The Global Value Chains Initiative seeks to develop an industry-centric view of economic globalization that highlights the linkages between economic actors and across geographic space. It is a multi-year effort to test and develop the GVC framework with the aims of creating greater analytical precision, intellectual impact and policy relevance. Our efforts include a research agenda, a publishing thrust, the development and dissemination of industrial upgrading handbooks for practitioners, and a series of intensive workshops convened to test and broaden the framework through interactions among network participants and with the broader academic, policy-making and activist communities.

**PUBLICATIONS**

- **World Investment Report 2011: Non-Equity Modes of International Production and Development**  
  Timothy Sturgeon, consultant, 2011  
  The world investment report 2011 forecasts that, barring any economic shocks, FDI flows will recover to pre-crisis levels over the next two years. The challenge for the development community is to make this anticipated investment have greater impact on our efforts to achieve the Millennium Development Goals.

- **The Dynamics of Local Learning in Global Value Chains: Experiences from East Asia**  
  Momoko Kawakami and Tim Sturgeon, 2011  
  This book examines how local East Asian firms have encountered, and sometimes overcome, barriers to capability development through participation in Global Value Chains in the personal computer, mobile phone handset, consumer electronics, and motorcycle industries.

- **Mapping Global Value Chains: Intermediate Goods Trade and Structural Change in the World Economy**  
  Timothy Sturgeon & Olga Memedovic, 2010
Agenda

Research goals and scope

GVC analysis
- Key components
- Value chain mapping of two ocean technologies

Centers of Excellence

Key findings & initial recommendations
Nova Scotia
Ocean Technologies
GVC Analysis: Scope and Plan
Project Scope

Global value chains in:

- Remotely Operated Vehicles (ROVs) & Automated Underwater Vehicles (AUVs)
- Acoustic & non-acoustic sensors and instrumentation
- Inshore and extreme climate vessels

Key end markets:

- Marine defense
- Offshore oil & gas
- Scientific research
- Finfish aquaculture
Research Objectives

- Identify the **high-value activities** in ocean technology GVCs
- Find **synergies** between the high-value activities and other portions of the ocean technology cluster
- Locate **regional economies** across the globe that specialize in these high-value activities
- Highlight **opportunities** for Nova Scotia companies to move into higher-value activities
- Provide **recommendations** to companies and government about promising upgrading trajectories
Research Methods

Interviews
- Lead firms
- Local companies
- Experts in technology
- Representatives of Centers of Excellence

Secondary sources
- Academic journals
- Industry publications
- On-line data sources

Database
<table>
<thead>
<tr>
<th>Project Activity and/ or Deliverable</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
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<th>Nov</th>
<th>Dec</th>
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<tr>
<td>Visit Halifax and undertake company interviews, industry round table, and seminar</td>
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<tr>
<td>Visit Halifax &amp; complete company-based research</td>
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<tr>
<td>Complete review of initial findings with Steering Committee</td>
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<td>Submit final report to Steering Committee</td>
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</tbody>
</table>
# The Global Value Chain Approach

## FOUR dimensions:

1. Value chain: raw materials → inputs → final product
2. Geographic scope
3. Analysis of lead firms and governance
4. Institutional framework

- Global value chain analysis provides both conceptual and methodological tools for examining the global economy.
  - **Top-down**: a focus on lead firms and inter-firm networks, using varied typologies of *industrial “governance”*
  - **Bottom-up**: a focus on countries and regions, which are analyzed in terms of various trajectories of *economic and social “upgrading”* or *“downgrading”*
What is a value chain?

A value chain describes the full range of activities that firms and workers carry out to bring a product from its conception to its end use and beyond.

Mapping firms and supply chain segments
Global Value Chain Mapping
Ocean Technologies
Marine Vehicles and Sensors
Value Chains

Marine Vehicles

Underwater
- Manned
  - ROVs (tethered)
- Unmanned
  - AUVs (untethered)

Surface
- Manned
- Unmanned

Inshore & extreme climate vessels

Aquatic sensors and instrumentation
ROVs/AUVs
ROV/AUV Types

ROVs

- ROTV (MacArtney Focus 2)
  - towed

- ROV (Oceaneering)
  - remotely controlled

AUVs

- AUV (Remus 100)
  - untethered

- Glider (Slocum)
  - unpowered

Source: CGGC and Westwood, 2010
## ROV Types (tethered)

<table>
<thead>
<tr>
<th>ROV type</th>
<th>Max. Depth (m)</th>
<th>Weight (kg)</th>
<th>Power (HP)</th>
<th>Uses</th>
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</thead>
<tbody>
<tr>
<td>micro</td>
<td>&lt; 300</td>
<td>&lt; 6</td>
<td></td>
<td>diver alternative; inspection</td>
</tr>
<tr>
<td>mini</td>
<td>&lt; 1,500</td>
<td>~ 15</td>
<td></td>
<td>diver alternative; inspections, light survey</td>
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<tr>
<td>general</td>
<td>&lt; 4,000</td>
<td>&lt; 700</td>
<td>&lt; 5</td>
<td>light survey applications</td>
</tr>
<tr>
<td>light workclass</td>
<td>&lt; 3,000</td>
<td>&lt; 800</td>
<td>&lt; 50</td>
<td>survey and drill support</td>
</tr>
<tr>
<td>heavy workclass</td>
<td>&lt; 5,000</td>
<td>&lt; 4,900</td>
<td>&lt; 220</td>
<td>drill &amp; construction support; inspection, repair maintenance, survey &amp; subsea intervention</td>
</tr>
<tr>
<td>trenching/burial</td>
<td>up to 6,000</td>
<td>up to 38,000</td>
<td>200 to 1,000</td>
<td>deepsea cable</td>
</tr>
</tbody>
</table>
ROV Market Trends

Size:
- 2010 expenditure on ROV sales & services in the global market -- $1.7B
- expected to grow to $3.2B (U.S.) by 2014

Drivers:
- Current market: oil & gas (50%) military/security (25%); scientific research (25%)
- offshore drilling; security environment; need for ocean data

Dynamics:
- mini and small ROVs sales have dramatically increased
- developing advanced sensor packages for smaller vehicles
- platform costs: 40%; instrument costs: 60%

Source: CGGC and Westwood, 2010
AUV Market Trends

**Size:**

- 2010 expenditure on AUV sales & services in the global market -- $200M
- expected to grow to $2.3B by 2019

**Drivers:**

- Current: Security (~50%), research (30%), cable/pipeline inspection (20%)
- AUVs have been quickly adopted in water survey use

**Dynamics:**

- AUVs with rated capacities <200m dominate current unit sales
- Large AUVs dominate $ sales because of high cost
- Platform costs: 66-75%; Instrument costs: 33-25%

Source: CGGC and Westwood, 2010
ROV/AUV Value Chain

- **Raw Materials**
  - Aluminum / Steel metal
  - Composite material
  - Syntactic foam

- **Components**
  - ROV/AUV Unit
    - ROV Electronics & “Tooling”
  - Surface Vessel

- **Production**
  - ROV/AUV manufacturers
  - Production support services
    (e.g. machining, engineering, integrating)
  - Auxiliary products

- **Distribution**
  - ROV Brokers
  - Post-production support services

- **Sales**
  - ROV Operators
  - Oil/Gas Exploration
  - Military
  - Scientific research
  - Aquaculture

**Interconnection w/ aquatic instrument GVC**

**Related Sectors**
- Research
- Education
- Government
- Policies & Regulations
## Top 20 ROV Manufacturers, 2000-2010

<table>
<thead>
<tr>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>SeaBotix Inc (USA)</td>
</tr>
<tr>
<td>VideoRay LLC (USA)</td>
</tr>
<tr>
<td>ECA SA (France)</td>
</tr>
<tr>
<td>Deep Ocean Engineering (USA)</td>
</tr>
<tr>
<td>Saab Seaeye Ltd (UK)</td>
</tr>
<tr>
<td>Mitsui Engineering &amp; Shipbuilding (Japan)</td>
</tr>
<tr>
<td>SMD Ltd (UK)</td>
</tr>
<tr>
<td>Oceaneering International Inc (USA)</td>
</tr>
<tr>
<td>AC-CESS Co UK Ltd (UK)</td>
</tr>
<tr>
<td>Elettronica Enne (Italy)</td>
</tr>
<tr>
<td>Gaymarine srl (Italy)</td>
</tr>
<tr>
<td>Sub-Atlantic Ltd (UK)</td>
</tr>
<tr>
<td>Kongsberg Defence Systems (Sweden)</td>
</tr>
<tr>
<td>Saab Underwater Systems AB (Sweden)</td>
</tr>
<tr>
<td>Outland Technology Inc (USA)</td>
</tr>
<tr>
<td>Perry Slingsby Systems Inc (USA)</td>
</tr>
<tr>
<td>International Submarine Engineering Ltd (Canada)</td>
</tr>
<tr>
<td>Shark Marine Technologies Inc (Canada)</td>
</tr>
<tr>
<td>Schilling Robotics (USA)</td>
</tr>
<tr>
<td>Saipem America Inc (USA)</td>
</tr>
</tbody>
</table>

Source: ROV Database of the World, 2010/2011 (Clarkson Publishing)
### Top 10 AUV Manufacturers, 2000-2010

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teledyne Webb Research (USA)</td>
<td></td>
</tr>
<tr>
<td>Hydroid Inc (USA)</td>
<td></td>
</tr>
<tr>
<td>OceanServer Technology Inc (USA)</td>
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</tr>
<tr>
<td>Kongsberg Defence Systems (Norway)</td>
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</tr>
<tr>
<td>iRobot Corporation (USA)</td>
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<tr>
<td>Kongsberg Maritime (Norway)</td>
<td></td>
</tr>
<tr>
<td>ECA SA (France)</td>
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</tr>
<tr>
<td>Teledyne Gavia ehf (Iceland)</td>
<td></td>
</tr>
<tr>
<td>International Submarine Engineering (Canada)</td>
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</tr>
<tr>
<td>Bluefin Robotics (USA)</td>
<td></td>
</tr>
</tbody>
</table>

Source: ROV Database of the World, 2010/2011 (Clarkson Publishing)
Nova Scotia’s Position in ROV/AUV Value Chain

Raw Materials
- Aluminum / Steel metal
- Composite material
- Syntactic foam

Components
- ROV/AUV Unit
  Moog Components Group; Hawboldt Industries
- ROV Electronics & “Tooling”
  Nortek Scientific; XEOS; Vemco Ltd. (Amirix Inc.); ODIM Brooke Ocean; Instrument Concepts - Sensor Software; Omnitech; Satlantic; Akoostix; MetOcean Data Systems; Welaptega; Ultra Electronics
- Surface Vessel
  General Dynamics Canada; Hawboldt Industries

Production
- ROV/AUV manufacturers
- Auxiliary product manufacturers
- Production support services (e.g. machining, engineering, integrating)

Distribution
- ROV Brokers
- Post-production support services
  OEA Technologies; Romor Atlantic; Kongsberg Maritime Canada

Sales
- ROV Operators
  Divetech; Dominion Diving; Oceaneering Canada; Guptill Consulting Services
- Oil/Gas Exploration
- Military
- Scientific research
- Aquaculture

No NS ROV manufacturing
Technology Trends in ROVs & AUVs

ROVs
- Software integration
- High definition camera & video
- Reduced size
- Hybrid (tether optional)

AUVs
- Increased functionality
- Longer mission life
- Reduced power requirements
- Miniaturization
Aquatic Sensors & Instrumentation
Radiometer
Laser Optical Plankton Counter
Acoustic Doppler Current Profiler
Chlorophyll Fluorometers
Temperature Sensor
Nitrate Sensor
Marine Magnetometer
Drifting Buoy
Conductivity, Temp & Depth (CTD) Profiler
Sonar System

Source: MetOcean (1), Satlantic (2), ODIM/BrookOcean (3)
Aquatic Sensors and Instrumentation

<table>
<thead>
<tr>
<th>Seafloor mapping</th>
<th>Ocean monitoring</th>
<th>Locating/detecting underwater noise</th>
<th>Observing/Locating marine life</th>
<th>Communication</th>
<th>Navigation/positioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Echosounders/Multibeam sonars</td>
<td>Acoustic current meters/ADCP</td>
<td>Sound surveillance systems</td>
<td>Fish-finding sonars</td>
<td>Acoustic modems</td>
<td>Ultra-short baseline systems</td>
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<tr>
<td>Side-scan sonars</td>
<td>Acoustic tomographic moorings</td>
<td>Variable depth sonars</td>
<td>Active acoustic tagging systems</td>
<td>Acoustic connectors and cables</td>
<td>Long baseline systems</td>
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<tr>
<td>Sub-bottom profilers</td>
<td>Inverted echosounders</td>
<td>Forward-looking sonars</td>
<td>Passive acoustic tagging systems</td>
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<td>Underwater GPS</td>
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<tr>
<td>Magnetometers</td>
<td>Acoustic rain gauges</td>
<td>Directional frequency and ranging sonobouys</td>
<td>Acoustic data-logging system</td>
<td></td>
<td>Inertial navigation sensors (INS)</td>
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<tr>
<td>Penetrometer</td>
<td>Acoustic releases</td>
<td>Surveillance Towed Array Sensor System Low Frequency Active Sonars (SURTASS LFA)</td>
<td>Passive acoustic monitoring</td>
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<td>Gyrocompass</td>
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<tr>
<td></td>
<td>Conductivity, temperature and depth (CTD) sensors</td>
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<td>Acoustic trawl monitoring system</td>
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<td>Motion control devices</td>
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<td></td>
<td>Bathymeters</td>
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<td>Optical plankton counter (OPC)</td>
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<tr>
<td></td>
<td>Turbidity sensors</td>
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<tr>
<td></td>
<td>Current/wave/tide meters</td>
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<tr>
<td></td>
<td>Underwater profilers</td>
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</table>

Legend:
- ACOUSTIC
- NON-ACOUSTIC
Call me paranoid if you like, but I feel as if people are watching me all the time...
Aquatic Instruments Value Chain

**Raw Materials**
- Key (acoustic)
  - piezo-ceramics
  - piezo-composites
- General
  - diodes, nanorods, chips, zinc, glass, metal alloys, plastic

**Components**
- Hardware Components
  - Transducer/Hydrophone sensor
  - Transmitter/Receiver
  - Beam-forming processor
  - Display system
  - Power supply
- Software Components
  - operation software
  - display software
  - integration software
  - communications & data processing software

**Production**
- Instrument manufacturers (e.g. sonars, CTD scanners)
- Sub-system manufacturers
  - Sensor suites
  - Communication
  - Data processing/storage

**Distribution**
- Marketing & Distribution
  - Technical Training & Customer Support
  - Consulting
  - Customer Service / Repair
  - Training

**Sales**
- ROV Operators, survey firms
  - Oil/Gas Exploration
  - Military
  - Scientific research
  - Aquaculture

**Interconnection w/ ROV/AUV GVC**

**Research**

**Education**

**Government**

**Policies & Regulations**
Nova Scotia’s Position in Aquatic Instruments

Raw Materials

- Key materials
  Piezo-ceramics;
  Piezo-composites

- General materials

Components

Hardware components
Open Seas Instrumentation Inc.;
ODIM Brooke Ocean

Software components
See H/W component & instrument mfg.

Production

Instrument/sub-system manufacturers

- Acoustic: GeoSpectrum Tech.; IKB Tech./Seistec;
  Instrument Concepts; JASCO Research; Kongsberg
  Mesotech; MetOcean;
  Nortek Scientific; Omnitech;
  Ultra Electronic Maritime Systems; Vemco

- Non-acoustic: Focal Tech.
  (MOOG Components);
  Satlantic; Xeos

Integrated systems manufacturers

Akoostix Inc.; General Dynamics CA;
Lockheed Martin Canada Inc.

Distribution

Marketing & Distribution
ROMOR Atlantic Limited

Technical Training & Customer
See instrument mfg.

Sales

Instrument Operators
Canadian Seabed Research; Fugro
Jacques GeoSurvey; McGregor
GeoScience; Seaford
Engineering; Seismap Consulting;
Tekmap Consulting

- Oil/Gas Exploration
- Military
- Scientific research
- Aquaculture
Technology Trends in Aquatic Instruments

- Smaller, more energy-efficient systems
  - advanced manufacturing technologies
  - lower cost
  - longer endurance

- Systems integration
  - Rapidly evolving integration technologies
  - increasing modularization
Market Trends in Aquatic Instruments

Increased **market consolidation** by MNCs

- Seeking complete measurement systems
- Pursuing economies of scale in R&D, marketing and end-market coverage

Growing demand in **non-Western**, developing countries

Global players are moving manufacturing to **emerging markets** (e.g., China)
Key Takeaways from Aquatic Sensors GVC

High-tech NS firms well-represented
  - Including lead firms in value chain
Synergies with underwater platforms
  - ROV/AUVs
Strong export capabilities
Bundling new product capabilities
Sustainable high-value niches
Centers of Excellence

Centers of Excellence are institutions seeking highest standards of achievement in a given industry.
Centers of Excellence

The main characteristics are:

- Critical mass of experts
  - R&D and innovation
  - Manufacturing excellence

- Multi-stakeholder participation:
  - public sector
  - private sector
  - academic institutions

- Access to global collaboration via research networks
## Centers of Excellence
(preliminary list)

<table>
<thead>
<tr>
<th></th>
<th>Woods Hole (US)</th>
<th>Trondheim (Norway)</th>
<th>San Diego (US)</th>
<th>Toulon (FR)</th>
<th>Houston (US)</th>
<th>Aberdeen, Scotland (UK)</th>
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<tbody>
<tr>
<td><strong>Scientific research</strong></td>
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<td>X</td>
<td>X</td>
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<td>X</td>
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<td><strong>Defense</strong></td>
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<tr>
<td><strong>Oil &amp; Gas</strong></td>
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<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Centers of Excellence

- Trondheim
- Aberdeen, Scotland
- Rogaland
- Woods Hole, MA
- San Diego, CA
- Seattle, WA
- Southampton
- Bremen & Schleswig - Holstein
- Trondheim
- Aberdeen, Scotland
- Rogaland
- Southampton
- Bremen & Schleswig - Holstein

Legend
- Oil & Gas
- Scientific Research
- Military
Woods Hole Oceanographic Institution (WHOI)

- WHOI is the world's largest private, nonprofit ocean research organization.
- WHOI employed 825 people plus 200 students and 246 institute affiliates.
- 2010 operating budget: US$127 million.
- MIT/WHOI Joint Program awards masters and doctoral degrees in ocean science and engineering.
- WHOI partners with local and international universities and research centers, public sector and private sector.
Kongsberg Marine System’s
Remus 6000 AUV

Company HQ
Kongsberg, Norway

R & D
USN/WHOI: Hydroid

Sales office
Halifax, NS

Manufacturing & Service
Victoria, British Columbia
The Norwegian University of Science & Technology (NTNU) Marine Coastal Development

- NTNU graduates 80% of the country’s civil engineers
- Core of strategic agenda is innovation through cooperation

- NTNU MS & PhD Students.
- Two advisors: Professor and private sector employee
- Companies sponsor professors & students

SINTEF
largest independent research organization in Scandinavia

Marintek
research company in the SINTEF Group. Shared infrastructure
Relevance for Nova Scotia

- International centers of excellence are potential partners for research networks and technology transfers with NS firms
- Examples of supportive public policies (e.g., employee training grants)
- Connections with end markets (e.g., San Diego, Houston)
- Understanding high-skilled labor requirements for ocean technology firms
Opportunities for NS Companies to Trade & Invest

Findings

- Demand for NS ocean technologies is largely driven by 3 main end markets
  - Offshore energy (oil & gas)
  - Military
  - Scientific research
- Growing market demand in non-Western and emerging economies (e.g., China, Singapore, Brazil)

Recommendation

- Identify and prioritize export opportunities in most promising international markets
## Market Opportunities
### Nova Scotia, 2012-2015*

<table>
<thead>
<tr>
<th></th>
<th>Oil &amp; Gas</th>
<th>Scientific Research</th>
<th>Military</th>
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<td>U.S.</td>
<td>![Strong](strong jpg)</td>
<td>![Strong](strong jpg)</td>
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<td>U.K.</td>
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<tr>
<td>Norway</td>
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<td>Brazil</td>
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<tr>
<td>China</td>
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<td>![Weak](weak jpg)</td>
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</tr>
</tbody>
</table>

* Preliminary estimates

[strong, weak]
Policy-induced Barriers

Findings

- International Traffic in Arms Regulations (ITAR) controls (export limitations from U.S. market) of critical concern to NS ocean technology companies in defence
- ITAR compliance information unequally distributed among companies
- SMEs: external counsel; large firms: in-house

Recommendation

- Actively support small and medium firms on ITAR compliance (e.g., create common pooled resources)
Learn from Centers of Excellence

Findings

- Centers of Excellence (CoEs) contain knowledge networks of high-tech firms
- CoEs can be markets for high-technology products
- Demonstrate successful policies and public-private partnerships to support ocean technologies

Recommendation

- Develop connections with international CoEs that match NS product, technology and end-market profiles
Next Steps…

- Complete interviews with NS firms in these chains
- Add lead firms to Ocean Technology value chains and assess strategic implications for NS
- Complete global benchmarking analysis of NS ocean technologies based on interviews with lead firms and other experts
- Highlight high-value activities (production and services) carried out by NS firms in each chain
- Link ocean technology GVCs to production and trade databases
Thank you for your attention!

Duke University
Center on Globalization, Governance & Competitiveness
ggere@soc.duke.edu