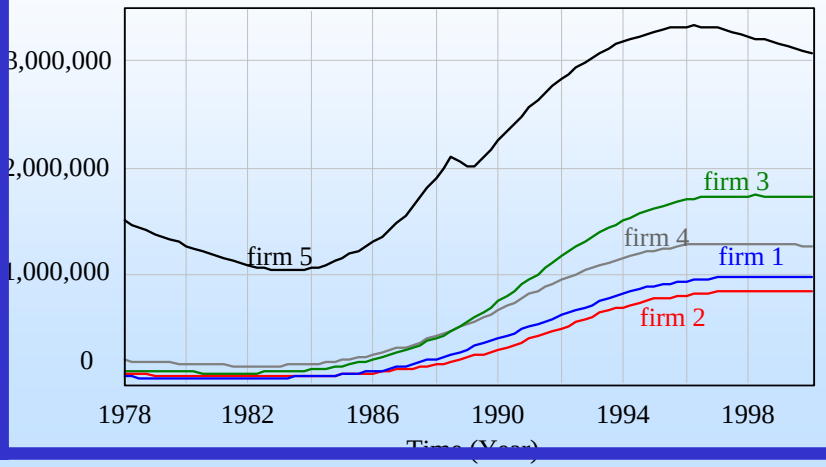

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Comparison scenario A and B

	Scenario A	Scenario B
"keiretsu" (Acting in own firm family)	search for technology restricted to firm family	search for technology in whole industry
"Spillover"	spillover of knowledge not from all firms of industry	technological knowledge of all firms relevant
"Priority own technology"	rarely chosen aim: adopt technology direction given by the firm	often chosen aim: technological leadership by own standards
"Market leadership" (= "Priority own technology" + "Innovation")	not primary intention level of satisfaction is lower than in scenario B	often chosen market leadership is aim
Market entrance	no market entrance in all scenarios	the more open the market considering innovations the more market entrances

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- **Result 1:** Tracing the real historical development is possible
- **Result 2:** learning and relevance of history and accumulated knowledge
- **Result 3:** incremental innovation and acting in family in scenario A (the Japanese case)
- **Result 4:** persistence of the structure in scenario A (the Japanese case)
- **Result 5:** spillover and industry knowledge in scenario B (the German case)
- **Result 6 + 7:** the case of Nixdorf: a contra factual historiography
- **Result 8:** Firm size: determining factor for success (i.d. positive performance) **is whether firm size nor duration of market membership**

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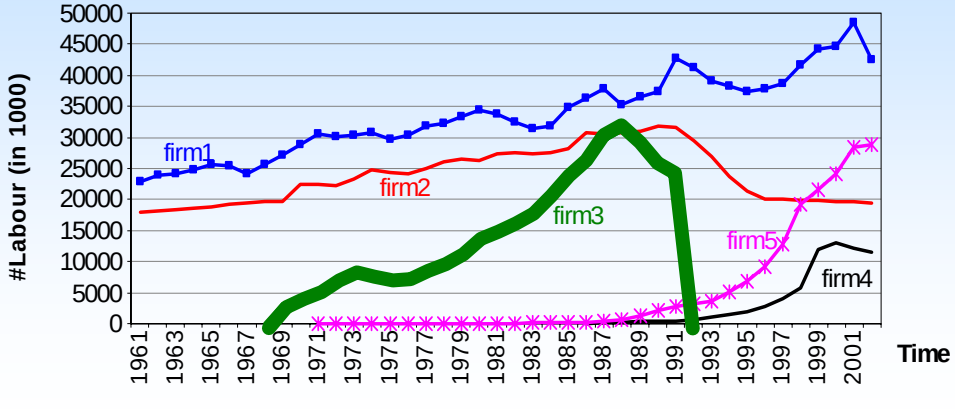
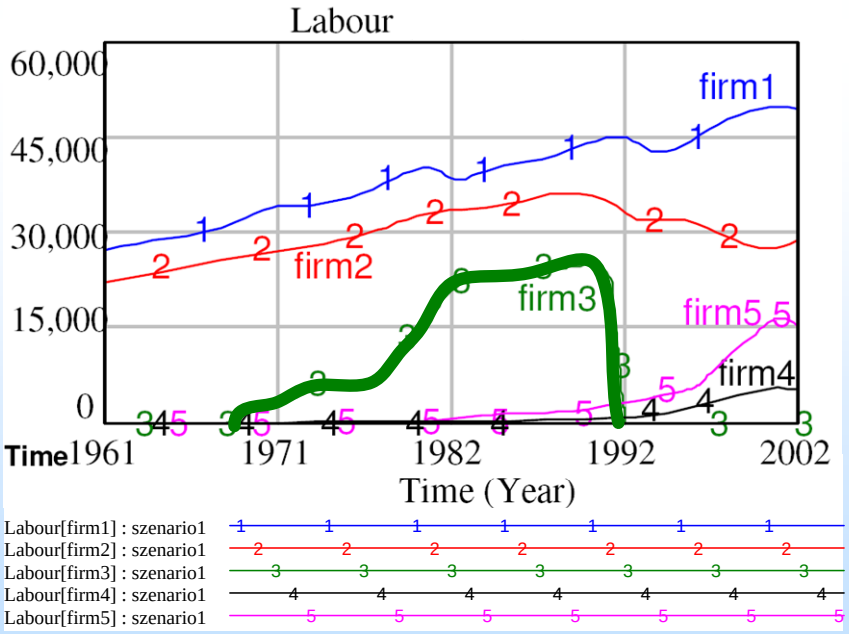
Result 6: the case of the company Nixdorf

Scenario B: Variable "employment"





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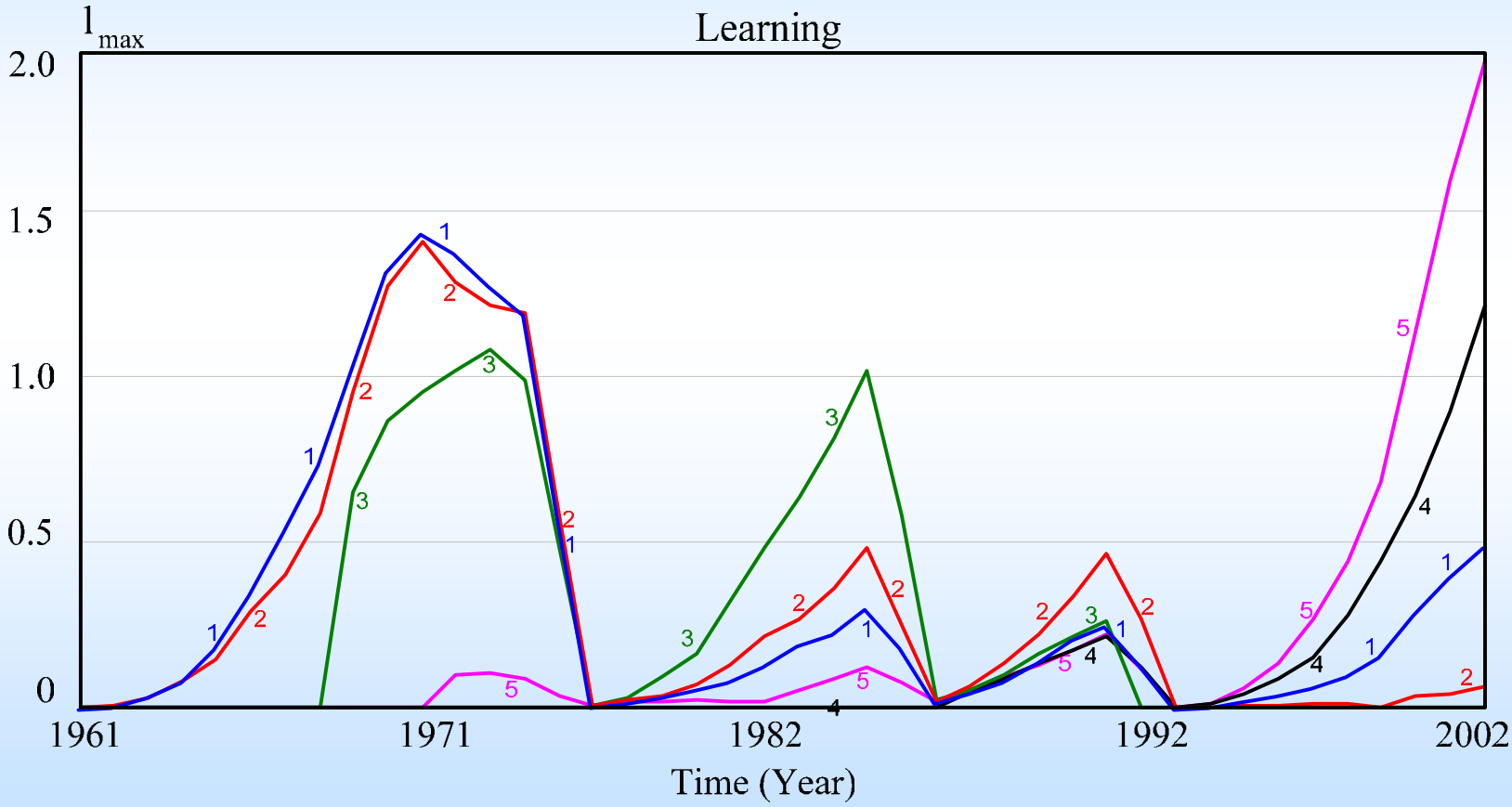
Result 6: the case of the company Nixdorf

Scenario B: Variable “Learning curve“



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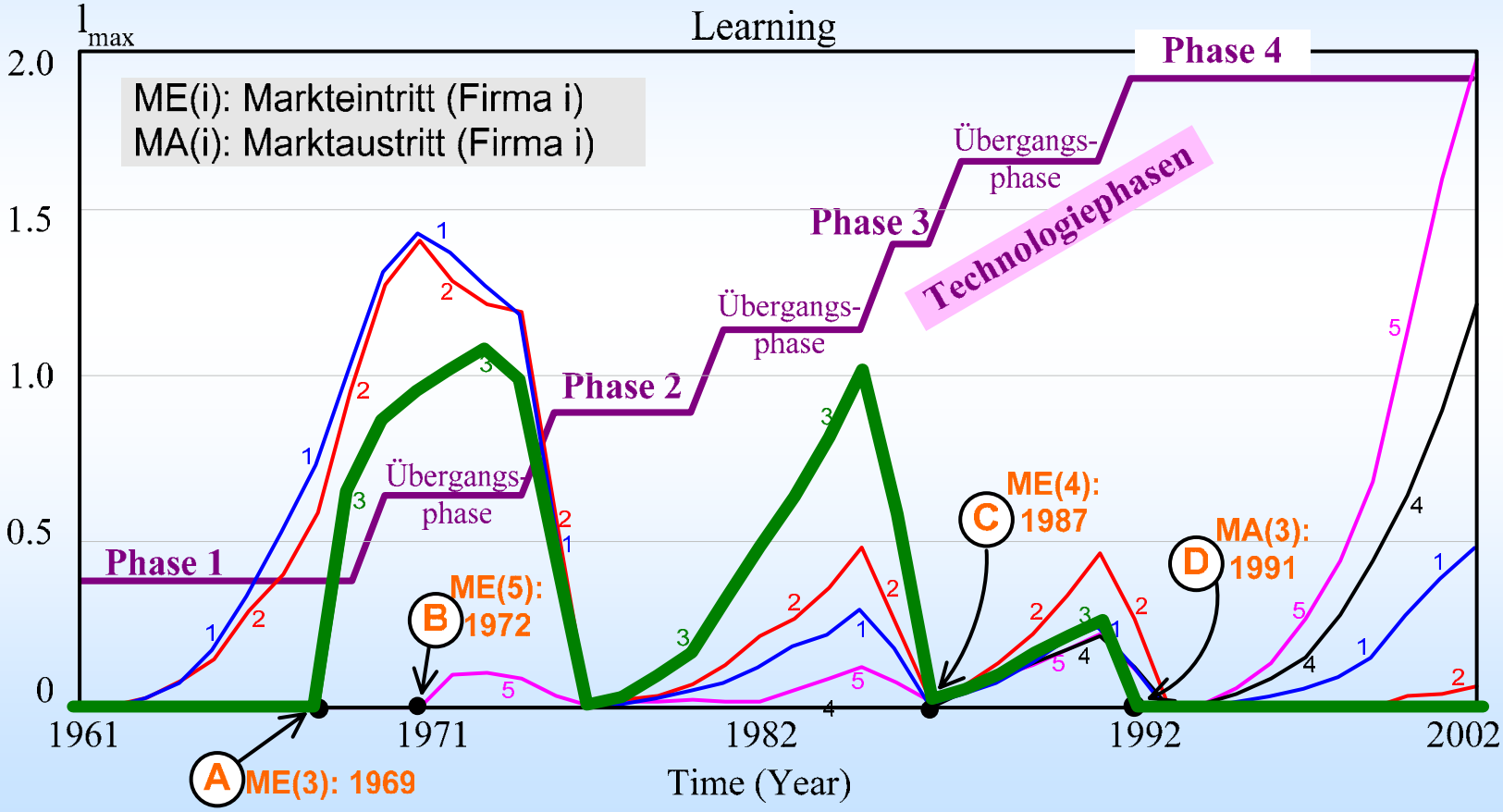
Result 6: the case of the company Nixdorf

Scenario B: Variable "Learning curve"



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Result 7: a counterfactual scenario B

Top 1

in scenario B for <u>firm 3</u>

Top 2

Firm 3 has <u>equal starting equipment</u> like before

Top 3

BUT: modification/change of behavioral parameters
→ like firm 1

Top 4

⇒ instead of "own technology" and
"focus on previous success"

Top 5

now more often: "focus on new technology",
"acquisition of new technology" and
"imitation"

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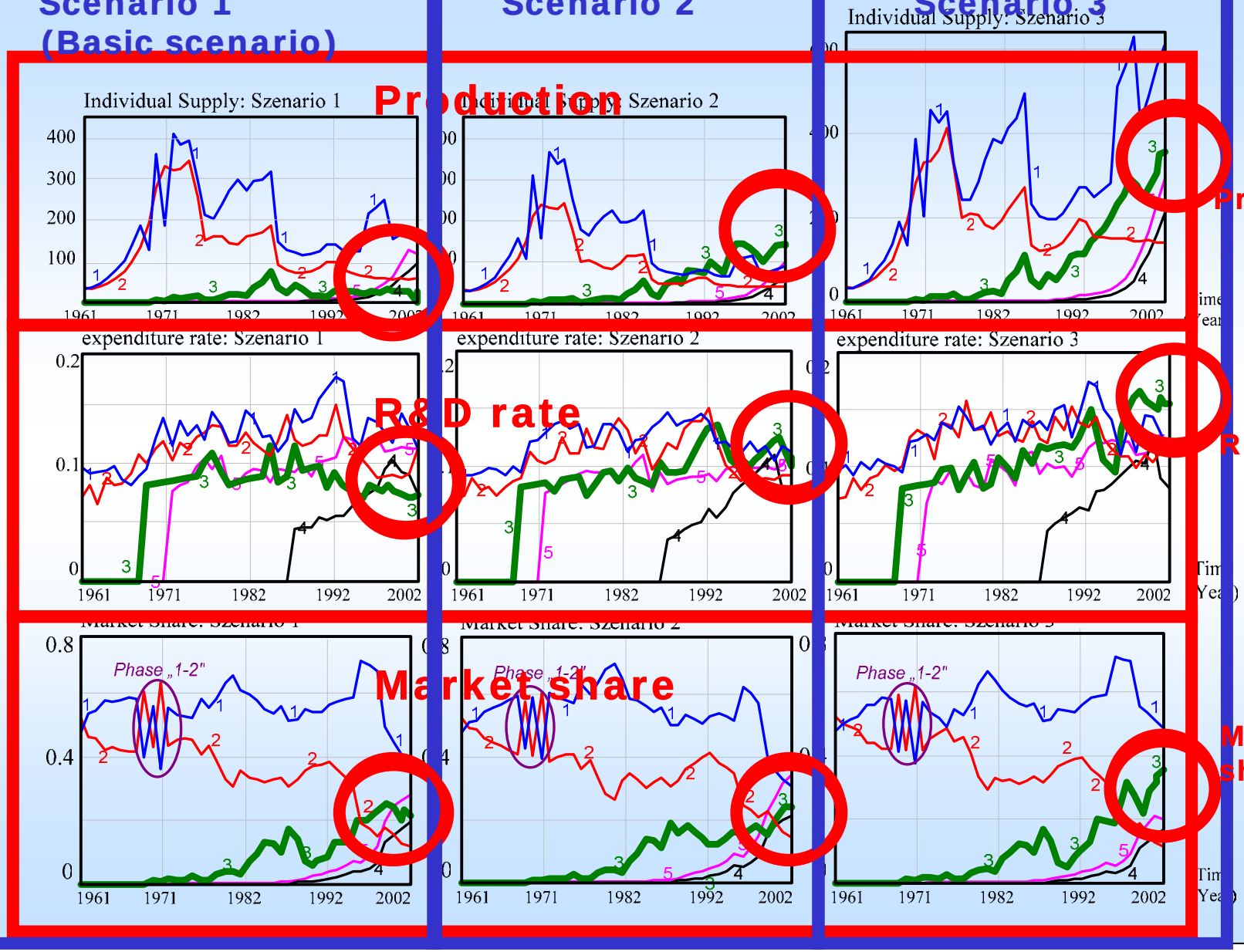
Scenario 1 (Basic scenario)

Scenario 2

Scenario 3



Top 1

Production

Top 2

Top 3

R&D rate

Top 4

Top 5

Market share

Top 6

Structure

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- identification of the for success of firms responsible parameters
- construction of a simulation model for both countries with <u>equal basic structure</u>
  but with individual behavioral parameters
- calibration with Japanese and German firm data
- aim: Historically consistent tracing (basic scenario)
- alternative scenarios:
  "what if"-scenario: changing of the firm's behavior
  without changing of the initial equipment

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The model shows...

- Market entrance and exit Top 1
- Strategy “Market leadership“
  Political framework necessary, but not enough Top 2
- **Differences Japan-Germany**
  - subjective cognition of competition / success Top 3
  - Differences due to: <u>not</u> technical components or production functions, but behavioral parameters Top 4
- **Factors for success**
  not firm size, not duration of market membership, not production methods but: Top 5
  Behavioral variables
  ⇒ essential for R&D respectively innovation strategy and learning behavior
  ⇒ decisive for innovation performance Top 6

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ρ_T and Λ :

Top 1

ρ_T = rate of obsolescence of a technology
= reciprocal value of product-life time

here for the IT-case

Top 2

average life time of an IT technology: ca. 4.9 years

$$\frac{1}{4.9 \text{ years}} = 0.2041 = 20.4\% \text{ per year} \quad \Rightarrow \quad \rho = 0.2041$$

Top 3

Top 4

Λ = Lead-Time: average time from R&D beginning of the technology until bringing onto the market

Top 5

$$T_{it} = \sum_{j=1}^{\Lambda} \frac{1}{\Lambda!} \cdot (\Lambda - j + 1) \cdot R_{i,t-1} + \ldots$$

here for the IT-case

Top 6

ca. 2.8 years $\Rightarrow \Lambda = 3$

therefore R&D expenditure rates of the last 3 years!

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Model calibration, optimization and questions

Model calibration:

- fixing: real (historical) data of capital, employment and R&D-expenditures
- estimation of the remaining parameters
  $\rightarrow$ realization of sufficient consensus between simulated and real time series. Optimization method: OLS

Questions:

- tracing near reality (concerning basis variables)
  K_{it}, L_{it} und r_{it} for both scenarios possible?
- market entrance and exit of firms possible in model?
- responsible variables?
- development of alternatives?

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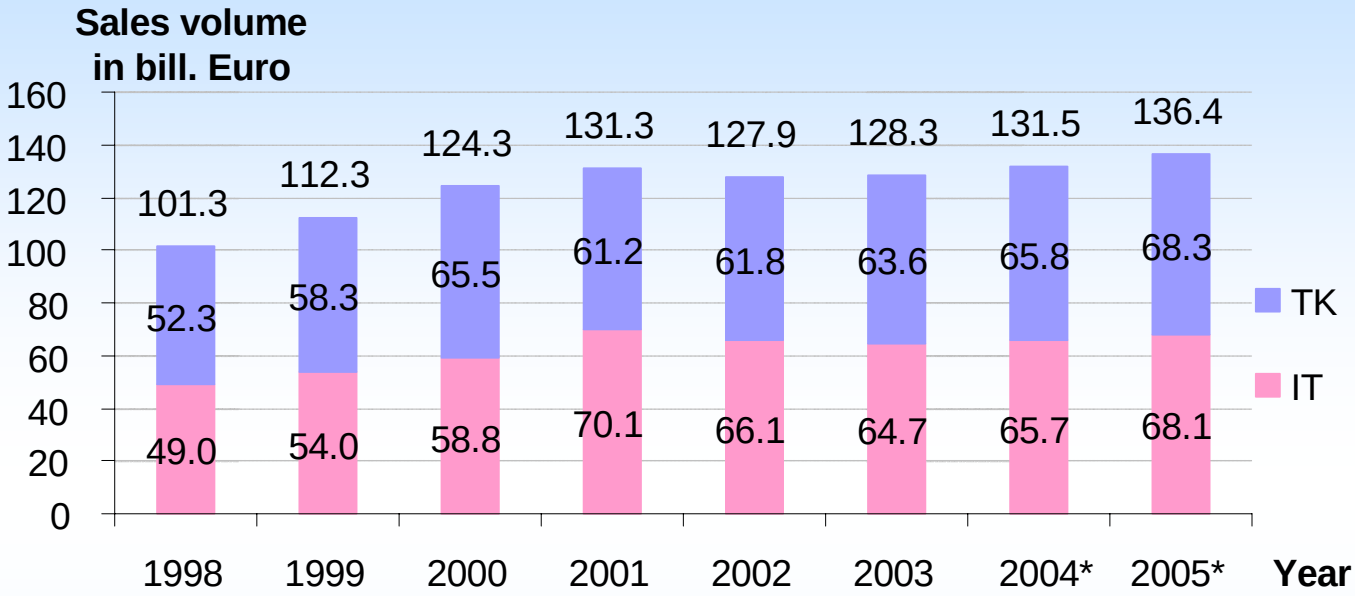
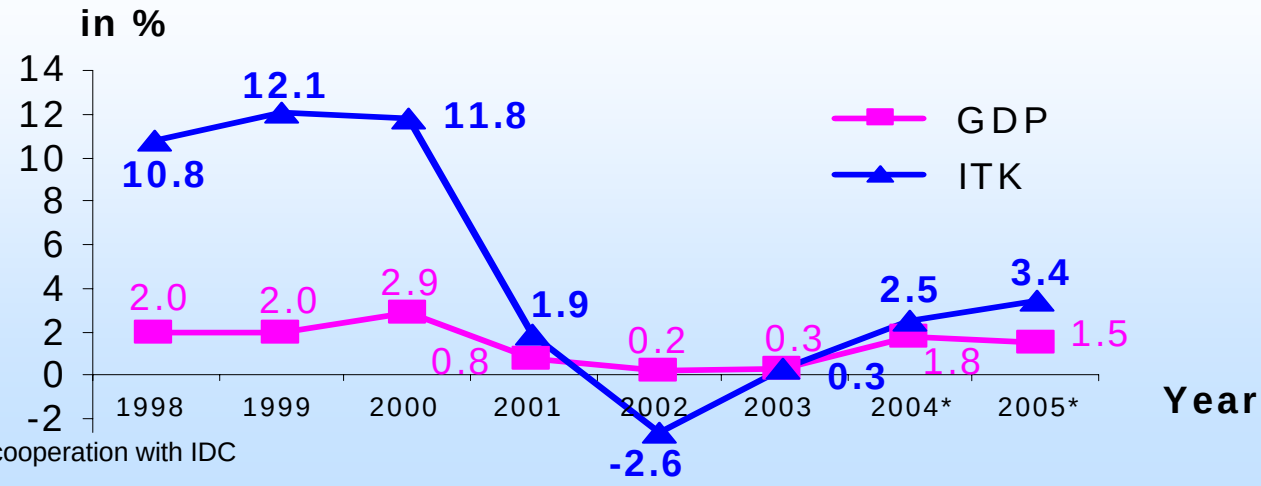
IT sector development in Germany





Source: EITO in cooperation with IDC

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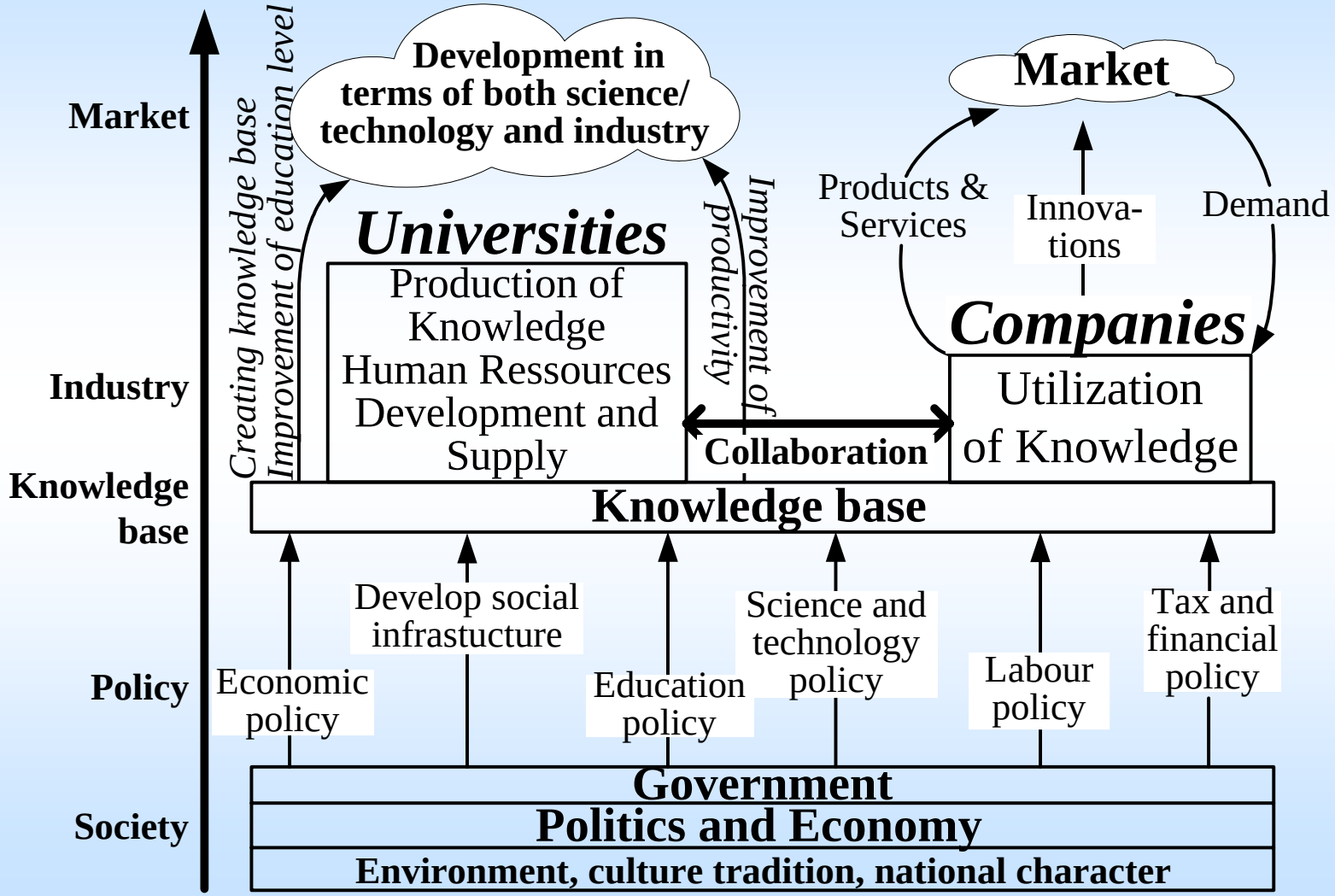
NIS-concept



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