The Future of Work in a Digital Environment

Purdue Spring 2019 Digital Enterprise Symposium

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About ITIF

- The world's leading science and technology policy think tank.
- Supports policies driving global, innovation-based economic growth.
- Focuses on a host of issues at the intersection of technology innovation and public policy across several sectors:
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 - IT and data
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ITIF Mfg. Reports





A Policymaker's Guide to Smart Manufacturing



Why Manufacturing Digitalization Matters and How Countries Are Supporting It BY STEPHEN EZELL | APRIL 2018

The digitalization of manufacturing is changing how products are designed, fabricated. used, and serviced, just as it's transforming the operations, processes, and energy footprint of factories and supply chains.

This report explains how digitalization is transforming manufacturing globally, detailing what exactly smart manufacturing (or "Industry 4.0") is and examining the productivity impacts that digitalized manufacturing promises to deliver. The report examines the small- to medium-sized enterprise (SME) manufacturing support programs and policies of ten nations—Argentina, Australia, Austria, Canada, China, Germany, Japan, Korea, the United Kingdom, and the United States—and provides insights countries can leverage to support the digitalization of their manufacturers. The report further examines how the development of common standards can facilitate technology adoption and proposes a typology that helps conceptualize different manufacturing production systems and strategies, showing how these need to be supported by

The Digitalization of Modern Manufacturing

Whether it's called "Industry 4.0," as in Europe, the "Industrial Internet of Things (IIoT)," as in the United States, or just "smart manufacturing," the application of information and communication technology (ICT) to every facet of manufacturing is in the midst of reshaping modern manufacturing. This digitalization of manufacturing is changing how products are designed, fabricated, used, operated, and serviced post-sale, just as it's transforming the operations, processes, and energy footprint of factories and the management of manufacturing supply chains. This convergence of digital technologies with manufacturing industries also promises to recast the landscape of global



Ten Principles to Guide the Trump Administration's Manufacturing Strategy

BY ROBERT D. ATKINSON AND STEPHEN EZELL | JANUARY 2017

ing should be clear in the wake of the election, it is that President s serious about growing U.S. manufacturing. But while he has sed the economic news with his comments warning companies shoring jobs and his involvement in the deal that led Carrier to out 800 manufacturing jobs that were previously headed to s words and actions have largely elicited derision from amentators and analysts. Their dismissive responses have om "this is totally trivial" to "it will never work, ""picking aly reduces economic welfare," and "we shouldn't care about ing, anyway." Emblematic of this widespread pundit opinion esident's pronouncements have been nonsense, or worse, hool professor Stephen Kobrin writes, "What happens when ze they've been taken?" In other words, the consensus s is that the president is pulling a fast one on ignorant and

as provided little substantive guidance for the incoming administ ical and effective U.S. manufacturing strategy should look like. On one in't be surprising: the Washington establishment and the broader godasical economias have no real idea what to do other than fall back on s measures such as reforming the tax code, training workers, and building Beture. Nor do they even offer an analysis of what has happened to U.S.

NOLOGY & INNOVATION FOUNDATION 1 JANUARY 2017

Manufacturing Digitalization: Extent of Adoption and Recommendations for Increasing Penetration in Korea and the U.S.

BY STEPHEN J. EZELL, ROBERT D. ATKINSON, DR. INCHUL KIM, AND JEAHAN CHO I AUGUST 2018

Whether it's called "Industry 4.0," as in Europe, the "Industrial Internet of Things (IIoT)," as in the United States, or simply "smart manufacturing," information and communication technology (ICT) is in the midst of reshaping modern manufacturing. This digitalization of manufacturing will transform virtually every facet of modern manufacturing, from how products are researched, designed, fabricated and produced, distributed, and consumed to how manufacturing supply chains integrate and factory floors operate.² But it's still early days in the smart manufacturing revolution: for instance, 77 percent of small U.S. manufacturers still lack plans to implement Internet of Things applications over the next three years. This report examines the extent of smart manufacturing adoption by U.S. manufacturers and offers policy recommendations to increase smart manufacturing penetration in the United States, Korea, and beyond.

Smart manufacturing enables manufacturers to converge the physical and digital wo combining sophisticated hardware with innovative software, sensors, connectivity, communing suprimitation instrument, with information and analytics to produce smarter products, more efficient massive amounts of data and analytics to produce smarter products, more efficient processes, and more closely linked customers, suppliers, and manufacturers. 3 The digitalization of modern manufacturing holds the potential not only to restore on manufacturing productivity growth, but also to reshape the landscape of global manufacturing, bolstering the competitiveness of the most innovative and most to technology-adopting companies while croding the advantage of enterprises—and it

INFORMATION TECHNOLOGY & INNOVATION FOUNDATION | AUGUST 2018

International Benchmarking of Countries' Policies and Programs Supporting SME

Manufacturers

BY STEPHEN J. EZELL AND DR. ROBERT D. ATKINSON

SEPTEMBER 2011



Today's Presentation

- Digitalization Transforming Modern Economy & Manufacturing
- 2 Digital Content of U.S. Jobs Rising; But Digital Skills Lagging

3 Public/Private Approaches to Address the Digital Skills Challenge

What Is Digitalization?

Digitalization is the process of employing digital technology and data to transform business operations and create value.









Source: Mark Muro, "Get With The Program: Digitalizing America's Advanced Manufacturing Sector"

Increasingly Digitalized Global Economy

- Digital economy accounts for 25% of global GDP.
- 50% of all value created in the global economy will be created digitally over the next decade.
- Value of international data flows has surpassed value of international merchandise trade.
- Digital services account for 25% of inputs in U.S. manufacturing; 40% for autos.

Sources: Accenture. "Digital Disruption: The Growth Multiplier": McKinsey Global Institute. "Digital Globalization: The New Era of Global Flows"



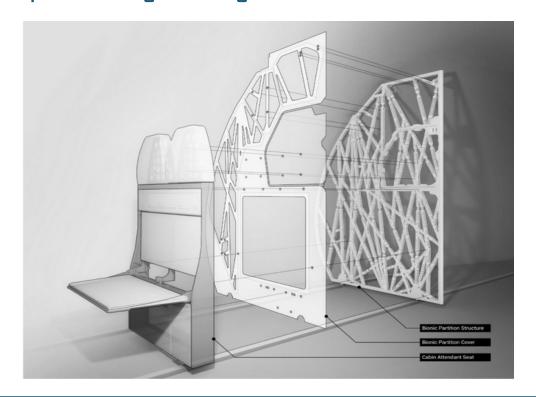
"Digitally Enabled" at Each Step of Modern Manufacturing

- 1. Product Design
- 2. Fabrication and Assembly
- 3. Factory Integration
- 4. Supply Chain Integration
- 5. Product Use and Consumption



Product Design

 Todays' CAD software leverages generative design techniques to herald a new era of how products get designed.





Fabrication and Assembly: 3D Printing & Robotics

 3D printing expected to impact up to 42% of production in U.S. aerospace, automotive, and medical devices sectors.



 Human-robot interactions in automotive plants are 85% more productive than either humans or robots working on their own.



- "We're moving away from trying to maximize automation, with people taking a bigger part in industrial processes again."
 - Markus Schaefer, Head of Global Production Planning, Mercedes

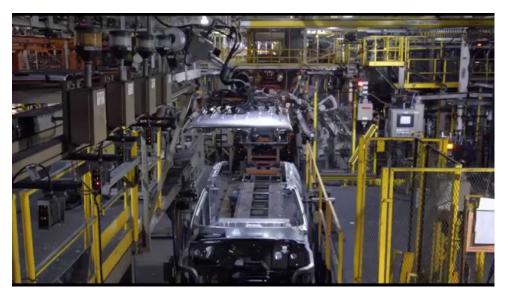


Markus Schaefer

Factory Integration

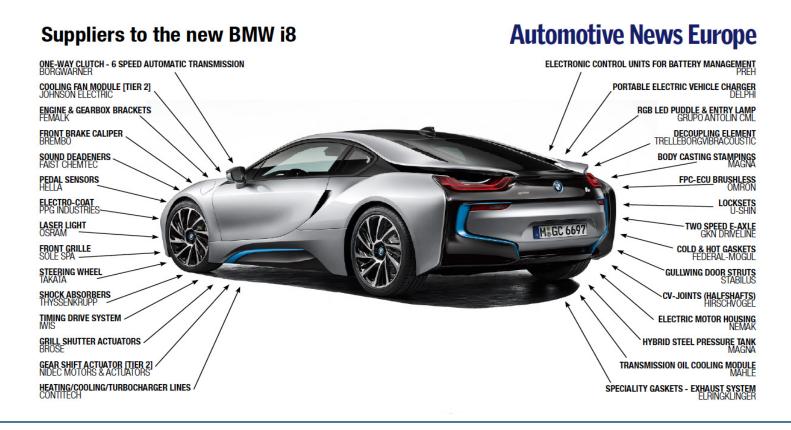
 Sensor-enabling equipment generates a comprehensive, real-time view of the status of machines, work cells, and systems.





Supply Chain Management

Real-time visibility into every machine making every component across supply chains.







Digitally Enabled Product Use and Consumption

• "Product servicification": Selling products as services.

E.g., Rolls Royce's "Power by the Hour" model.









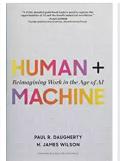
Reimagining Workflows to Leverage Humans & Machines

- StitchFix shows how to combine AI with people to create a powerful new business model.
- Delivers personalized clothing based on recommendations co-generated by human stylist and machine learning.
- Structured data (i.e., measurements/surveys) by machines; unstructured data (i.e., Pinterest posts/customers' notes) by stylists.











Sources: Paul Daugherty and James Wilson, "Human + Machine; Reimagining Wok in the Age of Al"; Fast Company, "The 50 Most Innovative Companies of 2019"

Implications for Companies' Digital Transformations

- Digitalization has become a central source of value creation; IT can't be managed as a "cost center" of the business.
- It's not about applying digital to existing processes; it's about using digital to *fundamentally* reimagine existing business processes.
- Companies need formal strategies to get the digital skills they need into their business, and to become "data mature."
- Smart companies build digital platforms allowing partners to make money alongside them.

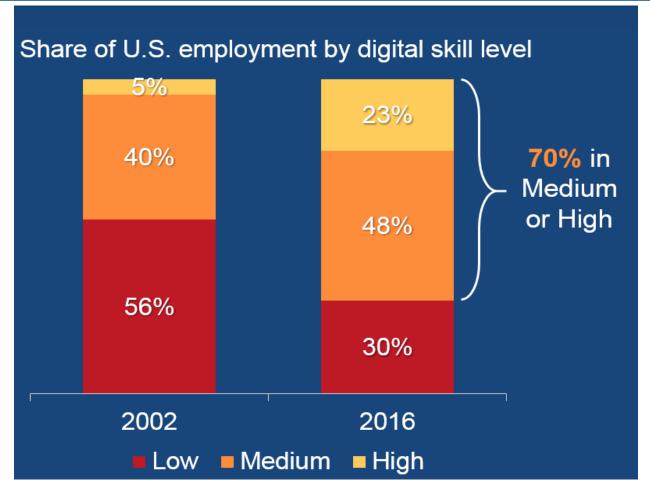
Policy Implications to Spur U.S. Manufacturing Digitalization

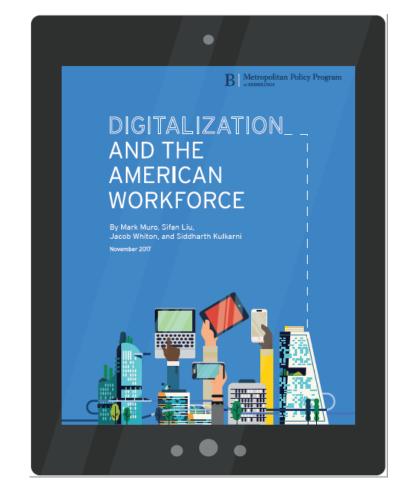
- 1. Expand MEP's use of its "Digital Manufacturing and Design" assessment tool to benchmark SME mfg. digitalization journeys.
- Launch a "National Manufacturing Digitalization Fund."
- 3. Introduce more generous incentives to encourage mfg. digitalization: innovation vouchers; "401Ks" for SME manufacturers.
- 4. Assist the private sector in solving the digital skills challenge.

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Digital Skills Content of U.S. Employment Rising Rapidly

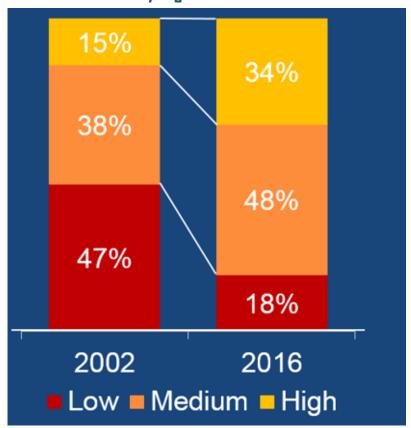




Sources: Mark Muro, Sifan Liu, Jacob Whiton, and Siddharth Kulkarni, Brookings Metropolitan Policy Program, "Digitalization and the American Workforce"

Including for Jobs in Advanced Manufacturing

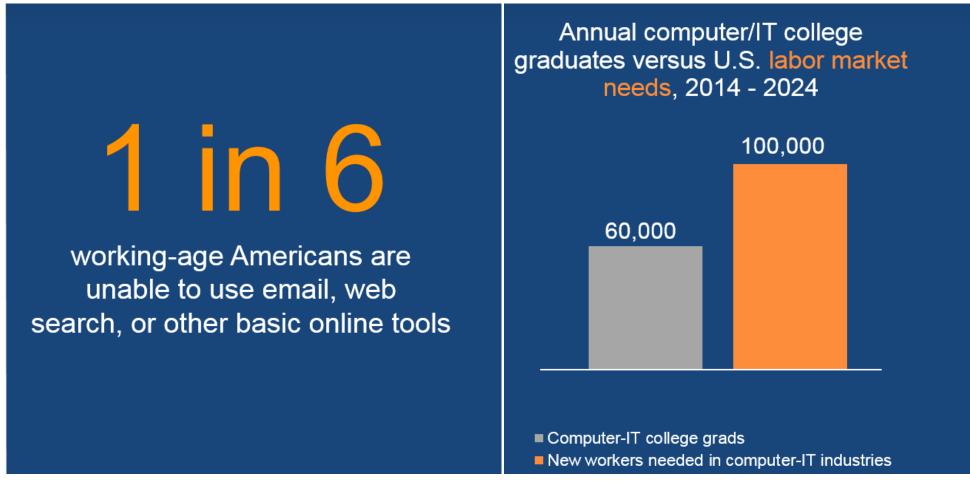
Employment in Advanced Manufacturing by Digital Skill Level



"82% of U.S. manufacturing jobs require a medium to high digital skill level today."

Source: Mark Muro, Sifan Liu, Jacob Whiton, and Siddharth Kulkarni, Brookings Metropolitan Policy Program, "Digitalization and the American Workforce"

Yet U.S. Workforce Faces Critical Digital Skills Gaps



Sources: Mark Muro, Brookings Metropolitan Policy Program "Get With the Program: Digitalizing America's Advanced Manufacturing Sector"; DECD; U.S. Bureau of Labor Statistics, 2016

U.S. Manufacturing Workforce Digital Skills Deficiencies



Skills in which manufacturing employees are most deficient



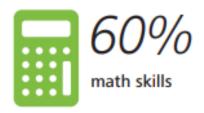
70% technology/ computer skills



69% problem solving skills



67% basic technical training



- 80% of U.S. manufacturing workers lack key digital skills.
- Mfg. skills gap may leave 2.4 million positions unfilled between by 2028; a potential economic loss of \$2.5 trillion.



Sources: Deloitte and The Manufacturing Institute, "The Skills Gap in U.S. Manufacturing 2015 and Beyond"; "2018 Skills Gap in Manufacturing Study";

Edy Liongosari et al., "Smart Production: Finding a Way Forward: How Manufacturers Can Make the Most of the Industrial Internet of Things"

Leaving Companies' Digital Transformations Stillborn



Companies are making meaningful investments and commitments...

In 2017, companies will spend \$1.7 trillion on digital transformation technology alone.

96% of organizations see digital transformation as critical or important.

42% of executives say "digital first" or "digital to the core" is now their company digital business posture.

...but feel like they're struggling.

75% of organizations are "not very confident" in their ability to execute a digital transformation.

84% of executives believe that their organizations do not have the skills and capabilities to deliver on its digital ambition.

59% of companies are worried that the laggard pace of their digital transformation efforts is causing them to lose ground competitively.



The roadblock? People.

63% of executives believe their digital transformation efforts are stalled because of difficulties in "changing company culture to be agile."

39% of executives see "resistance to new ways of working" as a primary challenge to digital transformation efforts.

One in five executives secretly believes digital transformation projects are a waste of time.

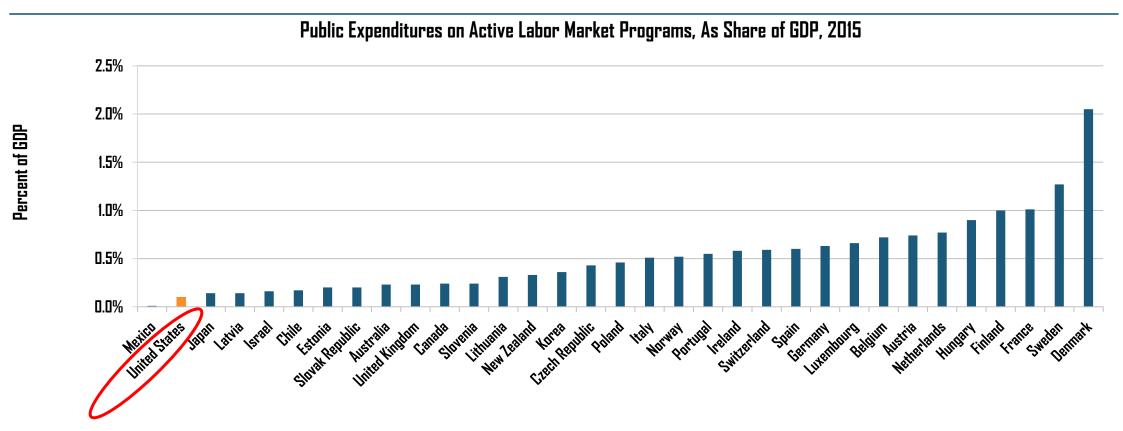
Source: Korn Ferry, "Digital Talent Strategy: The Organizational Structures and Roles of the Digital Future" (March 2018)

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U.S. Underinvesting in Labor Market Skills (Comparatively)



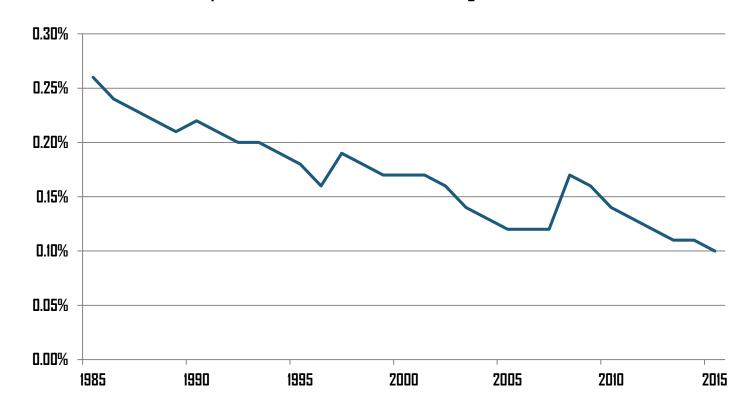
Source: OECD, "Public Expenditure and Participant Stocks on LMP"

U.S. Underinvesting in Labor Market Skills (Historically)

Percent of GDP

- Public investment in U.S.
 workforce training down
 50% as a share of GDP
 over past 30 years.
- Private investment has fallen 30% over last 10 years.

U.S. Public Expenditure on Active Labor Market Programs as Percent of GDP



Source: OECD, "Public Expenditure and Participant Stocks on LMP"



Workers Will Increasingly Need New Skills

"Double-deep" employees: Individuals who know both their job-be it accounting engineering, marketing, and so on-as well as the IT relevant to that job.



David Moschella, CSC Leading Edge Forum

"Employers want workers with *strong* analytical, creative, and adaptive capabilities."

"But the skills employers desire and demand are poorly related to competencies schools teach."



Manuel Trajetnberg, NRFR

Source: David Moschella: "Seeing Digital"; Manuel Trajtenberg, "Al as the Next GPT: A Political-Economy Perspective," Working Paper 24245, (2018, Nation Bureau of Economic Research)

"Industry 4.0" Demands "Education 4.0"



Apprenticeship

Up through the early 19th Century, Characterized by studying the Master, and focused on specific customer needs. Difficult to reproduce.



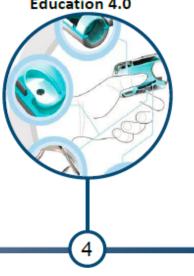
Manual Arts

Through the 19th and beginning of the 20th centuries. Focused on work and tools of the day. Discussion of a formal discipline began.





Education 4.0



Industrial Arts

Beginning to middle of the 20th centuries, Included a focus on breadth of topics to develop technological literacy, but clinging to its vocational roots. Focused on putting students to work.

Technology Education & the Designed World

Today. Characterized by national movements and formal curriculum standards. The design process and its use as a problem solving method is central.

Source: Nathan Hartman, Purdue University

Skills Requirements for a Digitalized Economy

- Built upon the old literacies of reading, writing and mathematics.
- New literacies include:
 - Data literacy: read, analyze and apply information
 - Technological literacy: coding and engineering principles
 - Human literacy: humanities, communication and design

Higher order mental skills – mindsets and ways of thinking about the world.

- Systems Thinking: the ability to view an enterprise, machine or subject holistically, making connections between different functions in an integrative way.
- Entrepreneurship: applies the creative mind to the economic and social sphere.
- Cultural Agility: how to operate deftly in a varied global environment.
- Critical Thinking: the habit of disciplined, rational analysis and judgement.

New Institutional Approaches to Education Needed

 Olin College of Engineering reimagined engineering education; hands-on, project-based learning; ½ students women/minorities.



On a per-student graduated basis, graduates launch more start -up businesses than even MIT students.





 LaunchCode, a nonprofit group of coding schools in St. Louis, helps firms needing "midtech" workers identify prospective employees and upskills them in no-cost coding bootcamps.



Public/Private Initiatives Tackling the Skills Challenge

Expand MOOCs, like SME's ToolingU



Provides 500+ online manufacturing technology classes.

 Leverage DMDII's "Digital Manufacturing and I Roles Taxonomy."

Identifies 165 distinct digital manufacturing ar roles.





Source: Digital Manufacturing and Design Innovation Institute (DMDII) and Manpower Group, "The Digital Workforce Succession in Manufacturing"

Federal-Level Skills Policy Recommendations

- Expand the Manufacturing Engineering Education Grant (MEEG) program.
- Expand use of industry-defined, nationally portable skills credentialing.
- Expand Section 127 tax benefits for employer-provided tuition assistance.
- Create "LILAs": Lifelong Learning Accounts.
- Establish a "knowledge tax credit."
- Enable students taking short-term courses for occupational credentials to qualify for Pell grants and other financial aid.

Source: Robert D. Atkinson, ITIF, "How to Reform Worker-Training and Adjustment Policies for an Era of Technological Change"



How to Reform Worker-Training and Adjustment Policies for an Era of Technological Change

BY ROBERT D. ATKINSON | FEBRUARY 201

Rather than slow down change to protect a small number of workers at the expense of the wast majority, policymakers should focus on doing significantly more to help workers transition easily into now jobs and new occupations.

There has been growing speculation that a coming wave of innovation—indeed, a tunuant—powered by antificial intelligence (AI) and robotics, will dampe take markets, generate must unemployment, and shift the few jobs that remain into the insecture "jog economy." Knoejeck "culturent" from und technology Casandrias include sleas lide taxting "robota" and implementing universal baset income for everyone, employed or not. The first woodd slow needed productivity growth, employed or not. The first woodd slow needed productivity growth, employed or not. The first woodd slow needed productivity growth, employed or not the second would reduce worker opportunity.

The truth is those unknowings will provide a departmently resided because is preductively as suggest, but that does not man to meet with leaving and support an advant in major consumit transition. But suffer that also does though to present a modest major consumit transition. But and the that also does though to surpose a modest angle containing the support of the support of

When it comes to labor market adjustment policies, most nations, including the United States, can and should do better. This report first discusses the recent and current views of

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Thank You!

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