

## Final exam: Advanced Analysis of Innovation Systems

Date: June 25<sup>th</sup> 2007

Time: 13:15-16:00

*No entrance after 13:45*

*You are not allowed to leave before 13:45*

### Instructions:

- Check whether your exam consists of 11 questions
- Mark each page with your name and student number.
- Make sure your handwriting is clear and legible
- Observe the page limits for questions 8-11
- Answer questions 10 and 11 on a separate sheet

### Grading

- The exam consists of 5 multiple choice questions and 6 open questions
- Overall you can obtain 45 points, preliminary grade =  $(\text{points}+5)/5$
- Results will be made available through webCT on June 28th
- The exam will be discussed on June 28<sup>th</sup>, between 11:00-13:00 in Best L&E

### General:

- Questions were graded as a whole (so if we were unsure (in doubt between 0 or 0.5 for example) we have tried to be fair w.r.t. the points given for the entire question)
- Deduct point for obvious errors

Question 1	1 points	92.5 % points scored
Question 2	1 points	90 %
Question 3	1 points	82.5 %
Question 4	1 points	92.5 %
Question 5	1 points	70 %
Question 6	3 points	46 %
Question 7	2 points	40 %
Question 8	8 points	66 %
Question 9	8 points	50 %
Question 10	9 points	50 %
Question 11	10 points	74 %
Total	45	
Grade = $(\text{points}+5)/5$		

### Multiple choice questions

#### Correct answer underlined>

**Question 1** (1 point): The linear model of innovation corresponds to a

- A. technology-push model
- B. demand-pull model
- C. technological trajectory

**Question 2** (1 point): Which of the concepts below are all characteristics of exploration according to Gilsing and Nootboom?

- A. Technology-oriented innovation, relation-based trust, tacit knowledge
- B. process innovations, loose alliances, limited use of contracts
- C. locally embedded networks, codified knowledge, spin-offs

**Question 3** (1 point): Point X in Figure 1 (adapted from Kash and Rycroft) illustrates a

- A. Normal pattern
- B. Transformation pattern
- C. Transition pattern

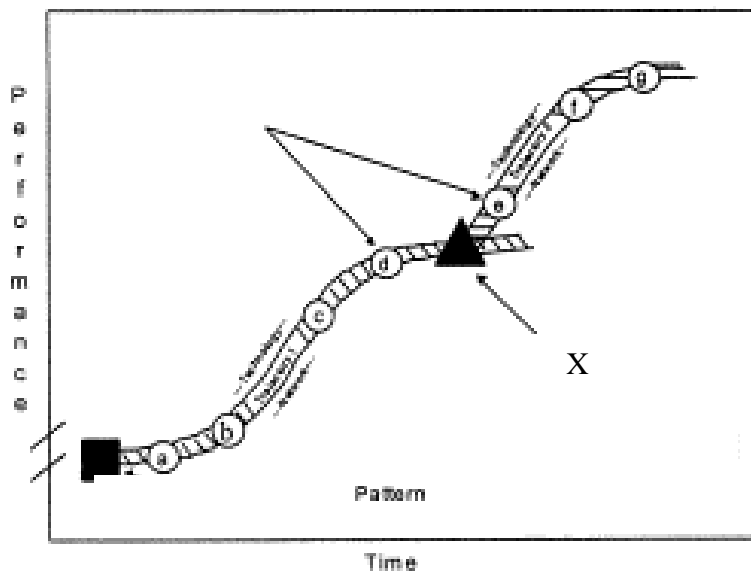


Figure 1 (adapted from Kash and Rycroft)

**Question 4** (1 point): Freeman identifies several outstanding characteristics of the US National System of Innovation during the 5<sup>th</sup> wave. These characteristics include:

- A. The relatively high price of labour in the US
- B. The role of universities

C. The system of lean production

**Question 5 (1 point):** The concept of optimal cognitive distance (Nooteboom) describes a trade-off between:

- A. absorptive capacity and ability to cooperate
- B. learning performance and absorptive capacity
- C. absorptive capacity and novelty value

**Open questions:**

**Question 6 (3 points):** Give the definition of an Innovation System according to Edquist.

“all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion, and use of innovations”

**Question 7 (2 points):** Give the definition for key factor as presented by Goransson and Soderberg.

“that input among all other inputs in a technological system that most apparently lacks substitutes for a longer period of time and embodies the innovative element of the technological system”

**Question 8 (8 points/1 page):**

- a. Name the most important physical infrastructures that characterize each long wave according to Freeman and Louça (at least 1 physical infrastructure for each of the 5 waves).
- b. Describe the contribution of these infrastructures to the upswing of the wave.

Wave I:

Canals and turnpike roads: allowed cheap transport of core inputs (also improving their availability)

Wave II:

Iron railways: higher speed, greater regularity and reliability were advantages for commerce. Also: passenger traffic: firms depended on the speed of commercial travellers and executives; coal and iron available as cheap inputs.

Wave III:

Steel railways: longer lasting than iron; coal and iron became available as cheap inputs.

Telephone: new management practices,

Electricity: cheap, new, robust and flexible source of new energy

Wave IV:

Motorways: stimulated motorization of society by increasing demand for cars; job creation; improvement of mobility of individuals

Radio: forerunner of electronic revolution and ICT

Wave V:

Internet: delivery of services, rise of the networking firm, increased speed of processing but also rapid access to sources of information

**Question 9** (8 points/1 page):

Describe the development and the importance of the knowledge infrastructure component of the Innovation System during each of the 5 waves using the empirical material from the book by Freeman and Louça.

Wave 1: Knowledge infrastructure undeveloped, most innovations by user-inventors  
Wave 2: Knowledge infrastructure still rather undeveloped, railways played an important role in training highly skilled workers, some inventors were also scientists  
Wave 3: Innovations directly science related, secondary education systems arising in Germany and US (technology institutes), in-house R&D  
Wave 4: Mass education, R&D cooperation  
Wave 5: R&D networks, KI as we know it today

### **START QUESTION 10 ON A SEPARATE ANSWER SHEET**

**Question 10** (9 points/1.5 pages):

Gilsing and Nootboom (2006) describe the evolution of the pharmaceutical biotechnology sector by distinguishing 3 periods.

- a. Discuss the innovation networks in the pharmaceutical biotechnology sector during each of the three periods.
- b. Discuss the technological trajectories of drug discovery technology in each period.
- c. Use the framework of Kash and Rycroft to discuss each period, thereby identifying core capabilities, complementary assets, organizational learning, path dependence and the selection environment.

Ad a.

*Period 1:* Large pharma firm, not really a network

*Period 2:* 2 types of networks (large pharma with DBFs, DFBs with science), properties see Table 2 and 3 in article

*Period 3:* idem but increasing globalization

+ discussion

Ad b.

*Period 1:* organic chemistry, random screening

*Period 2:* organic chemistry + molecular biology, more guided screening process - > towards rationalization

*Period 3:* genetic engineering – 2 trajectories (process tool to produce proteins, combi genetic engineering + molecular biology – to speed up process) – move back to include randomness in search process (enables by HTS)

+ discussion

Ad c. example from perspective of large pharma firm, there are grey areas, fuzzy boundaries

	Period 1	Period 2	Period 3
Core capabilities	Highly tacit random screening knowledge	Highly tacit random screening knowledge + cooperation (more codified knowledge), network learning	tacit screening knowledge + cooperation (more codified knowledge), network learning
Complementary assets	Testing, regulation	Biomolecular knowledge, cooperation, networking, testing, regulation	Genetic engineering knowledge, cooperation, networking, testing, regulation
Organizational learning	Local, in-house, tacit learning	Local and Network learning	Local and Network learning, cosmopolitan
Path dependence	High because dependent on tacit knowledge	Less strong, because of new collaborations, also new bodies of knowledge, new skills necessary	Similar to 2 maybe even weaker (globalization)
Selection environment	Stable – market with large pharma firms, high revenues from blockbusters, regulatory system	network, regulatory system, limited market	Network, Regulatory system, limited market

**Question 11** (10 points/1.5 pages):

Figure 2 below illustrates the general pattern of a long wave. In this question you are asked to describe this pattern using the following concepts:

- I. Lock-in
- II. Radical innovations
- III. Decreasing returns to scale
- IV. Schumpeterian entrepreneurs
- V. Exploitation

- a. Give a short description of each concept
- b. Describe the four phases of the wave pattern in Figure 2 thereby using the concepts (I-V) given above to describe each phase.

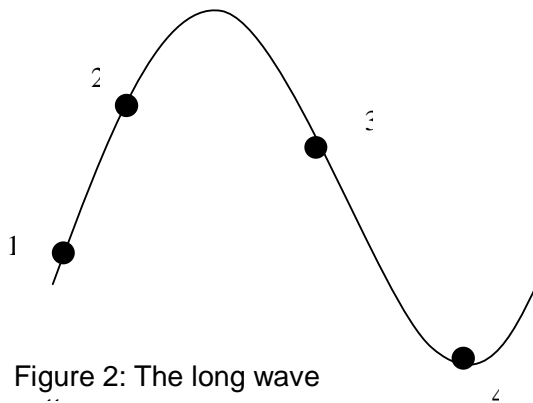


Figure 2: The long wave

Ad a:

I. *Lock-in:*

W.B. Arthur (Economic Journal 99:116-131).

“Modern, complex technologies often display increasing returns to adoption in that the more they are adopted, the more experience is gained with them and the more they are improved. When two or more increasing-return technologies ‘compete’ then, for a ‘market’ of potential adopters, insignificant events may by chance gains an early lead in adoptions. This technology may then improve more than the others, so it may appeal to a wider proportion of potential adopters. It may therefore become further adopted and further improved. Thus a technology that by chance gains an early lead in adoption may eventually ‘corner the market’ of potential adopters, with the other technologies becoming locked-out.”

“self-perpetuating market-dominance”

II. *Radical innovations:*

Radical innovation, new product demanding a new way of seeing the whole problem. There is often considerable uncertainty about future outcomes. Radical innovation involves considerable change in basic technologies and methods, created by those working outside mainstream industry and outside existing paradigms.

III. *Decreasing returns to scale*

Returns to scale refers to a technical property of production that examines changes in output subsequent a proportional change in all inputs (where all inputs increase by a constant). If output increases by less than that proportional change, there are decreasing returns to scale (DRS).

IV. *Schumpeterian entrepreneurs*

is a person who is willing and able to convert a new idea or invention into a successful innovation, thereby taking a risk

V. *Exploitation*

The efficient employment of current assets and capabilities (Nooteboom and Gilsing)

Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, execution (March Organization Science 2(1), 1991).

*Phase 1:* Radical innovations, Schumpeterian entrepreneurs (risk-takers),

*Phase 2:* Lock in, exploitation

*Phase 3:* Decreasing returns to scale, lock-in

*Phase 4:* (still decreasing returns to scale and already overlap with phase 1 but benefits are not yet clear because of mismatch)

Discussion must also be present (not only name concepts) in order to obtain full points