IHS QUARTERLY

Q2-2014

THE NEW RISKS

As the economic recovery begins to accelerate, global corporations face many new challenges. We take a look at six, starting on page 28.

- MACROECONOMIC THREATS
- CHINA'S MILITARY MODERNIZATION
- ENERGY DEVELOPMENT IN AFRICA
- NEW CAPEX FOR CHEMICALS
- BUILDING NEXT-GEN MICROCHIPS
- IMPROVING OPERATIONAL PERFORMANCE

IHS QUARTERLY

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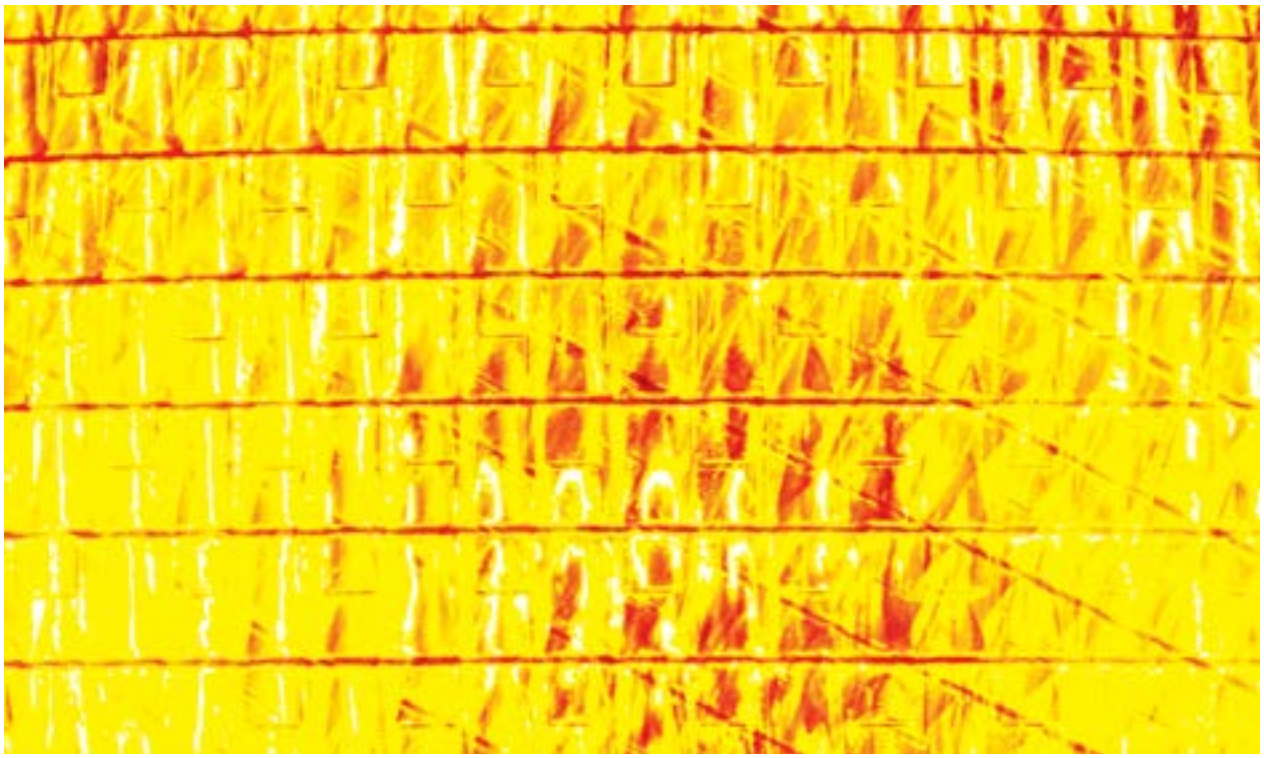

EFFECTIVE RISK MANAGEMENT

Managing risk is a big part of every executive's job description. That's because understanding risk is required for decision making, whether it's a strategic multibillion-dollar capital investment or a tactical operational course correction. The mission of *IHS Quarterly* is to provide insightful analysis and expertise to help our readers manage risk across a variety of industries, including aerospace, defense & security, automotive, chemicals, energy, maritime, and technology. Our depth and breadth can elevate your understanding of risk and lead to more informed decisions.

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Scott Key
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Change, risk and unconventional wisdom

Change is a constant. It's a fact of life. For businesses today, though, change typically means exposure to new risks both globally and locally. If the risks are misjudged, ignored or simply not recognized they can lead to missed opportunities or worse: reputational and financial loss. But if they are analyzed carefully they can reveal new opportunities with potential for new upside.

Change sometimes forces companies to rethink assumptions and challenges deeply held beliefs. It can herald new ways of thinking and organizing with implications for both operations and investment. This issue of *IHS Quarterly* explores both new risks and challenges to conventional wisdom.

On the topic of risk we tapped thought leaders from across IHS—in aerospace, defense & security, chemicals, economics, energy, operational excellence, and technology—and asked them to share their views on some of the emerging risks they are analyzing in their respective fields of expertise.

IHS Chief Economist Nariman Behravesh leads off with a review of five risks to the fragile global economic recovery that could slow growth and impact business performance. From secular stagnation in Europe to the lack of much-needed structural change in emerging economies, global companies need to monitor these risks closely in the coming months.

Tate Nurkin looks at the implications of China's military modernization. China is emerging as both a competitor to western defense and aerospace companies and a disruptive force in the regional and potentially global balance of power. The former has immediate business implications for the defense industry while the latter has longer term implications for all global corporations.

This issue also has two articles that disrupt business perceptions. The first is *Big (data) insights*, by John Larson. John argues that while it's important for companies to exploit big data, the challenge they face is less about the form or volume of the data and more about asking the right questions, having the expertise to interpret the answers and the confidence to act on the evidence.

In *The Future of Urban Mobility*, Phil Gott looks at the steady rise in urbanization of the world's population and concludes that the second century of the global automotive industry will be very different than the first, with profound implications for all players in the automotive value chain.

Understanding risk, challenging conventional wisdom and revealing opportunities. That's what we do at IHS and it's what we offer you in the pages of this issue of *IHS Quarterly*.

Unconventional feedstocks to increase China's clout in global chemical markets

A wave of coal-based chemical and propane dehydrogenation (PDH) development in China has ushered in an era of chemical production derived from unconventional feedstocks likely to impact not only the domestic Chinese chemical market, but global chemical markets as well.

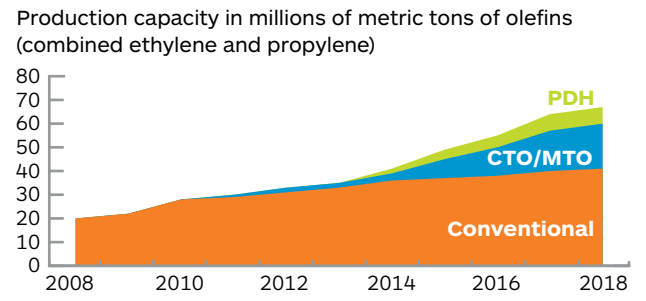
While China has limited crude oil and natural gas reserves, it sits on the world's third-largest coal reserve. The country's fast-growing dependence on imported oil and persistently high oil prices have encouraged China to utilize those coal reserves for chemical production.

Recent breakthroughs in coal chemical technology have sped up the process, and a number of plants are now coming online, including coal-to-olefins (CTO), coal-to-monoethylene glycol, coal-to-methanol, and coal-to-ethanol facilities. Among these, the most prominent is CTO. Currently, three CTO plants and three merchant methanol-based methanol-to-olefin (MTO) plants are in operation, representing 2.7 million tons per year of olefin capacity. A further 19 projects are under construction, and by the end of 2018 total olefin capacity from coal and merchant methanol will reach 19 million tons.

IHS Chemical has studied China's coal chemical development and concluded that its CTO plants can be very cost competitive if they are located in its coal-rich northwest region. However, a looming constraint on the growth of the coal chemical industry is its reliance on water, which is in short supply in China's northwest. A 600,000-ton CTO plant consumes 20 million tons of water per year. The same plant emits 8.5 million tons of CO_2 annually. It is likely that issues around water supply and carbon emission will limit the total coal chemical capacities installed in China.

A second significant development in unconventional feedstock-based chemical production is PDH, which uses liquefied petroleum gas (LPG) to produce the light olefin propylene. Propylene, in turn, is used to produce both specialty chemicals and polypropylene, the latter utilized in a wide range of globally traded products, including packaging and textiles. Until now, olefin supply in China has been dominated by three state-owned companies. With one PDH plant in operation and 18 others under planning or construction, by 2017 propylene capacity from PDH is forecast to exceed 7 million tons. By 2018, ethylene and propylene capacity from CTO, MTO, and PDH will account for nearly 40% of the country's olefin capacity (see chart).

Unconventional ethylene and propylene capacity to comprise 39% of China's olefin production by 2018



Source: IHS

The major constraint on PDH development is feedstock availability. China relies heavily on imports of LPG, or propane. As LPG-based ethylene crackers under construction in the Middle East and PDH projects being built in North America begin operations, global LPG supplies are likely to tighten. The resulting rise in LPG prices is expected to disadvantage Chinese PDH operators.

While Chinese producers of unconventional feedstock-based chemicals face a number of challenges as their operations ramp up, this emerging sector is nonetheless poised to play a growing role in both the Chinese and global chemical markets.

By Paul Pang, vice president, IHS Chemical, and managing director, IHS Chemical China

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bit.ly/PaulPang

For more information on China's coal chemical market, visit ihs.com/Q12CoalChem

Cloud computing takes hold

While cloud-based services have been around for some time—web-based email and file storage, to name two—they are now redefining the information technology (IT) industry and the way companies do business.

"Cloud services" refer to any utility delivered over the internet—application, software, hardware platform or storage—for which the customer pays a user fee based only on the amount of services consumed. Outsourcing such functions to a cloud provider eliminates much of the need for companies to buy and install, maintain and upgrade hardware and software essential to business operations.

For smaller companies, forgoing the labor and capital required to build and maintain a datacenter is frequently an easy decision, as it frees resources to be used in other areas of operations. Increasingly, however, large companies with existing IT infrastructure are shifting to the cloud as well—not only for cost savings, but for the value-added services that cloud companies can provide (see chart).

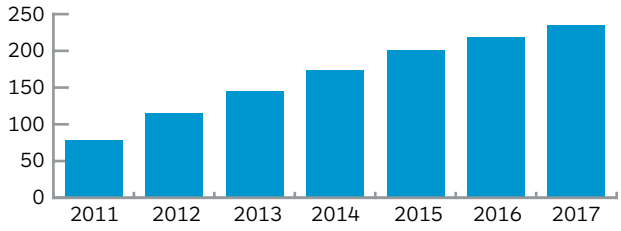
But it's about more than just contracting-out the IT function. As consumers become more connected across a range of devices and expect to interact with businesses in real time—and as devices begin to communicate with each other—companies are increasingly opting to use cloud services that provide the processing power, storage and syncing technologies to help foster these customer relationships.

A case in point is Netflix, which in 2010 migrated the hosting of its streaming services to a cloud to accommodate the surges in capacity it faces during peak viewing times. The move allowed the company to focus on its core competency—streaming movies and TV—rather than building new datacenters to handle spikes in bandwidth and a growing customer base.

Still other large companies are using cloud-based data analytics and delivery tools to facilitate proactive customer relationship management. A leading US drug store chain, for example, is developing a cloud-based application that sends consumers timely reminders on their smart devices to take their prescription drugs.

Cloud services growth is increasingly driven by large companies

Global spending on cloud infrastructure and services will triple between 2011 and 2017 (US$ billions)



Source: IHS

To be certain, migrating to the cloud requires risk and cost-benefit analyses. Businesses need certainty that critical information and intellectual property stored on cloud servers are protected against theft, viruses, and malware. Depending on their confidence as to the security of their data on a cloud server, businesses must then determine which applications to move and when.

While the expense and effort associated with migrating to the cloud will drop in the coming years, companies looking to gain a competitive edge are already experimenting with cloud services. Most are adopting a phased approach comprising:

- Building new applications in the cloud
- Augmenting on-premises capacity with cloud storage
- Migrating existing applications to the cloud
- Moving their remaining services to the cloud

Businesses' growing needs for flexible, responsive technology infrastructures that promote engagement with customers are reshaping their operational models. For an increasing number of these companies, the way forward is clear—it's in the cloud.

By Jagdish Rebello, senior director, cloud and computing electronics, IHS Technology

ihs.com/experts/jagdish-rebello.aspx

linkedin.com/in/jagdishrebellophd

For more information on trends in cloud computing, visit ihs.com/Q12Cloud

Russia, China driving return to growth in global defense market

Global defense spending is forecast to increase 0.6% to US$1,547 billion this year, as expenditures in Russia and China help offset continuing cuts in the West. The growth is the first since 2009, following a period during which budgetary challenges prompted by the global financial crisis have seen military spending fall by 6.8% in real terms.

While the increase is a positive development for defense contractors, global spending is projected to contract again in 2015 before resuming sustained growth through 2020. US defense cuts continue to be the largest factor impacting global defense spending, with the Pentagon's budget expected to remain flat through 2018 as the US withdraws from Afghanistan and faces continuing pressure from Budget Control Act caps and sequester reductions.

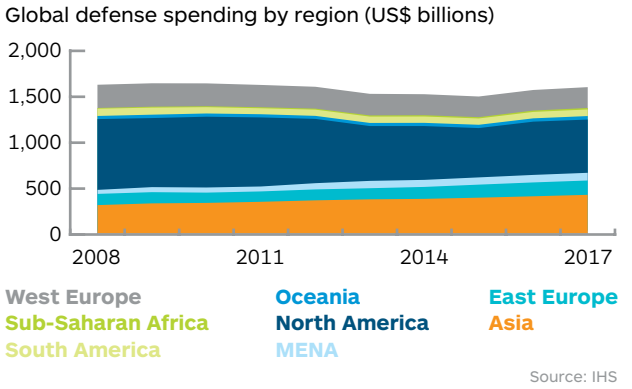
Defense budgets in the five largest Western European markets (UK, France, Germany, Italy, and Spain) decreased 1.6% in 2013 and are projected to contract a further 2.4% in 2014. The UK military budget, largest of the five, is forecast to dip 7.6% between 2013 and 2016.

While Western defense budgets continue to be scaled back, Russian defense spending, forecast to grow 13.5% in real terms this year, will help fuel the return to growth in 2014. Russia has more than doubled its defense budget in nominal terms since 2007 and will have tripled since that time by 2016. Moscow has now overtaken the UK and Japan to become the third-largest spender on defense globally.

The fastest-growing region over the past two years proportionally has been the Middle East and North Africa (MENA), which is projected to grow 3.5% in real terms in 2014. Of the world's 10 fastest-growing defense budgets in 2013, six were MENA countries, which now account for 7.8% of worldwide defense expenditure, up from 5.2% in 2008.

China and India continue to drive growth in defense spending in the Asia-Pacific region, which now accounts for 24.1% of global spending, compared with 20% five years ago. That share is forecast to grow to 28.5% by 2020.

As North America and Western Europe rein in defense spending, China, Russia and MENA nations ramp up



Source: IHS

IHS analysts estimate China's 2013 defense funding at US$131.7 billion, accounting for approximately 7.8% of global military expenditures. Despite the country's slowing economy, China's official defense budget forecast calls for strong growth in the coming years, with 2014's budget nearing US$140 billion. (For an analysis of China's defense strategy, turn to page 34.)

India's total defense spending grew 7.1% in real terms in 2013. IHS expects its defense budget to reach US$63.7 billion by 2020, by which time it will be the fourth largest global defense market.

By Paul Burton, content director of industry and budgets, IHS Aerospace, Defense & Security

ihs.com/experts/paul-burton.aspx

linkedin.com/in/paulburtonihsjanes

For more on global defense budgets, visit ihs.com/Q12Defense

Easing of sanctions boosts Iran's petrochemical industry

The US and European Union's partial lifting of sanctions against Iran represents a potentially important step toward eventually allowing foreign investment to return to the country's energy and petrochemical industries.

In exchange for Iran ceasing uranium enrichment beyond 5% potency, the easing of EU sanctions, from January 20, will allow the country to export petrochemicals and obtain insurance for shipped cargoes for six months while negotiators consider more permanent and expansive relief. In the meantime, many banking, financing, oil, and investment sanctions remain in force.

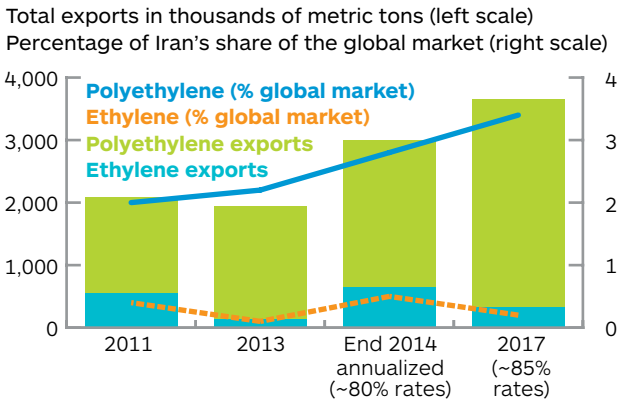
As with the rest of the Iranian economy, the country's petrochemical industry has been hurt by the trade restrictions. Ethylene exports were cut sharply from 2011 to 2013 as the inability of shipowners to secure insurance—or insurers to obtain reinsurance—for Iranian cargoes restricted bulk petrochemicals trade (see chart).

Trade in polymers and methanol has also dropped dramatically. Exports of methanol—of which Iran is a key supplier on the world market—have slumped almost 30% since their 2010 peak. This has led to a price disparity on the global methanol market between those regions, principally China and India, that have continued to import comparatively inexpensive Iranian methanol and the US, Europe, and non-China Asia—a disparity that would be expected to disappear as trade resumes in these other areas.

As Western insurers resume coverage of cargoes during the six-month window, Iran's chemical exports are expected to recover somewhat. But its government's plans to roughly double petrochemical capacity to 100 million tons per annum in the coming years face upstream and downstream hurdles.

While Iran's economy is likely to rebound modestly this year, little growth is expected in its largest petrochemical-consuming industries, including construction and agribusiness. If additional sanction relief is not negotiated, its export potential will continue to be weighed down by ongoing restrictions on Iranian financial institutions, prohibition of US firms' investment in Iran's energy sector, and slowing demand growth from China.

Lifting sanctions to spur Iranian ethylene and polyethylene exports



Source: IHS

In the long run, Iran's realization of its petrochemical ambitions hinges on its attracting capital, technology, equipment and construction expertise to build its natural gas infrastructure. Iran sits atop the world's largest reserves of gas, a key source of petrochemical feedstock; yet production fields such as the huge South Pars are producing at a fraction of their potential. Gas shortages, due to operations and infrastructure limitations, plague the country, with the recently bankrupted National Iranian Gas Company on occasion suspending supply to petrochemical complexes to keep homeowners warm.

Interim sanctions-relief measures will give Iran's petrochemical sector a needed boost. But broader relief from restrictions on Western investment in Iran are likely required if the country is to meet its longer-range production and export goals.

By Matthew Thoelke, senior director, IHS Chemical

linkedin.com/in/matthewthoelke

For more on Middle Eastern light olefins and derivatives markets, visit ihs.com/Q12Ethylene

LNG emerging as a viable future marine fuel

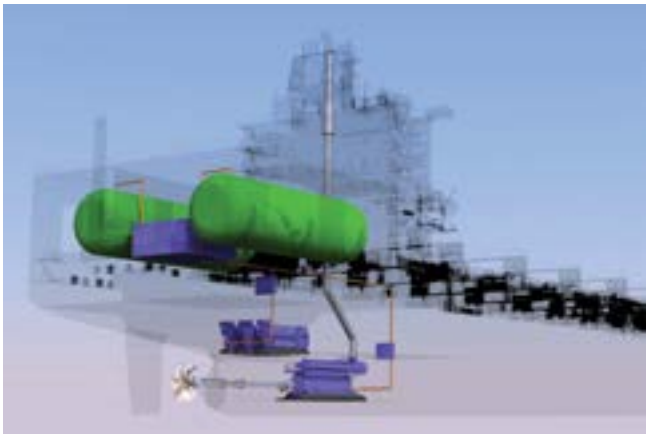
Ship operators are assessing their compliance options ahead of the adoption of stringent new emission regulations that come into effect in 2020.

Under the International Maritime Organization's (IMO's) MARPOL Annex VI, sulfur content of ships' emissions will not be permitted to exceed 0.5% in the open sea and as low as 0.1% in designated Emission Control Areas. Owners must choose from burning low-sulfur fuel, installation of scrubber systems, and use of liquefied natural gas (LNG)—the latter seen as an increasingly viable option.

Over most of the past decade, aside from large LNG carriers using their cargo boil-off, only small-scale examples of LNG-fueled ships have been observed, primarily in the Baltic region close to dedicated LNG supplies. Starting in 2011, however, a new market for larger LNG-powered vessels began to emerge:

- Marine equipment supplier Wärtsilä partnered with Tarbit Shipping to convert the 26,000-dwt tanker *Bit Viking* to LNG propulsion, leading others to consider this a viable fuel.
- In December 2012, TOTE became the first operator to order a gas-powered container ship, when it placed an order with General Dynamics' NASSCO yard for two 3,100-teu ships to operate on its Florida-Puerto Rico service. TOTE subsequently strengthened its commitment to gas by announcing the conversion of its two Orca-class ro-ros, which operate a truck service between Washington and Alaska.
- In January 2013, the 57,000-ton cruise ferry *Viking Grace* became the largest vessel (non-gas tanker) to be propelled by LNG, demonstrating that the technology works on a large scale.

But for LNG to become seriously considered as a marine fuel, infrastructure will need to be put in place globally. The bunker hubs of Singapore and Rotterdam have developed terminals that will make supply possible in the future. Already, United Arab Shipping Company (UASC) has ordered 16 ultra-large container ships designed to be retrofitted with gas tanks when that infrastructure is in place. But the market has yet to see the commitment to dedicated LNG bunkering tankers that will be crucial for supplying such vessels on a widespread basis.



Source: General Dynamics NASSCO

The challenge for ship operators that switch to LNG is where to put the tanks to minimize the loss of revenue-generating cargo space

Fuel storage is a second potential obstacle to LNG adoption, as in most instances fuel tanks will occupy valuable revenue-generating space. This is clearly evident in the TOTE container ship design, in which much of the stern hold capacity is lost due to the location of the tanks. In the case of UASC's container ships, a potential solution is the placement of the tanks in the void beneath the accommodation block, minimizing the loss of cargo-carrying space. A second potential retrofit solution, fitting Type-B prismatic tanks within the ship's hull, awaits the finalization of the IMO's International Code for Gas or Other Low Flash-Point Fuels (IGF Code), which is not set to be approved until November 2014.

The maritime sector has started to seriously consider LNG as a future fuel. If the IGF Code is finalized this year, and LNG bunker facilities developed at global hubs, larger ships with greater long-haul fueling requirements will be able to operate on gas.

By Krispen Atkinson, principal analyst, IHS Maritime

ihs.com/experts/krispen-atkinson.aspx

For more on marine bunker fuel, visit ihs.com/Q12MarineFuel

Thermal stress promises higher electricity costs

Extreme heatwaves, like those experienced earlier this year in Australia and across the US Midwest in the summer of 2013, place considerable stress on the electricity system. Sharp rises in temperatures boost power demands for refrigeration and air conditioning. Critically, thermal stress can also lead to a reduction in power supply at the very time it is most needed.

Rising ambient air and, particularly, water temperatures exacerbate these problems by reducing thermal power plants' cooling and production efficiencies. Water is an essential input for the cost-effective operation of such power plants. Once-through cooling (OTC) systems—of the sort employed in many coal and nuclear plants—extract water from rivers, lakes, seas, or oceans, circulate it through pipes to absorb the heat from the steam discharged from the generating turbines, and return the resulting warmer water to its source. As intake water temperatures rise and cooling-water discharge temperatures exceed environmental limits, plant shutdowns loom in areas of the world that regulate thermal pollution.

The efficiency of thermal power production in a steam-cycle turbine depends on pressure and temperature differentials that are greater when cooling water is abundant and available at consistently low temperatures. Here again, extreme heat waves and thermal stress undermine that consistency. A one-degree Celsius water temperature increase can reduce the thermal efficiency of some plants by as much as 2.5%. This leads to higher fuel consumption and increased generating costs for plant owners in the short term. Over the longer term, efficiency losses left unaddressed sow the seeds of power system instability.

When heat waves build upon rising ambient water and air temperatures, the implications for generating units and the wider power system that they support can be severe. At the grid level, the loss of available generation due to thermal stress translates into power price spikes. A recent example of acute supply/demand tightening occurred in the Australian state of Victoria in January 2014. After temperatures of 47°C (117°F) brought rapid electricity demand growth and the loss of generating capacity at the Loy Yang brown-coal-fired plant, power prices jumped 10 times their average level (see chart).

The electricity industry is already working to accommodate thermal stress. But these solutions come at a cost. For example, power-generating units can be retrofitted with supplemental cooling capacity to reduce the temperature of discharge water to comply with thermal pollution regulations. Likewise for new investments, dry or hybrid cooling systems that withdraw little or no water may avoid some of the efficiency and output losses associated with OTC systems under high water temperatures. Newer gas-fueled plants have greater thermodynamic efficiency—i.e. less need for cooling and lower water consumption levels—which make them preferable to nuclear or coal plants in the context of water stress.

The response to thermal stress is already bringing an increased focus on technologies that can reduce water withdrawal requirements and increase cooling efficiencies. These will be key factors shaping power sectors around the world in the years to come.

By Steven Knell, principal researcher at IHS Energy

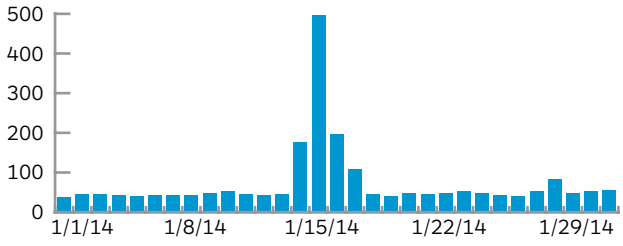
linkedin.com/in/stevenknell

For more on thermal stress and the risks to electricity generation, visit ihs.com/Q12Thermal

Is this the new normal?

A heatwave in Victoria, Australia, in January raised water temperatures, causing a 10X spike in electricity rates

Regional reference power price for the Loy Yang power plant (Australian $ per megawatt hour)



Source: IHS

Large platform supply vessels: Filling demand or building a bubble?

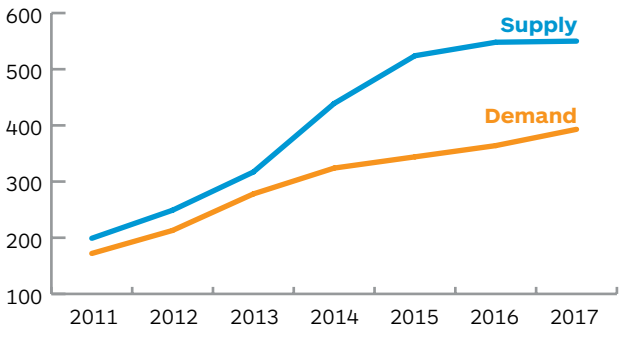
The offshore supply vessel market has undergone dramatic growth in recent years, particularly in the anchor-handling tug supply segment, with more than 700 new vessels joining the fleet since the start of 2008. But in the past couple years, focus and finance have swung toward the construction of platform supply vessels (PSVs) and especially the largest class, those with a deadweight of more than 4,000 metric tons (dwt).

Exploration in harsh and deepwater environments, including the Arctic, which takes place farther from shore and carries the increased need for conveyance of hazardous and noxious materials, supports the business case for building these large, high-technology vessels. Large under-deck tanking and increased deck area allow greater volumes of freight to be carried in a single trip, with dynamic positioning as standard and hybrid and diesel-electric power and drivetrains increasingly common. These new large PSVs are capable of transporting more and spending less time at the delivery location, with reduced fuel usage and lower emissions.

However, the number of these vessels being built and ordered far outstrips current demand forecasts. In early 2008, the fleet of PSVs of 4,000 dwt numbered just 126 vessels; by early 2014 it stood at 359 vessels. Shipyard orderbooks show a further 200 vessels scheduled to join the marketplace before the end of 2016, with 75 orders placed in the past year alone.

Supply-demand imbalance could cause problems in the large platform supply vessel market

The number of large platform supply vessels produced and ordered globally



Source: IHS

China and the United States are the two leading countries building these vessels. The build boom in the US is driven by Jones Act compliance and the need to replace older, smaller US-flagged tonnage that is unsuitable for deepwater work. Chinese growth, meanwhile, is driven by financing deals structured with a low initial deposit and full payment only on delivery, which may be encouraging speculation on the part of shipowners.

For shipowners, purchasing vessels in an oversupplied, but comparatively inexpensive, market makes long-term business sense—assuming sufficient capital costs are avoided up front and an eventual improvement in the supply/demand situation for vessels' services. In the short term, however, such a glut can curb day rates and profits.

And while long-term market trends support the need for high-capability supply vessels, current IHS demand projections indicate a looming surplus. The forecast for large PSVs shows a need for 75 additional vessels by the end of 2017, far fewer than the current supply scenario of more than 200 vessels.

So far, there has been strong uptake of large PSVs in the North Sea, and if owners are to avoid increased financial difficulties, they need this to be replicated in other growth regions around the world. However, that poses a conundrum as to what happens to the smaller, older tonnage in a maritime segment that has been reluctant to scrap vessels.

By David Hunter, senior analyst, IHS Energy

For more on the offshore supply vessel market, visit ihs.com/Q12Vessels

Holography: The next Big Thing in medical imaging

Holography is a hot topic in the technology sector, with many start-ups already demonstrating its potential use in telecommunications and entertainment. Yet it could have far-reaching impacts in other industries too, most notably the medical imaging market.

Holography is a technique enabling generation of 3D images that change as the position of the viewer changes, in the same way as if the object were actually present. A collaboration between imaging system vendor Philips Healthcare and holographic start-up RealView Imaging offers a glimpse into the technology's potential application in medical imaging. Admittedly, the system has been trialed only on small patient volumes in one hospital, but it is unique in terms of implication and timing.

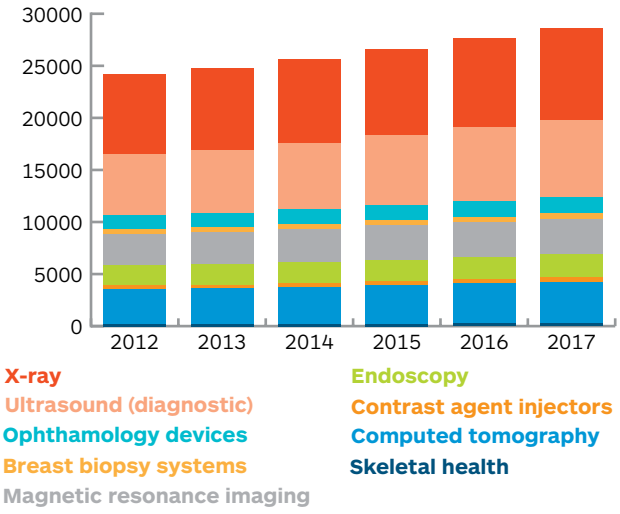
In context, innovation in the medical imaging market has been slow in the past five years, dogged by falling demand for cutting-edge technology from recession-weary markets in North America and Western Europe. Most new product releases have focused on one critical factor for healthcare: cost. This has resulted in a new generation of highly efficient, cross-application, low-cost imaging devices. While this is no bad thing for cash-strapped healthcare providers, the scramble to offer cost-effective solutions has stifled development of new technology and product innovation.

That may change, as trials have demonstrated how 3D images collected from an interventional X-ray system (provided by Philips Healthcare) and a "holographic video projector" (provided by RealView) produce a holographic video stream of the targeted anatomical structure. This allows physicians to view the organ from multiple angles and manipulate the holographic stream during a procedure, for example to test the fit of an implantable or guide-wire within the structure.

In principle, this development will have major implications for how surgical procedures are planned and conducted, as well as offer an entirely new field for diagnosis using holographic technology. Moreover, it serves as a reminder to the cost-conscious healthcare industry of the importance of investing and collaborating with new technology start-ups.

Will holography lift the growth rate in the medical imaging market?

Global revenues for medical imaging devices are projected to grow at 3.5% CAGR through 2017 (US$ millions)



Source: IHS

The IHS forecast for the medical imaging market predicts an average annual revenue growth of 3.5% between 2012 and 2017, mostly driven by demand from emerging cost-sensitive markets (see chart). While it is undoubtedly too early for holographic technology to impact this trend, it is expected to have a significant impact in the long term. For this to happen, however, vendors of holographic systems will need to adapt to the paradigm shift in healthcare provision and focus on answering four questions all health providers are sure to ask:

- Will it improve clinical outcomes and patient care?
- Will it improve procedural efficiency?
- Will it save money in the long run?
- How much does it cost?

By Stephen Holloway, associate director of medical device and healthcare IT research, IHS Technology

bit.ly/steveholloway

For more on healthcare and technology, visit ihs.com/Q12Holography

Sub-Saharan Africa on the rise

Long on promise but short on results, sub-Saharan Africa is once again showing signs of strong economic growth and the emergence of consumer economies. Could this be Africa's century?

By Chris G Christopher, Jr and Samuel Champanhet

Shutterstock

As the United States and eurozone economies continue to struggle to achieve steady growth and the hype about the emerging markets turns to concern, many multinational corporations are evaluating sub-Saharan African economies for potential consumer markets, as well as sourcing opportunities. Although sub-Saharan Africa has not resolved such long-standing problems as political instability and corruption, the social and economic fundamentals in some of these countries are starting to change for the better.

Growth prospects for Africa's consumer markets

Recent evidence of the fragile predicament of emerging economies points to the end of the BRIC (Brazil, Russia, India, and China) "party." Meanwhile, the US economy is faring better than the northern tier of the eurozone economies, while in the southern tier, Portugal, Italy, Greece, and Spain have serious economic downside risk. Many emerging, as well as advanced, economies are facing ageing populations, low fertility rates and, in the case of Germany and Japan, a shrinking workforce. (See feature on page 28 for more on emerging economies.)

In the midst of this weak economic performance and troubling demographic dynamics comes an interesting surprise: strong economic growth and improving socioeconomic conditions in sub-Saharan Africa. The improving social and economic fundamentals in many sub-Saharan African nations are at odds with the West's dated image of Africa and have placed the continent on many multinationals' radar screens.

In past years, much of the news from Africa, especially the sub-Saharan countries, has concerned political instability, the AIDS and HIV epidemic, famine, civil strife, and war. However, economic data suggests that conditions may be improving. IHS forecasts that between 2013 and 2017, sub-Saharan African economies are

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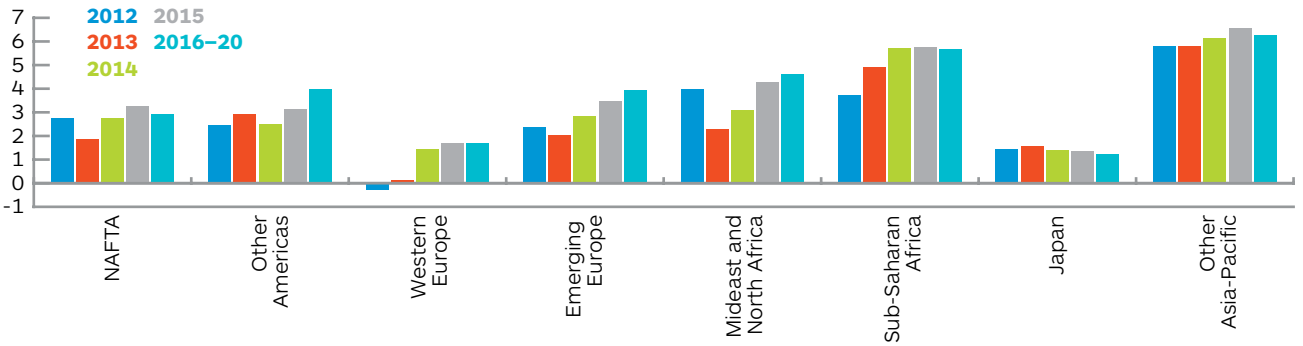
Nairobi, Kenya

Sub-Saharan Africa: A bright spot in the world economy

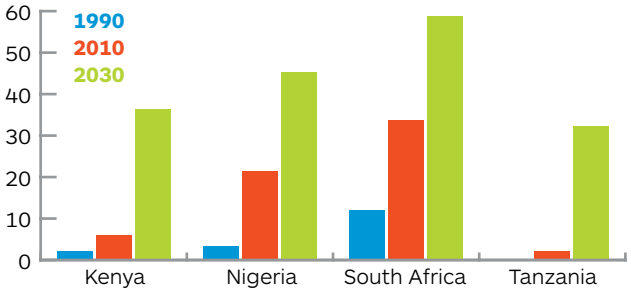
Between 2016 and 2020, sub-Saharan African real GDP growth is expected to outpace every major regional economic bloc, except one. Percent change in real GDP.



Source: IHS

Africa's improving educational standards bode well for economic development

Educational standards are rising in key African nations. Total enrollment in tertiary education, regardless of age, as a percentage of the total population of the five-year age group following secondary-school leaving.



Source: IHS

likely to outpace every major regional economic bloc, except China, in both real GDP and population growth. Indeed, real GDP growth for sub-Saharan Africa is likely to be 4.9% in 2013 and to average 5–6% annual growth between 2014 and 2022. In contrast, real annual GDP growth for the global economy is expected to be in the 2.5–3.9% range between 2013 and 2022. (See chart on page 15.)

Sub-Saharan Africa's demographic indicators are also improving: HIV infection and infant mortality rates are falling, while life expectancies are on the rise. During the past 20 years, infant mortality in the region dropped markedly, while fertility rates declined only modestly, leading to a baby boom in the region. Currently, 40% of the sub-Saharan population is 14 years old or younger. However, over the next 30 years, assuming fertility rates keep declining, the working-age population is expected to grow significantly faster than total population, setting the demographic pillar for an economic leap.

A concern is that sub-Saharan Africa's growing labor force is a ticking 'time bomb' that could be triggered by a lack of job growth. In 2012, while the world's unemployment rate stood slightly above the 9% mark, joblessness approached 14% in 11 of the most populous sub-Saharan African economies. More than half of all Africans aged 15 to 24 are unemployed, and 40% of working-age women are without a job. An increase in women's participation is widely considered a necessary driver of economic growth.

African nations have acknowledged that neither current growth rates nor political stability can be expected in the future without higher youth employment. In 2009, the leaders of the 54 member states of the African Union labeled the next 10 years as the "African Youth Decade," and issued a plan of action aimed at "accelerating youth empowerment for sustainable development," notably by reducing youth unemployment by two percentage points every year. On a positive note, the rapid increase in young Africans' education levels during the past 20 years might help bridge the current mismatch between demand and supply of qualified labor. (See chart on left.)

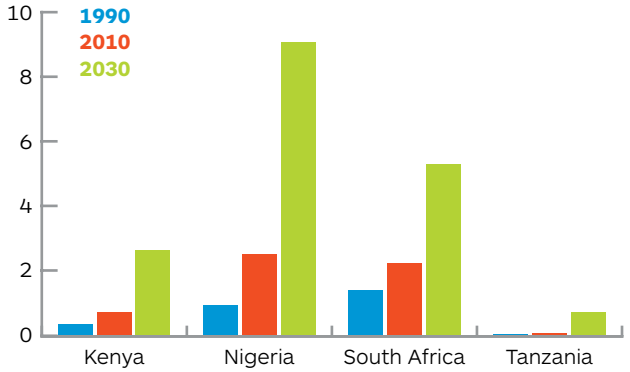
Commodity boom fuels growing middle class

From the late 1980s to the early 1990s, only about 5% of African nations were considered to be democracies; today, only a handful of the 55 African states do not have a multiparty constitutional system. On the heels of this political liberalization has come greater encouragement of foreign investment, mostly for commodity and mineral extraction, which has contributed to economic growth in the sub-Saharan African nations. (See feature on page 44.)

But there is more than just commodity extraction driving sub-Saharan Africa's growth. Consumer market opportunities have also emerged—largely as a result of the commodity boom. Robust growth in the number

Middle class on the rise in Africa

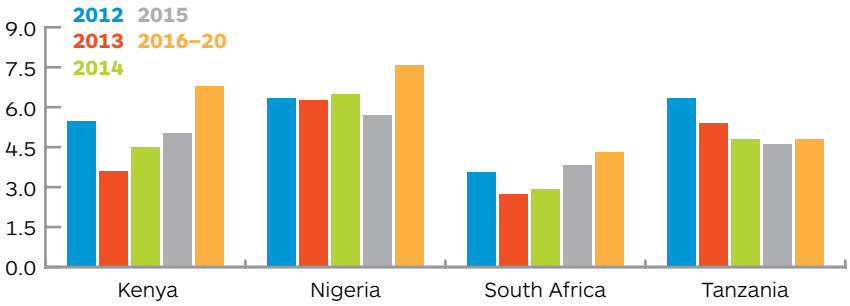
Millions of households earning between US$20,000 and US$80,000, in real 2005 purchase power parity US dollars.



Source: IHS

The boom in resource development is driving Africa's consumer spending

Real consumer spending in key sub-Saharan African economies will grow at a quickening pace toward the end of the decade. Annual percentage change of real consumer spending.



Source: IHS

of middle-income households is helping drive consumer spending at well over double the 1.9% growth expected for 2013 in the United States. During 1990–2012, the number of households earning US$20,000–80,000 a year increased faster in 11 of the most populous sub-Saharan African economies than in Brazil and Russia. (See chart on left.)

Beyond commodity-driven economic growth, reduction in income inequality, increasing job stability, and increasing education levels have also fueled the expansion of Africa's middle-income class. The growth of this segment means that many African households have gained the ability to own a car, buy their first refrigerator, or send their first child to college. Many more Africans are purchasing their first television or cell phone, or are starting to utilize consumer conveniences such as disposable diapers. (See chart above.)

The rising middle-income class has repercussions beyond the consumer goods industry. Middle-income consumers are more likely to buy their home, save more, put their children in private schools, and purchase health insurance. This new-found middle class is bound to have a profound impact on future international trade and investment patterns and should also reduce the external dependency of Africa's economies.

The big 'ifs'

There are several caveats to keep in mind when describing sub-Saharan Africa as the 'new' emerging market of the 21st century. Several decades ago, the outlook appeared to be similarly promising, as several African nations—Cameroon, Côte d'Ivoire, Ghana, Kenya, and Nigeria—entered the international economic community only to suffer financial contraction and tremendous political instability. Sub-Saharan Africa is still plagued by poor infrastructure, a high percentage of its population in poverty and, in many nations, fragile economic and political fundamentals and ethnic tensions. Sub-Saharan Africans still spend approximately 40% of their consumer outlays on food, and local economies are only a drought or rapid increase in world food prices away from devastation.

Still, with the region's robust population growth, high fertility rates, new consumer market opportunities, and the beginnings of a new middle class, there is reason for optimism. As Africa's economies develop, more companies are starting to consider sourcing raw materials and finished goods from the continent. The region should be carefully monitored and evaluated against others such as China, which it lags well behind, especially in per-capita terms. Nevertheless, it boasts considerable potential as a growth market.

Chris G Christopher, Jr is director of US Macroeconomics and Global Consumer Markets, IHS Economics.

Samuel Champanhet is senior economist for Global Consumer Markets, IHS Economics.

www.ihs.com/experts/chris-christopher.aspx

For more on this topic, visit www.ihs.com/Q12AfricaRising

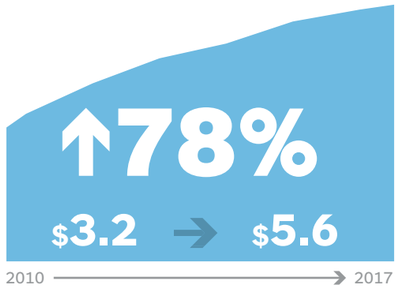
Where's the car going?

The auto industry's three big challenges: CO_2 emissions standards, integrating new technology and balancing global production.

TECHNOLOGY

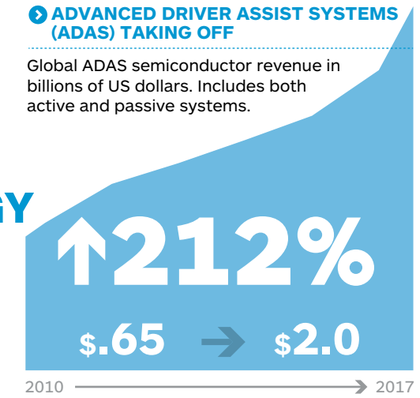
RISING DEMAND FOR HIGHER TECH INFOTAINMENT SYSTEMS

Global infotainment semiconductor revenue (OEM market only) in billions of US dollars.



ADVANCED DRIVER ASSIST SYSTEMS (ADAS) TAKING OFF

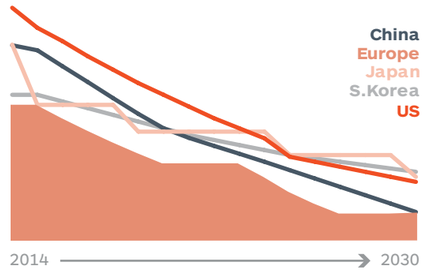
Global ADAS semiconductor revenue in billions of US dollars. Includes both active and passive systems.



EMISSIONS

THE BIG CHALLENGE AHEAD FOR AUTO MAKERS

CO_2 reduction targets measured in grams per kilometer, normalized to Europe's NEDC Test Cycle.

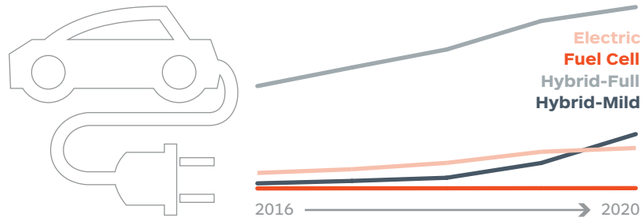


Percent of CO_2 reduction required by 2020

Percent of CO_2 reduction required by 2025

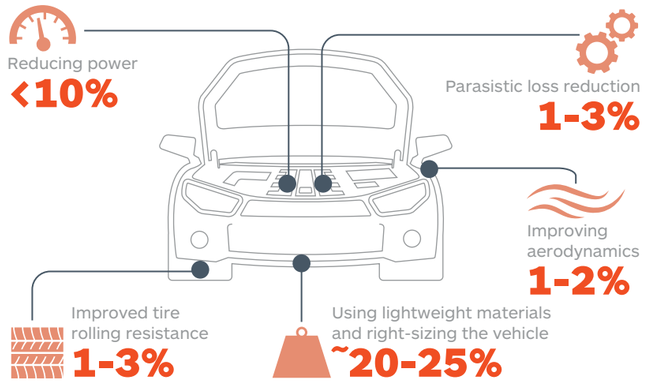
FOUR POWERTRAIN OPTIONS TO REDUCE CO_2 EMISSION

Full hybrids are leading the way. Millions of vehicles produced worldwide.



FIVE WAYS TO IMPROVE FUEL CONSUMPTION

Estimates of potential gains in fuel efficiency from new technologies.



SUPPLY & DEMAND

BIG GROWTH AHEAD FOR AUTO MAKERS IN EMERGING MARKETS

Percentage change in annual production volume and sales of light vehicles by region, 2014 to 2025.

PRODUCTION SALES

	PRODUCTION	SALES
WORLD TOTAL	30.3%	32.6%
NORTH AMERICA	9.7%	5.5%
SOUTH AMERICA	50.8%	47.7%
MIDDLE EAST/ AFRICA	44.4%	36.2%
EUROPE	21.1%	25.7%
JAPAN/ KOREA	-7.2%	-7.9%
GREATER CHINA	48.6%	46.9%
SOUTH ASIA	83.3%	88.4%

Sources: IHS, International Council on Clean Transportation (CO_2 reduction targets)

Big (data) insights

Big data, small data, structured data, unstructured data. It's all necessary to answer critical questions and set business strategy. But data is just a raw material. The differentiator is the power of the tools and analyst expertise that, combined, creates true competitive advantage.

By John Larson

Data is unquestionably the primary business intelligence tool of global business; it offers a method by which companies can analyze the market and their position within it to develop informed strategies that will help them compete profitably. Companies have always collected data, and executives have always used that data to help them make decisions. But today managers are frequently overwhelmed with data. There is simply too much of it available to adequately process without advanced tools and methodologies. Organizations are struggling with how they can leverage this ever-increasing data flow to their advantage.

Indeed, the sheer volume of data available today enables corporate leaders to combine and analyze it in ways that produce new insights into markets, customers, and business strategies. Global corporations are pinning their hopes on the transformational opportunities that this big data can purportedly unlock.

Few would doubt that the collection and analysis of the vast quantities of data now available to companies is essential to effectively and competitively run many areas of business operations. However, producing value from such expansive and amorphous data sets can pose a serious challenge. Technology alone won't solve the problem. In fact, most failed data analysis efforts derive from one or more of these three strategic errors:

- The wrong question is asked.
- The wrong data is used.

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- The data is treated as part of a discrete project rather than as part of an ongoing process.

Executives must recognize—and avoid—these potential pitfalls if they hope to harness the full power of the data now available to them to help realize their business objectives.

What is 'big data' and why do companies need it?

The aforementioned strategic errors stem, at least in part, from a basic misunderstanding of the term 'big data' and what companies should do with it. The term came into vogue so quickly that many don't know what it encompasses. One familiar definition cites the 'four Vs': volume, variety, velocity, value. While descriptive, however, this alliteration doesn't address how big data should be integrated into the analysis process.

Indeed, there are valuable insights to be gained from a range of data, both big and small. The key is to utilize the right set of data that captures the complete picture and provides insights that were formerly not apparent. This includes "differentiated data" that is typically found outside one's organization. It is typically third-party or proprietary data that fills the gaps in the understanding of a trend or market.

Of course, data analysis involves more than just data. It requires the appropriate industry expertise, analytical models, and enabling tools that must be integrated into a solution that surfaces specific actions and informs key decisions. Here, perhaps, is a more useful definition that captures the role of big data in the analysis process:

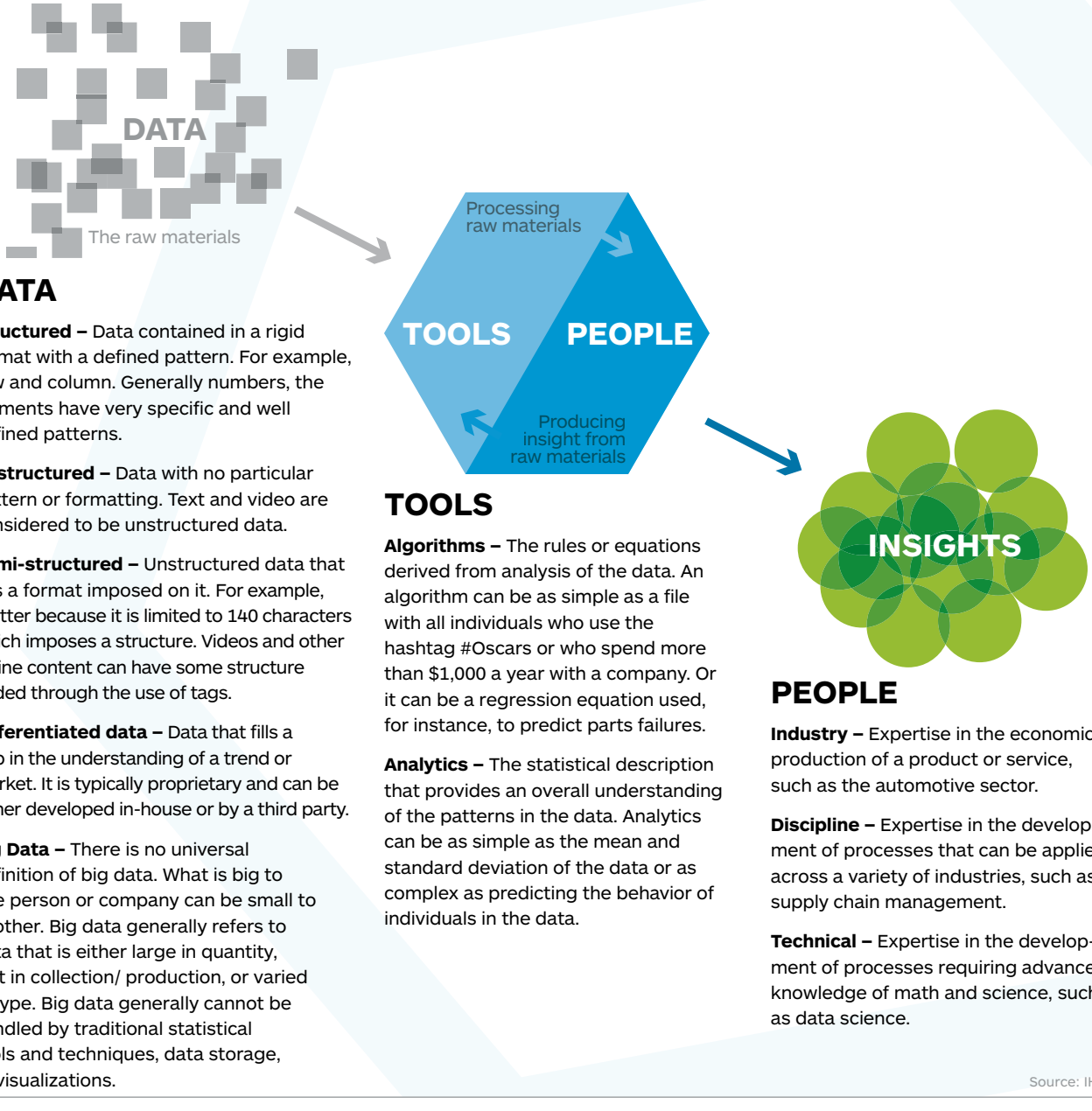
True big data analysis gives context to a complex set of information; applies sophisticated analytics that transform the information in ways that answer important questions on demand; and highlights new insights yielding critical information that informs big decisions and strategy.

This "complex set of information" typically relies on a large amount of data but it can also include small bits of data, discrete information sets, high-value differentiated data, and industry knowledge drawn from a number of sources. Companies are no longer limited to just curating information in their structured databases. Data can come from many places, such as videos or social media snippets, and can be structured, as in the information found in traditional databases, or semi-structured, such as Twitter data.

As we increasingly use digital devices to conduct business, access information, and interact socially, we ourselves are becoming data agents—generating previously unfathomable volumes of information regarding our activities. And the emergence of connected devices, often referred to as the Internet of Things, will add even more usable data in the years to come. Indeed, there is a full spectrum of data, from small to large, both structured and unstructured, each type of data playing a critical role in helping answer the questions we dare to ask.

Data collection is just the first step in the process of utilizing data to help inform business strategy. Effectively analyzing that data involves guidance and knowledge from the right people (industry experts and

The three ingredients for big insights



DATA

Structured – Data contained in a rigid format with a defined pattern. For example, row and column. Generally numbers, the elements have very specific and well defined patterns.

Unstructured – Data with no particular pattern or formatting. Text and video are considered to be unstructured data.

Semi-structured – Unstructured data that has a format imposed on it. For example, Twitter because it is limited to 140 characters which imposes a structure. Videos and other online content can have some structure added through the use of tags.

Differentiated data – Data that fills a gap in the understanding of a trend or market. It is typically proprietary and can be either developed in-house or by a third party.

Big Data – There is no universal definition of big data. What is big to one person or company can be small to another. Big data generally refers to data that is either large in quantity, fast in collection/ production, or varied in type. Big data generally cannot be handled by traditional statistical tools and techniques, data storage, or visualizations.

TOOLS

Algorithms – The rules or equations derived from analysis of the data. An algorithm can be as simple as a file with all individuals who use the hashtag #Oscars or who spend more than $1,000 a year with a company. Or it can be a regression equation used, for instance, to predict parts failures.

Analytics – The statistical description that provides an overall understanding of the patterns in the data. Analytics can be as simple as the mean and standard deviation of the data or as complex as predicting the behavior of individuals in the data.

PEOPLE

Industry – Expertise in the economic production of a product or service, such as the automotive sector.

Discipline – Expertise in the development of processes that can be applied across a variety of industries, such as supply chain management.

Technical – Expertise in the development of processes requiring advanced knowledge of math and science, such as data science.

Source: IHS

analytical specialists) armed with the appropriate tools (platforms and analytical models) that can 'connect the dots' between seemingly unrelated phenomena. In our highly interconnected world, competitive advantage comes not only from the speed with which data can be analyzed, but also from how effectively the barriers between different types of information can be broken down to help establish the big picture and provide big insights. (See chart above.)

Big data produces new information that unleashes the power of modeling. The ability to develop models based on all the data—the entire population rather than just a sample—empowers analysts and greatly enhances their predictive ability. With a sample, analysts must make difficult assumptions that may or may not be correct. Big data offers insights into what is truly occurring because it is drawing from a complete set of actual data. That data tends to be contemporaneous—it is generated and analyzed in near real time and so reflects the state of the world now rather than several weeks

or months ago. Importantly, this analysis leads to entirely new information that businesses can use to make faster, better decisions that lead to competitive advantage.

Best practices for big data

Big data analysis requires adherence to a disciplined approach to ensure the process results in clear and actionable insights. This approach can be captured with three core best practices:

1. Ask the right question, clearly

This practice may seem obvious. Nevertheless, failure can often be traced back to a bad or unclear question. The data may be correct and the analysis flawless but, if the issue under analysis is poorly defined and the query off-base, the answer suggested by the analysis may not be what the company needs to know or act on. To ask the right question, managers are well advised to employ experts with a deep understanding of the company's industry and markets—and often related industries as well. Also needed are analysts who understand the data and analytical tools in the context of specific industries and markets and who ultimately can translate data into clear insights for industry executives.

While on the surface it might seem that a simple question will result in a simple answer, the process is often more complex. For example, the Panama Canal Authority (ACP) started out wanting to know how the expansion of the canal would impact its revenues. Ultimately, a series of interdependent questions emerged that broadened the analysis. If the ACP had simply built a model to forecast revenue based on historical trends and relationships, it would have missed important nuances about dynamic shifts in global trade, some of which could significantly impact the canal's competitive position in the market. (See sidebar on page 24.)

2. Look beyond your own horizon

We live in an increasingly interconnected world. Markets, technologies, and industries across the globe are converging. Aerospace suppliers now compete for critical parts and equipment with suppliers to the automotive and maritime industries. Consumer preferences in the mobile media market are now shaping the development of technologies in the automotive sector. The greatest power of big data comes from its ability to integrate information from a multitude of sources, allowing organizations to see the big picture and form insights never before discernible.

But to tap this power, companies need to look beyond themselves and their immediate market. That means identifying and using data from sources outside the company and perhaps outside the industry. In a dynamic, global economy, businesses cannot rely on extrapolations of the past to predict the future. Industry experts who understand emerging trends and can help adjust a mathematical model to ensure greater forecast accuracy must be relied on.

In the case of the ACP, it brought together more than 30 experts from across many industries and disciplines, including trade and transportation, maritime, energy, chemical, automotive, and economics, to construct detailed

(*Continued on page 27*)

In our highly interconnected world, competitive advantage comes not only from the speed with which data can be analyzed, but also from how effectively the barriers between different types of information can be broken down to help establish the big picture and provide big insights

Ask the right questions

The Panama Canal Authority's (ACP's) use of big data illustrates how applying best practices can ensure better results.

The authority originally wanted to project how the upcoming completion of the canal's expansion would change its market opportunity. The ACP already collects data on the nearly 11,000 ships that pass through the canal each year. It knows how changes in the number of ships are likely to impact revenue based on this historical data. However, a US$5 billion-plus expansion expected to be completed in 2015 will widen the canal significantly, allowing much larger ships to pass through. Historically, it could handle ships 106ft wide and 965ft long (32m x 294m). After the expansion, it will be able to handle Supermax ships measuring 160ft x 1,200ft. The number of containers each ship can carry is expected to almost triple from 4,800 to 12,500.

Analysis of this data is vital to the canal's operations and revenue generation potential. The Panama Canal is a key trade link between the Atlantic and Pacific and competes with numerous alternative water and overland routes, including the Suez Canal, transit options around Cape Horn, and other water-overland combinations. Shippers assess a variety of factors—such as bunker fuel costs, canal transit fees, port fees, and locations—when determining routing options, so it is imperative that the ACP has the right data and tools to maintain and expand its market share.

The ACP could have built a model taking the increase in ship size into account and melded it with historical trends. In fact, that was the initial approach. And the original question the ACP wanted to answer was: How will the canal's expansion impact its available market?

However, after expert analysis and discussion, the ACP realized that the picture was more complex and a much broader set of data needed to be brought into the analysis. It needed to connect the dots between developments around the world and take into account a variety of changes in global trade for goods and commodities. Quite simply, it needed to ask a new set of questions.

IHS helped the ACP build a meta-model and an interactive, inter-related framework. Experts were brought together with knowledge of trade and transportation, maritime, energy, chemicals, automotive, and economics. The model incorporated factors from various markets into the analysis and asked three questions instead of one:

How is the world's fleet evolving? This required information on both fleet size and vessel mix. The data gathered included how many ships there are by type, size, operating characteristics, and what goods they can carry. The compositional shift in fleet size and vessel mix are a function of numerous factors, including berthing options, the widening of the Panama Canal, how many ships are likely to be retired, environmental emission requirements, and how many new ships are expected to come on to the market.

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How will shifts in supply and demand for commodities impact shipping? This required information on commodity flows and how shipping prices may change. There are many factors that influence commodity flows, such as relative economic performance; how the oil and gas boom in the United States impacts shipping patterns for these commodities; understanding the growing trend to co-locate production facilities close to customers; and how likely emerging industrial and manufacturing locations, such as Mexico, will become major players in the global trade markets.

How will carriers optimize shipping methods and routes to minimize costs? This required in-depth understanding of voyage costs, including data on current and future transportation costs for trade lanes by origin and destination for ports throughout the world; the cost to operate each ship (fuel, crew, time, value of money, number of transit cycles) and the cost of other transit options, such as rail or pipeline, and other routing options such as Cape Horn.

The model that was developed to answer these questions can generate transits by vessel size and global trade lanes. It can also compare alternative shipping routes—Suez Canal, Cape Horn, and Cape of Good Hope—and estimate how they stack up in terms of cost and risk to the Panama Canal.

The ACP is using the model for market planning and budget projections, including setting rates for ships passing through the canal. It now has insight, for example, into how pricing might impact customers who are considering alternative trade routes or transit methods, such as rail or pipeline.

Taking the first step

When a company sets out to solve a business problem it must draw on the expertise and experience of many stakeholders and evaluate all possible sources of data. The first step in the process is critical.

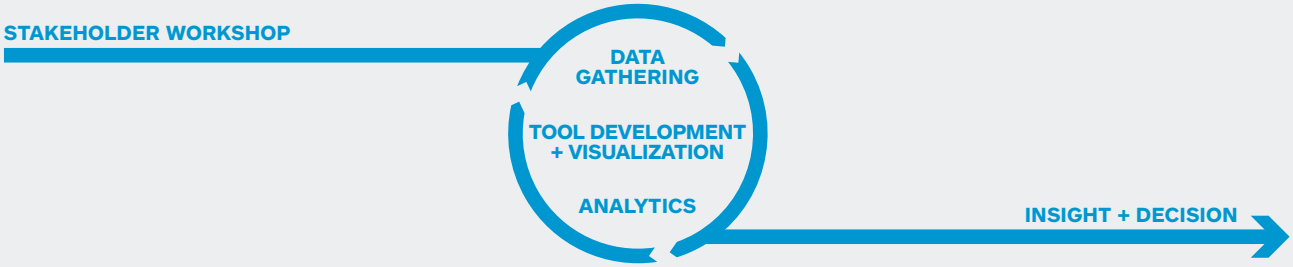
Working with the Panama Canal Authority (ACP), IHS convened a workshop of ACP representatives from each stakeholder group to discuss the challenge of accurately forecasting traffic through the canal. The goal was very specific:

1 – **Identify** the data needed for accurate forecasting.
2 – **Define** the analytics and models needed to extract insight from the data.
3 – **Develop** the tools and visualizations that communicated these insights.

A workshop leader moderated the discussion, asking stakeholders for information and insight, and drafting outlines and visualizations for participants to critique. The discussion allowed stakeholders to hear others' perspectives and build consensus. The result was a significant expansion of the type of data that was needed as well as changes in tool design, structure, calculations, and final visualization of the solution.

By having the group work together, new details of trade flows and canal operations came to light, resulting in a more robust model and more accurate forecasts.

From building consensus to making decisions



Source: IHS

CASE STUDY: PANAMA CANAL AUTHORITY

Gather the right data—big and small

The forecasts produced by the models developed for the Panama Canal that predict future trade routes require a wide range of data and a need to look beyond historical relationships between GDP and commodity tonnage shipped—the traditional key drivers of trade.

The map below offers an example of how important the inclusion of new data can be to "connect the dots" to reveal a more accurate story of traffic flow through the canal. In this case, the data has captured the unconventional oil and gas revolution in the United States. The map shows the annual shipments in metric tons of refined petroleum products passing through the Panana Canal from the Gulf of Mexico to Asia and the west coast ports of South America. The addition of the unconventional oil and gas data reveals a significant shift in market share forecasts that were not evident within the GDP and commodity data.

The 2009 data shows the historical values of trade without factoring in the production of unconventional oil and gas in the United States.

By 2013, as unconventional oil and gas data is incorporated into the analytical mode, the trade tonnage for refined petroleum products has shifted dramatically, increasing by 20% to Asia and 65% to South America. This rapid shift was driven largely by exports of diesel fuels, which is a direct result of the unconventional revolution in the US.

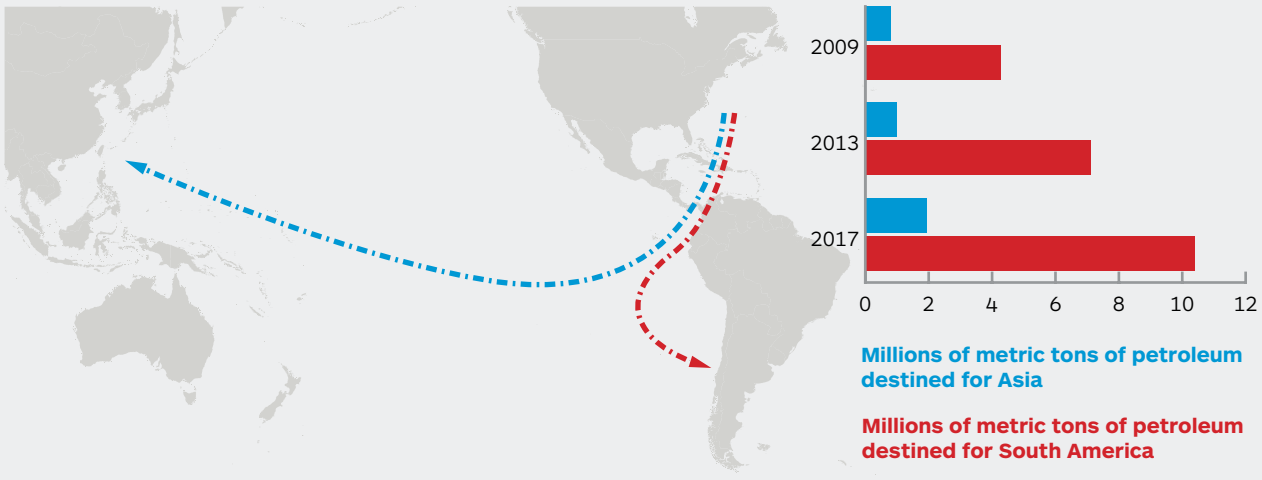
By 2017, the IHS outlook for the annual tonnage of refined petroleum products traversing the Panama Canal is forecast to increase by more than 140% compared with 2009. The rapid increase in forecast tonnage is based on data for well counts, production volumes, refinery capacity, and build-out plans to predict how production and, therefore, exports of refined petroleum products will impact tonnage traversing the canal.

The unprecedented growth of shipments to each destination illustrates the power of combining data from many sources with insight from industry experts on market trends to produce a model that provides insight beyond that which projections of historical trends alone can produce.

John Larson

The US unconventional oil & gas boom revealed growth opportunities for the Panama Canal Authority

Adding US refinery data into its model provided the APC with insight not captured in its traditional data sources. Annual shipments in metric tons of refined petroleum products passing through the Panama Canal from the Gulf of Mexico.



Source: IHS

models of trade flows by type of goods and commodities, type of vessel, and origin and destination of shipment. The models combined the canal's own data with other industries in ways they had never done before. For example, these models analyzed data on the boom in US natural gas production and uncovered new shipping routes and corresponding shipping requirements that historical trade data could not have projected. Among other things, they demonstrated that the development of capacity for 6.5 billion cubic feet/day of liquefied natural gas exports from the Gulf of Mexico to Asia would likely create shipping transits that they never expected for the Panama Canal. (See sidebar on page 26.)

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3. Big data analysis is a voyage, not a destination

In an increasingly volatile world, data changes quickly. Accordingly, data analytics needs to be an ongoing, iterative process. Economic and political environments change rapidly. Commodity prices rise and fall. Models need to be updated not only with the latest data but also the latest expert insights. Technology improvements may not only change a company's markets, requiring the updating of data, but may also impact the ability to analyze larger amounts of data. Significant ongoing investments in infrastructure may be required to guard the return on investment. Processes for regularly collecting and using the latest data should be in place.

Perhaps most importantly, data analysis should be a process of continual improvement and fine-tuning. It is imperative to learn from the past as well as to try to project into the future. Failures often offer critical insights that help make future efforts more successful. Comparing what the model predicted would happen with what actually happened provides the ability to adjust models as required. Continual refreshing of the data, models, and industry insight are critical to producing the best, most accurate projections which, in turn, provide the basis to make the best decisions.

Applying these three best practices will increase the odds that data analysis yields high-quality results—and that data analysts avoid making strategic mistakes by answering the wrong questions, getting waylaid by forces outside their own company or market, or hitting an unforeseen roadblock because of a failure to update information and fine-tune their analysis.

Big data is important but it is no panacea. It's just one type of data, albeit an important one, that is required to help companies understand the world and make informed decisions. Equally important are the years of accumulated wisdom from industry experts who ask the right questions, build the models, analyze the data, and interpret the answers to deliver the big insights.

John Larson is vice president of Big Data Analytics at IHS.

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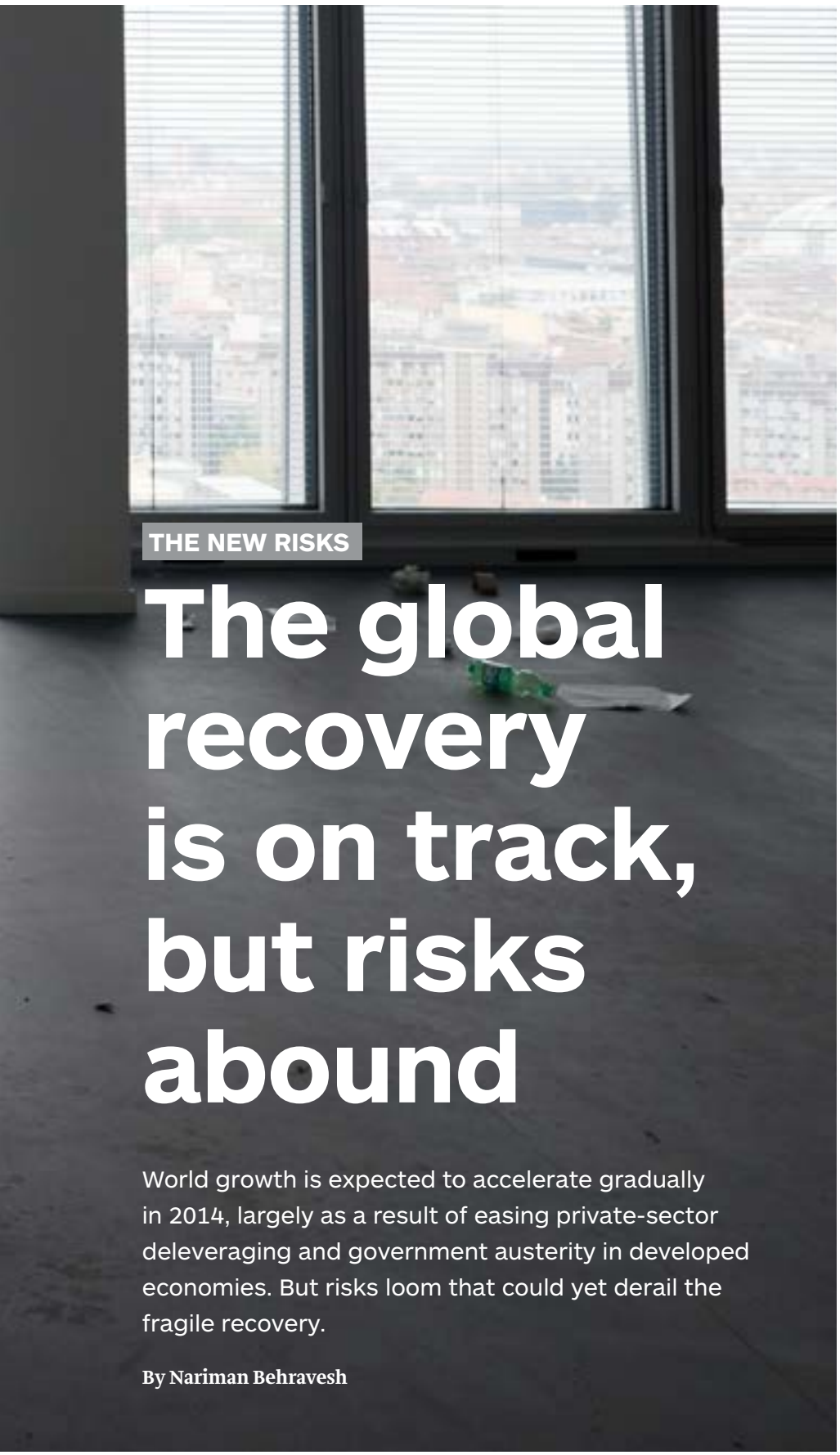


THE NEW RISKS

The global recovery is on track, but risks abound

World growth is expected to accelerate gradually in 2014, largely as a result of easing private-sector deleveraging and government austerity in developed economies. But risks loom that could yet derail the fragile recovery.

By Nariman Behravesh

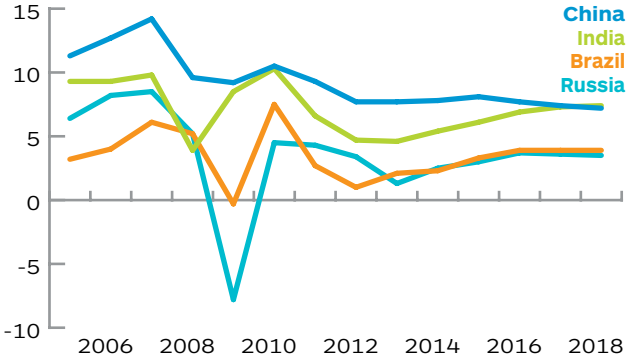
Global economic conditions are expected to improve modestly in the year ahead, as markets continue their bumpy rebound from the Great Recession. A somewhat mixed forecast will see slowed growth in emerging markets, including China, partially offsetting the gains expected in developed economies such as the US. However, a number of risks loom that, if realized, could yet dim the global economic outlook.

Potential concerns include an oil supply disruption and accompanying price spike; inflation rates approaching deflation in the developed world; and further reductions in capital expenditures. In addition to these known risks, there are also unforeseeable ones, such as those that have emerged in the wake of Russia's March intervention in Ukraine. The manifestation of any of these risks as a full-blown crisis could well trim global economic growth prospects for 2014 and beyond.

The good news is that global growth is expected to accelerate to 3.2% in 2014 up from 2.5% last year, and the world economy will finally shrug off its two-year stagnation. The irony is that the new locomotives of growth will be the advanced economies, including the United States, the United Kingdom, Germany, and possibly Japan. Meanwhile, average growth in the emerging markets, which fell from 7.3% in 2010 to 4.7% in 2013, will continue to disappoint in 2014. In the coming year, emerging markets will contribute the least amount to global growth since 2010, while advanced economies will see their strongest growth in four years, according to IHS estimates. (See figure on page 30.)

Emerging market growth is moderating

Annual percentage change in real GDP for the four largest emerging economies



Source: IHS

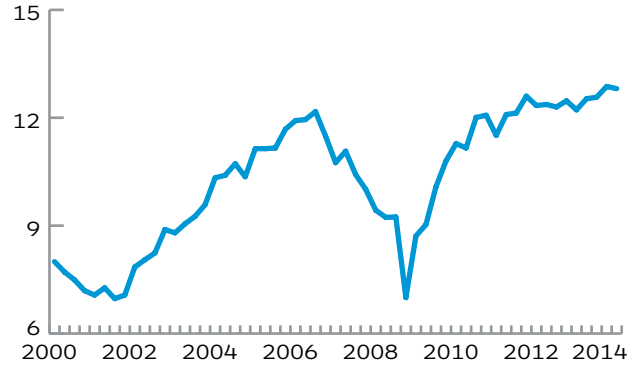
Notwithstanding this cautiously optimistic assessment, there are multiple risks that could bring about another year of sluggish growth—or possibly worse.

Corporate caution in the developed world

One of the unusual and troubling characteristics of the current business cycle has been the disconnect between profits and capital expenditures (capex). Profits and corporate cash as a percentage of GDP are at or near record highs in the developed world, whereas spending by businesses on physical capital has been extremely anemic. Lackluster topline growth and uncertainty about policy have been the major culprits. (See figure below.)

US corporate profits near all-time high

Ratio of monthly corporate profits to nominal GDP in percentage terms



Source: IHS

Since the end of the Great Recession, corporate profits as a percentage of GDP have risen in most of the world's advanced economies. This is not a new trend, but the continuation of a trend that has been in place since the mid-1980s. There are many reasons for the rise in relative profits. The principal long-term, structural driving force has been the plunge in the cost of computing, thanks to rapid advances in information technology which, in turn, have reduced the price of capital relative to labor. This trend has been reinforced by the fall in the effective corporate tax rate and the steady decline in borrowing costs over the past three decades in the developed world, with the notable exception of Southern Europe. To finance the shift from labor to capital, companies have boosted their profits and savings.

In stark contrast, real gross private nonresidential investment (non-housing capex) is barely above its 2007 peak in the United States and well below its peak in much of Europe. In past economic cycles, this strong growth in profits would have triggered a sharp rebound in capex. (See figure on page 31.)

There are five key reasons why this time is different. First, weak top-line growth and worries about the sustainability of the recovery are major factors. Massive public- and private-sector deleveraging has been a big drag on growth in the developed world. This has made companies extremely cautious. The sharp rise in profits has been almost entirely due to their laser-like focus on cost cutting and productivity improvements.

Second, the severe lack of credit availability in the past few years has made the financing of capex a major challenge and reinforced business risk aversion. This is a particularly big risk in Europe now.

Third, these trends have been more pronounced among publicly traded companies than privately held ones. For example, capex is approximately 7% of the total assets of private companies, versus 4% for listed companies. For obvious reasons, the latter are more focused on earnings per share than are the former. This can reinforce the bias in favor of cost cutting and efficiency over risky investments with longer-run payoffs.

Fourth, policy uncertainty has been a major factor in the current capex cycle. The toxic budget debates in Washington and the lack of clarity regarding which taxes might be raised and which programs might be cut have made strategic planning by corporations extremely difficult. Similarly, the protracted sovereign debt crisis in Europe has made businesses extremely risk averse.

Lastly, the regulatory environment has also become more onerous. Since 2009, the Dodd-Frank financial

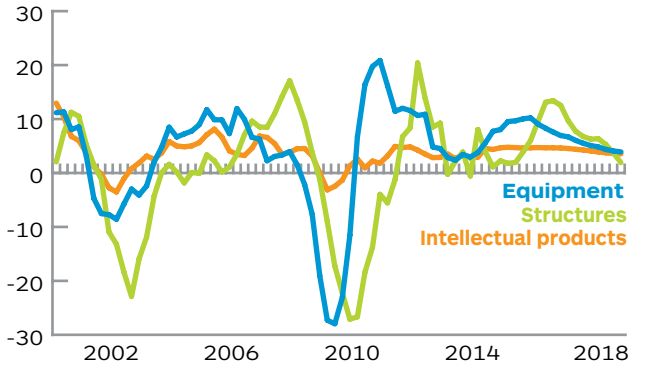
reform legislation and the Affordable Care Act (along with other regulatory changes) in the United States have raised corporate anxiety with respect to both their design and implementation. In Europe, the complex and sometimes contradictory energy and environmental policies have hurt competitiveness and become major headwinds for European businesses.

Threat of secular stagnation

Corporate caution has raised the specter of "secular stagnation," a concept that dates back to Karl Marx, who asserted that overproduction in capitalist societies would drive down the rate of return on capital and thus bankrupt the system. This concept was revived by Harvard economist Alvin Hansen in the 1930s. Hansen, a disciple of John Maynard Keynes, worried that too much saving and too little investment would lead to a permanent slump, the only cure for which was more aggressive fiscal stimulus.

Business investment will be slow to recover

Annual percentage change in United States fixed investment in 2009 US dollars



Source: IHS

Recently, some economists (notably Lawrence Summers of Harvard and Paul Krugman of Princeton) have taken up the banner of secular stagnation again. These new "stagnationists" worry that with short-term interest rates at the "zero lower bound," central banks have no room to maneuver. Moreover, with rates of inflation falling in the developed world and dangerously close to deflation, real interest rates are rising—further depressing capital spending.

Fortunately, the hypothesis of secular stagnation is belied by recent US data. Many of the trends that have worried analysts and policymakers in recent years—low rates of household formation, depressed birth rates, low levels of capital spending relative to GDP, and large numbers of long-term unemployed workers—have recovered and are on track to attain pre-recession levels in the next few years. Still, if US corporations retreat back into their shells, then another period of subpar growth cannot be ruled out.

Arguably, secular stagnation was a more apt description of Japan's economic circumstances until a year ago, when the government of Shinzo Abe began a series of aggressive stimulative policies. Until then, Japan's economy had suffered through two lost decades and persistent deflation. Part of the problem was the unwillingness of the Bank of Japan to expand its balance sheet and the monetary base. "Abenomics" has changed all that, with inflation rising and real interest rates falling over the past year.

A mild form of secular stagnation is also likely afflicting parts of Europe—especially in the south. Compared with the United States, Eurozone banks are less well capitalized, home prices in several key economies, including France, have only just begun to fall, and the demographic and growth outlooks are much less favorable. All of this hurts the prospects for capital spending. Just as crucial, the European Central Bank (ECB) has fallen "behind the curve." After expanding the monetary base from 2010 to 2011, the ECB has allowed this essential tool in its monetary arsenal to contract. This means that the risk of deflation in the Eurozone is higher than in the United States.

A lot will depend on what policymakers do next. In the case of Japan, Abenomics needs to "stay the course" to ensure that the improved economic prospects and easing deflationary pressures are a permanent part of the economic landscape. In Europe, where secular stagnation is a bigger risk, the burden is on the ECB to expand the monetary base again—aggressively—and prevent a dangerous drift into deflation. The United States probably has the easiest challenge. Given that the risks of secular stagnation are relatively low, the need for more fiscal stimulus is difficult to justify. By the same token, as the economy is beginning to show signs of life, any further austerity would be highly counter-productive. The implications for the Federal Reserve are also relatively straightforward. The decision to begin a gradual tapering of its bond purchases seems to be justified in light of improving economic conditions. But it is one thing for the Fed to take its foot off the accelerator in a measured way and another to step on the brakes. The latter should

not—and likely will not—happen until there is further evidence a sustained recovery is in place and the risks of deflation are fading.

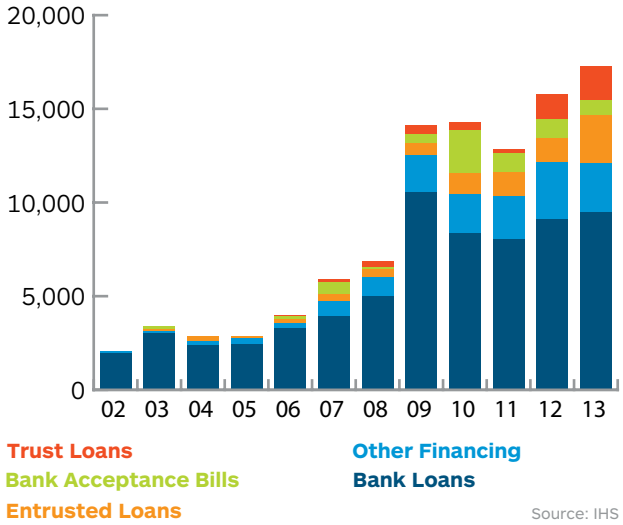
China's shadow banks pose a big risk

The proliferation of shadow banking activities in China continues to pose systemic risk and, as such, is set to become a key political priority in 2014 and beyond. A recent near-default case involving a CNY3 billion shadow banking product issued by China Credit Trust clearly illustrates the inherent risks and underlying interconnectedness within China's financial system. Rescue for the near-bankrupt fund stands at odds with authorities' increasingly clear preference to grant market forces a more decisive role in the economy.

While recognizing some justifications for the bailout, including higher pre-holiday market volatility and the pending release of new shadow banking regulations,

China's total debt on the rise

Total annual social financing in trillions of yuan. Shadow banking includes all categories except bank loans



Source: IHS

IHS considers this event a missed opportunity for the authorities to have shown clear commitment to restraining a prominent moral hazard and bringing shadow banking under greater control. Although there appears to be a general consensus favoring financial sector liberalization, the demand for cheap credit from powerful state-owned enterprises and well-connected local governments threatens to slow or block reform. Lower economic growth increases the latent risk from shadow banking while exacerbating the very high overall level of credit risk within China's financial system. (See figure above.)

Prior banking/debt crises in China have shaved about one-third off real growth rates over a five-year period relative to the prior five-year period. By a rough definition that would include 2009 or 2010 onward as a debt "crisis," Chinese GDP growth over a five-year period could drop by another 1 to 2.5 percentage points if the current banking/debt crisis deepens considerably. Single-year drops could be more dramatic, which could have serious ramifications for global growth.

Renewed emerging markets crisis

The fragile predicament of emerging markets came into sharp focus again in the early months of 2014. Weaker-than-expected data on the Chinese economy, expectations of further tapering by the Federal Reserve, and continuing fears about the precarious finances of some emerging markets caused a run on the Argentine peso, which in the end Argentina's government chose not to fight. The following week, Turkey was forced to raise short-term interest rates massively in an effort to halt the run on its currency. At roughly the same time, the central banks of India and South Africa also raised rates. Most of these countries now face stagflation—very weak growth and rising inflationary pressures—which is being exacerbated by market pressures and central bank actions.

The good news is that a repeat of the 1997–98 emerging-markets crisis is unlikely. The fragilities seem to be specific to a relatively limited group of countries, and there does not seem to be a systemic problem. Compared with the earlier episode, most countries have more flexible exchange rates, larger foreign exchange reserves, and healthier banks. Meanwhile, countries such as China, Mexico, South Korea, and Taiwan have not been hurt much by the recent market turmoil.

The bigger problem for the big emerging economies, including China, is that after having enjoyed a boom in the decade of the 2000s, there has been an alarming deceleration in the past four years. This has little to do with the "taper panic" that gripped financial markets in the spring and summer of 2013; the more daunting challenges facing most emerging markets are structural. The "BRICs party" of the 2000s was fueled by three global drivers: a credit boom, a commodities "super cycle" propelled in large part by China's double-digit growth rates, and "hyper-globalization" as multinational corporations expanded global supply chains.

All three of these drivers have lost their steam, leaving many emerging markets high and dry. Meanwhile, most of these economies enjoyed the boom without putting in place the structural reforms that would have improved their productivity, raised their competitiveness, and guaranteed a strong long-term trend in GDP growth. In fact, potential GDP in the emerging world is now growing at barely half the rate that it grew in the mid-2000s. Without major microeconomic reforms that would open up labor and product markets, reduce fiscal burdens, and lower unit labor costs as a result of productivity gains, a return to the "BRICs party" of the 2000s is unlikely.

Supply disruptions and the risk of an oil shock

Ongoing supply outages and the fear of further political instability in major producing countries are counteracting downward price pressure from the uncertain economic climate—especially in emerging markets—and the ongoing US tight oil production boom.

Geopolitical risk—especially within OPEC—will continue to preoccupy the market, as about 3 million barrels per day (mbd) of crude remains off the market. In Libya, the seizure of infrastructure by regional and tribal groups continues to shut in more than 1 mbd of production. In Venezuela, antigovernment protests underscore the risk that the country's economic and political climate will deteriorate further, possibly turning its production profile from sideways to downward. Talks for a final nuclear accord with Iran will be a tough slog. Meanwhile, Iran's oil production and exports are unlikely to increase appreciably. In Iraq, looming elections, political uncertainty and rising violence could disrupt the oil sector. Finally, renewed fighting in South Sudan threatens oil output. These and other factors suggest that any further disruption in oil supplies could begin to push oil prices back up again, threatening global growth.

And then there is Ukraine

The ouster of the pro-Russian president of Ukraine earlier this year and the subsequent annexation of Crimea by Russia have precipitated a geopolitical crisis not seen since the end of the cold war. IHS analysts assess that the most likely outcome of this crisis is a sustained standoff or a "frozen conflict"—a scenario in which Russia remains in control of Crimea but makes no further territorial incursions into Ukraine. This means that existing US and EU sanctions will remain in place, but there will be no further tougher measures. If, on the other hand, Russia does invade parts of Eastern Ukraine (motivated perhaps by clashes between ethnic Russians and Ukrainian nationals) then much tougher sanctions are likely to be implemented.

Ukraine's economy was already in very bad shape before this crisis, because of serious mismanagement. However, recent promises of aid from the International Monetary Fund and closer trade links to the European Union will likely provide some relief, though probably not enough to prevent a deep recession for Ukraine this year.

Arguably, the biggest economic loser from this crisis—even in a "frozen conflict" scenario—is Russia itself. Its economic growth last year was an already weak 1.3%. Investor sentiment towards Russia had already turned very sour, in large part because of Russian resource nationalism. And even though Russia has a current account surplus, its currency was hammered along with those of other emerging markets last spring and summer during the so-called "taper panic."

Russia's recent actions have exacerbated an already bad economic situation. The ruble is now one of the hardest hit currencies, as more investors have fled the market; stock prices have dropped precipitously; inflationary pressures are rising; and the central bank has been forced to raise interest rates. The crisis has also galvanized Western Europe to reduce its reliance on Russian natural gas—which currently supplies 30% of consumption—though such a shift will take time. This is very bad news for Russia, because natural gas exports account for about 40% of its total exports.

If the crisis escalates and Western sanctions become tougher, then the impact on the Russian economy could become quite severe, pushing it into recession. In such a scenario, European growth would also be hurt, which would be an unwelcome risk for the global economy.

Nariman Behravesh is Chief Economist at IHS.

www.ihs.com/experts/Nariman-Behravesh.aspx

For more on global economic risk, visit ihs.com/Q12Economy

The global implications of China's military modernization

China is flexing its military muscles, in large part to satisfy its insatiable demand for resources. The consequences and resulting competition with other nations will be felt far and wide.

By Tate Nurkin

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China's military modernization is integral to the country's ambitions to expand its global economic and political power. Already the world's second-largest economy—and forecast to become the largest by 2021—China sees its continuing growth and prosperity as being linked to its ability to secure energy and mineral resources, expand trade and access new markets.

Since embarking on its most recent modernization in the late 1990s, China has exhibited periodic provocative tendencies to challenge extant security arrangements, as well as maritime borders and boundaries, particularly in the South and East China seas. Moreover, it has been an occasionally destabilizing force beyond its region by exporting arms and technology to states under Western sanctions, such as Iran.

China clearly aspires to establish itself as the pre-eminent geopolitical, economic, and military power in East Asia, eventually expanding its ability to influence political and economic conditions; shape geopolitical competitions; and secure critical sea lines of communication on a much more ambitious geographic scale—from the Middle East to the eastern Pacific. Its pursuit and attainment of this goal are of interest and potential concern not only to the global aerospace and defense industry and national security communities in Asia, North America, and elsewhere, but to all companies with international business interests.

Risks of China's military modernization

On January 15, 2014, China's Ministry of National Defense confirmed in a press release that it had conducted a test of a "new ultra-high-speed missile delivery vehicle"—later confirmed by the US Department of Defense to be a hypersonic glide vehicle (HGV) capable of traveling between Mach 5 and Mach 10 and, once the technology is mature, enabling a kinetic strike anywhere in the world within minutes to a handful of hours. The HGV test was a direct response to the US Prompt Global Strike program and served as a signal of the steady and significant progress of China's ongoing military modernization program.

The investment is paying dividends for China's People's Liberation Army (PLA) and its increasingly capable indigenous defense industry, while also creating

new risks for regional security. These risks include proliferation of advanced military capabilities; exposing vulnerabilities associated with integration of advanced Chinese systems; and increasing competition in the global defense industry.

China's modernization effort began in earnest soon after the 1995–96 Taiwan Strait crisis, and has sought to achieve two objectives. First, China has sought to provide a specific set of linked, enhanced, and advanced military capabilities to the PLA Navy (PLAN) to deny access in the western Pacific to potential competitors during a crisis or conflict. In the short term, these capabilities are focused on controlling access to the Taiwan Strait or in the East or South China seas (the "first island chain," according to the US Department of Defense). During the next 10–15 years, the objective is for PLA forces to be able to operate freely out to Guam, the "second island chain". (See map on page 37.) In the next two-plus decades, China hopes to be able to leverage its modern military to more effectively project power and secure critical sea lanes from the Indian Ocean to the eastern Pacific.

China's anti-access/area denial (A2/AD) strategy, as it is called, has prioritized investments in a number of areas including: development of advanced missile technologies (including anti-ship ballistic missiles); launching a robust network of intelligence, surveillance, and reconnaissance (ISR) satellites designed to track the movements of surface ships and aircraft flying into the networked area; developing counter-space capabilities to disrupt potential-adversary ISR assets; and developing cyber capabilities to be able to deliver a massive, difficult to attribute (and therefore to deter), and highly asymmetric pre-emptive strike to debilitate increasingly networked advanced military forces. (See sidebar on page 41.)

China has also invested in tactical aviation, including developing two fifth-generation fighter designs, and strategic lift aircraft, which, along with an air-to-air refueling capability, is critical for China to effectively project power beyond Asia during the next two decades. China has also invested in naval assets, especially in its carrier fleet. A case in point is the *Liaoning*, which came into service in 2012, the first of a four-ship carrier fleet that IHS reported in February 2014. China has also invested in an enhanced submarine capability, amphibious assault ships, and improved surface combatants.

The second core objective of China's military modernization effort is to develop an indigenous defense industry that is self-sufficient in its ability to provide required PLA capabilities and can support expansion of Chinese influence through defense exports. Recent activity has been notable in key areas frequently seen as indicators of growing indigenous capability, including military aviation, shipbuilding, missile development, and space, where China has "enhanced its space-based ISR, navigation, meteorological, and communications satellite constellations" and improved its capacity to deny "the use of space-based assets by adversaries during times of crisis and conflict," according to a 2013 US Department of Defense report to Congress.

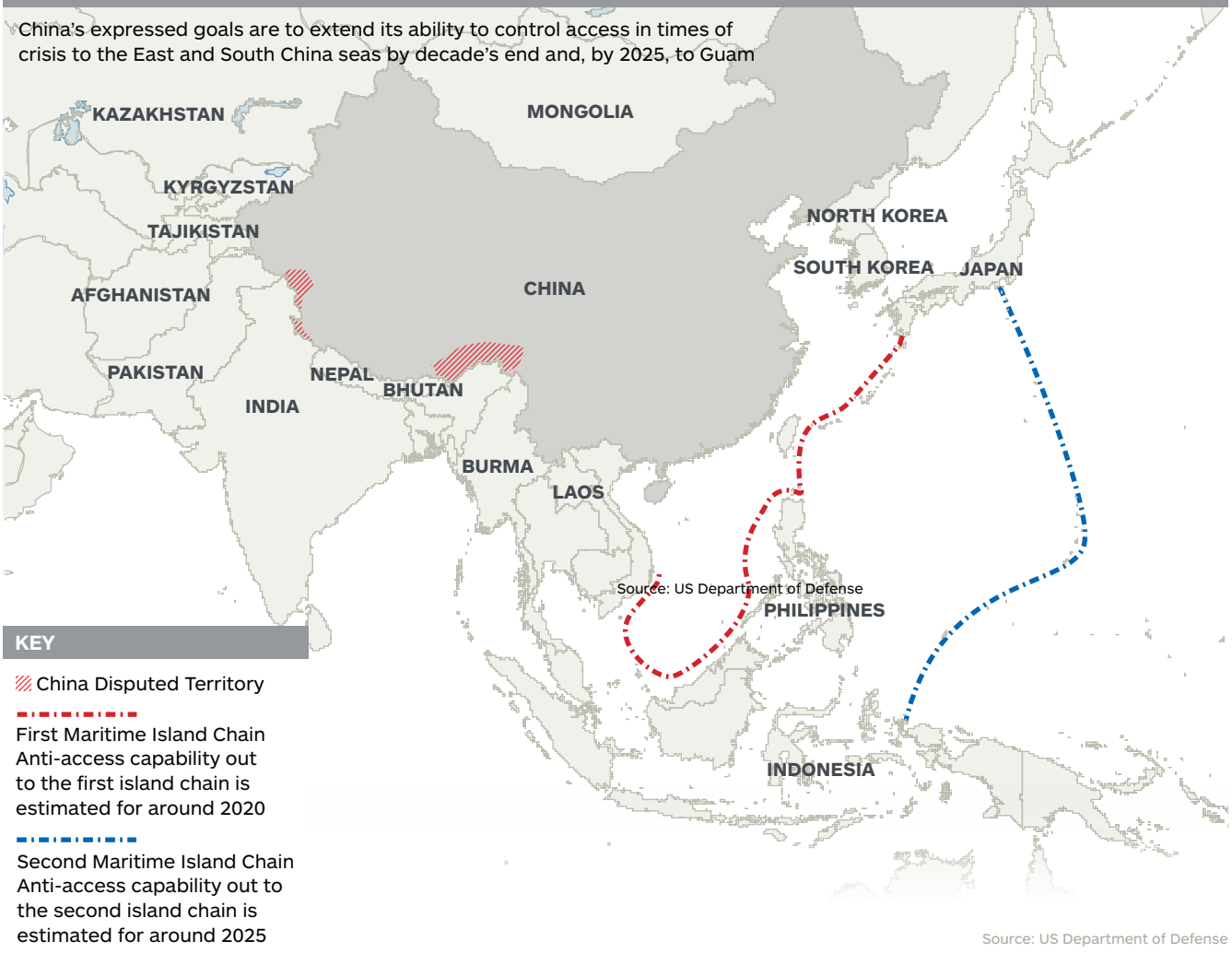
China's steady and significant modernization has been supported by increased investment—the official defense budget grew from $20 billion in 2000 to $148 billion in 2014 and is estimated to reach $189 billion by 2018—but actual spending is estimated to be at least 20% higher. This includes China's acquisition of foreign technology, and an impressive capability to reverse-engineer this technology to create indigenized versions of military platforms for internal use and export.

Indeed, China's reliance on foreign technology has diminished as indigenous capability has increased, but China still seeks foreign technology to fill capability gaps, particularly around engines, advanced radars, and guidance systems. Russia has been China's primary provider of military equipment, but even Russia has grown squeamish about continuing high-end military exports to China. This is evidenced by the protracted negotiations surrounding a deal for Russia to sell 48 advanced fourth-generation Sukhoi-35 fighters to China over concerns that, according to IHS, the aircraft's passive electronically scanned array radar and engine will be reverse-engineered by China. As a Russian industry representative said in March 2012: "Some of us would be happier if this deal with Beijing is just never signed because we know how it will end."

While China's A2/AD capability is not expected to reach full maturity for another decade or more, the competition between the development of these capabilities and US and allied development of enhanced power projection (P2) and territorial defense capabilities is accelerating. The military and geopolitical risks are becoming more evident as the rhetoric and territorial disputes in Northeast and Southeast Asia

China's military power marches eastward

China's expressed goals are to extend its ability to control access in times of crisis to the East and South China seas by decade's end and, by 2025, to Guam



Source: US Department of Defense

In the next two-plus decades, China hopes to be able to leverage its modern military to more effectively project power and secure critical sea lanes from the Indian Ocean to the eastern Pacific

intensify. While these risks tend to grab headlines, China's military modernization has also produced risks that are increasingly occupying the attention of defense industry executives and military and security planners throughout the world. Their concerns include increased competition from China in the next decade in the already savagely competitive defense export market; cyber risks associated with the integration of advanced Chinese systems into existing military frameworks; and risks associated with the proliferation of advanced military and dual-use technologies to and from China.

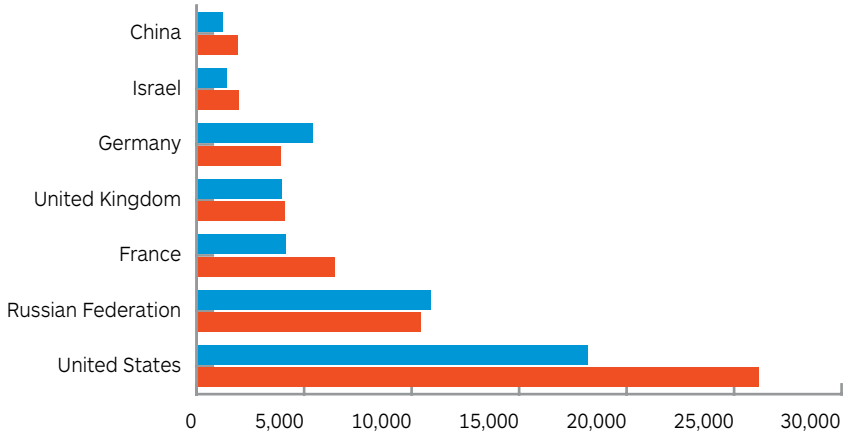
The competitive risk from China

China's defense exports have increased substantially in the past six years, from US$1.2 billion in 2009 to US$1.8 billion in 2012 and a slightly higher total of US$1.9 billion in 2013. As a consequence, China has moved up from the eighth-largest global defense exporter in 2012 to seventh in 2013, just behind Israel and surpassing Italy. (See chart on page 38).

While China's current exports constitute approximately 2.8% of total global defense exports, up from 2.1% in 2009—which IHS estimates its total exports to be

China is fast becoming a major player in the global arms market

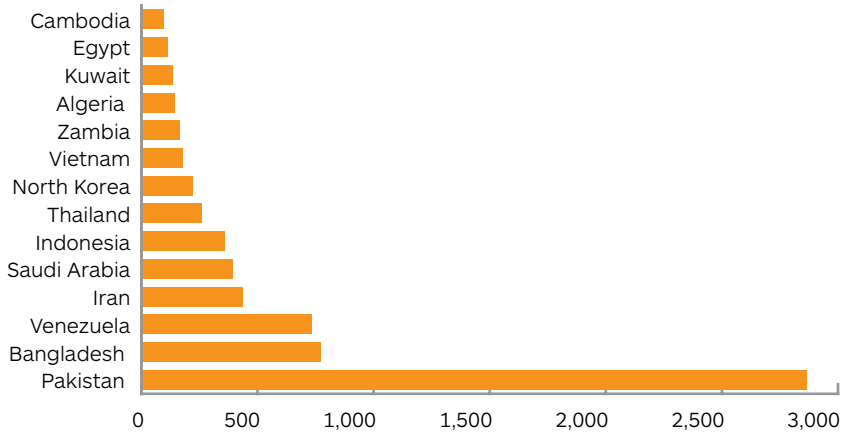
During the past five years, China's defense exports grew faster than any other major arms-exporting nation in percentage terms. Defense exports in millions of current US dollars by country for 2009 (blue) and 2013 (red)



Source: IHS

China is providing "good enough" weapons to emerging defense markets

To date, China's arms exports have gone largely to markets of secondary focus to Western defense industry and those under Western sanctions. China's exports by country in millions of US dollars, 2009–13



Source: IHS

just under US$70 billion in 2013—it is clearly very competitive with recognized Western defense exporting nations, such as Spain, Italy, Sweden, and Canada and is closing the gap on Israel, Germany, and the United Kingdom. This upward mobility and increased competitiveness as a defense exporter is likely to be sustained over the next five years and beyond and has positioned China to become a consistent competitor in the global arms market. Indeed, China maintains a backlog of orders estimated at around $11 billion, according to IHS.

China's export activity has focused primarily on secondary and tertiary defense export markets that are under US or Western export sanctions (Iran, for example) or simply cannot afford or do not need the most expensive Western and Russian platforms and systems. (See chart below left.) These markets seek to balance "good enough" military technologies with cost, forgiving payment terms and, in a growing number of cases, a strong desire to build or enhance indigenous defense industry through production work-share and technology transfer programs.

While many of China's export markets are not attainable or even desirable for the Western defense industry, there are some that are. China's ability to access these markets is of concern to Russian, Western and Korean defense companies because it comes at a particularly vulnerable time. The defense industry in the West, in particular, is already enduring home country budget cuts and political issues by seeking to navigate emerging markets in Latin America, the Middle East, and East Asia, including Saudi Arabia, Thailand, and Indonesia—all of which are significant export markets for China—as well as other "good enough" markets China is well suited to service.

This risk may well be set to intensify. In September 2013, the Turkish government announced it had selected China Precision Machinery Import-Export Corporation's FD-2000 air defense system as the winner in its T-LORAMIDS project to provide a long-range air defense capability that will operate within NATO's Integrated Missile Defense System. Turkey selected the FD-2000 over bids from Raytheon and Lockheed Martin; Russia's Rosoboronexport; and Eurosam, an Italian-French consortium.

The Turkish announcement was shocking, but clear: China's

offer beat the competition in terms of "price, technology, local work share, technology transfer, and credit financing terms," according to Murad Bayar, Turkey's Undersecretary for Defense Industries. These are all critical selling points for a Turkish government seeking both to save money—the FD-2000 bid was $1 billion less than the next-closest bid—and build its own indigenous defense industry.

Protests from US and NATO member states have delayed the deal, and when this article went to press there were signs that Turkey might in fact back down. Still, Bayar indicated in late 2013 that it could be signed by April 2014 and delivery of the system could occur by 2017.

If the deal is completed, the T-LORAMIDS procurement would be a bellwether deal for China. It would enhance China's credibility as a defense exporter and could indicate an intensification of the risk of China's military modernization for Western, Russian, and emerging Asian defense industries. The fear is that China will now be in a position to compete for sales in critical emerging markets and force China's competitors to adjust their export models by offering lower costs and better payment terms. In addition, Western defense companies may be forced to expand technology transfers to remain competitive in the sizeable "good enough" market.

Critically, though, China's state-owned enterprises will also accrue risk as they are exposed to a more diverse and sophisticated set of customers. China's defense industrial establishment will need to ensure that it is a good partner to its new customers and that it reliably provides the "value" for which these customers are looking. Initial research by IHS on China's export record indicates that China's 2008–10 exports to Latin America, in particular, but also to Southeast Asia, were plagued by issues pertaining to equipment quality, after-market support, and even concerns over China's ability to export critical components of finished platforms—such as Ukrainian engines on the Chinese VT-1A tank, which was scheduled to be exported to Peru in the early 2010s. Of course, China's is not the first nor will it be the last defense industry to struggle to deliver on proposal promises. Still, despite a notable focus on enhancing the buying experience, China risks a stunted emergence into the more advanced "good enough" markets it is targeting.

Integration and network vulnerability

The T-LORAMIDS deal also presents risks associated with the integration of Chinese systems into advanced militaries that are linked to critical military systems of other states, alliances, or partnerships. US and NATO objections to Turkey's decision not only to select the FD-2000, but also to integrate the Chinese system into NATO's Integrated Missile Defense System reflect deep and abiding concerns about the network security and cyber vulnerabilities arising from a Chinese state-owned enterprise having access to this critical system.

As seven US senators wrote to President Obama in October 2013: "We are concerned about the risk of third-country access

China's export activity has focused primarily on secondary and tertiary defense export markets that are under US or Western export sanctions (Iran, for example) or simply cannot afford or do not need the most expensive Western and Russian systems

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to NATO and US classified data and technology." Turkey claimed in November 2013 that it had developed a notional solution that would cut Chinese personnel out of NATO communications, but no technical solution is likely to fully alleviate the concerns surrounding Chinese access to NATO systems, given China's demonstrated cyber capabilities.

This specific risk is unlikely to be precisely replicated in the near future. Turkey is perhaps the only NATO ally that would consider acquiring Chinese military systems, although it is worth noting the expanding economic relationships between Western European states and China. However, the T-LORAMIDS deal is instructive of a category of potential risk that could result from the combination of increasing Chinese defense exports and cyber capability and the continuation of a recent trend toward new geopolitical, defense, and military relationships and evolving geopolitical competitions, particularly in the Middle East, where China, Russia, and even Western European powers have sought to enhance their geopolitical as well as defense relationships.

Proliferation and dual-use threats

China's military modernization has also generated intense concern, particularly in the United States, about the proliferation of advanced military and, significantly, dual-use technologies both to and from China. The importance of dual-use imports and the related difficulty in distinguishing between military and civilian activities in China's state-owned enterprises was highlighted in the US Department of Defense's 2013 Annual Report to Congress on China, which stated bluntly that: "China's defense industry has benefited from integration with its expanding civilian economy … particularly sectors with access to foreign technology." The report also noted that China's opaque corporate structures, hidden asset ownership, and the connections of commercial personnel with the central government, serve to obfuscate the true nature of commercial activities in industries related to military modernization, enhancing access to militarily relevant technologies.

The difficulty in controlling export of such items to China—despite the existence of export-control regimes—and the complexity of the geopolitical relations associated with these controls are highlighted by the late December 2013 resignation of Meir Shalit as the head of Israel's Defense Export Control Agency following the accidental re-export of an Israeli-manufactured miniaturized cooling device to China. The item, which is used in electro-optic systems and in missiles, was originally part of a licensed export to a French company but had subsequently been retransferred to China. The US expressed its intense concern over the incident, fearing that the item would have been marked for transfer from China to Iran—China has a history of ballistic missile sales to Iran—to support the development of Iran's ballistic missile program.

While Israel has complied with US export-control requests since the early 2000s, the issue is becoming more delicate as Israel seeks to

deepen trade relations with China, including establishing agreements to develop an alternative trade route between Israel and China that bypasses the geopolitically vulnerable Suez Canal. Israeli newspaper *Haaretz* reported in late December 2013 that Israeli defense and technology companies have started lobbying the prime minister's office as well as the economic and foreign affairs ministries to increase exports of defense and dual-use items to China, including currently controlled items, in response to growing market and economic pressures affecting the Israeli defense industry.

Even with export regulations in place, China has proven deft at acquiring advanced technology—including technologies undergirding US military modernization—to plug gaps, reinforce areas of relative strength, and better understand the platforms and systems that could be deployed against the PLA. Much is made of Chinese cyber and corporate espionage efforts but, during 2012 and 2013, China has complemented these efforts with a more transparent and direct approach to acquiring dual-use technologies, specifically through company acquisition.

IHS tracked two completed acquisitions in 2012 and five in 2013 in which Chinese enterprises acquired US or European aerospace companies with varying degrees of exposure to defense activities, including Chongqing Helicopter's purchase of Enstrom, a US manufacturer of commercial and military helicopters with sales to various Asian and Latin American militaries.

How military strategies translate

China's military modernization, which is focused on territorial claims and anti-access/area denial (A2/AD) missions, in conjunction with US power projection capability development, is contributing to military tensions in the region that will play out over the next couple of decades. Here are three of the key areas that are being watched closely:

Undersea: The United States maintains the world's largest and most capable submarine fleet, which is viewed as a considerable advantage in the unfolding military modernization competition in east Asia, especially given widespread perceptions that anti-submarine warfare constitutes a weakness for China's military. However, Congressional Research Service analysis of the US conventional submarine (SSN) fleet indicates that this advantage may be difficult to sustain because of funding and political issues. The US conventional fleet is projected to fall below the US Navy's minimum required force of 48 SSNs in 2025, bottom-out at 42 SSNs in 2029, and remain below the 48-boat level until 2035. While the Virginia class SSNs in service from 2014 will have more capability and firepower, the decline in the size of the fleet will coincide closely with the expected timeframe for full maturation of China's A2/AD capabilities. Significantly, several other states in east Asia, including Japan, Malaysia, Vietnam, Singapore, Indonesia, and Australia, have announced plans to upgrade their submarine fleets.

Missile attack versus missile defense: China's investment in missile technologies has been designed to hold possible adversary assets, bases and infrastructure in east Asia at risk. While its status is uncertain, China's DF-21D anti-ship ballistic missile is considered a 'game-changing' technology because of its alleged ability to bring increased firepower at longer ranges—estimated at 1,500 km—against the most critical component of US power projection: carrier battle groups. Analysis of the missile's suspected capabilities has led to a debate over the ability of current US Aegis ballistic missile defense systems to meet this evolving threat.

The information blockade: Advanced modern militaries have become increasingly reliant on sophisticated networks of command, control, communication, intelligence, surveillance, and reconnaissance systems (C4ISR), which have driven a step-change in operational efficiency and capability. These networks also create potential avenues for cascading and paralyzing disruption through cyber-attacks and electronic warfare. China's information operations capabilities are designed to leverage this vulnerability to create an information blockade in which potential adversaries are unable to collect information and communicate, and in which command-and-control networks fail to function. A pre-emptive non-kinetic information blockade strike could render regional military forces inert, obviating the need for traditional kinetic operations.

Tate Nurkin

Proliferation of dual-use and advanced military technologies to China is a risk in part because of the potentially accelerating effect such proliferation will have on China's military modernization, but also because of concerns over the pace at which such technology will subsequently proliferate from China to key trading partners. China is not a member of critical arms and export-control regimes such as the Wassenaar Arrangement and Missile Technology Control Regime and, as a result, has a well-earned legacy as a powerful proliferator of advanced military technologies—primarily ballistic and anti-ship cruise missiles and, potentially, air defense systems—and critical dual-use items to states such as Iran, Syria, Pakistan, and even North Korea, enhancing these states' military capability and technological base.

For example, in November 2013, Pakistan launched its first two indigenous unmanned aerial vehicles—the Shahpar and Burraq. IHS described the Shahpar as "bearing more than a passing resemblance to the CASC CH-3"—China reportedly exported 20 CH-3s to Pakistan in 2010. Similarly, IHS reported in February 2014 that Pakistan was in negotiations to export the JF-17 Thunder fighter—co-developed with China—to long-time US defense partner Saudi Arabia, clearly demonstrating the cascading effects of Chinese proliferation as well as the potential knock-on export risks to Western, Russian, and emerging Asian defense industries.

Such proliferation is rightly viewed as a significant risk to international security because

China's cyber-espionage activity

A key element of China's military modernization is the development of robust computer network exploitation capabilities to support the surreptitious collection of sensitive and technical information (cyber-espionage). China's cyber-espionage capabilities and activities have received particularly acute attention since the release of a series of high-profile reports in early 2013, including reports from the US Defense Science Board, the private internet security company Mandiant, as well as a classified National Intelligence Estimate, elements of which were leaked to the press.

Collectively, the reports describe a significant and sustained cyber-espionage campaign against US companies in a variety of industries emanating from China and initiated by the Chinese government. This campaign has allegedly led to the theft of a disconcerting amount of high-technology engineering data and network security program data, the acquisition of which is designed to help accelerate China's national development and military modernization and also enable it to better understand the platforms, systems, and networks that could potentially be deployed against China's People's Liberation Army in a crisis. A sampling of targeted industries includes defense, IT, aerospace, energy, finance, chemicals, satellites, telecommunications, and media.

Of particular concern for US national security planners and regional security is the US Defense Science Board's contention that more than 24 critical military programs have already been compromised by activity originating in China, including some of the platforms and systems most critical to US efforts to counter China's A2/AD military modernization including: PAC-3; Aegis and terminal high-altitude area defense missile defense systems; the F/A-18 fighter, which is the US Navy's primary carrier-based fighter; the next-generation Littoral Combat Ship; and the fifth-generation F-35 Joint Strike Fighter.

The Mandiant report identified the "most prolific" of China's purported hacking groups, known as Unit 61398, detailing the scale of its

it provides novel advanced capabilities to states that would not otherwise be able to acquire them. This is a risk that is frequently amplified because proliferation can occur in ways that actually increase the uncertainty about the capabilities specific actors possess and about their ability to use these capabilities. Such enhanced capability and uncertainty complicates the tasks of deterrence and dissuasion.

US Air Force Chief of Staff General Mark Welsh summed up the risks created by Chinese proliferation in a November 2013 discussion with reporters. General Welsh noted that while the US did not expect to fight China directly, it did forecast fighting China's modern military technologies: "It will be on the street, and we will be fighting it. Their new stuff will be better than our legacy stuff. That's just the way it is."

China's desire to modernize its military is a natural development for an increasingly confident and capable power seeking to enhance its security and influence in Asia and throughout the world. However, the scale and approach of modernization and nature of the capabilities being developed, combined with recent activities in the East and South China seas, have increased tensions and the risks of escalation, miscalculation, and even crisis in east Asia. While these layered and complex risks require the attention of foreign, security, and defense policymakers in affected states, China's military modernization has already created critical issues and risks, particularly surrounding proliferation. These risks are driving uncertainty and competition related to the procurement of advanced military capabilities.

Tate Nurkin is managing director, Consulting and Thought Leadership, IHS Aerospace, Defense, and Security

bit.ly/tatenurkin

Contributors to this article include Paul Burton, content director of industry and budgets, Tom Skomba, consultant, and James Hardy, IHS Jane's Asia-Pacific editor, all with IHS Aerospace, Defense and Security.

For more information on China's military modernization, visit www.ihs.com/Q12ChinaMilitary

alleged activities (141 organizations hacked in at least 20 industries); geographic focus (87% of attacks were in English-speaking countries, 115 against US targets); its spear-phishing tactics for penetrating systems; its recruiting history going back to 2004; and the average length (356 days) that the unit maintained access behind firewalls of targeted organizations.

The Chinese government and state-run media have vehemently denied accusations of cyber-espionage. Instead, they highlight the considerable issues associated with attributing cyber-attacks to state governments based primarily on the location of IP addresses and suggest that the narrative is another attempt by the United States to isolate and "encircle" China.

Tate Nurkin

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THE NEW RISKS

Africa's new energy frontier: The promise and the peril

International oil companies seeking to develop East Africa's hydrocarbon resources must align their commercial expectations with the political realities in their host countries.

By Raad Alkadiri and Natznet Tesfay

The strategic oil and gas landscape is entering a transition phase. Faced with limited access to resources (around 60% of global hydrocarbon deposits are held by national oil companies that offer no equity access to international oil companies [IOCs]), and with costs on the rise, IOCs have shifted their focus to exploration in new frontier areas over the past few years, including East Africa. These exploration efforts have led to significant finds. The challenge now for IOCs is to move "beyond the drill bit" to monetize these assets through development and production of the newfound reserves.

This process goes beyond the application of below-ground technologies, project management, and capital to access molecules; these are elements that IOCs, especially the largest, are expert at managing. An equally significant challenge for IOCs is to navigate the above-ground risks associated with investments in frontier areas. Everything from contract type to hydrocarbon policy to regulations will be shaped by the needs and desires of host governments, IOCs' partners in these ventures. The domestic political, financial, economic, and environmental pressures that the host government

iStockphoto

faces will drive its external behavior toward IOCs. Thus, the key to commercial success for investors in these frontier areas is IOCs' ability to anticipate how stakeholder demands will evolve and how these changes will shape the investment environment.

East Africa: The new energy frontier

East Africa has emerged as a major new frontier for oil and gas in the past half-decade, and the region is increasingly attracting the attention of large IOCs. Significant deepwater gas fields have been discovered off the shores of Mozambique and Tanzania. Cumulative discovered reserves in deepwater Mozambique's Rovuma and Mamba basins total around 20 billion barrels of oil equivalent, higher than those of either Angola or Nigeria; gas finds in the Tanzania deepwater have been more modest (cumulative discovered reserves total around 5 billion barrels of oil equivalent) but nonetheless are significant. Meanwhile, onshore exploration has yielded oil finds of commercial quantity in Uganda, with reserves estimated at around 2.5 billion barrels (the fourth-largest oil reserves in sub-Saharan Africa). There have also been discoveries in neighboring Kenya, which aspires to be East Africa's first oil exporter by mid-decade. Large onshore hydrocarbon deposits are also thought to exist in Ethiopia and Eritrea, although exploration in those locales has lagged.

The discovery of hydrocarbon resources on this scale in East Africa not only has whetted the appetite of IOCs, it is generating domestic expectations as well. Despite the nascence of the sector and significant production and export challenges (including a dearth of hydrocarbon infrastructure), government and populations-at-large nevertheless anticipate massive financial windfalls. Moreover, they are determined to develop the sector in a way that drives the wider economy and boosts living standards. Visions of wealth on the scale of the Persian Gulf states may not yet have set in, but the discovery of hydrocarbon resources is regarded as a springboard to economic prosperity.

These hopes and expectations are, in turn, shaping the investment environment that IOCs face. Government ambitions, and the pressure that is felt from below, are guiding national hydrocarbon policies and the legal and regulatory structures that are being put in place to underpin them. The key to success, for governments and investors alike, will be to align the commercial expectations of the IOCs with the political imperatives of host states. Experience so far suggests that this will pose challenges, as well as significant above-ground risks for investors.

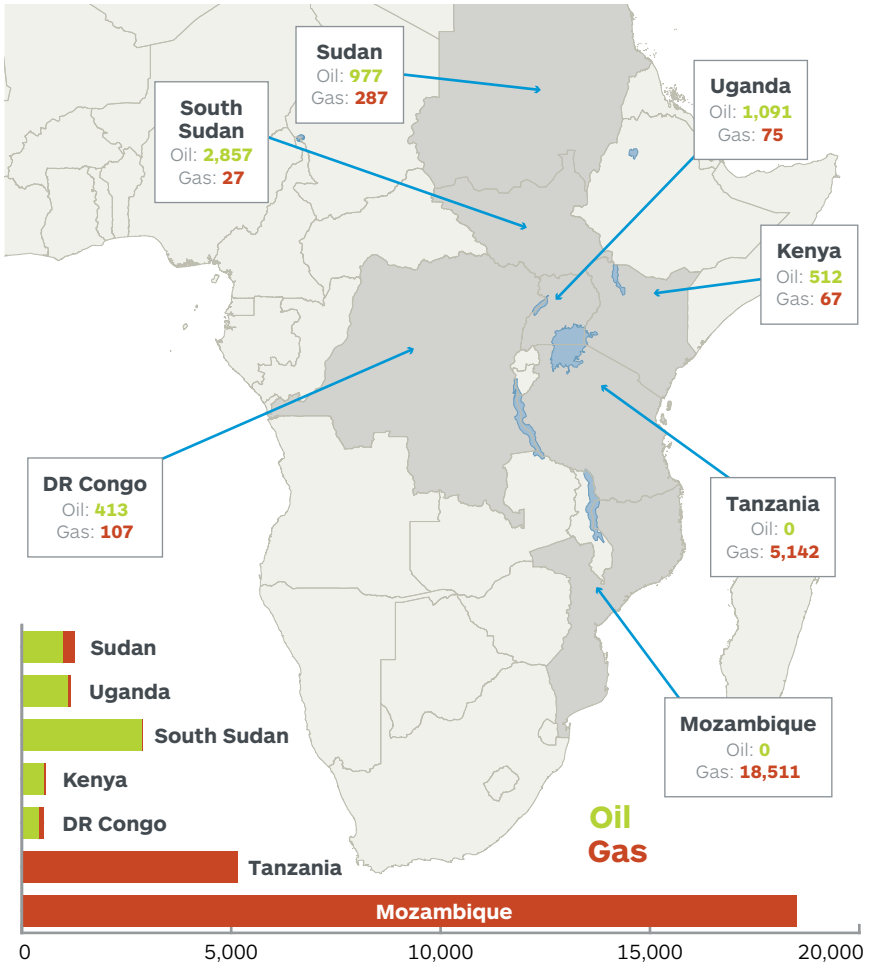
At the state level, host governments are intent on achieving more than just the monetization of assets from their partnerships with IOCs. Indeed, contract terms thus far have been relatively favorable to investors, with the undiscounted government take in the 70–80% range. This is no surprise; host states in frontier provinces, lacking the institutional wherewithal and the investment capital to find and develop resources, traditionally offer favorable terms to attract exploration. Further along in the production cycle, contracts are likely to become more onerous as the law of the obsolescing bargain takes hold: once investors have significant fixed assets in place with long amortization periods, (re)negotiating leverage shifts in favor of the host government.

Nevertheless, even in this exploration and early development phase, host governments across East Africa have pushed a hard bargain, seeking to determine the pace of production as well as demanding

that companies invest in and develop mid and downstream infrastructure. A case in point is Tullow Oil's experience in Uganda. The company, along with partners Total and CNOOC, recently reached a deal to develop its onshore finds after a three-year standoff with the government over terms. Uganda's government insisted that the development plan include a 60,000-barrel-per-day refinery, an export pipeline via Kenya, and a power station in Uganda's main oil-producing region. The government also demanded a say in the pace of future production, indicating that it is seeking a slower ramp-up than its IOC partners prefer. Reports that Tullow may be seeking to divest some of its interests in Uganda in favor of focusing on assets in Kenya, which is seen as having a less onerous investment regime, illustrate the potential pitfalls if a host government pushes its partners too far.

High expectations for East Africa's oil & gas reserves

2013 estimates of oil and gas reserves for select East African nations. Oil in millions of barrels, gas in millions of barrels of oil equivalent.



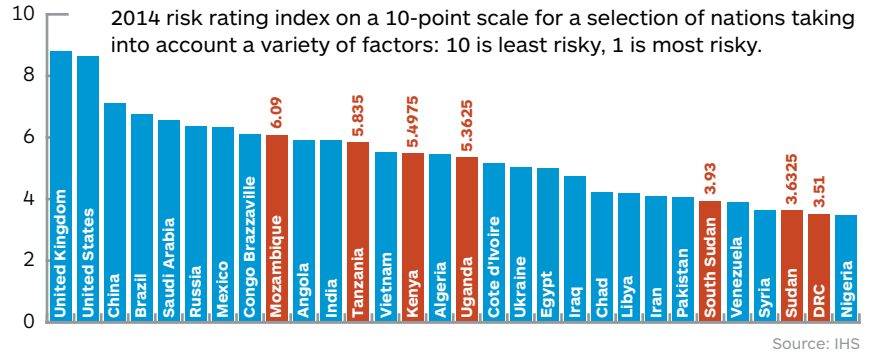
Source: IHS

Insistence on "local content provision"

Striking a balance between economic needs and commercial terms plays out in another key area: so-called "local content provisions," by which host governments earmark a portion of a project's work to be performed by indigenous companies. East African states are not alone in seeking to use their hydrocarbon resources to generate ancillary economic benefit and boost employment; local content demands are a feature of many producing provinces, from Brazil to Iraqi Kurdistan. The key is for governments to establish provisions that promote the development of their resources, not the retarding of it. This has not always been easy to achieve, particularly where qualified domestic human resources have been inadequate to allow targets to be met, or where the capacity of the sectors involved was insufficient. Difficulties in accommodating all stakeholders' objectives have been a key driver in protracted debates around hydrocarbon legislation and resultant regulatory uncertainty for operators in such places as Uganda. In countries where local content bills have been enacted, such as Ghana in late 2013, the ambitious targets for local participation and the shortfall in domestic capacity not only have raised costs and risks of project delays for IOCs, but also have left operators open to increased scrutiny and consequent penalties, which in extreme cases have included license revocation.

Experience from countries with local content quotas has already raised concerns around the inefficient allocation of economic resources, which are magnified in nascent energy sectors in Africa. Mandatory targets can lead to the creation of numerous short-lived and inefficient companies that typically would not prosper in a

A mixed bag: Risk ratings for seven East African nations



Source: IHS

competitive market. They also force the use of suppliers who often lack the requisite technical and financial competencies, resulting in the IOC and eventually the state paying a higher price for services. Stipulations for local equity participation, especially where host governments control the formation of consortiums, also expose IOCs to risks of breaching anti-corruption legislation in their home jurisdictions, but failure to oblige can also result in adverse discrimination, as demonstrated with Cobalt International Energy in Angola. When provisions for local content participation prove to be beyond the capacity of the local industry and labor force, bureaucratic bottlenecks are likely to emerge as applications for exemptions are processed, setting the stage for increased corruption to avoid project delays. Operators in Ghana have already warned that the local content bill endangers the expansion of the energy sector and the government's objectives, namely its production target of 250,000 barrels a day by 2021.

Despite these difficulties, expectations among local constituencies for immediate benefits and a multiplier effect remain high, especially in countries such as Sierra Leone, Tanzania, and Mozambique, where skepticism around efficient resource management is acute based on past experiences with the mining sectors. However, a lack of community engagement by key stakeholders, including host governments and operators, can fuel grievances over unequal distribution of wealth and displacement of livelihoods and give rise to disruptive unrest around operational sites.

In Tanzania's Mtwara—while bouts of unrest in early 2013 were eventually quelled after costly damage and delays to a US$1.2 billion gas pipeline project—the underlying drivers persist as communities in the underdeveloped region complain about the opaque manner in which offshore gas is being developed. Although the affected communities currently support the IOC's activities and instead hold the government accountable, operators face increased risk of targeted disturbances if the local population continues to feel sidelined in the resource's development. If expectations for local content provision are left unchecked or dividends are seen to be mismanaged, operators in the hydrocarbon sector and host governments will be at risk of backlash from the surrounding population. Recent militancy in the Niger Delta and industrial action for "Gabonisation"—a government policy signed in 2010 but never ratified that would require 90% of all workers in Gabon's petroleum sector to be citizens—provide palpable examples of the potential risks that IOCs face. Moreover, the reputational risk for these companies is also high, especially given growing shareholder activism over the past decade.

IOCs face challenges managing their relationships with host governments and local communities as they seek to develop East Africa's rich resources. Aligning their plans early with the expectations of stakeholders in producing areas is critical to IOCs' success; failure to do so leaves the companies at risk of creating—or at least allowing—unrealistic expectations to develop. This process requires of IOCs not only an understanding of the immediate needs and desires of stakeholders, but also the ability to judge how they will evolve over the lifespan of their investments. Change is inevitable, but IOCs can secure their long-term interests—and the commercial value of their projects—if they understand how the investment environment will evolve and why.

Raad Alkadiri is managing director, petroleum sector risk, IHS Energy.

bit.ly/ralkadiri

Natznet Tesfay is senior manager, Africa, IHS Economics & Country Risk.

www.linkedin.com/in/natznettesfay

For more on energy development in Africa, visit www.ihs.com/Q12AfricaEnergy

THE NEW RISKS

Investment risk for chemical producers

The industry is betting big that unconventional oil and gas will make North America the low-cost chemical-producing region of choice for years to come.

By Mark Eramo

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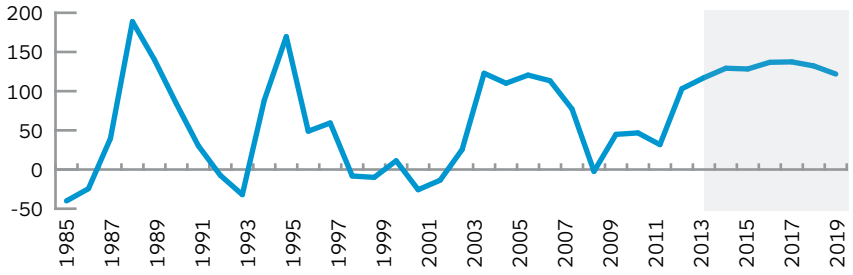
Whether in the form of crude oil, natural gas, or coal, energy provides the basic raw material that is used in chemical plants the world over to produce higher-value basic chemicals, intermediates, and plastics. These basic chemicals and plastics, in turn, represent the key building blocks from which a wide variety of durable and non-durable consumer goods are manufactured, including clothing, construction materials, household items, food and beverage packaging, and various modes of transportation.

Every year, billions of dollars in new capital investment and sustaining capital is required to ensure the basic chemicals industry is able to meet future demand growth. Because they are upstream in the value chain from durable and non-durable consumer goods, demand for basic chemicals and plastics is driven by global economic growth. The ability to align investments in capacity growth with global demand growth determines whether the market is in a period of over- or under-supply, which has a direct impact on overall industry profitability. The development of significant imbalances between capacity and demand growth gives the chemical industry its cyclical nature. (See chart below.)

Supply and demand imbalances wreak havoc with profitability

Weighted average of earnings before interest and taxes of chemical market covered by IHS (US$ per metric ton)



Source: IHS

Energy: A key input driving investment

The production costs of basic chemicals and plastics are highly dependent upon the price of energy and energy-derived raw material inputs (feedstocks), as the combination can represent as much as 75% of the total cost of the end product. Given this linkage, absolute energy price levels, and the price differences among key energy sources, have a direct impact on the regional competitiveness of chemical producers. In particular, the proximity of chemical production plants to areas with distinct energy and feedstock advantages is a key input into investment decisions.

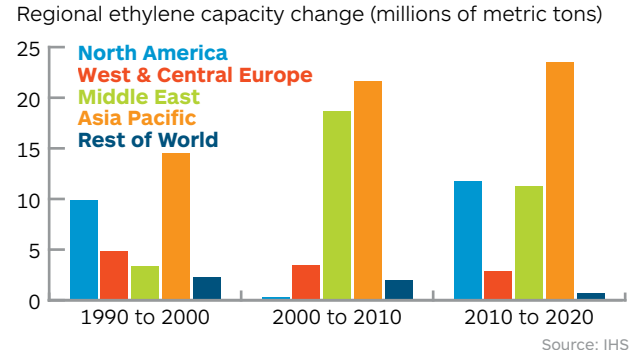
As a result of the dramatic changes in global energy supply that have occurred in recent years, clear winners and losers are emerging in chemical markets. Developments in North American non-conventional oil and gas markets are having profound impacts on the global chemical industry, as investments in North America are reignited after more than a decade of not only very limited investment activity, but the consolidation and closure of many high-cost operations. Significant differences in prices between North American natural gas-based raw materials and those

derived from crude oil are transforming the continent into a low-cost region for chemicals production once again. This advantage is attracting significant capital investment as regional chemical producers leverage these raw materials to create for themselves a price-competitive global supply position. A growing number of global chemical companies have announced plans to build or expand facilities in North America. These investments, fueled by competitive feedstocks derived from unconventional oil and gas, have the potential to reshape the global chemical capacity profile along with regional trade patterns in basic chemicals and plastics.

Between 2000 and 2010, new investments in basic chemicals and plastics capacity occurred mostly in the Middle East and Asia, driven by competitive feedstock incentives (in the Middle East) and a desire by producers in Asia (mainly China) to maintain a higher level of self-sufficiency in chemicals manufacturing. Using ethylene capacity investment trends as a proxy for the basic chemicals industry, nearly 90% of new ethylene capacity (about 41 million out of 46 million metric tons) during this decade was built in those two regions. From 2010 to 2020, IHS forecasts that, while chemical investments will continue in the Middle East and Asia regions, North America will re-emerge as a location of choice for building new capacity. Of the 58 million metric tons of new ethylene capacity forecast to be added during this period, about 18% (more than 10 million metric tons) will be built in North America. (See chart, above right.)

The benefits of this capacity expansion are obvious: unprecedented investment and commensurate job and revenue creation throughout the value chain. While this vision is especially evident in the United States, other geographic markets hold promise for significant development as well, provided an indigenous supply of competitively priced hydrocarbon feedstocks can be sourced and leveraged. These large differences in production costs will pave the way for global market entry by new and extremely competitive participants. China is a good example of a country that has embarked on a chemicals investment program based on locally sourced, low-cost feedstock, principally coal located within the inner provinces of the country. China's quest for an attractive cost position and the security of self-sufficiency, combined with a political imperative to migrate economic prosperity to its more remote regions, has prompted the launch of an aggressive coal-to-chemicals program of such scale that, if even

Capacity growth could put the North American market in oversupply before the end of the decade



Source: IHS

partially successful, will have a powerful impact on the global chemical markets.

The risks facing chemical producers may be harder to visualize, but they are very real and have the potential to significantly dilute or even eliminate their ability to leverage energy and raw material price differentials for higher levels of profitability. Key risks that are inherent to the forecast for the basic chemical and plastics industry include capital cost escalation, market access/trade exposure, stringent regulatory legislation (environmental and/or protective tariffs), significant market imbalances (shortages or oversupply) created by variations in regional supply versus demand growth, and unpredictable energy market dynamics.

Managing upstream and downstream risk

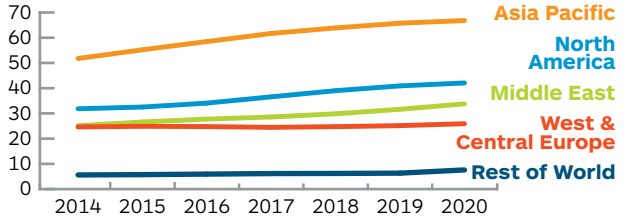
Over time, the two most consistent and prominent risks to chemical manufacturers are market supply and demand imbalances and changes in production costs brought about by shifts in the underlying energy market. Chemical plants built today are designed for scale and continuous operation between maintenance shut-downs. New plants ideally operate at maximum capacity utilization, producing millions of tons of chemicals per year for periods of five years (or more) between closures for maintenance. During periods of oversupply, high-cost plants may be forced to run at reduced capacity utilization, increasing the unit cost per ton of production and placing downward pressure on operating cash margins. Market oversupply can result from a sudden decline in demand (due to an economic or natural event) or from a high concentration of new plant start-ups in a short period of time.

The North American market faces the risk of oversupply in the 2018–20 timeframe, given the large number

of new plants that are currently being considered for start-up during this time period. Returning to ethylene as a proxy for the overall industry: Of the 10 million tons of new ethylene capacity forecast to be installed by 2020, nearly 6 million tons (60%) is targeted for 2016–18. Such acceleration in capacity growth will likely outpace domestic demand growth, placing the market in an oversupply situation that can only be managed through a rapid increase in exports or reduced operating rates on a portion of that capacity. Typically, oversupply will force prices lower, increasing the pressure on the highest-cost units to reduce production. (See chart below.)

North American ethylene demand growth through 2020 likely will not keep pace with new capacity

Regional ethylene demand forecast (millions of metric tons)



Source: IHS

Changing energy market dynamics have had the greatest impact on the North American chemicals market over the past 10 to 15 years. The significant differences in price between raw materials derived from North American natural gas and those derived from crude oil—which have since transformed North America into a low-cost region for chemicals production—did not exist a decade ago. During the early part of the last decade, production cost advantages had yet to materialize, and many chemical manufacturers were faced with difficult decisions as to retrofitting or closing high-cost assets that could not compete with low-cost producers based in the Middle East and Asia.

The billions of dollars of new chemical capacity investments targeting the North American market over the next 5–10 years are driven primarily by an assumption that current energy market dynamics (and the feedstock cost advantages) will be sustained for the next 10 years or longer. There is a risk to these investments: if energy market dynamics shift again, crude oil and natural gas may come into closer price parity (on a BTU basis), which will return market conditions to those that North American chemical producers faced 10 years ago.

The impact of the risk associated with high production costs is very evident in such established chemical markets as Western Europe. Lack of competitively priced raw materials to produce basic chemicals and plastics, combined with rising regulatory costs, are placing many downstream assets under intense cost pressure. The loss of upstream integration benefits exposes most intermediate and certain specialty chemical producers to supply inefficiencies that may force their closure unless they reduce operational costs or discover ways to increase product value. The resulting impact is being felt throughout the supply chain and across allied industries. At the same time, where enhanced integration and cost benefits allow the production of intermediates and some specialties in remote locations, import pressures may increase and lead to the commoditization of certain specialty products and other hard goods made from these chemicals and plastics.

A significant portion of North American and Middle Eastern chemical production growth is destined for customers in Europe, South America, and Asia, as the global market and supply chain are transformed by cost-advantaged chemical production supplementing local supplies in rapid-growth economies and replacing cost-disadvantaged production elsewhere. This transformation will be characterized by difficult, politically charged decisions to close unprofitable facilities, in stark contrast to the complex analysis regarding the site placement and financing of new capacity representing hundreds of billions of US dollars in investment. While the benefits of these massive investments are obvious, the risks are very real. Never before has the focus on making the right chemical product at the right location for the right market been more intense.

Mark Eramo is vice president, chemical market insights, at IHS Chemical.

http://press.ihs.com/leadership/chemicals-experts/mark-eramo

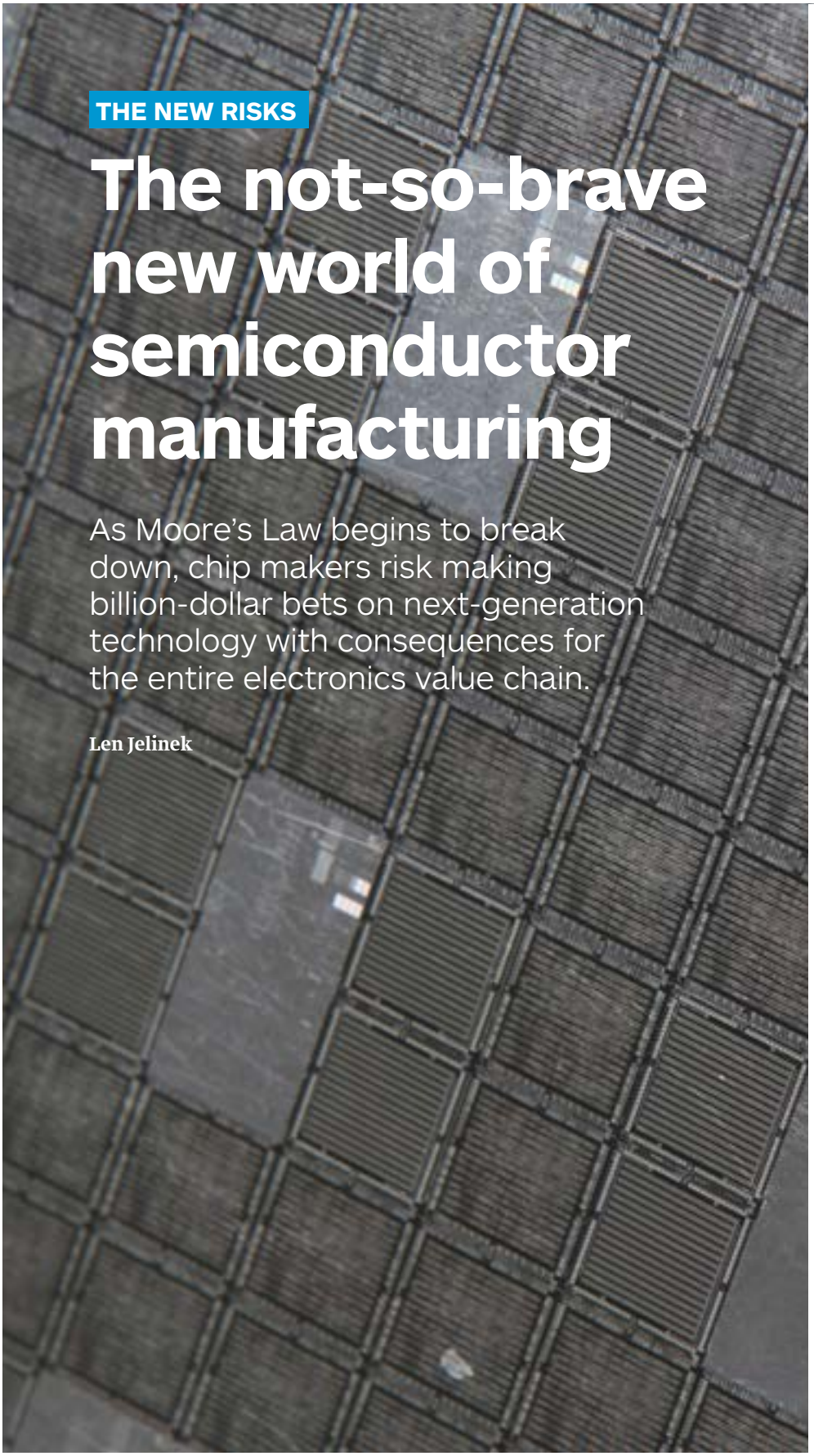
For more information on the global chemicals market, visit ihs.com/Q12Chemicals

THE NEW RISKS

The not-so-brave new world of semiconductor manufacturing

As Moore's Law begins to break down, chip makers risk making billion-dollar bets on next-generation technology with consequences for the entire electronics value chain.

Len Jelinek



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The semiconductor industry has a problem with two four-letter words: cost and risk. After a couple of decades of boom-and-bust cycles, the industry settled into a period of modest yet relatively stable growth in the early part of this century. Driving the vast majority of the industry's revenue was the personal computer, sales of which grew steadily year after year. More recently, however, the world's ardor for PCs has cooled as consumers and businesses have gravitated to mobile devices, principally smartphones and tablet computers. The growth rates for smartphones and tablets, at least at the high end of those markets, are beginning to slow, as buyers shift to lower-priced products, especially in emerging markets, such as China. The problem for the semiconductor industry is that as the PC market has slumped, mobile devices aren't taking their place as the profitable drivers of increasing chip sales.

An expensive proposition

A sampling of estimated costs for next-generation chip manufacturing.

450mm wafer fab	$10 billion-plus
Extreme-ultraviolet lithography system	$100 million to $125 million
20nm fab	$4 billion to $7 billion
10nm fab	$10 billion

Other wafer fabrication equipment required

- Chemical-mechanical planarization systems
- Chemical vapor deposition and physical vapor deposition systems
- Dry and wet etch systems
- Ion implanters
- Molecular-beam epitaxy systems
- Rapid thermal processing systems

Source: Semiconductor Equipment and Materials International and IHS

In the midst of this product transition, the industry has an expensive and tricky juggling act – continuing to shrink the dimensions of semiconductors while reducing the manufacturing cost of those chips. Scaling, as this shrinking is called within the industry, proceeds apace, but the cost of scaling is becoming a significant concern.

For nearly five decades, the semiconductor industry has conformed to the widely known and often misunderstood phenomenon known as Moore's Law, which predicted that the number of transistors on a semiconductor device would double every year (later revised to every two years). Gordon Moore postulated the trend in 1965 while he was working at Fairchild Semiconductor; three years later he would become a co-founder of Intel. Moore also speculated that the cost of these multiplying transistors would continue to fall as their volume grew, a prediction that has generally held true for decades. Until now.

As the tiny features of microchips shrink to line widths of 28 nanometers, 20 nanometers, and even 14 nanometers, the cost of making these chips that contain billions of transistors continues to rise. (A strand of human DNA is about 2.5 nanometers in diameter and the width of a piece of paper is about 100,000 nanometers, according to the U.S. National Nanotechnology Initiative.) This breakdown of the cost-density relationship is a new wrinkle and a serious

departure from what the industry has come to count on. Indeed, it threatens the financial viability of many chip companies, their material and equipment suppliers, as well as their customers. That's the risk part of the problem.

Some market observers believe the answer to the cost problem is migrating to larger silicon wafers (the round disks that can contain thousands of individual microchips). In the last couple of decades, the diameter of wafers has increased from 200 millimeters to 300 millimeters, which has become the standard size typically produced around the world today. On the horizon is the promise of 450-millimeter wafers, which could contain many more chips on a single wafer. However, that promise is threatened due to the sheer cost of producing 450-millimeter wafers. (See sidebar below.)

For the first time in its history, the semiconductor industry may not be able to reduce prices on its next generation of microchips because of the increasing complexity of manufacturing. For many years, the critical dimensions of semiconductors could be processed with one layer, and photolithography equipment (also known as microlithography systems) could do its work with one exposure for a chip. With the current generation of 193-nanometer immersion lithography – a deep-ultraviolet technology – it's becoming necessary for chipmakers to require multiple lithography exposures in the manufacturing process.

Top 10 semiconductor companies

2013 revenue, US dollars in billions

	2013
Intel	$46.960
Samsung Electronics	$33.456
Qualcomm	$17.341
Micron Technology	$14.168
SK Hynix	$13.335
Toshiba	$12.459
Texas Instruments	$11.379
Broadcom	$8.121
STMicroelectronics	$8.076
Renesas Electronics	$7.822

Source: IHS and company reports

Extreme-ultraviolet lithography (EUV), the next generation in photolithography, has been in development for several years, principally by Netherlands-based ASML Holding and its partners. Chipmakers will probably be able to turn out 14-nanometer

Dim prospects for 450-millimeter semiconductor wafers

Which leading semiconductor manufacturers will be building 450-millimeter wafer fabrication facilities? It's always been a short list, but it may be getting shorter still in the near future thanks to the astronomical cost for equipping a next-generation fab.

Intel, Samsung Electronics, and Taiwan Semiconductor Manufacturing (TSMC) have long been the leading proponents of the proposed move to the bigger wafers, which can produce up to 225% more chips on one substrate than the present generation of 300-millimeter wafers.

With PC sales slowly but surely declining along with demand for the microprocessors that power them, Intel isn't likely to lead the charge for 450-millimeter wafer fabs. Similarly, producers of memory chips, such as Micron Technology, Samsung, and SK Hynix, aren't likely to adopt the larger wafers any time soon. TSMC, the world's largest silicon foundry measured by annual revenue, perhaps has a better cost incentive to make the move, which will give it a cost advantage over its foundry competitors. TSMC's production capacity can provide enough volume to justify the 450mm transition, yet Intel, Samsung, and GlobalFoundries are all seeking more foundry business, limiting TSMC's volume.

Even so, unless wearable electronics or another high-growth semiconductor-based product can be manufactured cheaply and profitably, the 450-millimeter fab is likely to remain a pipe dream for the semiconductor industry. Both Intel and TSMC have put up "shell" buildings that could be equipped

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chips with the current generation of 193-nanometer lithography systems, but EUV may be necessary for the next generation of microchips with line widths of 10 nanometers and even 7 nanometers.

Indeed, EUV is the semiconductor industry's only reasonable hope to minimize the risk of rising manufacturing costs, since it promises a return to one-step lithography. Still, at 10 or 7 nanometers, manufacturing costs are expected to increase yet again, perhaps by as much as 15-20%. At 10 nanometers, semiconductor manufacturers may have to tell their customers, "Costs are going up." And that will be a hard pill to swallow for an industry that has been able to offer regular cost reduction for decades.

At the same time, it's not clear whether EUV will even fit the bill, since ASML and its Cymer subsidiary have been unable to date to produce an energy source powerful enough for volume throughput of wafers. ASML has been shipping beta EUV tools to customers since about 2005, to help them develop processes. All of the top chipmakers have collaborated on EUV development and have essentially placed all of their eggs in that one basket. If EUV can't produce semiconductors in volume – even at higher prices – it will be a disaster for the continued evolution of the extended semiconductor value chain.

for 450-millimeter manufacturing, yet they are letting those facilities go unused at present. Intel is constructing its D1X Module 2 facility in Hillsboro, Oregon, for 450-millimeter development fabrication, which is scheduled for completion in 2015. But even if Intel, Samsung, and TSMC all go full-steam ahead with their 450-millimeter fab plans, it still may not present enough business for the producers of semiconductor manufacturing equipment to justify their research and development expenses for 450-millimeter gear.

Equipment suppliers have long and unhappy memories of the industry transition from 200-millimeter to 300-millimeter wafer fabrication. Their customers urged them to plunge into 300-millimeter R&D and to turn out 300-millimeter-capable equipment, only to be extremely stingy or tardy when it came time to place orders for the equipment.

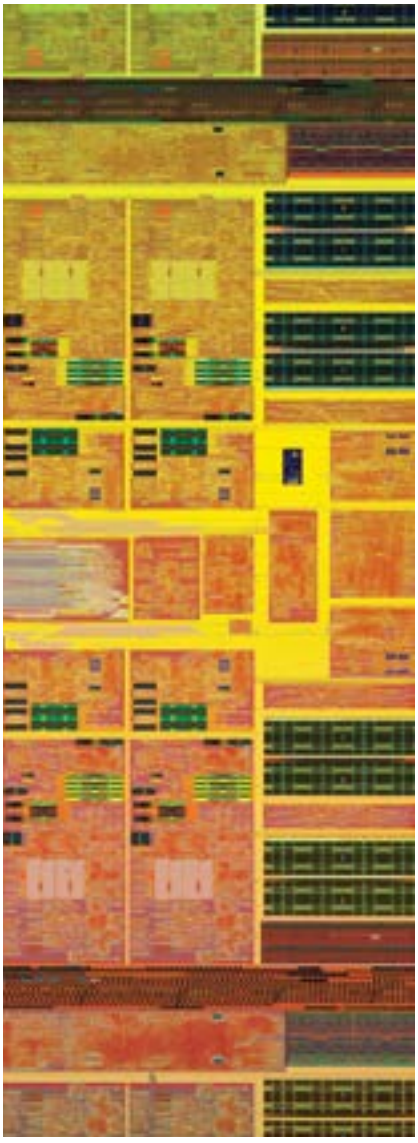
Indeed, the semiconductor foundry market is where the DRAM market was a decade ago – full of entrants eager to claim market share and ready to spend on the factories to gain that share. TSMC's limit may be the willingness of its shareholders to accept billions of dollars in capital expenditures for a 450-millimeter fab or two. The world's No.2 foundry, GlobalFoundries, is privately held, owned by an Abu Dhabi investment fund, and could spend whatever its investors are willing to bear.

There are indications that 450-millimeter volume wafer production will be pushed out from 2018 to 2019 or even 2020. Before the 450-millimeter wafer fab becomes a reality, cost reductions and technical breakthroughs in semiconductor manufacturing are clearly needed.

Len Jelinek

What is essentially at risk for the industry is the ability to enable new products that don't just provide incremental improvement from previous electronics. Producing a chip that can improve the battery life of mobile devices by 10% isn't very impressive. Consumers crave products that are essentially free to purchase and operate, yet that's not practical. Semiconductor manufacturers need to help their customers hit price points that are attractive to consumers and ultimately to corporations and government agencies that make volume purchases of electronic equipment.

Battery technology, which is essentially stuck in the 20th century, has proved to be a major concern for the evolution of mobile devices and wearable electronics, two potentially large-volume, high-growth markets. The challenge in the next few years is to produce advanced semiconductors that will be the basis of cool new products, perhaps in areas that have not even been conceived of, which will be priced low enough for mass-market commodity products. That's the make-or-break value proposition of the near future for chipmakers.



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Consolidation the only recourse

Consolidation is a growing trend among semiconductor manufacturers and their suppliers. For instance, Texas Instruments acquired National Semiconductor in 2011, and smaller chip companies have been active in mergers and acquisitions since then. Similarly top-ranked semiconductor equipment maker Applied Materials last year agreed to merge with Tokyo Electron, one of its largest rivals in semiconductor production equipment. In other high-dollar deals in the semiconductor equipment sector Lam Research bought Novellus Systems in 2012 and ASML purchased Cymer last year. In February, Entegris agreed to acquire ATMI.

The simultaneous development and implementation of three process nodes – 28nm, 22nm, and 14nm – is placing phenomenal pressure on leading chipmakers, integrated device manufacturers and silicon foundries alike. The 14-nanometer node involves more than the usual scaling in that it requires novel chip design, such as adding silicon 'fins' to traditional field-effect transistors, called FinFETs, produced with silicon-on-insulator substrates.

Keeping up with the most advanced manufacturing technology has become a bet-the-company, multibillion-dollar decision for the biggest chipmakers. This year, Intel, the world's largest semiconductor manufacturer as measured by annual revenue, decided against equipping Fab 42, its new wafer fabrication facility in Chandler, Arizona, after completing construction of the building. Fab 42 was meant to be the company's premier 14-nanometer FinFET fab, slated to begin production at the end of 2013. Instead, Intel has indefinitely mothballed the facility and will upgrade other fabs in Chandler to handle 14-nanometer chip manufacturing, after processes are qualified at the company's D1X plant in Hillsboro, Oregon. Evidently, Intel CEO Brian Krzanich, who came from the manufacturing side of the company, looked at the cost of equipping Fab 42 and blinked.

Changing of the guard

For years, bragging rights in the semiconductor industry went to the company that could turn out the fastest, most powerful microprocessor. As long as Windows-based PCs were being sold in significant volumes, Intel was generally king of the hill, holding about 80% of the processor market. The majority of the remaining market share went to Intel's long-time rival Advanced Micro Devices, which designed microprocessors based on an architecture licensed from Intel.

As the PC market fades, fast processors have become déclassé. Today's watchword is "low-power", particularly in the applications processors that are at the heart of smartphones. When it comes to low-power chip designs, UK-based ARM Holdings has long held the crown in that category. Apple, Nvidia, Qualcomm, Samsung, and others have incorporated ARM's processor cores, which they license, into their chips. ARM gets revenue coming and going – first from licenses for its technology and then from royalties on each chip sold by its licensees.

The microprocessor is being eclipsed by the system-on-a-chip (SoC) device, which incorporates logic, memory, and other functions on one chip. SoCs can be more versatile in a variety of applications. They could relegate microprocessors to being more like microcontrollers, the workhorse chips typically found in computer printers and microwave ovens, among other products.

The Next Big Thing

What can replace the PC as the driver of semiconductor sales and profits? Smartphones and tablets would have been the predictable answer in 2013, yet those products are maturing, at least at the high end. While Apple and Samsung were able to set records with sales of their mobile devices last year, the growth rates for those products began to flatten, and that trend is expected to continue this year.

The semiconductor industry is anxiously awaiting the Next Big Thing to emerge that will drive demand for cutting edge chips. Some speculate it could be wearable electronics. The 2014 International Consumer Electronics Show in January, for example, featured a host of wearable electronics including smart watches, fitness trackers, health monitoring devices, and the like. The Google Glass wearable computer has inspired a host of copycat products. Augmented-reality headsets for playing video games are also commanding a lot of consumer interest. Pricing for most of these products remains high, however, and it's expected to take a couple of years before price tags settle at a comfort level for the average consumer and demand starts to accelerate.

The semiconductor industry is anxiously awaiting the Next Big Thing to emerge that will drive demand for cutting edge chips

Qualcomm last year came out with the Toq smartwatch, priced around $300, which uses its Snapdragon processor and Mirasol display technology. The IC design company made it clear that it didn't want to compete in the smartwatch market with the likes of Samsung, Sony, and (it is rumored) Apple, but wanted to demonstrate how such a product could be made.

The cost and risk factors facing chipmakers are, naturally, a concern to their customers as well. Whether chip companies can cheaply and easily produce advanced semiconductors will affect developments in a variety of market sectors including automotive electronics, industrial equipment and medical systems.

The semiconductor industry has always answered the call for better and cheaper chips, yet it now seems like "cheaper" will be a hard promise for the industry to keep, with possibly dire consequences for the entire electronics value chain.

Len Jelinek is senior director and chief analyst at IHS Technology.

For more on the future of the semiconductor industry, visit www.ihs.com/Q12Semiconductors

The essentials of managing risk at the enterprise level

By Jeff Ladner

Corporate and accounting scandals, such as Enron and WorldCom, in the early 2000s precipitated significant changes in corporate governance and public disclosure of financial information. With a decade passed, most companies have established, or are well on their way to establishing, the necessary financial management discipline required to avert potential financial catastrophes. However, the risks that may adversely affect financial performance are far from being fully addressed from the perspective of investors.

Investor scrutiny is expanding beyond financial capital to include all forms of capital contributing to value creation, including manufactured,

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human, intellectual, social, and natural capital. With this expanded view comes the challenge of encompassing a broader array of corporate performance areas in the public disclosure of non-financial performance information. Often, significantly less mature management systems in these operational areas translate into less rigorous corporate governance, oversight, and disclosure. The net result is potentially significant material risks to long-term financial performance and corporate sustainability, which is increasingly the focus of interest by investors and other stakeholders.

The material risks associated with deficiencies in effectively understanding and managing all bases of capital for value creation are particularly evident in asset-intensive industries, including the energy, chemical and capital-intensive manufacturing sectors. Asset-intensive industries have risk profiles weighted more heavily toward operational risks because of the nature of their businesses. These risks are the direct result of the industrial environments in which their employees operate, the environmental and community impacts of their operations, and the massive resources consumed as part of doing business.

In many areas, companies have performed admirably. For example, US industry has seen a significant decline in total injury rates during the past decade, which reflects a steady, continuous improvement in safe operations. Nearly three million non-fatal workplace injuries and illnesses were reported by private industry employers in 2012, resulting in an incidence rate of 3.4 cases per 100 equivalent full-time workers, down from 5.0 cases per 100 equivalent full-time workers in 2003, according to estimates from the US Bureau of Labor Statistics.

However, these metrics fail to capture the impacts of catastrophic events, which have far broader implications than their direct impact on human or financial capital. Industrial accidents, such as the 2010 *Deepwater Horizon* oil spill, the 2010 Pike River Mine tragedy, and the 2011 Fukushima Daiichi nuclear accident, impact all bases of capital with a reach far beyond the four walls of a corporation. Ultimately, they have the potential to adversely impact entire industries and local economies.

It is only a matter of time until catastrophic events analogous to those in the early 2000s, that triggered substantial financial risk-management reforms, trigger equivalent reforms that cascade to all aspects of operational performance and risk management. In fact, some would argue that it's amazing that it has not happened already. Ideally, companies should be taking proactive steps now to effectively manage all of their operational risks more effectively in order to prevent such incidents and preclude the need for regulatory intervention.

Four steps to managing operational risk

Fortunately, the era of financial risk-management reforms provides a road map for how to expand and improve risk-management practices to encompass all facets of enterprise risk, especially operational risks for asset-intensive industries. There are four fundamental elements to establish an enterprise-level system for managing operational risk.

1. Corporate policies and procedures

Companies must articulate formal corporate-wide policies and procedures for achieving non-financial performance objectives. This means establishing corporate management systems that address all bases of capital—financial, manufactured, human, intellectual, social, and natural capital—and establishing standardized policies and procedures across the entirety of the business. These management systems provide a starting point for establishing operational discipline and a foundation on which companies can comprehensively manage enterprise risk.

For many companies, operational excellence programs that govern non-financial elements of corporate performance, including capital stewardship, personnel and process safety, environmental protection, third-party services, asset reliability and more, have been in place for decades. Yet, in many other companies, comprehensive programs that

bring together disparate policies and procedures are only now starting to be developed. This disparity is indicative of the relatively early stage in which many companies find themselves with regard to establishing rigorous management systems analogous to their financial management systems.

This should not necessarily be a surprise, however. While formal financial disclosure regulations have been in existence for upwards of 80 years, non-financial disclosure guidelines and compliance regulations are often less than half as old and, in many cases, are just emerging. For example, the US EPA's Clean Air Act was signed into law in 1970, while China's Ministry of Environmental Protection introduced its first comprehensive plan to reduce air pollution only in 2012. In many cases, it is these programs that ultimately drove the creation of the management systems that are in place today. However, regulation should not be a necessary precursor to this operating discipline.

2. Standardized risk-management practices

Companies need to establish proactive risk management across all of their management systems. Only through a comprehensive view of the organization and the application of standardized risk-management practices can management understand the corporate risk profile.

A key challenge is that senior management often lacks the detailed knowledge underlying any given potential hazard, which means that they are not necessarily able to discern meaningful differences or errors in risk assessments that have been performed across the business. This can lead to skewed comparisons of risk that in turn lead to improperly informed decisions. For example, two facilities with similar operations should be similarly assessing the frequency and consequence of a control system failure at their manufacturing facility. If two different risk rankings are given for what is fundamentally the same issue, this leads to inconsistent control strategies being applied.

This situation is further complicated when trying to assess the relative importance of significantly different risk types across financial, operational, legal, IT, and other categories. Foreign-exchange risk, supply-chain risk, and the risk of potential loss of containment for a storage tank are substantively different. However, the financial implications for the company are not. As a result, it is essential that companies employ standardized risk-assessment methodologies and employ a systematic means for assessing financial liabilities at the enterprise level.

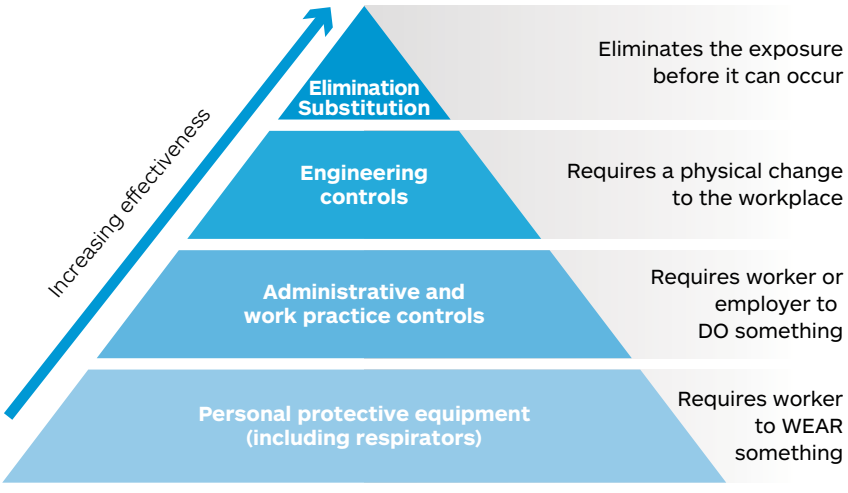
With a holistic view of its risk profile, management can far more effectively marshal resources to mitigate the critical risks that represent the most potentially damaging threats to the business.

3. Hierarchy of controls

As risks are prioritized, careful consideration needs to be given to ensure that the most feasible and effective controls are employed,

Managing risk with a hierarchy of controls

Investors are paying more attention to formal systems which companies adopt to manage risk, such as Hierarchy of Controls. These systems demonstrate a strategic commitment to reducing risk and clear quantitative measures of performance, both of which impact financial performance.



Source: US Department of Labor, OSHA

USCG

not simply the most convenient. Looking at established practices in health and safety as a point of reference, the widely accepted framework used for accident prevention, known as the hierarchy of controls, provides valuable insight into how to achieve this objective (see chart on page 60).

The hierarchy of controls is an effectiveness rating system used to select the most feasible and effective control for hazards in order to reduce risk. The key concept is to employ the highest level of control that is pragmatic for the level of risk exposure.

Controls at the top of the hierarchy reflect risk reduction through design, and are generally the most effective at reducing risk. The effectiveness of these controls reflects the fact that they fundamentally eliminate a hazard, make a substitution that does not produce a hazard, or modify processes to reduce sources of risk. For example, if a storage tank is deemed environmentally hazardous in its location next to a river, the company may choose to site the tank in a different location, build a containment wall around the tank, or increase the frequency of inspections of the tank. Each of these controls represents the varying degrees to which the risk is mitigated.

Alternatively, administrative controls, which are near the bottom of the hierarchy, are not considered as effective as they typically reflect efforts to more simply limit exposure to hazards. Administrative controls are almost always the most convenient short-term solution to managing risk. For instance, controlling the number of hours workers are in an operating environment which includes exposure to hazardous chemicals is an administrative control, whereas making a chemical substitution to eliminate the chemical exposure itself could eliminate the risk entirely. As such, administrative controls should predominantly be used only until long-term control strategies can be enacted or in conjunction with higher-level controls.

4. Checks and balances

A critical lesson learned during the financial accounting scandals of the early 2000s was the importance of checks and balances, more specifically the difference between controls and oversight, within corporate financial risk-management systems. Many companies had formal policies and procedures in place that prohibited the types of activities that can lead to scandalous outcomes. However, they were not institutionalized and adequately enforced. Defining controls is not enough: there needs to be diligent monitoring of their performance with ongoing feedback into the management team—and the management system—to ensure risks are reduced as intended.

As companies look to the future, a mindful awareness of past lessons learned and deliberate consideration of how those lessons can be applied to new challenges presents great opportunity to get ahead of the curve. The financial world that all corporations operate in is becoming increasingly sophisticated, while investors and other stakeholders are increasingly interested in the fundamentals that drive business performance. This applies to not only financial fundamentals but also operational fundamentals and the risks that may adversely affect their performance over the short, medium, and long term. As a result, comprehensive enterprise-level, risk-management strategies are essential to delivering sustained long-term financial returns.

Jeff Ladner is senior director, IHS Operational Excellence & Risk Management

For more information on operational risk management, visit www.ihs.com/Q12OE

www.linkedin.com/in/ladner

The future of urban mobility: Planning for disruptive change

What are the prospects for the automotive industry as the world's population explodes and cities fill with new residents? One thing is for certain: The future is not what it used to be.

By Phil Gott

The scene is a familiar one to any recent traveler to Southeast Asia: swarms of bicycles and motorcycles at a busy urban intersection, edging into moving traffic, impatiently awaiting their chance to move. Now imagine that all those bicycles and motorcycles have been transformed into cars and light trucks, each with the footprint of six to eight two-wheelers. Suddenly, the chaos of the intersection has multiplied exponentially into acute congestion and unbreakable gridlock. That nightmare is the future of urban mobility, if the personal car ownership rates hold true to historical trends.

But will those trends hold true? That is the burning question that confronts the automotive industry and its suppliers. For almost as long as the automotive industry has existed, its growth has been predicted, with uncanny accuracy, by a simple formula. That formula posits that as a nation's population and personal wealth increase, its motorization rate (that is, the number of automotive vehicles per 1,000 people) increases at a predictable pace. Today, though, that formula's predictive power is rapidly waning.

The urban tipping point

What is emerging is an alternative scenario. It posits that as the world becomes increasingly crowded and urbanized, the automotive industry will take a radically different growth trajectory.

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Motorization peaks when urbanization reaches 80%

Urbanization rates for various parts of the world

	2012	2035
Japan	92%	97%
Oceania	89%	91%
MERCOSUL	86%	90%
Korea	83%	88%
NAFTA	81%	86%
ANDEAN	80%	85%
Western Europe	77%	82%
Middle East	76%	81%
Eastern Europe	69%	75%
Taiwan	72%	74%
China	52%	71%
Central America	64%	70%
Central Europe	62%	67%
ASEAN	47%	61%
Africa	47%	57%
Indian Subcontinent	32%	43%
Rest of the World	29%	42%
World	55%	65%

Source: IHS

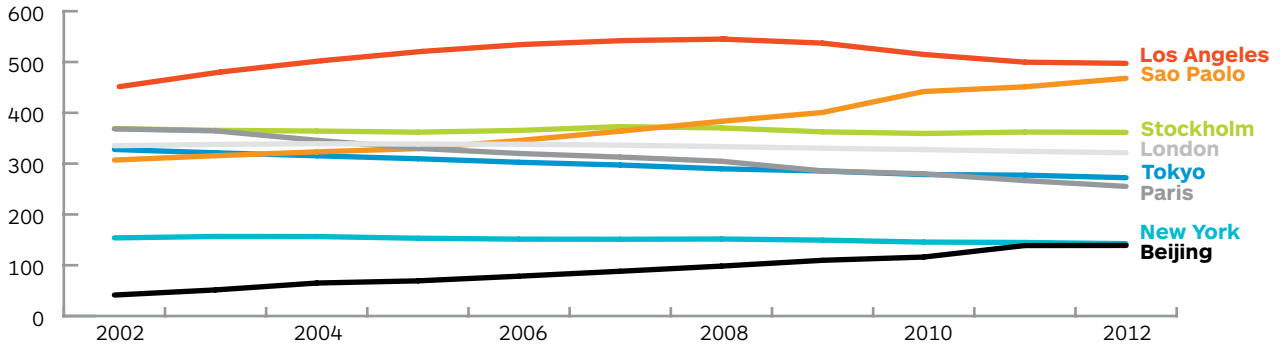
A tipping point occurred in 2005 when, for the first time in human history, more than half the world's population lived in urban areas. By 2035, according to the United Nations, the global population will have increased by 2 billion, to 9.2 billion, and nearly all of this additional population will live in urban areas. By 2035, roughly two-thirds of the world's people will be urban dwellers. (See table on the left.) Because most cities in the future will likely grow vertically rather than sprawl horizontally, they will be far denser—that is, they will contain more people per square kilometer—than they are today. So if the world's population grows as projected and motorization growth continues at historical rates, urban traffic will become unmanageable—and cities themselves unliveable.

Weak signals of an epochal change in personal mobility preferences are already sounding from many quarters. A growing percentage of younger people are deferring obtaining their first driving licenses. Mass transit options are steadily multiplying, despite their expense. And in mature cities such as London, Paris, New York, Stockholm, and Tokyo, motorization rates have been declining steadily for the past decade, as more and more urban dwellers happily relinquish their cars. (See figure below.) For these people, the sheer misery of urban driving—with its clogged roads, limited alternative routes, uncertain trip and arrival times, and anxieties around parking—outweighs the increased freedom and autonomy that car ownership provides.

The people opting out of car ownership will likely have plenty of company in the next 25 years. As congestion increases and alternatives to driving within cities proliferate, the links between wealth, population, and motorization are weakening, and forecasts of automotive growth that rely solely on that link are becoming less and less reliable. The implications of this breakdown are profound and reach far beyond the automotive industry itself. They have the potential to affect the plans of developers of connectivity solutions, suppliers of chemicals and materials, energy producers,

Drivers in dense urban environments are starting to give up their cars

Cars per thousand people for major urban areas, 2002-2012



Source: IHS

and makers of mass transit systems, to name just a few. Some companies will anticipate the change and prosper from it. Others, to their peril, will see growth continuing in a straight line and continue to plan for a future that might very well never arrive.

It all comes down to congestion

The auto industry may well be approaching an inflection point of its own. Extensive analysis reveals that, generally speaking, motorization rates peak when about 80% of a country's population lives in urban areas. At that level, it appears, there simply is not enough room on city roads for more cars. But that number is more of an average than an absolute rule. An IHS study of motorization rates in 20 model cities shows that motorization is declining, at least in developed markets, at a rate that the traditional formula for motorization cannot account for. In some cases, population density alone accounts for the decline. In others, though, multiple factors come into play, including access to the internet, the availability of acceptable transportation alternatives, and government regulations designed to mitigate congestion.

The factors that limit the growth of the total number of light vehicles in operation—a figure referred to in the automotive industry as the "parc"—vary widely, depending on the level of regulation, the type and number of mobility options that each city offers, their population, and their stage of development. The one thing they share is congestion. Some cities address the problem by imposing regulatory or financial measures to control car ownership and usage, while others allow congestion itself to impose limits.

The study groups more than 1,600 cities covering 25% of the world's population—and more than 30% of the addressable automotive market—by their level of regulation, categorizing them as "reactive," "soft active," and "tough active." Reactive cities have no anti-congestion regulations, and congestion itself will limit the growth of motorization. Soft active cities are building or have built the infrastructure for transportation alternatives (such as light rail, dedicated bus lanes, and municipal bike-share programs) but have not yet established incentives or sanctions to shift drivers into other forms of transportation, such as stiff tolls at crossings or pay-as-you-go pricing for road use. Tough active cities have regulatory regimes that all but force people out of their cars, through strong fiscal incentives and penalties, outright bans on driving in certain areas or at certain times, caps on vehicle registrations, or strict controls on parking.

The regulations are a response to economic concerns. Congestion is enormously costly. Not only are there direct costs, such as wasted fuel, the deleterious effects of pollution on public health and infrastructure, and the time lost sitting in traffic, but the indirect costs are also significant. Cities with unmanageable (or unmanaged) congestion suffer economic losses from reduced employment opportunities and lack of access to leisure activities, cultural events, and entertainment.

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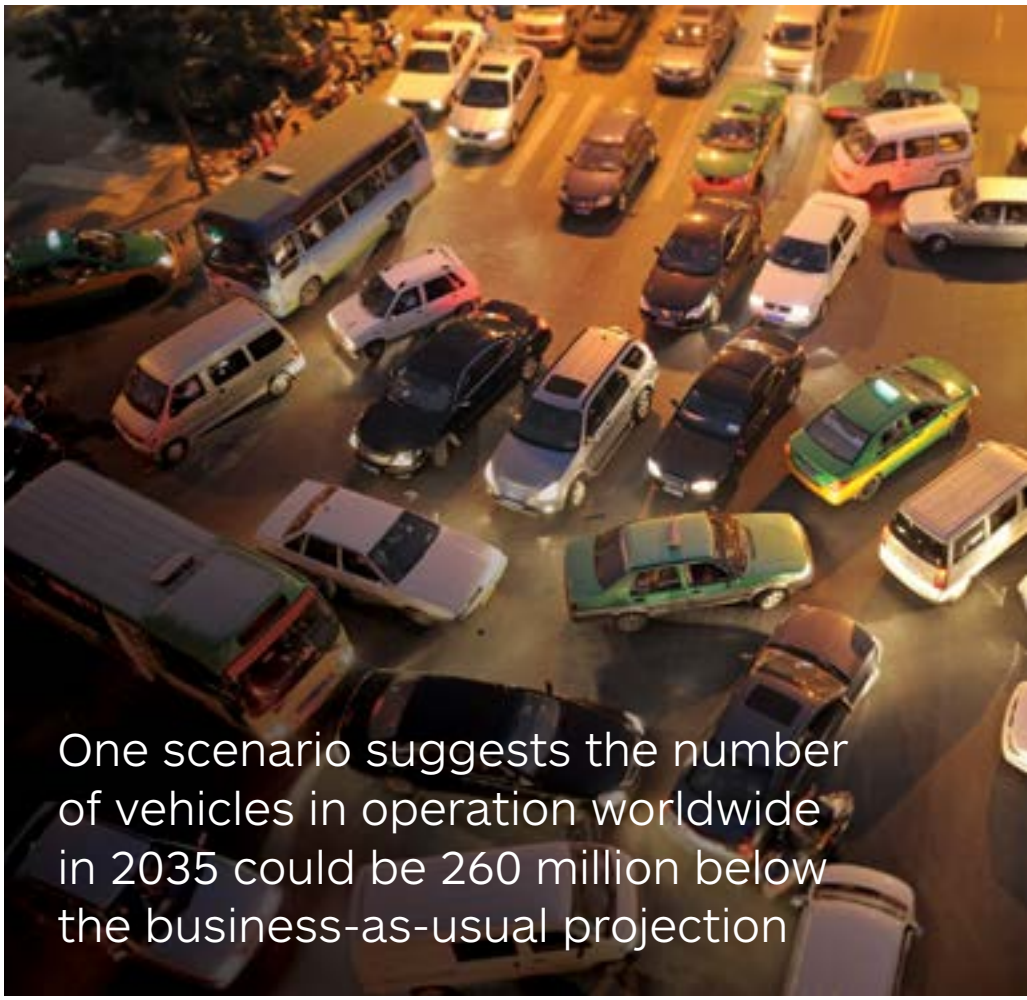
Congestion and the various tough and soft measures taken to address it will have a significant impact on the automotive industry and its stakeholders. To quantify that impact, IHS developed three different scenarios for how motorization could develop in cities of 300,000 people or more over the next quarter-century. These three scenarios are the Base Case, the New Urban Mobility (NUM) model, and the Technological Breakthrough model.

The Base Case is a standard industry projection of the global light vehicle parc and resultant annual sales. This projection takes into account the various limitations on growth imposed by congestion and regulation, the different characteristics of cities in developed and developing markets—such as the widespread use of two- and three-wheeled vehicles in the developing world—and the need to control congestion in order to enable economic growth. The Base



One scenario suggests the number of vehicles in operation worldwide in 2035 could be 260 million below the business-as-usual projection

Innovation through anticipation

How Valeo connects the trends of tomorrow to today's product design

"Anticipation is the key word for what we do," says Derek de Bono, product marketing director for Valeo Group, a global producer of automotive components, systems, and modules, with US$16.2 billion in annual sales and 73,300 employees working in 28 countries. In effect, de Bono and his product design team strive to know in advance what consumers want and deliver it to them precisely when they want it. "We don't want it before," de Bono says, "because then it will be too early, and we don't want it after, because we lose the innovation edge on the market." Innovation, de Bono makes clear, is what fuels Valeo's impressive growth.

Anticipation in de Bono's world is both an art and a science, and Valeo's product designers take both quantitative and qualitative data into account when preparing the annual 10-year product development plan. The research includes long-range trend and sentiment analysis as well as traditional quantitative forecasting. The team analyzes economic growth trends, the price of fuel and batteries, and coming technological developments, but they also listen closely to consumers, holding focus groups around the world to determine what drivers like and dislike about the driving experience.

Through a series of such focus groups, de Bono and his team learned that parking is one of the biggest pain points for drivers, who would welcome a bit—or a lot—of assistance from technology to make it less of a chore. Based on that feedback, Valeo has developed a range of parking-assistance technologies, from backup cameras

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Case, however, does not weight these factors as heavily as does the NUM model.

The NUM model, by contrast, proceeds from the assumption that new trends in urban mobility—including mobility options such as car-sharing and car-pooling—will gain momentum, with a growing impact on the number of light vehicles in operation and annual vehicle sales.

The Technological Breakthrough scenario assumes that autonomous and self-driving vehicles will come into wide use. Should this scenario be realized, the effect on the number of registered vehicles and annual sales will be profound, and not necessarily in a negative way. However, these developments occur at a rate that will delay the full impact until roughly 2050.

This article focuses on the NUM model because it represents the most plausible near- and medium-term alternative to the Base Case. Under the NUM model, the growth in the global number of vehicles in operation would be at least 13% less than the growth projected under the Base Case. The real number could be larger if today's vehicle owners scrap their vehicles sooner than the model anticipates. If scrappage rates accelerate, the number of vehicles in operation would shrink proportionately, widening the gap between the parc growth projected in the Base Case and that projected by the NUM model.

If the world develops in line with the NUM model, the number of vehicles in operation worldwide in 2035 could be some 260 million vehicles less than the number projected in the Base Case. New sales worldwide in 2035 could come in at 27 million less than the Base Case projection. Sales in India and China, the two countries to which the industry looks for aggressive growth, could fall short of the base case projection by 15 million units annually in the same year.

to fully automated parking. That response to consumer needs typifies Valeo's approach to innovation. "The first goal," says de Bono, "is to address moments when the driver does not enjoy driving."

In pursuit of that goal, Valeo is now exploring ways to more fully automate the driving experience. The company's product designers have learned that in some parts of the world many drivers would willingly give up control of the car, at least in congested conditions, to focus on other activities. American workaholics, for example, would happily relinquish control in a traffic jam in order to turn their attention to writing emails or conferring with work colleagues. "Automation allows them to take back two hours a day to work," de Bono says. Millennials, on the other hand, would prefer to use the time spent stalled in traffic on entertainment. So Valeo is working on new display technologies.

Not every driver, though, is ready to let go of the wheel. Chinese drivers, de Bono says, are wary of automated driving because they do not believe that any algorithm, no matter how clever, is equal to the chaos that prevails on China's roads. German drivers, for their part, enjoy driving at high speeds on the country's *autobahns*, where there are no speed limits, and would not willingly cede that fun to a computer. Technology marches on, but it will never eliminate the human need for speed. That is one more thing for Valeo to anticipate, and one more opportunity for the innovation that drives growth.

Based on an interview with Derek de Bono, product marketing director, Valeo Group.

For more on Valeo's strategies for developing products that anticipate future trends, visit www.ihs.com/Q12Valeo

If those projections are realized, then by 2035 there will be little or no net organic growth in the automotive market, with total worldwide sales topping out at roughly 100 million vehicles annually. Sales in some regions such as Asia, Africa, and Latin America will grow, but declines in the developed world will largely offset the increase. And there will be no need for an increase in net new manufacturing capacity to meet anticipated demand, although some capacity may have to move closer to pockets of growth. In fact, the industry, already on pace to expand capacity to 120 million units a year by 2016, could face acute overcapacity. (See figure below.)

Disruption brings opportunity

The NUM scenario presents automotive manufacturers with an opportunity to grasp the growth possibilities inherent in disruptive change. The key is to recognize that though there may well be, in the aggregate, a reduction in the net demand for new vehicles, there will be a growing need for mobility. People will still have to move about, both physically and virtually. Digital connectivity will address some of this need. But new solutions to enable physical mobility will drive the emergence of a new mobility industry, which will include both existing light vehicle manufacturers and new entrants offering innovative solutions. Manufacturers, though, will need to recognize that they are no longer in the business of selling cars and light trucks. They are selling mobility.

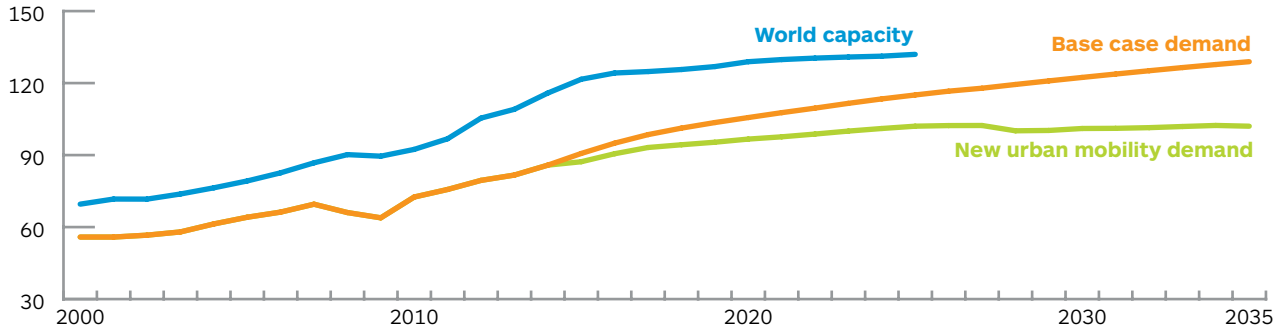
This shift requires manufacturers to reconceive themselves as service businesses, selling end-to-end mobility as a concierge-level service. Just as the music industry has evolved from manufacturing and distributing tangible artifacts such as vinyl records and CDs into delivering the experience of music, manufacturers have an opportunity to evolve toward selling the experience of mobility.

The NUM model also implies that the industry will need to rethink its plans to add capacity. The NUM scenario's projection that capacity will exceed demand by more than 25 million vehicles by 2035 implies that manufacturers must adjust their investment plans. They may choose to sell subsystem and assembly plants to contract manufacturers or collaborate with other manufacturers. In addition, they may want to shift some capacity to regions where the demand for new vehicles has room to grow substantially.

Manufacturers may also find growth potential in markets adjacent to the existing private-vehicle market. The New Urban Mobility model will call for new types of vehicles to move people and goods through increasingly crowded urban spaces. This hardware will have to be integrated with software, services, and lifestyle products to solve the problem of mobility and meet customer preferences. As mobility service providers, today's manufacturers can offer time-pressed customers various options for moving from

Auto makers could face overcapacity of 30 million units a year by 2025

Global light vehicle production capacity, sales of light vehicles for the business-as-usual Base case and New Urban Mobility case (Millions of units a year).



Source: IHS

The sharing economy and the future of urban mobility

By Veronique Lamblin

Groupe Futuribles is in the business of telling stories—stories about the future. The Paris-based organization uses qualitative and quantitative information about organizations, regulations, personal values, and other phenomena as the basis for storylines that describe what might unfold in consumer markets in the next two decades or so.

The narratives we develop rely also on quantitative forecasts that make them compelling and persuasive to business leaders. The combination of quantitative forecasts from IHS and qualitative foresight from Groupe Futuribles offers a compelling vision of the future of the automotive industry based in part on how young people around the world are converging around the idea of the sharing economy.

Thanks in large part to exchanges enabled by the internet, we have found that young people in developing and mature markets alike are more willing than their elders to share many forms of consumption. They use the internet to swap apartments, exchange services, or band together to form ad hoc buyers' clubs.

The sharing economy is nothing new. It has existed at the neighborhood level for generations—think of the bakers who, once the day's bread was baked, allowed local women to use their ovens to cook one-pot family meals. Today, though, the internet has enabled people to share over longer distances, and young people are taking advantage of digital connectivity to share a wider range of goods and services than their elders.

Several attitudinal shifts help account for the rise of the sharing economy, with implications for the automotive market. For one thing, younger people, who since childhood have been absorbing messages about pollution, climate change, and sustainable living, have developed an acute sensitivity to environmental concerns. They see the sharing economy as a more environmentally responsible way to consume. For instance, if you share a car with 100 other people, you need fewer cars.

Social trends impacting mobility

Social Trend		Implication for the Auto Industry
Increasing urbanization	→	Congestion, pollution, cost of car ownership driving usage of alternative modes of transport
Use of smartphones, social media, apps	→	Digital "mobility" replacing personal mobility as priority among younger people
Economic and environmental rationality among younger generation	→	Openness to sharing cars/vehicles rather than owning, to save money and resources
Postponement of marriage, kids, home ownership	→	Deferment of purchases such as personal vehicles

Source: Groupe Futuribles

In what might be the most startling twist, young people have developed an affinity for the sharing economy by observing the lifestyles of the rich and famous. They see celebrities moving from limousine to airplane, from rented luxury cars to hotels, then back to the limousine and the next airplane. The rich and famous don't own anything—they rent what they need and when they no longer need it, they just drop the keys off at the front desk. Why should the well-heeled be the only ones to enjoy such convenience?

Young professionals in emerging markets also enjoy the unique advantage of being able to learn from the developed world's mistakes. In my collaboration on the future of urban mobility with IHS, I had the opportunity to speak with young urban planners in places such as Jakarta and Shanghai. Nearly all of them studied in Europe or the US, where they saw firsthand the consequences of the unrestrained growth of automobile-centric economies. The philosopher George Santayana famously remarked that those who forget the past are condemned to repeat it. These young planners seem determined to avoid that fate, which may well lead to less urban congestion and a brighter future not only for their societies but for the entire planet.

Veronique Lamblin is foresight and strategy studies director, Groupe Futuribles.

Auto makers need to shift their focus away from unit volume growth to growth based on providing mobility as a service

Point A to Point B, at different price and service levels. They can tailor their offerings to customers looking for the most environmentally friendly option, or the most luxurious, or the service that allows them to use their time sitting in traffic to work or be entertained.

One of the most intriguing implications of the New Urban Mobility is the shift toward autonomous vehicles. It is already under way, in the form of Advanced Driver Assistance Systems, such as park-assist and self-parking systems, adaptive cruise control, lane-departure warnings, and forward-collision alerts. Just over the horizon is the possibility of self-driving or autonomous cars, which, in addition to improving road safety, offer passengers the opportunity to engage in work or leisure activities while on the road.

Development of autonomous vehicles is dependent upon a number of factors, including extensive changes to existing legal and regulatory regimes. Above all, though, it depends on further expansion of connectivity, especially in the field of the so-called Internet of Things. To be widely used, autonomous vehicles will need to be part of a network offering continuous connection to road sensors, other vehicles, and areas designated for passenger pickup and drop-off.

Finding a place in the new mobility ecosystem

This article describes where we believe things are heading, but it is unlikely that mobility will evolve precisely as projected here. Thus, the insights developed by this project may be viewed as a planning platform, a chance to imagine the future and the automotive industry's place within it. While the outlines of this new world are only now beginning to emerge, it is already clear that big changes are in store. So are the opportunities for industries that feed the automotive ecosystem.

Energy companies clearly have a large role to play in the mobility market of the future. Although reductions in the number of light vehicles on the roads and the road-miles driven will cut into sales of fuel and lubricants, opportunities abound for developers of alternative powertrains and their energy sources.

Possibly the greatest opportunities await technology companies. Automobiles, already bristling with electronic components, will increase their technology content in coming years. There is also an acute need for technology that can integrate information from across an entire urban mobility system in a form that allows travelers to choose the mobility option that best suits their needs at any given time.

A change of plans

The thesis underlying this article is that the car and light vehicle market simply cannot grow at historical rates. Even the Base Case scenario projects that motorization will grow at rates below the historical norm. In such circumstances, energy companies, safety regulators, urban planners, and operators of chemical and refining facilities must challenge the prevailing expectation that automobile usage will develop in line with historical trends.

As cities fill with more and more people, fewer of them will own their own cars. The automotive industry and its stakeholders should therefore plan ahead to ensure that they can provide the needed and desired levels of mobility to everyone who requires it in the most affordable, socially beneficial manner possible.

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Automobile manufacturers will have to shift their focus away from unit volume growth toward growth based on providing mobility as a service. In a world where incremental sales gains will come only by taking share away from rival manufacturers, they will have to find other growth drivers. Car-sharing services, production of people and goods transporters, and service on demand are all avenues that require a mindset that looks beyond the traditional car ownership model.

Technology companies will be key players in building and maintaining the mobility infrastructure. New forms of mobility will demand new technologies, from the systems needed to support autonomous vehicles (including both vehicle componentry and the road sensors those components communicate with), to new assembly techniques, including 3-D printing, to tracking the mobility grid in real time.

Planning for such an uncertain future is a challenge for all companies involved in the extended automotive value chain, from energy providers all the way to after-sale product and service companies. But what is the alternative? If a new type of urban mobility is emerging, then the status quo is untenable. The automotive industry and its stakeholders have a choice: to seize and profit from the opportunities that the disruption will create, or to stand by as others, perhaps from outside the industry, provide innovative solutions to urban mobility challenges, while the incumbents wither away, having realized only too late that the world has changed.

Phil Gott is senior director, long range planning, IHS Automotive.

www.ihs.com/experts/philip-g-gott.aspx

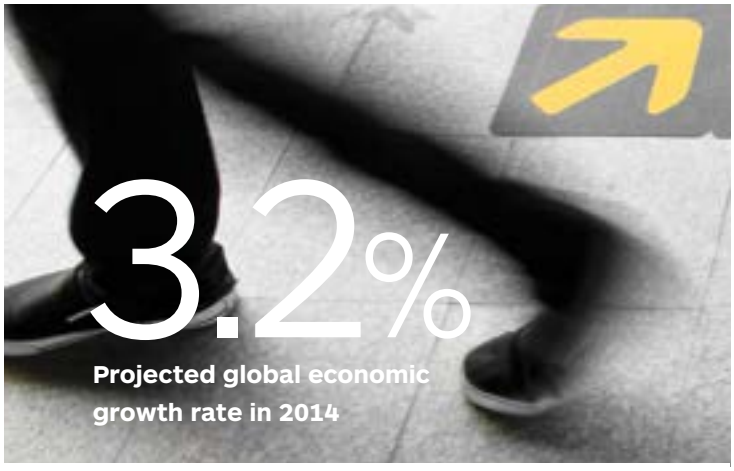
Contributors to this article include Chris G. Christopher, Jr., director, IHS Economics & Country Risk; Nigel Griffiths, chief automotive economist, IHS Automotive; and Egil Juliussen, research director, IHS Automotive.

IHS Automotive collaborated with Groupe Futuribles on the recently released Future of Urban Mobility study.

For more information on the study, visit www.ihs.com/Q12Mobility

3 Million

Number of non-fatal workplace injuries and illnesses reported by US private-sector employers in 2012 to the US government

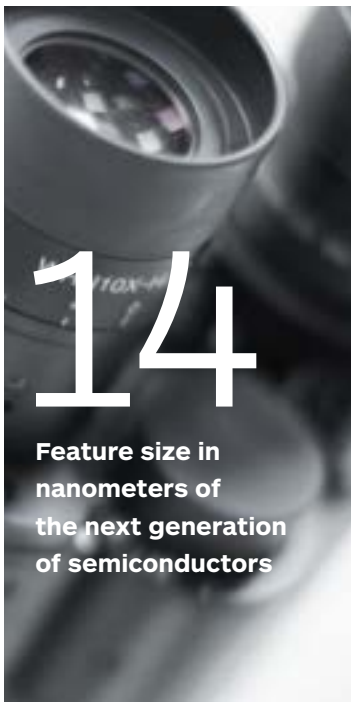


3.2%

Projected global economic growth rate in 2014

845%

The amount by which China's official defense budget is projected to grow between 2000 and 2018

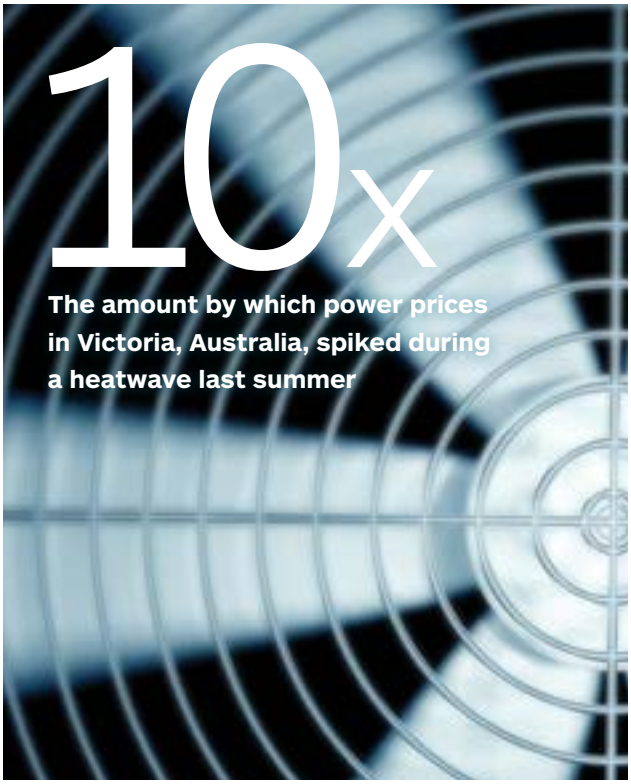


14

Feature size in nanometers of the next generation of semiconductors

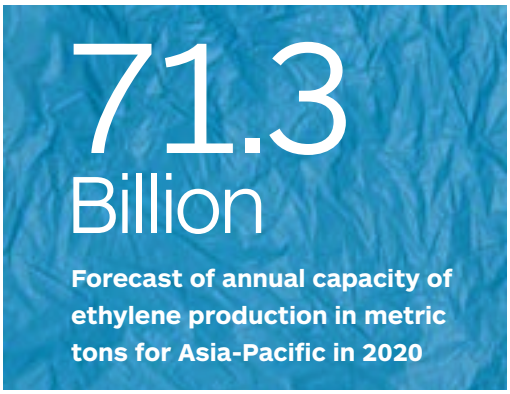
80%

Level of a country's population urbanization at which car ownership rates peak


10x
The amount by which power prices in Victoria, Australia, spiked during a heatwave last summer

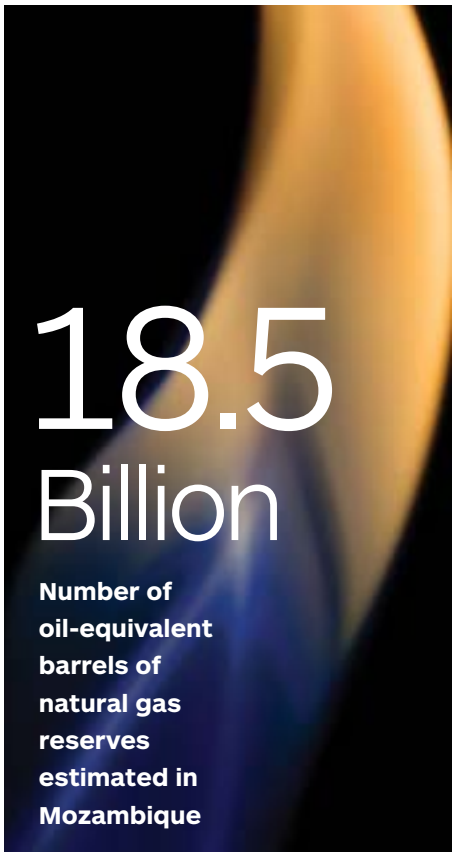

3x
Amount by which global spending on cloud services will increase between 2011 and 2017


25 Million
Global auto industry's excess vehicle capacity by 2035, under New Urban Mobility scenario projections


71.3 Billion
Forecast of annual capacity of ethylene production in metric tons for Asia-Pacific in 2020


57,000 Tons
Deadweight of the cruise ferry *Viking Grace*, the largest non-gas tanker to be propelled by LNG


100%
UN estimate of the earth's additional 2 billion population by 2035 that will live in an urban environment


18.5 Billion
Number of oil-equivalent barrels of natural gas reserves estimated in Mozambique

Source: IHS

Zbyszko Tabernacki
Vice President
IHS Economics and
Country Risk

New dimensions of risk

Not too long ago, assessing country risk as part of an investment decision was considered an afterthought. The long period of economic expansion and relative geopolitical stability following the fall of the Berlin Wall and the end of the Cold War ushered in an era when many global companies and financial institutions considered their country risk teams obsolete. As they developed market entry and expansion strategies, business executives focused mostly on market sizing, demand forecasting, and understanding basic regulatory dynamics. Economic, political, and security risks were taken into account only if they were severe enough to derail the entire investment or result in massive losses.

How times change. As the corporate investment universe has expanded over the last decade to include less stable emerging markets, the threats have become more dynamic and the time to react has been compressed. The aftermath of the Arab Spring, instability in Venezuela and Thailand, and the recent crisis in Ukraine are emblematic of a new class of unanticipated shocks that global corporations face. Simply designing mitigation strategies is no longer an option. Business leaders need sophisticated analytics and expert insight to accurately gauge—and pre-empt—the diversity of risks they face today. They need a holistic corporate risk management system that covers all the bases: from assessing investment risks during feasibility analysis to monitoring risks during implementation and operation.

IHS knows risk. We have been on the forefront of country risk assessment and analytics for over a decade. With the 2012 acquisition of Exclusive Analysis, IHS has significantly expanded its capabilities to monitor, analyze and forecast political violence and security risk at a very granular level. Using highly integrated, data-driven tools we can anticipate negative impacts on operations within an area of 500 square meters. Our 50 analysts based in the UK, US, and Singapore monitor both short- and long-term trends and design risk strategies with the mission of protecting assets, operations and personnel.

IHS is taking the lead in utilizing cutting-edge visualization and mapping tools to allow for quick decision making in times of crisis. Going forward, assessments of risk will become even more dynamic. We are developing tools to analyze real-time social media data to predict when and where an event might occur. And we are relying even more than before on gathering intelligence from sources on the ground. All with the objective of minimizing your business risk.

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