



**Asia-Pacific
Economic Cooperation**

Advancing Free Trade
for Asia-Pacific **Prosperity**

Disruptive Technologies and the Changing Nature of Work in the Transportation Sector

APEC Transportation Working Group

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ACRONYM AND TERMS LIST

APEC Acronyms

APEC	Asia-Pacific Economic Cooperation
GOFD	Group of Friends on Disability
HRDWG	Human Resources Development Working Group
PPWE	Policy Partnership on Women and the Economy
PSU	Policy Support Unit
SEN	Seafarers Excellence Network
TPTWG	Transportation Working Group

Organizations

EC	European Commission
IATA	International Air Transport Association
ILO	International Labour Organization
IMF	International Monetary Fund
IMO	International Maritime Organization
ITF	International Transport Forum
OECD	Organisation for Economic Co-Operation and Development
MOL	Mitsui Osk Lines
NYK	Nippon Yusen Kaisha
PNGWiMA	Papua New Guinea's Women in Maritime Association
TIPC	Taiwan International Ports Corporation
UIC	International Union of Railways
UNESCO	United Nations Educational, Scientific and Cultural Organization
WEF	World Economic Forum
WESTAC	Western Transportation Advisory Council
WMU	World Maritime University

Technology Terms

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
AIS	Automatic Identification Systems
AR	Augmented Reality
ATPs	Autonomous Truck Ports
ECDIS	Electronic Chart Display and Information System
EDI	Electronic Data Interchange
GPS	Global Positioning System
ICT	Information and Communications Technology
IoT	Internet of Things
IT	Information Technology
LDWS	Lane Departure Warning Systems
PTC	Positive Train Control
RPA	Robotic Process Automation
RPAS	Remotely Piloted Aircraft System
VR	Virtual Reality

General Terms

DWT	Deadweight Tonnage
MOOC	Massive Open Online Course
NGOs	Non-Governmental Organizations
STEM	Science, Technology, Engineering and Mathematics
TEU	Twenty-Foot Equivalent Unit
TVET	Technical and Vocational Education and Training

NOTE:

All dollar amounts in this report refer to USD unless stated otherwise.

EXECUTIVE SUMMARY

Advanced technologies have arrived in the freight transportation sector and are starting to change everything from planning and logistics to operations and maintenance across all modes — road, rail, marine and air. These changes are having a profound effect on the workplace, disrupting the very nature of work done by millions of workers in APEC economies. While technologies have yet to automate or digitize functions in every firm and economy, their widespread implementation is inevitable, and governments should begin preparing for and addressing the impacts on workers. Failure to manage their displacement effectively will have repercussions on social and economic prosperity and impede competitiveness in the global freight transportation marketplace. It may also mean that opportunities arising from new technologies will not be seized and used to attract workers who face barriers to traditional occupations in the sector.

The emerging technologies highlighted in this report include big data, artificial intelligence (AI) and predictive analytics, Internet of Things (IoT), automation and robotics, automated vehicles and machinery, and drones. Certain occupations within the transportation sector are particularly vulnerable to the changes in tasks driven by the implementation of these technologies. These include clerical and administrative support staff, dock workers, seafarers and truck drivers, whose jobs currently involve significant manual or highly routinized tasks. While the impacts have been gradual, workers in these occupations are already seeing job losses and further impacts will be significant. However, the adoption of new technologies will increase the need for workers such as data scientists and drone operators or pilots, but there will be fierce competition for these workers.

Underrepresented groups such as women and disabled workers make up only a small part of the APEC freight transportation workforce, facing well-documented challenges to joining and remaining in the sector. Advanced technology may offer a path to furthering their participation by lowering some barriers, through changes to the occupational tasks performed. For example, the marine and trucking industries are introducing innovations in equipment and processes that could open up occupations such as dock workers, truckers and seafarers to those unable to perform work requiring physical strength. Future advances in exoskeletons, software and a greater penetration of high-speed internet in the APEC region may also help open new and emerging occupations to this group.

The COVID-19 pandemic has caused upheavals in transportation supply chains, with particularly deleterious impacts on women's employment. Although much of the transportation impacts are related to disruptions in the supply chain and atypical consumer demand, the impacts will be multiplied by the forward leap in technology. Companies have accelerated the introduction of new automation and digitization platforms to lower costs and reduce health risks. The pandemic has amplified and hastened a pre-existing trend in the transportation sector.

Recommendations

With a target audience of APEC region policymakers, the following are tools that member economies can use to support their workforce's adaptation to the changing nature of work caused by disruptive technologies. These tools are intended to prepare workers for new technology-oriented tasks in the workplace, facilitate the retraining of current workers who wish to transition to higher-skilled tasks, and help workers who cannot transition to higher-skilled jobs. The tools are also designed to help underrepresented workers take advantage of new kinds of work, as traditional occupations in the transportation sector are reshaped by technology. Appendix D provides a broad overview of more general supports for increasing the participation of underrepresented workers in the sector.

A: Recommendations to mitigate the negative impacts of technological change on workers

1. Workers need to be prepared for skills and occupations of the future through all levels of education, particularly Technical and Vocational Education and Training (TVET) with an emphasis on skills that help them complement what technology does rather than compete with it. Training curricula need to be continually updated to reflect changing skills requirements, drawing on the resources and expertise of the private sector and other providers, while using new education models and technologies such as augmented and virtual reality.
2. Governments should raise awareness about the nature of occupations in the transportation sector, providing information that reflects both real-time and future prospects. Licensing and regulatory frameworks must also be updated to manage the risk and occupational repercussions of technology implementation. Collaborative processes can help in the creation of standardised profiles of technology deployment specific to each APEC economy, which will also help even out its implementation across member economies.
3. Governments should create a web of social safety nets and adjustment programs that help workers transition out of the workforce, to lower-value jobs or to keep pace with transitions to higher-tech tasks within their occupation. These include retraining programs for workers already in the workforce and income security supports such as wage subsidies, tax credits for employers and early retirement allowances.

B: Recommendations to increase opportunities for traditionally underrepresented groups in transportation

4. Governments should prepare and attract a more diverse group of workers to the transportation sector, as the business case for their participation in economic activity has been proven. Programs in Science, Technology, Engineering and Mathematics (STEM) should target underrepresented workers and provide funding supports where needed. Awareness campaigns should publicize new opportunities for women in more traditional as well as technology-enhanced occupations. Additionally, governments should create partnerships with industry, unions, educators and other stakeholders to enhance their involvement in transportation, using tools such as mentorships, internships, scholarships and technological innovations to engage and retain these workers in the sector.

These tools and strategies provide governments and policymakers with a range of responses to technological change revolutionizing the transportation sector and adversely impacting many in its workforce. They also provide ways to seize emerging opportunities within the occupations most affected by advanced technology, for both existing and potential workers. It will take a concerted effort by each economy to invest scarce resources into the programs needed to respond.

Responding to disruptive technologies will also require the member economies to envision a labour force with occupations and workers that look very different from those of the past. Governments should take a proactive approach to supporting these workers and addressing their challenges in a rapidly and irrevocably changing sector. Member economies could also benefit from partnering with other regional organizations, industry organizations, and multilateral partners such as the United Nations, World Bank, Asian Development Bank and bilateral partners with shared concerns and available support.

1. INTRODUCTION

The growing automation of workplaces will be difficult for workers in the transportation sector. The adverse impacts of the implementation of advanced technologies and platforms are already at play, as automation and digitization increasingly change the fundamental tasks performed in the workplace. Some workers have already lost their jobs while others have to retrain to carry out new or revised tasks in the wake of automation. As the deployment of emerging technology gathers speed, further accelerated by the COVID-19 pandemic, the implications for APEC economies with a large labour force in the transportation sector are deepening.

The situation demands that governments focus on the programs and policy measures designed to support all workers in transition. It also means looking very carefully at how technology is changing workplaces and promoting opportunities for work that can be done by groups often underrepresented in the transportation sector. This is good news, where the increased engagement of women and others in non-traditional sectors is made possible by the changing nature of some occupations. It also highlights the strategic, long-term benefits of education and training that sets up all workers for success in the highly-automated workplace.

When it comes to traditional occupational sectors, female workers are defined as underrepresented when they comprise less than 25 per cent of workers. Typically, the underrepresented also includes Indigenous peoples, disabled, youth, the elderly, racial and ethnic minority workers. This report focuses on women and, to a much lesser degree, the disabled as workers who are underrepresented in traditional transportation occupations. While there is a definite need for further research on other underrepresented groups, the situation for women in transportation is clear. In 2018, women represented less than 20 per cent of workers in the global transport sector, even though their participation provides quantifiable economic benefits, the business case for which is already well established.¹

The context within which governments should act is a challenging one, as technologies are emerging and combined to create new commercial applications. This report is intended to support governments in developing programs and policies to support workers in what are still the early stages of the automated and digitized workplace, in most modes and economies. Research, findings and recommendations show consideration for the differing degrees of development, market maturity and availability of resources in the economies across the APEC region.

The first section of the report focuses on the key emerging disruptive technologies in the freight transportation sector, building on a 2019 report prepared by the World Maritime University (WMU), “Transport 2040: Automation, Technology, Employment - The Future of Work”.² Subsequent sections address the transportation sector jobs most affected in the APEC region and identify those most threatened and those where technology is creating new job opportunities. The report then looks at technological advances creating new employment opportunities for women and concludes with high-level recommendations for how APEC economies can strategically plan for and adapt to the changing nature of work brought about by disruptive technologies in the transportation sector.

At present, no report would be complete without reference to the ongoing COVID-19 pandemic. Appendix A focuses on its early impacts on the global freight sector and each transportation mode. Specific examples of the pandemic's influence on sector stakeholders have been added throughout the report where most relevant (in blue boxes). The pandemic is ongoing, and its final fallouts have yet to be calculated. However, there are already clear indicators of the implications of a more aggressive and fast-paced implementation of disruptive technology on transportation modes and the occupations upon which so many economies depend. There is absolutely no doubt that one of its chief legacies will be the acceleration of technology use in the transportation sector. This further drives the imperative for all APEC economies, regardless of their resources and level of development, to address the challenges to workers brought about by technology.

Methodology

This report focuses primarily on the changing nature of work in the freight transportation sector.

For this report, primary and secondary research focused both on qualitative and quantitative analysis. Most of the secondary research material was publicly available online.

More than 60 in-depth interviews were conducted globally with industry leaders, unions and stakeholders across all modes of transportation. Around 40 per cent of the interviewees identified as female and 60 per cent as male. The purpose was to better understand how disruptive technologies could impact the workforce and their potential to remove some of the barriers that prevent underrepresented groups from seeking employment in certain occupations.

In addition to the interviews, two online focus groups were conducted. Each consisted of approximately 8-10 participants, with industry, union leaders and other major stakeholders worldwide. One discussed potential policy recommendations to mitigate the negative impacts of technological change by reintegrating potentially displaced workers, and the other discussed how disruptive technologies could increase opportunities for traditionally underrepresented groups in the transportation sector. Each session ran for 90 minutes.

Western Transportation Advisory Council (WESTAC) also conducted a survey of its membership to gather views on the timelines for adopting new technologies, the barriers to implementing technologies and their impact on skills.

2. DISRUPTIVE TECHNOLOGIES

The past 10 years have seen a dramatic increase in the adoption of disruptive technologies across all economic sectors. Defined by McKinsey & Company as technologies that will transform life, business and the global economy, they vary in their scope, value, impact and the pace at which they are implemented.³ Their use is dependent on external factors like industrial context, fiscal resources and geography. Other important factors affecting their adoption are local skill levels and familiarity with the new technologies.

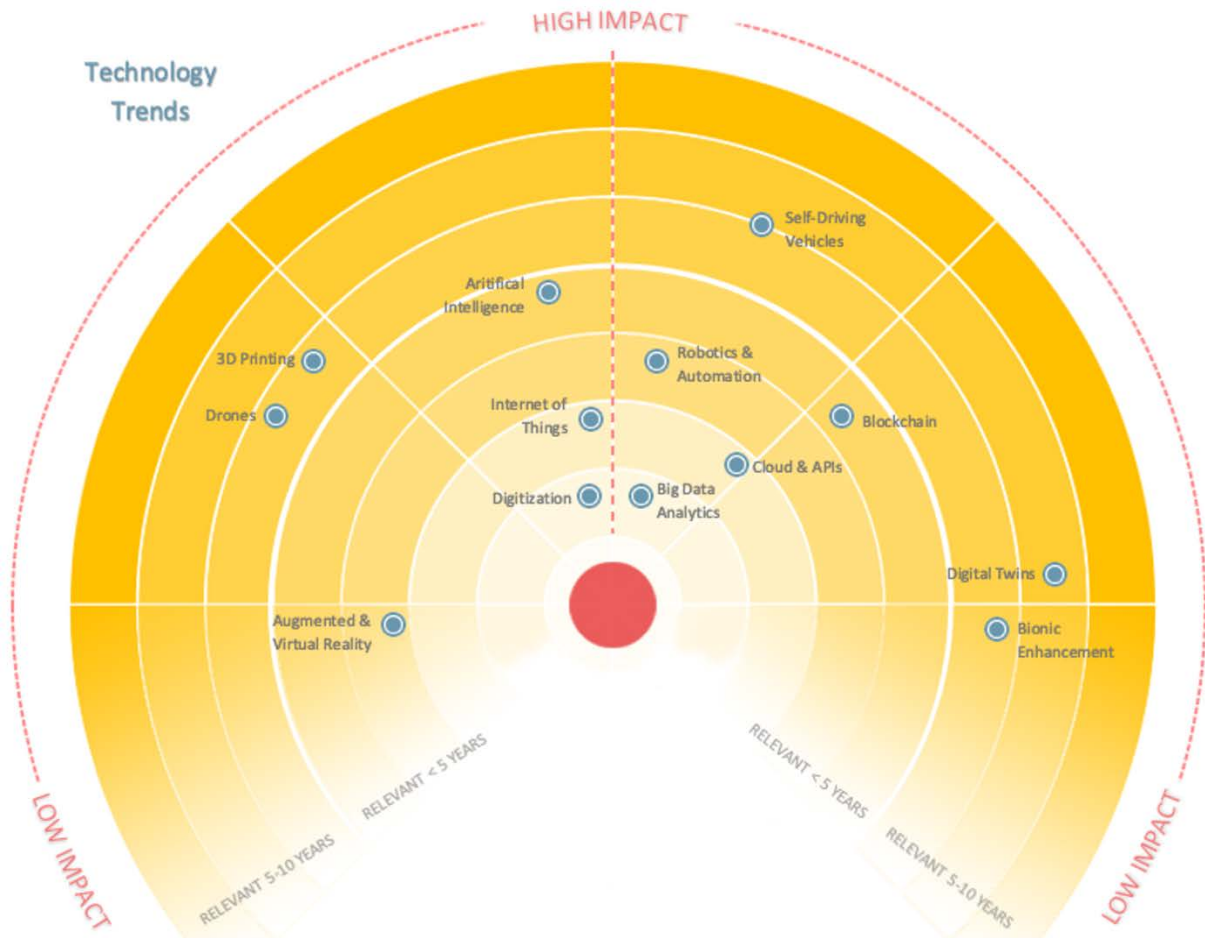
Within the freight transportation sector, the deployment of emerging technologies, ranging from big data analytics and AI to robotics and automation, is well underway. Yet the pace of implementation varies significantly across modes, firms, and economies. As technologies continue to develop and become more cost-effective, safe and reliable, and the return on investment becomes clearer, they will become more ubiquitous.

Deciding on Automation

Firms consider many factors when deciding whether to automate or not, including labour availability and costs. Some firms may choose not to automate based on lower labour costs, and yet maintain competitiveness with firms in other jurisdictions that do automate. For example, aircraft maintenance is open to such competitive situations. Airlines may choose to have aircraft servicing done in economies with lower wages, such as Indonesia, rather than in economies with higher levels of automation, such as Singapore.

Figure 1 on the following page illustrates when various technologies are expected to become commonplace across the transportation industry and assesses the extent to which each will impact the sector. The use of robotics, big data analytics and the IoT will be widespread within a five-year time frame, limiting the window within which to plan for new occupations and changes to existing occupations. Integration of other technologies, such as digital twins, self-driving vehicles and drones will take longer to actualize, delaying their impacts. The broader implementation of these technologies will bring about challenges, particularly related to ethics and labour issues and the creation of regulations and legislative frameworks to accommodate the implementation of disruptive technologies.

Figure 1: Impacts of Technology Trends Over Time



High impact: disruptive technologies

Low impact: technology changes with incremental improvements

Relevancy: when a technology will become ubiquitous or commonplace in freight transportation

Modified from source: WESTAC analysis and DHL 2020⁴

2.1 Key Disruptive Technologies

The following is a brief description of six disruptive technologies that have already had a significant impact on the transportation sector, and those likely to become more prevalent as the technology improves and familiarization with their applications within the industry grows. These technologies were selected based on interviews with transportation firms and research on the technologies most likely to impact workers across the APEC region.

Big Data

All digital technologies generate data. Big data refers to much larger, higher frequency data sets that often include more individualized information, which can help decision makers optimize their businesses' capacity and performance. It provides new ways of gathering information about operations and infrastructure that can be used to address issues in real time. In the transportation sector, big data has positively impacted asset management, road infrastructure, traffic management and supply chain management.

Big data applications are visible across all modes of the transportation sector. The aviation industry uses it to enhance asset management, including collecting information from in-service jet engines to ensure potential engine issues are addressed efficiently and at the most cost-effective time. Similarly, the maritime sector uses digitization and big data in shore-based service centres to inform decisions about optimizing routine maintenance for vessels.

The railway sector uses big data to provide operators with condition-based, predictive maintenance systems to look after tracks and equipment. This kind of predictive monitoring system optimizes maintenance tasks and crew dispatch, while it lengthens maintenance cycles and decreases breakdowns and disruptions. Road authorities are increasingly using AI-enhanced big data traffic management systems to predict and manage congestion. Sensors built into transport networks and fleet vehicles enable firms to collect data streams from local transport authorities, helping them to manage delivery times for freight forwarders.

Artificial Intelligence and Predictive Analytics

Artificial intelligence and predictive analytics are providing new ways to generate and use data. AI is defined as a machine's ability to perform human cognitive functions, such as perceiving, reasoning, learning, interacting with the environment, problem-solving and even exercising creativity. Business applications include robotics, automated vehicles and machine learning. Predictive analytics encompasses a variety of statistical techniques from data mining, predictive modelling and machine learning, which are all designed to analyze current and historical facts and make predictions about future or otherwise unknown events.

Both technologies are being used within the air transport sector to improve operational efficiency, analyze demand, and increase customer satisfaction. For example, AI is being used to develop robot customer service agents at airports to enhance user interfaces. It is used in facial recognition, through kiosks, to identify and match travellers with their luggage. Chatbots are being used by airlines to sell products or answer customer inquiries. Such AI-backed interfaces allow airlines to increase their understanding of customers and help resolve problems more efficiently.

Similarly, the marine industry is increasing its investment in the expanded use of AI and predictive analytics for the near future. Shipping companies are actively exploring AI's potential in predictive maintenance, intelligent scheduling and real-time analytics. For example, intelligent interfaces allow customers to self-book customized services. AI can also be used to reduce fuel consumption. For instance, Stena Lines are piloting AI technology to provide real-time suggestions to the captain and crew on the most fuel-efficient way to operate the vessel.

The Internet of Things

IoT refers to the system of interrelated computing devices, mechanical and digital machines, provided with unique identifiers that can transfer data over a network without requiring a human-to-computer interaction. For example, hardware or objects like traffic controls embedded with sensors, software or other technologies can collect and exchange data with other devices and systems over the internet. The technology generates enormous amounts of data to fuel big data processing and analytics.

One IoT application involves monitoring the location of cargo being transported in order to improve visibility. Using an advanced GPS called geo-fencing, this kind of tracking locates cargo within a set of geographic coordinates. It can be extended to include tracking of transport vehicles, providing real-time information about the efficiency of the routing and performance of the assets. It also helps businesses reduce emissions by optimizing cargo movements.

IoT sensors can also be used by trucking firms to monitor conditions such as temperature, shock and tilt of cargo. This data can be used to verify to customers that the cargo was transported according to specified parameters. The trucking sector could also use IoT sensors to monitor tire pressure and alert drivers to tire problems before they become serious. Railways can use IoT sensors to collect data on switches. By analyzing the trends on vibrations and switch timings, for example, real-time warnings can be issued to the operation centre when measurements indicate imminent failure of a switching mechanism.

Automation and Robotics

Automation refers to the application of technologies that minimize direct human interaction with equipment or systems. It usually involves the integration of computer-related platforms with mechanical objects to improve business and operational processes, increase reliability and enhance safety. Initially, automation and robotics were used to replace routine tasks. Robotic process automation (RPA) is an intelligent automation software that uses machine learning, natural language processing and AI to mimic the rote tasks a human performs daily, whether reading email or quoting rates. Through RPA, software bots can automate routine tasks such as appointment scheduling. Increasingly, automation and robotics are being used for more complex activities and are being combined (or stacked) with other technologies. The implementation of AI and big data has provided innovative new ways for businesses to utilize automation.

The automation of vehicle and infrastructure maintenance in the aviation and rail modes is starting to replace traditional maintenance regimes with data-driven and automated mechanisms for on-demand preventative or repair work. Predictive maintenance will save time and money on operating costs and protect inventory.

Robotic technology is being used across the sector to increase performance and reduce injury risks to workers. Robots are also used to load and unload trucks or containers. Logistics companies, such as DHL and e-commerce giant Amazon, are incredibly advanced in their use of robotics, with extensive applications in their supply chain's warehousing component, specifically in large distribution centres where they move, track and pick products. Amazon has more than 200,000 robotic devices across its warehouse facilities.⁵

Newer forms of technological innovation are also beginning to appear in the transportation sector. For example, Delta Air Lines has been one of the first to explore the use of wearable robotic exoskeletons to bolster the safety of its employees. The device bears the full weight of the payload being carried by an employee, enabling repeated lifting without strain or injury.

Ports See the Benefits of Automation Technology

Interviewees for this report who worked at ports using advanced technology and automated equipment outlined how some of these, including RPA, are changing how work is done. Ports are at the forefront of import/export and trade, and the speed at which a port handles cargo will affect the development of foreign trade, to an extent. In the past, port operations were labour-intensive, and manual labour was the predominant force.

According to one respondent, electronization and informatization have affected daily operations. For example, the procedure of orders and certifications were all done manually, which was time-consuming with a high error rate. If staff was unable to finish on time or they could not meet departure time, they had to cancel the shipments. Additionally, the orders and certifications were all in hard copy and could be lost easily, making future enquiries impossible.

Benefiting from information technology (IT) applications, many ports have implemented paperless electronic operations, [electronic data interchange enabling] automatic verification and automatic release, reducing the number of operators required at the port. Clients no longer have to physically deliver the orders and certifications to the port. If port authorities do not keep pace with technology and optimize and innovate procedures, the port will fall behind competitors and be eliminated from the market.

Automated vehicles and machinery

Automated vehicles and machinery refer to devices that operate without full-time human interaction. These vehicles rely on a combination of technologies such as sensors (e.g., cameras, radars, GPS), advanced communications (e.g., 5G wireless systems) and software (e.g., algorithms, AI). They are being developed, and in some cases have already been deployed, across the freight transport sector. These include automated trucks, trains, and marine vessels.

New Technology and the Pandemic

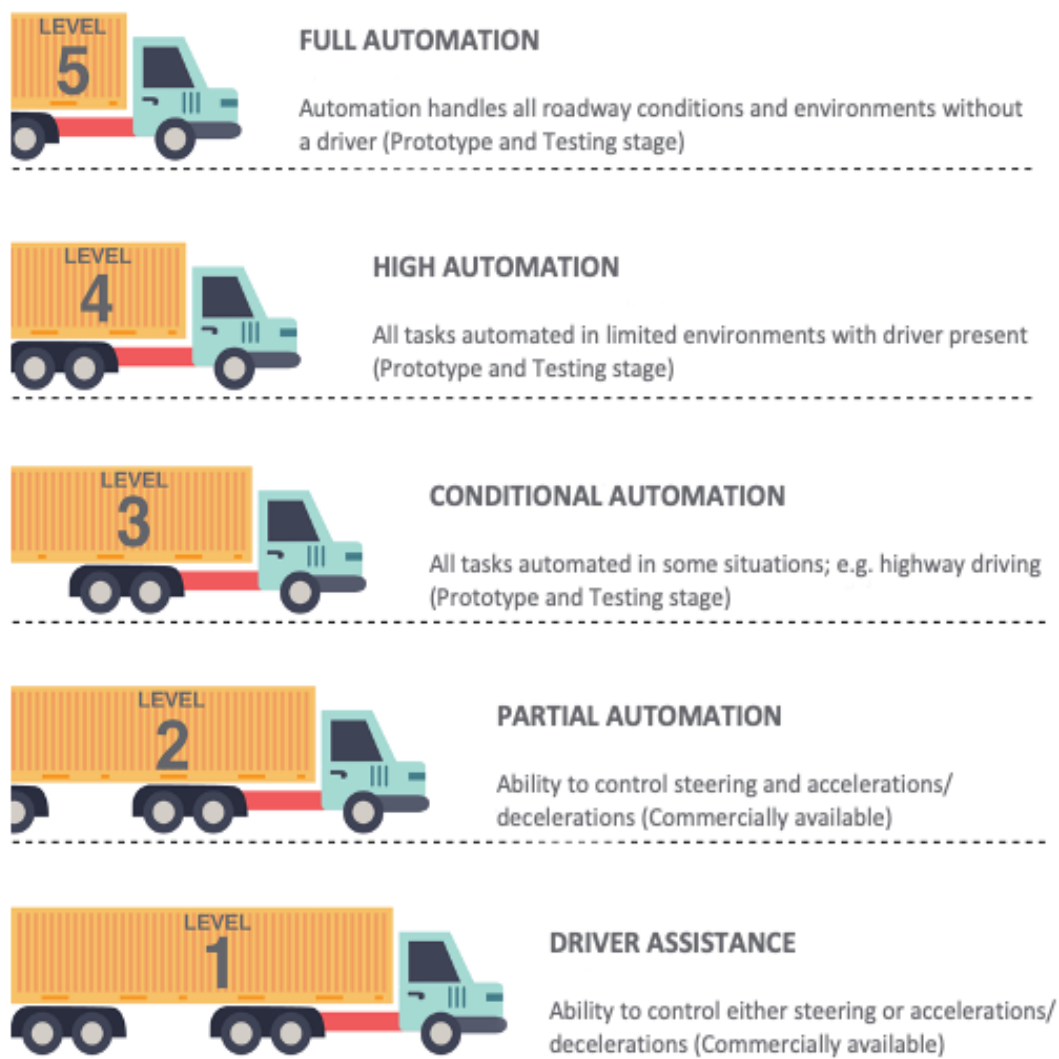
The global COVID-19 pandemic is accelerating the adoption of technology. With the onset of social distancing, Chinese self-driving start-up Pony.ai, began offering autonomous delivery service in Irvine, California (population of 200,000) to accommodate soaring online purchases. Pony.ai uses automated electric vehicles to deliver packages from Yamibuy, a local e-commerce platform. This kind of service is not yet widespread but might become common in the near future and begin replacing delivery drivers, particularly in smaller towns and cities that are easy to navigate.

Potential advantages of automated vehicles include greater safety from reducing accidents caused by human error, decreased fuel costs through efficiency gains and reduced driver costs. In terms of the deployment of automated trucks, most scenarios focus on trucks achieving 'high automation' (Level 4 autonomy, where most driving tasks are automated but still require the presence of a driver onboard) by the end of the decade. It will still be many years after that before fully automated trucks (Level 5, without a driver onboard) are deployed on a wide scale on public roads. See Figure 2 on the following page.

Global mining companies have led in the implementation of automated vehicles in their operations. Australia's BHP Billiton and China's SANY are currently using fully automated trucks on some mine sites. In 2019, Rio Tinto deployed a fully automated heavy-haul railway to operate between its iron ore mine sites and two ports in Western Australia.

Figure 2: Levels of Driving Automation

As the level of automation increases, the driving tasks performed by a human driver are reduced. The diagram below describes these automation levels in greater detail.



Modified from SAE International's Standard J3016⁶

As an example, Daimler Chrysler released a Level 2 truck in North America in 2019. It can apply its own brakes, shift gears and hold paths between highway markings. The truck can also act like a co-pilot by issuing warning sounds when drivers lift their hands off the wheel for too long.⁷

Work on the automation of maritime vessels is currently underway, although progress is a matter of debate among industry stakeholders. In 2016, Rolls-Royce announced plans to develop fully automated cargo ships for operation within one economy's waters. Multiple ships are to be controlled by a land-based control hub. Without crew on board, these vessels would be cheaper to operate, offer greater cargo capacity, and reduce risks of human-caused errors and piracy. The company completed successful trials and predicts commercial use of a remote-controlled ship by the end of the decade. The adoption of automated/remotely piloted vessels will be based on calculations of distance, the relative labour costs of operating automated vessels and the ease of navigation within their route, inside a single domestic jurisdiction. Interviewees for this study believe that, in the short to medium term, automated ships are most likely to be operated in special trade areas and restricted regions. Regulatory regimes designed to manage the risks and infrastructure related to the operation of automated vehicles in international waters and under maritime conventions are being developed. The

International Maritime Organization (IMO) is expected to have regulations for operating automated ships within domestic, inland or near-coastal waters in place by 2028. Regulations for full international use will not be ready until 2035.⁸

Automated Ships in APEC Economies

Some APEC member economies are already seeing significant investment in automated vessels, including China, Japan, and Korea. Major Japanese shipping firms like Mitsui Osk Lines (MOL) and Nippon Yusen Kaisha (NYK) have been working on automated ships since 2016. In Japan, the philanthropic group The Nippon Foundation has contributed ¥3.4bn (\$31 million) into a consortium working on developing the necessary technology. In 2019, NYK successfully tested an autonomous navigation system on a container ship with 71,000 tons of cargo on a four-day voyage from China to Japan. In 2020 it deployed a remotely navigated tugboat in Tokyo Bay.⁹

In 2019, Korea embarked upon an automated ship initiative with an investment of 160 billion won (\$130 million) over 6 years. The project aims to develop automated navigation and engine systems and includes plans to construct an automated ship performance centre. By combining IoT, big data and AI, the project intends to develop a Level 3 automated operating vessel (remotely controlled from shore with a minimal crew onboard) by 2025.¹⁰

Drones

Drones, also known as remotely piloted aircraft systems (RPAS) and unmanned aerial vehicles (UAV), are unoccupied aircraft vehicles controlled remotely, with increasingly automated functions. They are being used more frequently to improve the efficiency of short-distance or last-mile delivery, especially in regions where road infrastructure is limited. China's e-commerce giant, JD.com, has a fleet of drones that have made thousands of deliveries, primarily from its centrally located warehouses to special landing pads in rural areas where local contractors complete the last-mile delivery.

Currently, the technology has a wide range of applications. Drones are helping businesses improve the visibility and maintenance of their industrial supply chains. For example, they can locate goods that are difficult to see and/or reach in massive warehouses by using sensors to identify the shape and code of the inventory items. They have also been equipped with cameras and used for yard surveillance as well as for inspections of assets and equipment in remote locations. Coupled with predictive analytics, they can play a significant role in optimizing asset maintenance and planning.

Economies like the Netherlands, Denmark and Norway are using drones to find ships committing emissions infractions. The manufacturer Rolls-Royce plans to use smaller drones to help inspect ships above the surface. Tech start-up Orobotix has designed an underwater drone that can inspect hulls from below the water. Ports and terminal operators are using drones for patrolling and inspecting their property and equipment. Drone applications are also being found for the rail sector, in the cost-effective capture of high-quality images useful in monitoring and inspecting rail infrastructure. In addition, officials can use drones as an alternative to helicopters to investigate rail accidents. In the aerospace sector, companies use drones to photograph inaccessible parts of airplanes. A technician on the ground can then inspect the photos to identify potential structural issues.

In 2020, WESTAC surveyed its membership of large Canadian freight transportation companies and found that 47 per cent were already using drones. In 2018, NASA estimated that by 2030 a fleet of 40,000 drones could be making 500 million deliveries annually in the United States.¹¹ New entrants such as Amazon, Google, Zipline, Flirtey, Flytrex and others are quickly enhancing the technological capabilities and exploring drone deliveries. Existing aerospace and air freight companies are also seeing the value in drone delivery and view drones as complementary to established aviation systems rather than direct competition. These early adopters are also streamlining the delivery processes and challenging governments to redefine, clarify, and in some cases, relax regulatory restrictions.

2.2 The Connection between Digital Disruption and Market Maturity

In addition to understanding the evolution and pace of emerging technology trends, it is important to recognize where each APEC economy stands in terms of the level of digital disruption relative to their market maturity and how it will influence their policy response. As is done in Figure 3 on the following page, charting their position provides member economies with a high-level or macroeconomic perspective on their current positions. Even where some show market maturity, technology will still have a major disruptive impact on their economies. This context may help with their evaluation and calculation of how to move forward with policy decisions that address changes to the transportation labour market resulting from technological disruptions.

The correlation between market maturity and digital adoption is relatively significant as developed markets can invest in technologies more than developing economies. Matured markets indicate a level of stability in different components that set the foundation for digital disruption to thrive. For instance, the level of infrastructure development, general level of information and communications technology (ICT) adoption, innovation capability, and labour market participation between genders can influence an economy's capability to adopt technologies. Additionally, most mature economies with ageing populations and lower birth rates are increasingly concerned about replacing their workforce and are considering automation of more tasks and normalizing the use of robots in daily lives.

Figure 3: Current level of digital disruption in relation to market maturity for APEC member economies



Source: WESTAC Analysis and modified from Bain & Company¹²

As a digital leader, China has a high level of digital disruption even as it has a relatively low market maturity. This is influenced by large capital investments China has made into technology that has allowed them to be leaders in AI, automated vehicles and drones. There is still a lot of potential for a maturing economy like China to grow, since they are on the lower end of the market maturity spectrum. Other factors such as the size of the economy, population and innovation capabilities all impact where economies are placed on the graph.

Mature followers are those economies that have relatively high levels of digital disruption and a high level of market maturity. Most of these economies have adapted fairly well to managing the disruptive effects of new technologies on their labour force. For example, Singapore has increased its level of technological innovation in order to remain competitive. Many workforce members are receiving ongoing training to develop the skills needed to work with new technologies.

Fast modernizers like Viet Nam and Indonesia currently have low levels of digital disruption (at least in the context of the transportation industry). Yet their growing economic potential indicates the likelihood of technological disruption and transformation. Another group of economies, developing digitizers, have medium market maturity and new technology will create higher potential for digital disruption in the near future. At one firm in a Southeast Asian member economy, crane operators are being retrained to work as remote operators. The workers appreciate learning new skills, along with a multi-skill job allowance that they receive. Finally, the developing modernizers are those in the earliest stages of development, with low digital disruption and market maturity levels.

3. TRANSPORTATION JOBS IMPACTED BY TECHNOLOGICAL CHANGE

The impact of emerging technology on jobs is a topic of enormous interest and concern to governing bodies worldwide. While the impacts will be widespread across all economic sectors, jobs involving manual labour or routine tasks are most susceptible. Many employers will strive to redeploy displaced workers into other parts of the business or retrain workers to enable them to perform new tasks. However, many jobs, or at least some tasks within vulnerable occupations, will become obsolete.

Calculating the exact number of affected workers is challenging, and most estimates simply provide a range of possible impacts. For example, the WMU's "Transport 2040" report analyzed the Organisation for Economic Co-operation and Development's (OECD) data and concluded that by 2040 between 6 and 50 per cent of low-skilled workers' occupations are at high risk due to automation. For middle-skilled workers like truck drivers and seafarers, the estimated share of employment at risk from automation by 2040 ranges from 7 to 23 per cent. Based on technical feasibility alone, these forecasts could change based on economic benefits, regulation and governance, and labour market dynamics.¹³

3.1 Impact on Six Transportation Occupations

This section highlights how six transportation occupations across the APEC region are evolving due to changes in technology. The occupations profiled were selected based on interviews with more than 60 senior corporate, union and educational leaders across APEC economies and in other regions. These interviews, generally 45 to 60 minutes in length, sought to validate the findings from an extensive review of secondary literature and obtain the most current information on technological impacts on transportation jobs.

The first four occupations spotlighted were identified in the interviews as facing substantial change and disruption: truck drivers, administrative clerks, seafarers and dock workers. The final two occupations – data scientists and drone operators – were viewed as occupations which will be increasingly required by transportation firms.

Truck drivers

Owing to the large numbers of truck drivers working in the global freight transport system, changes to their employment levels are of particular interest to policymakers. In the United States alone, approximately 3.5 million people are employed as truck drivers.¹⁴

Adopting automated vehicle technology can potentially cause large-scale job losses for truck drivers, especially in the more lucrative long-distance hauling segment. The WMU suggests that North America has the most potential for land transport automation due to the large share of older workers and continued shortages of long-distance truck drivers. According to a joint report by the International Transport Forum (ITF) and OECD, it is estimated that between 50 and 70 per cent of truck driving jobs in the United States and Europe could be impacted by 2030 with the implementation of self-driving commercial vehicles.¹⁵

Policymakers will need to balance the livelihoods of truck drivers against the savings in fuel, labour and efficiency related to the use of automated trucks. In an attempt to protect workers in the United States, for example, unions successfully lobbied Congress in 2017 to exclude trucks from legislation aimed at speeding up automated vehicle development.¹⁶

To date, few fully automated trucks have been deployed other than in some closed loop mining, container terminal and warehouse settings. Many firms are piloting Level 3 (conditional automation) and Level 4 (high automation) trucks on highways in several APEC economies. At these levels of automation, drivers or operators are required onboard. However, government experts suggest it will take far longer (perhaps several decades, if ever) before driverless trucks will be able to routinely navigate urban streets packed with cars, pedestrians, cyclists, road construction, and other

unexpected challenges. In addition, industry experts emphasize that it will take time for policy and regulations to support this adoption. One interviewee related the purchase of new technology to the value of current inventories:

“The practical consideration of the costs for this adoption needs to be considered. Fleets are purchasing vehicles today that have an expected ‘shelf life’ and the transition to replacing all of these commercial trucks currently on the road is exponential. The sheer amount of current capital investments would dictate a significant cost, especially when you consider that the majority of firms are small-to-medium-sized enterprises. They will also need to recruit staff with the knowledge and expertise to determine which technologies are best for their operations. As for training a new cadre of drivers, it may fall to manufacturers to take the lead creating programs for the required skills.”

One of the technological advancements taking shape in some economies, within the next few years, features platooning, a technique where a convoy of trucks is connected wirelessly to a lead truck, allowing them to operate safely closer together, reduce emissions and realize fuel efficiencies. Networks of these connected convoys will develop, using algorithms to link up and operate in dedicated lanes set up on major highways. The goal is to have only one driver in the lead truck. Humans will still be needed to handle the many non-driving tasks — coupling tractors and trailers, fuelling, inspections, paperwork, communicating with customers, loading, and unloading, etc. — currently performed by drivers. Platooning trials have been undertaken in Australia, Japan, Korea, Singapore, and the United States.

Another advancement that will likely see widespread adoption involves autonomous truck ports (ATPs) located on the outskirts of cities, next to major highway exits. Truck drivers will deliver trailers from nearby factories or warehouses, which are then transferred onto automated tractors that transport them along stretches of highway. At the other end, the process would happen in reverse for the last-mile delivery. In addition to the introduction of these technologies, much of the paperwork and dispatch associated with handling loads will be digitized, effectively matching truckers and loads through online freight platforms.

As the role of truck drivers shifts in response to the introduction of disruptive technology, their skill sets will change. As part of its Steer to Career project, the European Union’s Erasmus Program (launched in 2018) has been researching the necessary skills. Their studies have identified four skill-related categories as key to a successful career in trucking: maintenance, safety and security of automated vehicles; managing connected digital tools and records; customer service; and fleet and hub management.

The program includes professional and social skills development. While many drivers currently work in isolation or with minimal customer interaction, automated trucks mean the job will involve more human interactions with others, as they will work from a control centre with other automated truck operators. Consequently, drivers will need to develop awareness, conflict management and duty of care skills to successfully make the transition to working within a more automated environment.¹⁷

In the private sector, the United States’ Pima College has collaborated with the self-driving truck company TuSimple to create an Autonomous Vehicle Driver and Operations Specialist certificate program for drivers operating Level 4 automated vehicles. While the curriculum will be adapted over time, it currently consists of five courses: industrial safety; electrical systems; introduction to automated vehicles; computer hardware components; and transportation and traffic management. Graduates from Pima College have been hired by TuSimple to participate in their piloting of automated vehicles, which will increase employment as deployment spreads.¹⁸

Job Skills for the Future

A survey of Canadian freight transportation executives identified skills that will be needed by workers in the future.

75% of the respondents selected:

- **Innovation and creativity skills** – skills required for innovation, including complex problem-solving, analytical thinking, creativity and systems analysis.
- **Active learning skills** – the ability to learn things along the way for continuous improvement and skills development.
- **Critical thinking ability** – the ability to engage thoughtfully with complex problems, analyze and propose well-rounded solutions.

65% of the respondents chose:

- **Technology skills** – developing digital skills, including programming, digital responsibility and the use of technology.
- **Interpersonal skills** – interpersonal emotional intelligence, including empathy, cooperation, negotiation, leadership and social awareness.

50% selected the option of *diversity and cultural intelligence* that focuses on the ability to be thoughtful, sensitive and aware, which enables employees to work effectively and cross-culturally.

15% of the respondents selected *language skills*.

Results of WESTAC member survey, June 2020

Clerks/administrative support staff

In 2017, the McKinsey Institute estimated that 64 per cent of office and administrative tasks can be automated by 2030.¹⁹ Every transportation firm employs administrative and clerical workers responsible for tasks such as data entry, invoicing and verifying shipment accuracy, amongst others. According to labour statistics gathered by the International Labour Organization (ILO), in 2018, approximately 102,000 people were employed in clerical positions in the transport sector in Malaysia and around 611,000 in Russia, which indicates the prominence of clerical roles in the transportation industry (derived from ILOSTAT explorer).

In some economies, the job losses following the automation of administrative tasks are already mounting. A 2019 study in the United States showed that, in 2016, there were already 29.5 per cent fewer bookkeeping, accounting, and auditing clerks than in 2000, a decline of half a million jobs. Jobs for secretaries and administrative assistants declined by 13 per cent, or 460,000 positions. Additionally, 20 per cent fewer first-line supervisors of office and administrative support workers were employed, a decline of 330,000 jobs.²⁰

The greater use of RPA in companies is one causative factor in the declining numbers. Companies are also increasing the digitization of formerly paper-based processes, such as bills of lading, matching truckers with loads, or tracking cargoes. Software can help schedule meetings and voice recognition can be used to send typed messages.

As these systems become more sophisticated and technical, it is raising entry requirements for new hires. Some interviewees for this report highlighted how even entry-level administrative positions in their organizations now require a university degree. Fewer data entry and basic accounting jobs are available in many organizations. Those who stay in the occupation are required to develop such skills as leadership, listening, reasoning, collaborating, working in complex and uncertain situations, and empathy, along with requisite technical skills.

As has been documented in previous APEC reports, women employed in the global transportation sector tend to be concentrated in administrative and support occupations rather than in occupations related to the core competencies of transportation activity. Consequently, the impacts on this type of work will be disproportionately experienced by female workers, at a scale similar to the pending job losses occurring in blue collar sectors, which have received more public attention. The Washington Post commented in 2019:

“If you think about the amount of emotional energy we’ve devoted to what the future of truck drivers is as opposed to the future of administrative assistants, it’s mind-boggling. We’re so focused on jobs that men do that we allow the suffering of women in this area to be silent.”²¹

There is some debate about the transferability of skills for women laid off from administrative positions in the transportation sector. While some analysts argue they can transfer to sectors where the impact of automation is not as great, this ignores the prioritization of those with post-secondary education over those with years of service by some companies. It does not take into account the increasing automation across other industries. Nor does it acknowledge the decrease in administrative positions in some higher income economies, where companies have outsourced administrative tasks to lower income economies.

In terms of potential job opportunities arising from the shift towards automation, one scenario is that administrative workers could work on-call and get paid for specific tasks. For example, temporary on-call workers in a shipping office could use AI to access a knowledge base with the institutional history needed for them to cover for another worker on maternity leave. Work of this nature reflects the trend towards the sharing or gig economy.

Seafarers

Of the top five global sources of seafarers, four are APEC economies: China, Indonesia, the Philippines and Russia. The Philippines alone supplies about 20 per cent of seafarers engaged in international shipping. Yet today’s ships require smaller crews than in the past. Over the last 40 years, as engine rooms were automated and communications technology advanced, onboard crews declined from an average of 33 to 35 individuals to approximately 18 to 20 for a typical merchant ship of 15,000 deadweight tonnage (DWT).²²

Workers in this occupation have already felt the impacts of new technology. With the evolution of technological advancements onboard vessels, and the potential for fully automated ships in the distant future, the demand for seafarers could fall by 22 per cent by 2040.²³ Vessels controlled from onshore centres will require significantly different skills and training for the current labour force. The traditional knowledge and core competencies of seafarers working in control centres will need to be supplemented by a much broader understanding of technology, communications and operational contexts. Due to expected growth in global waterborne trade by 2040, the WMU estimates the absolute number of seafarers to nearly double the approximately 1.6 million seafarers working today. According to a report for the European Union’s SkillSea training initiative, new technologies require a new vision for the role of the seafarer:

“(T)he users of autonomous technology are seafarers. Seafarers should know how to interact with the computer systems to respond to difficulties of autonomous ships, such as when routes are changed, or ships are in dangerous waters. Land workers [future seafarers] need to know how to re-control the ships manually and know relative international and domestic law to safeguard the company’s profits. Humans will always be in the centre when developing autonomous ships. The important thing is to understand their new roles and new abilities for the future, such as communication abilities in different languages, information security knowledge – how to secure and safeguard ships; negotiation ability – knowing specific cultures and laws in specific areas; and data analysis ability – analyzing data from different data resources, such as GPS, lasers, radars, and other systems and devices.”²⁴

As technology's impact on the maritime sector grows, the training required to equip seafarers to work in the future workplace needs to provide additional skills and knowledge. The core skills of international seafarers – good seamanship and (independent) problem solving and resilience will remain. However, the sophisticated technology on board ships as well as operational innovations are creating new demands for skills in IT, communications (increasingly spoken and written English), and engineering. At the same time, training institutions are urged to make greater use of e-learning, virtual reality simulators and other technologies. The following are three areas on which to focus training for seafarers:

1. Combine traditional maritime skills with additional competence and skill sets in response to the rapid development of onboard technologies such as information and communications ICT and sustainable technologies. Digital skills, including data fluency, and an ability to interpret and analyze large amounts of data, are also critical.
2. Improve seafarers' soft skills in leadership and management with new training programs to further their onboard career and support the transition to an onshore career.
3. Establish bridging programs that complement the IMO certificate-based education will be required to help bridge the gap between shore-based and seagoing skill requirements. These courses would cover more material in the areas of digital, sustainability, and leadership skills.

Singapore has developed programs to upgrade the skills of its maritime workforce across job functions in port operations, shipping (including seafarers), and maritime services, to equip them for work in an automated and digitalised future. Refreshed in 2020, the Skills Framework for Sea Transport provides information on sector trends and opportunities; career pathways; job roles; existing and emerging skills; and training courses for skills upgrading and mastery. The APEC Seafarers Excellence Network (SEN) has also been active on a variety of issues related to the digital seafarer.

Dock workers

Since 1960, the port sector has experienced several developments in the automation and standardization of cargo handling processes. The most notable levers of change have been cargo containerization and the constantly growing cargo capacities of ocean-going vessels. In 2020, container ships plying Asia to Europe trade routes are capable of holding up to 24,000 TEU (twenty-foot equivalent units). Ports being served by these vessels have had to invest in technology and infrastructure to handle thousands of incoming and outgoing containers within short periods of time. According to the WMU report, nearly 85 per cent of current tasks performed by dockworkers are projected to be automated by 2040.²⁵

As container shipping lines consolidate to fewer global players, they are focusing their business on the few hub ports that can accommodate their vessels and ensure cost effectiveness. To meet these competitive pressures, ports are introducing automated cranes, trucks, automated gates, and other robotic equipment that rely heavily on advancing technology. Automated systems, digitization and smart infrastructure are more likely to be utilized in new or "greenfield" port container terminals. According to the WMU, as of 2019 there are 60 container terminals around the world that are either significantly or fully automated.

The advancement of technology at ports is inevitable because of the potential to increase efficiency, improve safety and reduce costs. Implementation is complex and will have many challenges, including its impact on labour. For example, the fully automated Qingdao Port in China reduced labour requirements by 80 per cent.²⁶ The challenge will be to retrain workers for new skills and provide support for those workers who lose their jobs.

Digitization of Marine Operations		
<p>The management and transmission of information essential to the transfer of cargo in many ports around the world is still largely manual and paper-based and is, therefore, slow and inefficient. New technologies that digitize data management will be fundamental to the way ports operate in the future. The table below, compiled through interviews and analysis of published texts, presents some of the digitization initiatives currently being developed for ports.</p>		
Port Digitization Initiative	How Does it Work?	Examples/Leading Implementers
Integrated trade platform	Platform using cloud-based and blockchain technologies. Connects containers moving on land and sea. Enables all actors in the supply chain to securely exchange information in real-time about shipments moving across borders and trading zones.	Cosco Shipping with Alibaba Group and Ant Financial. IBM-Maersk (TradeLens) PSA International
Smart ports	Fully AI-powered automated ports using IoT, big data and 5G technology. These tools enable the use of advanced analytics and decision making to manage the port autonomously.	chainPORT (association of smart ports) Port of Los Angeles (port optimizer) PSA Singapore Shekou Container Terminal, Qingdao Port (China)
Smart Vehicle Booking Systems (VBS)	Using artificial intelligence, VBS manages containers with a high degree of sophistication. It can identify and unlock container space, assist with truck pickups and drop offs, and eliminate queues.	Maersk
Predictive analytics for vessel arrival/exit	Through a database of every route offered by the world's 30 biggest carriers combined with five years of Automatic Identification System (AIS) vessel movement data, this system can predict in real time if a vessel is likely to arrive on schedule.	CargoSmart

The WMU report estimates that approximately 27 per cent of the current tasks traditionally carried out by dock workers are already automated. This number may increase to 85 per cent by 2040 and could be as high as 90 per cent for crane operators.²⁷ If those jobs are to be replaced, there is time to retrain interested workers for the opportunities offered by new technologies, both in operations and maintenance.

As larger ports in some economies implement increasingly sophisticated advanced technologies, the job of dock workers has seen significant change. For example, following the introduction of automated cranes, operators moved from a crane cabin into an office environment in an operations centre and retrained to operate multiple cranes simultaneously using computerized controls. In other ports,

workers control hands-free mooring technologies or oversee the operations of automated trucks. Mechanics who have undergone retraining maintain the more sophisticated systems of an automated crane.

In lower income economies with smaller facilities, many of which cannot afford to automate, it will be years before jobs are threatened or required to change. As the WMU notes, change demanded by new technologies will likely be more evolutionary than revolutionary in these places, allowing time for workforces to adapt.

From a skills perspective, the recategorization of jobs and functions demands greater workforce training to provide many dock workers with critical new skill sets. The ability to understand and operate computer programs, devices and systems requires digital skills rather than manual equipment operating skills. Some of the existing workforce will be unable or unwilling to adapt. Demographic changes in the workforce mean many new entrants are now more digitally savvy, better educated and, in some cases, prefer white collar jobs.

Previous generations of workers have shown some capacity to transition with the technological evolution of ports because of sustained trade growth. However, with the rapid acceleration of the adoption of technology caused by the COVID-19 pandemic, the exponential growth of the use of new technologies means that existing jobs might disappear more quickly than in the past.

With respect to the workforce of the future, the changing skills required of dock workers were summarized in a 2018 study of Australian container ports:

“The increasing adoption of smart computer and robotic technologies at work has, in addition to displacing workers, significantly disrupted the traditional organization of work and the workforce skills required. We conclude that a completely different port terminal worker has emerged with a different job role and skills profile. Unlike the traditional ‘wharfie’, the emerging terminal worker is well educated and highly skilled. Furthermore, as physical shop floor operations are computerized and automated, greater importance is placed on soft, generic and transferable skills, with increasing emphasis on computer skills to facilitate effective work within a highly mechanized and digitalized work environment.”²⁸

Data scientists

Modern planes, trains, ships, ports and trucks generate enormous amounts of data. For example, during one flight, aircraft sensors and onboard equipment gather up to a terabyte of data, the equivalent of five million digitized books.²⁹ Automated trucks produce and rely on vast amounts of data to operate effectively. In the rail sector, drones flying over tracks transmit valuable information on maintenance issues. Railcars equipped with sensors enable network managers to locate them within meters. In shipping, smart containers communicate information about their location via relay antennas that help terminals prepare for their arrival in port. Analyzing this data requires the work of data scientists.

Data scientists require a high level of technical and analytical skills. They conduct independent research and analyze large volumes of data from various internal and external sources. To assess and interpret this data and use it for modelling, data scientists employ advanced analytics programs, statistical methods, and machine learning. Generally, data scientists require a degree in computer science. They may then obtain another degree in data science that includes courses in machine learning, data visualization, data mining and cloud computing.

Data scientists enable transportation organizations to use data for purposes such as:

- Compare past data to enhance efficiency
- Streamline overall supply chain processes
- Track and optimize key performance indicators
- Identify optimal delivery routes
- Predict maintenance needs for equipment
- Build and test new business models

Across all transportation sectors, businesses interviewed for this study emphasized the increasing importance of employing data scientists. Well-trained professionals can help select, analyze and interpret the vast amounts of data that sensors, drones and other devices provide. To be most effective, the scientists need to have some incipient knowledge of the transportation mode, its function within the supply chain and the areas to target for maximum business benefit. One interviewee noted that:

“Most of the good data scientists can grasp the specific knowledge of an industry quickly, and we have found success when there is a close linkage with the business experts to understand and frame the questions to be able to plan how to get the answers. This is critically important as getting insights and outcomes need to be actionable.”

Recruitment of data scientists in the transportation sector has been challenging, owing to fierce competition for potential hires with AI or IT companies or with different sectors seeking to maximize benefits from data analysis. For example, in the United States, employment for data scientists is expected to rise 19 per cent by the year 2026, much faster than the average for all professions.³⁰

The Case for a Return on Investment

A June 2020 report from Massachusetts Institute of Technology speculates that, in the post-pandemic economy, demand for data science and analytics is likely to increase, especially where their application has demonstrated a positive return for businesses. “For those data teams that have demonstrated strong, positive returns on investment, the demand for analytics (and data scientists) might increase in a recession.”³¹

Drone operators/pilots

Increased use of drones is driving the demand for drone operators and pilots. More supportive government regulations have also contributed to the growing demand, such as in Australia, Canada, China and the United States. However, the United States technology association, CompTIA, asserts that regulations concerning the operation of drones are still lagging behind in some jurisdictions.³² A lack of skilled pilots is impeding sector growth, even where delivery drivers can be retrained as drone operators.³³

Globally, transportation is among the top industries rapidly recruiting drone talent, competing against the manufacturing, professional/technical services, and real estate sectors. Until 2020, most companies relied on freelance contractors. As the sector grows, however, more full-time and salaried pilot positions are becoming available. According to CompTIA, hiring intent for drone pilots increased 183 per cent between 2017 and 2018. Additionally, the American Federal Aviation Administration estimated (in 2018) that by 2022 the United States alone will employ more than 300,000 commercial drone pilots.³⁴

Each economy sets up its own regulations and skills requirements for drone pilots. For example, the following knowledge requirements for acquiring a pilot's licence for drones of a certain weight, operating within visual-line-of-sight, were released in Canada in June 2019: air law, air traffic rules and procedures; airframes, power plants, propulsion and systems; human factors; meteorology; navigation; flight operations and theory; and radiotelephony.

While there are gaps in standardization between economies' regulatory requirements for operators, pilots and manufacturers, which can create barriers or uncertainty, there is a concerted global effort to develop standards and harmonize regulations through bilateral relationships and multilateral forums. For example, international standards-making bodies including the Joint Authorities for Rulemaking for Unmanned Systems (JARUS), RTCA, and ASTM International are leading the development of technical standards that will underpin domestic regulatory frameworks for drones.

A growing number of institutions offer training for drone operators, from traditional flight schools and aeronautical and technology-focused colleges to universities and online pilot test preparation programs. These range from a basic five-day licensing course for a government-approved licence to a year-long certification course. Longer programs enable learners to obtain a commercial licence, build, repair and maintain drones, and analyze data collected by drones. However, the lack of standardized training requirements in many economies can make it difficult for potential students to determine the program that will best help them launch a career.

Drone operators and the Pandemic

Prior to the pandemic, research firm MarketsandMarkets estimated the drone delivery market would generate revenues of \$800 million in 2020. The COVID-19 pandemic has further accelerated the adoption and use of drones worldwide. For example, China was among the first economies in February 2020 to use drones to transport test samples and medical supplies from a hospital in Zhejiang province to a nearby disease control centre. In the United States, the federal government allowed a private drone operator to deliver medical supplies and personal protective equipment to a medical centre.

Consequently, MarketsandMarkets revised the market's forecast value at the end of 2020 upward to \$1 billion increasing to \$2.2 billion by 2022. Drone deployment during the COVID-19 crisis has also provided learning opportunities for updating airspace regulations, specifically on how to increase their use in transportation beyond emergency response efforts.³⁵

3.2 Skills of the Future

Advanced technologies are altering tasks within the preceding selection of occupations in the transportation sector. As discussed below, some tasks are already or are on their way to becoming obsolete within certain transport modes. Five general drivers underlying the changing nature of work across all economic sectors have been summarized and defined in the 2020 report “Understanding the Future of Skills: Trends and Global Policy Responses”:³⁶

- **Decline in routine work** – Routine work, whether manual or cognitive, is in decline. As the capabilities of AI systems increase, and the abilities of complementary technologies like physical robots multiply, the number of tasks, jobs and occupations susceptible to automation will continue to grow.
- **Unbundling of tasks** – Occupations and jobs are being disaggregated into more discretely defined tasks and commodifying them will become easier. When combined with digital platforms and their AI-enabled matchmaking, a more fluid piecework-based labour market will emerge, characterized by increasing numbers of temporary and contract workers. On digital work platforms like Upwork, Fiverr, and Freelancer.com, clients can buy nearly any service—often from someone halfway around the world.
- **Greater need for adaptability and resilience** – In its “2019 World Development Report”, the World Bank noted that as routine tasks are replaced, the demand for advanced cognitive skills, socio-behavioural skills, and skill combinations associated with greater adaptability is rising. These attributes will be critical for workers to successfully navigate the need for professional pivots and reinventions, which will characterize the future labour market.³⁷
- **Ability to work with technology** – Skills in STEM will continue to be critical. As software and robots take over more of the tasks that humans carry out today, many of the remaining tasks will involve inventing, monitoring, directing and repairing these technologies.
- **Increased emphasis on hard-to-automate skills** – As mentioned previously, humans can perform tasks requiring skills that are difficult to automate and this will likely remain so for the foreseeable future. These tasks involve abstract, complex decision-making skills with a strong focus on creativity, critical thinking and interpersonal social skills.

As noted by the WMU report, it is crucial that the transport sector identify specific essential skills needed to effectively work in a world of advanced automation and technology and incorporate them in education and training programs.³⁸ It argues that vocational and higher education institutions must adjust and be prepared to retrain existing transportation workers in skills like data fluency, digital operation and basic software engineering. These skill sets, which were summarized by the World Economic Forum (WEF) in 2018, focus on thinking, creativity and analytical skills and will be increasingly important in the years ahead. They are summarized in the table on the following page.

Table 1: Skills Needed for Jobs of the Future

Growing	<ol style="list-style-type: none"> 1. Analytical thinking and innovation 2. Active learning and learning strategies 3. Creativity, originality and initiative 4. Technology design and programming 5. Critical thinking and analysis 6. Complex problem solving 7. Leadership and social influence 8. Emotional intelligence 9. Reasoning, problem solving and ideation 10. Systems analysis and evaluation
Declining	<ol style="list-style-type: none"> 1. Manual dexterity, endurance and precision 2. Memory, verbal, auditory and spatial abilities 3. Management of financial and material resources 4. Technology installation and maintenance 5. Reading, writing, math and active listening 6. Management of personnel 7. Quality control and safety awareness 8. Coordination and time management 9. Visual, auditory and speech abilities 10. Technology use, monitoring and control

Source: World Economic Forum, 2018³⁹

4. PROSPECTS FOR UNDERREPRESENTED GROUPS

Segments of the transportation sector's existing workforce will be adversely affected by the implementation of new technologies. However, this change will also create opportunities for transport employment for underrepresented groups, both in new occupations and in traditional ones.

Underrepresented groups are generally considered to be those comprising less than 25 per cent of the workforce. Typically, these groups include women, disabled people, Indigenous peoples, youth, the elderly, and racial and ethnic minorities. For this report, women and (to a lesser extent) disabled workers are the primary focus.

This section begins with an exploration of the unique situation of women in the transportation workplace, the barriers to entry and challenges to retention in the sector. Next, there is an exploration of several occupations and how the introduction of advanced technologies can actually lower barriers. However, while technology can reduce certain barriers by changing the nature of work within some occupations, a broader range of factors needs to be addressed to ease entry into or support retention of women in the transportation workforce.

A Business Case for Diversity

Studies clearly demonstrate that including people from underrepresented groups in education and the workforce can help economies grow and become more competitive. In the WEF's "Global Gender Gap Report 2015," it was highlighted that Asia and the Pacific "loses \$42 to \$47B annually as a region because of women's limited access to employment opportunities."⁴⁰

The ITF recently articulated additional societal benefits of gender diversity:

"Gender diversity in the workplace does not only benefit women. Mounting evidence shows that it is a benefit to societies, economies, the environment and enterprises themselves (ILO, 2019). Greater gender equality or diversity in the transport workforce will not only address the discrimination women face in the workforce as a matter of human rights and fundamental principles and rights at work, it will also create more economic efficiency leading to poverty reduction."⁴¹

Similarly, companies can benefit from a more inclusive workforce. A 2018 report from the consulting firm Accenture concluded that American companies employing persons with disabilities are above average in terms of revenue, net income and value creation.⁴²

4.1 Women in the Labour Force

Organizations like APEC are working to promote inclusion of women in the workforce and some transportation companies have launched programs or created policies that support the engagement of female workers in non-traditional jobs. These include gender diversity recruitment targets, mentoring and networking programs for women, flexible work schedules, clear sexual harassment guidelines and paid maternity leave. Notwithstanding these positive improvements, the overall progress has been very limited, and women remain generally underrepresented in the sector.

According to the “Action Strategies Toolkit: Increasing the Participation of Women in Non-Traditional Sectors”, released by APEC in 2019, roughly a quarter of total transportation jobs are held by women. In some economies, the representation of women in the sector is even lower (see Appendix B for details on each APEC economy). This occurs where their participation in the labour force is hampered by factors like safety and difficulty accessing job sites, or where they are even actively discouraged through regulatory or other impediments based on beliefs about a woman’s role in society.⁴³

Like other underrepresented groups of workers, women face a unique kind of exposure to the implementation of new technology. Women are generally overrepresented in some of the occupations most likely to be adversely impacted by disruptive technologies and underrepresented in technology occupations. This vulnerability has been detailed in an International Monetary Fund (IMF) working paper released in 2019:

“Using individual level data on task composition at work for 30 advanced and emerging economies, we find that women, on average, perform more routine tasks than men that are more prone to automation... Our results indicate that female workers are at a significantly higher risk for displacement by automation than male workers, with 11 per cent of the female workforce at high risk of being automated given the current state of technology, albeit with significant cross-[economy] heterogeneity. The probability of automation is lower for younger cohorts of women, and for those in managerial positions.”⁴⁴

Modal Differences in Women’s Participation

An ITF report titled “The Gender Dimension of the Transport Workforce” examines the share of women’s participation in the transport sector by mode. For example, the employment rates in the railway industry in the United Kingdom are 16 per cent female and 84 per cent male, even though 47 per cent of the overall workforce is female. The International Air Transport Association (IATA) also estimated in 2019 that only 5 per cent of the global pilot population is currently female. The fact that women are underrepresented as pilots, as well as in maintenance, repair and overhaul roles, is largely a result of stereotyped views that women do not have the abilities required to fly or repair an aircraft, and a lack of encouragement for women to choose careers in aviation. Similarly, in maritime areas, women represent only 2 per cent of the world’s 1.2 million seafarers (IMO, 2020), while some estimates suggest that 28 to 30 per cent of cruise ships workers are women seafarers, particularly working in hospitality. In long haul trucking in the United States, 6 per cent of drivers are female; Women in Trucking Canada estimate Canada’s figure is 3 per cent.

Source: International Transport Forum, 2020⁴⁵

4.2 Barriers to Employment

Implicit and explicit barriers impede women from employment in general and in specific occupations. As all work happens within the context of a highly complex matrix of socio-cultural variables unique to each economy, providing economy-specific explanations is not possible within the scope of this study. Yet there are a broad range of general factors which manifest in the intersection between work and society, as suggested in the ITF discussion paper. The same barriers have been summarized by the European Commission (EC) in 2018 and were mentioned by interview subjects across the APEC region who were surveyed for this report.⁴⁶

Below is a list of barriers that women face in regard to technical transportation occupations. This list is further elaborated in Appendix C.

- Discrimination and stereotyping
 - Gender stereotypes
 - Gender discrimination
 - Company/working culture
- Labour conditions
 - Work-life balance
 - Safety
 - Sexual harassment
 - Health and hygiene
 - Wage gaps
 - Training
 - Atypical contractual relations
- Job perception
- Corporate/public policies
 - Lack of corporate gender policies
- Career prospects
- Shortages of competencies
 - Physical demands
 - Investment need for education and training

4.3 Occupational Opportunities for Underrepresented Groups

Technological advancements and automation are changing how and where some work is carried out. Repercussions of these changes include the creation of new tools and production systems, alongside new physical work environments and the reorganization of traditional work relationships. Within these emerging scenarios, changes to the tasks within some occupations are reducing certain barriers faced in the workplace by underrepresented groups.

In this section, some of the early changes to a sample of transport-related occupations are explored, offering a preliminary view of potential opportunities for underrepresented groups.

Dock workers

As discussed earlier, the implementation of automated equipment and infrastructure is changing and, in some cases, eliminating occupations at terminals. At most container ports, terminals use gate control, optical character readers, GPS tracking devices and computerized yard management systems. Some also use advanced cargo-handling equipment such as dual-hoist cranes, automated guided vehicles and automated stacking cranes. This creates opportunities for women to be trained to operate such equipment where physical strength is no longer required.

At semi-automated terminals, workers oversee automated cranes from a centralized office, and one operator can control 6 to 8 cranes simultaneously, rather than one operator per crane as in the past. Even though the operator must sometimes adjust individual cranes, the job has essentially changed from a hands-on task to one focused on managing exceptions. Similarly, operators in quiet, air-conditioned control rooms can oversee automated trucks or cargo equipment activities. Companies use virtual reality (VR) simulators to train operators.

Individuals interviewed for this study estimate that, where cranes have been automated, women now make up an estimated 20 to 30 per cent of control room operators. This is significantly higher than when cranes were operated manually. However, even with the improved working environment and change of tasks brought about by automation, interviewees stated that challenges remain in attracting women to these jobs, as they continue to see transportation as physically demanding.

Seafarers

In 2020, the tasks carried out by many seafarers still require lifting heavy equipment, cargo clearing, and handling mooring ropes. However, the functions of seafarers are evolving towards more supervisory and monitoring activities. For example, seafarers use satellite-based aids such as GPS, AIS, Electronic Chart Display and Information System (ECDIS) and similar tools to create efficiencies and simplify navigation. Furthermore, advanced security systems and software can identify and help negate potential threats to ships.

The potential impact of automated shipping will further affect the work of seafarers. Some people interviewed for this study believe that seafarers may not ever have to go to sea in the future; instead, they will work in operation centres that monitor and control ships from a shore-based bridge. Working in these centres would mean that seafarer operators could return to their families each night, eliminating the need for living onboard a male-dominated vessel for months at a time.

New positions emphasizing IT skills will be created. These will allow operators to avoid some of the demanding physical tasks currently required onboard ships, which have long been a barrier to entry for women. Research related to the qualification for future seafarers and remote operators for safe operation has been included in the interim guidelines for the test of the Maritime Autonomous Surface Ship.⁴⁷ The IMO is also reviewing training and qualification requirements to permit remote operation of vessels. Nonetheless, gender may continue as a barrier to entry, as noted on the next page.

Gender and automation were explored in the WMU's Journal of Maritime Affairs. Interviews with 21 Korean shipowners, maritime education and training providers, and shipboard officers, of which one-third were women, indicated how automated or even semi-automated ships could open up opportunities for women but with the caveat of an increase in barriers to entry.⁴⁸ The report concluded that adoption of automation technology could mean that the maritime sector will grow to be highly technical and IT dependent that may still favour men due to their dominance in the IT field. Of the 8 APEC economies included in a study by a job-platform, the percentage of women working in information and communication technology sector out of the total labour working in ICT ranged from 12.9 per cent in Japan to 24.9 per cent in Canada.⁴⁹

Truck Drivers

In recent years, innovations in trucking equipment have made driving safer and even, for certain tasks, less physically demanding. These have addressed some of the concerns commonly expressed by women about driving trucks, including personal safety, being physically strong, and fear of causing an accident or getting lost. Some interviewed for this report believe that major changes in equipment and associated benefits, detailed below, are alleviating some of the problems deterring women and disabled people from employment in this occupation:

- ***Automatic transmissions make driving easier*** – Many women were not comfortable manually shifting gears, but automatic transmission trucks have eliminated this concern.
- ***Fleet-tracking and navigation software improve efficiency and safety*** – Real-time communication devices, using forms of telematics technology enhanced with GPS. This allows drivers to take the shortest and safest routes, which results in increased efficiency and driver security.
- ***Lane departure warnings help truck handling*** – Lane departure warning systems (LDWS) detect markings in the road and warn drivers who unintentionally leave their lane without using the turn signal. These systems reduce the likelihood of accidents.
- ***Hydraulics reduce the need for physical strength*** – Many companies have replaced the manual crank lowering the landing gear (that supports the trailer and keeps it upright) with an air-operated automated system that only requires the driver to toggle an activation switch. Hood releases are also hydraulic, as are dollies for materials.
- ***New cab features improve personal safety while stopped*** – Alert switches that behave like a panic button (flashing external lights and sounding alarms) when someone attempts to break into the cab, are enhancing safety.
- ***Automated trucks improve the working environment*** – Automated trucks currently deployed in closed environments are managed by operators in a control room, typically a comfortable, safe office environment. One interviewee for this report noted the diversity of their control room operators (in one control room, 50 per cent women, compared to 12 per cent with traditional truck operations), as the skills needed to operate the vehicles were no longer manual, but computer-based.

4.4 Other Technology Innovations Changing Occupational Tasks

Several advancing technological innovations will ultimately change tasks in one or more transport occupations, making them more feasible and/or attractive to underrepresented groups. For example:

- **Exoskeletons** – In 2017, Ekso Bionics partnered with Ford Motors to supply the carmaker with an upper body exoskeleton. These frames, which allow a physically limited person to lift heavy tools while maintaining human manoeuvrability, can be used to help workers lift an additional 8 kilograms on each arm.⁵⁰ At a trade show in 2020, Delta Air Lines demonstrated a full-body exoskeleton.⁵¹ This robotic garment enabled a worker to lift up to 90 kilograms repeatedly for up to eight hours without strain or fatigue. Exoskeletons also allow people with physical limitations to stand and move. Still mostly in the pilot phase, they will become viable supports in jobs that require heavy lifting as the technology advances.
- **Specialized Software** – Screen readers and other software products can help workers with dyslexia or visual impairments work more effectively on computers. Software can be combined with hardware, such as tech-enabled glasses. Used in conjunction with an app, wearable devices allow users to operate software and electronic equipment solely through eye movements. In practice, users can do anything from taking a photo with a smartphone to controlling lights.
- **Job Accommodation** – Technology can be used by employers to accommodate some needs of workers with physical disabilities. For example, a suspension seat and vehicle cushion that reduce vibrations allow truck drivers with back impairments to sit comfortably for longer periods. Other accommodations include a swivel seat and lift (so wheelchair users can get in and out of the cab), hearing aids, hearing protection and portable teletypewriter units for drivers with hearing impairments. Two-way radio allows a driver with a learning disability to confirm each order with the dock manager.

The APEC Group of Friends on Disability (GOFD) issued a report in 2017 on the issue of increasing employment opportunities specifically for people with disabilities.⁵² Their research emphasizes the critical importance of the Internet in facilitating persons with disabilities' understanding of, and participation in, the digital economy within the Asia-Pacific region. APEC member economies have established preliminary cooperative initiatives for promoting persons with disabilities. Some initiatives, as per the 2018 workplan include developing policy research on advancing participation of persons with disabilities in internet economy in the Asia-Pacific region, as well as providing vocational training for persons with disabilities.⁵³

5. RECOMMENDATIONS

This report has shown that technology advancements are already occurring to greater or lesser extents across all transportation modes. Some technologies are already in use, some are still in the early or exploratory stages of deployment, and others will not be commercially viable for years. However, interviewees all agreed that there is little doubt that technology development and adoption will continue at a steady rate throughout the industry and will continue to change the nature of work for many.

This section provides two sets of recommendations. The first set recommends concrete actions that APEC region policymakers can take to mitigate negative impacts on workers, and measures to facilitate less painful transitions. The second set of recommendations focuses on how the changes to occupations can create new opportunities for traditionally underrepresented groups within the freight transportation workforce.

The recommendations consider APEC member economies' levels of development, the structure of their transportation sector (e.g., labour intensive versus capital intensive) and their state of readiness for technological adoption. The intent is to provide practical recommendations that respect the fiscal, social and cultural constraints faced by many APEC economy governments, especially in light of the costs of managing the COVID-19 pandemic. In addition, the authors of this report were mindful of the cost to individuals of prolonged gaps in employment for education and retraining purposes.

Mitigate the Negative Impacts of Technological Change on Workers

As more transportation firms integrate new technologies into their operations, workers are already seeing job losses. There is a broad consensus that many transportation workers are likely to be negatively impacted as their occupations are substantially altered or rendered obsolete. In its "Employment Outlook 2019", the OECD urged governments to address the labour market impacts of automation:

"Most importantly, without immediate policy action, labour market disparities are set to increase further, as the costs of the structural adjustments occurring in the world of work are not shared equally. Job losses are concentrated among certain groups of workers and in some regions, and some workers suffer disproportionately from poorer job quality than others. Failing to address such growing disparities will result in deeper social divisions, with adverse implications for growth, productivity, well-being, and social cohesion.

These challenges do not lie on a distant horizon. The future is now as the transformations... are already taking place. In fact, some of them have been occurring for a few decades already. Some of the challenges they entail have therefore been in need of policy action for quite some time, but many [economies] have been slow to respond. Other challenges, however, are gaining strength now or remain difficult to foresee given the uncertainty about future changes in the world of work. In this context, responsible policy making should aim to enhance the resilience of the labour market, effectively preparing for a range of potential futures."⁵⁴

In the context of APEC, the capacity of each economy to address structural unemployment and skills mismatches will depend on their level of development, income and the current extent of automation of their transportation sector, among other factors. This means that different economies may need to focus on different aspects of skills training and social support measures. Economies will need a multi-pronged approach to support the evolving transition of workers.

Three approaches to addressing the impact of technology are set out in the following pages. Displacement will not occur simultaneously across transportation sectors, firms or even within individual economies. Therefore, governments have time to put in place appropriate programs and policy responses to minimize the impact on workers. Consequently, recommendations are organized around the timing of the specific policy interventions, from those that prepare workers in advance to interventions that address job loss already in progress.

Recommendation 1 – Prepare workers for skills and occupations of the future

Governments can proactively minimize future job losses by equipping citizens with skills of the future, like digital literacy, even before the deployment of advanced technologies in the transportation workplace. For example, as trucks deploy more onboard technology and move towards Level 4 or Level 5 automation, drivers will require new skills to operate them. As noted in Section 3 of this report, truck drivers will need to maintain new components of the truck, such as sensors, and manage telemetrically connected digital tools and records. Similarly, as new technologies are implemented onboard ships, seafarers will need more advanced levels of digital literacy in order to operate newly automated equipment and computer platforms.

Government has a role to play in providing adult workers with opportunities to adapt and acquire new skills to complete the new tasks in their occupations. In some economies, government or government institutions may need to subsidize or provide training themselves. In other economies, preparing workers for skills and occupations of the future will be done at the individual firm level. Tools that can be used by economies to equip workers with the skills needed to adapt to technological advances that affect their occupation are provided below.

1.1 Update training and course content

As the WMU report discusses, many middle-income jobs for semi-skilled transportation workers will dry up or require workers to retrain to achieve higher level skills by 2040. When tasks are automated, the most vulnerable workers, including those in low-paying service jobs, the gig economy or those who leave the workforce entirely, are typically those without post-secondary education. Economies that focus on providing quality education to youth and keeping them in school at post-secondary institutions will benefit, from lower costs, than those economies that try to address resulting gaps later in a worker's life.

All educational institutions should focus on enabling students to complement the work that machines cannot do. This reflects the belief of many analysts and educators who argue that education systems must move beyond teaching basic skills. Instead, they should focus on skills that are increasing in importance such as analytical thinking, complex problem solving and systems analysis. Education should focus less on manual dexterity and memory skills, as related tasks will ultimately be automated.

There is a role for government in ensuring there are broadly recognized proficiency standards in any education or training course. A diploma or certificate has to be meaningful and marketable. This is particularly important for educational institutions that adopt TVET.

Example

Inspiration can be taken from programs such as the ADB: Viet Nam Skills Enhancement Program that was launched to strengthen Viet Nam's formal TVET system in 2010. The program aimed to address gender inequity through targeting rural areas and attracting women to male-dominated industries, including communication technology, navigation and shipping industries. The program provided management and instructor training in 15 public and five private vocational colleges in five economic zones.⁵⁵ This project has now concluded as of 2019 with the accomplishment of three major outputs:

1. Quality and management of vocational training improved.
2. Vocational colleges upgraded to deliver priority occupational programs.
3. Partnerships with the private sector strengthened. This benefitted from increased enrolments in private vocational colleges specifically of female students by having a gender-specific strategy.⁵⁶

1.2 Work with new educational models and training providers

Private sector firms are playing a growing role in designing digital curricula/disciplines that keep pace with technological progress. Transportation companies requiring more customized skills could supplement on-the-job training for specific capabilities with training provided through privately sourced programs.

Example

The PSA Institute is the training arm of the PSA Corporation, providing training in shipping, logistics, warehousing and maritime sectors. The trainers are industry practitioners, providing hands-on experience to the students. There are several funding options available for individuals and even for corporations.

Microsoft has launched an initiative to increase digital skills and provide job-ready training programs. The company launched a global skills initiative aimed at bringing more digital skills to 25 million people worldwide. One of the program's aims is to provide the skills for in-demand jobs by offering free access to learning paths and content, and low-cost certifications for those who have developed the skills.

Google is also moving into the educational sphere. Its Google Career Certificates are a collection of courses designed to help participants obtain qualifications in high-paying, high-growth job fields without attending college or university. Google currently only offers an IT Support Certificate but will soon offer certificates in 3 other areas, including one for data analysts. In addition, to assist with job placement, a consortium of more than 50 large employers have committed to recognize successful completion of such certificates for entry-level positions in their firms.

For less company-specific training, massive open online course (MOOC) platforms like Udacity and Coursera can be used for nanodegrees or micro-credentials. MOOCs are fully digital online courses with unlimited enrolment, offering significant economies of scale. They are typically offered by educational institutions and others, including the World Bank, which has created a series of courses related to global supply chains. They can be used to provide approved accreditation or job qualifications by governments with limited fiscal resources.

Employers can help governments decide on the courses and institutions which provide the appropriate content and skills for locally in-demand occupations. For example, the government of Costa Rica recently partnered with Coursera to train 50,000 people over six months in the strategic

and technical skills required for the knowledge economy. Employers identified the courses that would be most appropriate to enhance the workforce's skills and help Costa Rica enhance its competitiveness and attract foreign investment.⁵⁷

Example

New public-private educational partnerships are emerging in response to the COVID-19 pandemic. In July 2020, UNESCO launched a Global Skills Academy aiming to equip one million youth with employability and resilience skills and help them find jobs during periods of bleak employment prospects. Founding partners include Coursera, Dior, Festo, Huawei, IBM, and Microsoft. Other contributors to this project include the ILO, OECD and WorldSkills Competition.

1.3 Use new technological tools for advanced education or training

Training tools based on VR and augmented reality (AR) can effectively teach students to operate safely, cost-effectively and productively in real-world operating environments. Training simulators like these are becoming quite sophisticated, for example, training individuals to guide oil tankers into ports or a train into a station. Real-world applications of these tools are increasingly common, an example being Japanese helmsmen who look through AR overlays that show the depth of the surrounding seas and position of nearby ships.

Importance of High-Quality Early Education

It is critical that governments use the time before the arrival of advanced technology to invest more in high-quality early education for all children. Previous APEC reports have highlighted the importance of economies emphasizing primary and secondary education as a necessary foundation. According to the "APEC Economic Policy Report 2017," gaps in knowledge and ability between children from disadvantaged backgrounds and more advantaged peers tend to persist throughout life. It recommends the following policy priorities for education systems:

Low-income economies – Increase the number of persons with primary school attainment, upgrade teacher training, balance spending on secondary and tertiary education with the need to increase primary school enrolment, balance spending between physical capital (new schools) with human capital (teacher training). A vital prerequisite for inclusion is that access to primary education be expanded for all, especially girls, minorities, and vulnerable groups.

Middle-income economies – Balance equality of educational quality (e.g., excellent urban schools in contrast to poorly resourced rural schools), respond to occupational training needs of private firms, ensure that regulations and other tools meet international labour standards.

Medium and high-income economies – Determine the type of education and training (vocational training and university/college education) that young people need most, and the best forms of retraining for experienced workers who have become redundant. This includes finding the right balance in the supply of various skills to ensure that the skills grow in proportion with demand. Economies should also seek to maximize the role of the private sector in providing and funding training that is relevant to their needs, through apprenticeships, on-the-job training, and lifelong learning.⁵⁸

Recommendation 2 – Raise Awareness, Promote Dialogue and Create Regulations

As economies seek to adjust to changing technologies, there are several areas where governments can lead actions to mitigate the impacts on workers. APEC governments will choose to support adjustment activities and programs that best suit their economy's unique circumstances. However, some possible interventions include the following:

2.1 Promote dialogue and collaboration among transportation stakeholders

Governments should promote dialogue and collaboration among transportation firms, educational institutions, unions and workers to proactively consider the impacts of technology on the existing workforce. As the WMU report states, “social acceptance of more technologies and higher levels of automation will...depend on the effects that the introduction of automation creates for the labour force in [an economy] and the society at large.”⁵⁹

A result of these discussions could be the formation of strategies or sector-wide policy positions, not only for the labour market but also for education and infrastructure investments. A 2017 report to APEC leaders, “APEC's New Challenge: Inclusive Growth through Smarter Globalization”, noted that:

“Our conversations with labour organization leaders demonstrated that they understand and proactively think about the realities of the future for workers. We suggest that better, more effective, more inclusive policies can only result from including the labour voice in forward thinking labour market policies. Equally, more work needs to be done on the narrative to make clear that curtailing trade, cross-border investment or technology should not be seen as the answer to these challenges.”⁶⁰

Governments should establish multi-stakeholder committees to provide advice on strategies to manage transitions to new technologies. Such advisory committees could be comprised of transportation firms, technology providers and manufacturers, labour representatives and policymakers. The OECD and ITF suggested such an approach in a joint report “Managing the Transition to Driverless Road Freight Transport.”⁶¹

The advisory committees would also make periodic recommendations to government about the nature of the trade-off between the benefits of technology and their social costs in terms of displaced workers. This would help governments prepare appropriate policies and programs in advance of significant worker displacement.

Example

Singapore has undertaken such a process with its Future Economy Council, which is responsible for driving the growth and transformation of Singapore's economy in the years ahead. Chaired by the Deputy Prime Minister and Minister for Finance, the Council comprises members from government, industry, unions, and educational and training institutions. The use of a multi-stakeholder organization is designed to improve overall economic productivity.

In addition, governments should encourage employers to discuss plans for implementing new technologies directly with their workers. Employers can alleviate some worker anxiety by explaining how technologies such as AI and digitization will enhance their work and not necessarily replace it. Further, having workers involved at an early stage often leads to better outcomes.

Example of Stakeholder Collaboration: Industry or Sector Councils

One type of stakeholder collaboration is an industry or sector council. These are typically industry-led organizations that address skills development issues and implement solutions in their respective economic sector. They have been introduced in developed and developing economies such as Australia, Canada, India, the United Kingdom and others. Examples include the Canadian Professional Logistics Institute and the Transport and Logistics Industry Skills Council based in Australia.

Sector councils are collaborative in that they can include a range of stakeholders such as employers, workers, unions, educators, professional associations, governments, and others key in developing and applying solutions to workforce issues. The concerted efforts by many players are needed to connect the right skills with jobs, productivity, prosperity and social cohesion through diversity.

Having private sector participation adds considerable value and relevance to skills policies and, especially to training, according to those interviewed for this report. While many economies have developed public-private partnerships for skills training, it is also helpful to develop additional opportunities for private sector participation in areas like supporting training academies, skill levies and apprenticeship models.

Workplace skilling in some APEC economies lacks a well-developed training infrastructure at the institutional level. Therefore, developing capacity within transportation companies as training partners, or with training organizations funded by the private sector, can be a faster and more sustainable pathway to skills development and knowledge in the workforce.

2.2 Raise public awareness of occupational shifts

Raising public awareness of occupational shifts is important so that job seekers have accurate information about the demand profile for occupations and the necessary skills and education. Governments should play a more proactive role by communicating realistic expectations of when new transportation technologies will be widely adopted in their own economy. For example, many trucking firms have commented that it is difficult to recruit new drivers as many potential candidates falsely believe the occupation will disappear with the deployment of automated vehicles in the next year or two. Communication would help overcome any misconceptions about the timing of occupational change and job displacement.

Governments should also outline the costs and benefits of automation and promote, by various means, a frank dialogue on changes that will impact jobs, and the measures that will be taken to address worker needs. One idea is to create local and sector-specific roadmaps for developing and implementing new technologies and further automation.

Another exercise would be to hold a workshop to map current practices against future practices to understand the dimensions and implications of technological change. The results could help quantify the jobs both lost and created and highlight skills required in the future. This would be especially effective with the participation of other stakeholders, including employers, workers, labour unions, educators and trainers. Canada's Brookfield Institute carried out such an exercise, holding cross-economy workshops on changing occupations and the skills needed for future employment. The workshop aimed to identify in-demand skills and how these would be distributed across industries, demographics and geographies.⁶²

2.3 Update regulations and occupational licensing standards

Government regulation has a significant impact on how and when automation is deployed. Policymakers across APEC economies may need to update regulations and create new regulatory frameworks to permit operation of many new technologies. Regulatory bodies will need to address new and shifting issues related to infrastructure, liability, public safety, jurisdiction, environmental emissions and many more.

In some economies, regulations must also be developed by governments at various levels. Depending on the technology, regulatory approval for interregional or international transport will be required by bodies such as IMO, which regulates the safety and security of international marine shipping, and IATA, which sets global standards for airlines.

Governments can also use regulatory power for other purposes:

- **Regulate risk** – Through safety and other regulations, policymakers can influence the scale and pace at which new technologies are implemented. For example, in 2020, the EC proposed a risk-based approach to regulating AI in which the regulatory framework is proportional to AI risk levels. It included AI in transportation among “high risk” applications; given the characteristics of the activities typically undertaken, significant risks can be expected to occur. As such, the EC argues that AI activity in these sectors warrants close governmental oversight and regulation.
- **Develop appropriate occupational licensing and standards** – Occupational licensing and standards must change to reflect new technologies used within certain occupations. For example, seafarers’ skills must meet IMO standards. As new technologies are implemented onboard trucks, licensing requirements should be updated to ensure truck drivers are familiar with and can safely utilize the new technology. Entirely new licensing regimes may need to be created for new occupations, such as drone operators.

For some technologies, such as automated trucks and vessels, the high number of workers impacted may warrant additional measures to influence the speed of adoption. For example, governments could require businesses to purchase a permit to operate automated trucks or vessels in their jurisdiction. The revenue from such permits could help offset the social costs of supporting displaced workers. However, these could be seen as a hindrance to technological advancement despite being used to ease the transition for workers.

2.4 Support low-income economies by developing standardized indicators and profiles

As adoption of technology continues in the transportation sector, its uneven deployment risks widening the divide between lower and higher income member economies. Developing a more detailed profile of the state of transportation technology in each economy could help better identify emerging digital divides and alert officials to emerging competitive and labour force challenges. APEC could also share best practices in adjustment assistance for displaced transportation sector workers on an ongoing basis.

Officials from APEC economies should collaborate to develop indicators of the changes from or impacts of introducing advanced technology and benchmark the stages. For example, indicators or benchmarks looking at company investment in emerging technologies, firm-level technology absorption, and digital skills among the population can be used to monitor the pace and level of introducing new technologies to develop future strategies to prepare the workforce of the future.

Increase dialogue with APEC Human Resources Development Working Group

Dialogue between APEC technical working groups provides useful opportunities to share results of participants' ongoing research. The APEC Human Resources Development Working Group (HRDWG) has and continues to produce reports of relevance to the Transportation Working Group (TPTWG). These include the following reports and initiatives:

- *Policy Research on Advancing Participation of Persons with Disabilities in Internet Economy in the Asia-Pacific Region*
- *Digital Workforce Development: Leveraging Digital and Distance Education Technologies to Build the 21st Century Workforce Through Improved Career and Technical Education*
- *Role of Education and Skills in Bridging the Digital Gender Divide in APEC*
- *Strengthening Innovative Skills Training and Education for Increasing Workers' Inclusion in the Digital Age*
- *Trade and Human Resources Development: Capacity Building for Inclusive Trade*
- *Pathways to Gender Inclusion: Can Technology Close the Gender Gap and Deliver Economic Gains for Women?*
- *APEC Digital Resilience Worker Readiness Checklist (in progress)*

Recommendation 3 – Enhance Social Safety Nets and Adjustment Programs

Having strong social safety nets for displaced workers is a critical strategy for governments. Many economies have already developed adjustment programs as technology and trade changes have adversely affected the labour force for decades. These strategies are calculated based on their available budgets, traditional practices and local circumstances. Other potential adjustment measures involve retraining, reaccreditation and income supports.

Government ministries responsible for transportation matters should collaborate with those developing adjustment programs and include educational providers, businesses and unions to help develop tailored offerings for displaced transportation workers. Additional consideration should be given to developing measures that meet women’s specific needs. In a 2020 report, McKinsey comments:

“Looking ahead, other structural forces could further compound gender inequality. Our previous research on the impact of long-term automation trends on work concluded that, worldwide, 40 million to 160 million women—7 to 24 per cent of those currently employed—may need to transition across occupations by 2030 as automation transforms the nature of work. (The range reflects different paces of automation.) This is roughly the same level of impact that automation would have on men. However, long-established barriers to acquiring new skills and making mid-career shifts, as well as other factors, make the transition harder for women.”⁶³

The COVID-19 pandemic has added pressure on governments to modernize and enhance their adjustment programs (or develop them if none exist). This may reduce the governments’ abilities to support transportation workers in the future.

Negotiating Worker Protections

The International Longshore and Warehouse Union Canada and the British Columbia Maritime Employers Association are preparing for a more automated port environment to handle container volumes projected for the late 2020s. A new labour contract covering British Columbia ports ensures unionized longshore workers will be protected as ports automate. It addresses the issue through a combination of guaranteed pension benefits for older workers who choose to retire, and the retraining of younger workers to perform maintenance and repair on automated cargo-handling equipment and battery and electric-powered equipment. Additionally, marine clerks continue to be trained to interact with and process digitized programs in the terminal operating systems.⁶⁴

3.1 Retraining with accreditation

Widespread retraining of workers and other support measures will be needed. Some employers and unions are putting adjustment frameworks in place that focus on the retraining of workers already employed in the transportation sector, even before advanced technology implementation disrupts occupations. This approach to skills development and retraining has demonstrated success over the long term. Many of these programs share some or all key design features, including:

- Strong focus on outcomes through close tracking of program effectiveness.
- Well-established training evaluation frameworks that provide rigorous evidence of what works and what does not, based on relevant and timely labour market information.
- Digital service delivery when appropriate and online platforms that provide information to clients and exchange information between initiative partners.
- Flexibility to adapt to the specific circumstances and needs of the industry and continuous program innovation and iteration that best serves workers.
- Cross-sectoral approaches that align with other program and policy interventions to focus resources effectively and avoid overlap and duplication.
- Cost-sharing among industry, workers and governments.

In a review of the implementation of training and retraining programs of nine economies, including five APEC economies (Canada, Korea, Peru, the Philippines and the United States) in response to the recession of 2008, the ILO provided additional guidance related to retraining. It emphasizes the importance of connecting retraining programs with other labour market interventions and employment services and stresses the need to accredit competencies:

“More comprehensive and integrated interventions enabled governments to achieve economies of scale when addressing the barriers to work facing unemployed people. Connecting training initiatives with pre-training counselling services increased post-training employment rates. In most cases, public employment services were well positioned to supplement and enhance existing programs, given their experience in managing various types of active and passive labour market measures, their expertise in analyzing labour market information and their nationwide service delivery networks. Accrediting the competencies gained by beneficiaries of job training programs implemented as part of stimulus packages helped to improve their employment prospects and stimulated future participation in job-related training.”⁶⁵

Example

Korea has several public employment information platforms that are interconnected and interoperable, which allow big data analytics to efficiently deliver tailored employment services. For instance, a job-training portal (HRD-net) that provides vocational training information is connected with a job matching platform (Work-net). The system can analyze each job seeker's work history and qualifications and provide each with tailored employment services such as recommended employment opportunities. Job seekers can also view data on career pathways and actual employment prospects for different training programs.

When designing retraining programs, policymakers should recognize that many of those displaced from their jobs in the mid-to-late stage of their careers will be financially unable to participate in multi-year education programs. Consequently, education programs need to be shorter and directly practical to career change. Nanodegrees or micro-credentials should be more readily available from educational institutions (at both TVET and university level) and private sector training, which is all intended to enable workers to transition more quickly.

3.2 Income security supports

Retraining will not be the answer for every displaced worker. Older people can be taught new skills, but they need to have interest and passion for the job, or they can be much more difficult to retrain.⁶⁶ Additionally, educators interviewed for this report highlighted that some workers require extensive upgrading in literacy and numeracy to prepare for higher-skilled occupations, a full-time process that can take months, if not years. As a result, some workers may accept a position which does not require formal education, even if it pays less.

Studies on displaced workers show that many individuals end up in jobs that pay less than their previously held positions, and this is especially true of older people.⁶⁷ Governments should develop broad income security supports specifically to protect workers during transitions and facilitate less painful adjustments. Programs can take many forms, including those described below:

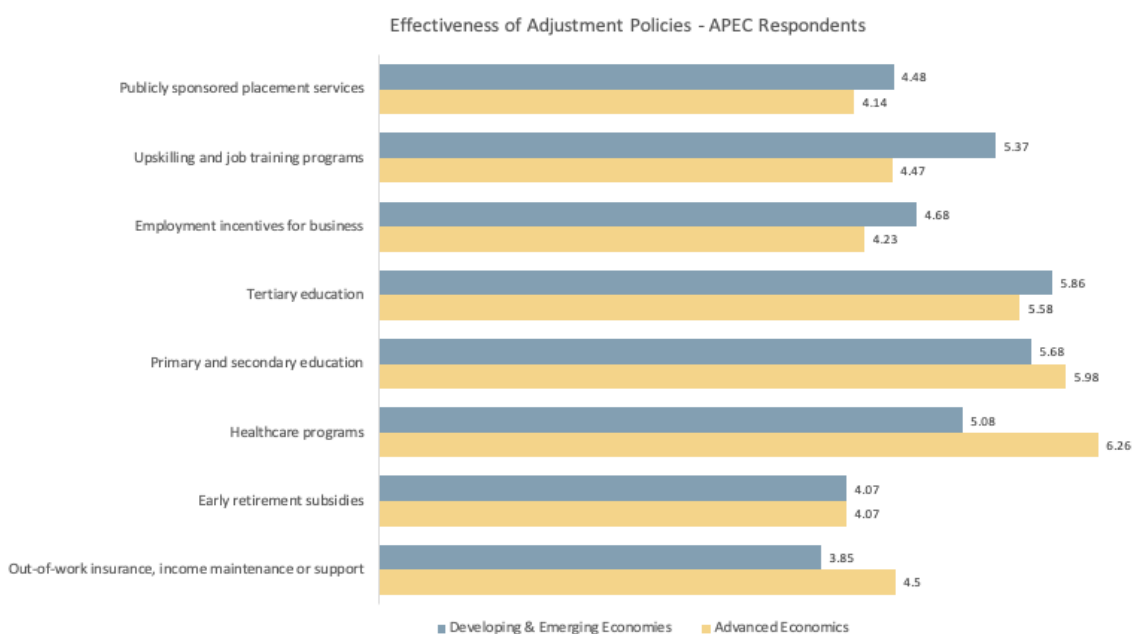
- **Wage Subsidies** – Such programs compensate workers forced to accept a job with a lower wage and have been used in the past to deal with job losses from changing trade relationships. For example, the United States' Trade Adjustment Assistance Program includes a wage insurance component offered to workers over 50 years of age earning less than \$50,000 per year who lost their job due to growth in imports or shifts in production. The wage insurance program provides a cash payment equal to 50 per cent of the difference between the worker's new wage and previous wage, up to a two-year maximum of \$10,000.
- **Tax Credits** – Instead of direct payments to businesses to offset potential lower productivity caused by using human workers, governments can offer corporate tax credits to employers retraining displaced workers or those hiring older displaced workers until they reach retirement age. Alternatively, they could provide individuals with personal income tax incentives to compensate for lower-paying work and extend a worker's career.
- **Early Retirement Allowances** – Retirement bridging programs can facilitate the exit of older workers unable or uninterested in participating in retraining courses or in taking lower-paid jobs. For example, a program for truck drivers could provide drivers with payments of up to 75 per cent of previous weekly earnings for a maximum 72 weeks, or until they are eligible for a pension (whichever is shorter).⁶⁸ This assistance could also augment any early retirement programs offered by private firms.
- **Relocation Allowances** – Government-funded mobility vouchers, relocation allowances or tax credits could support workers in finding employment elsewhere, where automation has not affected jobs. Grants or tax credits can help workers participate in in-person interviews out of town. Such supports may reduce the need for costly long-term programs described above.

Adjustment Program Effectiveness

Technological and trade adjustment initiatives in APEC economies were reviewed in “APEC’s New Challenge.” The findings were presented to APEC leaders in Viet Nam in 2017 and clearly assert the need to address the issue of displaced workers:

“Our research in the APEC region has found that domestic policies have not kept pace with the rate of change and seem unlikely to be adequate to respond effectively to the massive changes still to come. APEC economies need springboards, not just safety nets, to reorient workers in the face of the inevitable job churn and to address distributional issues around income inequality. At the same time, business and government leaders have an important opportunity to develop a better narrative about trade liberalization and technological progress in order to bring society along with them as they pursue sustained economic prosperity through greater regional economic integration.”⁶⁹

Approximately 350 business, government, labour, academic, and non-profit leaders in APEC economies were surveyed on their views of the effectiveness of different adjustment programs, for this report. As evident in the chart highlighting the survey results (below), economies differ on their assessments of program effectiveness. Notably, respondents from developing and emerging economies had greater regard for the effectiveness of upskilling and job training programs than those from advanced economies.



Source: USC Marshall Survey, 2017 (350 respondents)

Note: Effectiveness is average of respondents scored on a 10-point scale.

Increase Opportunities for Traditionally Underrepresented Groups

Much research has been done on the barriers women face in working and building careers, both generally and in the freight transportation industry. Yet much of this work has not considered the issue from the perspective of new technologies and how they already have and will increasingly change occupations for the sector's workforce. As the technologies described earlier in this report are implemented, they have the potential to reduce some barriers limiting the participation of women in occupations traditionally held by men.

However, technology will not remove all barriers. Much broader collective action will be required to overcome many of the general, societal and cultural challenges that continue to thwart women's participation in the transportation workforce (see Appendix C). Lest it seem that government policy changes are ineffective, however, the following is a comment made by a participant in a webinar, "Women in Maritime: The Shipping Agenda and the Mechanisms for Change":

"We have come a long way. During my years in the maritime industry, I've gone from being told straight out, 'No, we don't employ women in this shipping company' (in the 1990s) to then actually being sought after actively to be a female mascot that shipping companies would want to show, 'Hey, look how progressive we are: we have a woman here!'. We still have some work to do, but we're getting there and have come so far to acknowledge that gender equality is not a numbers game. It's not about the number of women; it's actually more a question of women having real power to influence their own society and also their own working conditions."⁷⁰

While positive changes have occurred, even if slowly, there remains a clear need for government policy improvements and regulatory support, as well as continued motivation to advance this agenda. It is critical that opportunities be identified, and women and other underrepresented groups are positioned to take advantage of them. The following recommendations focus on women and underrepresented groups more generally.

Recommendation 4: Prepare and Attract a More Diverse Group of Workers

Creating the option for women and other underrepresented groups to participate in the increasingly technology-dependent transportation industry means equipping these workers with the skills and training needed to perform. This begins with providing a high-quality education at the primary and secondary levels, focusing on STEM subjects, then working with tertiary educational institutions (including TVET institutions) and other partners to provide updated and sector-specific skill sets. Once these workers find their way into the workplace, they require supportive working conditions at the corporate level, including equal access to further training opportunities and programs that advance their particular needs, such as mentoring or use of adaptive technologies. To be more effective, it is imperative to also include women in the decision-making process in the design and implementation of programs and initiatives.

Governments could collaborate with stakeholders on a strategy to prepare for a more diverse group of workers, as digitization and automation in the workplace change the nature of work in many transportation occupations. The building blocks of such a strategy are illustrated on the following page.

4.1 Increase enrolment in STEM programs

As discussed earlier in this report, women will require an education in STEM to qualify for jobs such as data scientists and drone operators. In an OECD report from July 2020, “Enhancing Equal Access to Opportunities for All in G20 Countries,” the OECD argues that reducing the gender gap in earnings and the incidence of low pay requires government’ action and recommends that:

“Governments must help fight and eliminate gender biases and stereotypes by reviewing and, where necessary, adapting school and early childhood education curricula and teachers’ education, offering career counselling at schools that addresses gender stereotypes and by campaigning and raising public awareness among parents, teachers and students.

They must attract more women into careers in science, technology, engineering and mathematics (STEM) by offering internships in those fields targeted specifically at girls, setting explicit targets for female enrolment in STEM university programs and providing scholarships to female STEM students, and developing mentoring and coaching programs for women who would like to pursue a career in STEM and other male-dominated fields.”⁷¹

For instance, the education system in Malaysia has been quite successful in their efforts to increase the number of women in STEM programs at universities. In 2014, 51.9 per cent of science and engineering undergraduates were women. In 2016, The Malaysian Ministry of Education, alongside UNESCO published a document elaborating how women have been encouraged to pursue an education in STEM. This grows from the belief of economic development through a fair, inclusive, sustainable and gendered balance approach in promoting STEM.⁷²

Government agencies should collaborate to ensure that career counsellors have information on employment opportunities for underrepresented groups in all industries, including transportation. Some interviewed suggested that governments allocate a specific number of spots at training institutions for women and other underrepresented groups. Doing so can increase the supply of women and others who will be qualified to work with the growing levels of digitization, AI, and autonomous technologies in the industry

Transport Occupations Requiring STEM Training

Given the rise of technology in the workplace, several transportation-related jobs will require workers with an education in STEM. Examples of these occupations include:

- logistics engineer
- process engineer
- computer programmer
- aviation and rail maintenance technician
- data scientist (analytics, AI)
- drone or crane operator
- automated vehicle operator
- IT technician

APEC economies may choose to provide financial support for such training. This could take the form of offering reduced tuition fees to underrepresented workers, providing income support for students while undertaking necessary education or training, and providing employers with wage subsidies for a set period to hire underrepresented groups in new occupations.

Example

Interviewees revealed that the government of Singapore provides employers of recent graduates with wage supports (for certain occupations), subsidizing their first year or two in the workforce. This encourages employers to hire recent graduates while they obtain real-world experience and become more productive. Tools like tax credits or wage subsidies can be used to incentivize employers to hire women or disabled workers in similar situations, specifically those newly graduated and without workplace experience in their field.

4.2 Develop a targeted education and awareness strategy to engage underrepresented populations in the workforce

Government-directed publicity campaigns should make explicit links between new technologies that transportation companies are adopting and their impact on traditional transportation occupations. The campaigns can emphasize that automation will change the workplace (for example, from working on the dock operating a crane to operating a crane remotely from an office) and create occupations relying more on digital and mechanical skills than on physical strength. The private sector should be called on to participate in such campaigns.

In their 2020 article, “The Gender Revolution is Stalling”, the Brookings Institute sums up the argument for public awareness campaigns that can influence social and cultural change:

“Cultural change is also needed to reduce the strong level of sex segregation in fields of study and in occupations. While some of this segregation undoubtedly comes from employer discrimination, it is also buttressed by social forces from childhood through adulthood that shape differences between men and women in which jobs they are confident they can do, and which they find interesting, meaningful, and identity-enhancing. Deliberate attempts to change these cultural messages could change behaviour on the supply side of labour markets by orienting men and women to different jobs, and on the demand-side by changing employers’ assumptions about who fits and will perform well in what job and who deserves higher pay.”⁷³

The messaging should focus on how these high-paying and interesting jobs can be more open—and potentially more appealing—to underrepresented groups because technology has nullified some traditional barriers to entry. In addition to conveying messages via internet or other media channels, they can be combined with job fairs or school and college programs. As part of these events, VR and AR simulations of occupations can help counteract stereotypes by demonstrating realistic job functions and testing an individual’s aptitude for various occupations in a safe, controlled environment.

Examples

In Chinese Taipei, the Taiwan International Ports Corporation (TIPC) launched a port operation introduction campaign in an effort to introduce jobs associated with port operations to college students. One of the goals of this campaign is to encourage women to pursue careers in port operations upon graduation. As of 2017, one-fifth of TIPC's employees are women. Professional employees make up half the staff, with one-third of them being women.

Additionally, targeted associations such as Papua New Guinea's Women in Maritime Association (PNGWiMA), do a good job in increasing awareness for women within a specific industry. Their goal is to pursue gender equity, maritime training and career opportunities among others. In 2012, the association conducted a "Women in Maritime Road Show" in a number of communities to build awareness of the maritime field and promote seafaring jobs. PNGWiMA has been very active in advocating to change perceptions among men and women in the maritime field, specifically by discussing the value that women can provide.⁷⁴

Attracting Underrepresented Groups to the Transport Sector

Interviewees for this report described general initiatives to attract more individuals from underrepresented groups into the transportation sector. Examples include:

- **Funding professional groups that reach out to schools and act as role models and mentors** – One interviewee recounted that, with funding from a government aid agency, her professional organization developed programming for local schools, designed to encourage more girls to consider maritime careers. These programs can offer young people the opportunity to visit job sites and gain an understanding of the transportation sector.
- **Developing transportation-focused educational programs that reach out to underrepresented groups** – An educator interviewed for this report described his work developing training for Indigenous youth. The program provides students with entry-level basics and prepares them for more than 25 varied positions within the freight rail industry. Instructors travelled to the students' communities and used VR and AR to enable them to practice within a virtual railyard environment. Since the training began in 2018, employment of graduates within the rail industry has been almost 100 per cent. Another interviewee described a different program for Indigenous youth seeking positions in the marine industry. Funding for the marine program came from the federal government.
- **Fund scholarships** – The Women's International Shipping and Trading Association (WISTA) has organized a program of scholarships with the Institute of Chartered Shipbrokers. These annual scholarships help women receive specialized training in topics such as logistics, dry cargo, port agency, liner trades and other skill areas. They are intended to support women's participation in all areas of the transportation sector workforce.

4.3 Form partnerships

Partnerships between government, private sector, trade organizations (labour and industry), NGOs (non-governmental organizations) representing underrepresented groups, educators at multiple levels and other stakeholders help create sector-specific policies or programs that assist workers facing advancing and ubiquitous technology adoption. These can target the needs of women and other underrepresented groups in tasks and occupations that are being digitized and automated by addressing barriers to employment in transportation or factors that make it difficult to retain women in the workforce.

Partnerships can take many forms and generally support the ultimate matching of worker skills with the needs of industry. Examples, including industry sector councils and educational partnerships, have already been provided in this report. Additional examples of partnering initiatives between stakeholders include:

- promoting training and education, e.g., scholarships, workshops, matching services, consultation groups
- providing mentoring opportunities with workers in non-traditional sectors, who share the same gender/abilities/ethnicity
- collaboration on the creation of new technologies that extend capabilities of some workers, and reduce injury- or fatigue-related risks, e.g., exoskeletons, tech-enabled devices

The table below, developed by Fundación ONCE and the ILO Global Business and Disability Network, suggests how such a coordinated partnership might work in the case of disabled workers. The same model could be employed with other underrepresented groups.

Table 2: Key tasks for skills development and lifelong learning made inclusive of persons with disabilities

Governments	Invest in and encourage education and training of persons with disabilities with a special focus on digital skills, including workplace-based training (apprenticeships) and entrepreneurship training.
Corporate Sector	Ensure that training is accessible for employees with disabilities Engage and support training programs promoting inclusion of persons with disabilities in the context of the future of work.
Disability NGOs	Promote and support disability-inclusive training focused on the skills demanded by the labour market.
Trade Unions	Support the rights of persons with disabilities to be trained in the same way as other employees.
Academia	Develop open and accessible knowledge platforms, as well as targeted programs for students with disabilities, related to skills in demand.

Source: Fundación ONCE and ILO, 2019⁷⁵

6. CONCLUSION

Despite uncertainty around the return of post-pandemic economic activity and the intersecting changes brought about by rapidly evolving technology applications, the need to devise a set of tools and strategies to address the impacts of these changes on workers is not up for debate. Technology is already making its presence felt and policymakers in all APEC economies should support those adversely affected, within the capacity and relative availability of their resources. They should also recognize and leverage opportunities that may benefit workers who do not currently enjoy equal access to employment.

The decision-making context is evolving. Technologies are being further developed or newly deployed as applications multiply or combine in innovative ways. Decades-old trading relationships are shifting, owing to political shifts and allegiances. Global supply chains are shifting along with innovations, all while the pandemic has dramatically shifted the economic playing field for regions and economies even where some are surmounting the challenges, the repercussions on their markets are undeniable and unfolding. Given the breadth of factors and the pace of change, it is not easy to know how to respond. Yet there are some effective tools and strategies to begin managing the repercussions on workers.

Policymakers can look to the various options recommended in this report that focus specifically on the workers' needs and situations in the transportation sector. Workers in occupations adversely affected by technology need to be supported financially and provided with updated training programs with new curricula and training modalities. Underrepresented workers can be enfranchised through enrolment in STEM programs, targeted education and awareness programs, creative partnerships with stakeholders, and regulatory changes. While some of the responses need to target long-standing barriers and address the gender imbalance in the technology sector, others can leverage opportunities specific to new tasks or occupations created through technology.

In many ways, the key to managing the outcomes of advancing technology is information. Policymakers and governments in APEC economies should repeatedly revisit what is known, as new research brings new information to light. Strategies should be continually informed and redirected by new data. Policies to mitigate technology's impact on employment should be reassessed, following implementation, for any information that helps streamline and improve subsequent programs. The outcomes of programs designed to remove or bypass barriers to employment and engage underrepresented workers need to be measured.

As has often been said, however, what has not been measured cannot be changed. While research about women in the workforce, specifically in the transportation sector, is starting to produce valuable data, the research carried out for this report reveals a real lack of data about disabled workers and other underrepresented groups. More data is needed to shed light on the nature of their employment challenges. It is also imperative to organize standardized research methodologies and fora for collecting this information. If nothing else, it makes economic sense, as their increased involvement in the labour force has been shown repeatedly to drive growth. This data can provide a foundation for discussions between different working groups within APEC, which can move towards developing a longstanding mitigation strategy for the APEC member economies, taking into serious consideration the competitive advantage of each economy alongside the level of technological disruption.

As the fallout from the COVID-19 pandemic continues, governments have the opportunity to observe how it is influencing the adoption of advanced technology by the transportation sector, as well as valuable information about how to prepare and respond to major disruptions in the future. If the pandemic has demonstrated anything, it is that economies with the capital, human resources and desire to adapt to new technology will do so. Where economies face greater challenges in providing for their people's basic needs, such as literacy and numeracy, they are likely to lag in technology implementation to the detriment of their competitiveness. These policymakers need to use every creative tool at their disposal to prepare the next generation of workers to succeed in the inevitably evolving nature of work in this critically important economic sector.

APPENDICES

Appendix A: Impact of the COVID-19 Pandemic on Freight Transport and Workers

To date, the COVID-19 pandemic has led to staggering losses in economic activity and jobs. According to APEC's Policy Support Unit (PSU), the region's economies were forecast to contract by 2.7 per cent in 2020—the worst downturn since the 2008 global financial crisis. This decrease translates to a loss in output of \$2.1 trillion. Unemployment in the region was also expected to increase to 5.8 per cent, with a total of 81 million people unemployed in 2020, 23 million people more than in 2019.⁷⁶ The impact on the informal economy, where official data is sparse, is also likely to be undercounted.

As the pandemic's uncertain course unfolds into 2021 and beyond, it is important to consider the implications on the transportation sector and, ultimately, its workforce. Even though the fallout so far has affected different regions in different ways and to differing degrees, the interconnectedness of APEC region economies means that none will remain untouched. The repercussions of the crisis will also vary significantly by sector, with the shape and duration of the disruption to trade determined by supply shocks related to lockdowns and the effects of the global economic downturn on demand.⁷⁷

Women are disproportionately impacted by the pandemic, as generally across the globe they earn less than men and have less access to social protections. For those who were able to work from home, they continued to be pressured with childcare and family responsibilities. As the pandemic unfolds the ITF are demanding a gender responsive approach for female transport workers in the COVID-19 response and recovery planning, especially prioritizing women on all decision-making bodies. The ITF notes that “as a result of the gender-segregated nature of the transport industry, women are concentrated on the frontlines of this pandemic in customer-facing and cleaning roles with a higher risk of infection.”⁷⁸

Even as a return to pre-pandemic social and economic conditions is generally unlikely until at least 2022 or 2023, governments should consider its effects on the transportation workforce.⁷⁹ Lockdowns and other measures have accelerated the deployment of digital and automated technologies that both amplify the displacement of workers and hasten the demand for those with the skills to deploy and manage the new devices and software. This reinforces the case for governments to create and implement policies and programs suggested in this report, with a particular focus on underrepresented workers.

1. Outlook for freight transportation by sector

As noted, the pandemic's implications for transportation workers will be accelerated by the hastened deployment of new technology. Compiled in October 2020, the following are snapshots of the projected impacts of the COVID-19 pandemic on operations and employment, broken down by marine, trucking, air freight sectors and rail.

Marine Freight

Despite restrictions in 2020, ports have remained busy as trade continues in most regions of the world, driven by a change in consumer spending habits. According to a report released in July 2020 by shipping consultant Drewry, worldwide container handling is forecast to see an overall 7.3 per cent drop for 2020, which would be the sector's worst performance since the 2009 global trade collapse. However, a recent adjustment forecasted a more modest 3.3 per cent drop for 2020.⁸⁰ It also estimates that the pace of global container capacity expansion will contract at least 40 per cent to 2025 in the wake of the pandemic-related slowdown in port throughput.⁸¹ The pandemic has not, however, affected the pace of construction of automated terminals, according to Drewry's forecast for 2020/21:

“In recent years global operators had already scaled back investment plans, with only limited greenfield projects in the pipeline. However, leading operators look set to continue to lead the way in terms of terminal automation. Currently more than three-quarters of automated terminals are operated by global and international operators, and of the 22 automated terminal projects currently planned (including both greenfield and brownfield), more than 80 per cent will be delivered by this group of leading operators.”⁸²

Despite rebounds in container volumes in July and August 2020, some container lines are considering restructuring that will lead to some reduction in the workforce. Even though volumes may rebound as the global economy recovers, the increased use of automation and digitization may cancel out the return of some jobs.

The COVID-19 pandemic had a major impact on the welfare of seafarers. Many economies that classified truck drivers, pilots and cabin crew as essential workers overlooked seafarers. As a result, after their contracts expired, many seafarers could not leave their ships for months. Some economies accepted repatriation of their own citizens, (though not citizens of any other economy), but many struggled to return home. An interviewee, a ship manager, described how a crewmember spent four days sleeping at an airport in an attempt to return home, as flights were cancelled and delayed. The IMO has drawn up a protocol for crew changes during the pandemic, which it hopes regulators will enact. In September 2020, the IMO estimated that at least 200,000 seafarers worldwide were stranded on ships and required immediate repatriation, and a similar number were urgently needed to join ships to replace them.⁸³

Trucking

The global general freight trucking market was expected to decline from \$748.8 billion in 2019 to \$742.1 billion in 2020, in response to the pandemic. The market is then projected to recover and grow at a compound annual rate of 9 per cent from 2021 to a value of \$934.2 billion in 2023.⁸⁴ These shifts are significant to APEC economies, as the Asia-Pacific region accounts for 32 per cent of the global general freight trucking market. North America had the second largest regional market share, at 24 per cent, while South America had the smallest market share.

The following are considerations of some of the potential impacts of the pandemic, with a view to employment in this field:

- Prior to the pandemic, truck drivers (particularly long-haul drivers) were in short supply in Asia, North America and Latin America, yet played a critical role in the early months of the pandemic, hauling food, personal protective equipment, medicine and other essential supplies. Even though turnover decreased in the early part of the pandemic, companies expect the shortages to reappear over the longer term.
- Labour shortages may be exacerbated by the economic downturn, even as employers try to assist drivers with health concerns, educate truckers on important safety measures, and implement measures and devices to ensure drivers have safe places to work and park.
- Supply chain challenges and demand for last-mile deliveries that minimize human contact could prompt regulatory changes that support the greater use of drones and automated vehicles.
- The industry's dependence on truckers to move goods will likely benefit from continued growth in e-commerce. In China, online shopping increased 15 to 20 per cent to about 25 per cent of total retail sales while most United States' retail categories saw a 15 to 20 per cent growth in online shopping, raising e-commerce to about 14 per cent of retail sales.
- As unemployment rises in some economies, the resulting short-term drop in consumer spending will reduce freight demand for nonessential goods. Large carriers will likely survive, but many of the owner-operator or small firms will go under. As the economy recovers, the reduced freight capacity may lead to higher rates.⁸⁵
- More trucking companies will realize the benefits of incorporating data analytics and using digital platforms. Transport capacity sharing via digital platforms allows companies to match loads with available capacity. Data sharing can reduce idle time from traffic delays, loading operations, communication lag and can also speed up back office processes.

Air freight

Restrictions on movement and travel caused by the pandemic have hit the air transportation sector particularly hard. The Asia-Pacific's air industry was the first region to feel the impacts of the COVID-19 crisis and is expected to post the largest absolute losses in 2020. In June 2020, IATA estimated that airlines will lose \$84.3 billion in 2020, if the pandemic does not worsen and lead to further lockdowns. The biggest driver of losses is decreased passenger demand, while cargo is the bright spot for the air sector. Compared to 2019, overall freight tonnes carried are expected to drop from 60.3 to 51 million tonnes in 2020.⁸⁶

Yet this decrease in volume will be offset by higher cargo rates due to fewer delivery options for shippers. With 45 to 50 per cent of air cargo carried on passenger airplanes and so many passenger flights grounded, the resulting shortage of capacity is expected to push up rates by 30 per cent overall for 2020. Some passenger airlines have removed seats and are using planes as cargo carriers to capture some freight market share.⁸⁷

The pandemic's impact on employment in the air industry has been extreme across the globe, even as the industry was already seeing shortages of pilots and aircraft maintenance engineers. The repercussions of the pandemic on the air transport industry will likely amplify existing pressures on employment and the nature of occupations in the sector.

A report prepared in May 2020, “COVID-19 Air Transport Near-Term Impacts and Scenarios”, offered the following predictions for the end of 2022:⁸⁸

- 68.4 per cent of respondents expect investment in digital transformation to increase
- 60.3 per cent expect investment in automation and the deployment of AI technology to rise
- 54.2 per cent expect increased spending on sustainability and environmental initiatives
- 53.5 per cent expect investment in innovation to increase

The implications for air freight workers are similar to those in other sectors. The pandemic will likely stimulate more use of digital technologies, including IT systems to manage knowledge and best practices by frontline workers and increase touchless interfaces with passengers. There will also be a greater need for remote assistance capabilities where pilots and mechanics are supported in real-time by a centralized specialist using technologies such as augmented or mixed reality. These systems will also be needed to capture the extensive knowledge base of retiring pilots and aviation mechanics.

Rail

According to a report issued by the International Union of Railways (UIC) in July 2020, rail traffic was hit hard as economies closed borders, internal economic activity slowed, and freight rail volumes saw major decreases.⁸⁹ Losses in China were less significant, as the economy ramped up quickly following the lifting of lockdowns. In the United States, the Association of American Railroads reported that, for a week in early May 2020, total carloads dropped 30 per cent from 2019 volumes and total traffic was down 22 per cent. By July 2020, this drop moderated to a decline of 14 per cent, as compared to 2019.

Automation in the industry continues, with clear implications for employment and the nature of occupations. Health concerns, specifically protection against the transmission of the COVID-19 virus, have become priorities in operating environments across all economic sectors. The resulting safeguards and procedures, as conceived for the rail sector by the Association of American Railroads in 2020, will likely accelerate the use of technology and, concurrently, the demand for workers with the necessary technological skills, includes the following:

- transitioning workers to telecommuting
- entry of records in systems done remotely
- greater use of telemetry to monitor movements of trains and reduce movements of workers across the network
- activating secondary dispatch and operating centres to discourage staff travel across the network
- greater use of automated maintenance of rail assets⁹⁰

2. Implications of COVID-19 for disruptive technologies: an APEC perspective

In June 2020, APEC's Policy Support Unit (PSU) issued "COVID-19, 4IR and the Future of Work." The authors argue that the economic uncertainty and upheaval introduced by the pandemic will likely accelerate the introduction of 4IR technologies in many sectors of APEC economies. Their briefing outlines some of the forces considered most likely to influence the transportation workforce.⁹¹

Senior executives interviewed for this report support many of these suggestions. These influential forces include:

- **Firm-level reorganization and increased automation to reduce costs** – Economies are likely to face the negative financial repercussions of the pandemic for years to come. Businesses must address workforce safety-related and financial challenges, which may compel acceleration of the automation of production processes or restructuring (e.g., staff cuts, mergers or spin offs of low-performing divisions). As a result, disruptive technologies could become increasingly attractive to firms looking to reduce costs.
- **Constraints to labour supply leading to more automation** – The economic downturn related to the pandemic has been particularly hard on female workers in many economies and some have renamed it the "shecession".⁹² The hours many women spend on household responsibilities, such as overseeing home-based schooling, while working from home have increased their overall workloads. With potentially lower productivity as a result, businesses may be further incentivized to automate occupations with a high percentage of female employment (like clerks/administrative staff in the transportation sector). The transition to automated processes may also be hastened if older workers and those with pre-existing health conditions decide to leave the workforce entirely or if firms avoid hiring from these groups.
- **Safety considerations** – Workers may support automation if it allows for greater physical distancing or enhances personal safety in some way. They may also be more attracted to occupations that allow for more personal space at the work site or offer work-from-home possibilities. These attitudes could speed firms' drive to automation. As one trucking executive remarked, "Much of our office work is now done from home, and I could see this continuing even after the pandemic is under control. Technology makes the whole process easier."

Impacts of COVID-19 are Disproportionate

The impacts of the pandemic have had a particularly adverse impact on underrepresented workers. At an October 2020 meeting of the APEC Women and the Economy Forum, APEC Ministers noted the following:

"The impact of the current health and economic crisis is being felt disproportionately by women and girls across the APEC region due to the existing gender inequalities. Women face higher levels of economic hardships, income and job losses, are forced to take more hours of unpaid care work and are more susceptible to face domestic violence. Despite all the challenges brought by the COVID-19 pandemic, our main attention and commitment to enhance the women's agenda, especially in strengthening the socioeconomic well-being of all women and girls in this region, remains indispensable."⁹³

— Datuk Seri Rina Mohd Harun, Minister of Women, Family and Community Development, Malaysia

Appendix B: Women's Participation in the Transportation Industry

This data was derived from the ILOSTAT explorer.⁹⁴ The values represent females working in transport, storage and communications in 2019.

APEC Economy	Female Employment (thousands)	Females as % of total
Australia	276.4	25.4
Brunei Darussalam	3.8	35.2
Canada	288.5	23.2
Chile	147.3	18.9
China	5493.6	15.2
Chinese Taipei	224.2	29.5
Hong Kong, China	113.9	24.5
Indonesia	430.1	6.8
Japan	1266.6	23.6
Republic of Korea	379.4	16.7
Mexico	345.7	11.7
Malaysia	177.3	18.9
New Zealand	69.7	31.4
Peru	145.9	10.4
The Philippines	270.9	7.0
Papua New Guinea	3.4	7.6
Russia	1863.8	25.2
Singapore	111.8	25.5
Thailand	296.3	19.4
United States	4516.4	28.4
Viet Nam	313.4	14.0

Appendix C: Barriers to Technical Transportation Occupations for Women

(from employees' perspective)

Discrimination and stereotyping	
Gender stereotypes	Social belief that females are less suitable to perform the tasks demanded by the specific transport profession.
Gender discrimination	Expectation that female candidates are less likely to get hired because of company perceptions that women are less able to perform the tasks demanded by specific transport jobs.
Company/Working culture	Belief that the company environment is not conducive to women.
Labour conditions	
Work-life balance	Working conditions that hinder balancing work and family/social life obligations. These can be inflexible working times, little schedule control, atypical shifts or changing working locations that prevent women with child/elder-caring or other responsibilities from performing their obligations.
Safety	Safety concerns arising in transport modes where workers are vulnerable to violent behaviour.
Sexual harassment	Sexual violence against women by colleagues, clients or managers as well as unwanted physical contact, sexist "jokes" or repeated sexual invitations threaten retention of female employees.
Health and hygiene	Lack of segregated dressing rooms, dormitories, appropriate medical and toilet facilities as well as a low level of hygiene at these facilities.
Wage gaps	Gender discrimination in terms of wages at the workplace. Lower wages resulting from unequal career prospects. Wage gaps because women are often employed in lower-paid or part-time positions.
Training	Lack of (visibility of) training opportunities for women to gain the relevant skills needed for specific professions. This can also create a barrier for further career development and retention in the sector for women already in transport professions.
Atypical contractual relations	The use of self-employment or third-party contracts that can reduce employees' rights, job security and can bring in worsened working conditions deter women from entering specific professions. Reduced job security can be a significant barrier when significant financial investment is required to enter a profession.

Job perception	
Job perception	Negative perception of the job either true or driven by social prejudices that associate the job with a lower quality of life, the perception of poor career growth, the expectation that experience is expected for certain jobs in the sector or other unappealing characteristics. This is a barrier for both genders, however, the expectation of poor career prospects (see below), especially discourages newcomer employee groups (such as women) from pursuing transport professions.
Corporate/Public policies	
Lack of corporate gender policies	Lack of corporate policies for gender-balanced recruitment or to particularly facilitate women entering the workplace. Also, the absence of company support mechanisms for women in male-dominated professions (e.g., mentorship) and the absence of role models.
Career prospects	
Career prospects	Career prospects that can be perceived as leaving limited room for career advancement for women. This is aggravated for part-time workers.
Shortages of competencies	
Physical demands	Jobs being too physically demanding for most women and lack of accommodation for the physical difficulty.
Investment need for education and training	The need to finance one's education or training to acquire the relevant skills, especially when combined with other barriers (e.g., career prospects, atypical contracts, etc.) deter women from pursuing specific professions.

Source: "Business Case to Employ Females in Transport," European Commission, 2018.⁹⁵

Appendix D: Overcoming General Barriers to Underrepresented Groups' Participation

This report focuses on improving the hiring and retention of underrepresented workers, primarily women, in non-traditional occupations as new opportunities open through the deployment of new technologies in the transportation sector. While this brings its own set of challenges, there remain general barriers to participation of women and underrepresented workers in the workforce that were discussed in Section 4 of this report. Listed below are some important policy measures to overcome such general barriers.

1. Increase hiring and retention of women and persons with disabilities

Governments should develop policies and programs that actively encourage the participation of underrepresented workers and target structural obstacles to their participation. These can be done at the regulatory level, as well as by working with industry members to create workplaces that do not discriminate against these workers. They should also include enforcement of the measures designed to make the hiring and retention of these workers easier, tying performance to government fiscal rewards wherever possible. Support for this is found in international human rights conventions, which are supported by international multilateral and bilateral agencies with which governments can partner.

1.1 Promote best practices in diversity with local employers and unions by promoting the following internal company practices:⁹⁶

- Connect with young people to promote the industry as a desirable career option through mentoring and providing opportunities for others in the industry to mentor as well.
- Encourage participation in professional organizations, especially leadership participation and networking event attendance.
- Promote educational and career opportunities through scholarships, internships, and awards that increase the recruiting talent pool so that minorities are afforded opportunities that would not otherwise be possible.
- Intentionally promote desired perceptions by advertising support of diversity through as many outreach opportunities as possible, promoting the public image the company wants to create, rather than allowing outsiders to define it.
- Create standardized processes and measurements that develop and adhere to a well-defined succession plan to help eliminate bias in promotion decisions.
- Create company policies that can form the basis of a toolbox or guide for others.
- Conduct, or participate in surveys to understand the effectiveness of the cultural diversity efforts in place.
- Offer diversity training to employees and managers.

1.2 Enforce anti-discrimination policies in hiring decisions by dedicating budget and staff to the active enforcement of laws and policies related to harassment and anti-racism and monitoring results.

1.3 Adapt legal and regulatory structures to remove gender-based legal restrictions and discrimination, starting with abolishing laws, regulations and cultural practices that restrict the types of transport jobs in which women can engage or that limit women's hours of work or freedom of movement.

1.4 Use labour market information to enhance understanding of the outlook for transportation occupations in a specific economy and help guide efforts to promote in-demand transportation occupations for underrepresented workers.

1.5 Set metrics/key performance indicators working with employers and unions, to set benchmarks that measure progress on policy goals and use company measurements as a proxy for longer-term educational changes and awareness campaigns.

2. Help Women Balance Work and Family Lives

One way to help increase the number of women working in transportation is by helping balance work and family lives. General workplace programs like maternity and parental leave, day-care and flexible work schedules support women working while also supporting them with their many responsibilities outside the workplace. When trucks and ships are operated from remote control centres, women working as truck operators or remote seafarers will no longer need to be absent from home for days, weeks or months at a time.

The Importance of Data

In some economies, the time and value of unpaid work is untracked. As noted in the book, *Invisible Women: Data Bias in a World Designed for Men*:

“The failure to collect data on women’s unpaid workload can stymie development efforts. Marya Buvinic, senior fellow at the UN Foundation, points to a history of initiatives in low-income [economies] littered with training programs that have failed because they have been built on the mistaken assumption that women have plenty of free time, backed by limited data on women’s time-intensive work schedules. Women may sign up for these programs, but if the initiatives don’t account for women’s childcare demands, women don’t complete them. And that’s development money down the drain and more women’s economic potential wasted.”⁹⁷

3. Improve Working Conditions

Technological changes such as digitization of processes and operations can also bring about additional improvements that enable women to perform tasks in an operational centre or at home. Such tasks include:

- administrative and clerical work
- monitoring displays or equipment
- remote customer service functions
- programming and data analysis
- order processing
- logistics planning and management
- remote operations of equipment
- equipment and inventory monitoring
- tracking equipment in yard

Creating an Inclusive Work Environment

Feeling secure at work is a priority for many women working in a primarily male-dominated industry. In recent years, the administrators of one Asian railway have introduced high-tech and smart facilities, gradually lowering the barriers to administrative jobs for women and underrepresented groups. The organization is striving to do this by improving the recruitment system and working environment. For instance, it is improving the working environment by providing women-only dormitories, changing training methods, adjusting shift scheduling during pregnancy, and installing surveillance equipment to enhance security.

A senior executive interviewed for this report noted that his company was increasingly successful in attracting women to work as automated crane operators at one of its ports. He stated, “the female employees like working in the air-conditioned and quiet control room. They especially appreciate the company-sponsored onsite daycare which helps with their childcare responsibilities and makes balancing work and family life easier.”

4. Support Retention of a Diverse Workforce

Once someone from an underrepresented group is participating in the transportation workforce, internal company policies and practices play the predominant role in ensuring they remain. Nonetheless, sound government policies and enforcement activities can help retain workers by ensuring that unenforced safety and equity measures do not create a situation in which a worker feels they must leave their occupation. And as occupations shift in response to the introduction of new technologies, it is even more critical that governments use this opportunity to help underrepresented workers feel comfortable enough to stay in the workplace within the uncertain and changing nature of their job.

4.1 Enforce anti-harassment and anti-discrimination policies in the workplace

Understanding the role of challenges like sexual harassment and discrimination in women’s participation in the workforce remains vital, even if technological changes mean that more women move into less physically demanding tasks in control or operation centres. In interviews for this report, women’s groups and union representatives mentioned concerns about sexual harassment on the job. They pointed to this problem as one that required significant attention in some transportation workplaces and strong enforcement actions by government. Simply having laws on the books was not enough in their view.

Building off the work of the APEC TPTWG’s Women in Transportation Initiative, governments can deepen their knowledge and understanding of the needed skills and vulnerabilities that women and disabled workers face, especially in the context of the technology-driven changes to tasks involved in traditional occupations. Such information is key to improving outcome-based, evidence-driven, and targeted policies that will support women and people with disabilities in new workplace roles.

Example

In 2013, legislators in Japan passed a law aimed at eliminating discrimination against disabled workers. This law was part of broader government reform, including the ratification of the *Convention on the Rights of Persons with Disabilities*, in 2014. The government’s deliberate policy focus has spurred steady progress. In June 2019, the number of people with disabilities working in Japan’s private sector exceeded 560,000—a 4.8 per cent increase from the previous year.⁹⁸

4.2 Update standards related to workers' health and safety

Without policies that protect workers' health and safety, the transportation sector risks losing them (to injury or simply leaving their job) at a time when there is a great deal of uncertainty and transition in the workplace because of new technologies. Studies from 2014 and 2016 in the United States and United Kingdom show that women working in hazardous industries often have limited access to correctly fitting personal protective equipment (PPE) and in some cases the PPE can hinder rather than protect. Loose clothing and gloves can get caught in machinery, while overly large boots can be a tripping hazard.

While some employers and manufacturers are beginning to acknowledge and address the issue, researchers continue to call on industry and governments to do more to protect women effectively. Governments can amend health and safety regulations on PPE to include a requirement that PPE must be selected to ensure that it properly fits each employee. Research shows that rectifying health and safety standards (such as providing separate toilets for women) was not a priority for their organization without outside pressure or enforcement penalties.

Examples

In a 2019 United Kingdom study about *Invisible Women* in the workplace, one rail industry worker explained that the standard size 13 gloves she was issued were "dangerous for climbing on/off locomotives". She had complained to her manager, then waited months for new gear.⁹⁹

Interviewees for this report also raised the issue of access to toilets and changing facilities for women. Governments in their economies had regulations that two toilet facilities be available on the work site, but inspectors did not enforce the provision, and so the entire workforce used one. Some women found this situation unacceptable but were largely resigned to it.

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