Lessons from the USA’s Experience with its Advanced Manufacturing Institutes

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Part I – The Problem:

• Drawing from studies -- What is the US manufacturing problem?
The Problems Facing US Manufacturing – 4 Findings - Finding #1: Signal from Manufacturing Job Loss

- US lost - from 2000 to 2010 – one third of manufacturing jobs
  - **Manufacturing output** in decline in 16 of 19 sectors
    - output only recovered to 2000 levels in 2018
  - **US productivity low:**
    - 1995-2005: 2.5%
    - 2005-2015: 1% range – historic low
  - **Capital, plant, equipment, IT investment – low**
  - **Major trade deficit:** now $900b in mfg. goods; in adv’d mfg. tech’s, jumped from $130B to $191B in 2019 from 2020

- Job loss data: signal that US manufacturing was hollowing out and facing international competition – **Decline in productivity levels:** signal of innovation gap
US Manufacturing Productivity Lags Behind Competitor Nations

Manufacturing Productivity over Time

Value Added Per Employee, Index (2010=100)

Year

[From: Ben Armstrong, MIT 2/21]
Small and Mid-Sized Mfg. Firms Lag in Productivity:

From: Ben Armstrong, MIT 2/21]
Productivity-related Capital Investments Stagnate at Small Mfg. Firms:

Capital Expenditures per Employee over Time

From: Ben Armstrong, MIT 2/21
Nos. of New Entrepreneurial Firms in Decline in Manufacturing:

Share of Young Firms by Industry over Time

From: Ben Armstrong, MIT 2/21]
Finding #2: Production must be seen as part of the Innovation System

- Manufacturing not pictured in the US as part of the innovation process
  - US focus is on only R&D: fragmented view
  - Innovation is a system, from early-stage research through manufacturing
- Treat production as critical element that must be connected to innovation system
  - Or risk innovation erosion
Finding #3: The Tie between Innovation and Production

• US had: **innovate here/produce here** – got full spectrum of gains
• Then US did: **innovate here/produce there**
• But - for most products need to tie innovation closely to initial production
  • Need dense feedback loops as you do product design- initial production requires **very creative** engineering and design – it’s part of innovation
  • So if you shift production capability, in many cases innovation capability has to follow it
  • Result: **Produce there = Innovate there**
• **Innovation is U.S. strong suit** – what it does best
• But if many important innovations have to follow production, endangers US core innovation strength – **creates system gap**
• And **Innovation is the key growth factor**
Finding #4: Lessons from Germany – Illustrate U.S. System Gaps

• US thought that it had to lose manufacturing jobs to low cost producers in Asia because it was high wage.
• But Germany is high wage and high cost – German wages and benefits are 60% higher than the U.S.
• Germany runs a major manufacturing surplus, including a manufacturing surplus with Asian nations
• Germany has a deep ecosystem for their manufacturers, small and large – they aren’t “home alone” – shows U.S. gap
• Extensive collaborative R&D shared by industry- gov’t- universities around manufacturing technologies and processes – Fraunhofer Institutes
• Shared training system for their workforce – shows U.S. gap
• Ways to link their supply chains for rapid scale up
• Some German practices don’t apply, some do
Gaps in the U.S. Production Innovation System = Capabilities Problem

• **Signals of Gaps in Innovation System:**
  • productivity low,
  • supporting ecosystem weak,
  • scale up problem,
  • delinked innovation and production,
  • weak workforce training
  • = Social Disruption

• Way out? **Apply innovation system model?**
• Core idea: Create new capabilities around **system innovation**
• **This is not the linear innovation model anymore** – it goes beyond research to production stages
And Manufacturing Decline = Social Disruption

• Between 2000 and 2010, U.S. manufacturing employment fell by 5.8 million jobs – 1/3

• Manufacturing – historically important middle class pathway for the high school educated – that was hit hard

• Median income of men with high school educations or less fell by 20% between 1990 and 2013.

• Growing income split between college and non-college educated
Behind it all:
Understanding the Hourglass --

<---- Resources, Suppliers, Components, R&D

<---- Production (12m jobs)

<---- Distribution, Sales, Life Cycle

AND: Value Chains run throughout
Part II – the Remedy

• Apply the Innovation System to the Problem
• Fill System Gaps, build new capabilities at the national and regional levels
• i.e., “Advanced Manufacturing”
Idea: Scientists/Engineers Say There Are: New Manufacturing Paradigms

There new advanced manufacturing “Paradigms” –

• **Idea:** raise efficiency, compete with lower cost economies; could lead to restoration of mfg. leadership? – And **innovation is its own reward**, creates new opportunities -- some examples:

• “Network centric”/Digital Production/ “Industry 4.0”

But also, non-IT technologies:

• Advanced materials
• Nanomanufacturing
• Mass Customization
• Distribution efficiency
• Specific Technologies: Photonics, Advanced Composites, Biofabrication, Power Electronics, etc.
New Model - Advanced Manufacturing

• **Advanced Manufacturing Partnership (AMP)** - idea:
  ▪ From industry-univ. collaboration – reports in 2012, 2014
  ▪ Need innovation-based efficiency gains to compete with low cost/low wage nations
  ▪ So: Apply innovation capabilities to manufacturing
  ▪ So: New Technologies/Processes/Business Models

• **Manufacturing innovation Institutes** - 16 set up
  ▪ Collaborative–industry/univ/gov’t – in a way, Sematech model
    ▪ Tech Dev. around potential new technology paradigms –
      ▪ 3D printing, digital production, robotics, photonics, advanced composites and materials, flexible electronics, cybersecurity, bio fabrication, power electronics, etc.
    ▪ Testbed role
    ▪ Workforce education role
    ▪ Cost shared between: federal gov’t/industry/state gov’t
Institutes: Addressing the “Scale-up” Gap

Focus is to address market failure of insufficient industry R&D in the “missing middle” or “industrial commons” to de-risk promising new technologies.
The Institute Design
Creating the space for Industry & Academia to collaborate

Note: Complex model: Like standing up a country
Advanced Manufacturing Institutes – now 16
Point: Manufacturing Innovation Institutes are the right model

• To improve manufacturing efficiency, need **private sector leadership**, (large co. leaders, with innovative new tech co’s and with SMMs who are tech adopters) with **education institutions** (research universities, community colleges), and **government** (federal, state and local economic development) – MIIs involve all three – via public/private partnerships

• **Need technology development** – need to develop the advanced manufacturing technologies in a series of areas – MIIs focus on this

BUT it’s not just the technology – need supporting infrastructure:

• **Need regional engagement** – have to bring technologies into regional manufacturing ecosystems – MIIs do this

• **Need workforce education** in the new technologies – it the workforce isn’t ready, the technologies will not be adopted - MIIs do this
Institute Case Study: Composites Manufacturing – Institute of Advanced Composites Manufacturing

Innovation

Opportunity:
Lightweight composites:
• **Major benefits to energy efficiency, renewable power generation – auto, aerospace, wind**
• Problem: overcome barriers to deployment
• How: advanced technologies to make composites
• Means lower cost, faster production, using less energy
• readily recycled

• **Big Idea:**
  • The Institute: world-class resources to partners
  • develop new low-cost, high-speed, and efficient manufacturing and recycling process technologies
  • promote widespread use of advanced fiber-reinforced polymer composites.

Focus on:
• **cut overall manufacturing costs of advanced composites by 50%**
• **reduce the energy used to make composites by 75 percent**
• **increase the ability to recycle composites by 95 percent**
• **In ten years**
**IACMI - Each Institute to create value for industry participation in return for cost-share funding**

- **Access to Shared RD&D Resources:** access to equipment, from lab to full-scale, to for demonstration -- reduce risk for industry investment

- **Applied R&D:** significant government, industry, and academic funding for innovative solutions to member challenges

- **Composites Virtual Factory:** access to end to end commercial modeling and simulation software for composite designers and manufacturers through a web based platform.

- **Workforce Training:** Provide specialized training to prepare current and future workforces for the latest manufacturing methods and technologies
IACMI - Strong Private-Public Partnership

*institute evaluations – Deloitte, NAS, GAO*

A partnership of world-class companies including:

- **Dow**
- **Ford**
- **GE**
- **BASF**
- **Dassault Systèmes**
- **Boeing**
- **Lockheed Martin**
- **Volkswagen**
- **DuPont**
- **Local Motors**

Top universities including:

- **The University of Tennessee**
- **UT Research Foundation**
- **Purdue University**
- **Vanderbilt University**
- **Colorado State University**
- **University of Louisville**
- **University of Kentucky**
- **Ohio State University**

Economic Development Council to leverage state support and investment

Collaboration of state development leaders: seeding economies worth $2 trillion.
It’s not just new manufacturing technologies...

Have to build regional infrastructure and workforce education to introduce advanced manufacturing
Critical Manufacturing Institute Role: Engage with Regional Ecosystems

- Manufacturing is like real estate – it’s local, it’s regional
- Manufacturing is owned by the private sector, not government
- Need collaborations – *industry, government, education institutions*
- And the *collaborations have to be imbedded in regions*
  - Alliances with local manufacturers, small and large
    - Want groups of employers not single companies
    - Single firms have ups and downs, groups are more sustainable
  - Tie to colleges, universities, secondary schools
  - Apprenticeships with co’s and these schools to break down “work/learn” barriers
  - Bring in local economic development
- All pilot programs have to work regionally – they can scale to other regions
Critical Manufacturing Institute Role: Workforce Training

• Germany: Fraunhofer Institutes have a “Fraunhofer Academy”

• It trains apprentices for “mittelstat” small and mid-sized as well as large firms in the advanced technologies that its Institutes are creating
  • learning by doing, classroom and workplace

• The Training is the ADVANCED MFG. TECHNOLOGY DISSEMINATION MODEL
  • The way advanced manufacturing technologies get into company plants –
  • Learning walks on two feet, not through plans
Workforce Education Lessons:

• Small manufacturers are slow to adopt new technologies –
  • They get into a “Catch-22” –
    • can’t bring in new technologies because they don’t have the trained workforce;
    • won’t train the workforce until they have the new technologies
  • SO: new equipment and new workforce programs have to be offered together
• “Technicians” aren’t enough, need “technologists”
  • Technicians are trained for a single machine/task – CNC, welding
  • Advanced Manufacturing requires systems thinking:
    • linking all the equipment across the factory floor,
    • analyzing all the data across the equipment to optimize flow,
    • Know-how in processes, systems, management
  • Engineers are still “upstairs” – do design not production
  • Need technologies who specialize in advanced production systems
Part III: Conclusion – Lessons Learned

• **CORE IDEA:** Apply Innovation to Manufacturing for new production technologies

• **Create Advanced Manufacturing Institutes**
  • Why: Need to boost efficiencies and productivity to compete
  • Collaboration with industry, univ’s, gov’t

• **But that’s not all** –

• *Need an Innovation Systems approach*

• This means **new supporting infrastructure** for the new technologies:
  • Build **regional ecosystems**
  • Strengthen **workforce education**