DP WORLD

A turning point: The potential role of ICT innovations in ports and logistics

A report for DP World
Prepared by The Economist Intelligence Unit

November 2015

Executive Summary

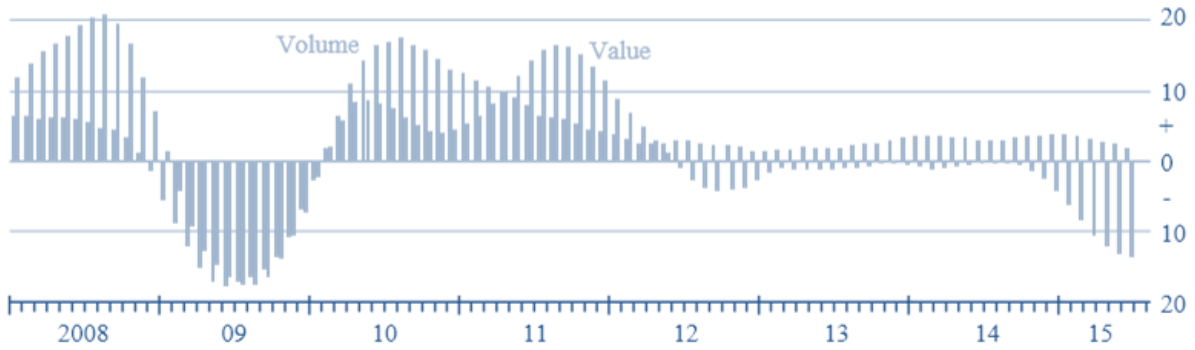
The slowdown in global trade has added fresh impetus to the need for ports and logistics firms to invest in the latest innovations in information and communications technology (ICT). Five innovations are particularly relevant and will affect almost all aspects of the trade and logistics process: robotics and automation; autonomous vehicles; the Internet of Things and big data; simulation and virtual reality; and cybersecurity.

A. Background

The slowdown in global trade is becoming more pronounced

After growing at breakneck speed throughout the noughties, the value of global merchandise trade shrank in the first six months of 2015 by more than 13% year-on-year. In volume terms, trade is still growing, by 1.7% year-on-year, but that is far below the long-term average of around 5% per year.[1] This also means that trade is no longer growing faster than world GDP, reversing a long-term trend. The slowdown is all the more remarkable given the decrease in transport costs due to cheaper oil – which would normally be expected to boost trade.

Global trade – six-month average (% change on a year earlier)



Source: The Economist, OECD, CBP

[1] http://www.economist.com/news/finance-and-economics/21665040-slowdown-global-trade-growth-bad-news-many-emerging-markets-becalmed

What is driving the slowdown?
As with many global trends, China is key. Its economy is cooling and future growth will be driven more by domestic consumption that exports. China is also making more at home, and the share of imported components in its exports has fallen from 60% in the 1990s to 35% this decade.

Stagnant growth in Europe is also important as its share of global trade (one-third) is much larger than its share of global GDP. Although the US is enjoying fairly robust growth, its crude oil imports have fallen sharply because the country is exploiting its own huge domestic reserves of shale oil. Russia and Brazil, feeling the effects of the slowdown in China, the strong dollar, and (in Russia's case) sanctions, are mired in recession.

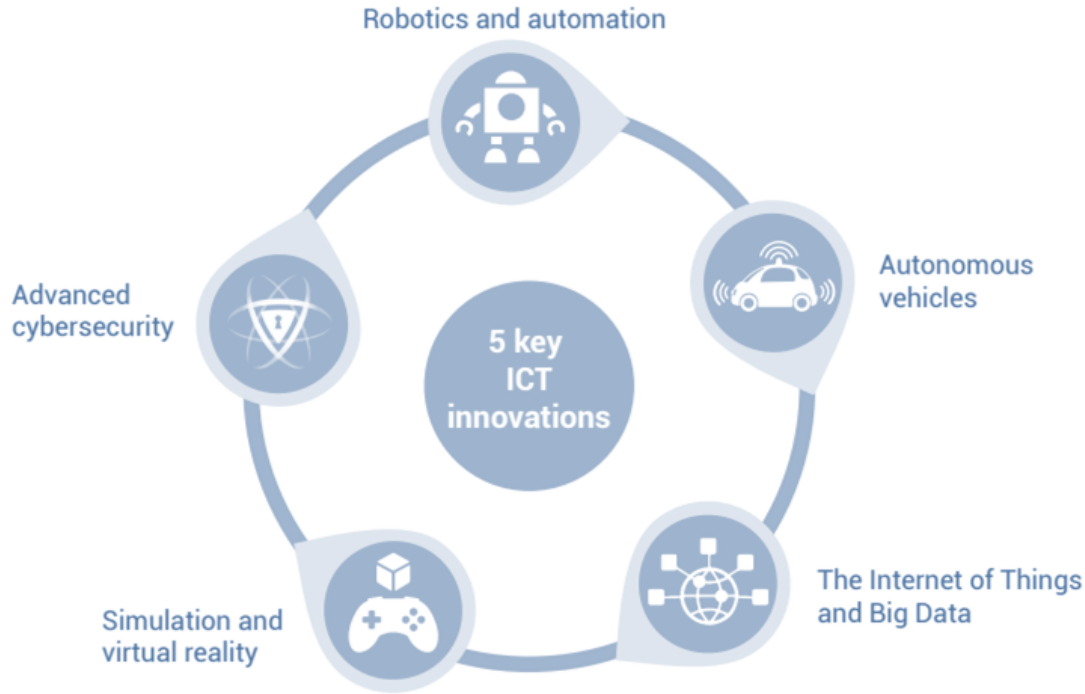
At a global level, trade agreements have also stalled. The biggest deal currently under negotiation is the 12-country Trans-Pacific Partnership (TPP). On October 5th, after years of negotiation, the 12 countries reached an agreement. However, the deal still faces a major battle to gain domestic approval in the US Congress. The deal on trade facilitation that the WTO reached in 2013 requires ratification by two-thirds of the organisation's 161 members. So far, just 16 have signed up.

What does the slowdown mean for ports and logistics firms?
The slowdown in trade is unlikely to be dramatically reversed in the short term. As a result, competition between ports and across the logistics sector looks set to intensify. As ports and logistics firms battle to protect and gain market share, the race to find cost savings and efficiency gains will become even more pronounced.

However, firms also face an opportunity – offered by rapidly evolving innovations in ICT. The ports and logistics sector has already embraced technology to a certain extent. For instance, the operations of many ports have changed dramatically over the past few decades. Today, scanning technologies can monitor for harmful or illicit substances, and importers can visit a "one-stop-shop" website to arrange an order directly from their smartphone.

However, over the next decade the sector will witness more substantive changes as automation becomes more widespread and operations are increasingly directed and optimised in real time by sensors and intelligent software. Five innovations are particularly relevant and will affect almost all aspects of the trade process (see graphic, below).

Five key ICT innovations for ports and logistics firms



Source: EIU

B. Five key ICT innovations for ports and logistics firms

1. Robotics and automation

There has been a steady increase in automation in ports since the first automated stacking cranes were installed at the European Container Terminals in Rotterdam in 1990. Automated equipment, produced by firms such as Kalamar, is now available for most terminal functions including ship-to-shore movements, straddle carrier ground transportation, and the management of container stacks and trucks loading.

Some of this equipment can operate entirely autonomously, while some utilises remote operators who are able to work more efficiently in safer and more comfortable environments. Software is also used to monitor and optimise the flow of goods through the port, which provides savings in time, fuel and personnel.

The extent of automation varies considerably across ports. Shanghai, the world's busiest container port, is almost entirely manual, while Rotterdam's Maasvlakte II terminal, which opened in April 2015, has no personnel inside its cargo-handling section, thereby boosting efficiency and reducing the risk of accidents. Automation is easiest to implement at greenfield sites such as this, but can be partially or fully retrofitted at existing terminals.

The cost of automation can be as high as US$0.5 billion for a large port with more than 1m TEU (twenty-foot equivalent unit) capacity.[2] Automation makes most sense in ports where the cost of local labour and land is high and where there is a competitive need to efficiently handle larger ships. The rise in "megaships" has driven the latter need – there are now over 120 container ships of between 13,000 and 20,000 TEU. The trend is expected to continue given the cost efficiencies such vessels offer and the recent expansion of the Panama Canal (which can now accommodate ships of 13,000 TEU).

One example of the growth in automation is TraPac's Los Angeles terminal, which is the first in the US to automate both ship-to-shore and ground transport. The expectation that labour costs will be reduced by up to 50%[3] has sparked industrial action and demonstrates how resistance from trade unions is a particular barrier to retrofitting automation at existing ports. However, the rise in automated ports is likely to continue as they will have a clear advantage over regional rivals in terms of greater and more efficient loading and unloading capabilities.

Beyond container handling, firms are looking to automate other parts of the supply chain by leveraging the latest innovations in robotics. This is dictated in part by cost savings. As the cost of labour increases and the cost of technology decreases, companies are fast approaching a point where investments in robotics are becoming cost-effective. Another driver is the continued growth of e-commerce and changes in consumer preferences. Today many consumers expect same-day delivery and also want to be able to customise the products that they order. This is placing an onus on warehouses to dramatically increase their speed and productivity.

The use of robotics is key to this. Perhaps the most famous example is Amazon which has installed 15,000 Kiva robots in its warehouses, allowing products to be stacked at a faster rate and more accurately. The result is that the company expects a 20% reduction in the operating costs of warehouses that use them.

2. Autonomous vehicles

One of the most advanced types of "robot" under development is autonomous (or driverless) vehicles. Aside from the use of specialised autonomous vehicles within ports to move containers, the broader development of autonomous vehicles – across the three mediums of land, air and sea – will have significant implications for ports and logistics firms, both in terms of practical operations and commercial threats and opportunities.

[2] http://www.joc.com/

[3] http://www.joc.com/

Autonomous vehicles in action

Driverless Trucks	Driverless cars	Drone planes	Drone Ships
In May 2015, Daimler's 18-wheeler Freightliner, called the "Inspiration Truck", was unveiled.	Google has been working on its self-driving car project since 2009. It is currently being tested in Austin and California, in the US.	DHL is using drones to deliver medicine to Juist, a small German island.	Rolls-Royce Holdings launched a virtual-reality prototype of a drone ship in 2014.

Source: EIU

A) Driverless trucks and cars

Driverless trucks are already under development. Daimler's 18-wheeler Freightliner, unveiled in May 2015, is the first to be licensed for road tests. It operates on autopilot on highways but switches to a human driver for lane changes and parking. It uses radar sensors, cameras, and servomotors to detect objects around it, and then takes over actions from the driver such as steering and braking.

Given the ongoing investment in the area, it is likely that fully automated trucks and delivery vans will one day be used by logistics firms. A key motivation is to reduce the liability these firms face when a human driver makes an error. Once the technology has a solid track record and a clear safety record, its attraction may become too compelling to ignore.

However, others argue that a human will need to stay in the driving seat for the foreseeable future, especially for long-haul trucks. While the technology will allow these trucks to drive themselves, they will still carry considerable destructive potential. This raises awkward liability questions. If an accident occurs, who is liable? The logistics firm or the truck manufacturer? A middle ground in the medium term may be the development of automated convoys in less populated areas – where automated trucks are programmed to follow driver-led trucks.

Investment in driverless cars is also heating up rapidly, with a large number of big automotive and technology companies (including Google and Apple) investing. To attract such firms, governments are racing to position themselves as leaders in the sector. For instance, in December 2014, Innovate UK announced that it would invest £10 million in four new testing facilities for driverless cars.[4] The trials will demonstrate driverless cars to the public and test their ability to reduce congestion and improve road safety. Similarly, in July 2015, M-City opened on the University of Michigan campus. A 32-acre testing district, it will feature a fully-fledged road network with traffic signals, pedestrians and construction barriers. Backed by government and industry partners, it is part of a long-term goal of having an automated, connected mobility system in Michigan by 2022.[5]

[4] https://www.gov.uk/government/news/uk-government-fast-tracks-driverless-cars

[5] http://www.mtc.umich.edu/test-facility

The rise of automated trucks and cars will have practical implications across the logistics supply chain. Ports, for example, will need to be able to load containers onto the driverless trucks. There will also be a competitive element as the reduced transportation costs and faster transit times (without breaks) achieved by driverless trucks could shift conventional trading routes. This could herald the arrival of new, unconventional, entrants into the logistics sector. Uber is currently in the process of upending the traditional taxi business – however, it has made no secret of its plans to expand into the logistics sector. It has also launched a research centre focusing on driverless cars.

B) Drone planes

The introduction of small drone copters as package carriers, currently being tested by companies such as Amazon and Google, is an important development in the final stage of the logistics chain. DHL is already using beyond-line-of-sight drones to deliver medicine to Juist, a small German island, and Swiss Post has launched a trial drone-borne parcel service for packages weighing up to 1kg.

In the US, the main barriers to date have been regulatory. For instance, Federal Aviation Administration (FAA) rules require operators to maintain a clear view of drones at all times – posing obvious challenges to a wider rollout across the logistics sector. It also insists that drones be tested at public sites, unless special permission is granted. As a result Google has tested its "Project Wing" in Australia, which has been more accommodating.

Of note for the shipping industry are larger drone planes that could significantly cut the cost of transporting cargo by air. In 2013, the ASTRAEA study, launched by the UK aerospace industry, conducted the first unmanned flight (of a retrofitted Jetstream) in British airspace. It concluded that it would be feasible to incorporate drone aircraft in controlled airspace, although low-altitude uncontrolled airspace would be more challenging as sense-and-avoid technology is needed to respond to obstacles. Separately, smaller drones are already being used for security surveillance in some ports (such as Abu Dhabi's Khalifa Port), and could also have a role in monitoring port operations and detecting problems requiring maintenance in both port equipment and ships.

C) Drone ships

Drone (or "ghost") ships appear to be the most distant of the three types of autonomous vehicles. The first serious initiative was unveiled by Rolls-Royce Holdings in 2014. By eliminating crew-related infrastructure, Rolls-Royce estimates that the ships could reduce fuel consumption (and hence emissions) by up to 20%. They could also store more cargo relative to the ship's size. Cutting out the crew could reduce operating expenses by around 40%.[6]

However, drone ships are unlikely to start operating this decade since they face significant challenges. One is regulatory, as international maritime conventions set minimum crew requirements. A related concern is safety, and it is unclear when autonomous or remotely operated ships will be able to adequately cope with the challenges of weather, obstacles and

[6] EIU estimates based on various sources.

in-trip repair. However, studies are already under way, including the European Commission-funded Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) project, which was completed in June 2015.

If the challenges can be overcome, drone ships could potentially improve safety, as the majority of shipping accidents are the result of human error, often related to fatigue. Moreover, drone ships would be less appealing for pirates to hijack given the absence of hostages.

From the perspective of port operators, drone ships would integrate best with the most automated terminals and would be beneficial for their business by helping to maintain the cost-competitiveness of sea transport. Simon Bennett, the director of external relations at the International Chamber of Shipping, predicts that the use of drone ships will not be realised for two to three decades.[7] However, even if that is the case, partial automation, with much reduced crew numbers, is likely to be an intermediate step well before then. Meanwhile, docking aid systems (using lasers and GPS) are already helping ships berth safely, while mooring load monitoring systems keep them secure in port.

3. The Internet of Things and big data analytics

One of the most revolutionary ICT developments taking place across all sectors in the economy, including logistics, is the expansion in the types and quantities of data being produced. Much of this data is provided by the growing number of robots and automation processes outlined above.

The development of cheap sensors means that firms can now track and measure the activity that almost any device is engaged in. These sensors are enabling the equipment in a port and the cargo in a warehouse to become “connected” – as part of the wider development of the the Internet of Things (IoT).

The IoT refers to the growing range of physical objects, or "things", that are connected to a network and that can send and receive data. For instance, in logistics, sensors can now monitor a cargo’s temperature (as well as other key variables). As well as sending and receiving data, when equipped with radio frequency identification (RFID) sensors, objects become uniquely identifiable. The firm Purfresh is using this technology to enhance the transport of perishable food items. It collects real-time data on the atmospheric conditions inside a refrigerated container and sends automatic alerts if the temperature falls or rises outside the required range, allowing logistics managers based remotely to take mitigating action.

The successful implementation of IoT requires robust communications systems to be in place. This is particularly important in environments such as ports, where containers and equipment can block signals. Similarly in warehouses, GPS is often not usable because of the attenuation and scattering of the signal, and so indoor positioning systems that can track RFIDs or other signals are needed. Network infrastructure at many ports was installed around a decade ago and often is not adequate for the high bandwidth and secure protocols

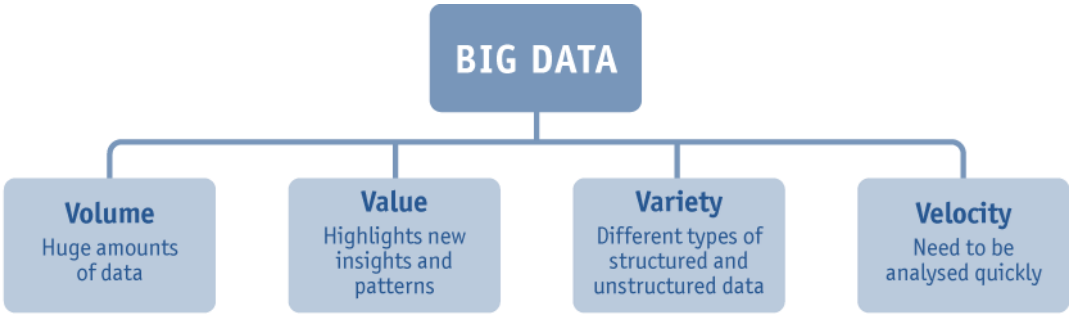
[7] http://fieldservice.com/2015/08/07/futuristic-fleet-drone-cargo-ships-may-soon-ply-the-open-seas/

required by new IoT applications, and so there is considerable scope for ports to expand their network infrastructure – both WiFi and 4G.

As data is gathered from the suite of connected devices, it can be made instantly and simultaneously accessible in many locations, and across many devices, through new cloud computing solutions. Blackberry, for example, is introducing a cloud-based IoT platform to help shipping companies keep track of the location of their freight. Germany's Hamburg Port Authority is already using a cloud-based analytics tool called Smart Port Logistics to streamline the flow of goods. It pulls in a variety of data, including vessel positions, the height and width of bridges, construction work and planned driving routes. The data can be viewed in real time on mobile applications. It allows port workers to know precisely when ships are expected to dock, while truck drivers know when cargo is expected to be offloaded.

The increasing amount of data being gathered requires the tools of big data – an all-encompassing term that includes the collection, curation, analysis and storage of large and complex datasets. This can be used both within port operations – for example, to help identify bottlenecks and indicate where preventative maintenance is needed to minimise downtime—and across the broader logistics chain.

The four "Vs" of big data



Source: EIU

Ports in countries such as Singapore and Malaysia have leveraged big data techniques to create intelligent inspection systems that assess an importer's history and cargo type in order to identify those that are most in need of inspection, allowing other importers to import their goods more quickly without impacting on their security objectives.

Similarly, UPS uses sensors to track data on the speed, direction and driving performance of over tens of thousands of its vehicles. This data is then mined using big data analytics to optimise future routes. In 2011 alone this led to a reduction of 85m miles in the daily routes of drivers, and savings of more than 8.4m gallons of fuel.[8]

4. Simulation and virtual reality

[8] http://www.acinh.com.br/download/358

Simulation software is used to model the operations of a port in order to diagnose potential bottlenecks, suggest process improvements, and assess the impacts of changes in design or throughput. It is valuable in planning new terminals or assessing existing ones, as well as in training staff.

Simulation software is also valuable for emergency planning in the event of incidents such as natural disasters, terrorist activity, labour disputes and the loss of power or communications. Given the strategic importance of ports, the US Department of Homeland Security's National Infrastructure Simulation Analysis Center has developed its own port operations simulator. Some simulators are now using "gamification" techniques to help train staff, such as SimPort, which has been developed to model Rotterdam's Maasvlakte II terminal using the Tygron gaming engine.

Looking ahead, simulation will become increasingly important in modelling the potential impact of some of the other ICT innovations discussed in this briefing note, such as automated vehicles, thereby helping operators to determine if and how to incorporate them into a terminal. Furthermore, as automation increasingly removes personnel from many areas of ports, simulation will allow remaining staff members to understand how the automated areas are functioning.

A much-discussed technology that will assist with this is virtual reality (VR) – defined as the expansion of physical reality by adding layers of computer-generated information to the real environment. For the broader VR industry, 2016 is widely expected to be a breakthrough year due the launch of headsets such as Oculus (owned by Facebook) and HTC Vive.

There are already a few port simulations available for VR, and the technology is likely to become commonplace so that operators can monitor operations in real time based on enhanced video feeds from fixed cameras, automated vehicles and drones. The simulations will become increasingly sophisticated as software evolves and incorporates the growing streams of data generated in connected ports.

For the broader logistics sector, VR may have several applications. At a basic level, a driver whose truck breaks down could launch a VR application that would show them how to fix it. Similarly, many of today's warehouses offer an increasing range of services from product assembly to repair. This means that existing warehouses must be redesigned to accommodate these new services. VR can be used to visualise any planned rearrangements at full scale.

5. Cybersecurity

The flipside of the increasingly central role played by ICT in ports and logistics is the potential vulnerability to software bugs and cyberattacks. These could range from small-scale attacks by criminals seeking to evade port security through to major assaults by terrorists or hostile countries seeking to disrupt trade flows as an act of war. For instance, if automated ports and trucks were to become the dominant mode for transporting food supplies, this would pose significant risks.

The number of worrying examples is rising. In 2011, a drugs cartel hacked Antwerp Port, using Trojan horses to capture passwords and thereby gain control of the terminal's operating system. The attack enabled them to monitor and direct a container in which they were smuggling two tonnes of cocaine and heroin. A similar hack was used to evade Australian customs authorities.

Primary types of cybercrime

Politically-motivated threats		
Threat	Description	Example
Cyberwarfare and cyber terrorism	Attacks that target a government's core data or infrastructure.	Stuxnet, a computer worm, was used to attack Iran's nuclear facilities.
Cyberespionage	Theft of information that compromises a country's confidential data.	The GhostNet secret spying network was used to infiltrate computers in various embassies.
Hacktivism	Sending a political message by defacing websites or blocking access to them.	In 2015, the Twitter account of US Central Command was hacked by supporters of ISIS.
Non-politically-motivated threats		
Threat	Description	Example
Corporate espionage and intellectual property theft	Theft of an organisation's data, e.g. confidential designs and proposals.	Petrobras, the Brazilian state oil company, was secretly monitored by an unknown attacker to gain access to confidential information.
Identity theft and online fraud	Theft of consumers' personal data and financial information using malware and phishing techniques.	In February 2015, 80m digital records belonging to Anthem (one of the largest health insurers in the US) were compromised.

Source: EIU

A different kind of attack happened in 2014 when an unnamed port suffered a seven-hour GPS signal disruption, the result of deliberate jamming. The attack crippled its operations, as automated cranes use GPS to establish their position and those of the containers they move. In 2012, Saudi Aramco, which operates oil export terminals, suffered a hacking attack and was infected with the Shamoon virus, resulting in a week-long outage in its systems and a substantial loss of data. Meanwhile, in 2014, the US Senate Armed Services Committee reported that Chinese hackers had been behind a series of advanced persistent threat (APT) attacks on shipping firms contracted by the US armed forces.

National authorities have only recently woken up to the seriousness of the threat posed by cyberattacks on ports. A 2011 report by the European Network and Information Security Agency found that awareness of cybersecurity in the maritime sector was "low to non-existent".[9] Similarly, a 2013 report for the Brookings Institution by Commander Joseph

[9] https://www.enisa.europa.eu/activities/Resilience-and-CIIP/critical-infrastructure-and-services/dependencies-of-maritime-transport-to-icts

Kramek of the US Coast Guard found very substantial deficiencies in cybersecurity preparedness in six US ports.[10]

Up until 2012, less than 0.3% of the nearly US$3 billion in grants that were made available under the US Maritime Transportation Security Act, a post-9/11 effort to improve port security, had been allocated to cybersecurity.[11] This was despite the assessment in a US National Intelligence Estimate that a cyberattack on critical infrastructure was just as likely as a physical attack.

These shortcomings are now being belatedly addressed, at least in the US, where the first Maritime Cybersecurity conference was held in March 2015, and the US Coast Guard is developing a cybersecurity strategy. In 2015, the round table of international shipping associations – comprising BIMCO, ICS, Intercargo and Intertanko – also announced that they are developing standards and guidelines on cybersecurity.

In this new environment, being able to demonstrate strong cybersecurity is likely to become a differentiating factor for terminal operators seeking approval from port authorities and national regulators, as well as a factor in attracting shipping customers. Conversely, suffering cyberattacks or failing to address potential vulnerabilities could be a significant source of reputational damage.

C. Key conclusions

The current global trade outlook is quite bleak for port operators and logistics firms, but the opportunities offered by innovations in ICT are promising. Each company will face its own set of challenges, but there are some clear principles that all should follow.

1. Significant investment is needed, but timing is key
At a time when trade flows are down and competition is rising, gaining approval for large-scale investments in port automation or a fleet of robots will be challenging. In competitive markets there is an imperative to be among the first in the game to automate. Elsewhere – such as in non-greenfield port terminals – it will probably make more sense to delay some major investments until capital costs come down (as the technology becomes more widely used). Investment also needs to be “smart”. For instance, any new machine will need to be “interoperable” with others used across the supply chain.

2. The threat (and impact) of cybersecurity breaches looks set to rise
Cybersecurity is not a new concept but it is growing in importance as the number (and impact) of attacks has quietly risen in recent years (many companies and government bodies do not confirm attacks in order to avoid negative coverage). Given the importance of the terminals that they operate, port operators are a likely target for attacks – especially as automation increases the damage that such an attack would bring. Crucially, port operators

[10] http://www.brookings.edu/research/papers/2013/07/03-cyber-ports-security-kramek
[11] http://www.brookings.edu/research/papers/2013/07/03-cyber-ports-security-kramek

cannot address the challenge in isolation. They need to work with private sector partners and the government to share information on attacks (both successful and foiled) and on new capabilities.

3. Government policy may be the primary driver of some innovations

The rise of autonomous vehicles and drones has the potential to upend the traditional logistics sector. As we are already seeing, the regulatory stance taken by governments will be critical in determining how fast the rollout happens. However, governments are not just a regulatory hurdle to overcome. In some countries, such as the UK, governments are actively investing in large-scale testing facilities for these innovations. The extent of such government support will depend on the ability of the supporters of the innovation in question to make the case for its merits to society and to explain why government support is needed (for example, the huge upfront costs needed for large-scale testing facilities).

4. A new suite of skills is needed

For ports and logistics firms, the rise of these ICT innovations will make some jobs redundant. However, they will also lead to a suite of new positions that will require new types of skills. In addition to the “21st century skills” that all employers want (such as creativity and problem solving), hard skills will also be needed in fields such as applied mathematics, statistics, data analytics, software engineering, and cybersecurity. In many of these fields there is already a dearth of candidates. What’s more, many of the candidates that do exist do not necessarily think of the logistics sector when planning their career. Large logistics firms will need to consider backing new courses, in partnership with universities and other knowledge partners, to ensure that a steady supply of able recruits becomes available.