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REINVENTING CONSTRUCTION THROUGH A PRODUCTIVITY REVOLUTION

RICE E&C ROUNDTABLE

Houston | Sep. 8, 2017

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RESEARCH. INSIGHT. IMPACT.

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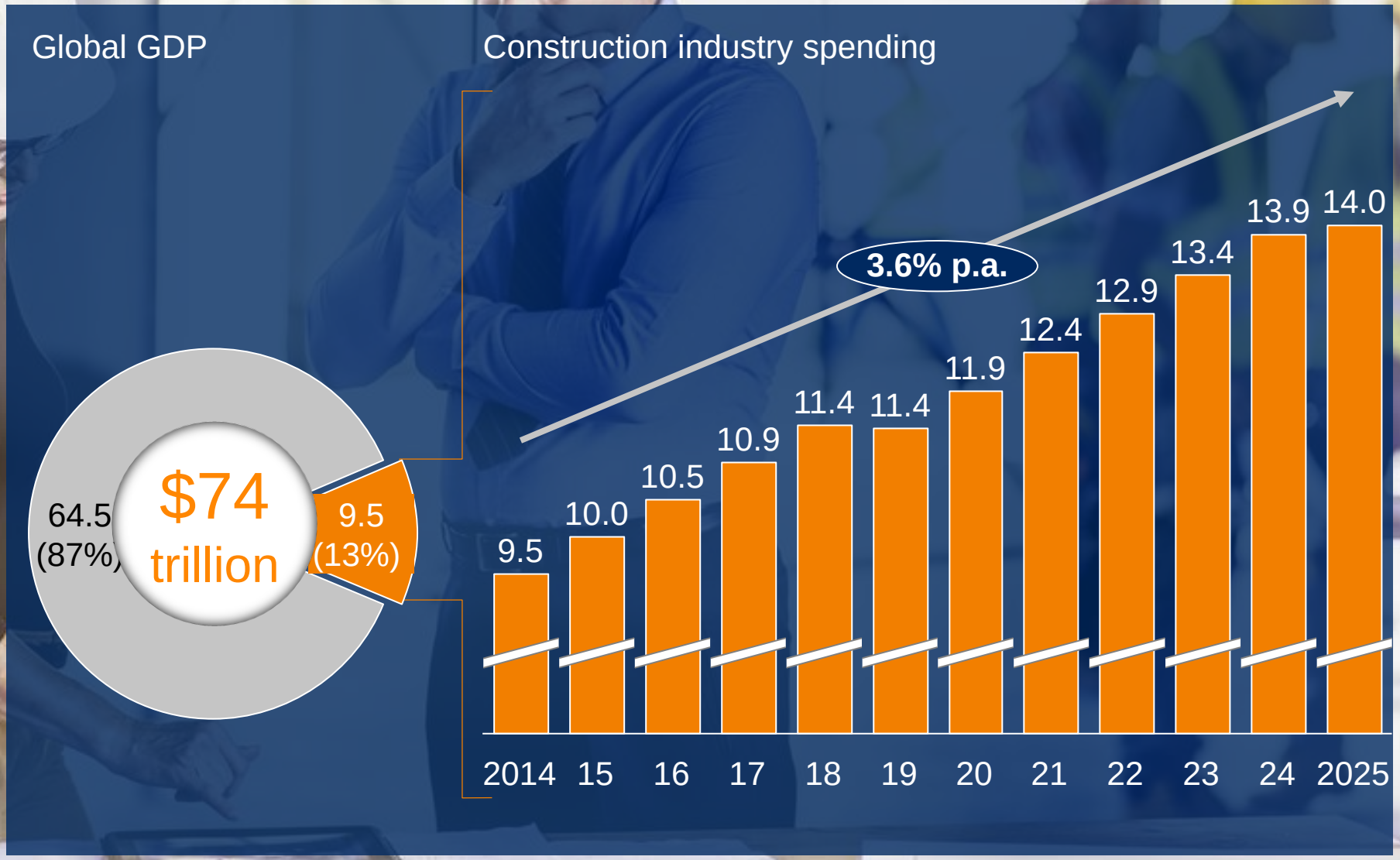
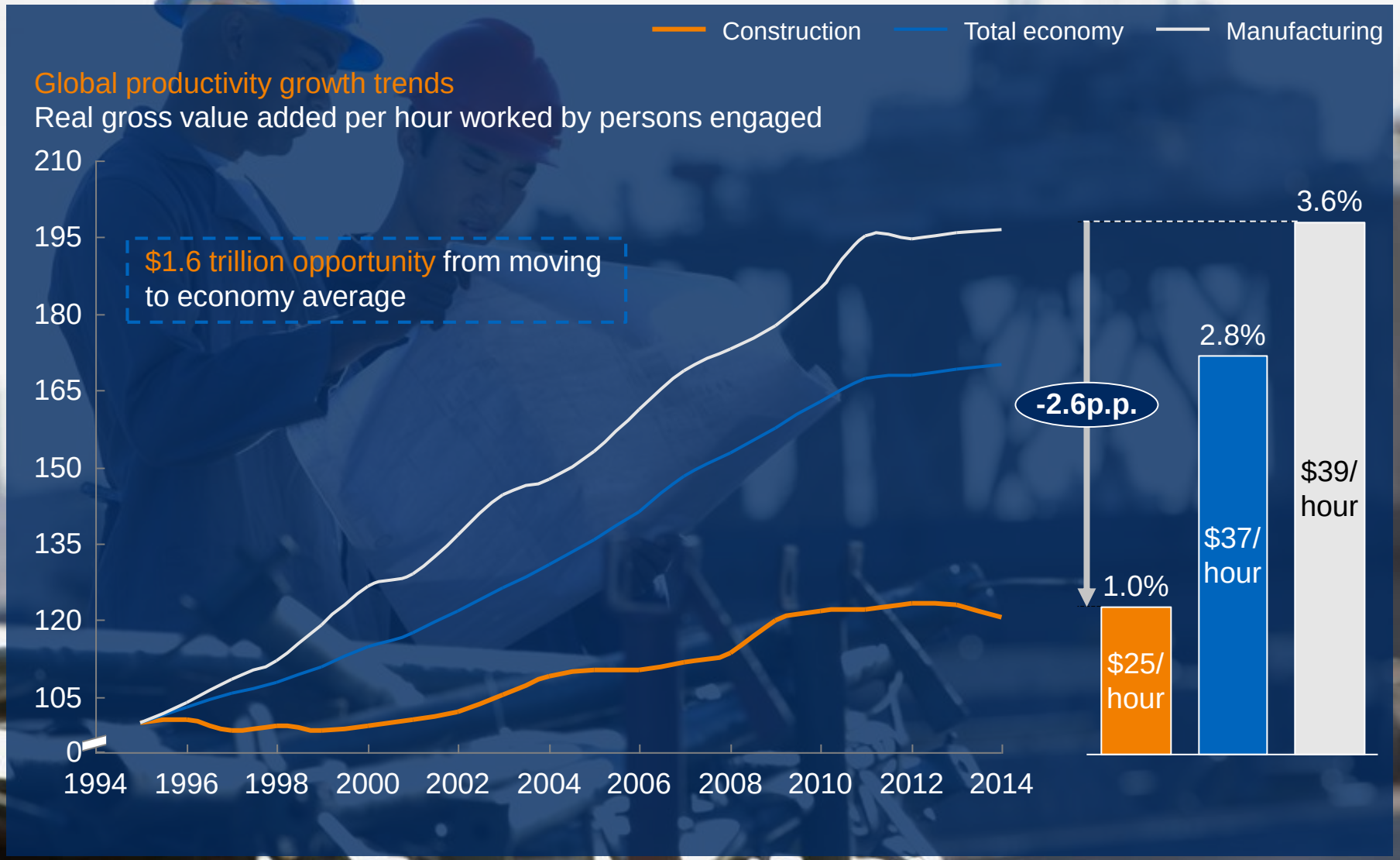
Construction matters: Construction related spending accounts for 13 percent of global GDP

$ trillion



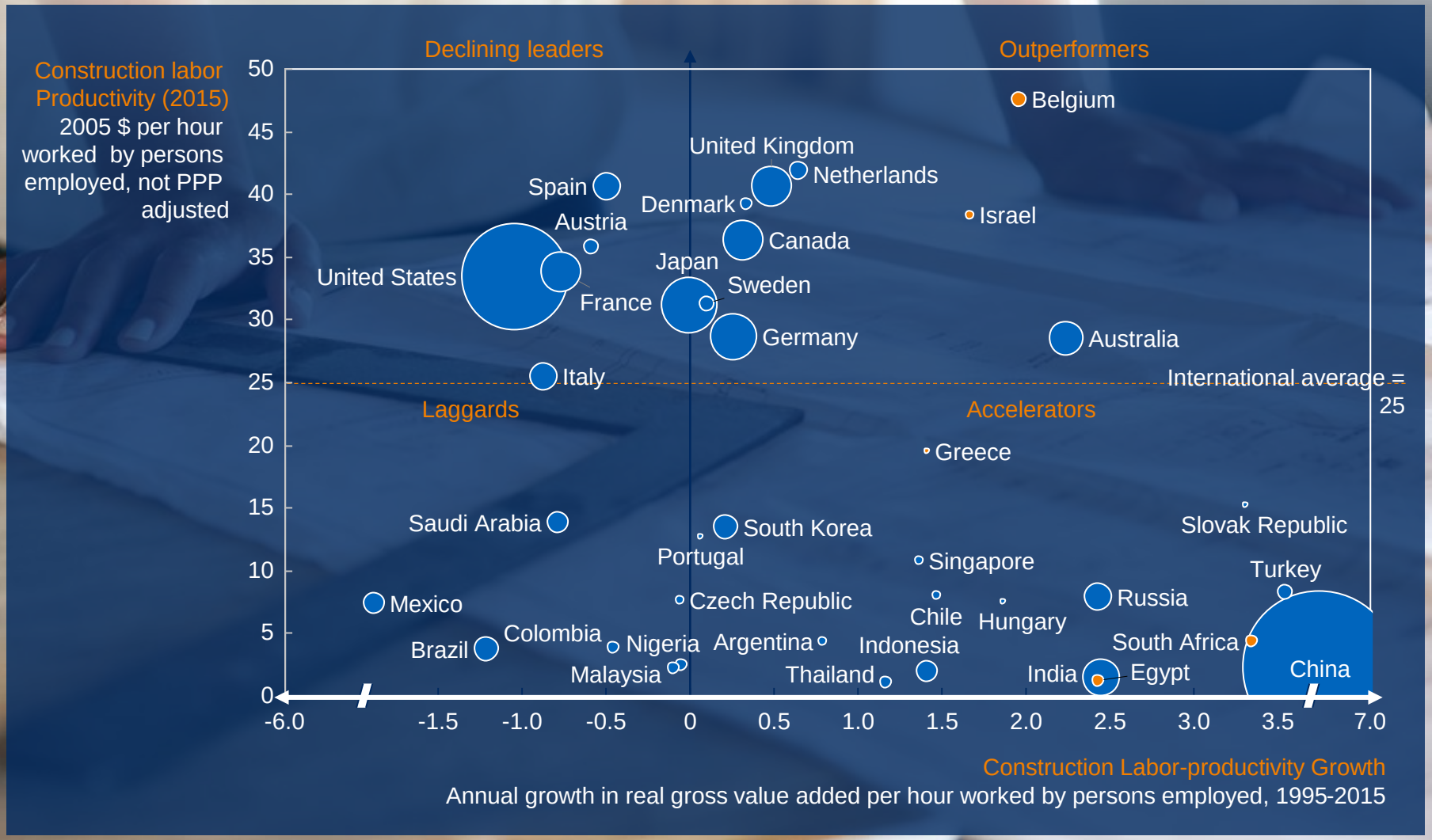
SOURCE: World Bank; IHS; ISSA

Globally, labor-productivity growth lags behind that of manufacturing and the total economy



SOURCE: OECD; World Input-Output Database (WIOD); GGCD-10; World Bank; US Bureau of Economic Analysis (BEA); US Bureau of Labor Statistics (BLS); Turkish National Statistics Bureau; Singapore National Statistics Agency; Malaysian Statistics Agency; Rosstat; McKinsey Global Institute analysis

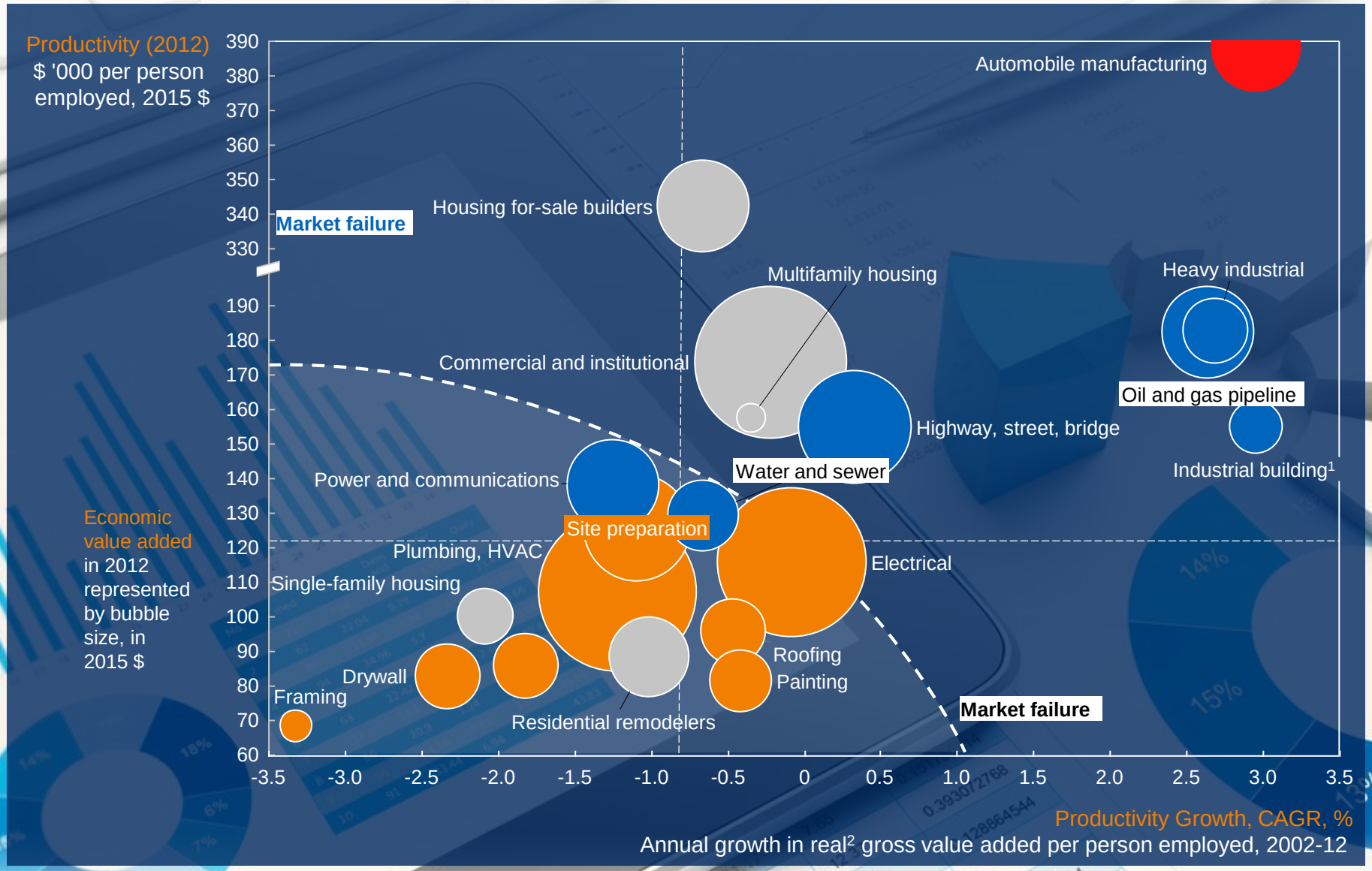
A small number of countries has achieved healthy productivity levels and growth rates



SOURCE: OECD Stat; EU KLEMS; Asia KLEMS; World KLEMS; KSA CDSI; KSA MoL; WIOD Socieoeconomic accounts, GGDC-10; Oanda; IHS; ITF; GWI; McKinsey Global Institute analysis

A sector of two halves

UNITED STATES EXAMPLE



1 Manufacturing plants and warehouses.

2 Using overall construction sector deflator for all sub-sectors

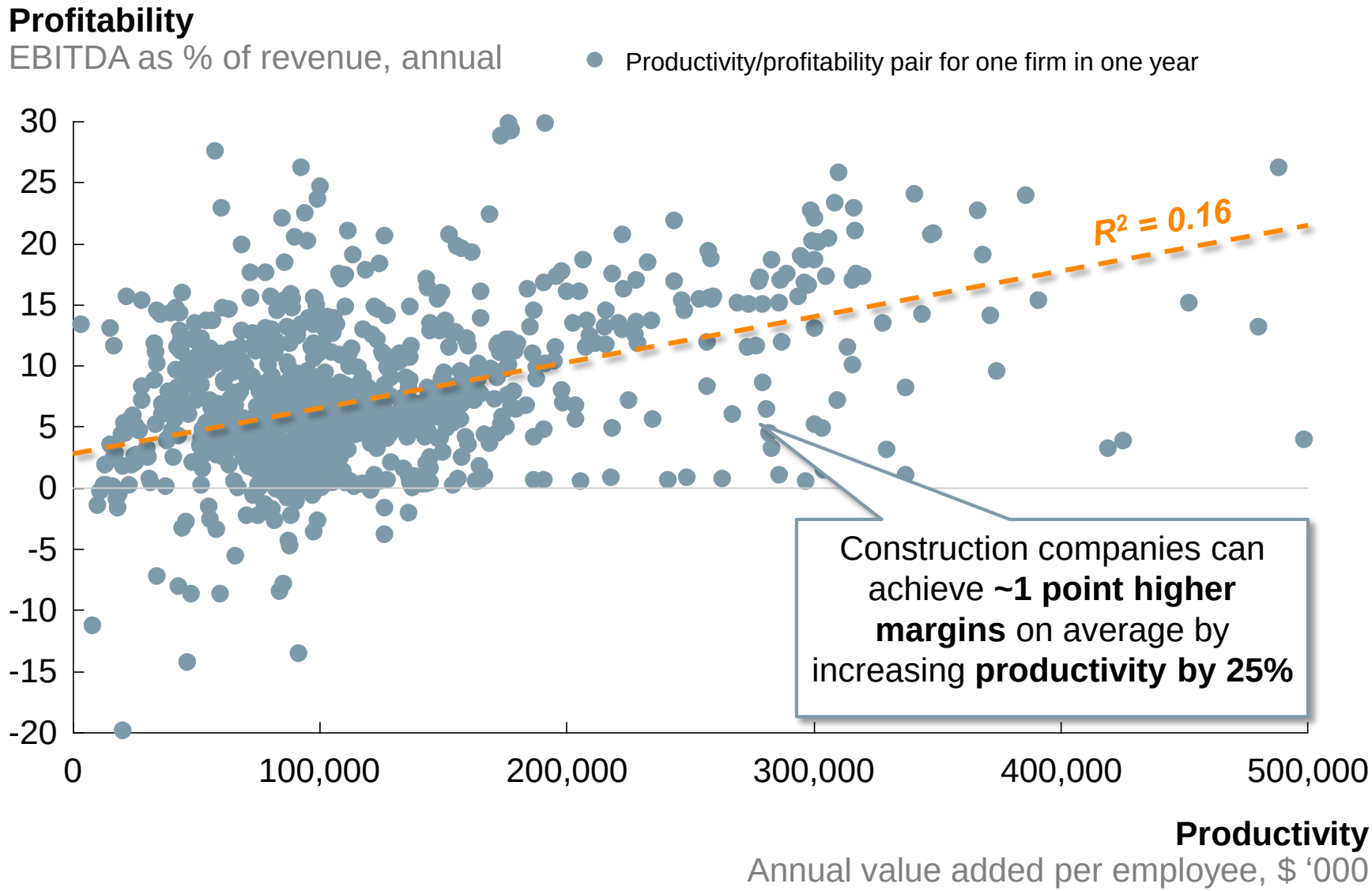
SOURCE: US Economic Census; McKinsey Global Institute analysis

Macro Factors that impact Productivity

- Increased size & complexity of mega-projects and project sites
- Complex & time-consuming regulations
- Dependence on public sector demand
- Cyclical nature of the construction business
- Increase in proportion of brownfield projects – could impact productivity ~-45% in some cases

SOURCE: Source

Some correlation between productivity and profitability: Productivity matters for the individual firm



SOURCE: Bureau van Djik, McKinsey Global Institute Analysis; 100 largest construction companies by revenue with publicly available data for FY 2005-2015

Aligned root cause Misaligned root cause

The 10 Root-causes of Poor Productivity – from McKinsey survey

	Root cause	Rankings (1 highest, 10 lowest) Overall	Contractor	Owner	Supplier
External Forces	Project and site complexities	4	3	4	3
	Regulation and cyclical public investment	8	8	8	7
	Informality and potential for corruption	10	10	10	8
Industry dynamics	**Misaligned contractual structures**	2	1	5	1
	Bespoke owner requirements	6	5	6	10
	Industry fragmentation	9	9	9	9
Firm-level operational factors	Inadequate Design processes	1	2	2	4
	Poor project execution basics	5	6	1	6
	Insufficiently skilled labor	3	4	3	5
	Underinvestment in digitization, innovation	7	7	7	2
Productivity impact					

NOTE: Number of respondents = 210

SOURCE: MGI Construction Productivity Insights Survey

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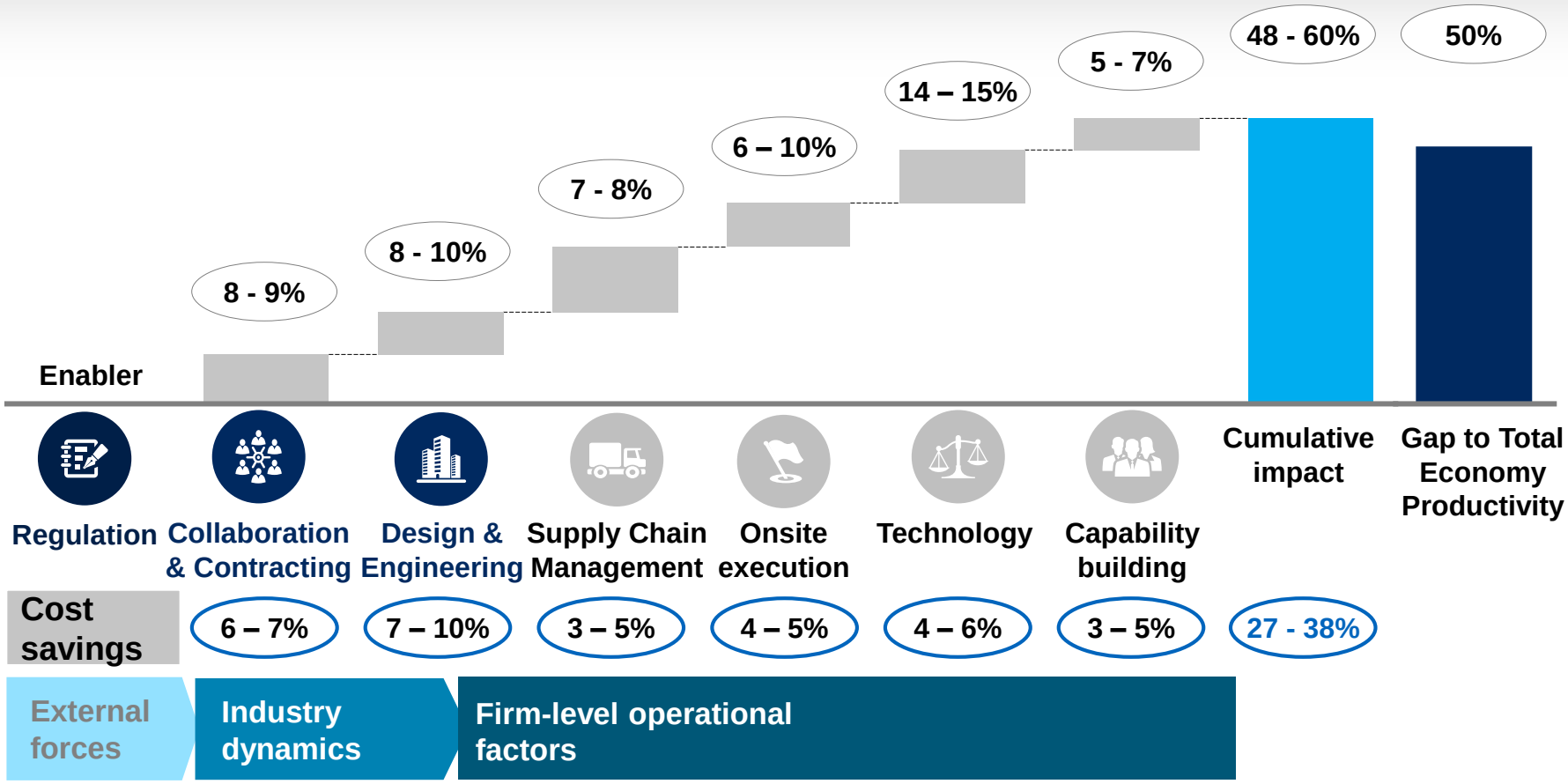
The 7 Levers for a ~50% increase in Productivity

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

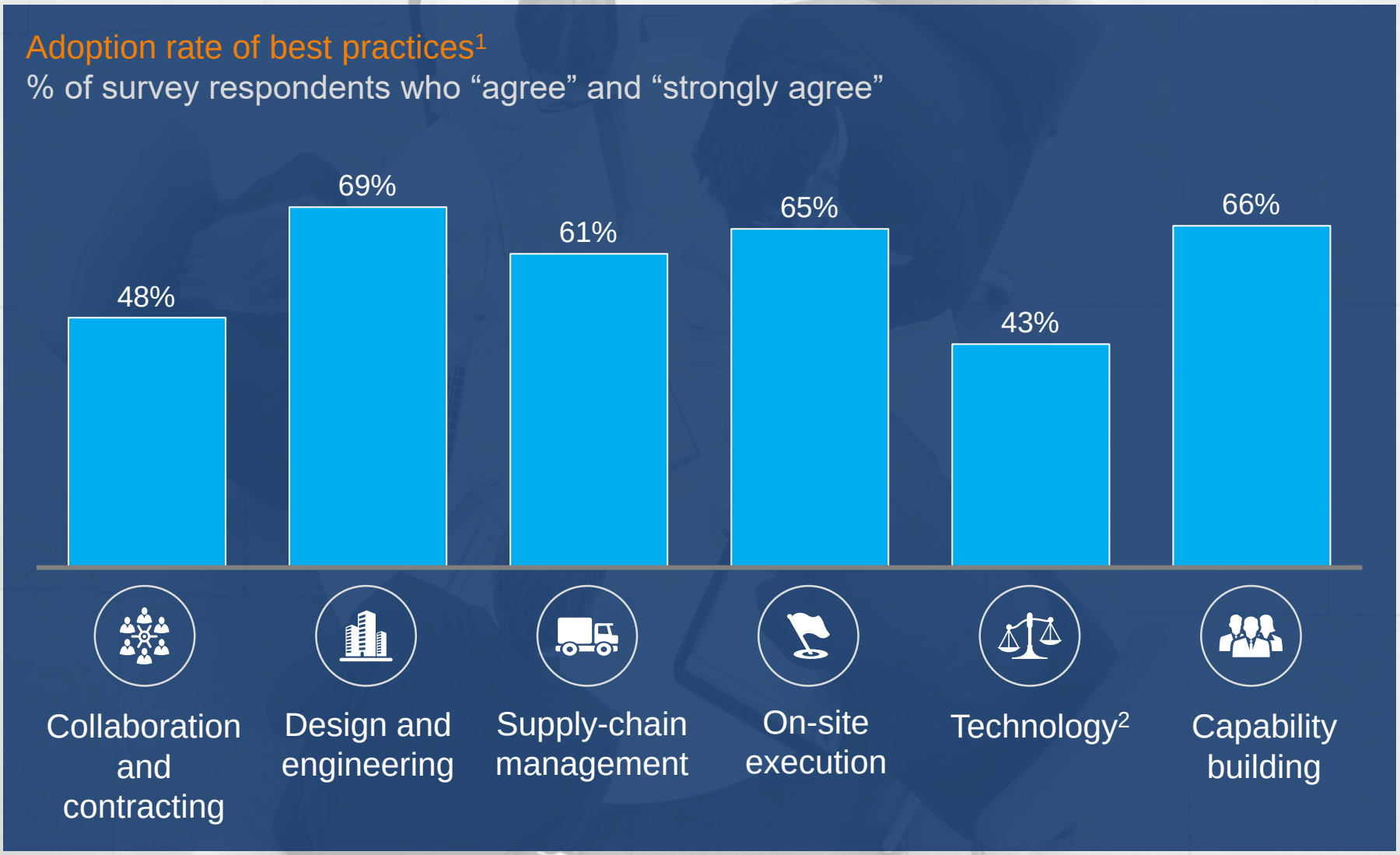
% impact on productivity



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 McKinsey & Co Global Construction Industry Productivity survey who responded agree or strongly agree to the questions around implementation of the solutions

SOURCE: McKinsey Global Institute analysis

There is a lot of room for firms to raise adoption of leading practice



1 Share of best practices marked as "agree" or "strongly agree“ out of total number of best practices listed in survey.
2 Current adoption; does not included anticipated adoption.

SOURCE: MGI Construction Productivity Survey, August 2016

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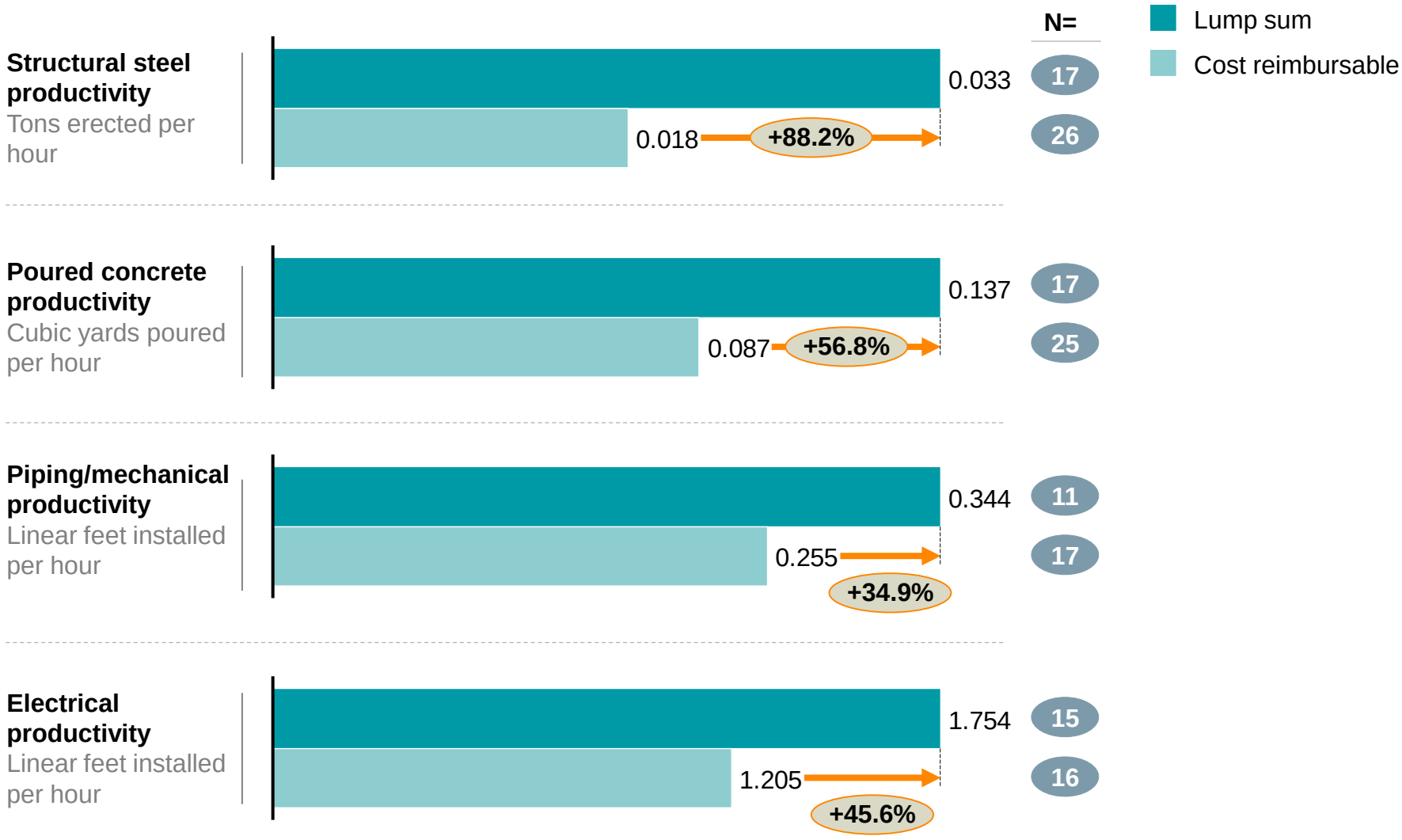
Projects that use lump-sum contracting methods have higher productivity on several measures

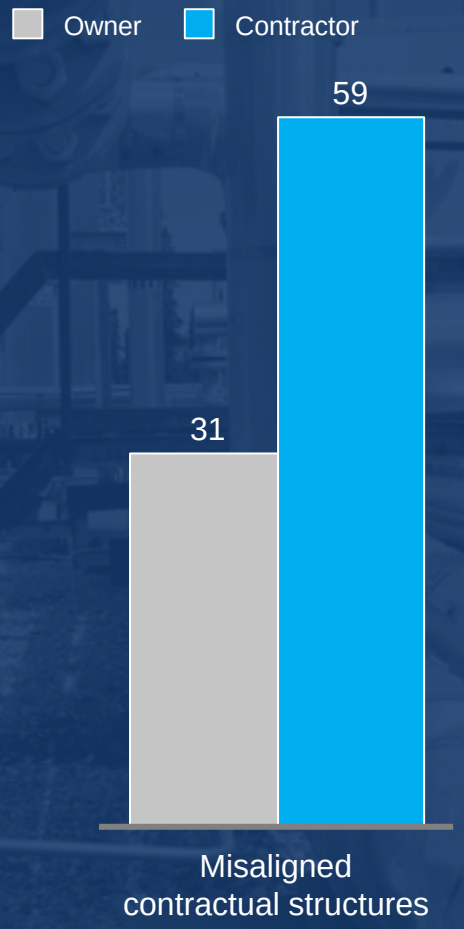


SOURCE: Construction Industry Institute Performance Assessment System, McKinsey Global Institute Analysis

2 The negative impact of misaligned contractual structures weighs heaviest on contractors

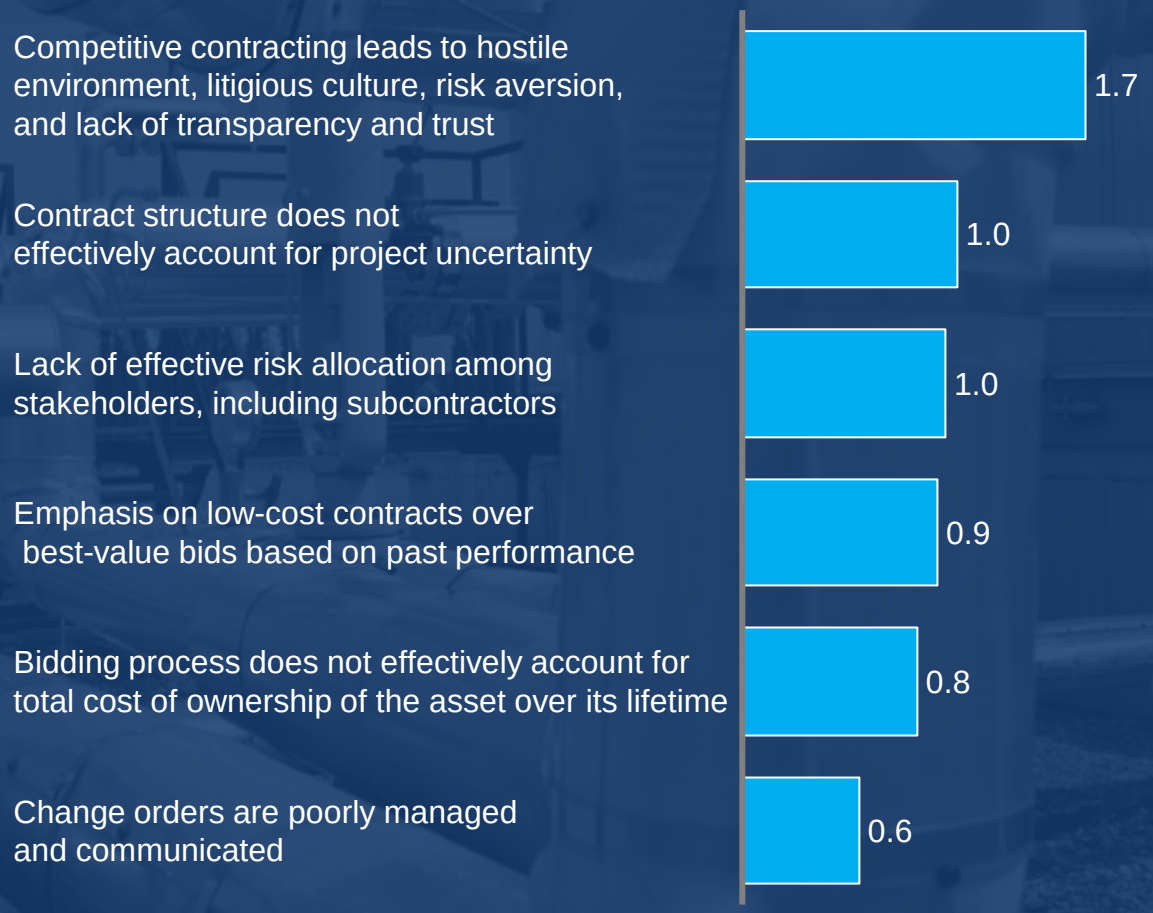
Impact of misaligned contracts

% naming this as top three driver



Relative importance of drivers of misaligned contractual structures

Impact score[1]



1 Respondents were asked to rank the top three most important drivers. A score of 3 was given to the driver ranked first, a score of 2 to the second, and a score of 1 to the third. Drivers not ranked in the top three were scored as zero.

SOURCE: MGI Construction Productivity Insights Survey

2 Rewire the contractual framework

Universally shape the basics…

1. Contract beyond cost for value
2. Establish a single source of truth
3. Add incentives to traditional contracts
4. Prioritize interface management

… and then push for advanced solutions

5. Move to collaborative strategies, e.g. IPD
6. Invest in upfront planning, w/ early contractor input
7. Contract based on robust estimates triangulated via multiple inputs

5. Example: Contracting strategies based on collaboration can maximize value for all parties

- Lump Sum Turnkey
- Design-Build (DB)
- FEED open book + PC

LOWER ← Level of collaboration and risk sharing between parties → HIGHER

- Owner Integrated
- Design-Bid-Build (DBB)

Alliance / Integrated Project Delivery (IPD)

IPD in practice

- Whole team contractually bound to collaborate (jointly defined KPIs)
- Conditions for implementation:

1) Multiple projects for knowledge transfer
2) Strong financial position to make up-front investments
3) Commitment to lean construction
4) Certain but not standardized scope and design

1 Cost overrun <25 percent / schedule slippage <25 percent

SOURCE: Edward W. Merrow, Industrial megaprojects: Concepts, strategies, and practices for success, Wiley, May 3, 2011

Owner

Sutter Health Implementation of an IPD framework on a large scale

Who are Sutter Health?

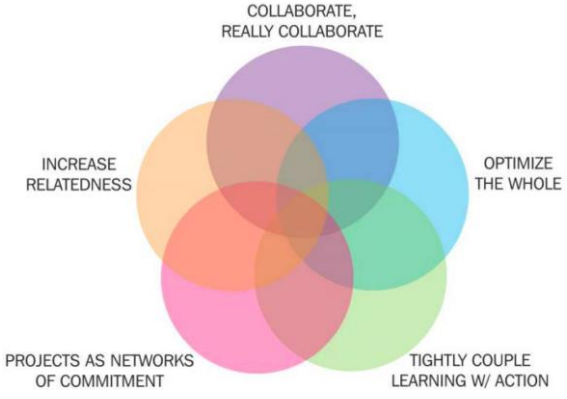
- A **not-for-profit health system** with more than 24 acute-care hospitals, and dozens of outpatient surgery and specialty centers,
- Serves over **100 communities** in Northern California.
- In 2000 it set out **to replace and upgrade its hospitals** in response to state-mandated seismic requirements via a $7 billion capital program.
- Early projects were **beset by late delivery and significant budget overruns**

Approach – five big ideas

- Focused on improving **reliability** by assembling integrated teams of designers, consultants and builders from project opening
- Companies put on **integrated teams** collectively rather than individually with **five big ideas**
  - **Optimize the whole project**, not the parts
  - Manage projects as a **network of commitments**
  - **Collaborate – really collaborate**
  - Tightly couple **learning with action**
  - Increase **relatedness**

Impact

- Since 2004, under this model, Sutter Health has completed more than $**1.5 billion** of capital work **on schedule and on budget**
- An additional **$3 billion** is under construction using the same principles



SOURCE: Sutter Health interview

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7 Reskill the workforce to address organizational challenges and improve efficiency

Universally shape the basics…

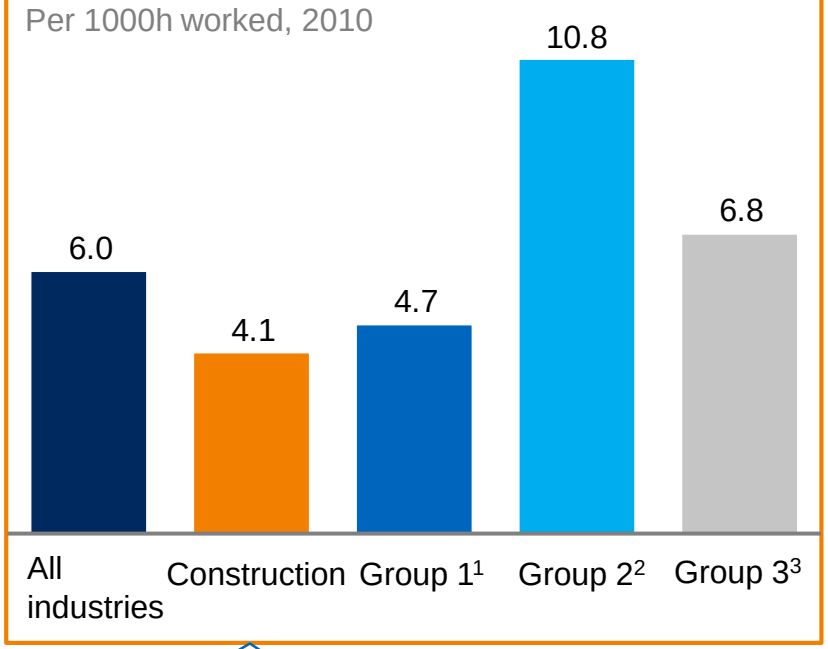
1. Build an **apprenticeship model**
2. Develop **front line training**
3. Ensure **knowledge retention** and **management**

… and then push for advanced solutions

4. Introduce **E-enabled micro-training** for frontline workers
5. Run **Field and forum**—mix of classroom & field training
6. Create **internal academies** to institutionalize best practices and roll out across sites

2 Example: Construction companies provide 30 percent less training than the economy average

Average training hours received in the EU
Per 1000h worked, 2010



Increasing the proportion of employees receiving training by one percentage point is associated with an **increase in productivity** between **1 and 1.6 percent**

1 Wholesale and retail trade, transport, accomodation and food service activities
2 Information and communication; financial and insurance activities
3 Real estate activities; professional, scientific and technical activities; administrative and support service activities; arts, entertainment and recreation; other service activities

SOURCE: Eurostat NACE Rev. 2; BIS Research Paper No. 72

Sizing logic and assumptions

Building (B)
Civil (C)
Industrial (I)

	Improve on-site execution				Infuse digital technology, new materials, and advanced automation				Reskill the workforce			
	Developed markets		Emerging markets		Developed markets		Emerging markets		Developed markets		Emerging markets	
	Prod.	Cost	Prod.	Cost	Prod.	Cost	Prod.	Cost	Prod.	Cost	Prod.	Cost
A Project impact What is the project level cost/ productivity impact of this solution?	20%	12%	25%	6%	65%	20%	60%	15%	10%	5%	10%	5%
	15%	10%	25%	15%	75%	30%	70%	25%	15%	15%	15%	15%
	25%	10%	35%	15%	80%	30%	80%	30%	15%	15%	15%	15%
B Applicability What portion of all projects could apply solution by 2030?[1]	60%		50%		40%		25%		70%		40%	
	70%		60%		50%		40%		80%		50%	
	70%		60%		50%		50%		80%		50%	
C Current adoption What portion of all projects are already using this solution?[1]	35%		20%		25%		10%		20%		10%	
	30%		15%		25%		10%		20%		10%	
	30%		15%		25%		25%		20%		10%	
D Total impact What is the total productivity/cost impact?	▪ **Total productivity improvement:** 6-10% ▪ Total cost improvement: 4-5%				▪ **Total productivity improvement:** 14-15% ▪ Total cost improvement 4-6%%				▪ **Total productivity improvement:** 5-7% ▪ Total cost improvement 4-6%			

SOURCE: McKinsey Global Institute analysis

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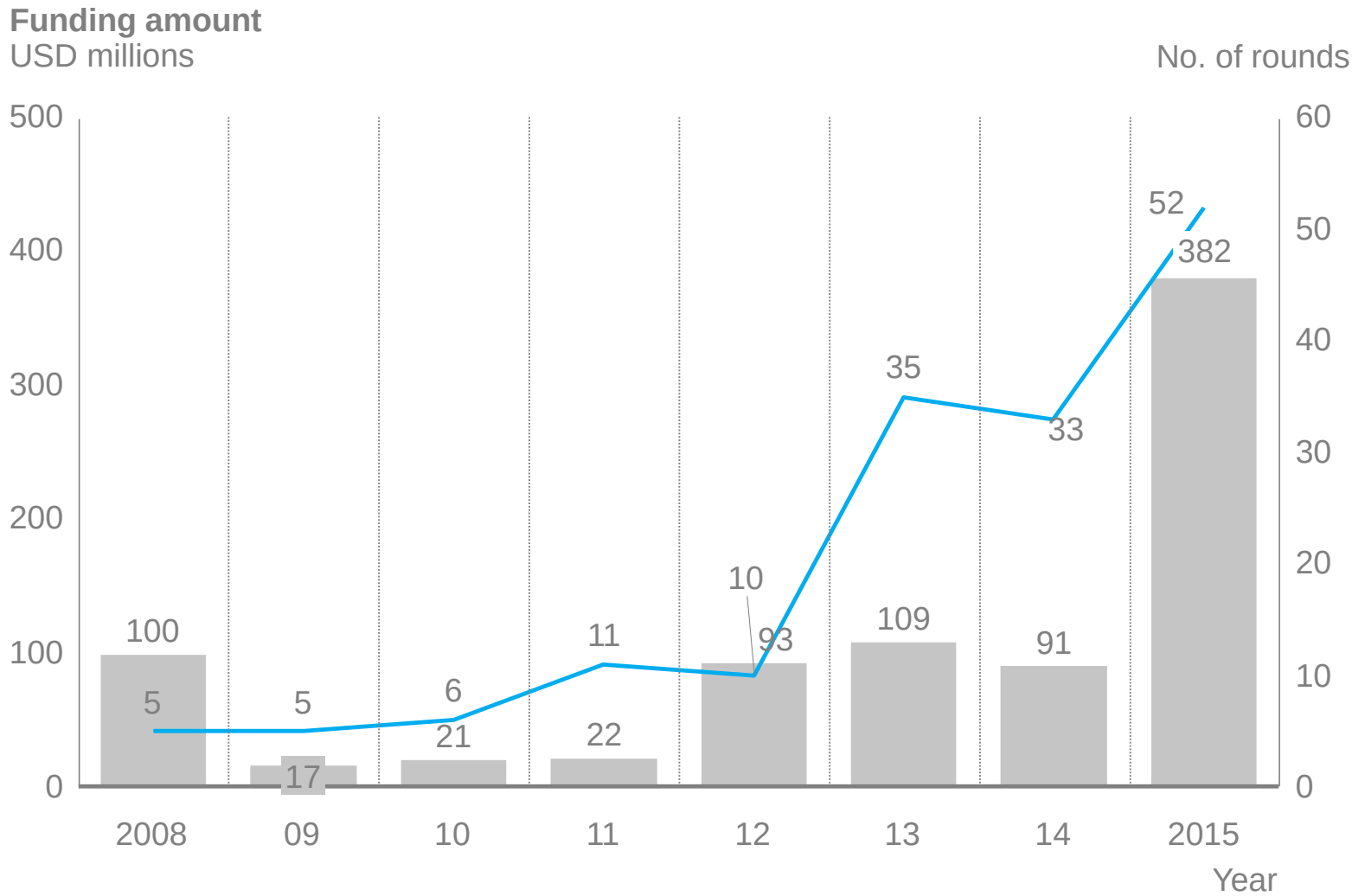
E&C technology solutions are proliferating, driven by substantial funding from the VC industry…

YoY Funding in Construction Tech (2008-15)

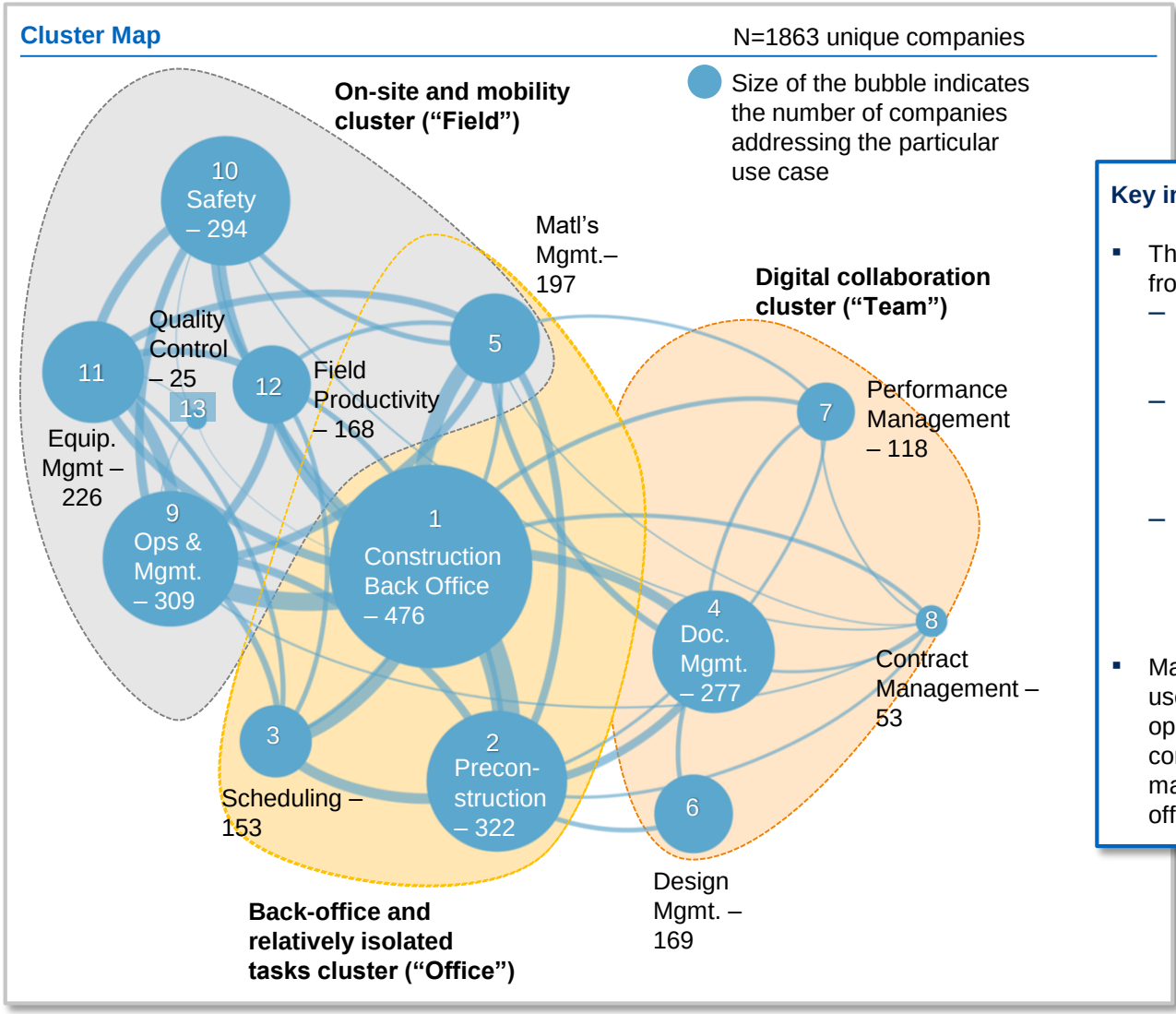


SOURCE: Tracxn Construction Tech Startups Report, February 2016

…however it is not yet clear to most owners and E&C companies which tools are worth implementing (and which will best improve productivity)

Our comprehensive mapping of the Construction Tech landscape indicates three interconnected clusters

PRELIMINARY



Key insights from the SILA analyses:

- Three key clusters organically emerge from the analyses
  - On-site and mobility: use-cases that require mobile deployment
  - Digital collaboration: use-cases that require engagement across multiple stakeholders
  - Back-office and relatively isolated-tasks: use-case with simpler flow path activities (e.g. estimating) or ERP functions
- Many companies trying to bridge across use-cases across the clusters (e.g. operations and management with construction back-office or doc management with construction back-office)

SOURCE : McKinsey Startup and Investment Landscape Analytics

Playing these 3 clusters forward, the capital project of the future will operate very differently from today…

Connectivity and sensing
Robotics and automation
Process digitization
Advanced analytics

Field

Advanced analytics

Advanced analytics optimizes facility run settings to maximize profitability/ Predictive maintenance minimizes down time

Digitized commissioning and handover

Construction completion, commissioning and handover are completed electronically

LiDAR as built verification

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

3D printing

3D printing removes construction delays due to missing parts, reduces freight costs, and simplifies supply chain and warehousing

Autonomous vehicles

Autonomous vehicles transport personnel, equipment and materials across site.

Automated construction

Robots complete activities more productively, accurately and safely than humans

Office

Capital portfolio management

Specialized software, and advanced analytics, optimize capital investment and portfolio management

Virtual reality

Operations staff review facilities and identify hazards during design

Automated design

Designs are produced within days for complex facilities, enabling rapid option comparison and assessment

5D BIM and beyond

5D BIM is used to unify the 3D model with schedule and budget, ultimately adding additional dimensions to support operations

Team

Customer co-creation

Design tools are crowd sourced and employ agile methodologies during design development

Digital performance management

Project leadership and site managers assess performance, anticipate issues, and develop action plans

X Expected savings range[1]

…and will deliver significant cost reductions (up to 45% of TIC)

5-20%

- On-site **construction & fabrication**
- Equipment **operation**
- **Workforce management**
- Asset **operation & maintenance**

10-20%

- **Capital strategy**
- Project & portfolio **planning & selection**
- **Risk analysis**
- **Scheduling & project controls**

5-20%

- Material & equipment **scheduling & delivery**
- Material & equipment **on-site management**
- On-site **contractor management**
- **Claims management**

5-15%

- Performance requirements
- **Initial design**
- Material **specifications**
- **Purchasing** materials & equipment
- Resolution of as-built challenges
- **Aligned** contract **incentives**

3-5%

- Organizational **structure & development**
- **Learning & development**
- **Functional capabilities**

5-15%

- **Knowledge capture /** lessons learned
- Common **source of truth**
- Stakeholder **alignment**

1 Expected savings range based on 80 projected or actual savings from digital application use. Cases identified through client work, internal research, and publications. Savings are not additive and are specific to cost categories

SOURCE: McKinsey Capital Projects & Infrastructure digital and innovation service line

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Case study: Cutting costs for a large solar power developer

Situation

- Client looking to manage portfolio and reduce costs for >15 projects in various states of construction (pre-construction to commissioning)
- Responsible for managing E&Cs with multiple contracts and structures. Need to drive down construction costs to meet cost targets
- Lack of transparency into project level performance. E&Cs and PMs often provide anecdotal data on project performance without fact-based discussions

Consolidating data

- Defined metrics for pre-construction, execution (cost, schedule, quality, and safety), and end-to-end materials management
- Gathered data not available at the site level (cost reports, purchase orders, shipment data, etc.)
- Ensure consistent collection from E&Cs across sites

Implementation

- Developed a dashboard using client-specific cost systems
- Conducted a CCT workshop with key stakeholders
- Benchmarked execution performance across projects
- Identified and shared best practices across sites and E&Cs
- Deployed teams in the field in response to issues identified

Results…

60% reduced committed contingency

18% decrease in labor hours required for installation

21% cost savings from bid

Case study: Improving engineering productivity for an Oil & Gas OEM

Context

- Leading global OEM, employing over 5,000 engineers
- Delivers EPC-like turnkey projects globally
- Engineering costs as a percent of spend have been rising, while a shortage of engineering talent has constrained growth and investment in other business priorities (e.g., new product development)
- Client asked McKinsey to identify drivers of productivity loss in engineering teams spanning 6 product lines and 100+ geographical locations, pilot key improvement levers, and then launch a transformation to improve productivity by 10% across the organization

Approach

- Leveraged 4 complementary approaches to identify opportunities to improve productivity
  - Nerve interfaced with engineers' systems to identify drivers of efficiency loss
  - Organizational Health Index to identify cultural performance drivers
  - Benchmarks from other engineering organizations
  - Project "tear-downs" to tie analytical results to on the ground observations
- Conducted pilots to prove concept, then rolled productivity playbook out across organization

Results…

20%
Productivity savings potential identified

15-25%
Productivity improvements during on-going mega-project pilots

10%
engineering savings across the organization

SOURCE: QuantumBlack

Case study: Institutionalizing 5D BIM at a leading real estate client

Situation

- Client looking to institutionalize 5D BIM for all high value, flagship projects and for use as project management
- Seeking to capture cost savings in current $500M project for two high rise towers through:
  - Pro-active clash resolution across stakeholder designs
  - Quantity variations between existing estimates and 5D BIM generated estimates

Changes made

- Converted all project specifications into 5D BIM tool and established a single database of data
- Restructured project team structure to ensure project design teams, costing teams, planning and reporting, IT, and 5D BIM software teams were in place and well supported

Implementation

- Created ready to use dashboards for project leadership review
- Established a project cost database for utilization in future projects
- Utilized scheduling feature and monitored progress to ensure project was on track

Results…

5%
cost savings from original estimate in just two floors

1,000+
line item cost database created

20+
clients trained in 5D BIM

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A production system in construction would look radically different from the current project-based approach

Large-scale manufacturers of components and work packages

Industry

Owner **Contractor or manufacturer**

Collaborative working team

1. **Design and procurement**
2. **Approvals and testing**
3. **Manufacture**
4. **Supply-chain coordination**
5. **Site work**
6. **Post construction**

Components selected on **digital marketplace** with full transparency on **life time costs**

Streamlined **approvals process** and **testing** at production facility

High-quality offsite manufacture facilitated through **automation** and new **lightweight materials**

Supply chain, with tools such as just-in-time and just-in-sequence, replaces project management as the predominant coordination challenge

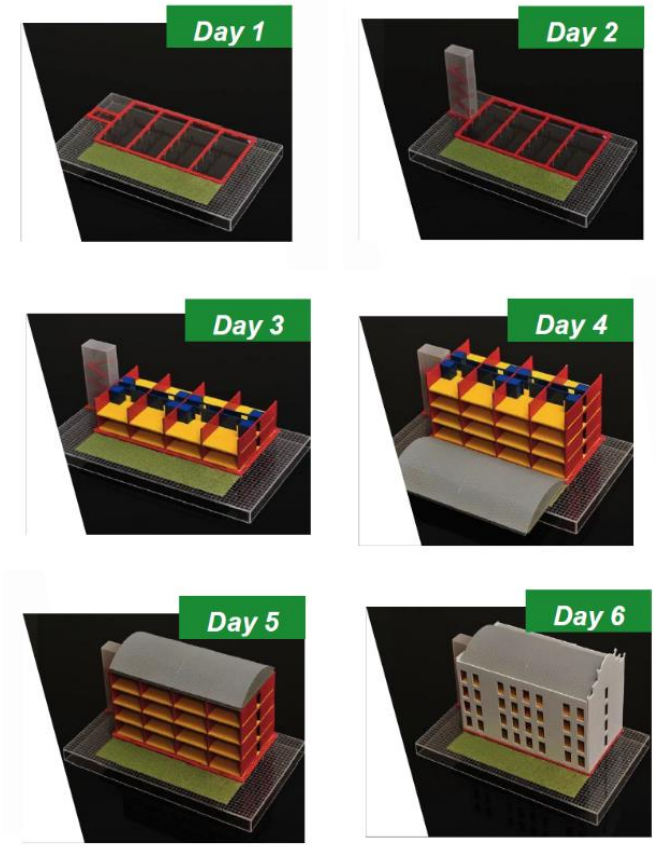
Lifetime guarantees on components and packages

Site work is minimized to assembly of components and packages facilitated through universal interfaces supported by technology

Example production system: Barcelona Housing Systems

Illustration of finished buildings

Illustration of construction process



SOURCE: Barcelona Housing Systems

Example production system: Segmental bridge launching machine in China

SOURCE: http://www.telegraph.co.uk/technology/0/watch-the-580-ton-monster-machine-constructing-bridges-in-china/

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Conclusions & Recommendations

- Improved productivity – a key differentiator & source of profitability: should be part of your strategic plan
- Take the initiative in collaborative contracting
- Invest in design, procurement & lean execution capabilities
- Make strategic investments in technology
- Invest in upskilling your people

SOURCE: Source

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Link to McKinsey's web-site: www.mckinsey.com

Link to the McKinsey Capital Projects & Infrastructure Practice:
http://www.mckinsey.com/industries/capital-projects-and-infrastructure/how-we-help-clients

Link to the McKinsey Construction Productivity Report :
http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution