

The Icelandic Geothermal Cluster: Enhancing Competitiveness and Creating a new Engine of Icelandic Growth

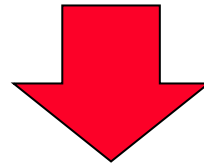
Professor Michael E. Porter
Harvard Business School

*Reykjavik, Iceland
November 1, 2010*

This presentation draws on ideas from Professor Porter's articles and books, including, The Competitive Advantage of Nations (The Free Press, 1990), "The Microeconomic Foundations of Economic Development," in The Global Competitiveness Report, (World Economic Forum), "Clusters and the New Competitive Agenda for Companies and Governments" in On Competition (Harvard Business School Press, 1998), ongoing research at the Institute for Strategy and Competitiveness, and a project on the Geothermal cluster in Iceland led by GEKON. Additional information may be found at the website of the Institute for Strategy and Competitiveness, www.isc.hbs.edu **No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means - electronic, mechanical, photocopying, recording, or otherwise - without the permission of Michael E. Porter.**

Building the Geothermal Cluster in Iceland

- **How can Iceland increase the competitiveness and internationalization of its geothermal cluster?**
 - Upgrading the value created by its domestic geothermal resources
 - Selling knowledge and technology, not just power



- **Clusters and competitiveness: New evidence**
- **Options for Iceland's geothermal cluster**
- **Broader implications for Icelandic competitiveness**

Clusters and Economic Performance

A geographic concentration of related companies and associated institutions in a particular field, linked by spillovers and complementarities

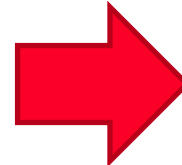
- Competitiveness is driven by the **strength of the cluster**, not only the strength of **individual companies**

Local Externalities

- Specialized skill pool
- Specialized suppliers
- Specialized infrastructure
- Specialized institutions
- Knowledge spillovers
- Competitive pressure



Productivity



Innovation



**New Business
Formation**

The Composition of Regional Economies

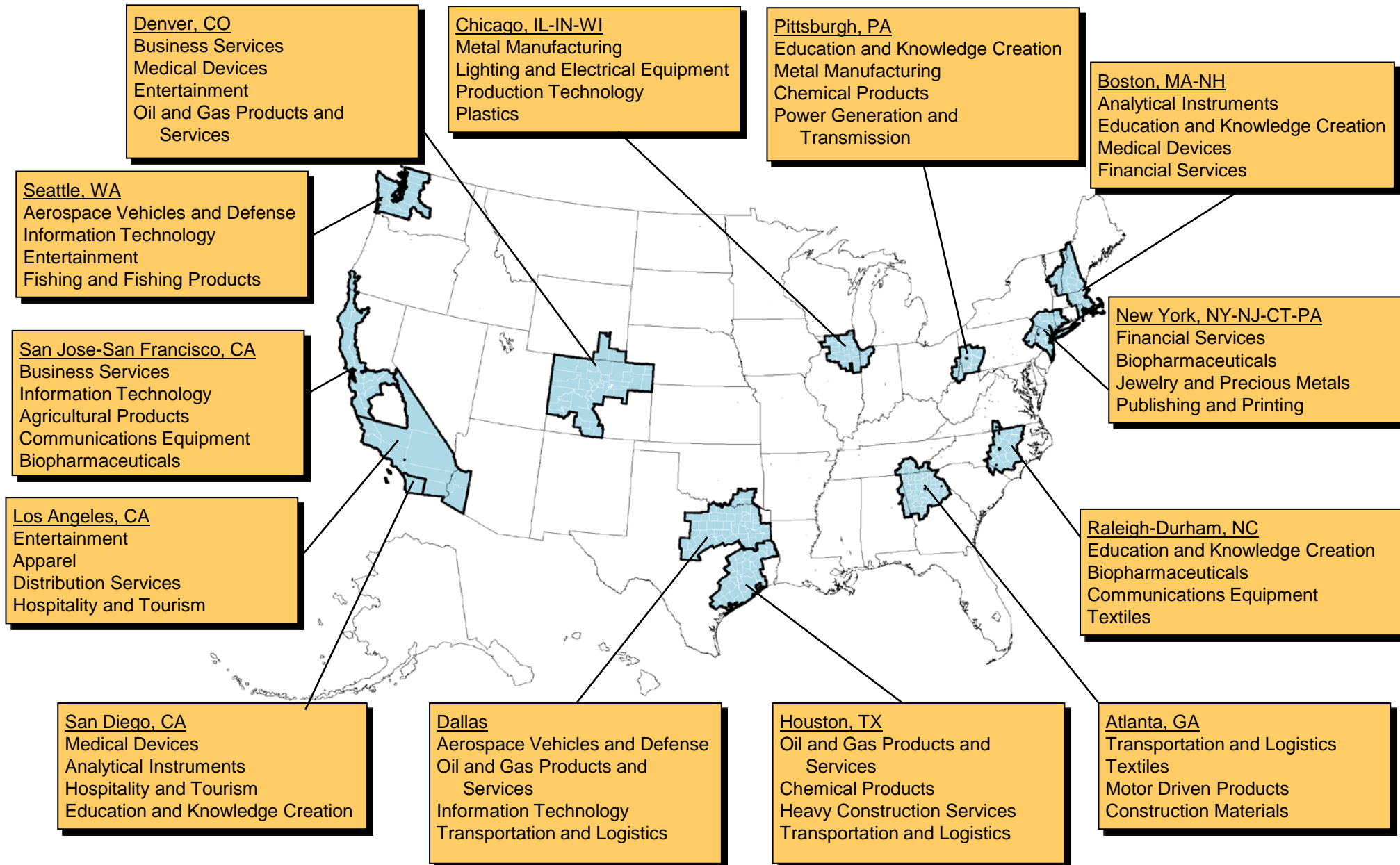
United States, 2008

	Traded	Natural Resource-Based	Local
Share of Employment	27.4%	0.9%	71.7%
Employment Growth Rate, 1998 to 2008	0.3%	0.6%	1.6%
Average Wage	\$57,706	\$40,142	\$36,911
Relative Wage	135.2%	94.1%	86.5%
Wage Growth Rate, 1998 to 2007	3.9%	2.9%	3.3%
Relative Productivity	144.1	140.1	79.3
Patents per 10,000 Employees	21.5	1.6	0.3
Number of SIC Industries	590	48	241
Number of NAICS Industries	677	43	352

Source: Prof. Michael E. Porter, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Project Director.

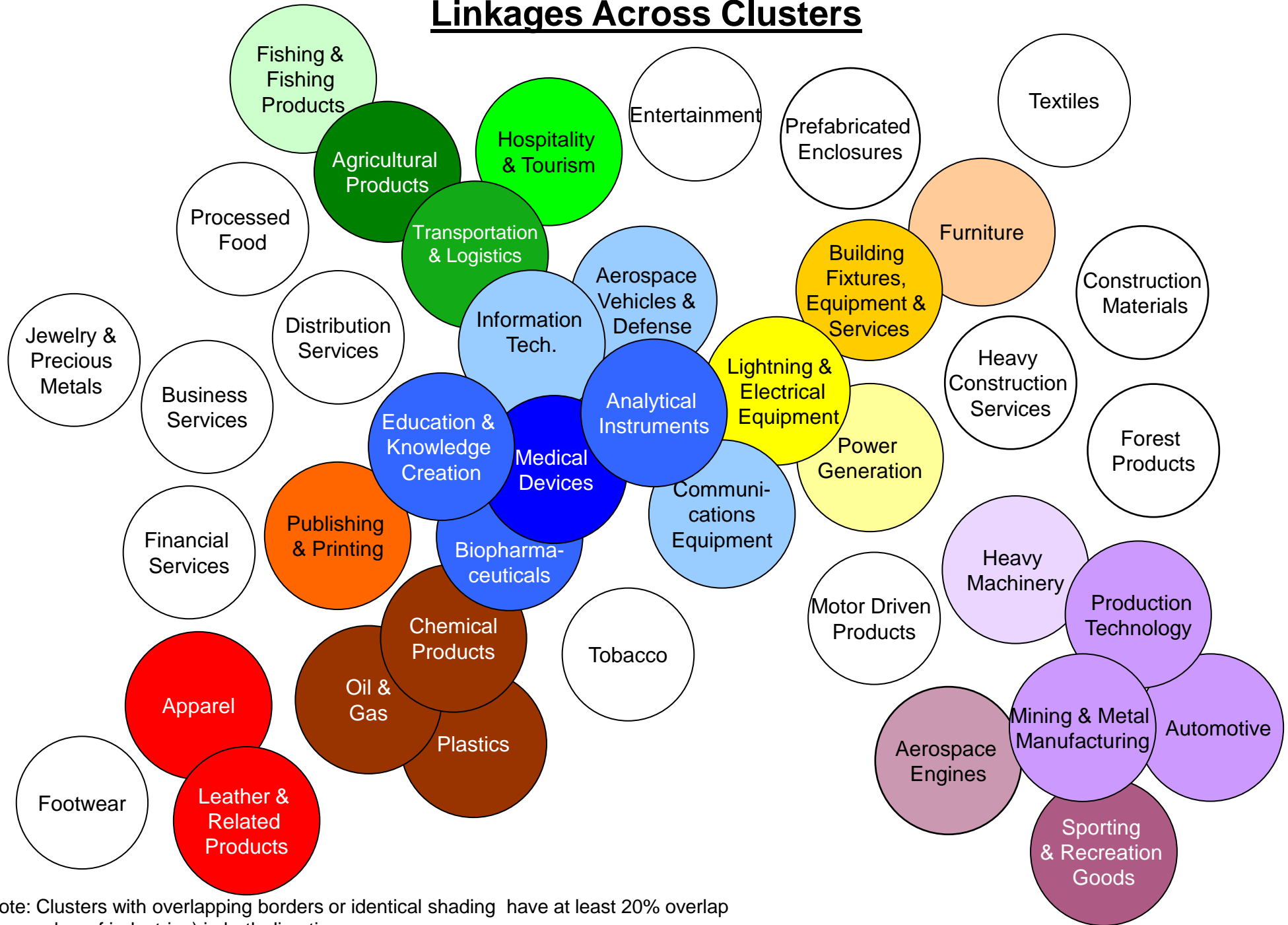
Specialization of Regional Economies

Leading Clusters by U.S. Economic Area, 2008



Competitiveness and the Composition of the Economy

Linkages Across Clusters



Clusters and Regional Prosperity

Recent Findings

Drivers of Regional Job Growth, Wages, Patenting, New Business Formation, and Success of Startups

- Specialization in **strong clusters**
- **Breadth** of position within each cluster
- Positions in **related clusters**
- Presence of a region's clusters in **neighboring regions**

Not significant

- Positions in “high-tech” versus other clusters

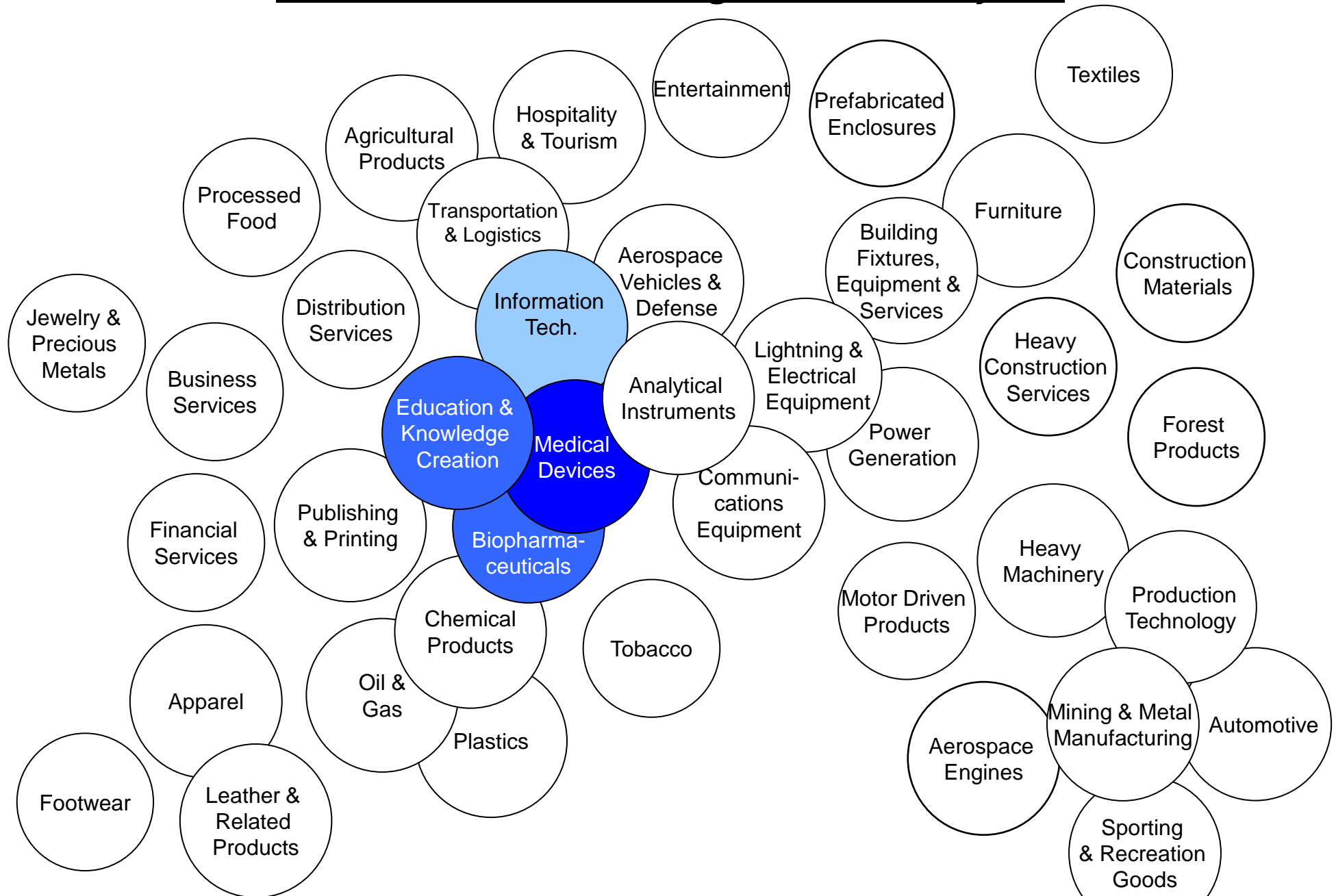
Clusters and Economic Performance

Pharmaceutical Clusters

		Cluster-driven Agglomeration			Industry Growth	
Region	High Industry Specialization	High Cluster Specialization	High Related Cluster Specialization	High Neighboring Cluster Specialization	High Growth	Employment Growth 1998-2008
Raleigh-Durham- Cary, NC	Yes	Yes	Yes	Yes	Yes	+29%
Greenville, NC	Yes	No	No	Yes	No	-52%

Strengths in Related Clusters

Pharmaceuticals in Raleigh-Durham-Cary, NC

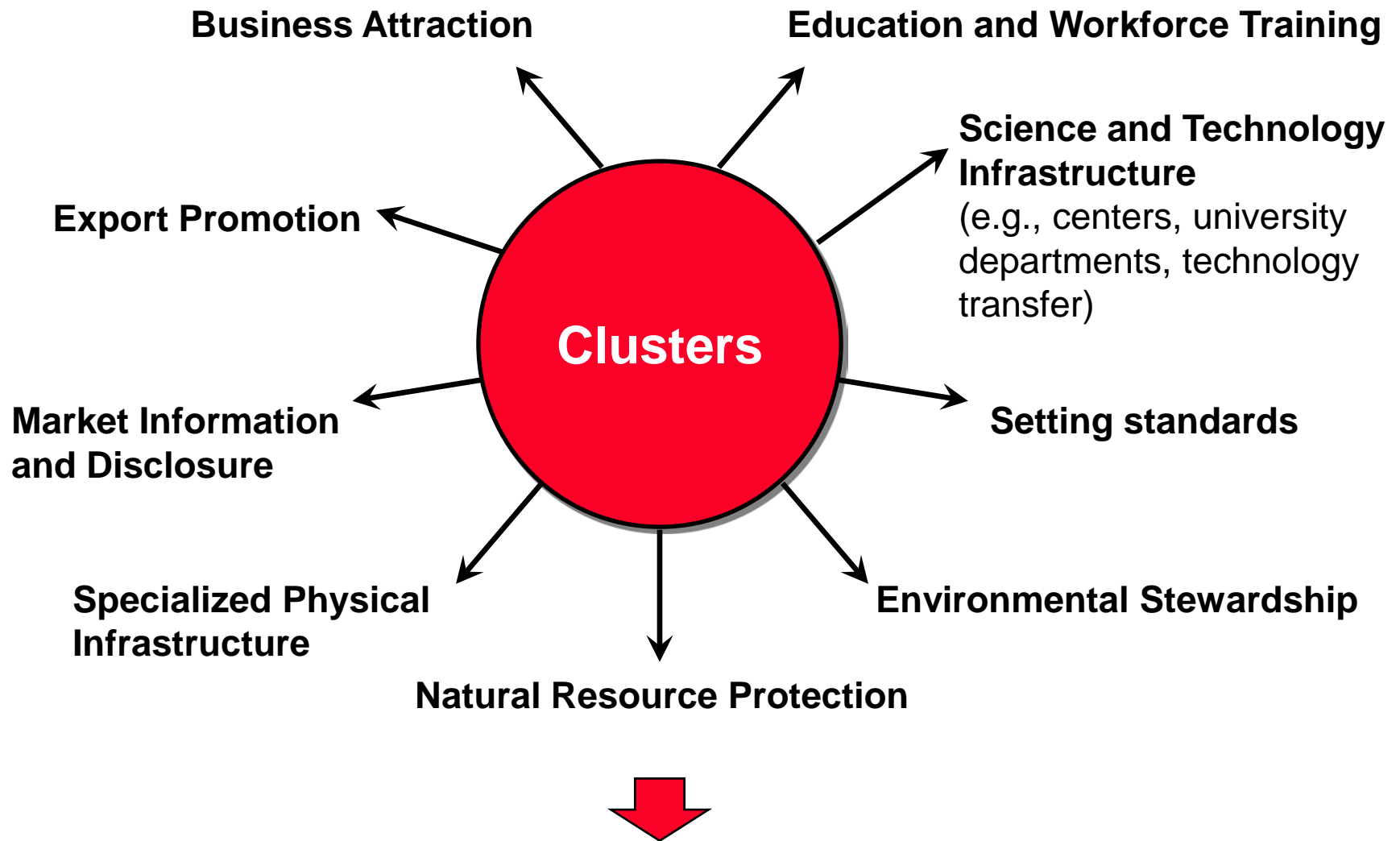


Note: Clusters with overlapping borders or identical shading have at least 20% overlap (by number of industries) in both directions.

Clusters as a Tool For Economic Policy

- A forum for **collaboration** between the private sector, trade associations, government, educational, and research institutions
 - Brings together **firms of all sizes**, including SME's
- Creates a **mechanism** for **constructive** business-government dialog
- A way to **organize** the implementation of economic policies
- A tool to identify **opportunities, problems** and develop a **concerted strategy** as well as **action recommendations**
- A vehicle for making public and private investments that strengthen **multiple firms/institutions** simultaneously
- An approach that fosters **greater competition** rather than distorting the market

Organize Public Policy around Clusters



- Clusters provide a framework for **organizing the implementation** of many public policies and public investments directed at economic development

The Role of Government in Cluster Initiatives

Government should

- Support *all* existing and emerging clusters
- Participate
- Enable data collection and dissemination at the cluster level
- Be ready to implement recommendations

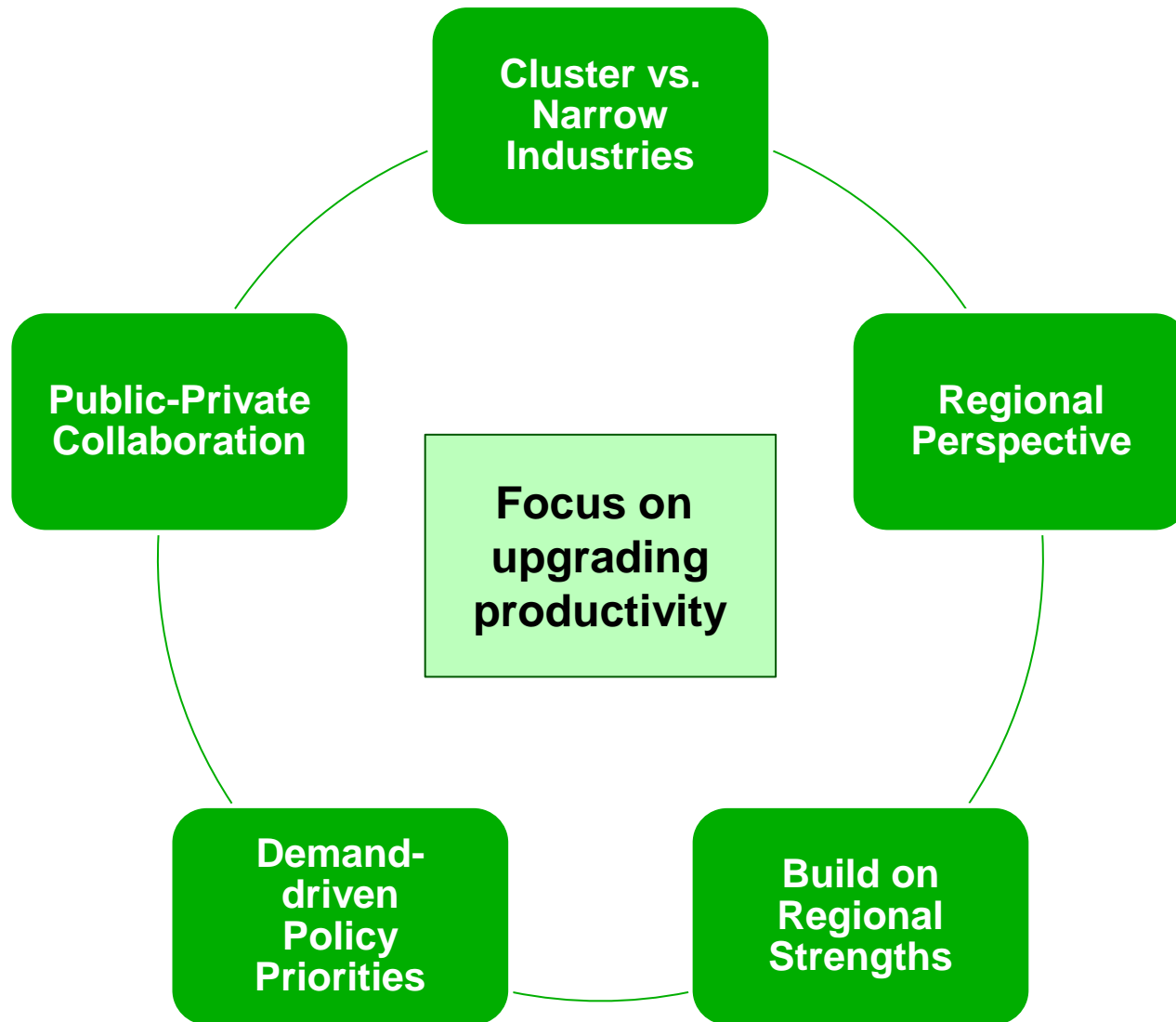
Government may

- Initiate/ Convene
- Co-Finance

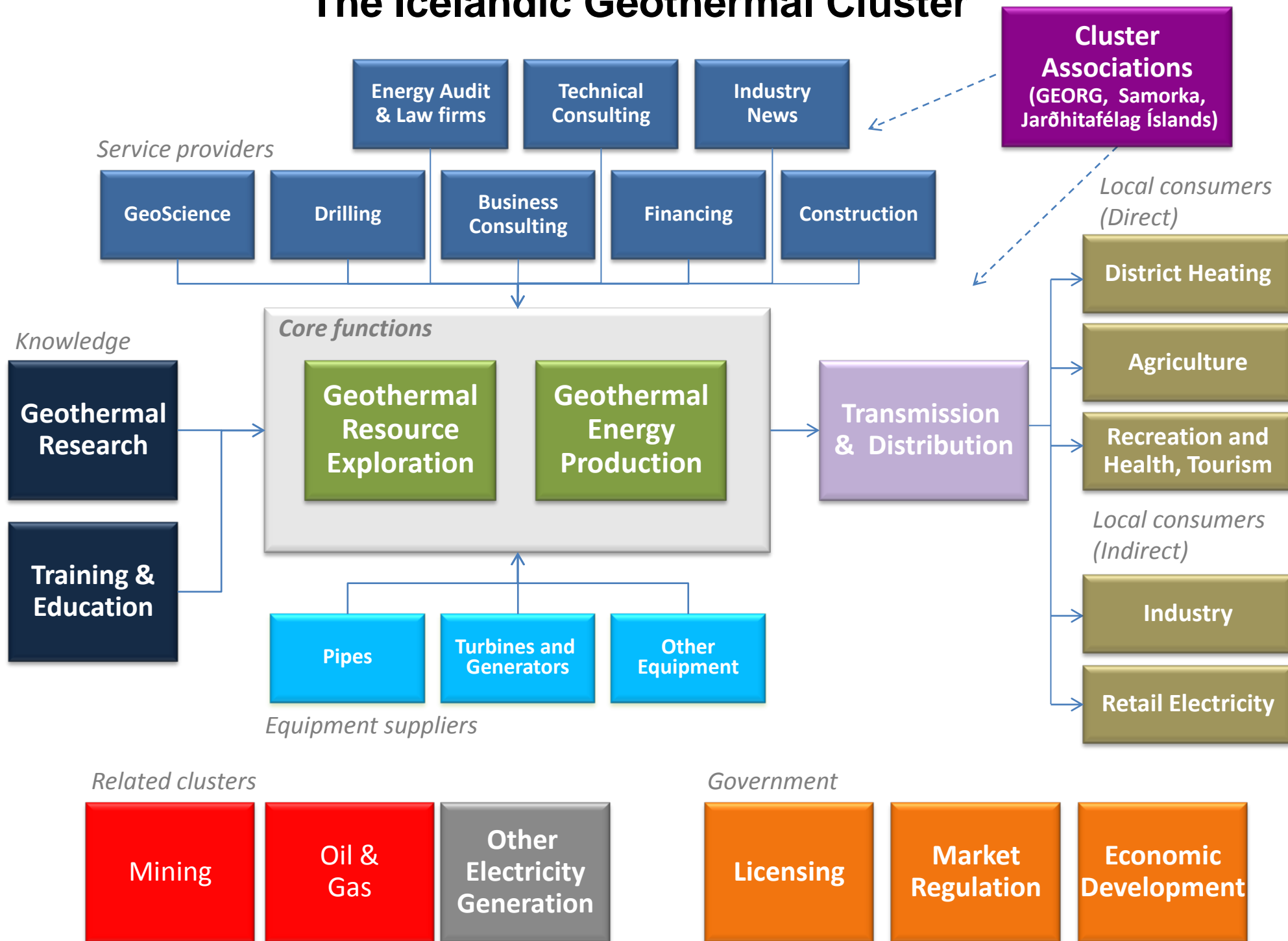
Government should not

- Pick favored clusters
- Pick favored companies
- Subsidize or distort competition
- Define cluster action priorities

What is Different about Cluster-Based Economic Policy?



The Icelandic Geothermal Cluster



The Icelandic Geothermal Cluster: Services Providers

GeoScience

- ÍSOR
- Mannvit
- Vatnaskil

Technical Consulting

- Mannvit
- Verkís
- Efla
- Reykjavik Geothermal
- Landsvirkjun Power
- Reykavík Energy Invest

Business Consulting

- Íslandsbanki
- KPMG
- Capacent Corporate Finance

Drilling

- Jarðboranir
- Ræktunarsamband Flóa og Skeiða

Construction

- ÍSTAK
- ÍAV
- Loftorka

Energy Audit & Law firms

- KPMG
- Pricewaterhouse Coopers
- Deloitte
- Lex (law firm)
- Logos (law firm)

Financing

- Íslandsbanki
- Arion banki
- Landsbankinn
- Þróunarsamvinnustofnun

Geothermal Research and Education Institutions

Geothermal Research

Research

- ÍSOR
- Mannvit
- Vatnaskil
- Utilities
- Universities

Research funding

- Orkusjóður
- Geothermal Research Group (Georg)
- Landsvirkjun's Energy Fund
- Orkuveita Reykjavíkur's Energy Fund
- Rannís

Training & Education

- University of Iceland
- Reykjavik University
- Reykjavik Energy Graduate School of Sustainable Systems
- The School of Renewable Energy Science
- Keilir, Atlantic center of Excellence
- United Nations University – Geothermal Training Programme

Educational Programs, Geothermal Industry

Country	University	Country	University
Iceland	University of Iceland	Macedonia	St. Ciril and Metodij
	Reykjavík University		St Kliment Ohridski
	REYST	Mexico	CICESE
	RES		IIE
	Keilir	New Zealand	University of Auckland
	UNU-GTP		Victoria University
Germany	University of Applied Science's in Bochum	Philippines	Bicol University
	Albert-Ludwigs-Universität		Mapua Institute of Technology
	RWTH		Adamson University
	Hochschule Biberach		University of the Philippines_NIGS
	Technischen Universität Darmstadt		Negros Oriental State University
	Technischen Universität Bergakademie	Poland	AGH - University of Science and Technology
	Universitaet Karlsruhe	Romania	University of Oradea
	Ludwig-Maximilians-Universität, Muenchen	Switzerland	University of Neuchâtel
Hungary	University of Miskolc Faculty of Earth Science	USA	Stanford University
Japan	Kumamoto University		Cornell University
	Kyushu University		University of Nevada, Reno
	Kyoto University		Truckee Meadows Community Collge
	Kanazawa University		Oregon Insitute of Technology
	Tohoku University		
	Akita University		
	Akita Prefectural University		
	Muroran Institute of Technology		

- Icelandic institutions are **internationally recognized** leaders in geothermal programs
- The programs at the UN University provide many **important linkages** into developing country markets

Research Output

Geothermal Patents, 2000-08

	Absolute number of patents	Relative to country's patents filed in the US
Iceland	2	1.18%
Norway	13	0.58%
Germany	402	0.44%
Japan	627	0.21%
Australia	15	0.17%
Italy	19	0.14%
US	475	0.02%

GeoScience Publications, 2004-08

	Absolute number of publications	Relative to country's total research publications
Iceland	148	13.2%
Norway	1,219	6.3%
Denmark	744	2.9%
EU-15	33,550	2.8%
US	29,411	2.7%
Sweden	1,144	2.3%
Finland	594	2.3%

The Icelandic Geothermal Cluster: Local Demand Structure

Direct Use (Heat)

District Heating

- Homes and organizations
- Soil Heating (snow melting) for public and private places

Agriculture, Fishing

- Greenhouses
- Fish Drying
- Fish Farms

Tourism, Bathing, Recreation and Health

- More than 130 swimming pools
- Blue Lagoon
- Mývatn Nature Baths

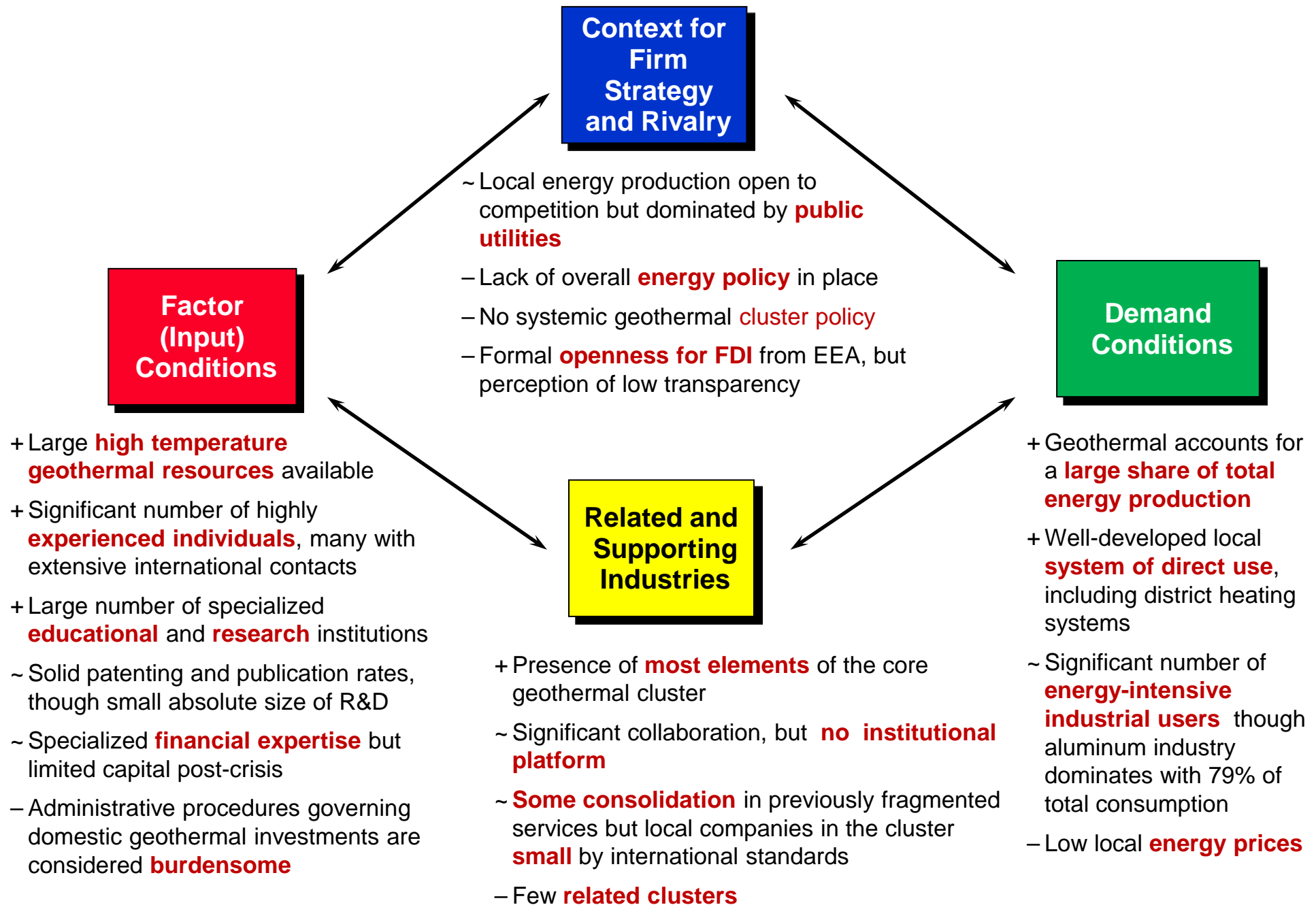
Indirect Use (Electricity)

Industries

- Aluminum smelters
- Data centers
- Seaweed manufacturer
- Liquid carbon dioxide and other industries

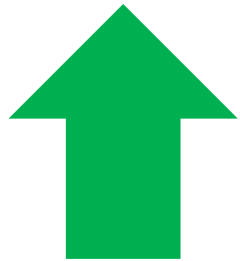
Retail Electricity

The Icelandic Geothermal Cluster Diamond

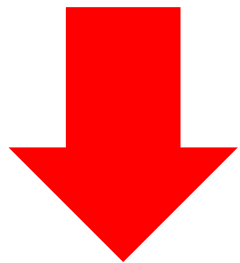


Market Position of the Icelandic Geothermal Cluster

- Iceland is a **significant player** in the global geothermal market, with a solid cluster and the highest share of geothermal in overall energy use



- Highly experienced companies and employees
- Well developed system for using geothermal energy in multiple ways throughout the energy system
- Strong international reputation and network



- Companies in the cluster lack critical mass and access to capital
- Domestic market environment increasingly complex
- Research activities and educational activities suffer from small size and fragmentation, despite collaborative projects
- There is a lack of formal platforms for collaboration, despite high level of connections
- Nature of resource is good for energy production but different from most other locations internationally
- Lack of related clusters limits position in some segments of the geothermal cluster

The Icelandic Geothermal Cluster: Market Opportunities

Attract energy-intensive industries

Direct export of energy

**Sell products and services; manage
operations**

Growing the Iceland Geothermal Cluster

Current Pipeline of Energy-Intensive Investments

Project/Industry sector	Company	Location	Energy needs (MW)	Start of operation	Energy provider	Status
Paper production	Icelandic paper	Hellisheiði	10	2010	OR	3
Data Storage I (1)	Verne Holding	Miðnesheiði	25	2010	Landsvirkjun	3
Data Storage II (1)	Greenstone	Blönduós	50	2011	Landsvirkjun	2
Silicon production I	Tomahawk/ISC	Helguvík	60	2011	HS and OR	3
Carbon fibre	UB koltrefja ehf.	Sauðárkrókur	10	2011	Undefined	2
Data Storage I (2)	Verne Holding	Miðnesheiði	25	2011	Landsvirkjun	3
Aluminum smelter (1)	Norðurál	Helguvík	156	2012	HS and OR	4
Data Storage II (2)	Greenstone	Blönduós	70	2012	Landsvirkjun	2
Silicon Production II (1)	BPI/Strokkur	Þorlákshöfn?	50	2012	Landsvirkjun	2
Aluminum smelter - extension	Rio Tinto Alcan	Straumsvík	75	2013	Landsvirkjun	4
Aluminum smelter (2)	Norðurál	Helguvík	156	2013	HS and OR	4
Aluminum smelter (3)	Norðurál	Helguvík	156	2015	HS and OR	3
Aluminum smelter (1)	Alcoa	Bakki	300	2015	Landsvirkjun	2
Aluminum smelter (4)	Norðurál	Helguvík	156	2016	HS and OR	3
Aluminum smelter (2)	Alcoa	Bakki	300	2016	Landsvirkjun	2
Aluminum smelter - extension	Norðurál	Grundartangi	40	?	OR	1
Silicon Production II (2)	BPI/Strokkur	Þorlákshöfn?	50	?	Landsvirkjun	2
Silicon Production III	Elkem	Grundartangi	100	?	No electricity secured	1
Aluminum foil - ext.	Becromal	Akureyri	75	?	Landsvirkjun	1

Source: ASÍ Fall Report 2009/ Íslandsbanki Iceland Geothermal Energy Market Report 2010

Growing the Iceland Geothermal Cluster

A Systematic Approach to Attracting Energy-Intensive Industries

- Solid **existing base**, especially in aluminum production
- Clear **interest** from investors
- Further growth will also require a significant increase in the **capacity for electricity production**
- Traditional challenge is to set **energy costs** at a level that provides “fair” division of benefits
- Growing public concerns about the **environmental impact** of large-scale investment projects



- Most obvious **short-term opportunity**
- Need to **evaluate** all opportunities, including direct use, based on the impact on employment, exports, upgrading, etc. per unit of energy
- Iceland needs a more **transparent and efficient regulatory environment** to seize these opportunities
- But Iceland needs to move **beyond** this approach alone

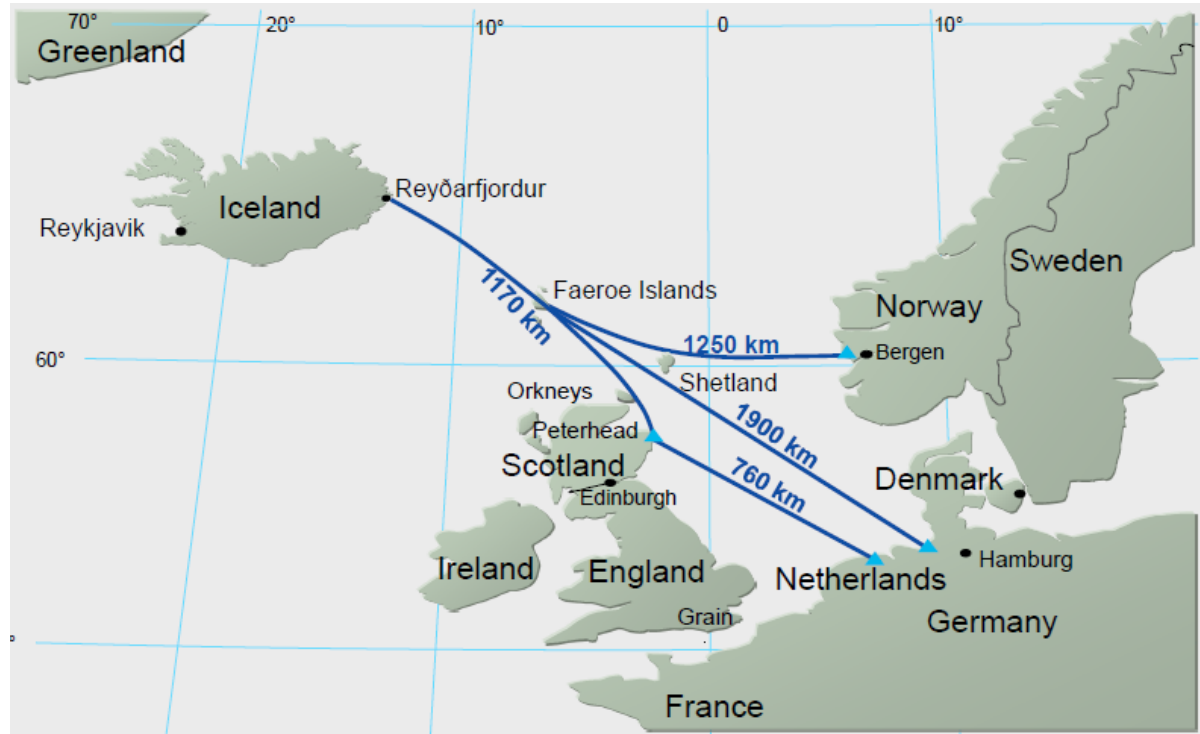
Growing the Iceland Geothermal Cluster

Direct Export of Electricity to Europe

Subsea power cable

- Essentially a technical and economic question:

“Is Icelandic electricity competitive on the European market, once construction costs and transmission losses are taken into account?”



- So far the answer has been **no**
- But **new technological solutions** and **rising electricity prices** in Europe might create an opportunity

Growing the Iceland Geothermal Cluster

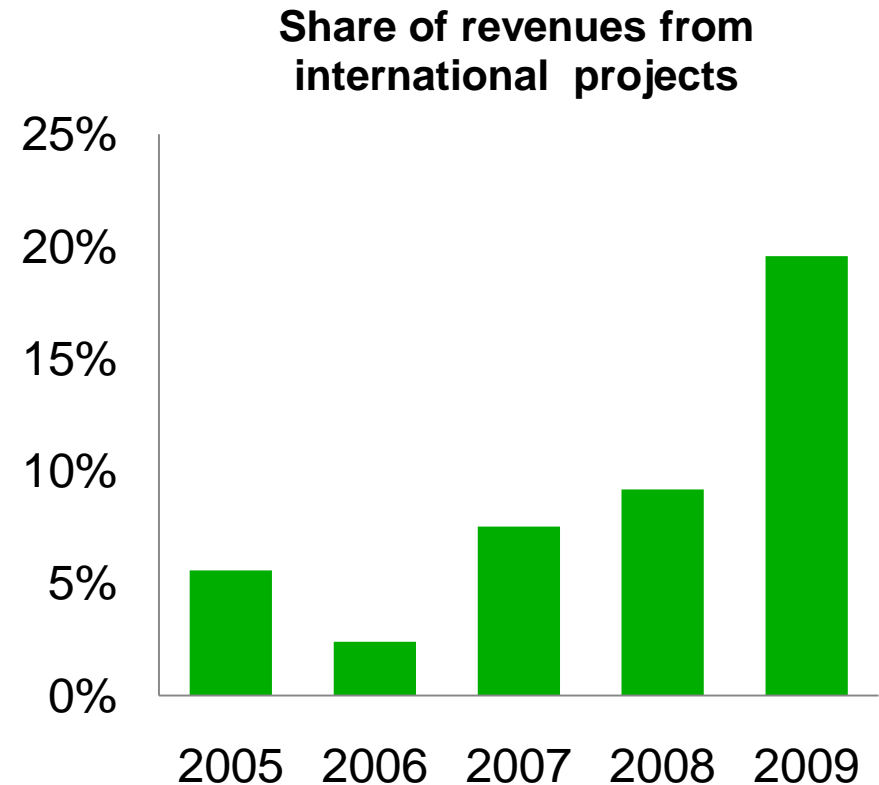
Experience in Selling Knowledge and Services Abroad

Year	Company	Country	Type of project/s	Role of company
1995	OR / REI	Slovakia	District heating	Owner/Developer
2002	GGE and OR/REI	China	District heating	Owner through Enex China's 49% share in JV with Sinopec Star
2005	Enex; Verkis, Mannvit	El Salvador	Electricity Power Plant	Consulting and contractors
2006	Mannvit	Hungary	Development of low and medium temperature geothermal fields	Consulting
2007	OR/REI	USA	Geothermal project development	Owner/Developer
2007	Envent (GGE and OR/REI)	Philippines	Electricity production development	Owner/Developer
2008	EFLA and RARIK	Turkey	Electricity production development	Owners/Developer through EFLA and RARIK's subsidiary Turkison
2008	Geysir Green Energy (GGE)	Germany	Electricity production development	Owner/Developer through GGE's 40% share in Geysir Europe
2008	Mannvit	Germany	Low enthalpy basins, EGS and CO2 storage	Consulting through Mannvit's 35% share in the Geothermie Neubrandenburg
2008	arðboranir	Germany	Drilling	Contractor through Hekla Energy GmbH, subsidiary of Jarðboranir
2008	Mannvit	Hungary	Geothermal development, mainly in low and medium temperature fields	Consulting through Mannvit Kft.
2009	Mannvit	India	Development of energy systems and infrastructure in India and Sri Lanka	Consulting in JV with Auromatrix Holding
2009	Reykjavík Geothermal	UAE	Development of geothermal for air conditioning system	Consulting
2009	Mannvit	USA	Development of geothermal projects in the USA	Consulting in Partnership with Technip
2009	Verkís and ÍSOR	Chile	Development for electricity production	Consulting through GeoThermHydro, a subsidiary of Verkís and ÍSOR
2010	Reykavík Geothermal	Middle East and Africa	Geothermal power generation in emerging markets	Consulting in Partnership with Ambata Capital Partners
2010	Group of Icelandic companies	No specific countries	Geothermal projects	Consulting in Cooperation with Mitsubishi Heavy Industries
2010	EFLA	Croatia	Development of low and medium temperature geothermal fields	Consulting

Growing the Icelandic Geothermal Cluster

The Icelandic Experience

- Foreign markets are **increasingly important** for Icelandic geothermal companies
- This process is driven both by **growing opportunities** abroad and investment **delays** at home
- The experience in foreign projects has been **mixed**
 - Technical consultants have been most successful
 - Project developers/operators have been less successful financially
 - Projects drawing on specific Icelandic competence, like district heating, performed better
 - Performance has been superior in JVs with local partners or as subcontractors rather than as stand-alone operators
 - Banks were once also well placed but have now largely lost their ability to finance



Source: Survey among cluster participants

Export Knowledge and Services for Geothermal Activities

Opportunities for Icelandic Companies

Export products

- *Equipment production is currently not significant*

Export knowledge

Export services

Investment to leverage expertise

- Lack of capital is a key constraint
- Could provide expertise in evaluating projects to others

Education and patents

- Educational offers exist but are so far not commercially viable
- Iceland subscale in scientific research
- Available knowledge is not codified

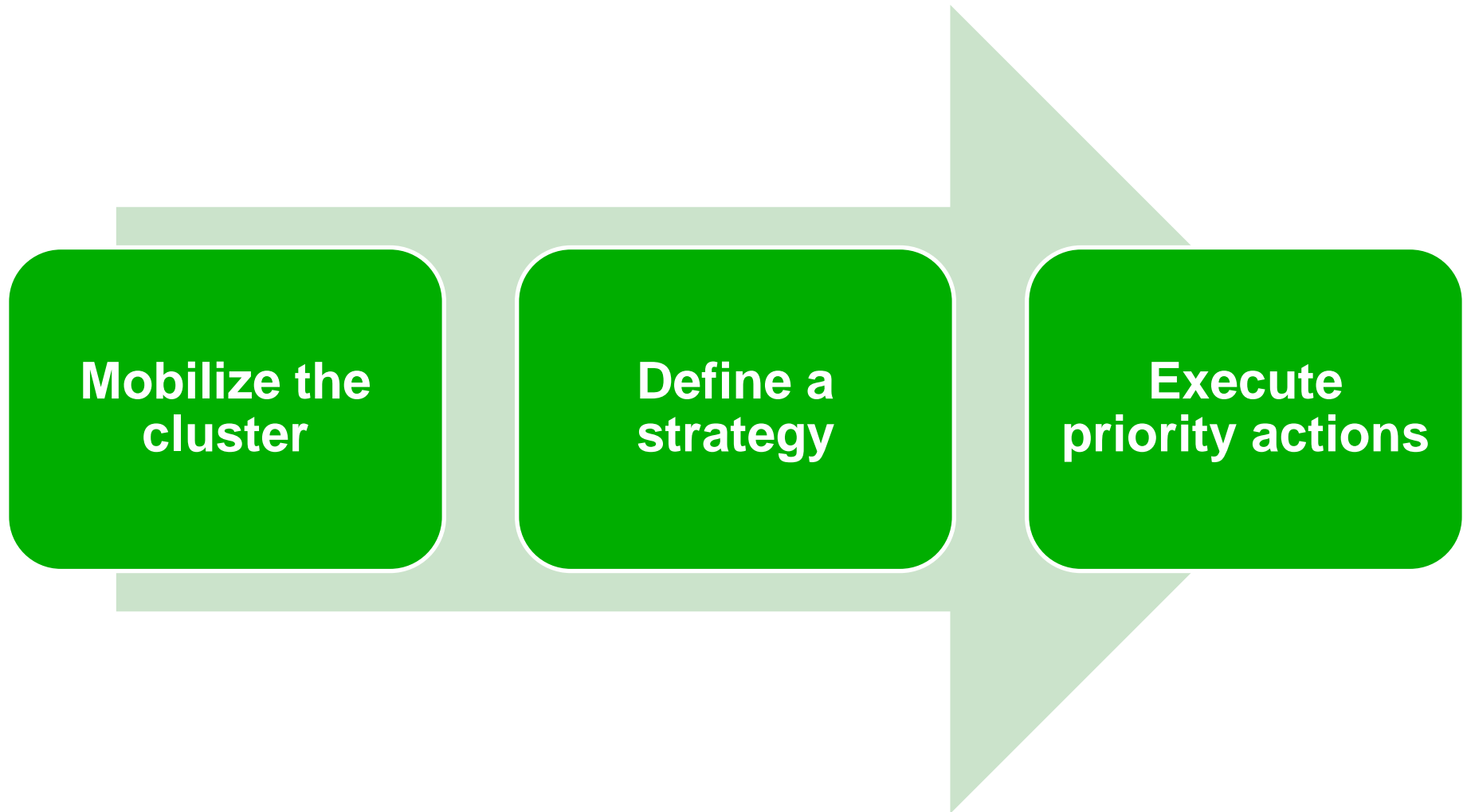
Technical services

- Solid capabilities and strong global network
- Currently also low price level
- Companies tend to lack size and capital to lead large projects

Operational management

- Solid practical experience
- Relevant companies largely publicly-owned
- Skills more technical than commercial

Seizing the Export Opportunities: The Next Steps for the Icelandic Geothermal Cluster



Mobilizing the Cluster

Critical Success Factors for Cluster Initiatives

Creating a Platform for Collaboration

Mandate/scope of activities

- Raising the **competitiveness of the cluster** as the overarching objective
- Focus on activities where **joint efforts** across the cluster are critical
- NOT a JV for export but an institution that improves the opportunities for companies and JVs to internationalize
- NOT a research consortium but an institution that facilitates joint research
- NOT a lobbying organization but a platform for dialogue and joint action

Structure

- Solid organizational basis, including funded **core secretariat**
- **Private sector** needs to lead and set the agenda
- Government needs to be **part of the dialogue**, not be outside or just providing co-financing
- Individual **leadership** is crucial

Developing a Cluster Strategy



Positioning

Defining a unique Iceland position

- What roles in the global market/value chain?
- What unique value as a home location?

Possible focus

- Focus on **high temperature resource** technology
- Focus on **technical consulting** and on provision of **training/education**
- Focus on **integrated energy systems** combining direct/ indirect use
- Focus on **emerging markets**

Possible advantages

- Wide availability of **high temperature resources**
- Experience and capabilities in **home market**
- Experience in **home market**
- Significant **network** through educational programs; global reputation



- Positioning drives the **prioritization of action initiatives** most critical to support the cluster's value proposition

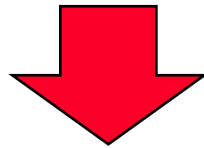
Seizing the Export Opportunities: Action Priorities

- Address weaknesses in the cluster profile
 - Consolidate institutions and activities in **education and research**
 - Clarify the role of **publicly-owned companies** in exports
 - Identify potential **international partners**
- Strengthen the cluster-specific business environment
 - Improve **government policies** towards the cluster, especially in
 - Innovation policy
 - Investment attraction
 - Education
 - Enhance Iceland's **regulatory transparency and efficiency** for investments in energy-production and energy-investment industries in Iceland
 - Address **capital shortages**; for example creation of a special financial instrument with government or foreign partners
 - Strengthen **rivalry** in the domestic market for energy production

Growing the Icelandic Geothermal Cluster

Conclusions

- Attracting energy-intensive industries offers the **greatest short-term returns** for Iceland
- Iceland needs to **allocate its energy** more strategically
- Moving from selling resources to selling services and knowledge will take longer to materialize, but has **significant potential**



- Geothermal is a clear **opportunity** that Iceland cannot afford to neglect
- Building advanced geothermal capacity at home and selling geothermal expertise abroad are **complementary activities**
- Iceland needs to transform the cluster into an **engine** of broader improvement in Icelandic competitiveness to maximize its impact

Iceland after the Crisis

**Acute crisis
response**



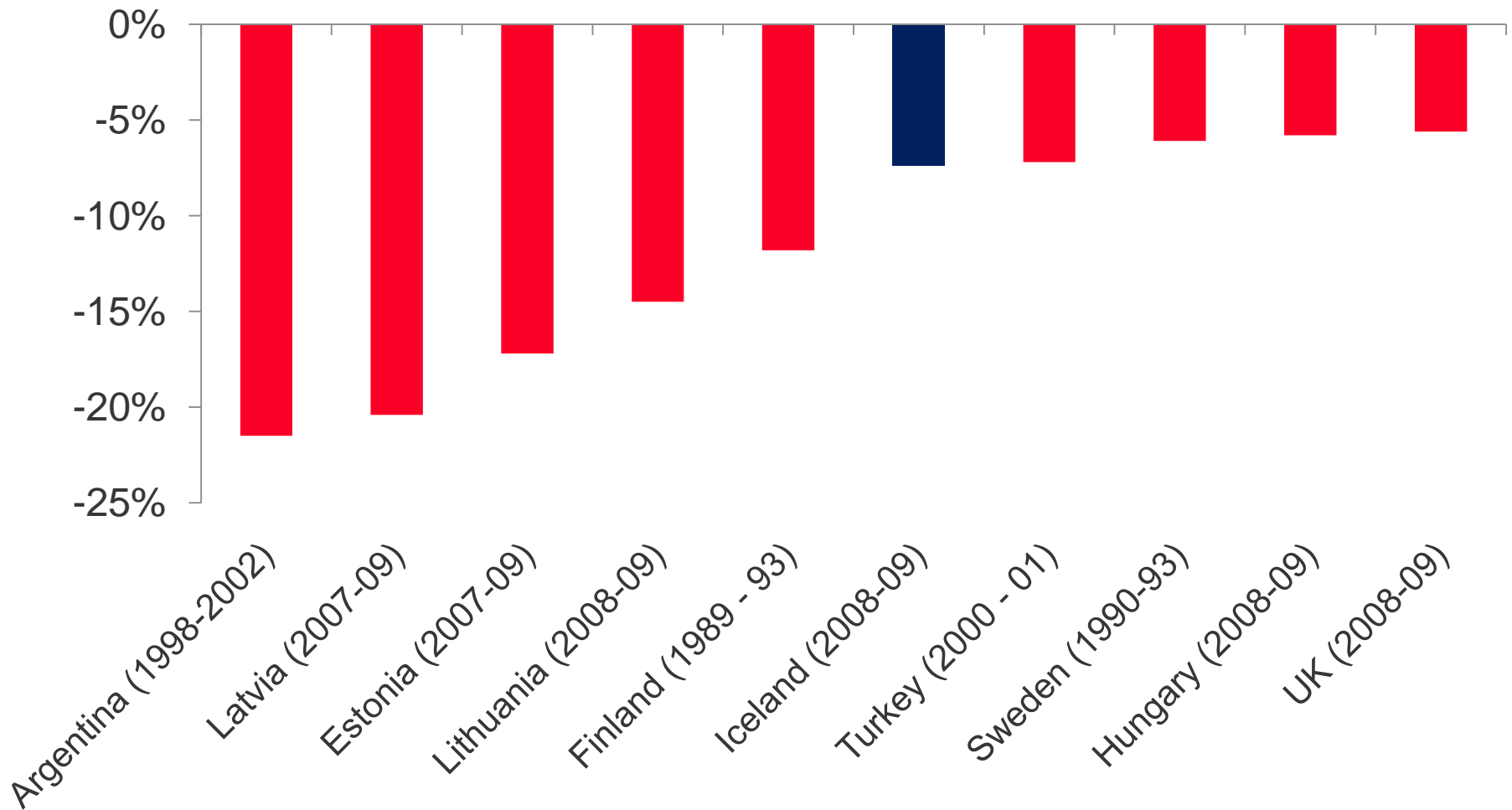
Stabilization



?

Putting the Crisis in Perspective

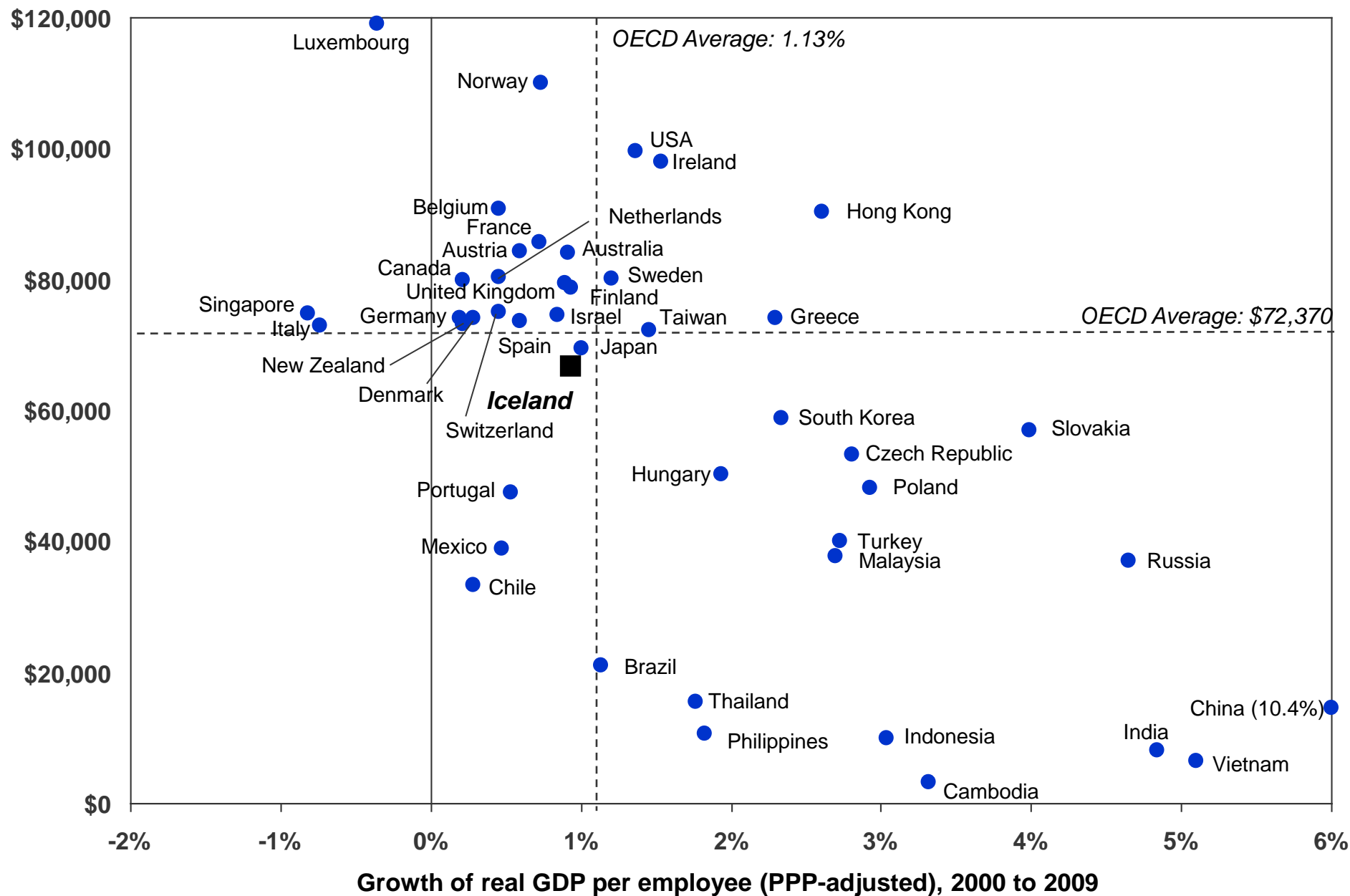
Change in GDP per capita (PPP adjusted)



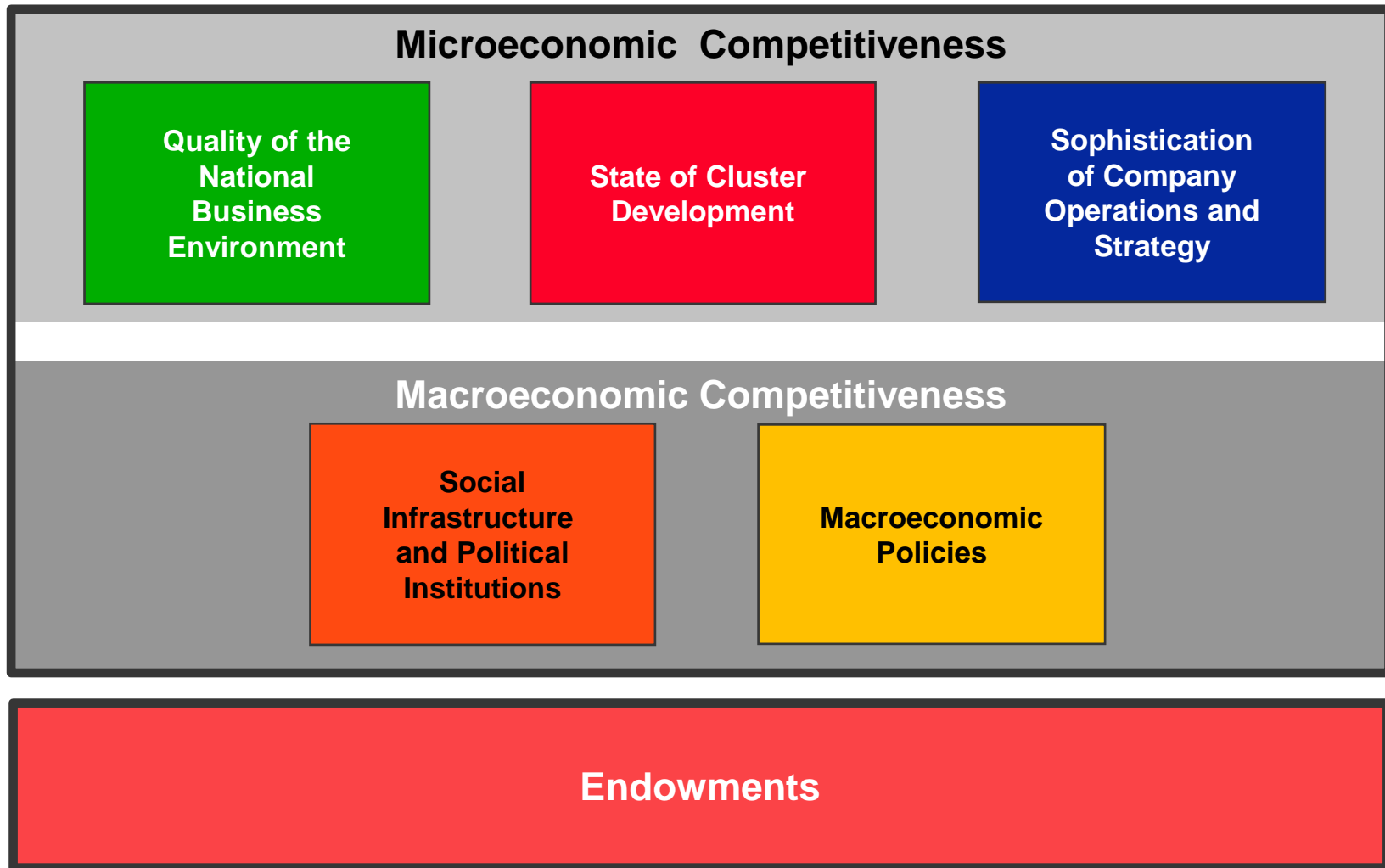
Real GDP per employee
(PPP adjusted US\$), 2009

Labor Productivity

Selected Countries, 2000 to 2009



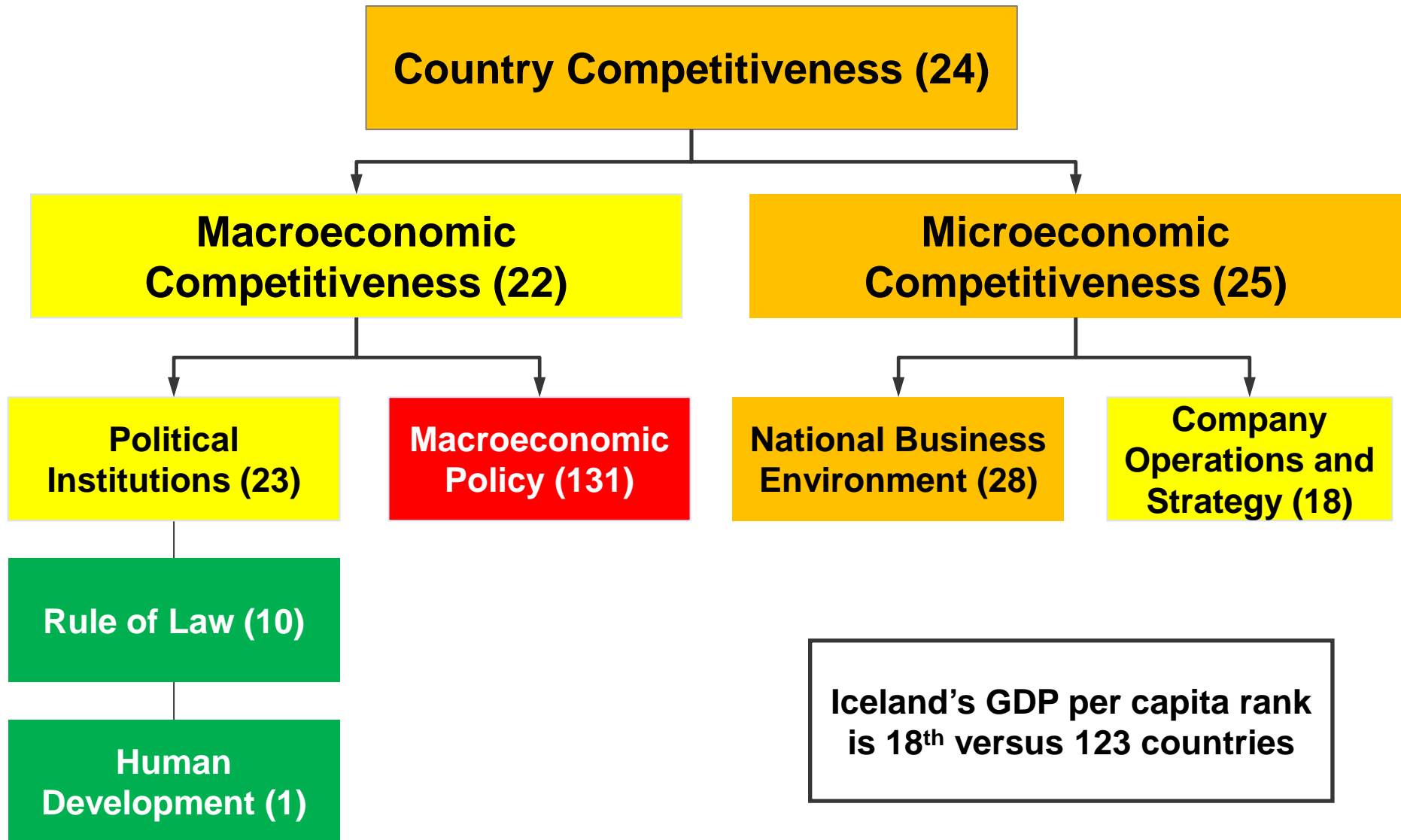
Determinants of Competitiveness



- Macroeconomic competitiveness creates the potential for high productivity, but is **not sufficient**
- Productivity ultimately depends on improving the **microeconomic capability** of the economy and the **sophistication of local competition**

Iceland's Competitiveness Profile, 2010

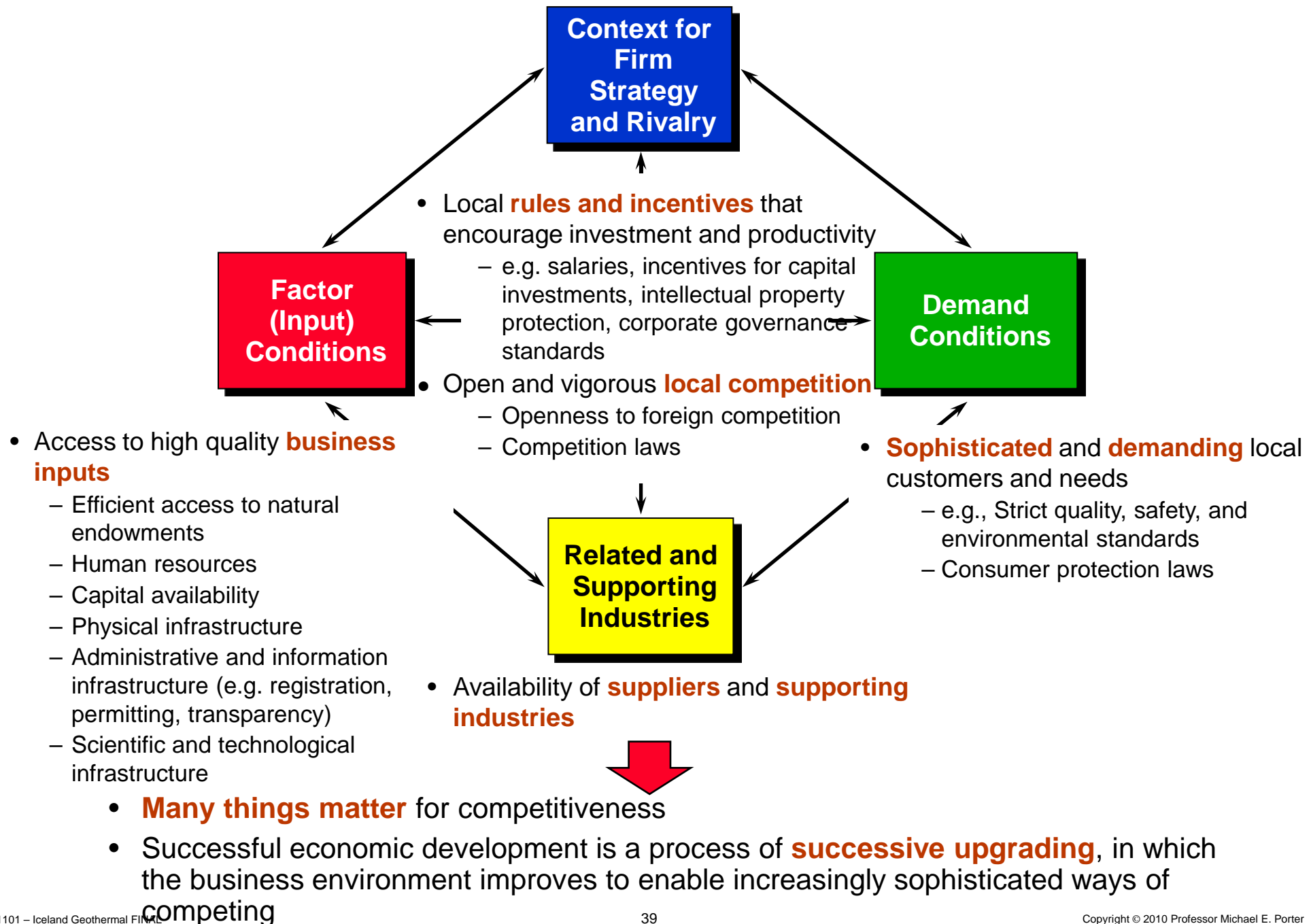
ISC Country Competitiveness Model



Note: Rank versus 139 countries; overall, Iceland ranks 18th in 2009 PPP adjusted GDP per capita and 24th in Global Competitiveness

Source: WEF Global Executive Opinion Survey and Institute for Strategy and Competitiveness, Harvard University (2010)

Microeconomic Competitiveness: The Diamond Model



Factor (Input) Conditions

Iceland's Relative Position 2010

Competitive Advantages Relative to GDP per Capita

Physical Infrastructure

Quality of electricity supply	1
Quality of telephone infrastructure	1
Telephone lines per 100 population	4
Quality of port infrastructure	7
Quality of air transport infrastructure	8
Internet users per 100 population	18

Science and skills

Quality of the educational system	3
Availability of scientists and engineers	3
Quality of management schools	8
Quality of math and science education	9
Utility patents per million population	11
University-industry research collaboration	12
Tertiary enrollment	14

Administrative Infrastructure

(Low) Time required to start a business	9
(Low) Burden of customs procedures	10
(Low) Burden of government regulation	14
Ease of starting a new business	18

Competitive Disadvantages Relative to GDP per Capita

Financial system

Soundness of banks	137
Financing through local equity market	128
Financial market sophistication	103
Regulation of securities exchanges	97
Protection of minority shareholders' interests	85
Ease of access to loans	81
Venture capital availability	68
Getting Credit (WB)	39

Physical Infrastructure

Mobile telephone subscribers per 100 population	35
Quality of roads	22
Personal computers per 100 population	20

Administrative Infrastructure

Tax Complexity (WB)	77
(Low) number of procedures to start a business	23

Science and skills

Quality of scientific research institutions	22
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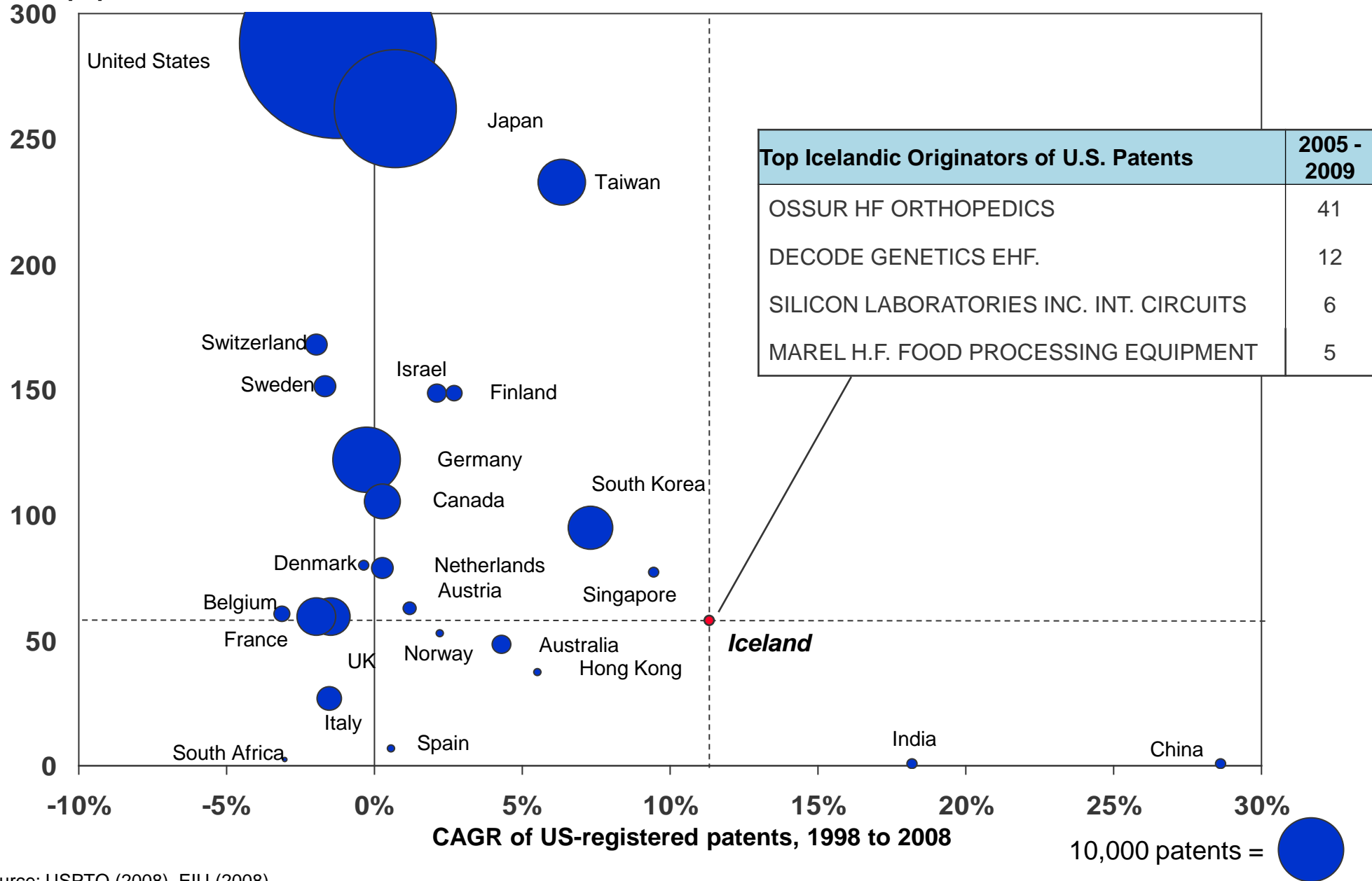
Note: Rank versus 139 countries; overall, Iceland ranks 18th in 2009 PPP adjusted GDP per capita and 24th in Global Competitiveness

Source: WEF Global Executive Opinion Survey and Institute for Strategy and Competitiveness, Harvard University (2010)

Innovative Output

Selected Countries, 1998 to 2008

Average U.S. patents per 1 million population, 1998-2008



Context for Strategy and Rivalry

Iceland's Relative Position 2010

Competitive Advantages Relative to GDP per Capita

Cooperation in labor-employer relations 4

Competitive Disadvantages Relative to GDP per Capita

Openness

Restrictions on capital flows 138
Business impact of rules on FDI 134
Prevalence of foreign ownership 129
Low Tariff rate 36

Labor market

Low Rigidity of employment 50

Domestic market rivalry

Market dominance by business groups 107
Prevalence of trade barriers 101
Intensity of local competition 67
Effectiveness of antitrust policy 45
Market disruption from SOEs 33

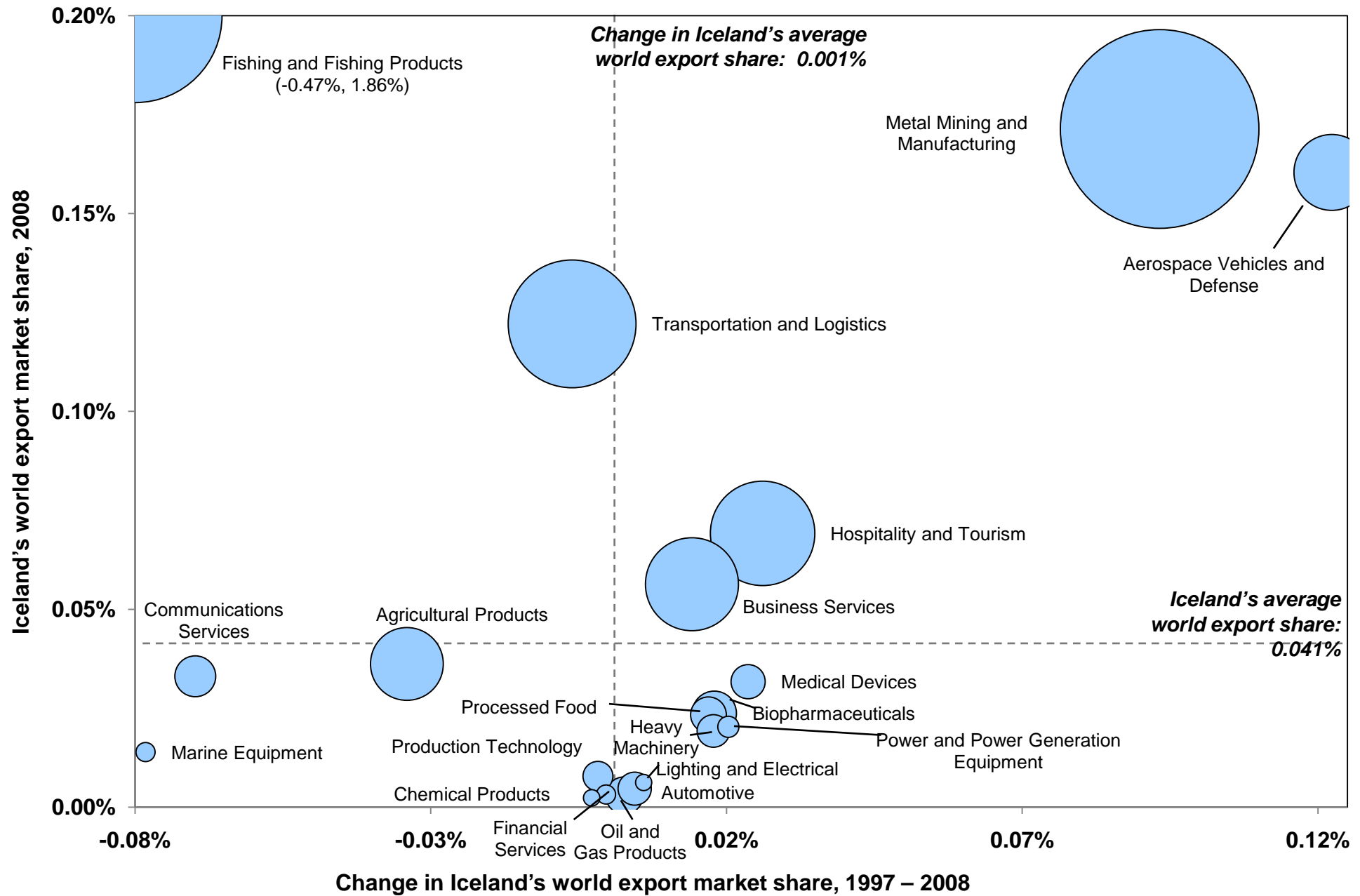
Government incentives and regulations

Tax impact on incentives to work & invest 86
Strength of auditing & reporting standards 83
Distortive effect of taxes and subsidies 74
Strength of investor protection 59

Note: Rank versus 139 countries; overall, Iceland ranks 18th in 2009 PPP adjusted GDP per capita and 24th in Global Competitiveness
Source: WEF Global Executive Opinion Survey and Institute for Strategy and Competitiveness, Harvard University (2010)

National Cluster Export Portfolio

Iceland, 1997-2008



Strategic Issues for Iceland

- Continue the path to **macroeconomic consolidation** and **financial market restoration**
- Strengthen the **business environment**, particularly its openness to foreign investment, competition, capacity for innovation, and the regulatory complexity
- Deepen and upgrade **clusters**



- Define a **national economic strategy**

National Economic Strategy



Country Positioning

Defining a unique position for Iceland

- What roles in the world and regional economy?
- What unique value as a business location?
- For what range or types of business activities?

Priority Policies

Developing unique strengths

- What elements of the business environment are **critical** to the national value proposition?

Best Practices

Achieving parity on necessary qualities

- What improvements are necessary to **maintain parity** with peer countries?

Others

Maintaining position

- What aspects of the business environment are **acceptable** and currently not a priority?

The Geothermal Cluster as an Engine for Iceland

- A clear strategy to enhance the geothermal cluster can become a **change agent for the broader economy**

1. Role model for cluster mobilization
2. Catalyst for upgrading of cross-cutting policies: e.g., FDI, innovation
3. Geothermal as a core element of a new national economic strategy for Iceland



Clusters as
Change Agents

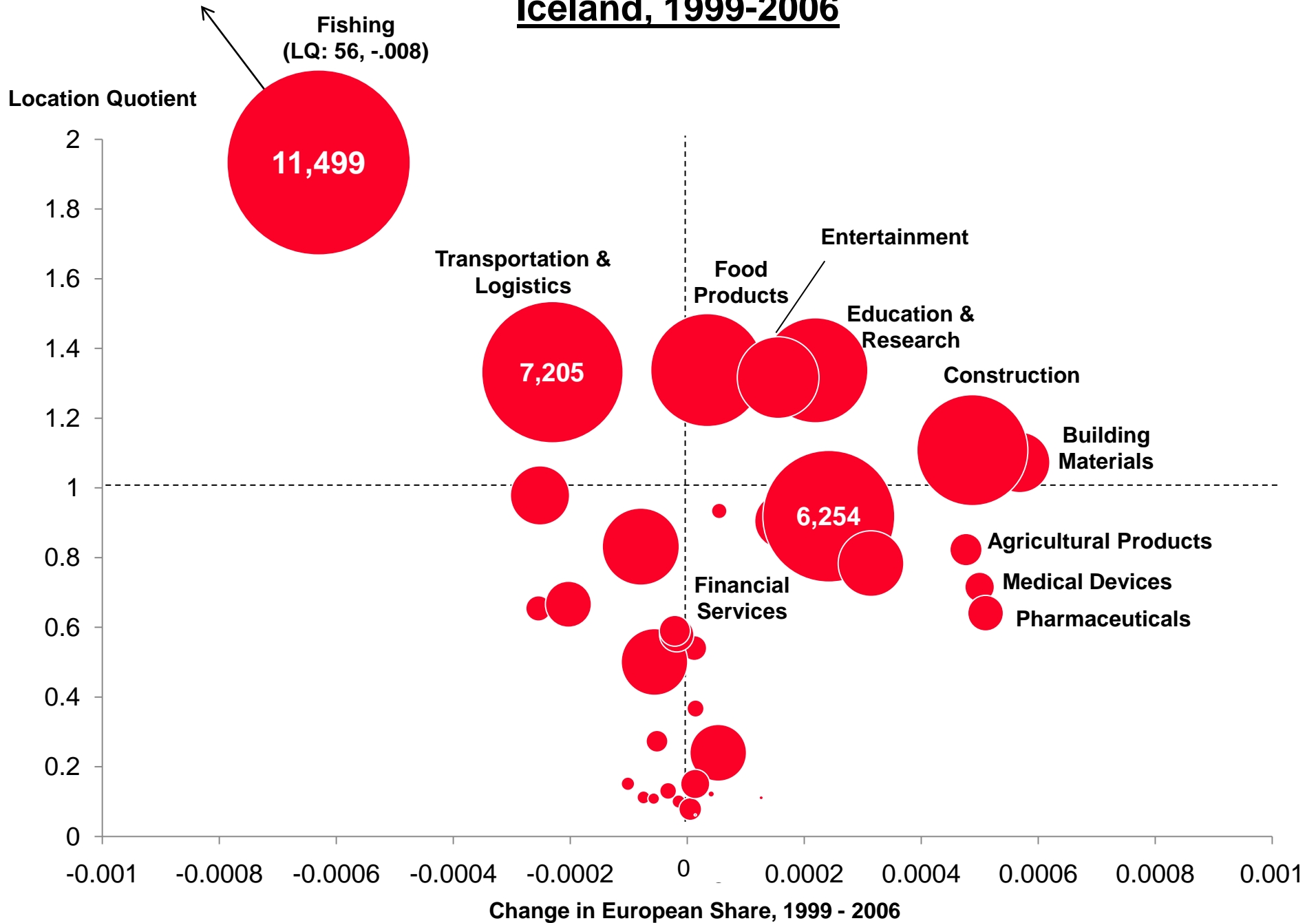
Clusters as
Tools

Clusters as
Symbols

Back-Up

Cluster Employment Portfolio

Iceland, 1999-2006



Company Sophistication

Relative Position of Icelandic Companies, 2010

Competitive Advantages Relative to GDP per Capita

Firm-level technology absorption	1
Degree of customer orientation	4
Control of international distribution	6
Willingness to delegate authority	9
Prevalence of foreign tech licensing	11
Extent of staff training	17
Capacity for innovation	18
Reliance on professional management	18

Competitive Disadvantages Relative to GDP per Capita

Extent of incentive compensation	57
Nature of competitive advantage	41
Value chain breadth	40
Breadth of international markets	36
Company spending on R&D	25
Extent of marketing	25
Extent of regional sales	24
Production process sophistication	21

Note: Rank versus 139 countries; overall, Iceland ranks 18th in 2009 PPP adjusted GDP per capita and 24th in Global Competitiveness

Source: WEF Global Executive Opinion Survey and Institute for Strategy and Competitiveness, Harvard University (2010)

International Perceptions About Icelandic Geothermal

