Optimizer's Curse in Project Portfolio Selection

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Systems Analysis Laboratory

Systems Analysis Laboratory was established in 1984 within the professorship of applied mathematics. The founder and director of the laboratory is Professor Raimo P. Hämäläinen. The team of professors also includes Harri Ehtamo and Ahti Salo. Professor Esa Saarinen continues with us as a co-director of the Systems Intelligence Group. In the new administration of HUT we are part of the Department of Mathematics and Systems Analysis in the Faculty of Information and Natural Sciences.

The research interests of the laboratory cover the area of systems science comprehensively ranging from the mathematical theories and algorithms of optimization, control, decision making to the practical interactive computer modeling and decision support systems and risk and technology assessment. The focus of the applications is in complex energy, production and environmental systems. The problems are analyzed with a balanced engineering-economic systems approach. We also have a long tradition in biological modelling. Currently we have a growing effort in studying systems intelligence and applied philosophy in human organizations.

As an university institution the laboratory is unique in Finland. It is responsible for the undergraduate program in *Systems Sciences* and for the graduate specialty of *Systems and operations research* in the Engineering Physics and Mathematics program. We also give basic courses in *systems sciences* and *applied mathematics* for all students of the Helsinki University of Technology. The laboratory is in charge of the Doctoral Program in Systems Analysis, Decision Making, and Risk Management.

President Martti Ahtisaari visited our course Philosophy and Systems Thinking on February 27, 2008.
President Martti Ahtisaari was awarded the Nobel Peace Prize 2008.

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Characteristics project portfolio selection

- Large number of proposals
  - Typically dozens or even hundreds of proposal
- Only a fraction can be selected with available resources
  - Even other resources than money may matter (critical competences)
- “Value” may be measured with regard to several criteria
  - International collaboration, innovativeness, feasibility of plans
- Reliable information about value is hard to obtain
  - Different experts may give different ratings
  - How much time and effort should be devoted to the preparation of project proposals? And how much to the evaluation of the resulting proposals?

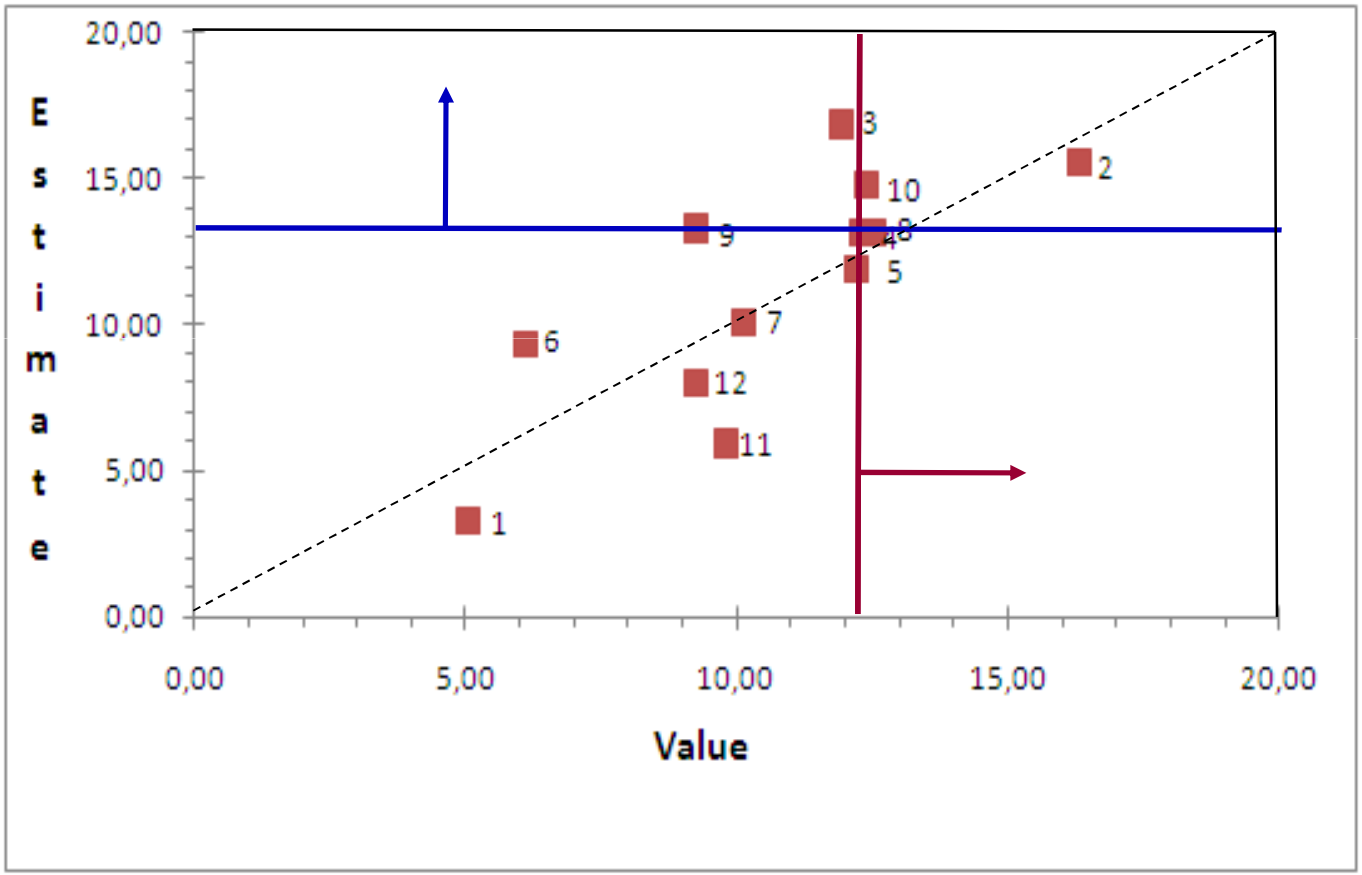
Logic behind the optimizer's curse

- Projects offer different amounts of value (eg NPV)
- Estimates about projects' values are inherently uncertain
- Yet decisions must be based on these uncertain estimates
- In reality, projects whose values have been overestimated have a higher chance of getting selected
- Thus the decision maker should expect to be disappointed with the performance of the selected portfolio

Example – choose 5 out of 12 projects

Mu_v	10	N	5
Std_v	4	Std_e	3

	V	V+e	Selected estimated	Selected actual	True optimum
1	5,04	3,27	0	0	0
2	16,32	15,56	1	1	1
3	11,94	16,85	1	1	0
4	12,32	13,14	0	0	1
5	12,22	11,92	0	0	1
6	6,11	9,35	0	0	0
7	10,12	10,07	0	0	0
8	12,51	13,18	1	1	1
9	9,24	13,29	1	1	0
10	12,38	14,78	1	1	1
11	9,79	5,92	0	0	0
12	9,25	7,97	0	0	0
			73,66	**62,39**	**65,75**
			Selected estimated	Selected actual	True optimum



Approach and research questions

- Key questions
  - How does (i) the number and (ii) quality of evaluation statements impact the optimal project portfolio?
  - What kinds of evaluation and selection procedures outperform others?
- Concepts
  - True value: Value (e.g., quality, research output) which would be produced, if the project were to be funded
  - Estimated value: Value that the expert reports in his/her evaluation statement
  - Optimal portfolio: The portfolio that maximizes the aggregate sum of true values (typically not known, can be determined only if true values are known)
  - Selected portfolio: The portfolio that maximizes the sum of estimated values
- Results based on simulation and optimization models

Value of information and optimality in DA

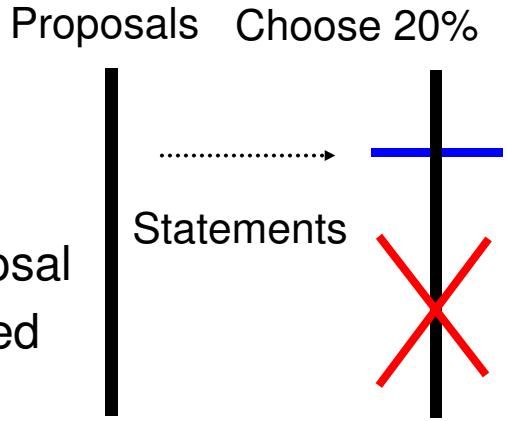
- The optimizer's curse: skepticism and postdecision surprise in decision analysis (Smith and Winkler, 2006)
  - Choose one out of many alternatives
  - Normally distributed values and errors
  - Positively correlated errors aggravate the curse

- Value of information in project portfolio selection (Keisler, 2004)
  - For some selection rules, the value of the selected portfolio is much higher than for other selection rules
  - It pays off to devote attention to the design of the selection process
- How bad is the optimizer's curse in project portfolio selection?
- What selection rules are better than others?

Illustration of project evaluation and selection

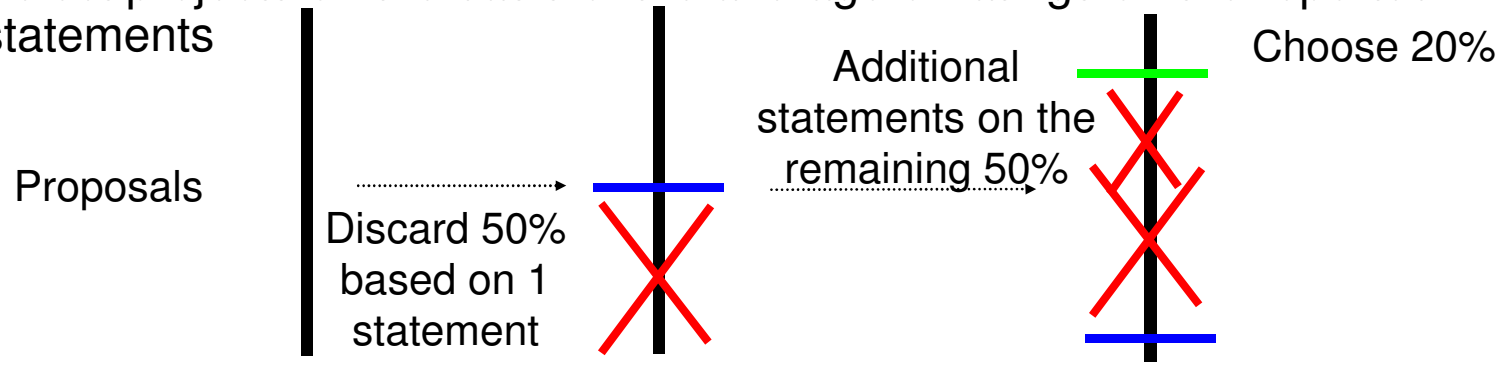
- 100 project proposals
  - 20 out of these will be selected (➔ approval rate 20 %)
- At least one statement on each proposal
  - All statements have the same cost (e.g., about 0.5% of project costs)
- The “true” underlying value distributed on the range 1-5
- Evaluation statements convey information about the true value
- Statements inform decision making

Examples of selection mechanisms



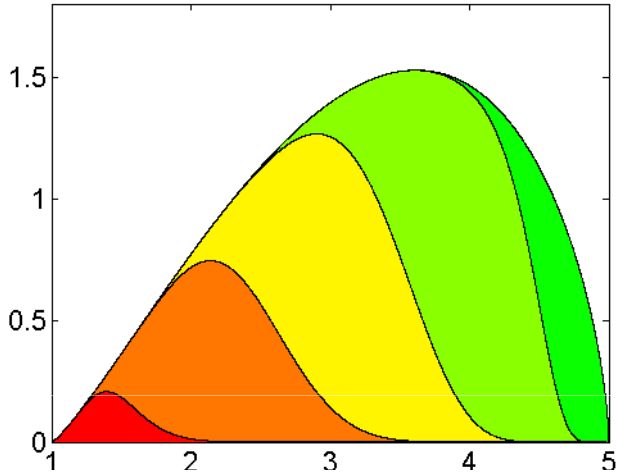
- One-phase (”batch-mode”)
  - Equally many evaluations (1 or several) on each proposal
  - Projects selected on the basis of the average of reported ratings on the evaluation statements

- Two-phase
  1. Discard 50 % of proposals based on a single evaluation statement
  2. Acquire additional statements on the remaining 50 %
  3. Select projects on the basis of the average of ratings on the reported statements



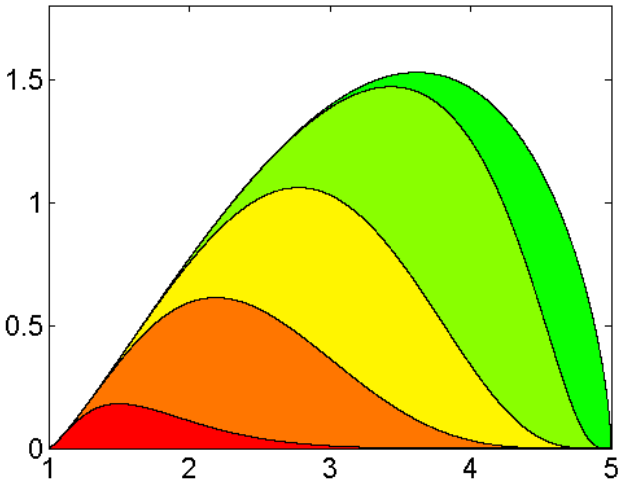
Distributions of true values and evaluation statements

- Distribution of “true” value is modelled using a probability distribution
- Evaluation statements depend on the true value
  - “Good” proposals are likely to have a higher rating on the 1-5 scale
- Non-optimal selection due to (i) errors and (ii) discretization



$$\frac{e^{x}}{1+e^{x}}$$

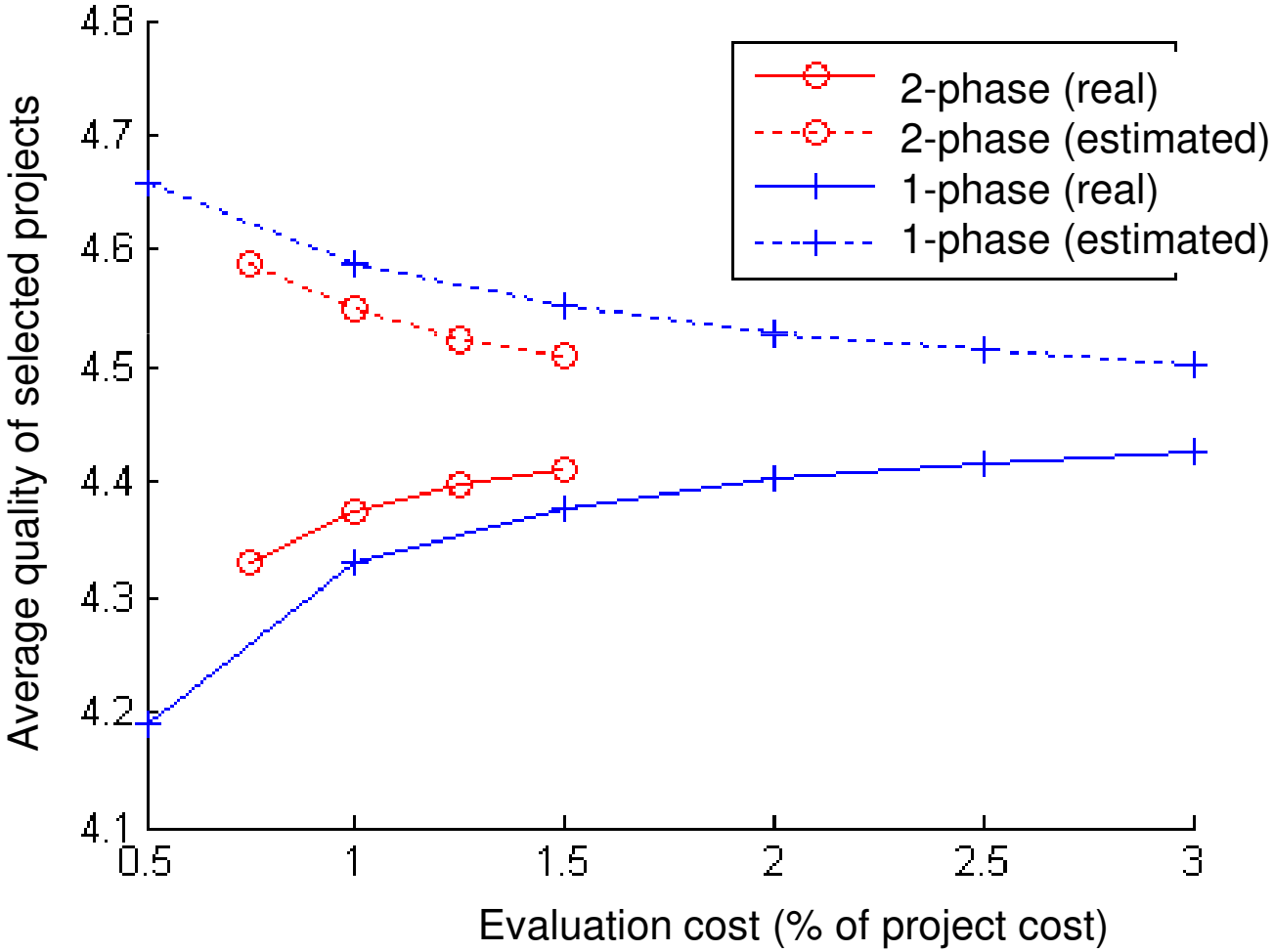
$$x \sim N(\alpha_i, \sigma_x)$$



$$\frac{e^{x+\varepsilon}}{1+e^{x+\varepsilon}}$$

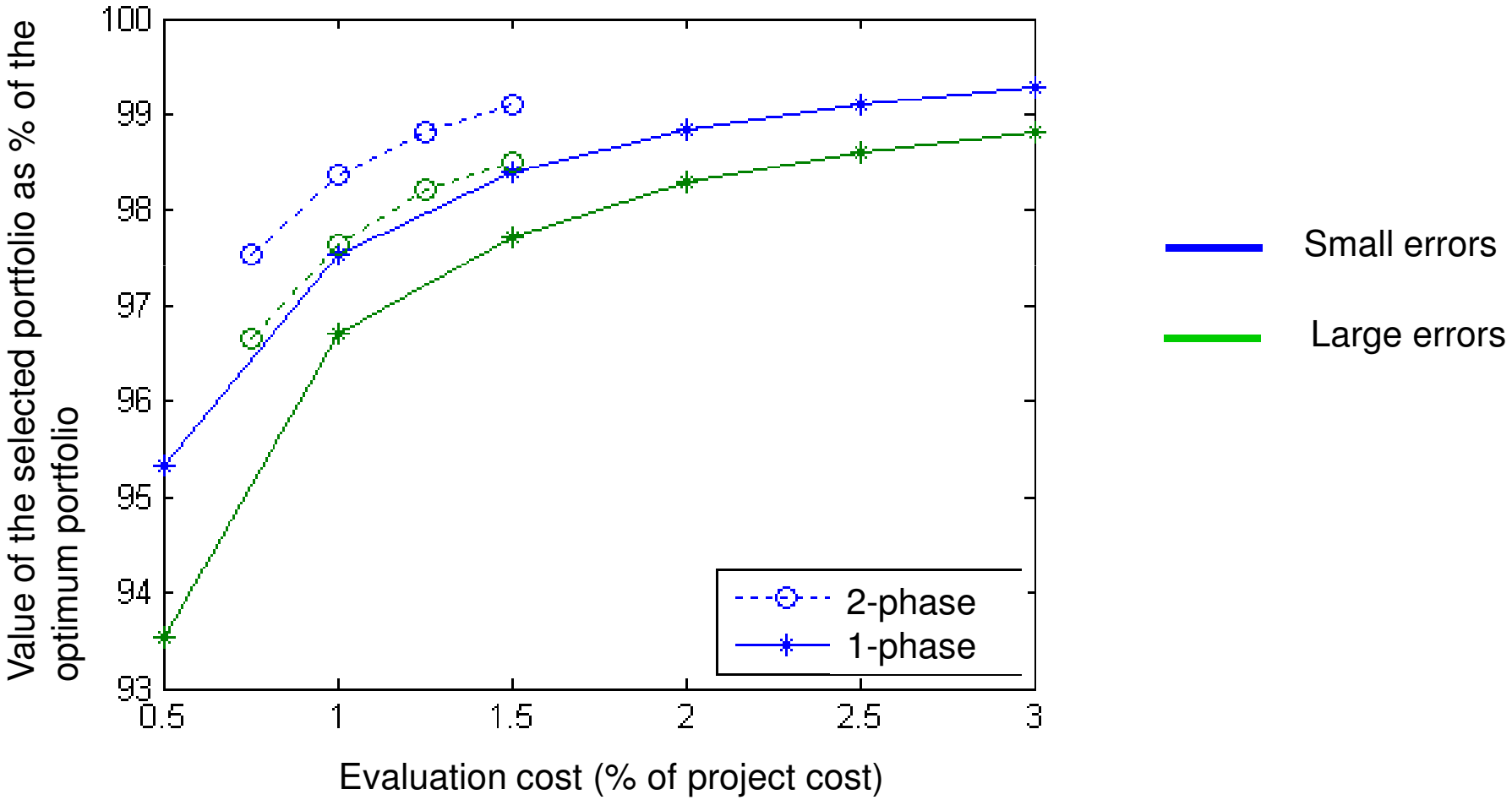
$$\varepsilon \sim N(0, \sigma_\varepsilon)$$

Optimizer's curse and the value of selected projects

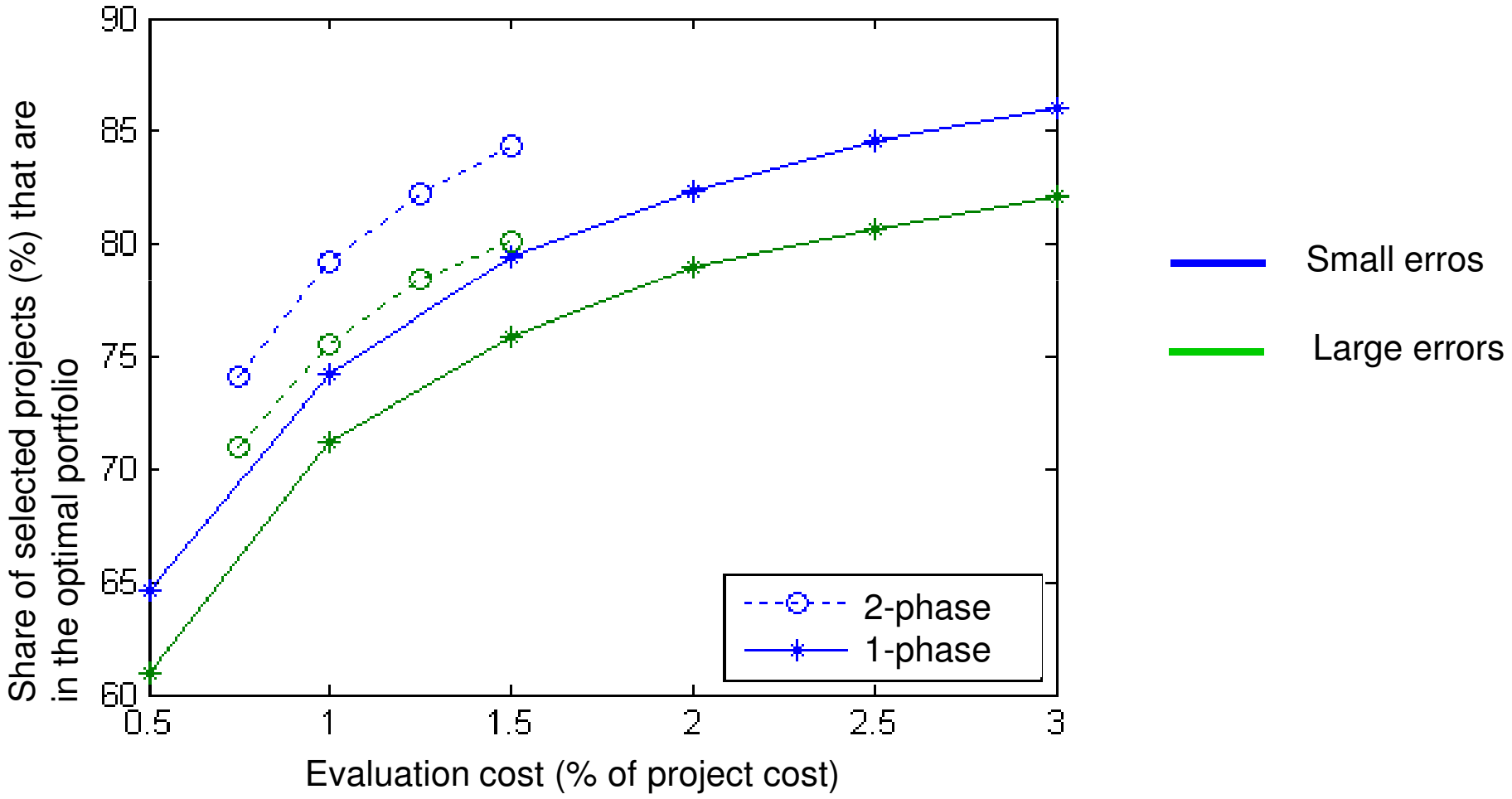


(based on the distributions on the preceding slide)

Evaluations bring portfolio value nearer the optimum



But justice to the individual is hard to guarantee



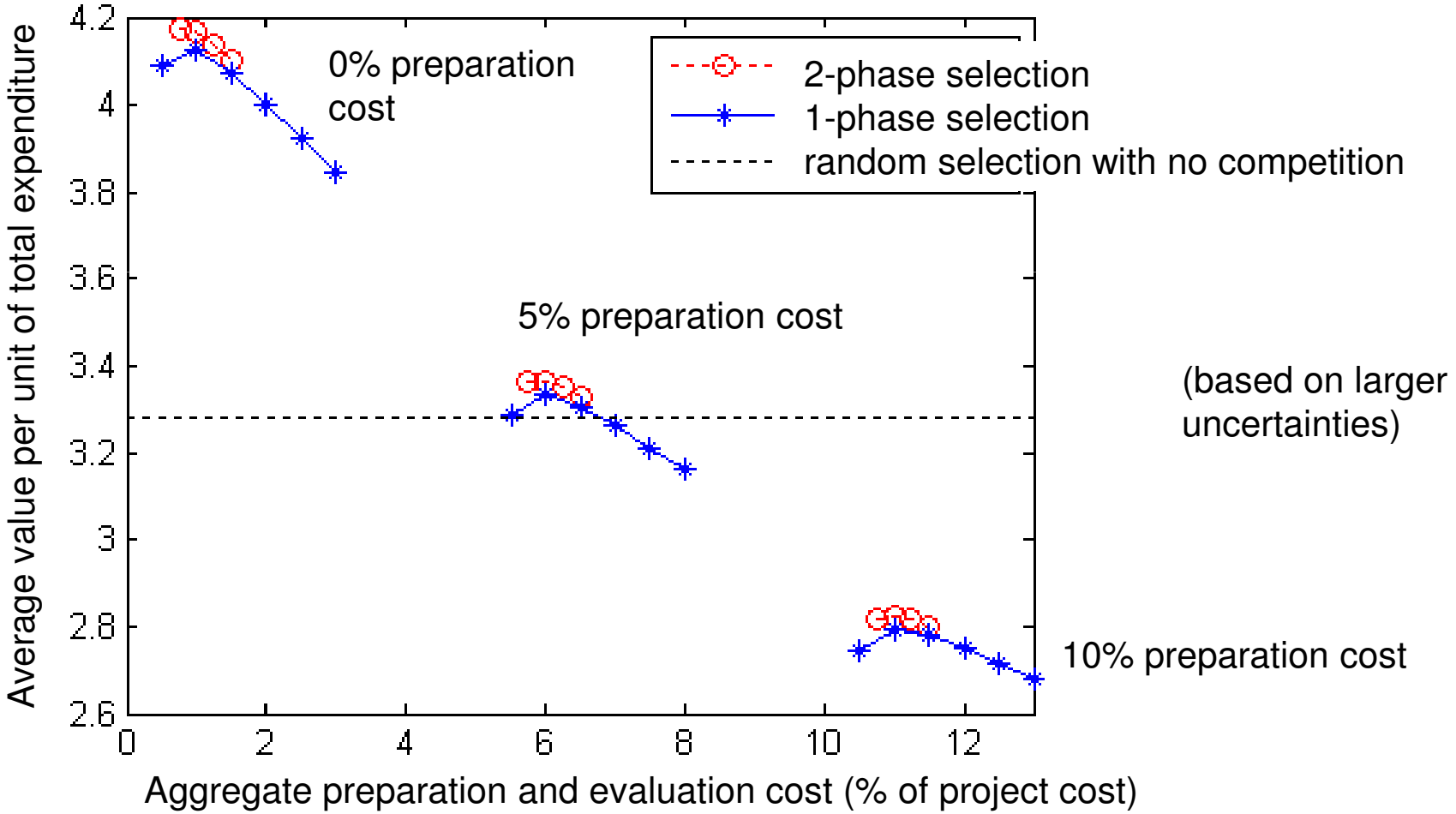
Impact of competitive tendering on productivity 1(3)

- Include the effort of proposal preparation in the analysis
  - Approval rate 20 % (select 20 projects out of 100 proposals)

- When do the benefits of further evaluation statements exceed the cost of obtaining them?
  - Evaluation costs still estimated at 0.5% of project costs
  - Hence a statement on a 100 000€ project costs 500 €

- Account for the efforts required by proposal preparation, too
  - Preparation efforts estimated at 5% of project costs (100 000€ *0.05 = 5000€)
  - If one statement is obtained on all projects, the total cost of (i) preparing the proposals, (ii) evaluating them, and (iii) launching the projects is 100*5000€ + 100*500€ + 20*100 000€ = 2,55 M€

Impact of competitive tendering on productivity 2(3)



Competitive enhances productivity when

1. There is high variability in the quality of proposals
   - Otherwise, it does not really matter much which projects are selected
2. Approval rate is high enough
   - Otherwise, a considerable amount of effort is spend on preparing project proposals that will not be launched
3. The preparation of proposals does not require excessive efforts
   - Otherwise, a heavy burden will be imposed on those who prepare the proposals
   - The proposals should be detailed enough to permit a reliable evaluation
4. Evaluation statements are reasonably good
   - Otherwise, they will be less helpful in decision support

Managerial implications (1/2)

- Selection processes can be analyzed systematically
  - Parameters can be estimated from data using maximum likelihood methods
  - Key determinants: (i) approval rate, (ii) value distribution of proposals, (iii) quality of evaluation information, and (iv) structure of the selection process
  - These are intertwined
- This framework helps improve selection processes
  - How much funding should be devoted to the preparation of proposals? (if this helps ensure that proposals can be evaluated more accurately)
  - How much funding should be spent on evaluating the proposals? (rather than using this funding for launching additional projects)
- Design of the selection process is a key determinant of productivity

www.finnsight2015.fi - Netscape

FinnSight 2015

- Project homepage
- Organisation
- Panels
- 1. Learning and Learning Society
- 2. Services and Service Innovations
- 3. Well-being and Health
- 4. Environment and Energy
- 5. Infrastructures and Security
- 6. Bio-expertise and Bio-society
- 7. Information and Communications
- 8. Understanding and Human Interaction
- 9. Materials
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Search

Suomeksi På Svenska

FinnSight 2015 – Science and Technology in Finland in the 2010s, is a joint foresight project of the Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation. The project was carried out in 2005-2006.

The foresight project examined the change factors that have impact on Finnish business and industry and on Finnish society, identified future challenges of innovation and research activity and analysed such areas of expertise which will foster the well-being in society and the competitiveness of business and industry by means of scientific research and innovation activities. The focus in foresight was on social and global issues.

Foresight will lay the foundation for the Strategic Centres of Excellence in Science, Technology and Innovation. Simultaneously, foresight will reinforce strategy work at the Academy of Finland and Tekes.

The core of the foresight project comprised ten expert panels, each of which was composed of twelve experts. The areas that emerged most prominently were the management of global risks, energy and environment issues, the renewal of the health care system as well as ICT and biosciences applications. All of these areas require science and technology cooperation that is based in human needs. The Academy of Finland and Tekes will publish the results of the foresight project in English in September 2006.

http://www.finnsight2015.fi/

ACADEMY OF FINLAND

PRESS RELEASE

FINNSIGHT 2015

Tekes

For release on June 13th, 2006

Academy of Finland's and Tekes foresight project identifies key priorities for the future

FinnSight 2015 experts have completed their work to identify what are considered the main focus areas in science, technology, business and industry, and society. The areas that emerged most prominently were the management of global risks, energy and environment issues, the renewal of the health care system as well as ICT and biosciences applications. All of these areas require science and technology collaboration that is based in human needs.

FinnSight 2015, a joint project between the Academy of Finland and Tekes, the Finnish Funding Agency for Technology and Innovation, involved 120 leading Finnish experts. The project was organised into ten panels dealing with the themes of learning and learning society, services and service innovations, well-being and health, environment and energy, infrastructures and security, bio-expertise and bio-society, information and communications, understanding and human interaction, materials and the global economy. In all, the panels identified some 80 areas of expertise that Finland should focus in order to reach scientific and technological breakthroughs and new innovations.

Selection criteria

- **The Strategic Centres of Excellence in STI have to be very significant with regard to their potential for the national economy and society as well as their R&D investment.**

- **The Centres must have sufficient human and financial resources at their disposal.** As soon as their operation has been established and stabilised, the overall financial volume of each Centre should be some €50–100 million per annum, depending on the subject area and activities.

- **The Centres must be based on applications that are vital with regard to the future of the field in question.** Application-based approach means that the RDI activities of each Centre are based on a combination of a variety of competences. The important role of innovation activities also presumes that the Centres are supplemented by operational environments, where new applications and ideas can be piloted and tested in circumstances that are as real as possible.

- **The core competence for the Centres must be found in Finland. All the Centres must have the potential to be among the best in the world.** The Centres must be internationally credible and renowned, and they must be able to attract the best experts and enterprises in the field throughout the world. Therefore, they must be globally networked and co-operate actively in the international framework.

- **The Centres are based on the strong commitment of the key enterprises, universities, research institutes, financiers and ministries in the respective subject areas.** Their operations and funding are long-term by nature. This facilitates the Centres to maintain their competitive edge. The Centres and parties involved must have a clear, shared and goal-oriented vision and a focused strategy.

The proposed subject areas are as follows:

- **Energy and environment**
  This Centre could focus on environmentally friendly energy production, while its central application areas could include bioenergy, decentralised small-scale energy production and its connection to energy systems, as well as solutions reducing energy system emissions.

- **Metal products and mechanical engineering**
  The activities could focus on moving machinery and vehicles, as well as on manufacturing and automation technology.

- **Forest cluster**
  This Centre could focus on the comprehensive exploitation of materials such as wood and its derivatives as well as on new intelligent products.

- **Health and well-being**
  This Centre could focus on two themes: firstly, the well-being and health of the elderly, with particular emphasis on support services and products supporting living at home, as well as on the support for self-reliance and self-care; and secondly, the development of individualised medical care and diagnostics through exploitation of genetic and register information.

- **Information and communication industry and services**
  The theme of this Centre could be the services and products of the future information society. Research subjects could include user-oriented application and service concepts, technical platforms for digital services, data security, and software, telecommunications and equipment engineering technologies and their planning, implementation and business models.

Managerial implications (2/2)

- Where should the evaluation focus be?
  - Seek information on the borderline where it matters most!
- How much time and effort should be devoted to evaluation?
  - Spending too much effort on evaluation may undermine productivity
- For how long should the commitments be made?
- Should all projects should be managed in the same portfolio?
- How many projects should be killed before completion?

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