McKinsey&Company

CalPERS Board of Administration Discussion

DIGITAL & INNOVATION IN ENGINEERING AND CONSTRUCTION

July 16th, 2018
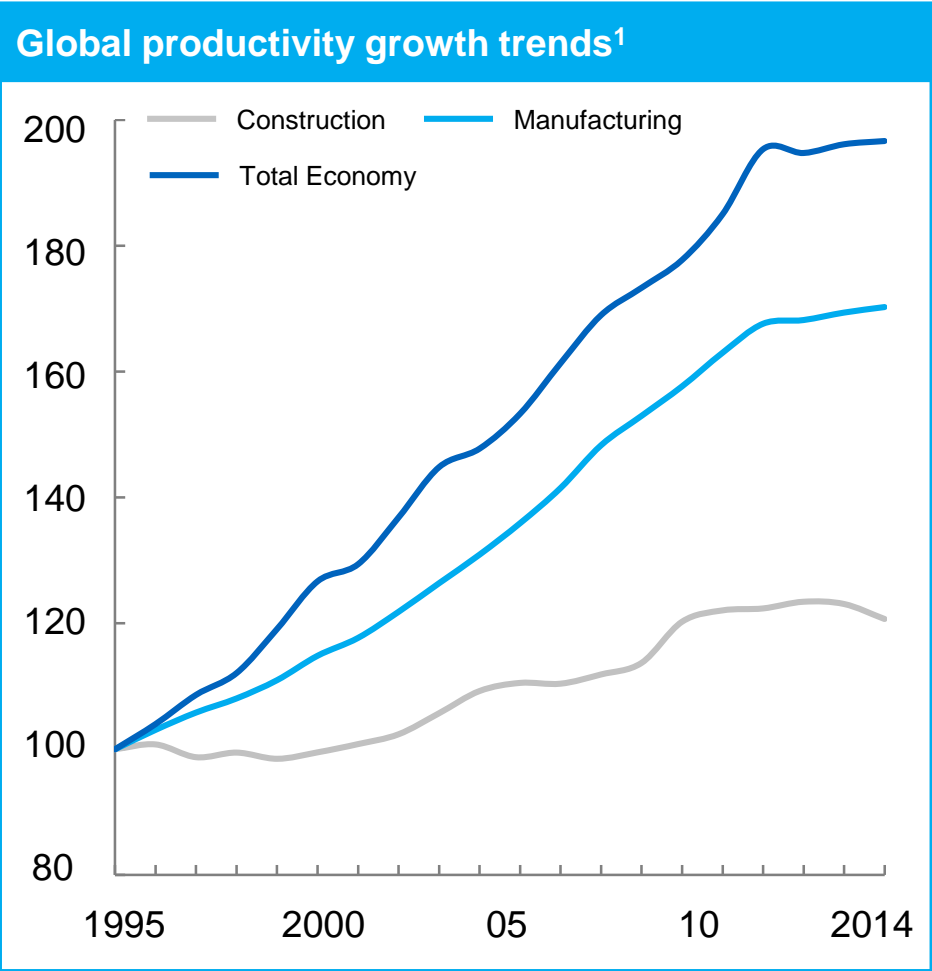
Opening thoughts

- **A major disruption** is occurring in the Capital Projects & Infrastructure industry

- **We believe that a 20-45% reduction in the cost of major development projects** is possible through emerging innovations; this is true across asset classes, e.g., energy, public infrastructure, real estate

- **In order to capitalize, greenfield Infrastructure Investors, must identify partners** who are leading in this area, as well as internal approaches to structure data & insights

- **What follows is a summary of the major digital trends** in the capital projects industry to help spur our discussion today

Lagging labor productivity has been a critical challenge for major projects and has led to disappointing project outcomes
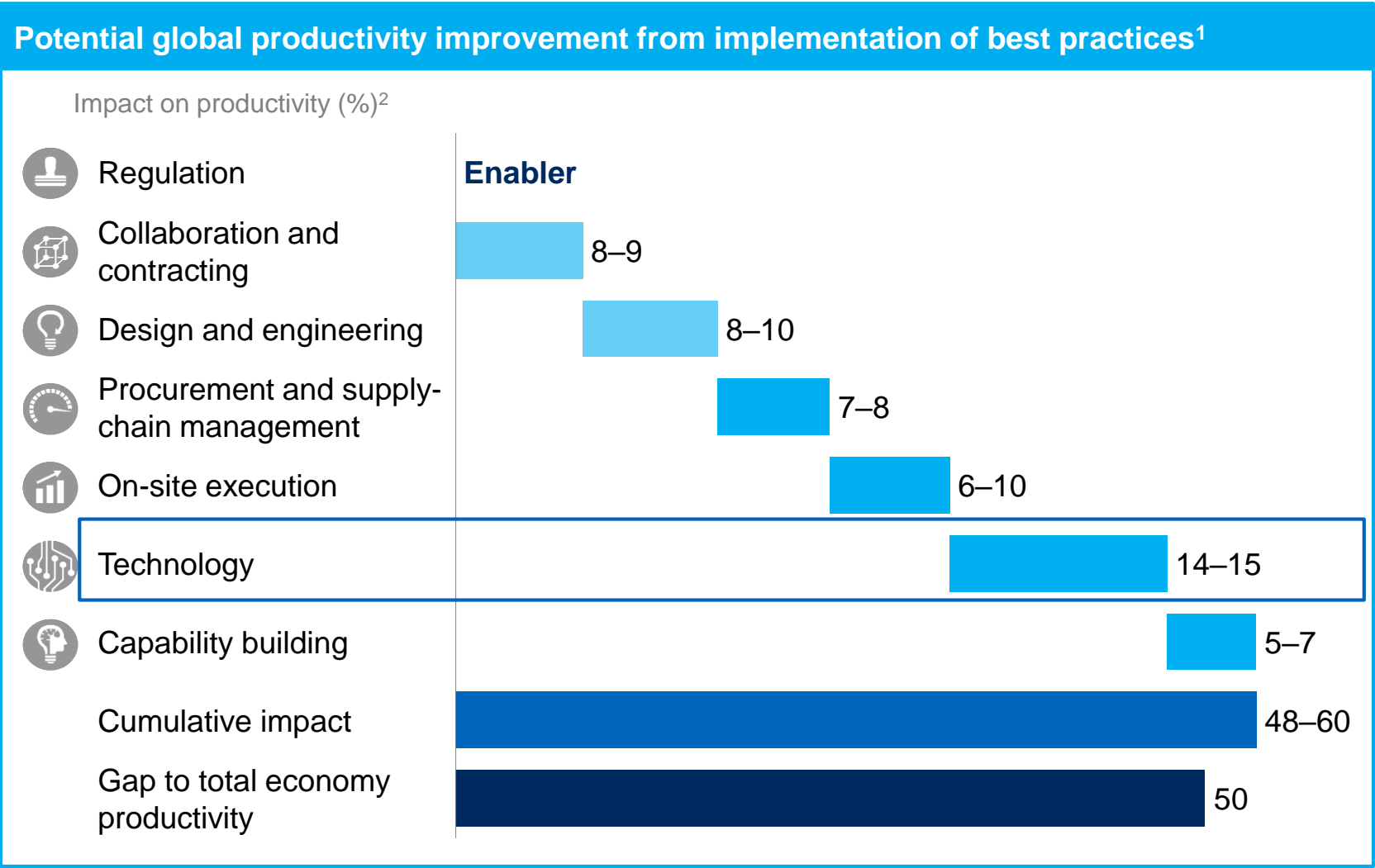
Global productivity growth trends[1]

Legend:
- Construction
- Manufacturing
- Total Economy

Y-axis: 80, 100, 120, 140, 160, 180, 200

X-axis: 1995, 2000, 05, 10, 2014

Recent major project performance

Average cost overrun	~80%
Average schedule overrun	20 months
Percent of projects over budget	98%+

Technology is the most promising avenue for productivity improvement…

Potential global productivity improvement from implementation of best practices[1]

Impact on productivity (%)[2]

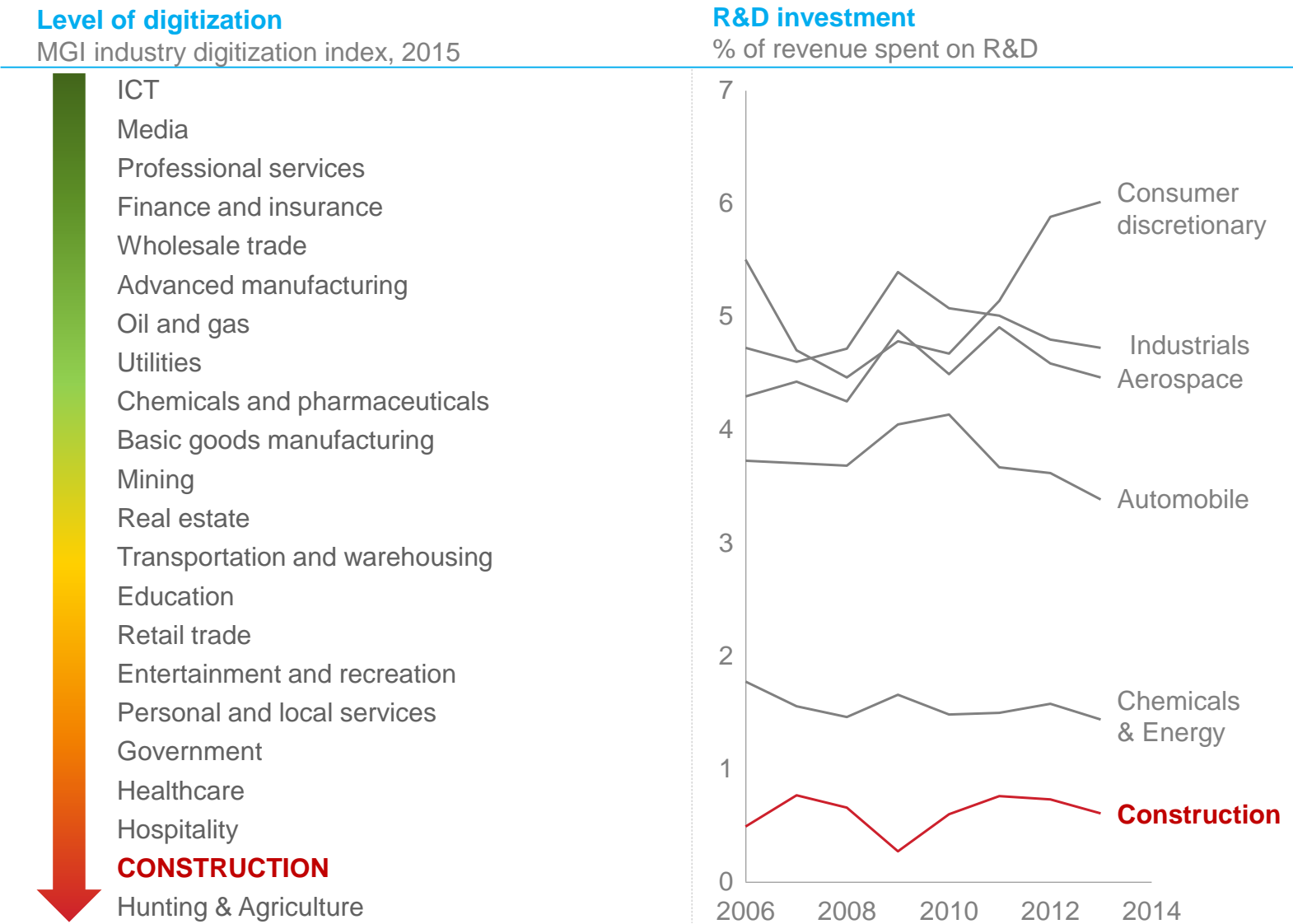|	
Regulation	**Enabler**
Collaboration and contracting	8–9
Design and engineering	8–10
Procurement and supply-chain management	7–8
On-site execution	6–10
Technology	14–15
Capability building	5–7
Cumulative impact	48–60
Gap to total economy productivity	50

1 The impact numbers have been scaled down from a best case project number to reflect current levels of adoption and applicability across projects, based on respondents to the MGI Construction Productivity Survey who responded "agree" or "strongly agree" to the questions around implementation of the solutions.
2 Range reflects expected difference in impact between emerging and developed markets.

… but engineering and construction has historically been one of the least digitized and lowest technology-focused industries in the world

Level of digitization
MGI industry digitization index, 2015

ICT
Media
Professional services
Finance and insurance
Wholesale trade
Advanced manufacturing
Oil and gas
Utilities
Chemicals and pharmaceuticals
Basic goods manufacturing
Mining
Real estate
Transportation and warehousing
Education
Retail trade
Entertainment and recreation
Personal and local services
Government
Healthcare
Hospitality
CONSTRUCTION
Hunting & Agriculture

R&D investment
% of revenue spent on R&D

Consumer discretionary
Industrials
Aerospace
Automobile
Chemicals & Energy
Construction

2006 2008 2010 2012 2014

Industry leaders are separating themselves by deploying new innovations that can lead to cost improvements of up to ~45%

Production systems

Software-enabled lean construction and supply chain management.

Capital portfolio management

Specialized software optimizes capital investment and portfolio management

LiDAR as built verification

Frequent LiDAR drone scans capture precise quantities and identify as built errors

Virtual reality

Operations staff review facilities and identify hazards during design or construction

3D printing

3D printing removes construction delays, reduces freight costs, and simplifies supply chain

Field

Office

Team

5D BIM and beyond

5D BIM is used to unify the 3D model with schedule and budget, adding clarity

Automated construction

Robots complete activities more productively, accurately and safely

Advanced analytics

Advanced analytics optimizes integration across teams and execution

Digital performance management

Project leadership assess performance, anticipate issues, and develop action plans
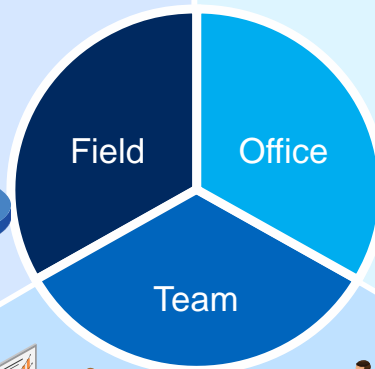
Advanced scanning and virtual reality have created multiple sources of value for capital projects
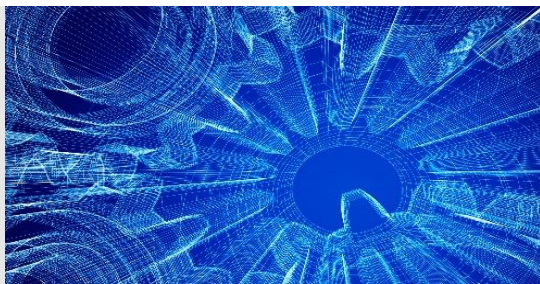
Survey and geolocation

- Drone and 3D-imaging technology create precise, millimeter-level site maps

3D modeling and virtual reality

- Virtual reality 3D modeling overlays site location to optimize site layout, prevent hazards, and remove clashes

As-built to as-designed validation

- Precise validation (i.e., mm level) of as-built configuration against 3D design models

SOURCE: Veerum

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Field automation drives productivity across three levers: labor availability, labor productivity, and rework avoidance

	Challenges	**Automation solution**
Labor Availability	▪ A **mismatch** between labor availability and project demands	▪ **Reduces demand** for front-line craft labor
Labor productivity	▪ Labor pool in the construction is increasingly **aging** and skills are not increasing	▪ Elimination of **low skill** tasks ▪ Enhancement of **high skill** tasks
Rework avoidance	▪ **Rework** has widespread negative impacts to project execution	▪ Mitigation or elimination of opportunity for **human error**

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Automation is being deployed in both predictable and ad-hoc physical tasks

Drones

Weld machines

Automated excavation

Vehicles

Brick laying

Automated timber construction

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Final thoughts

- **This is a rapidly changing landscape**…**but being able to get the digital basics right** will continue to be a large differentiator for major project outcomes in the next few years

- **Ultimately, the digital tools and innovations** we discussed today are just that – tools; organization and culture remain paramount to effective implementation

- Understanding the digital capabilities and innovation programs of contractors and project partners will be an increasingly **important value differentiator for greenfield infrastructure investments** in the years to-come