

The Evolution of Science and Technology: *The Need for a New Policy Model*

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RESTORING THE INNOVATIVE EDGE

Driving the Evolution of Science

and Technology



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The Present Policy Model

Characteristics:

- 1. Societal level;**
- 2. Inputs of funding and training;**
- 3. Static and does not make predictions;**
- 4. Does not indentify problems at other levels;**
- 5. Does not focus enough attention on innovation.**

Based on input-output models and market regulation

Evolutionary Model

Characteristics:

- 1. Sector specific;**
- 2. Has six arenas for funding and capabilities;**
- 3. Evolutionary and makes predictions;**
- 4. Identifies obstacles and blockages at four levels;**
- 5. Suggestions a new evaluation model that measures radical innovation at four levels.**

Based on a through-put model and network regulation

The Black Box: Six Research Arenas

- Basic research**
- Applied research***
- Product development**
- Manufacturing research***
- Quality research**
- Commercialization research***

***Policy should focus much more on
manufacturing and quality research***

Evolution in the Difficulty of Scientific and Technological Problems: Micro Level

Patterns:

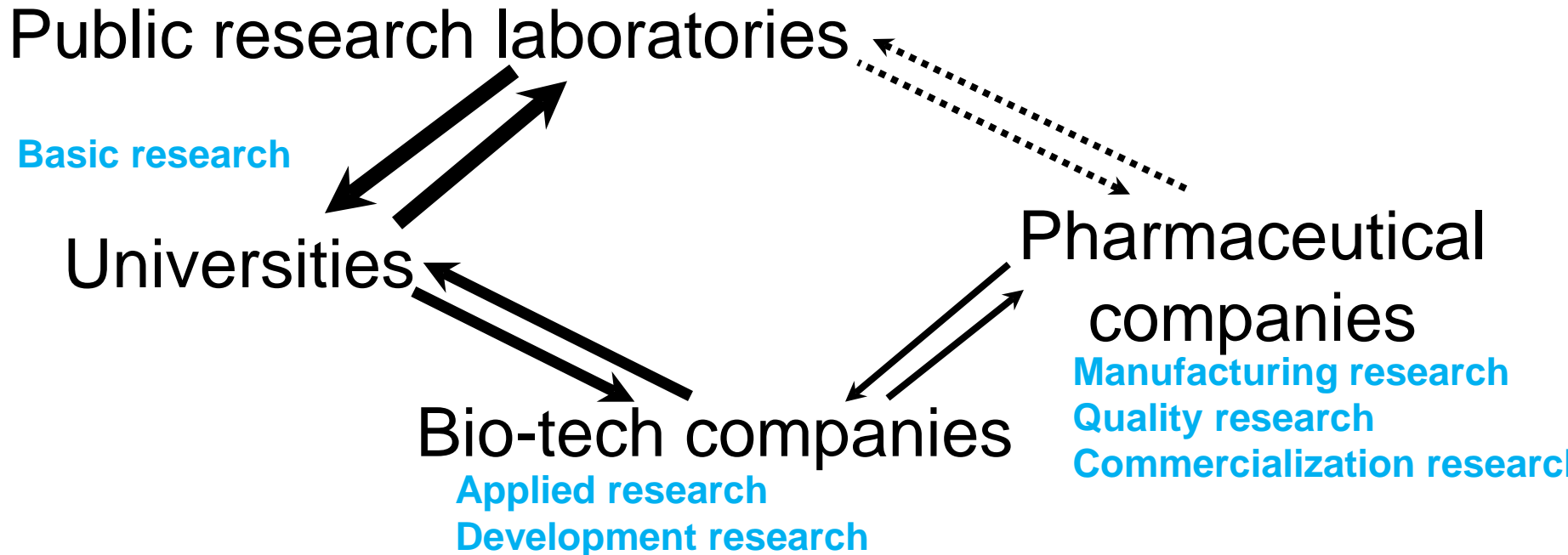
- ***Simple problems are solved first;***
- ***The scope of the problem grows;***
- ***The importance of reducing the cost of the solution increases;***

Implication: Construct more diverse and larger teams that span organizational boundaries to solve the learning problem

Evolution of Scientific and Technological Research

Growth in Knowledge leads to:

- **differentiation of research organizations in arenas**
- **evolution of new networks to connect arenas**



Two Kinds of Failed Evolution: Liberal Markets vs. Coordinated Markets

Liberal Market Economies evolve because:

- 1. Risk takers create new organizations;***
- 2. Institutional rules make spin-offs easy.***

But they fail to develop networks because of concerns over intellectual property

Coordinated Market Economies evolve because:

- 1. Institutional rules encourages cooperation;***
- 2. Safety net increases social capital.***

But they fail to develop new organizations because of reluctance to take risks and various institutional rules prevent spin-offs.

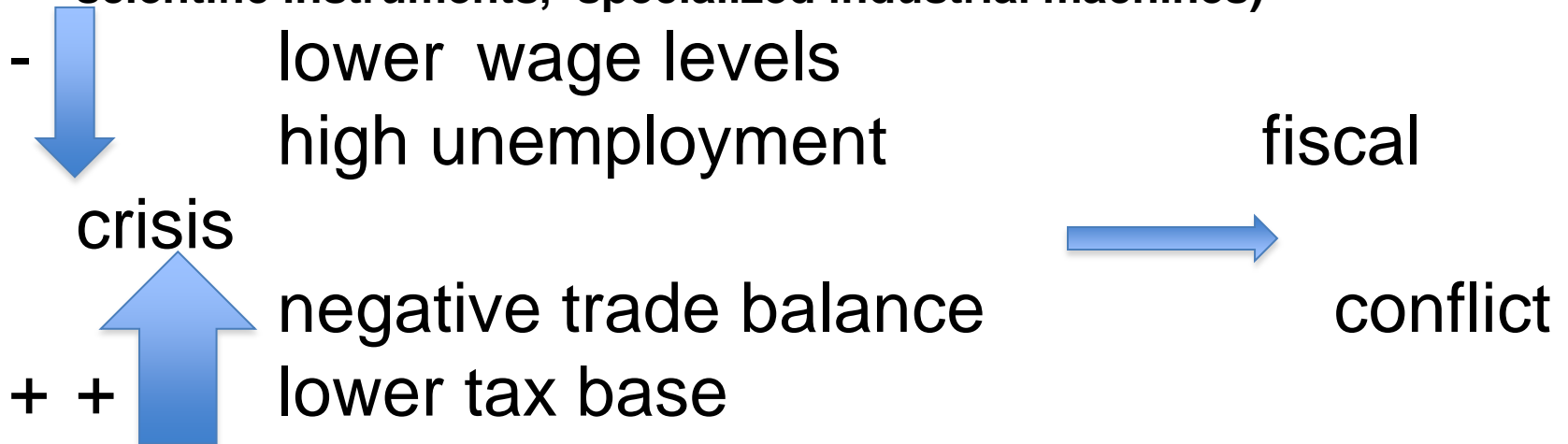
Signs of Failed Evolution

- 1. Negative trade balances in high tech sectors—reached \$85 billion in 2011**
- 2. *Decline in wage levels--\$53 K to 49 K ('09);***
- 3. Decline in scientific patents—46 vs. 107 Japan, 72 in Germany, 100 in Sweden ('10)**
- 4. *Decline in wage levels of educated workers (-3%, '09);***
- 5. Decline in employment in high tech sectors.**
- 6. *Large U.S. firms only average 4% of 100 R&D awards in 2010 and 2011, foreign firms more.***
- 7. One bright spot, national labs averaged 40%.**

This varies by sector, which then means policies have to be sector specific

The Balance between Evolution and Failed Evolution: The Fiscal Crisis

Evolution (airplanes, chemicals (plastics), chemicals (n.e.c.)
scientific instruments, specialized industrial machines)



Failed Evolution

Loss of niches: ADP, electrical machinery, industrial machinery, vehicles, chemicals (medicinal), chemicals (organic)

Loss of high tech sectors: oxide ceramics; semiconductor memory devices; semiconductor equipment such as steppes; robotics; video cassette recorders; digital watches; Interactive electronic games; touch screens, lithium batteries, televisions, etc.

Obstacles and Remedies

Obstacles

- **Static strategies**
- **Low risk research**
- **Lack of learning**
- **Stove pipes**
- **Reactive leaders**
- **Value of death**
- **No industrial policy**
- **Non-visible Blockages**

Managerial and Policy Remedies

- Seize evolutionary opportunities**
- Broaden research team vision**
- Stimulate cross-fertilization of ideas**
- Integrate the organization**
- Appoint transformational teams**
- Construct network coordination**
- Public/private cooperation**
- Perform timely feedback on innovation at team level and blockages**

Behind each obstacle are multiple blockages and the Remedy has alternatives, each with problems

Causes of Failure in Manufacturing

The Second Industrial Divide (U.S.):

- 1. Failure to buy machines;**
- 2. Failure in the design of the system;**
- 3. Conflictful labor-management relations.**

The Second Industrial Divide (Germany, Italy):

- 1. Knowledge of machine because of tech centers;**
- 2. Extensive education of technical specialists;**
- 3. Cooperative labor-management relations**

New Manufacturing Opportunity: The Third Industrial Divide

Definition: composition of parts is changed on the production line as well as the shape of the parts.

Example in military equipment:

- 1. Place scrape metals in acid bath:**
- 2. Zap with electricity once in a while;**
- 3. Create new metals with superior properties.**

Question: Can this be done in other sectors?

Objectives of Manufacturing and Quality Research

Objectives of manufacturing research:

- 1. Decreased defect rate;***
- 2. Decreased energy use;***
- 3. Economies of scale with customization;***
- 4. Maximizing flexibility (changes in production line).***

Objectives of quality research:

- 1. Longer product life;***
- 2. Lower repair costs;***
- 3. Lower operating costs;***
- 4. Lower externalities***

Why the Need for a New Industrial Policies

- **To gain more from scientific and technological advances: stove pipes, valley of death**
- ***To encourage the development of the third industrial divide in multiple sectors***
- **To focus on collective issues such as national competitiveness, global warming, national defense**
- ***To solve the volume or scale problem with customized products/services***
- **To match the cooperation between the public and private sectors in Europe and Asia**

Need Sector Specific Policies

A Typology of Economic/non-Economic Sectors:

- *High tech sectors dominated by a few firms or service providers, nationally or globally*
- *High tech sectors with many firms or service providers (SMEs) nationally*
- *Low tech sectors dominated by a few firms or service providers, nationally or globally*
- *Low tech sectors with many firms and service providers (SMEs) nationally*

Discussion of Type One

Different policies (aircraft, automobiles, chemicals, defense weapons, nuclear energy, pharmaceutical companies, train transportation equipment providers, etc.) ***for:***

- ✓ ***Automobiles use SEMATECH model for supply chain***
- ✓ ***Nuclear energy consortium with France or Russia***
- ✓ ***High speed trains consortium with Japan or France***
- ✓ ***Defense with NATO on issues of technology for civil war and genocide***

For this type with a relative few actors, the research consortium is a model

Discussion of Type Two

Different policies (alternative energies other than nuclear, specialized computer software, life sciences, advanced materials including nanotechnology, specialized medical equipment, etc.) ***for:***

- Network coordination between NIH institutes and firms;**
- More cooperation between national laboratories and firms in alternative energies, nanotechnology**
- Specialized studies of specific sectors**

For these sectors, joint public-private research in manufacturing and quality research is a model and the cluster model is attractive

Discussion of Type Three

Different policies (food products, glass, tobacco, paper products, and primary metals, cleaning products, etc.) for:

- ◆ **Proctor and Gamble is a model for this sector**
- ◆ **Corning Glass is another model**
- ◆ **Coal and gasification currently a project at GE**
- ◆ **Wood pulp industry needs a consortium with Sweden**

For these sectors, well-run companies can compete but in some cases, we need consortia

Discussion of Type Four

Different Policies (small scale construction, agricultural products, furniture, shoes, specialized machine tools, etc.) ***for:***

- **The adaptation of the agricultural model to different sectors with the use of extension agents and basic research in universities**
- **Commercialization research for distinctive American products such as furniture and some kinds of shoes**
- **Development of state funded efforts in specific agricultural sectors such as wine, tomatoes, etc.**

For many of these sectors, we need the agricultural extension model applied to industry as well as the need for specific kinds of research

Summary

The New Policy Model should be:

- **Sector specific;**
- **Be evolutionary and make predictions;**
- **Emphasize finding obstacles and blockages;**
- **Focus more on manufacturing and quality research;**
- **Encourage public-private sector cooperation and the development of networks**

***Evolution of Science and Technology and the* Need for a New Policy Model**

**Please contact me if you have questions,
suggestions, or opportunities to collaborate.**

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