Who is the Nanotechnology Economy? Obstacles and Methods of Identifying and Estimates of U.S. Nano Firms & Workers

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SNO Meeting: Santa Barbara, CA
November 4, 2013
Goals & Obstacles

**Goal/Objective:** Track and measure economic, social and/or environmental impacts related to nanotechnology.
- Positive: return on investment, job creation, revenue generation, energy efficiency
- Negative: exposure & risk
- Common key variables: firms, workers, products & geography

**Obstacles:**
- Nanotechnology is not an industry; it enables developments in all industries in different ways
- U.S. firms are not required to disclose activities on nanoscale
- No centralized effort to collect nano firm/product/worker data
- No firm or product classification
- Need to track developments along the entire value chain
Value Chain Analysis -> Life Cycle Assessment

- **Value chain**: activities firms and workers do in the process of creating a product/service
  - Physical alterations (supply chain) + activities that add value (research, branding, services)
  - Six main activities – need to identify firms in each stage performing each activity

Value chain, supply chain, production network, life cycle analysis – different research questions, rely on same data
Basic Nano Value Chain Model Overview

Layers: 120+
Stages: 5
Sectors: 27
Subsectors: 91

Firms / Supply Chain

Supporting Organizations

Value-Adding Activities
### Value Chain Mapping Example

**Quantum Dots in Displays**

<table>
<thead>
<tr>
<th>Nanoscale Materials</th>
<th>Nanoscale Intermediates</th>
<th>Component Products</th>
<th>Nano-Enabled Product</th>
<th>End-User/Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-Metallic</td>
<td>Coatings &amp; Ink</td>
<td>Electronic Subassemblies: Display</td>
<td>Consumer Electronics</td>
<td></td>
</tr>
<tr>
<td>Quantum Dots</td>
<td>Nanoparticulate Film</td>
<td>LCD</td>
<td>Tablets &amp; E-Readers</td>
<td></td>
</tr>
<tr>
<td>Nanosys QD Concentrate™</td>
<td>3M™ QD Enhancement Film</td>
<td>LG Display</td>
<td>Foxconn</td>
<td>Amazon Kindle Fire HDX</td>
</tr>
<tr>
<td>California, USA</td>
<td>Minnesota, USA</td>
<td>South Korea</td>
<td>China/Asia</td>
<td>Washington, USA</td>
</tr>
<tr>
<td>100 employees</td>
<td></td>
<td>$60 (prior to QD)</td>
<td></td>
<td>$229</td>
</tr>
</tbody>
</table>

- **Activities**
  - R&D, Manufacturing, Marketing: B2B
  - Manufacturing
  - Manufacturing
  - Marketing/Sales: B2C

- **Firms**
  - Red: negative exposure & risk
  - Green: positive benefits

- **Products**
  - Nanoscale Materials
  - Nanoscale Intermediates
  - Component Products
  - Nano-Enabled Product
  - End-User/Disposal

- **Geography**
  - California, USA
  - Minnesota, USA
  - South Korea
  - China/Asia
  - Washington, USA

- **Claims**
  - Publicly discuss collaboration; mention quantum dots; no change to mfg. process; improves color; more energy efficient
  - No claims
  - "Perfect color"
  - Red: negative exposure & risk
  - Green: positive benefits
Strategy 1: Firms/Organizations -> Workers

**Broad**
- Identify firms
- Find total number of workers employed by firms and organizations purportedly engaged in some degree of nano-related development by location

**Focused**
- Estimate ‘nano’ portion of total employment
  - Based on degree a stakeholder appears to be focused on nano-related activities
  - Apply percentages to total employment
    - Nano-specific: 100%
    - Partial or Micro/Nano: 10-50%
- Subjective, yet important step towards more accurate estimates
Strategy 1: Identify Firms
Data & Methods to Identify Firms and Metrics

Industries, Worker & Product Classification Codes (NAICS, SOC, HS, etc.)
Do not exist for nanotechnology

Publications
Patents
Government Funding

Lack supporting methodology & dataset

Expert Opinion Statistics

Firm-Level Reports & Directories
Firm-Level Reports & Directories
Firm-Level Reports & Directories

Often one-time efforts * Limited scope (geography, activities or supply chain) * Several lack a methodology
Strategy 1: Data Collection & Estimate Model

(1) Compile/verify existing info

(2) Add new companies & provide R&D details

(3) Add general business info; develop non-nano value chain maps
Key variable: employment

(4) Compare results to existing estimates

(5) Continue search for new sources; maintain & update info

**Existing Metrics/Statistics**
- Lux, BCC, F&S, NSF, etc.

**Business Data Sources**
- Dun & Bradstreet
- Government Statistics
- LinkedIn
- Company Websites
- Market Reports

**Firm-Level Nano Datasets**
- Web-Based Directories
  - Nanowerk, NSTI, NanoVIP, InterNano
- Research Projects, Reports & Journal Articles
  - Woodrow Wilson Center, CADTSC, Lux
- Conference Attendees & Presenters

**R&D Datasets**
- Publications & Patents
- Funding Sources
  - Government & Private
Strategy 1: Initial Results

- **Firms & Organizations**
  - Locations: 2,125
  - Employment:
    - Total: 446,900
    - Share (10-50%): 52,200-224,200

- **Shortcomings/Findings:**
  - Employment at nano-specific companies low (~2% overall)
  - Top five states (CA, MA, NY, TX & PA): ~50% of U.S. firm locations and total employment

- **Firms->Classification Codes: top three NAICS codes at three-digit level: 60% of all firms**
  - Computer & Electronic Product Mfg. (NAICS 334): 23%
  - Professional, Scientific & Technical Services (NAICS 541): 23%
  - Chemical Mfg. (NAICS 325): 15%

- **Next Steps**
  - Refine focus areas using subsequent strategies & primary research
  - Primary data; focus on states with largest shares of firms/workers
  - Long term: produce data useful for classification development; potential micro-data project
Strategy 2: Workers->Firms

- Companies and people can select “nanotechnology” as industry on LinkedIn
- People:
  - Global: 105,390
  - USA: 24,800
  - California: 5,060
- Companies
  - Global: 1,353
  - USA: 389
  - California: 77

- Shortcomings/Findings:
  - Likely underrepresents manufacturing
  - “Noise” – fake profiles
  - Benefit of being self-reported

- Next Steps
  - Collect data on occupations
  - Identify shares of nano employees at firms to help refine focused employment estimates
  - Add new companies to track

People & companies selecting “nanotechnology” as their industry on LinkedIn : October 16, 2013
Strategy 3: Education->Workers->Firms
Identifying potential “supply” (in-progress)

- Identified U.S. education nano-related programs
  - Community college & universities: 88 programs
    - 50 degree programs & 38 minors/concentrations
- Identify students engaging in nano-related research
  - Search U.S. dissertations for nano-related terms
    - 1997-2009: 4,800 people

- Next Steps
  - Survey of programs to get number of graduates
  - Update dissertation data through 2012
  - Track students into the workforce

U.S. Nano Workforce Estimates (2010-13)

United States: Existing Estimate (2010)\(^+\): 220,000

Preliminary estimates based on presented methods:

1) **Upper**: (all locations, all employees): 446,900
   - Focused (~50%): 224,200
   - Focused (~25%): 116,700
   - Focused (~10%): 52,200

2) **Lower** (LinkedIn): 24,800

3) Potential “supply”: 4,800 + graduates (TBD)
   - Focus so far has primarily been on methodology and database development
   - Numbers represent people potentially employed due to nanotechnology; not the number of people that will come into contact with nanomaterials

Application of Data for EHS

Frederick (2013); based on data from California in the Nano Economy.
California in the Nano Economy
www.CaliforniaNanoEconomy.org

- Industry and education-focused website for the nano community
- Presents California's footprint in nanotechnology
- Interactive, web-based application of a value chain research approach

Main Areas
- Firms & Products
- Value Chain Mapping
- Education and Workforce Development Programs
- Public Policy and Economic Development Initiatives

Center on Globalization, Governance, & Competitiveness (CGGC) at Duke University
Center for Nanotechnology in Society at UC-Santa Barbara
Value Chain Section

Educational

- Interactive value chain diagram
- Hover cursor over boxes for description & stats
- Click boxes for detailed info
  - Forward & backward linkages
  - Important global firms & organizations
  - Manufacturing methods
  - California locations
Firm & Organization Data

- **Location Pages** (Fig. 1)
  - Physical Location & Basic Info
  - Value Chain Mapping
  - Products
- **Profile Pages**: 100+ more-detailed profiles of firms & organizations
  - Company Overview
  - Buyers, Suppliers & Strategic Partners
  - Innovation & Technology

**Fig. 1**: Example Location Page on California in the Nano Economy Website

**Fig. 2**: Interactive Geographic Maps of Nano-Related Firms & Organizations

- **Maps**: interactive, geographic maps of locations by key variables (Fig. 2)
Summary

• Ability to measure and track impacts of nano (environment, social, economic) depends on ability to identify key actors: firms, workers & geography
  • Same data central to research questions from various groups; different terms, same fundamental ideas
• Complex process for nano but enough data exists to begin the process
• Focus of this research is to begin to put the necessary pieces together and make information available for multiple uses
Thank you!

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