The Dynamics of Value Creation
in Biopharmaceutical Research and Development

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30 Memorial Drive, E60 - 383, Cambridge MA, 02139
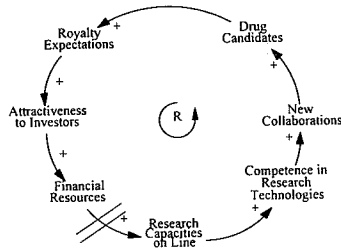Fax: 617-258-7579, e-mail: mugrossm@mit.edu

Presentation Outline[*]

I. Purpose of a formal evaluation framework for biopharmaceutical research companies
    a. Evaluation framework to measure royalty expectations
    b. Royalty expectations as limited by corporate policies
    c. Framework application in mature biopharmaceutical companies

II. Components of a formal evaluation framework to measure value creations
    a. Flow of drug candidates through R&D pipelines
    b. Present values of expected returns and future costs from drug candidates
    c. Net present values to measure value creations

III. Parameter assumptions and estimations to calculate net present values
    a. Revenue expectations as average and constant values
    b. Transfer probabilities to move drug candidates through R&D pipelines
    c. Cost of capital estimations derived by the Capital Asset Pricing Model

IV. Leverage concepts to understand the dynamics of cost of capital for R&D projects
    in the pharmaceutical industry
    a. Financial leverage and its risk amplifying effects for equity investors
    b. R&D leverage as an analogy to financial leverage
    c. Simulating the dynamics of cost of capital for research projects in the
        biopharmaceutical industry

The following figures are causal loop diagrams and simulation runs to be presented at the conference. Space limitations do not allow a satisfactory discussion of the topic and the interested reader is referred to the author's conference presentation and the working paper mentioned in the footnote. In addition, the parameter assumptions used for simulations are proprietary and can currently no be revealed.
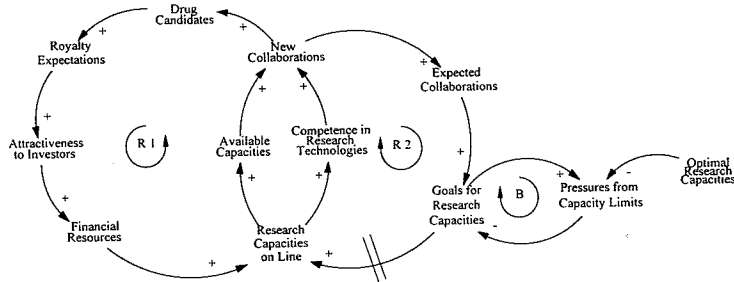
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[*] The presentation outline is also the table of contents for a working paper to be finished for both the M.I.T. system dynamics group and the M.I.T. Program on the Pharmaceutical Industry (Departmental Memorandum, D-4682). Basic knowledge on pharmaceutical R&D is required in order to understand the paper completely, which is an excerpt of the authors Ph.D. dissertation. He is a Visiting Scholar at the M.I.T. System Dynamics Group from Mannheim University (Germany) where his thesis is supervised by Professor Dr. G. v. Kortzfleisch.

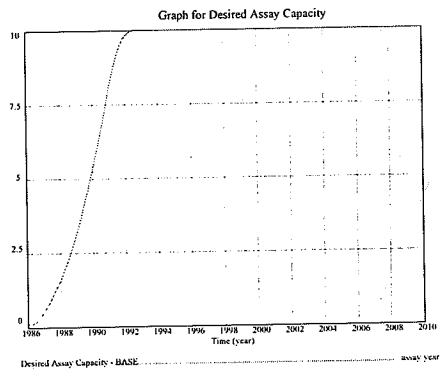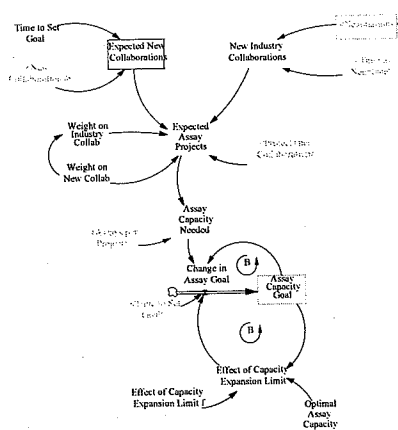# I. Major dynamic hypotheses causing and limiting growth for Biotech companies

Major reinforcing loop causing growth for Biotech companies

Royalty
Expectations

Drug
Candidates

Attractiveness
to Investors

R

New
Collaborations

Financial
Resources

Competence in
Research
Technologies

Research
Capacities
on Line

Limits to growth as caused by optimal research capacities

Drug
Candidates

Royalty
Expectations

New
Collaborations

Expected
Collaborations

Attractiveness
to Investors

R 1

Available
Capacities

Competence in
Research
Technologies

R 2

Optimal
Research
Capacities

Financial
Resources

Research
Capacities
on Line

Goals for
Research
Capacities

B

Pressures from
Capacity Limits

II. Decision rules on target research capacities and their time path

Time to Set
Goal

Expected New
Collaborations

New Industry
Collaborations

Weight on
Industry
Collab

Expected
Assay
Projects

Weight on
New Collab

Assay
Capacity
Needed

Change in
Assay Goal

B

Assay
Capacity
Goal

B

Effect of Capacity
Expansion Limit

Effect of Capacity
Expansion Limit

Optimal
Assay
Capacity

Graph for Desired Assay Capacity

10

7.5

5

2.5

0

1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010

Time (year)

Desired Assay Capacity - BASE .... assay year
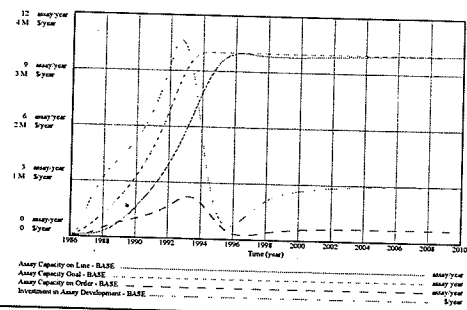
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III. Structure on research capacity supply chain and consequences of various expansion decisions
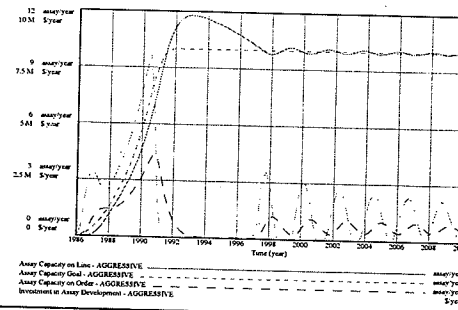
Research capacity supply chain for assay development
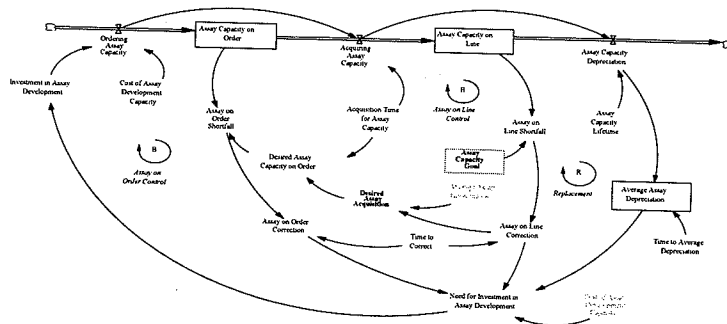
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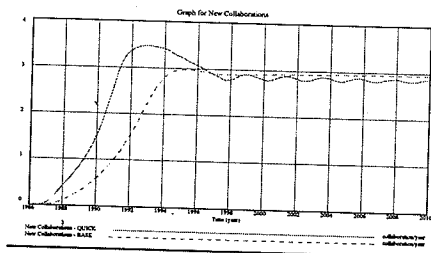*Decision rule, which insures smooth adoption of research capacity to the goal*

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Decision rule, which causes oscillations around the goal by very aggressive capacity expansions

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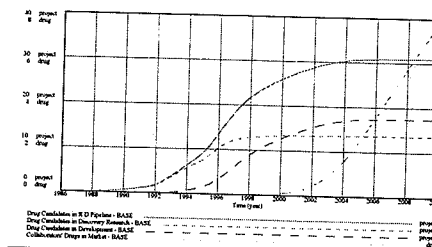</tr>
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IV. Consequences of research capacities on new collaborations and on drug candidates in the R&D pipeline

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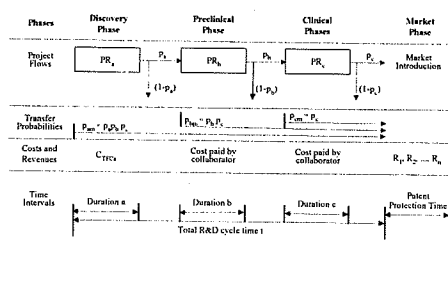*Aggressive capacity expansions transfer oscillations into the rate of new collaborations*

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Drugs in discovery research, development, the entire R&D pipeline, and in the markets
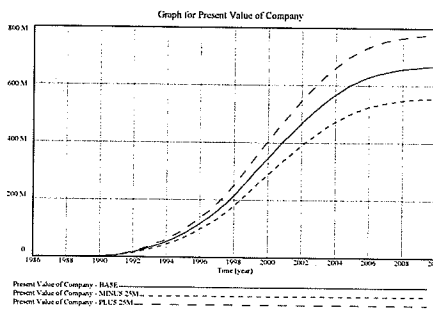

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V. Evaluation framework for drug candidates and value creation for biopharmaceutical research companies

Components of a formal evaluation framework

Value creation and value sensitivity

References

Brealey, Richard A. and Steward C. **Myers**: Principles of Corporate Finance, 5th ed., 1996, McGraw-Hill, New York et al.

Forrester, Jay, W.: Industrial Dyanmics: 1961, Productivity Press, Portland, Oregon

Graves, S. B. and Nan S. **Langowitz**: Innovative productivity and returns to scale in the pharmaceutical industry, Strategic Management Journal, Vol. 14, 1993, p. 593-605.

Groβmann, Martin, U.: Designing Policies to Achieve Sustainable Growth for Biotechnology Companies in the Pharmaceutical Industry, upcoming Ph.D. Dissertation, 1997.

Hines, Jim and Leap **Tec**: Molecules of Structure. Building Blocks for System Dynamics Models, 1996.

Lyneis, James, M.: Corporate Planning and Policy Design: A System Dynamics Approach, 3rd ed., 1988, Cambridge, Massachusetts

O.T.A., 1992, U.S. Congress, Office of Technology Assessment: Pharmaceutical R&D: Costs, Risks and Rewards, OTA-H-522, Washington, D.C.: U.S. Government Printing Office, February 1993.

Sterman, J. D.: Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment, Management Science, Vol. 35, No. 3, 1989.