Shaping the Future of Construction – A Landscape in Transformation: An Introduction

Prepared in collaboration with The Boston Consulting Group

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The first report of the World Economic Forum’s Future of Construction Series – The Future of Construction: A Healthy Outlook and How to Make It a Reality – will be published in the first quarter of 2016. As input for discussion, this document includes the Executive Summary of the report, as well as its first chapter, Introduction: The Construction Industry – Time for a Transformation. The remaining chapters – on companies as the spearhead of transformation, the industry’s need to collectively drive transformation, the government’s need to encourage and enable this transformation, and the way forward – will be part of the full report.
Context and Objectives of the Report

Scope
This report is the first publication of a multi-year project for guiding and supporting the Engineering & Construction (E&C) industry during its current transformation. The report describes the industry’s present state, assesses relevant global trends and their impact on the industry, and devises an industry-transformation framework with key areas for development and action. It also features many best practices and case studies of innovative approaches or solutions, and offers a view – at different points of action, such as at the company-, industry- and sector-level – of how the future of construction might look. The project’s subsequent phases and reports will deal with specific topics or will explore the subject in-depth by geography.

The project as a whole, and this report specifically, builds on the findings of an earlier World Economic Forum project – the four-year Strategic Infrastructure Initiative. That initiative identified and described the key government measures needed to close the infrastructure gap, by such means as improving the prioritization of projects, enhancing public-private partnership (PPP) models, improving the operations and maintenance (O&M) of existing assets, and better mitigating risks. During that research, it became evident that important contributions can also be made from the supply side – the Engineering & Construction industry – in the form of improvements to and innovations in project delivery.

Audience
This report is aimed at all firms active along the construction value chain, including suppliers of building materials, chemicals and construction equipment; contractors; and engineering, architecture and planning firms; as well as project owners and developers. Governments are another target audience, as they not only have an impact on the industry via regulation but also act as the main procurer of most infrastructure projects. Finally, this report is also aimed at members of academia and civil society, in view of the socio-economic importance of the construction industry. The industry will rely on effective collaboration with all stakeholders for its future success.
The Engineering & Construction (E&C) industry strongly affects society, the economy and the environment as a whole. It touches the daily lives of everyone, as quality of life is heavily influenced by the built milieu surrounding people. The construction industry serves almost all other industries, as all economic value creation occurs within or by means of buildings or other “constructed assets”. As an industry, moreover, it accounts for 6% of global GDP. It is also the largest global consumer of raw materials, and constructed objects account for 25-40% of the world’s total carbon emissions.

Multiple global megatrends are shaping the future of construction – trends related to markets and customers, sustainability and resilience, society and workforce, politics and regulation. Consider just two developments: first, the number of disasters reported last year amounted to three times the number in 1980, such that certain major hazard-mitigation endeavours are needed; second, the population of the world’s urban areas is increasing by 200,000 people per day, all of whom need affordable housing as well as social, transportation and utility infrastructure. Such trends pose challenges but also offer opportunities; either way, they require an adequate response from the industry as a whole.

Compared to many other industries, the construction industry has traditionally been slow at technological development. It has undergone no major disruptive changes; it has not widely applied advances in processes such as “lean”. As a result, efficiency gains have been meagre. In the United States over the last 40 years, for example, the productivity of construction labour has actually fallen.

Given the sheer size of the Engineering & Construction industry, even a small improvement would provide substantial benefits for society. To capture such potential, this report presents an industry transformation framework (Figure 1), listing 30 measures, including many best practices and case studies of innovative approaches. Some of the measures can be adopted by private companies on their own, while others require collaboration with their peers or with other companies along the construction value chain. In addition, some of the measures can be adopted by government alone, acting both as the regulator and as the major owner of infrastructure projects.

![Figure 1: Industry Transformation Framework](image)

Source: World Economic Forum; BCG analysis
Substantial improvements are already within reach for companies

It is companies themselves that should spearhead the industry transformation. Tremendous opportunities are available through the application of new technologies, materials and tools. New technologies in the digital space, for example, will not only improve productivity and reduce project delays, but can also enhance the quality of buildings and improve safety, working conditions and environmental compatibility. Building and Information Modelling (BIM) plays a central role here, as it is the key enabler of and facilitator for many other technologies; the building of a bridge, for example, can be greatly facilitated by combining robotics and 3D printing via a parametrically designed 3D model. Connecting these 3D models to all the dimensions available with Enterprise Resource Planning systems allows further improvement in the accuracy of processes and operations. Although many innovative solutions are already being applied on a small scale or in a few countries, the industry still needs a large-scale application or better adaption of current technological developments.

To unlock the potential lying in new technologies, materials and tools, the industry also needs to adopt the appropriate processes. For instance, the benefits of BIM are reinforced if companies exploit the new opportunities it provides – notably, a new way of collaborating and sharing information between stakeholders. Large productivity improvements can be achieved by optimizing existing processes: the broader use of lean principles and methods, for instance, could reduce completion times by 30% and cut costs by 15%.

Another core lever is early project planning. To improve such planning, companies should promptly draw on the knowledge of all stakeholders, and should explore new contracting models. A minimal increase in upfront costs of about 2% to support optimized design will lead on average to life-cycle savings of 20% on total costs.

Every change has to be driven and supported by the people involved, so companies must focus on attracting, retaining and developing talent, and establishing a company culture conducive to innovation and improved skills. This is all the more necessary as the industry is traditionally regarded as not particularly attractive by prospective employees.

Cross-company collaboration is pivotal

Engineering & Construction companies cannot realize the full potential on their own. The industry is one of the most fragmented in the world and relies on a seamless interplay of all participants along the value chain and throughout a project’s life cycle. To reduce complexity and improve cooperation and exchange, companies need to enhance coordination across the value chain and jointly define standards and agree on them. Australia is duly pioneering the standardization of project alliance agreements to reduce initial costs.

To gain the support of society at large, the industry again needs to work collectively, along multiple dimensions. For example, it should promote itself as an attractive employer, and it should engage local communities by means of participatory planning and ongoing community-involvement initiatives during operations. A good example in that regard is the Considerate Constructors Scheme, a non-profit, independent organization founded by the United Kingdom’s construction industry to improve its image.

The industry is also very much affected by politics and regulation, and thus needs to optimize its interactions with the public sector. Again, companies should cooperate in their efforts here, to ensure constructive communication with public agencies, to monitor political developments accurately and to implement an effective advocacy strategy. In the German “national initiative on energy transition”, for instance, the construction industry coordinated well in developing a strategy on climate change with the German government.

As both regulator and major client, the government too needs to take action

In any given country, the public sector, in particular the national government, can enhance competition and productivity by simplifying and harmonizing building codes and standards. By setting and enforcing time limits for regulatory and environmental approvals, governments can greatly reduce project delays. Ideally, they should also minimize barriers to competition at an international level. And they should provide appropriate support to academia and companies for developing technological innovations. The British government, for example, recently put the construction industry on the national agenda to develop a long-term view of ways to put Britain at the forefront of global construction.

Governments can also shape the industry by their actions as key project owners. The Crossrail project in London, for instance, involves systematically generating, capturing and replicating innovative ideas and eventually translating them to practical innovations and industry standards. It also aims to raise the bar for other construction projects by making those ideas, technologies and practices available to the industry as a whole. Finally, the issue of corruption on construction projects can only be resolved if all participants cooperate in developing and implementing effective anti-corruption actions – actions that address both the supply and demand sides of corruption.
1. Introduction: The Construction Industry – Time for a Transformation

1.1 The industry is crucial to the economy, society and environment

1.1.1. Societal relevance

Construction is one of the first businesses that humankind developed, and it continues to shape our daily life in unique ways. Virtually all other businesses rely on the construction industry to provide and maintain their accommodation, plants and infrastructure, and almost everyone relies on construction to some extent for housing, work and play. For almost the entire population of the world, quality of life is heavily influenced by the built environment.\(^6\)

Hence the value of improving the quality of construction, increasing its sustainability and reducing its cost. Any endeavour serving any of those causes is likely to generate welcome benefits – whether for families investing in their first private home, or governments embarking on a giant infrastructure project.

1.1.2. Economic relevance

With total annual revenues of almost $10 trillion and added value of $3.6 trillion, the construction industry accounts for about 6% of global GDP.\(^7\) More specifically, it accounts for about 5% of total GDP in developed countries, whereas in developing countries such as India, it tends to account for more than 8% of national GDP. The industry is expected to grow greatly in coming years, to estimated revenues of $15 trillion by 2025.\(^8\)

Construction is a “horizontal” industry (like the Financial Services industry), catering to all industry verticals, – in other words, construction has considerable interaction with numerous other sectors. To mention a few, residential housing accounts for 38% of global construction volume; transport, energy and water infrastructure 32%; institutional buildings 6%; commercial buildings 12%; and industrial sites (from cement to automotive manufacturing) 13%. For all of these sectors, value creation almost always occurs within or by means of buildings or other constructed assets.

If countries are to enjoy inclusive and sustainable growth, they crucially need modern and efficient infrastructure. According to a 2014 estimate by the International Monetary Fund, if advanced economies invested an extra 1% of GDP into infrastructure construction, they would achieve a 1.5% increase in GDP four years later.\(^9\)

1.1.3. Environmental relevance

The construction industry is the largest global consumer of resources and raw materials. It consumes about 50% of global steel production\(^{10}\) and, each year, 3 billion tonnes of raw materials are used to manufacture building products worldwide.

About 40% of solid waste in the United States derives from construction and demolition.\(^{11}\) Throughout the world, such waste involves the significant loss of potential valuable minerals, metals and organic materials.

As for energy use, buildings are responsible for 25-40% of the global total. In Europe, buildings account for 40-45% of energy consumption in society, and thereby contribute hugely to the production of carbon dioxide.\(^{12}\)
1.2 The industry’s future will be shaped by several megatrends

The construction industry is affected by megatrends in four categories: markets and customers, sustainability and resilience, society and workforce, and politics and regulation. The industry needs to identify and implement optimal responses to these megatrends – both to the opportunities they offer and to the challenges they pose.

Figure 2: Megatrends Shaping the Construction Industry’s Future

1.2.1. Market and customer trends

As demand in emerging countries rises, the industry must identify how these new markets can benefit best from the technological advances and increased safety standards being applied in developed countries, while taking into account local market conditions.

An increase in global competition will certainly produce winners and losers as strengths and strategies differ between companies and countries. Many Asian construction firms, on the basis of their cost advantages, put great effort into securing construction contracts abroad. Most Western markets, such as the United Kingdom’s, are characterized by a high degree of fragmentation, which impacts on their level of innovation and their ability to access foreign markets. Eventually, the firms with strong processes in place and the ability to adapt their business models to new markets will prove to be the winners. Many of the others will disappear. One particularly challenging area is that of infrastructure. Currently, fast-ageing infrastructure assets can jeopardize economic growth, and demand proper maintenance, upgrading or replacing – an immense opportunity, and responsibility, for the construction industry. The vast “infrastructure gap” cannot be bridged by public-sector money alone. Private capital is needed, so the trend in infrastructure construction projects is for PPPs. One other notable development is the increasing occurrence of infrastructure megaprojects, even though such projects have a poor record historically in terms of on-time and on-budget delivery, environmental footprint and public support.\(^\text{13}\)

1.2.2. Sustainability and resilience trends

Increasingly, sustainability is becoming a requirement rather than just a desirable characteristic, and its pursuit is bound to affect both the construction process and the built asset itself. The construction industry produces an enormous amount of waste, so the more efficient use and recycling of raw materials (i.e. establishing a circular economy), even a small improvement, offer huge potential benefits. New priorities are emerging accordingly, including optimizing space, for example, and ensuring more efficient methods of heating, cooling and lighting. The industry is increasingly involved
with off-grid/distributed power sources, such as wind power, geothermal energy and solar panels on roofs.

The industry also has to address growing concerns over natural hazards (notably, flooding, hurricanes and earthquakes), and to enhance resilience. So new emphasis is being placed on risk-mitigating solutions, especially in urban areas with high population density.

Finally, the industry must be engaged against the growing threats to cybersecurity. No doubt many important benefits will emerge from the convergence of web, cloud and mobile platforms, as well as the Internet of Things, but vulnerability will increase as well. So the imperative to protect the industry from threats without disrupting business innovation and growth has never been greater.14

1.2.3. Societal and workforce trends

The world’s urban population is expected to exceed 6 billion by 204515 – and about a quarter of that population would live in slums if the current share remains constant.16 Hence the need for a boost in affordable housing in urban areas – the very areas where the construction process is most complex, owing to the space constraints – and for increased infrastructure spending on water supply, sanitation, and so on.17

Another demographic trend, especially in developed countries, is the shifting age profile: the increasing proportion of elderly people in the population affects the construction industry in two main ways: first, it creates a need to construct or adapt buildings to accommodate ageing and convalescent citizens; second, it threatens to reduce the available supply of construction workers. That threat might seem less serious than in the past, since new technologies are now taking over many of the tasks that formerly required low-skilled workers.18 However, the new technologies themselves require a highly skilled workforce, and the construction industry – traditionally perceived as less glamorous than other sectors – will struggle to recruit the requisite “digital” talent.19

Among the other challenges faced by the construction industry are those involving the rights or wishes of local communities, and health and safety issues. Neighbourhood lobby groups, for instance, might influence permit decisions and, failing that, protestors might force the withdrawal of permits already granted. Communities are also becoming more organized and professional – partly thanks to new forms of communication and social media. As for health and safety issues, regulations and expectations are intensifying; asbestos has been outlawed globally as a construction material, and builders are increasingly motivated to ensure that the living and work environments that they create are ergonomic and allergy-free.

1.2.4. Political and regulatory trends

The various political challenges relate to regulation, bureaucracy, instability and corruption.

Regulation impacts on many dimensions of the Engineering & Construction industry: the industry is especially affected by changes in health and safety requirements, financial and labour legislation, and environmental standards. New regulations in any of these areas can affect profits adversely. If designed thoughtfully, however, regulation can actually prove advantageous to companies.20 For instance, retrofit investments prompted by Germany’s new Energy Conservation Ordinance were a major driver of innovation for the construction industry.

Next is the issue of bureaucracy. Construction permits are, quite rightly, more and more subject to environmental and social-impact studies. If these are conducted inefficiently, however, or if there is a backlog in permit decisions, projects are needlessly delayed and their prospects suffer: cash flows start later than anticipated, thereby compromising profitability. An appropriate balance is required: on the one hand, offering speedy approval processes; on the other, giving all stakeholders their due say. Even once the permits are granted, infrastructure projects remain vulnerable to cancellation, owing to the vagaries of national politics. Very often, a new government will set different priorities from those of the previous government.21

Political instability is also an issue. The international community has arguably managed to reduce overall levels of violence in recent decades, but regional hotspots obviously persist and new ones flare up, at enormous human and economic cost. Contractors are wary of getting involved in such locations, even in post-crisis states – especially in long-term infrastructure programmes, where predictability is key – and need to find ways of mitigating the risks.

Finally, the challenge of corruption must be addressed. In many countries, corruption remains one of the greatest barriers to economic and social development. Although bribery and other forms of corruption afflict almost every industry sector, they are a particular concern for companies in the Engineering & Construction and Real Estate sectors, given the nature of their business.

1.3 The industry must confront internal challenges as well

In most countries, over the past 50 years, productivity improvements in construction have been almost negligible, especially when compared to those in other industries. Some new technologies have emerged, but the rate of innovation and innovation adoption has been very slow.

Looking at construction projects today, I do not see much difference in the execution of the work in comparison to 50 years ago.

John M. Beck, Executive Chairman, Aecon Group, Canada

Weak industry performance is also reflected in stock prices: in Total Shareholder Return (TSR) comparisons, listed
Figure 3: Industry Productivity and Performance, 1964-2012

Index of US labour productivity, 1964-2012

Relative improvement

Non-farm business labour productivity

CAGR = 1.9%

Construction labour productivity

CAGR = -0.4%

-19%

1 Peer set based on US companies with Engineering, Construction and Services-related Standard Industrial Classification codes. Financials are inflation-adjusted and indexed to 1964; output per working hours.

CAGR = compound annual growth rate

Sources: Global Vantage; Compustat; Bloomberg; www.aecbytes.com/viewpoint/2013/issue_67.html; www.nber.org/papers/w1555.pdf; S&P Capital IQ; BCG ValueScience Center

Why does the industry have such an unimpressive record? The underlying issues are many and varied.

Lack of innovation and delayed adoption. The lifeblood of any industry is research and development (R&D). The benefits of R&D, however, are long term, whereas the costs occur in the present. That mismatch is ill-suited to the project-driven business in which the construction industry operates, so R&D has received less attention here than in other industries.

Informal processes or insufficient rigour in process execution. The processes typically adopted in construction companies regularly lack maturity. Companies often seem to put greater emphasis on defining the final product than on planning the actual construction process.

Insufficient knowledge transfer from project to project. Although each construction project will have its own unique characteristics, the processes of construction itself are repeated in their essentials from project to project. Lessons learned from one project could therefore often be usefully applied to subsequent projects, and each construction company would be expected to institutionalize this process. Yet few companies have done so. Past experience is therefore often lost, and projects continue to rely heavily on the expertise of the individual project manager.

Weak project monitoring. A related issue is the weak monitoring of projects, relative to other industries. In many manufacturing industries, for instance, production processes are planned in advance to a very high level of detail, and large quantities of data are continually collected. In that way, if something goes wrong, a car manufacturer, for instance, can quickly home in on the root causes and implement remedies immediately. Few construction companies are set up in this efficient way.

Little cross-functional cooperation. The conventional construction process is generally sequential, as it reflects the input of the project owner, designers, constructors and key suppliers. This set-up militates against sophisticated production planning. Ideally, the knowledge of all stakeholders along the value chain should be fully used early on in the design and planning process, but that is seldom easy or even possible under current arrangements.

Little collaboration with suppliers. For many large contractors, the purchasing strategy involves long-term relationships with key suppliers; nevertheless, the final decisions are often still made ad hoc, on a project-to-project basis. The problem is even more severe in smaller construction companies, where purchasing is almost exclusively project-based.

Conservative company culture. The construction industry operates in a somewhat traditional environment and generally retains a conservative corporate culture. The widespread perception is, justifiably enough, that construction companies are not quite progressive or forward-thinking.

Shortage of young talent and people development. The image that people have of the construction industry is a relatively poor one, with inadequate gender diversity and little job security (owing to the cyclical nature of the business). As a result, Engineering & Construction companies often struggle to attract talented recruits to their workforce. Relative to companies in other industries, construction companies engage less often and less effectively in internal people-development initiatives.

In fairness, the construction industry does have some inherent characteristics that make it a structurally difficult business and that hinder attempts at reform. It also represents just one step out of several in the value chain, and relies on many stakeholders. So the much-needed company and industry transformation is bound to be difficult. Figure 4 lists these unconducive characteristics in two categories: on the left, some of the industry’s main peculiarities; on the right, the specific issues resulting from the special role of its clients.

Clients do not want to be guinea pigs.

Roger Smith, Executive Director, Corporate Strategy, Fluor Corporation, USA
1.4. The industry is ripe for and capable of transformation

Given the construction industry’s societal, environmental and economic importance, even small improvements in performance will make a strong impact in all three domains:

- **Societal.** A mere 1% reduction in construction costs would save society about $100 billion annually—a sum equal to the entire global cost of cancer drugs. In fact, the possibilities go far beyond that: the vision formulated by the UK government for 2025 is of a 33% reduction in the initial cost of construction and the whole-life costs of built assets.

- **Environmental.** According to the United Nations Environment Programme, by harnessing the capacity of the building sector, many countries can cut emission rates cost-effectively and achieve energy savings of more than 30%. The target set by the United Kingdom’s construction industry for 2025 is a 50% reduction of today’s level of greenhouse gas emissions in the overall built environment.

- **Economic.** The global shortfall in infrastructure capacity is expected to reach $15-20 trillion by 2030. According to the B20 Infrastructure & Investment Taskforce, closing that worldwide infrastructure gap could create up to 100 million additional jobs and generate $6 trillion in economic activity every year in the long run. Up to 30% of this boost could come from improvements to construction projects and to asset operations.

All of this significant potential is ready for release. New opportunities are emerging as transformative developments reshape the Engineering & Construction industry—from innovative technologies to revolutionary construction techniques. Productivity and efficiency will surge. It is up to the industry to embrace these new opportunities more vigorously and change the way it has traditionally operated.

Other industries, such as the automotive industry, have already undergone radical and disruptive changes, and their digital transformation is now well under way. Construction companies need to act quickly and decisively: lucrative rewards await nimble companies, while the risks are serious for hesitant companies. Witness the shake-up that digital photography brought about in the affected sector.

Given all the megatrends and internal challenges, the construction industry should take action in several areas. A comprehensive approach is outlined in the industry transformation framework shown in Figure 5.

The framework structures the various areas of action according to responsibility. Initially, the transformation relies on the initiatives of individual companies—the adoption of new technologies and processes, business-model innovation, refinements to the corporate culture and organization, and so on. Individual action is not enough, however, in such a highly fragmented and horizontal industry: many of the challenges need to be tackled collectively—the industry as a whole has a responsibility also. It needs to establish new forms of collaboration, or to improve existing forms. Finally, governments have a large role to play as well, in their dual role as regulators and clients.
Figure 5: Industry Transformation Framework

The full report, including chapters 2-4 that discuss the steps all stakeholders must take, will be launched in the first quarter of 2016.

Source: World Economic Forum; BCG analysis
## Abbreviations

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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>B2O</td>
<td>Business 20</td>
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<td>BCG</td>
<td>The Boston Consulting Group</td>
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<td>BIM</td>
<td>Building and Information Modelling</td>
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<td>E&amp;C</td>
<td>Engineering and Construction</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>HSE</td>
<td>Health, Safety and Environment</td>
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<td>O&amp;M</td>
<td>Operations and Maintenance</td>
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<td>PPP</td>
<td>Public-Private Partnership</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<td>TCO</td>
<td>Total Cost of Ownership</td>
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<td>TSR</td>
<td>Total Shareholder Return</td>
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<td>UN</td>
<td>United Nations</td>
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<td>UN DESA</td>
<td>United Nations Department of Economic and Social Affairs</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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Endnotes

1 Lean in the context of construction is described in The Boston Consulting Group, 2015a.

2 The Boston Consulting Group (in a forthcoming report 2016) has outlined the key technological developments and the potential impact and implications for key stakeholders.

3 See The Boston Consulting Group, 2015a.

4 Kats, 2003 explains how an initial upfront investment of $100,000 to incorporate green building features into a $5 million project could lead to savings of $1 million over the lifetime of the building.

5 The German national initiative on energy transition, Energiewende, included a module focused on buildings, Plattform Gebäude. The key recommendations were developed jointly by the construction industry and the government, and were incorporated into a national action plan, Nationaler Aktionsplan Energieeffizienz (NAPE).

6 This is especially true, of course, for the more than 100 million people employed in construction worldwide.

7 This calculation is based on 2014 data from IHS, 2015, Oxford Economics, 2015 and World Bank, 2015.


9 This estimate applies specifically to public-sector investment into infrastructure. The effect is lower in emerging markets, because of the generally lower efficiency there of public-sector investment. See International Monetary Fund, 2014.

10 See World Steel Association, 2015.

11 See Environmental and Energy Study Institute, 2014.


15 See UN Department of Economic and Social Affairs Population Division, 2014.


17 Further infrastructure needs are, for instance, in transportation and social infrastructure.

18 Particularly in fast-ageing countries such as Japan, a heavy push towards these technologies is under way.

19 For a view on the potentially negative impact that a general workforce gap could have on national growth, see The Boston Consulting Group, 2014. The impact will be particularly severe where the cause is undereducation.


21 For a detailed assessment of such risks in infrastructure projects, see World Economic Forum, 2015b.

22 According to The Boston Consulting Group, 2015b, the median TSR of the Engineering & Construction industry has trailed the S&P 500 in three of the past five years.

23 Based on The Boston Consulting Group 2015c.

24 For instance, in a survey of almost 15,000 companies from enterprises in the United Kingdom, innovation activeness was consistently ranked as one of the lowest priorities. See HM Government, 2014.

25 See imshealth, 2015.


28 See B20 Australia, 2014.
Contributors

Project Team
Andreas Renz
Project Manager, Future of Construction

Manuel Zafra Solas
Practice Lead, Engineering and Construction Industries

Editors
World Economic Forum
Pedro Rodrigues de Almeida
Head of Basic Industries, Member of the Executive Committee

The Boston Consulting Group (Adviser and Knowledge Partner)
Philipp Gerbert
Senior Partner and Managing Director; Global Head of Digital in Construction and Industrial Goods

Santiago Castagnino
Partner and Managing Director; Head of Construction and Infrastructure Europe

Christoph Rothballer
Principal, Infrastructure Expert

Steering Committee of the Future of Construction Project
Acciona
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Luis Castilla, Chief Executive Officer, Acciona Infrastructure

Aecon
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Steve Nackan, President, Aecon Concessions

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Charles Mouzannar, President, Construction and Specialty Consulting (CSC) Operating Unit

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Lakshmi Mittal, Chairman and Chief Executive Officer

Arup
Gregory Hodkinson, Chairman
Peter Chamley, Director; Chair, Global Infrastructure Practice

BASF
Kurt Bock, Chairman
Dirk Funhoff, Head, Construction Network Team

Consolidated Contractors Company
Samer S. Khoury, President, Engineering and Construction
Jamal Akl, Group Vice-President, Sales, Proposals and Support
Antoine Haddad, Vice-President, Sales, Estimation and Proposals (Civil)

Danfoss
Niels Christiansen, President and Chief Executive Officer
Nis Jessen, Vice President, Business Development and Strategy

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Shervin Haghsheno, Professor, Department of Civil Engineering, Geo- and Environmental Sciences, Karlsruhe Institute of Technology
Geoffrey Hamilton, Senior Officer, Economic Affairs, United Nations Economic Commission for Europe (UNECE)
Franziska Hasselmann, Director, Studies CAS MIA, Institute of Accounting, Control and Auditing, University of St Gallen
Fiona Murie, Global Director, Health and Safety and Construction, Building and Wood Workers’ International (BWI)
Ibrahim Odeh, Director, Global Leaders in Construction Management - Research Group, Department of Civil Engineering and Engineering Mechanics, Columbia University
Aristeidis Pantelias, Lecturer and Course Director, MSc Infrastructure Investment and Finance, The Bartlett School of Construction & Project Management, University College London
Bob Prieto, Chairman and Chief Executive Officer, Strategic Program Management LLC
Spiro Pollalis, Professor of Design, Technology and Management, Harvard Design School; Director, Zofnass Program for Infrastructure Sustainability
Norbert Pralle, Vice-President, European Network of Construction Companies for Research and Development (ENCORD)
Aaron B. Schwarz, Principal, Plan A Architecture + Design
Douglas Stollery, Stollery Charitable Foundation
Jan Van Schoonhoven, Senior Advisor, PPP and International Relations to the Netherlands Government
Enrico Vink, Managing Director, International Federation of Consulting Engineers (FIDIC)
Edmundo Werna, Senior Specialist, Labour Administration, Labour Inspection and Occupational Safety and Health Branch, Sectoral Policies Department, International Labour Organization (ILO)
James X. Zhan, Director, Investment and Enterprise, United Nations Conference on Trade and Development (UNCTAD)
Bibliography


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