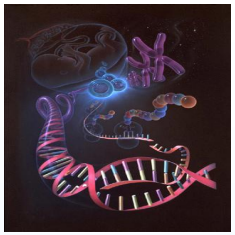
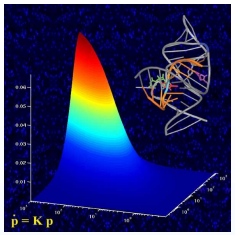
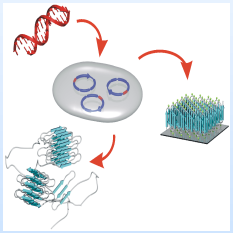
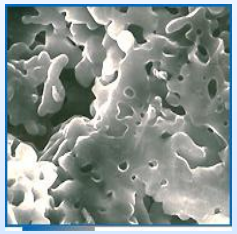




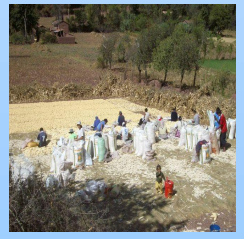
The Bioeconomy to 2030: Designing a Policy Agenda





Lucerne, November 2006

Second European Futurists Conference



Outline

- Definitions
- Where are we today?
- Drivers and trends
- Technologies
- Closer look at sectors involving biotech
- Challenges and uncertainties
- Public policy challenges
- The OECD Project

What is the bioeconomy?

The Bioeconomy is the set of economic activities relating to the invention, development, production and use of biological products and processes. While still relatively small, development is occurring rapidly and it is expected in the future to contribute significantly to economy and society by improving health outcomes, nutrition, energy efficiency, the environment and industrial processes, enhancing sustainability and improving human welfare more generally.

Realising a Bioeconomy

"an economy which captures the latent value in biological processes and renewable bioresources to produce improved health and sustainable growth and development".

- Building visions for the development of the bioeconomy
- Identifying technical, financial, human capital, regulatory bottlenecks
- Providing as much as possible a quantifiable benefit analysis of the main segments
- Providing a road map of necessary policy choices ahead

What can we say about the bioeconomy today?

OECD Biotechnology Statistics 2006
www.oecd.org/sti/biotechnology

Biotech Data – some remarks

- Existing sets of data – industry, academy and OECD
- Limitations of data - difficult to isolate biotech value added component and define a biotechnology firm
- Biotechnology is a generic technology with applications in many other sectors (downstream activity)
- What are we measuring?

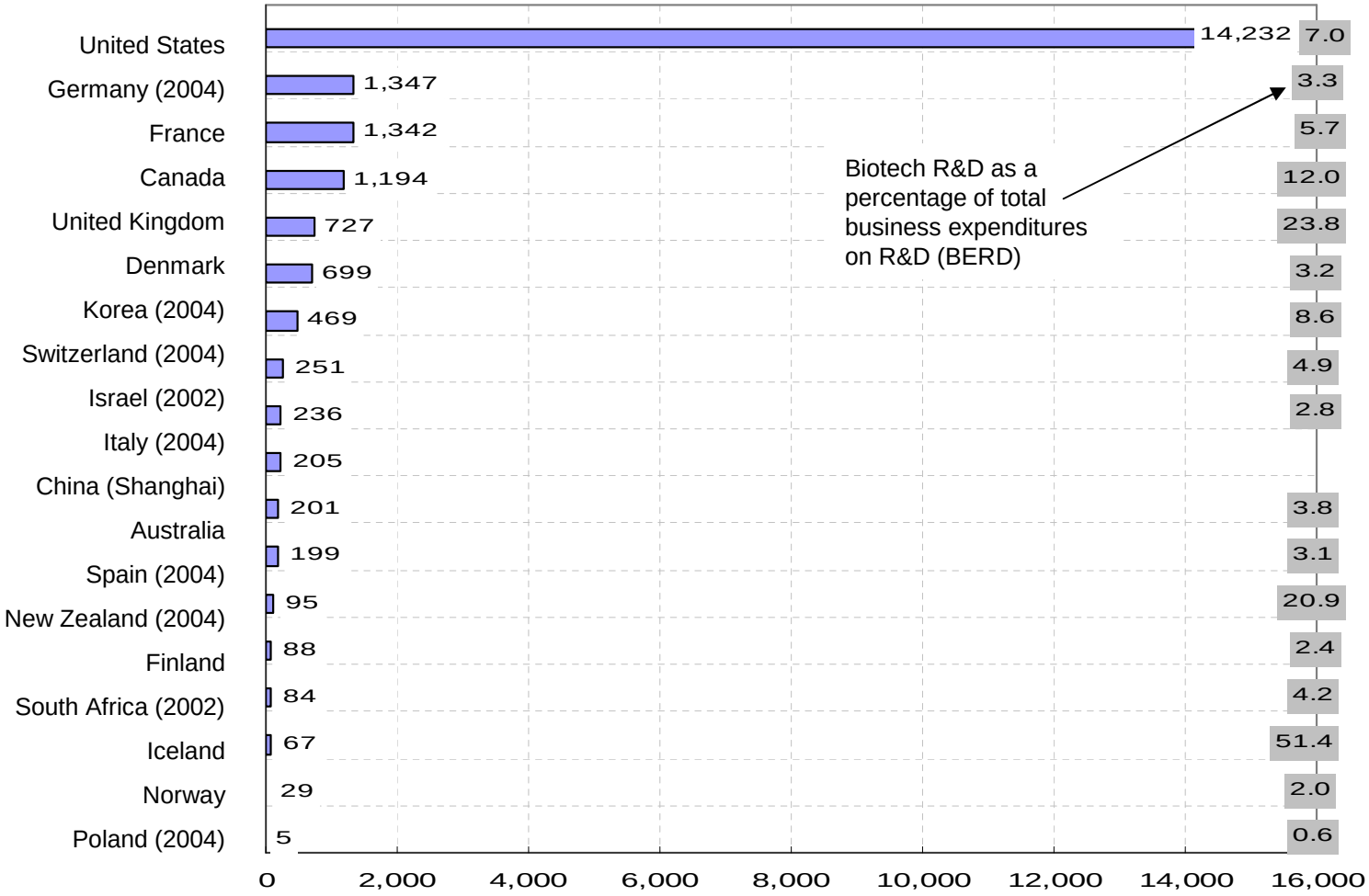
Key data on the biotechnology industry, selected OECD countries

	Firms engaged in biotechnology	Employment		Turnover		Research and development			
	Number	Number	As % of total	mill. nat currency	As % of total	mill. USD	As % of total BERD	Researchers	As % of total
Official statistics									
Belgium (2002)	57	1,650	0.04%	..	..	454	9.6%	..	..
Canada (1997)	282	9,019	0.06%	813	0.05%	419	5.6%	..	..
Canada (1999)	358	7,748	0.05%	1,948	0.11%	695	8.1%	2,100	4.2%
Canada (2001)	375	11,897	0.08%	3,569	0.18%	1,114	11.2%	2,836	5.7%
Finland (2001)	119	..	..	..	..	263	7.9%	..	..
France, dedicated (2001)	528	21,254	0.09%	..	..	..	..	3,412	3.9%
France, all biotech (2001)	625	125,000	0.51%	..	..	..	..	8,772	9.9%
Germany (2002)	539	8,750	0.02%	826	0.02%	730	1.9%	..	..
Iceland (2001)	..	919	0.72%	11,000	0.91%	..	..	..	..
New Zealand (1999)	180	3,057	0.22%	475	0.23%	..	..	610	28.5%
United States (2002)	1,031	66,000	0.04%	33,500	0.33%	16,441	8.2%	..	..
Other sources									
Ireland (2002)	59	4,000	0.23%	..	..	..	..	..	..
Japan, bioventures (2002)	334	6,757	0.01%	105,000	0.01%	350	0.1%	2,871	..
Korea (2001)	816	7,107	0.03%	1,814	0.14%	..	..	..	..
Netherlands, dedicated (2001)	120	2,400	0.03%	120	0.02%	81	1.6%	1,440	6.4%
Netherlands, all biotech (2001)	149	10,400	0.13%	520	0.07%	351	6.8%	6,240	27.8%
Sweden (1997)	135	2,677	0.07%	..	..	..	..	..	..
Sweden (2001)	183	3,975	0.09%	4,000	0.09%	..	..	..	..
United Kingdom (1996)	159	8,590	0.03%	479	0.03%	288	2.0%	..	..
United Kingdom (2001)	395	18,703	0.06%	1,838	0.10%	1,330	6.7%	..	..

Source: The Economic Impacts of Biotechnology – An Introduction, OECD / NESTI 2004

Biotechnology R&D

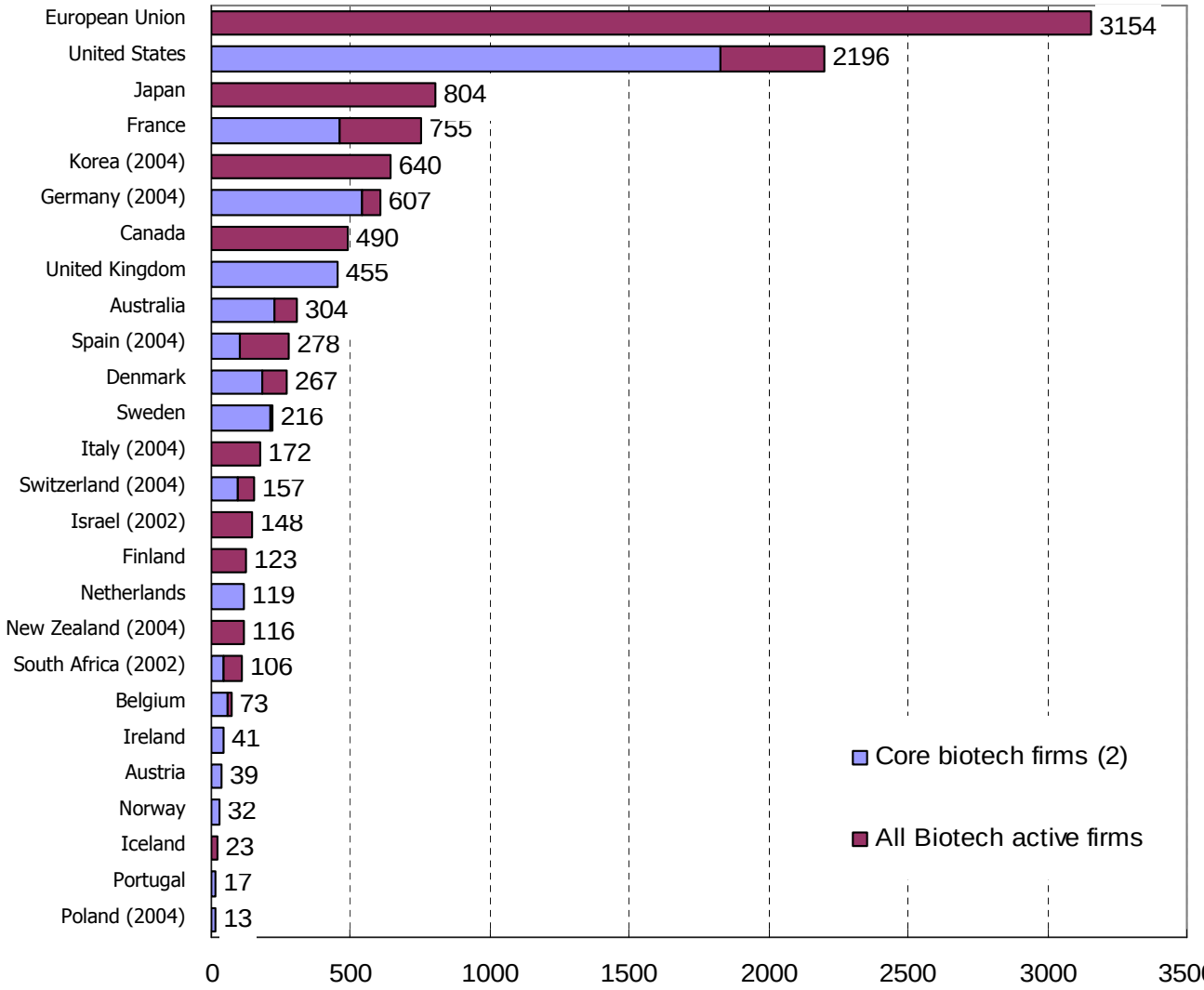
Total expenditure on biotechnology R&D by biotechnology-active firms, Million PPP$, 2003



Source: OECD Biotechnology Statistics - 2006

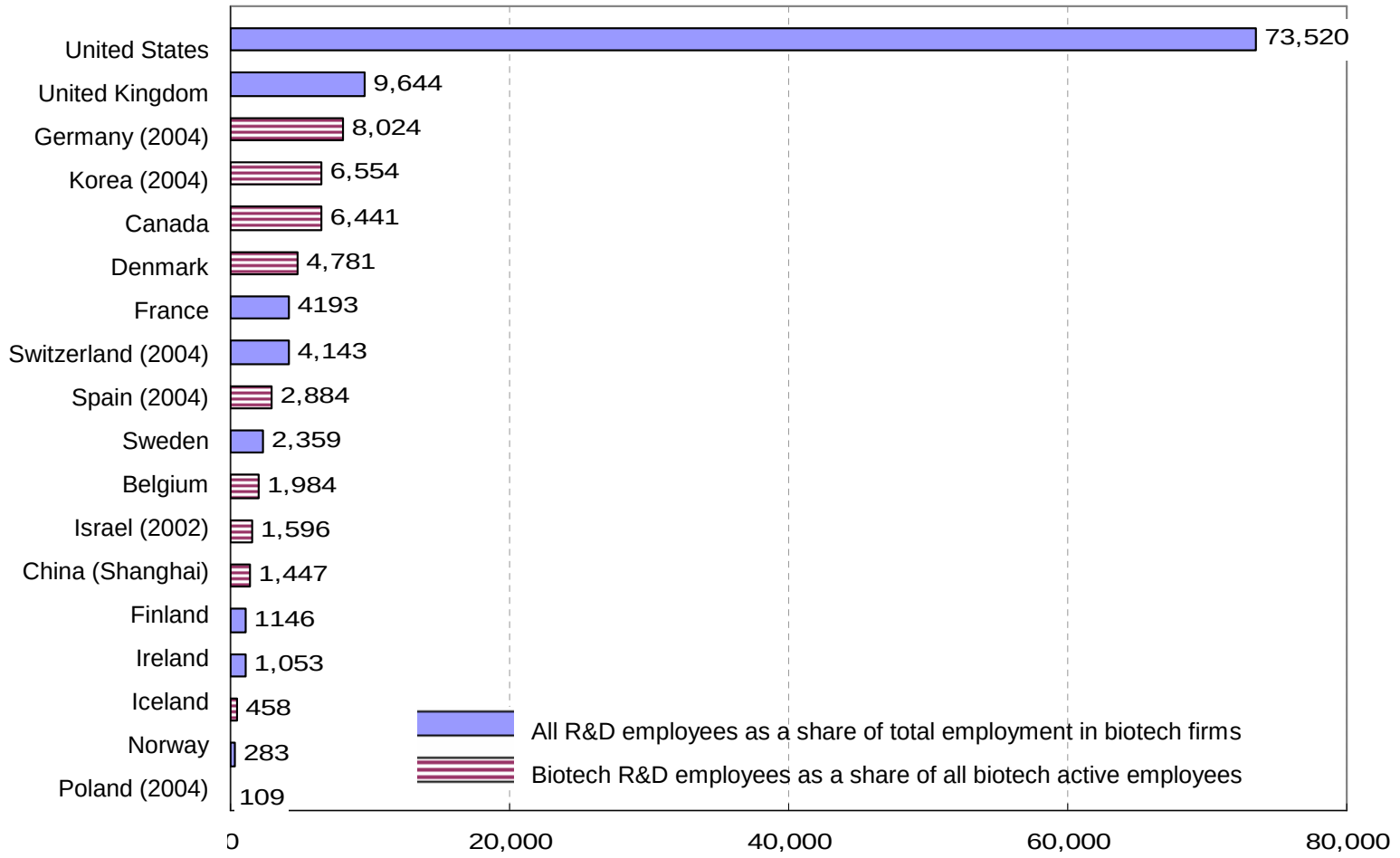
Biotechnology firms

Number of biotechnology firms, 2003



Source: OECD Biotechnology Statistics - 2006

Biotechnology employment
Biotechnology R&D employees, headcounts 2003

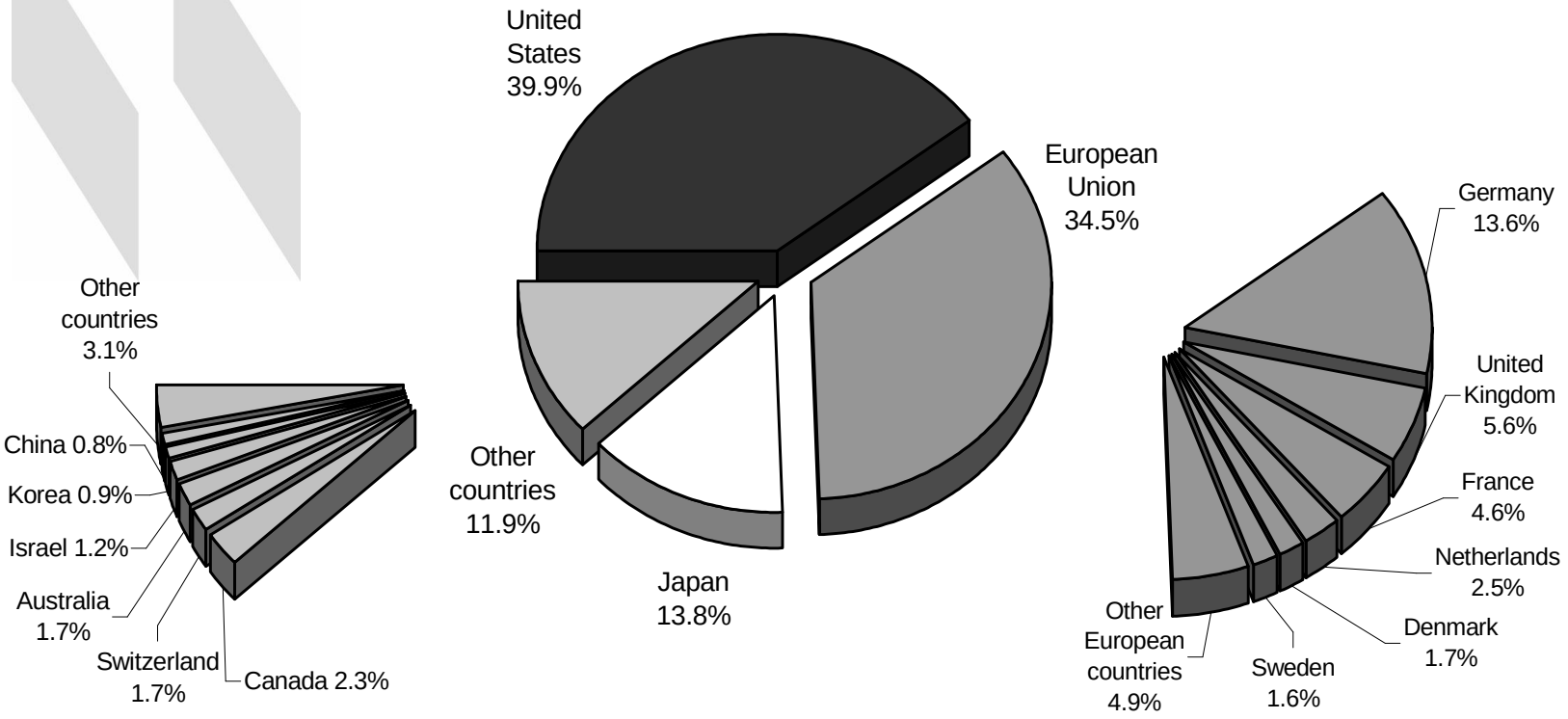


Source: OECD Biotechnology Statistics - 2006

Biotechnology Patents

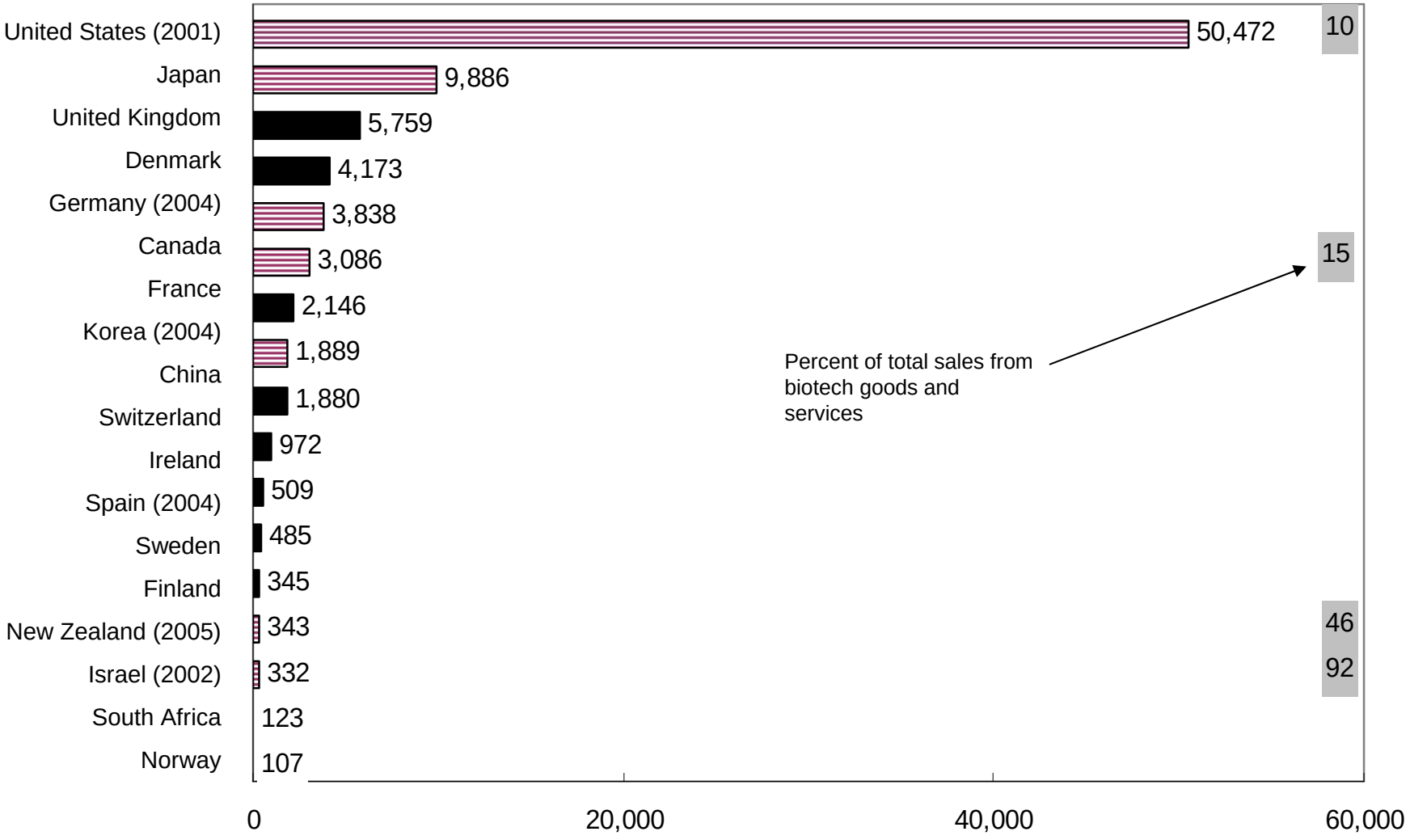
15. Share of countries in Biotechnology patents filed at the EPO

Shares, 2002

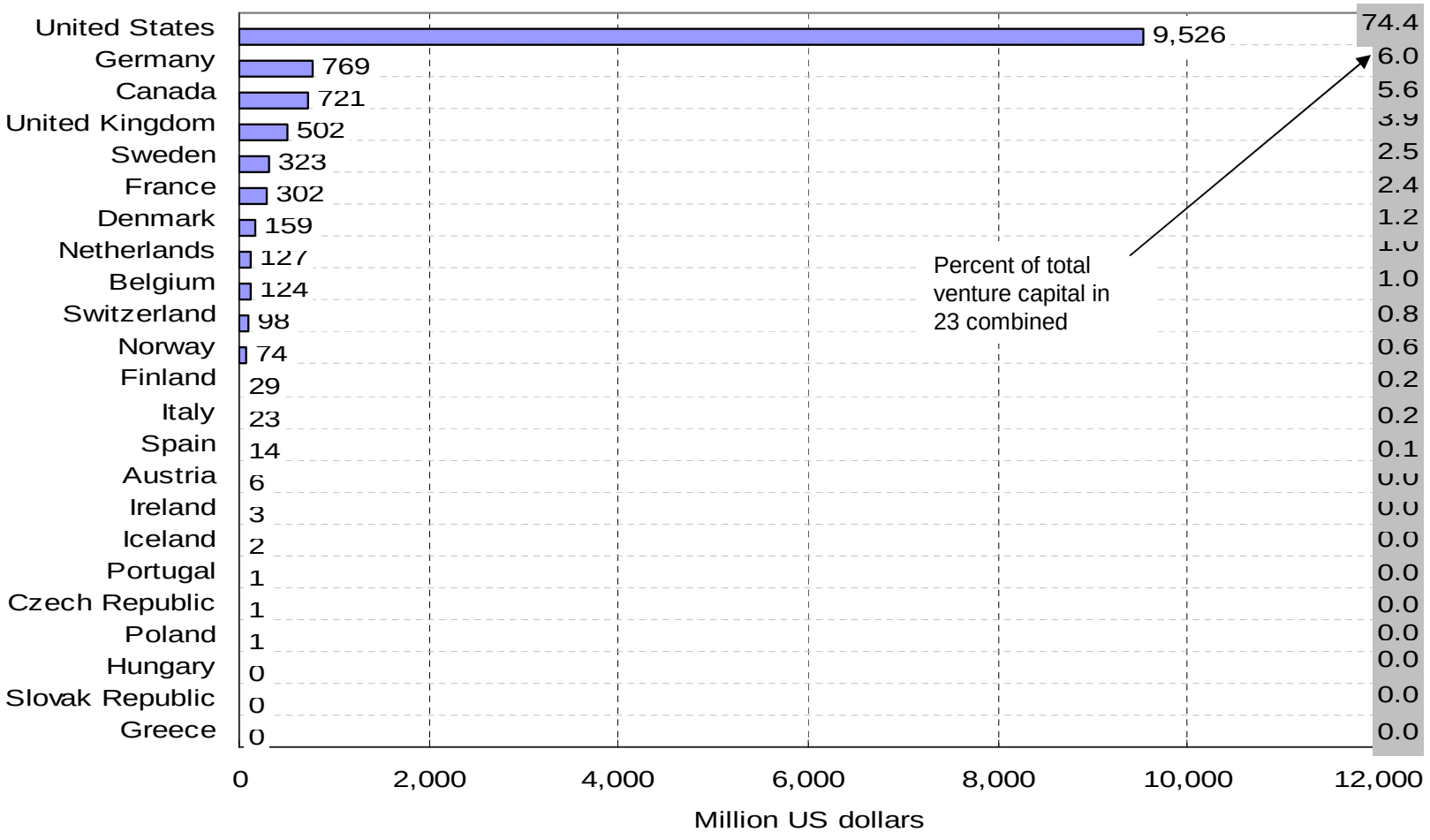


Source: OECD Biotechnology Statistics - 2006

Sales of Biotechnology firms, Million PPP$ 2003

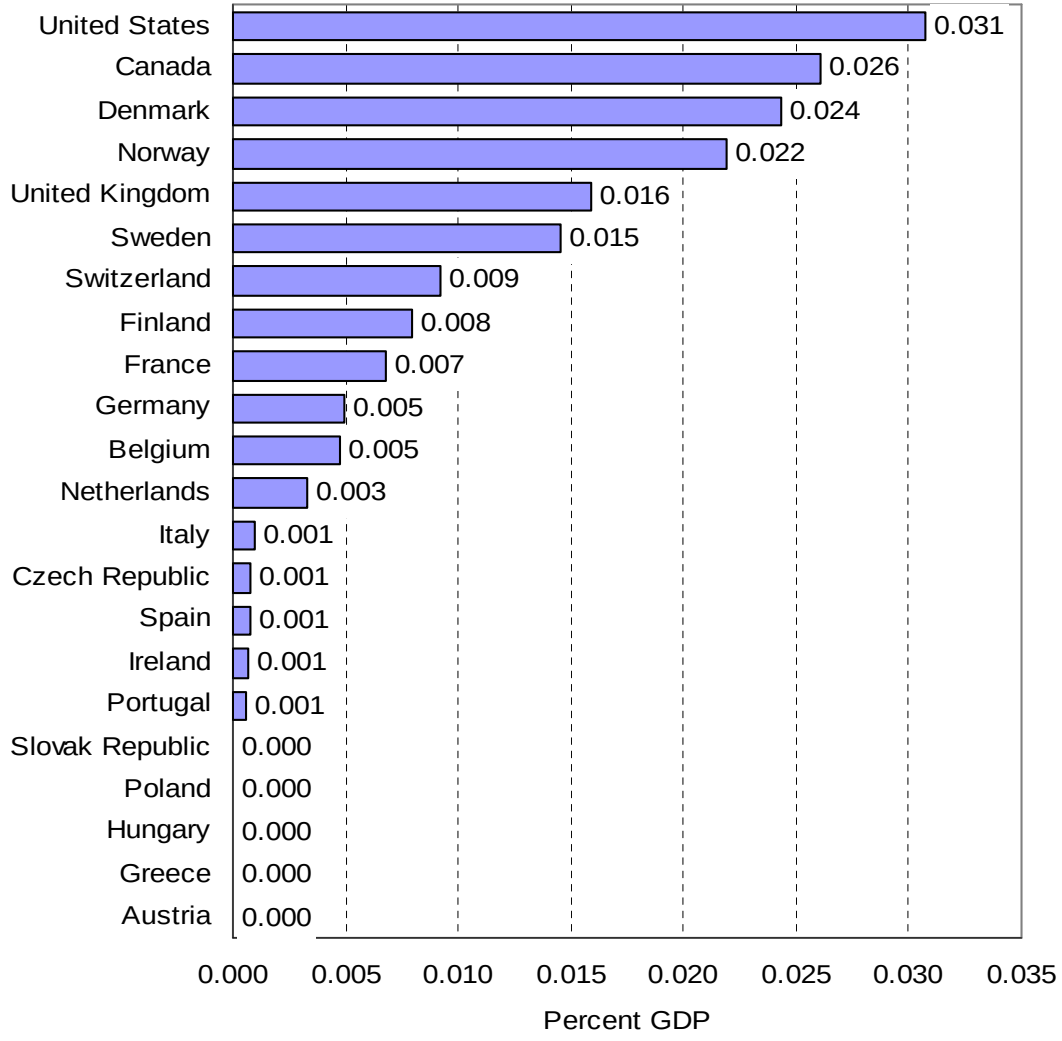


Total venture capital investments in biotechnology, 2001 to 2003 combined

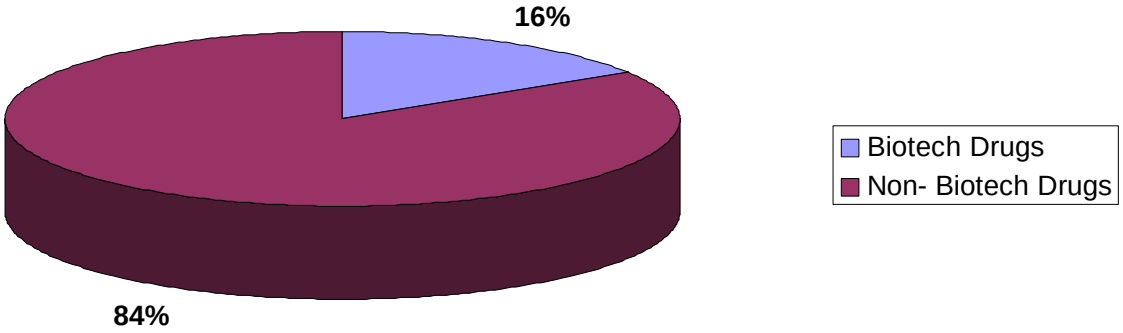


Biotechnology venture capital

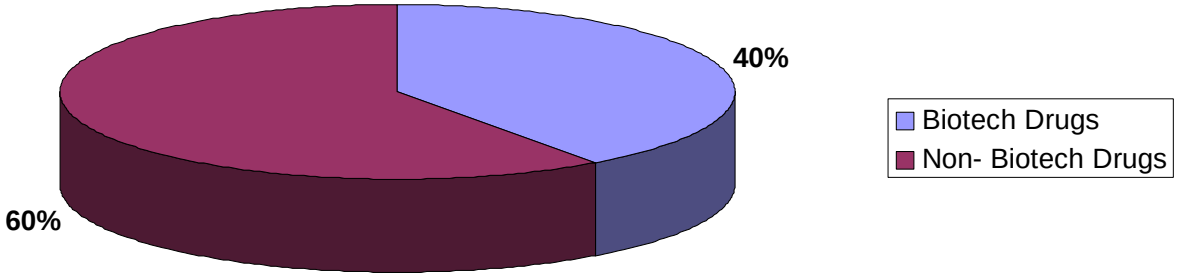
Biotechnology venture capital investments as a percentage of GDP, 2003



New Drugs, 1997 - 2004



Projected New Drugs in 2015



In 2004, more than 30% of drugs in development were biological.

Source: The Economic Impacts of Biotechnology – An Introduction, OECD / NESTI 2004

So where are we?

- Great on visioning. Real signs of success in raising interest / investment.
- Good measures of input – at national/ regional level. Still limited at sector / firm level.
- Progress on measuring activity, but needs to distinguish sectors and look at firm level.
- Output measures lagging. Market sluggish and probably inefficient, basically no idea at national / regional level. Firm level based on market response.

What's Missing? Would Resources Better be Put Elsewhere?

- Indicators (then measures) for productivity and other economic activity.
- Indicators (then measures) for policy goals (health, sustainability).
- Measures of value and value added (intangible assets).
- Endogenous growth models?

Where are we going?

Sectoral applications

- Medicine
  - Reproductive technologies, regenerative techniques, pharmacogenetics
- Agriculture
  - GMOs, biopharming, cloned livestock
- Industrial
  - Biofuels, biorefineries, enzyme engineering, bioplastics
- Environment
  - Biosensors, bioremediation
- Nutrition
  - Neutriceuticals, biosensor diagnostics
- Security and Defence
  - Biosensors, pathogen detection, new vaccine technology, anti-virals

Source: NZ Ministry of Research, Science and Technology, Biotechnologies to 2025, 2005

What would the bioeconomy look like in the future?

- Biologicals (living cells and organisms) would replace mechanical and chemical processes and products in goods and services
- Biologicals would be embedded, invisible and ubiquitous in our societies
- Biologicals would change everyday lives effecting health, nutrition, energy consumption, etc.
- New products and services would be more eco-efficient and environmentally friendly
- Biologicals would become increasingly cost effective

The public policy dimension

- Huge potential for the bioeconomy – **if we get it right**
- Public policy plays a large role in setting the scene:
  - Regulatory oversight
  - R&D policy – encouraging innovative research (stem cells)
  - Education and training – building human capital through investments
  - Creating and maintaining competition in markets
  - Appropriate intellectual property regimes
  - Building consumer confidence and trust

What trends are driving the Bioeconomy?

- Meeting climate change challenges
- Feeding global population
- Novel forms of energy to supplement fossil fuels
- Changing population demographics
- Evolving consumer appetites (individualised medicine and healthcare)
- Societal knowledge base
- Sustainability of consumption and production cycles

Life expectancy in OECD countries to 2050

Country	Men (2000)	Women (2000)	Men (2050)	Women (2050)
OECD average	74.4	80.4	80.5	85.7
United States	74.1	79.8	81.2	86.7
Japan	77.6	84.6	81.0	89.2
France	75.0	82.4	84.3	91.0

Source: OECD, ECO/WKP/(2005)7

Public health and long-term care expenditures to 2050 in % of GDP

Country	2005	2050 Cost-pressure	2050 Cost-containment
OECD average	6.7	12.8	10.1
United States	7.2	12.4	9.7
Germany	8.8	14.3	11.8
Japan	6.9	13.4	10.9
Italy	6.6	13.2	10.7
Finland	6.2	12.2	9.3

Source: OECD, ECO/WKP/(2005)7

What makes the bioeconomy unique?

- Affordability
- Impact
- Rapid, discontinuous change
- Human factor
- Safety
- Increased knowledge intensity
- Information
- High opportunity costs
- All of the above

A closer look at sectoral applications

- Health
- Industrial biotechnology
- Energy
- Primary production- food and animals
- Security

New approaches for medicine

- Biological based method for repair and regeneration of tissues rather than replacement
- Regenerative neurotechnological devices - mind controlled prosthetics for amputees
- From chemical based medicines to biological medicines based on genotypes - 16% of new drugs since 1997 have been biologicals
- Enhancement and well-being drugs which do not treat disease by appearance or well-being

Health

- Regenerative medicine
- Reproductive technologies
- Enhancement - designer babies, modification of non-pathological traits, gene therapy
- Nutrition –functional foods an nutraceuticals
- Nutrigenomics – specific foods for specific genotypes

Health

- Genomic Medicine – therapeutics -10 years away
- Tools:
  - diagnostics- gene testing
  - pharmacogenetics –personalized medicines
  - emerging gene based therapeutics

Health

- Regenerative Medicine
- Tools :
  - Cell derivation
  - Biomaterials, biomolecules and scaffolding technology
  - Biomanufacturing
  - Bioartificial organ development
  - Tissue engineering applications

Predicted trends as a result of new techniques

- Diagnostics will become more predictive
- Therapeutic interventions will become more preventive
- Healthcare will become more personalised
- Convergence with ICT – new levels of complexity in large scale data management

Industrial biotechnology

- Decouple growth from pollution?
- Platform technologies/ intermediates?
- Leverage infrastructure?
- Will subsidies be necessary?

The case of industrial biotechnology: drivers of growth

- Fossil fuel replacement
- Investment push from industry
- Energy security
- KYOTO Protocol ratification
- Affluent consumers readiness
- Policy push (EC Directive, US DOE investment, USDA Biobased Products Preferred Procurement Program...)

Energy

- Biomass- with enzymatic pre-treatment of lignocellulosic feedstocks (cost concerns)
- GM plants and trees modified for lignin composition
- Biorefineries - produce both high-volume liquid transportation fuel (meeting national energy needs) and high-value chemicals or products (enhancing operation economics)
  - Bioplastics, petrol/bioethanol blends, biodiesel, etc…
- Methane production from biomass waste
- Hydrogen production for fuel cells

The case of bio-fuels

Issue of environmental impacts:

Big difference on potential impact if the type of crop is chosen in a careful way:

- preserving water, soil integrity..
- tolerance to drought / water stress
- minimising risks: cross contamination or cross pollination

while maintaining profitability……

Primary production - food and animals

- **Genetically modified crops -** output based rather than input
- **Marker assisted breeding** selection of plants and animals
- **Genetic diagnostics** – animal production and plants
- **Cloning of animals** – very expensive and risky at present
- **GM animals as bioreactors** producing high value pharmaceuticals

The special case of biosecurity

- Cell based sensors working in real time
- Biometric technologies (scanning)
- Forensic DNA testing and result processing in real time
- Vaccines and antiviral treatments for identified high risk pathogens (smallpox, Ebola, anthrax)

What are the risks?

- Biologicals
  - Pathogens in vitro collections (higher risk)
  - Pathogens in situ (lower risk)
- Infrastructure
  - Safety regulations for biohazard laboratories
  - Transportation safety
- Personnel
  - Safety regulations
  - Awareness
- Information
  - Dilemma of scientific openness and potential for misuse
  - To publish or not to publish?

The case of biosecurity – what are the issues?

- How do we maintain an open democratic society and maintain security?
  - How do we maintain scientific openness?
- Is there an effective way to control dual-use equipment, materials, and information?
- What needs to be done to assure the public that the desired level of security has been achieved?
- Liability, legal systems

Uncertainties and Challenges of the Bioeconomy

Uncertainties

- Ethical, moral and religious
  - Human reproductive technologies
  - Use of embryos for stem cells lines
  - Misguided enhancement technologies
- Complexity
  - Basic ignorance of complex systems
- Systemic unreadiness
  - Markets
  - Regulatory and governance systems
  - Healthcare systems

Key challenges

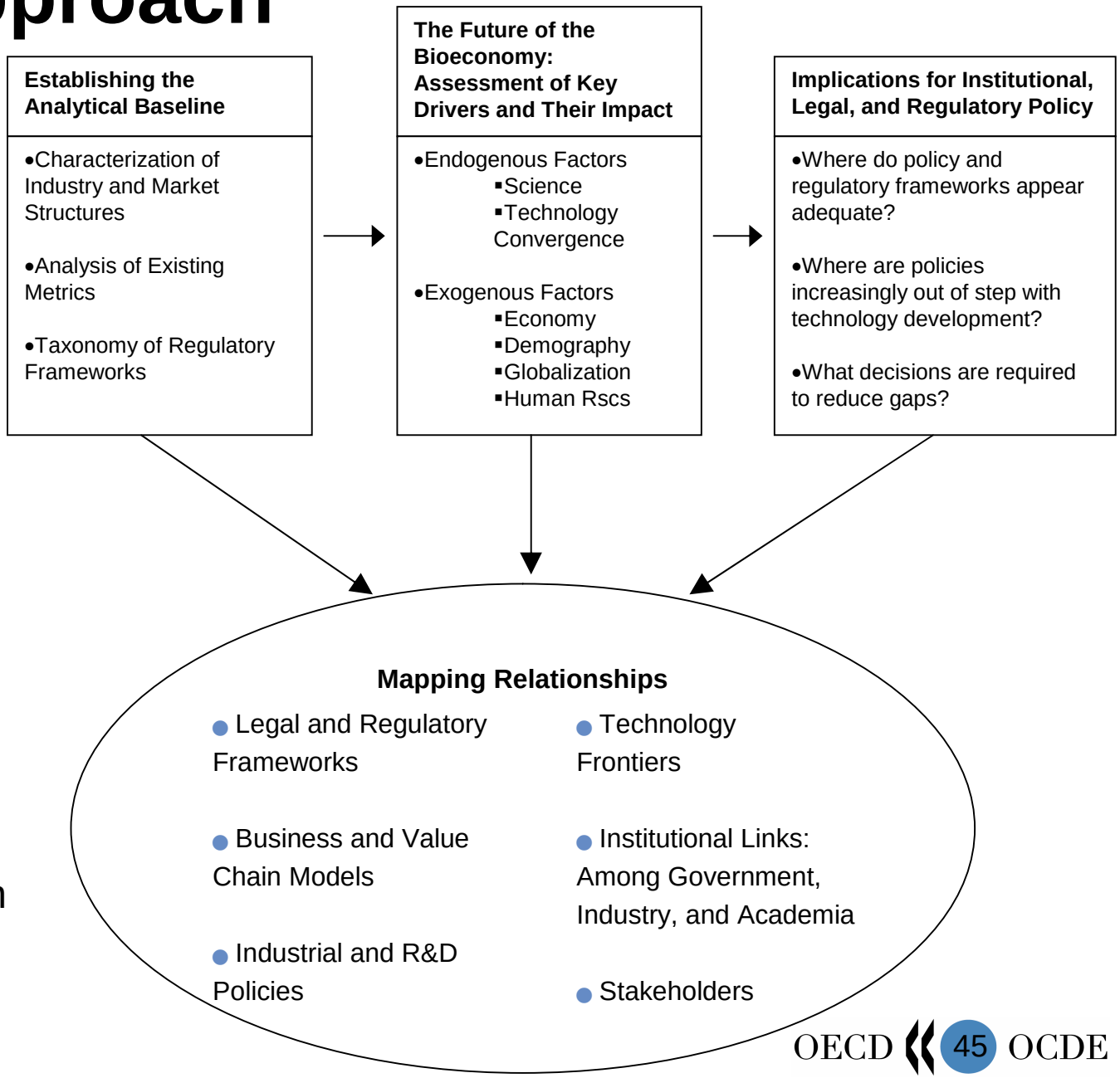
- System readiness? alignment of factors…
- Supply and demand chain inhibitors
- Infrastructure development
- Environmental impacts
- Incentives / support from governments (R-D, procurement policy, etc)
- Favourable business environment
- Appropriate regulatory frameworks
- Education / human resources shortages

The OECD Project on the Bioeconomy

Format

- Self funded OECD Futures Project conducted in cooperation with OECD Directorates, experts
- Participants in the Steering Group: 22 representing 16 OECD countries, 25 + Departments/Agencies, 5 private sector corporations/research centers
- Non OECD member countries, IGOs, NGOs will be involved on a selective basis
- Timetable: November 2006 to April 2008 (4 meetings of the Steering Group)
- Final report expected in May-June 2008

Project Approach



The project components are presented in the chart as phases but could, to some extent, run concurrently.

Approaches and tools

- Forward looking analysis on the basis of trends, drivers and interactions
- Backcasting approach in considering policy options
- Multidisciplinary approach

Approaches and tools

- Cross sectoral and sectoral analysis, holistic when needed
- Case study analysis when appropriate
- Use of existing modelling exercises (long term modelling of prospects or trade models, input-output, beyond our reach…)

Approaches and tools

- Comparative data acquisition: review of gaps and remedies, survey on a limited basis
- Maps of actors, institutional arrangements, value chains, successes and failures
- Benefits, best practices (reviews)
- When possible, “estimate” of impacts, interdependencies, interactions

Open questions

- Where and how will bioeconomy fit into governments priorities?
- What has already been done?
  - Surveys, databases, policies, plans / timetables, implementation processes
- What are the key challenges to the development of the bioeconomy?
  - Profit generation, public perceptions, risk acceptance, privacy issues, cross governmental cooperation

Open questions

- What are the key policy-dependent issues?
- How will public/consumer acceptance affect technology development?
- Given long timeframes, what role will private equity play?
- Is the required legislation in place?
- What are the international obstacles/barriers?

Thank you

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