The Future of Transportation Work:

Technology, Work Organization, and the Quality of Jobs

By Jim Stanford and Matt Grudnoff
Centre for Future Work at the Australia Institute

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This report was prepared for TWUSUPER.

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Summary

This research report considers the future trajectory of work in Australia's broader transportation industry. It takes into account the change and disruption that will occur across the sector as a result of a number of drivers – including, but not limited to, technological innovation. Transportation is a crucial part of the Australian economy, and generates significant spill-over benefits that are shared across all sectors and regions. Transportation is also an important employer, occupying some 625,000 Australians and generating above-average earnings. However, work in this sector is poised for dramatic change in the years ahead. It is the responsibility of all stakeholders in transportation to prepare for that change – to manage it, minimise its costs, and maximise its benefits.

Dramatic advances in technology – including the advent of driverless vehicle systems, but including other incremental and less visible innovations, as well – are one obvious driver of change in transportation employment patterns. The report reviews the major features of recent waves of innovation (including machine learning, artificial intelligence, and big data analysis), and catalogues their various potential applications in transportation. But other factors are also affecting the nature of transportation work, for better or for worse. Chief among these is a marked shift in work organisation and employment relationships, with a visible shift toward non-standard, more precarious forms of work. Part-time, casual, and self-employed positions now account for almost half of the total transportation workforce. And the expansion of digital platform intermediaries, with their reliance on "gigs" (rather than jobs), is likely to accelerate this trend. This shift in work organisation is having impacts on the quality and stability of transportation jobs that are as important as, and certainly more immediate than, the dramatic changes in technology that are also coming.

The report constructs three composite scenarios describing potential trajectories for transportation employment, and considers the likelihood and consequences of each of them. It then makes several recommendations for transportation stakeholders, to assist them in preparing to actively manage the coming change. The goal is to enhance the all-round economic and social benefits that are generated by a high-quality, effective, and sustainable transportation system; achieving this goal demands far-sighted, holistic analysis and decision-making by sector stakeholders. One of these recommendations is to develop more sector-wide capacity for dialogue, relationship-building, and integrated transition planning, since efforts to manage change are more effective when they occur through negotiation and consensus – rather than being

imposed by particular private interests or market decisions alone. TWUSUPER itself has a unique role to play, in this regard, by virtue both of its economic importance (as a vehicle for retirement planning and capital investment), and also its acknowledged role as a collegial meeting place for stakeholders from all parts of the industry.

I. Introduction and Overview

Transportation services are essential to the performance and success of Australia's economy. Movement of goods and people takes on particular importance given Australia's large geography and relatively sparse population. Hence the development and operation of transportation systems and services has always been a central force in Australian economic and social development. Today transportation services, broadly defined, contribute over $80 billion per year to national GDP (or around 5 percent of total national value-added), constitute a major and essential input to other industries and sectors, purchase another $80 billion of inputs and supplies from other sectors, and are one of Australia's largest employers (engaging some 625,000 people).

As important as transportation is to Australia's economy today, it is likely to become even more important in the future. The expansion of domestic and international trade; the growing popularity of on-line shopping; and the tendency of consumers to allocate a greater share of disposable income to travel and tourism as their income levels rise, are just some of the forces driving continuing growth in the overall demand for transportation services. Key transportation stakeholders – including transport and shipping firms, governments, municipalities, manufacturers of transportation equipment, and others – are consequently investing heavily in the expansion and modernisation of Australia's transportation infrastructure, to help meet those future needs in as efficient, safe, pleasant, and sustainable manner as possible.

However, even as Australia's transportation industry continues to develop in both quantitative and qualitative terms, the sector faces several enormous uncertainties and challenges that will exert a powerful but unpredictable influence on transportation services, and transportation jobs, in the future. Of course, one crucial driving force of change in the sector is the accelerating pace of innovation in the technology of transportation: including changes in propulsion systems, driving and navigation, logistics systems, and information and data management technologies. These and other technologies will have major impacts on the nature of transportation provision.

But it is not just technology that will determine the future of transportation. Many other forces are also driving change in the industry, such as environmental challenges, fiscal and governance issues, globalisation, and the demographic evolution of both society as a whole and the transportation workforce in particular. One particularly important dimension of change in the sector is the changing structure of employment relationships. New forms of engagement and compensation (including the growth of various forms of self-employment and contractor arrangements), and the vertical

disintegration of supply chain relationships (with an increasing share of total activity allocated to independent ancillary firms rather than integrated within a single enterprise), will change the nature of transportation work as fundamentally as will new technology. Interactions between new technology and new employment relationships further complicate the task of predicting the evolution of transportation work.

It is important for transportation stakeholders to consider these complex and overlapping forces of change, as they consider the potential direction of their industry – and position themselves to make the most of future opportunities, while minimising the negative effects of disruption. This report provides an overview of the forces that will shape transportation work into the future, considering both the challenges and the opportunities posed to existing transportation stakeholders, and to the role and sustainability of TWUSUPER, in particular. All participants in Australia's transportation industry – firms, workers, industry associations, training and research bodies, unions, governments, shippers, regulators, and more – must be pro-active in recognising how thoroughly the sector will change, how existing practices will be disrupted, and how change can and should be managed. At the same time, they can be confident that transportation services will remain fundamental to the future prosperity and efficiency of Australia's economy. This industry, and the jobs it provides, are here for the long term. The question is what kind of jobs will be created in the transportation industry of the future, and whether the people performing those jobs are able to make their fullest possible contribution to the overall economic and social performance of the industry.

The report is organised as follows. The next section provides a brief overview of the methodology followed in the research, followed by an overview of the broader economic and social importance of transportation in Australia. In Section IV, we provide a detailed statistical portrait of the present state of transportation work, and the characteristics of the transportation workforce. This is essential, in order to develop a more precise understanding of the ways in which transportation is positioned to benefit from, but is also threatened by, coming changes in technology and other disruptors.

Section V then undertakes a detailed review of the advances in technology that will alter transportation work in coming decades, considering both the accelerating pace of innovation, and the institutional and regulatory factors that will facilitate or delay the real-world application of those innovations. This includes the advent of driverless vehicle technologies, which have captured so much public attention, but also less high-profile but also disruptive technologies. We find that transportation is among the sectors likely to be most dramatically affected by the introduction of new labour-

saving or labour-replacing technologies over the next quarter-century. However, there is considerable uncertainty regarding the precise timing of these changes; moreover, there are countervailing forces that imply greater stability in overall employment levels than is often assumed in many projections.

Section VI conducts a similar overview of the substantial and ongoing changes in the organisation of work across the transportation sector. The expansion of non-standard employment arrangements (including part-time, casual, self-employment, independent contractor, and related job structures) in transportation has paralleled a similar trend in the broader economy. Coincident with, and contributing to, this trend is the growing role for independent sub-contracting firms, which now fulfil a greater range of functions in the overall transportation supply chain. The overall industry has thus become more fragmented, vertically disintegrated, and heterogeneous. The shrinking importance of traditional employment relationships poses significant challenges to ongoing efforts to establish and maintain higher standards for training, safety, and compensation in transportation work. Technological change may facilitate or accelerate the evolution of work organisation, making it difficult to distinguish between changes in the industry that are driven by technology and those that are driven by changes in the organisation and regulation of production (and hence which have a more subjective, social character).

Section VII of the report undertakes a "scenario analysis," to identify likely potential trajectories for the evolution of transportation work – recognising the inherent uncertainty which accompanies any such forecasting exercise. Attempting to generate point estimates of future industry outcomes (such as total output, employment, and compensation benchmarks) are not credible; this approach assumes an unlikely ability to predict the interaction of the complex forces affecting the sector's evolution. Instead, various combinations of outcomes are grouped into three broad scenarios, with broad probabilities are attached to each of them. This provides readers with a more nuanced appreciation of the complex and often contradictory nature of the varied forces shaping transportation work, as well as of the inherent uncertainty of forecasting in this context.

The final sections of the report consider more directly the implications of the foregoing analysis for the various stakeholders in Australia's transportation industry. Section VIII summarises the ways in which industry stakeholders will likely be affected by the future course of change (technological, organisational, and social), and makes five specific recommendations regarding how the sector can prepare to maximise the potential benefits of that change – while minimising the costs and risks stakeholders face as change occurs. Finally, the conclusion of the report reaffirms the importance of high-quality transportation work: as an essential input to the overall economy, as a

contributor to the quality of life of Australians, and as a source of quality work and income opportunities. The actions of industry stakeholders to prepare for change, and make the most of change, are essential for ensuring that this valuable economic and social contribution is sustained.

II. Methodology

The present report represents the culmination of a multi-stage research project undertaken at the request of TWUSUPER, and involving the following components:

i. Initial compilation and analysis of data from public sources.

ii. Literature review of extant research on transportation industry evolution and changing work practices.

iii. Interviews with key informants from Australian and international transportation providers, regulators, associations, and unions.

iv. Access of more specialized data on the nature of transportation work from specified sources (including the ABS, OECD, and other sources).

v. Development and analysis of major potential change scenarios.

vi. Presentation of initial findings to key stakeholders (including TWUSUPER Board of Directors).

vii. Refinement and documentation of full results.

The researchers were asked to consider the likely direction of changes in transportation work in both the medium-run (approximately 5 years) and the longer-run (25 or more years).

Where possible, the research considered transportation in a broad scope, including direct transportation provision in all modes (road, rail, air, and marine), but also the provision of ancillary and logistical functions and services (including transport support services, warehousing, and related functions). Given the trend toward the vertical disintegration of transportation services and the assignment or outsourcing of specific functions to independent firms (which are not always included within traditional transportation industry statistics), this inclusive scope is important for developing a composite portrait of the activities of the entire supply chain. In some cases, available data did not allow for this broad definition of the sector, in which case the narrower scope of analysis is duly noted.

The research team consisted of:

- Dr. Jim Stanford, Economist and Director of the Centre for Future Work at the Australia Institute. Dr. Stanford brings 25 years of professional experience in labour market, industrial relations, and broader macroeconomics experience to the project. This includes considerable applied policy experience in transportation sector analysis, covering the airline, railway, and trucking sectors. He holds a Ph.D. in Economics from the New School for Social Research in New York, and an M.Phil. in Economics from the University of Cambridge, U.K.
- Matt Grudnoff, Senior Economist at The Australia Institute. Mr. Grudnoff has worked in applied economic policy settings for over a decade, and is a Ph.D. Candidate in Economics at the University of Newcastle. He has wide experience in labour market, fiscal, and social policy research.

III. Understanding the Economic Importance of Transportation

Table 1 The Economic Footprint of the Transportation Sector (2016 or most recent year)	
Indicator	**Value**
GDP (value-added)	$80 billion
Total sales	$175 billion
Employment	625,000
Wages and salaries paid	$45 billion+
Average earnings	$75,000/yr.
Exports	$7.3 billion
Taxes paid	$25 billion+
Source: Authors' calculations from ABS Catalogues 5206.0, 5368.0, 6291.0.55.003, 6306.0, 6202.0.	

The transportation sector plays an essential role in Australia's economy, that extends well beyond the direct output and employment associated with the industry itself. Certainly, transportation providers themselves generate employment, incomes, and tax revenues that make a significant contribution to Australia's national performance on each variable. Table 1 summarises some of these direct indicators of the transportation industry's economic footprint. Direct GDP arising from the sector exceeds $80 billion per year. Total sales generated by the industry (including the value of intermediate inputs purchased and used in production) are more than twice as large. The industry directly employs some 625,000 workers, or over 5 percent of all national employment, who are paid a total of over $45 billion per year in combined compensation. That implies average compensation per person of around $75,000 per year – around 20 percent higher than average compensation per worker across the labour market as a whole. Transportation services also make an important contribution to Australia's international economic performance, generating over $7 billion per year worth of export revenues (arising from international purchases of

Australian-produced transportation services). The industry also generates a strong revenue flow to governments at all levels, exceeding $25 billion per year: representing the full inventory of transportation-related taxes and levies (including business taxes paid by firms, income taxes paid by workers, GST revenues arising from industry purchases, and more).

However, this direct economic footprint does not constitute the full extent of the economic importance of the transportation sector. We must also consider the indirect flow-through effects of transportation into other sectors of the economy. In this regard, two broad categories of inter-sectoral linkages should be considered:

i. *"Upstream" Linkages:* In the course of its own activity, the transportation industry purchases substantial quantities of goods and services from other sectors, as inputs in its own production. In aggregate, transportation providers in 2013-14 (most recent data available) purchased over $80 billion of Australian-made goods, materials, machinery, and services from other sectors of the economy. Table 2 summarises the leading components of these overall input purchases.

Table 2
Input Purchases by Transportation Providers
2013-14

Input purchases	**Value ($b)**
Primary industries	$0.7
Manufacturing	$12.5
Utilities	$1.5
Construction	$4.6
Trade	$6.2
Finance	$6.2
Professional / science	$7.1
Repair / maintenance	$4.8
Other services	$18.4
Total Australian-made inputs	**$81.4**
Imported inputs	$12.3

Source: Authors' calculations from ABS Catalogue 5209.0.55.001, Table 5.

In other words, the transportation industry purchases more than one dollar of Australian-made inputs (goods or services) from other sectors of the economy, for every dollar worth of value-added undertaken within the sector itself. These purchases thus provide an important source of demand that spreads throughout the broader economy – to all sectors, and all states. Without the purchasing power arising from transportation activity, those sectors would lose important sales, revenues, and profits – and employment in those other sectors would be compromised accordingly. Similarly, it is reasonable on the basis of these input-output relationships to conclude that as many jobs outside of the transportation sector depend on transportation activity, as exist within the transportation sector itself (625,000 in 2016). Especially during times of generalised macroeconomic weakness, the importance of these input-output linkages to national economic performance must not be underestimated.

ii. *"Downstream" Linkages*: The importance of transportation services to other parts of the economy also extends "downstream," to the myriad of other industries which use transportation as an input to their own production. Some transportation services constitute an end-use in their own right, such as the transportation utilised by consumers for their own personal use; but a large proportion of transportation output is purchased by other industries as an input to their own productive activity. Without reliable, quality transportation those industries would suffer considerable losses of production, value-added, efficiency, and reputation. Table 3 lists some of the other sectors into which transportation services constitute an especially important input to production. Two of the most transportation-intensive sectors of the broader economy are wholesale trade (whose transportation purchases are equivalent to almost 18 percent of value-added within the sector) and manufacturing (over 16 percent). The provision of high-quality, reliable transportation services are thus essential to ensuring continued productivity, profitability, and employment in all parts of the economy.

Another dimension of the "downstream" importance of transportation is the subsequent recycling of income generated in the sector, as transportation workers spend their wages and salaries (worth over $45 billion per year in aggregate) on personal consumption, and transportation firms reinvest their retained earnings in new equipment and facilities. This subsequent re-expenditure of incomes associated with transportation work provides an additional incremental source of purchasing power in the broader national economy. Once again, during times of sustained unemployment and underemployment, with economic growth held back by ongoing weakness in aggregate demand, the income-generating potential of transportation takes on additional importance.

Table 3 Transportation Input Purchases by Other Sector 2013-14	
Input purchases	**Input Purchases as % of Sector Value-added**
Wholesale Trade	17.9%
Manufacturing	16.1%
Rental and Hiring Services	9.3%
Personal Services	8.5%
Telecommunication Services	8.0%
Construction	7.9%
Sports and Recreation Services	7.4%
Employment, Travel, and Administrative Services	6.4%
Agriculture	6.2%
Source: Authors' calculations from ABS Catalogue 5209.0.55.001, Table 5.	

It is important to consider all of these spill-over effects of transportation activity, both upstream and downstream, in order to properly appreciate the transportation industry's importance as a driver of broader economic growth and development. All too often, customers and policy-makers tend to view transportation solely as a "cost item." According to this narrow view, undue and distorted importance is attached to reducing transportation costs, as the primary goal of transportation planning and policy.

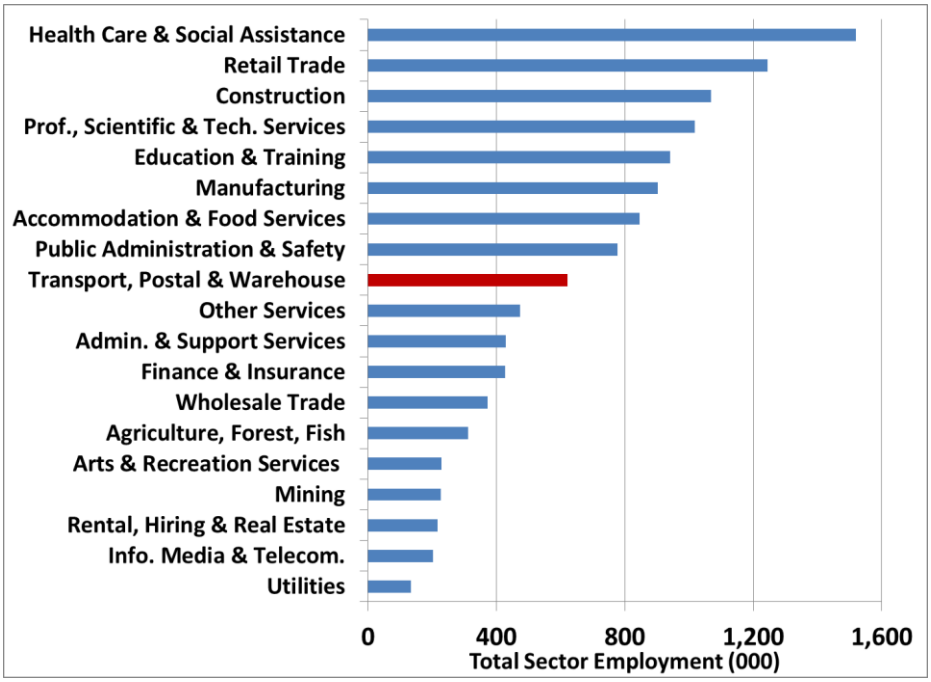
But as we have seen, from a broader economic perspective, transportation is not just a "cost." It is also an important source of value-creation, employment, demand, and social well-being in its own right. Due consideration of these spill-over benefits of transportation activity, and the dependence of other sectors on the health and reliability of transportation, must be a requisite component of any fulsome cost-benefit analysis of transportation policy and investment. Actions taken by other stakeholders in the economy (including government and regulatory bodies) to reduce private transportation costs over time, with no reference to the broader impacts of transportation on the overall economy, will undermine the extent to which the transportation industry can fulfil its wider economic and social mandate.

IV. Transportation Work Today

This section of the report will present a comprehensive statistical portrait of transportation work in Australia today, including the key characteristics of the transportation workforce. From this statistical starting point, subsequent sections will develop an analysis of the capacity of the sector and its workers to confront the myriad of changes that will impact on the industry in coming decades.

Transportation is an important source of employment in the Australian economy. In 2016 the industry employed 625,000 Australians (including those occupied in ancillary service functions such as warehousing, logistics, and others). As illustrated in Figure 1, this makes transportation the ninth largest source of employment among Australian industries (defined at the 2-digit level). Transportation is much larger than some other sectors – such as finance, mining, and agriculture – which attract a great deal of attention (not to mention favourable policy actions) from govrnments.

Figure 1. Employment by Two-Digit Industry Division, 2016

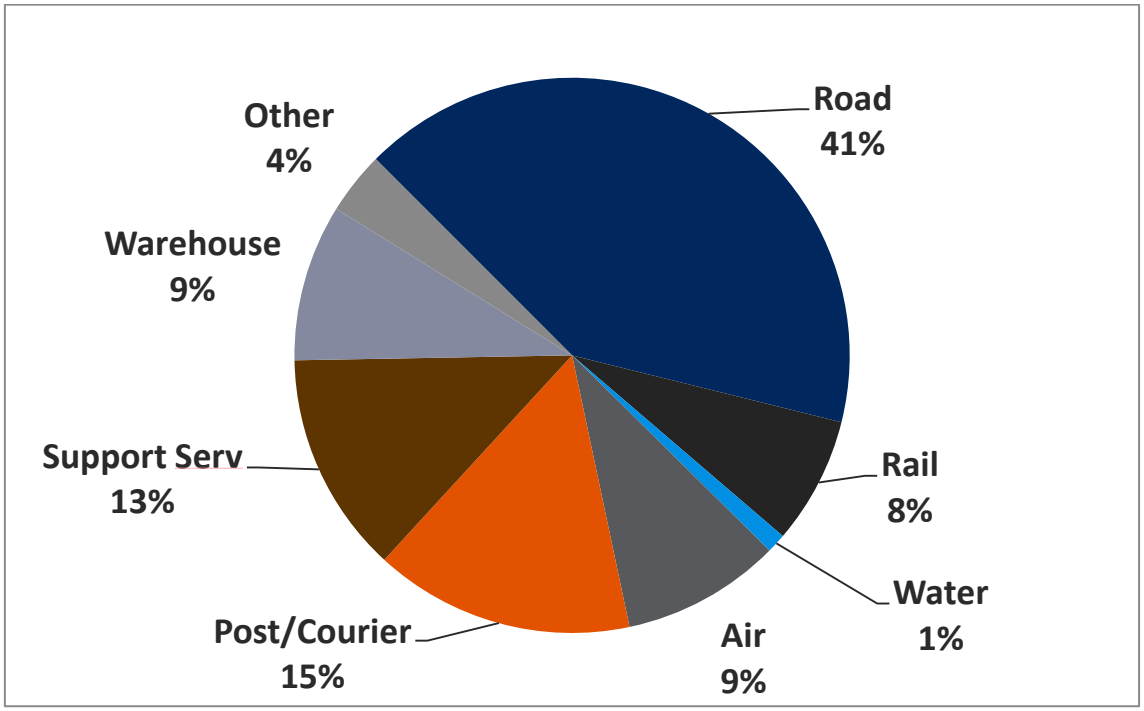


Source: ABS Catalogue 6291.0.55.003, Table 4.

Figure 2 provides a breakdown of total transportation employment into its various sub-sectors. Of these, road transportation is the largest single source of transportation work, accounting for close to 270,000 positions in 2016, or over 40 percent of all transportation work. In contrast, employment levels in other direct transport modes

(including air, rail, and marine) are smaller: just over 100,000 jobs in total across the three other modes. In fact, next to road transport, the largest concentrations of transportation work have arisen in the ancillary and support service functions, which have expanded steadily as a result of the outsourcing of specific functions to independent service providers (and the corresponding vertical disintegration of the overall supply chain). For example, the postal and courier sub-section accounts for close to 100,000 positions in total, with another 80,000 jobs in transportation support services, and close to 60,000 in warehousing. Undefined "other" transportation jobs account for the remaining positions (4 percent of the reported total).

Figure 2. Transportation Employment by Sub-Sector, % of Total, 2016

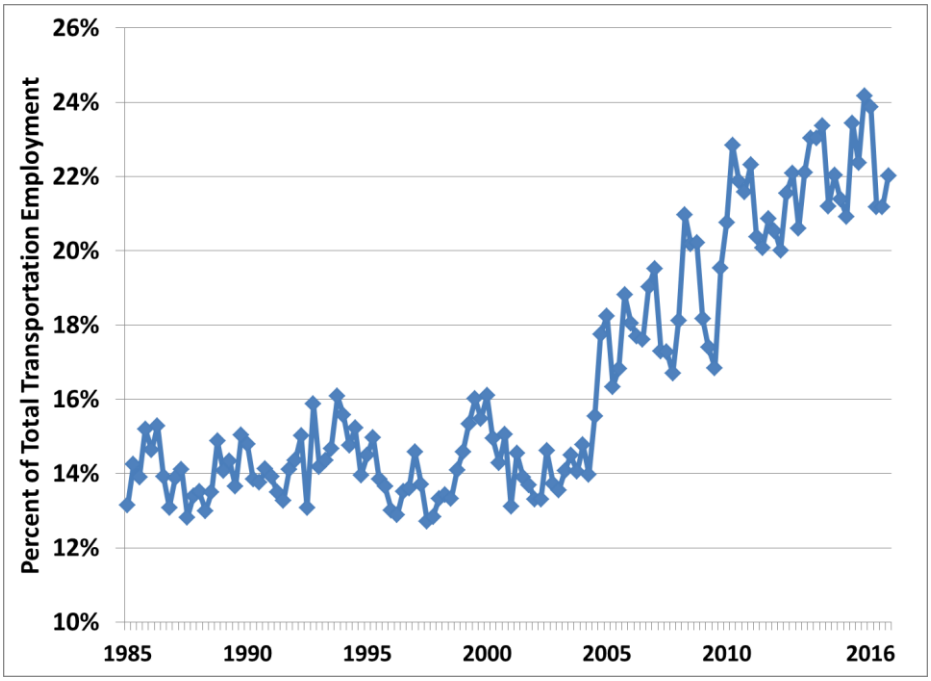


Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Table 6.

The growing relative importance of ancillary and support services in overall transportation employment is illustrated in Figure 3, which describes the combined share of the support service and warehouse/storage sub-sectors in total transportation employment over the past three decades. Beginning in approximately 2005, the share of these ancillary services – which traditionally were more likely to be performed in-house within integrated transportation firms, rather than outsourced to independent suppliers – began to rise steadily, more than doubling in the next decade. (Keep in mind that the statistical methodology of ABS employment surveys will assign workers to a specific sub-sector based on the main activity of the enterprise where they work; hence a warehouse worker employed directly by a trucking firm will be reported as

working in the road transport sub-sector, but if the work is outsourced to an independent logistics provider the same job will reappear in the support services category.) This growth was driven by rising employment in the "support services" sub-sector; in contrast, employment in warehouse functions has been steady. Today these ancillary functions together now account for close to one in four of all transportation jobs. This important change is highly relevant to our subsequent consideration of the coming impacts of the twin forces of technological and organisational change in transportation.

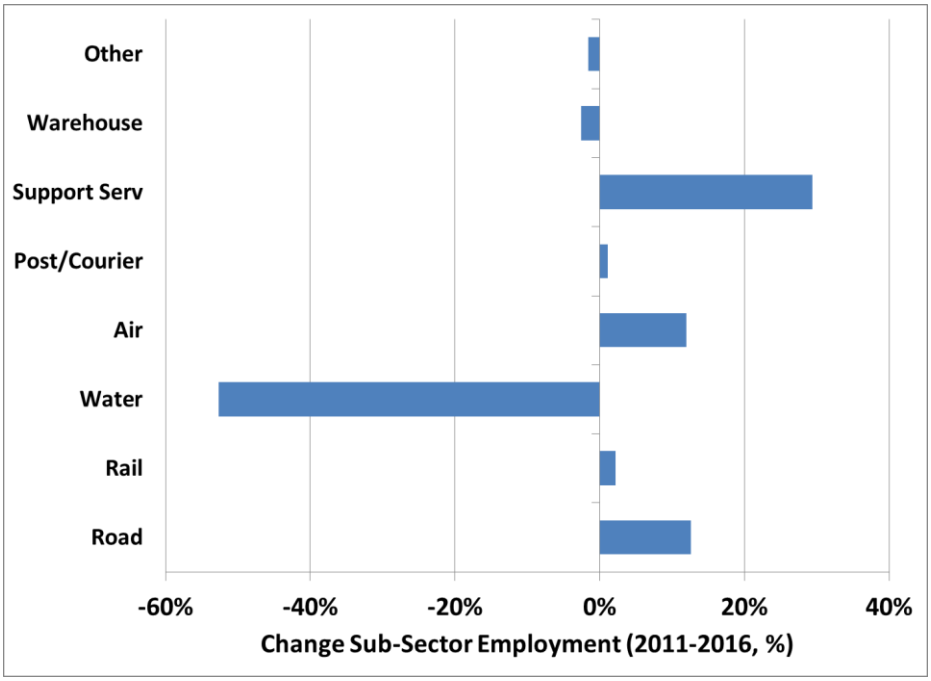
Figure 3. Ancillary Services as Share Total Transportation Employment, 1985-2016



Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Table 6.

Transportation support services have experienced rapid employment growth in recent years, and this accounts for their rising share of total transportation employment. As indicated in Figure 4, support services employment has expanded by 30 percent in just the last five years. The two other modes of transportation that have experienced rising employment levels have been road and air transportation, each of which have grown by more than 10 percent in the same period. Other sub-sectors of the broader transportation industry have demonstrated stagnant or slightly declining employment levels – with the exception of marine transportation employment, which has declined dramatically (by over 50 percent in just five years), reflecting both the loss of Australian mariner jobs to overseas suppliers and the introduction of labour-saving technologies in waterfront applications.

Figure 4. Change in Employment by Transportation Sub-Sector, 2011-2016

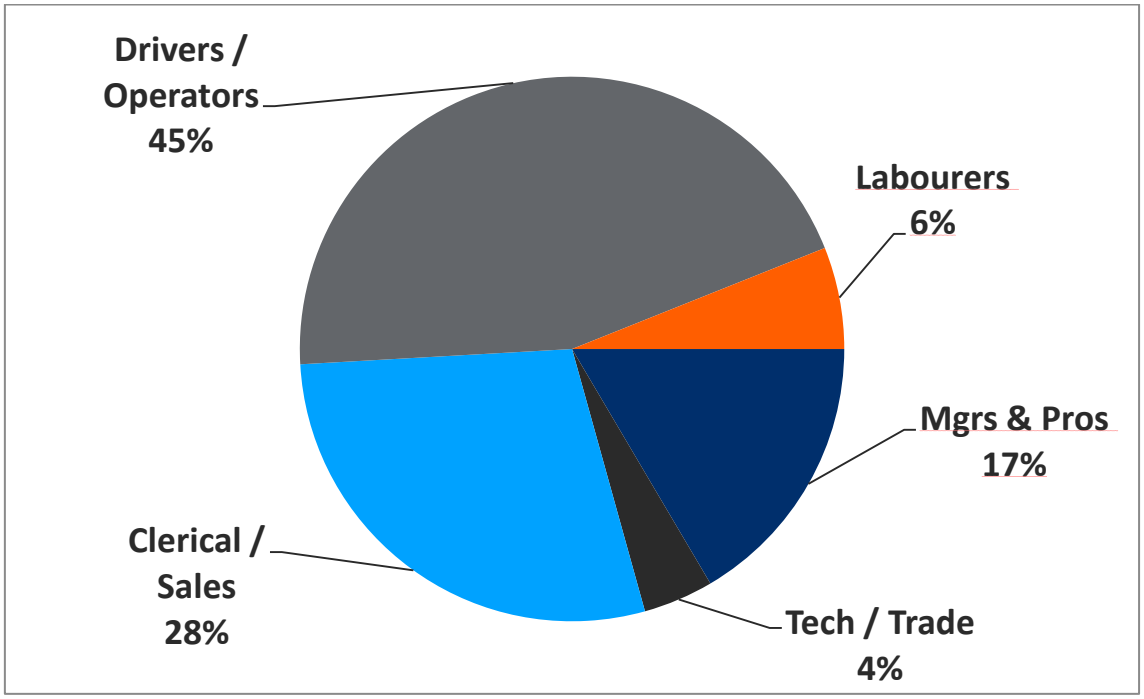


Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Table 6.

In addition to the preceding detail on sub-sector employment patterns, existing transportation employment in Australia can also be broken down according to occupational groupings. Figure 5 provides a decomposition of transportation work into five major occupational categories.

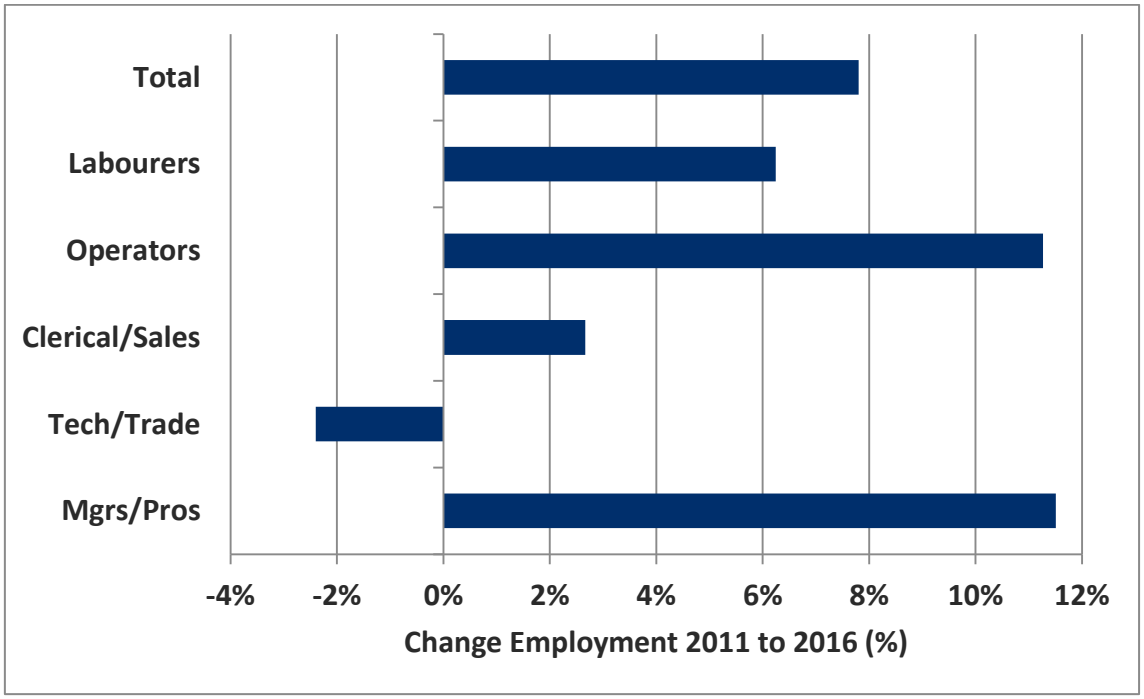
The largest group of workers, accounting for 45 percent (or close to half) of all employment, is drivers and operators. Interestingly, this is one of the occupational groupings considered to be most at risk from coming technological change, given the advent of semi-automated and automated driving and navigation systems—but there is no sign yet of that occurring. Clerical and sales workers account for over one-quarter of transportation jobs, and managerial and professional staff make up 17 percent. Two additional blue-collar occupational categories – labourers and technical and trades workers – make up a combined 10 percent of workers.

Figure 5. Transportation Employment by Occupation, 2016.



Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Data Cube EQ09.

Figure 6. Change in Transportation Employment by Occupation, 2011-2016

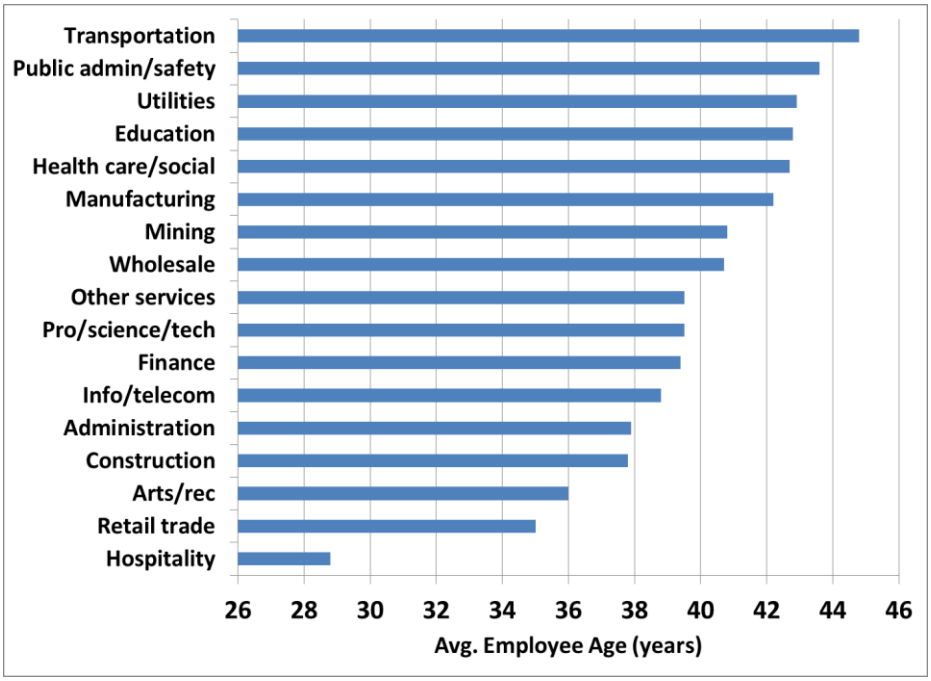


Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Data Cube EQ09.

Figure 6 indicates the cumulative growth in each occupation's employment within transportation over the last five years (the same time period covered by Figure 4, above). Perhaps surprisingly, the employment of drivers and operators has grown more strongly than employment for the transportation sector as a whole: by over 13 percent (while total transportation employment grew by 7.5 percent over the 2011-2016 period). Managerial and professional occupations also experienced strong employment growth, also expanding by about 13 percent. The employment of labourers grew by over 6 percent, nearly matching the sector-wide average. Clerical and sales jobs grew more slowly (by about 2.5 percent) over the same period, while employment of technical and trades workers actually declined (by over 2 percent).

It is important to note that Figure 6 shows no obvious or predictable relationship between the level of formal qualification in transportation work, and the trend in employment for each occupation. Relatively skilled blue-collar occupations (like technical and trades workers) have faced employment losses, yet drivers and operators have continued to experience strong job growth. Some office-based occupations (such as professional employees) have seen job-creation, but others have not. So the common assumption that job opportunities will be related to the level of skill or credentials of particular workers must be nuanced in the case of transportation. We will come back to this in discussing the likely impacts of technological change on transportation employment patterns.

Figure 7. Average Age, Employees by Sector, May 2016

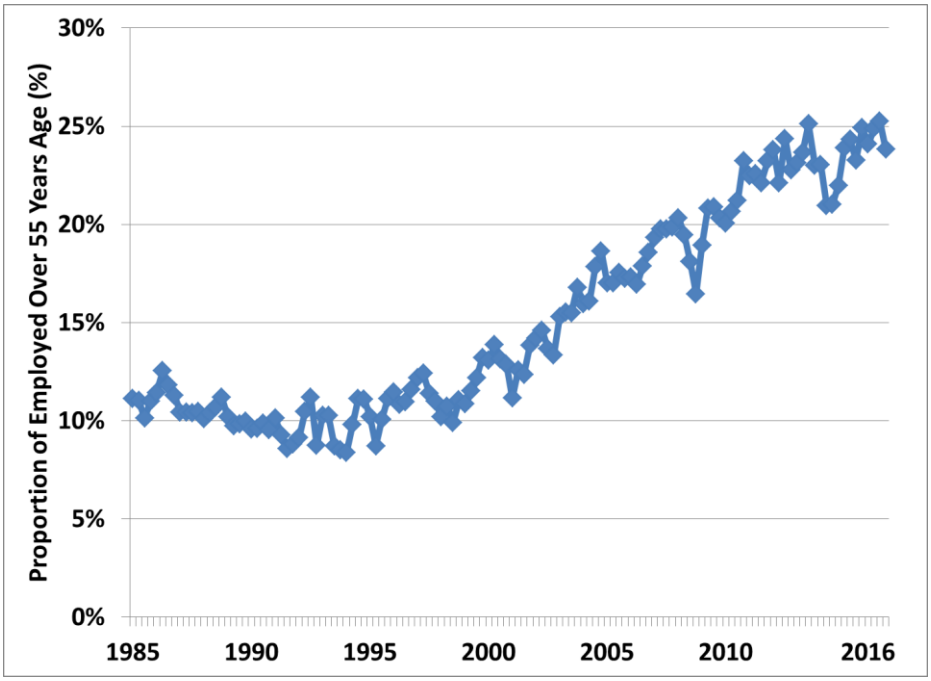


Source: ABS Catalogue 6306.0.

Now that we have described the sectoral and occupational make-up of the transportation workforce, we can consider a more detailed analysis of its demographic profile. Australia's transportation workforce at present demonstrates some unique characteristics that will also be highly relevant in judging the sector's capacity to respond to change in the decades ahead. The average age of transportation workers is higher than any other of the 19 industries measured (at the 2-digit level) by the ABS. As of mid-2016, the average age of paid employees in the transportation sector was almost 45 years, as shown in Figure 7. (Keep in mind that this age data covers paid employees only, and hence does not capture self-employed individuals – who may be somewhat younger than paid employees given the ongoing shift toward non-standard employment that is visible in this sector.)

Similarly, a growing proportion of the sector's workforce is approaching retirement age. As indicated in Figure 8, one in four transportation workers is now over 55 years of age. And the incidence of older workers has more than doubled since the turn of the century. As discussed below, this poses both a challenge and an opportunity for the sector as it prepares for significant change in the decades ahead.

Figure 8. Incidence of Older Workers, 1985-2016



Source: Authors' calculations from ABS Catalogue 6291.0.55.003 EQ12.

Another unique feature of the demographic profile of the transportation workforce is the high preponderance of male workers. Men account for over three-quarters of transportation workers. That proportion has remained steady since the turn of the century; the employment share of women in transportation increased in the 1980s and 1990s, but that trend has stopped since 2000. Among full-time transportation jobs, the proportion of males is even higher: 82 percent. In part-time transportation work, women have a stronger presence, accounting for 38 percent of all jobs (more than twice as large as their share of full-time jobs). The gender make-up of employment varies across sub-sectors, but men constitute a strong majority of transportation employment in all modes. The most male-dominated sub-sector of transportation is road transport, where men account for 87 percent of all jobs, and over 90 percent of full-time work.

A final relevant aspect of the demographic profile of the existing transportation workforce is its relatively low level of formal training and qualification. Transportation work is a demanding, high-skill occupation. But the traditional method for acquiring those skills has been through on-the-job training, rather than through formal qualifications and higher education. Table 4 compares the incidence of formal post-school qualifications in the transportation sector, to that found in the rest of the economy.

Table 4
Formal Educational Qualifications, by Sector

Qualification	All Transportation	Operators & Drivers*	Total Economy
Bachelor or Higher	15%	8%	31%
VET Cert III or Higher	31%	32%	32%
No post-school	49%	56%	32%
Other	5%	5%	5%

* Operators and drivers in all sectors of the economy.

Source: Authors' calculations from ABS Education and Work Survey, unpublished data.

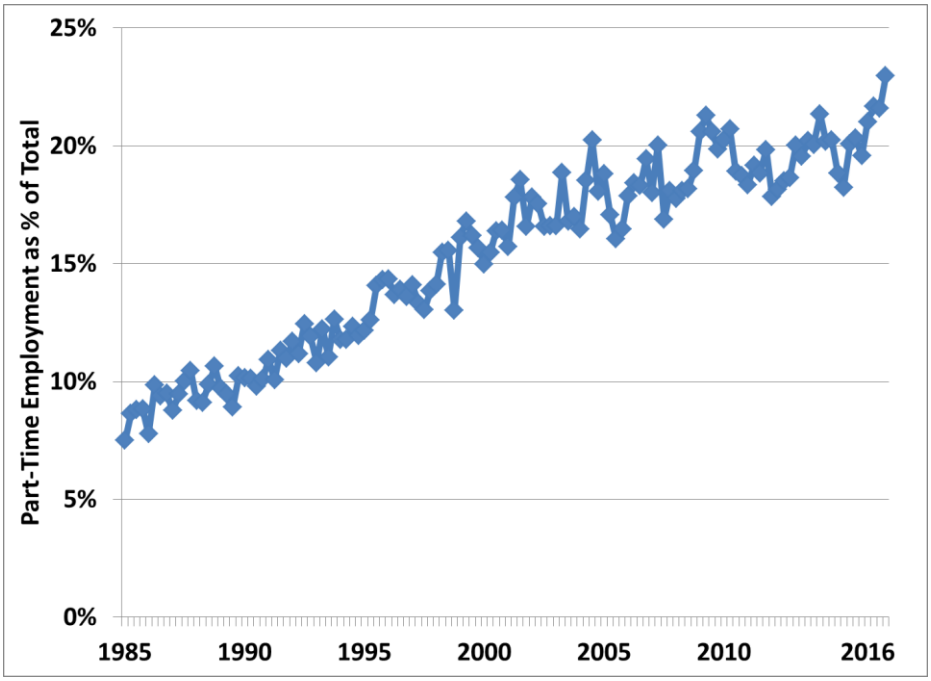
Across all transportation jobs, half of workers have no post-school certification at all. About 30 percent possess a Certificate III level of credential from a vocational education provider (such as TAFE), or higher. And 15 percent possess a university bachelor's degree or higher. The incidence of university degree holders is half the rate

in the economy as a whole, while the incidence of those with no formal post-school training is 17 percentage points higher than in the economy as a whole.

As described above, drivers and operators constitute the largest single occupational grouping within the transportation workforce, and they indicate an even lower average level of formal qualification. Table 4 reports that only 8 percent of operators and drivers hold a university degree (about one-quarter the rate in the overall economy), while 56 percent possess no formal post-school training. Operators and drivers are especially numerous in the road transportation sub-sector, which as we have seen is also the oldest component of the transportation workforce.

These varied indicators, then, are suggesting that the transportation workforce is characterised by a largely male, older population, which possesses considerable experience but relatively fewer formal qualifications and credentials. On one hand, this profile poses obvious challenges to a sector facing significant changes in work, technology, and skills: it is typically harder for older workers to reorient their careers in the face of new technology, the redefinition of jobs, or the geographical relocation of work. On the other hand, the fact that a significant proportion of the transportation workforce is in the latter years of their careers, and hence close to being eligible for retirement, provides a unique opportunity to facilitate transitions through early or phased-in retirement programs.

Figure 9. Part-Time Share of Total Transportation Employment, 1985-2016

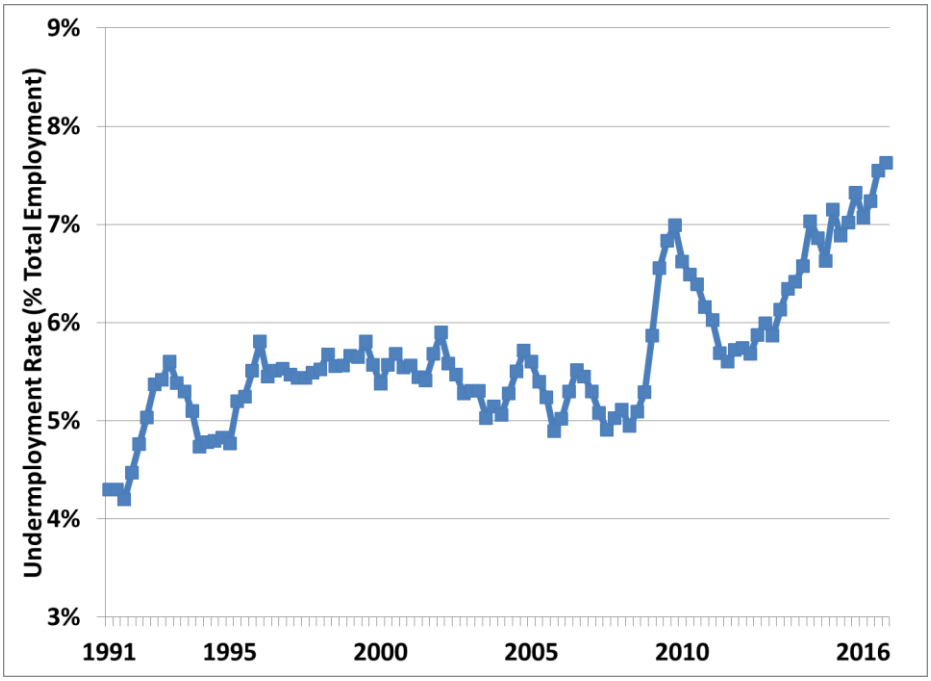


Source: Authors' calculations from ABS Catalogue 6291.0.55.003, Table 4.

We will now consider several indications of the quality of transportation work. As with the overall economy, transportation work has seen a marked shift since the turn of the century toward part-time work. The part-time share in total transportation employment is now at an all-time high, at around 23 percent of all jobs (Figure 9). That share has tripled since the mid-1980s, although it is interesting to note that the incidence of part-time employment in transportation is nevertheless significantly lower than in the overall economy (where part-time work now accounts for one job in three).

Driven largely by the growing preponderance of part-time work, average hours worked per week in the transportation sector have been falling steadily since the early 1990s. On average, each employed person in transportation works about 36 hours per week; this reflects a weighted average of long hours for full-time workers, but much shorter hours for the growing share of part-time employed. As recently as the turn of the century, the average was 40 hours per week; at that time, the overtime worked by full-time workers offset the influence of a smaller segment of part-time workers on the recorded average hours. More recently, however, the growing proportion of part-time work is pulling down the weighted average of weekly hours, even though hours remain long (often over 40 hours per week including overtime) for full-time workers.

Figure 10. Underemployment in Transportation

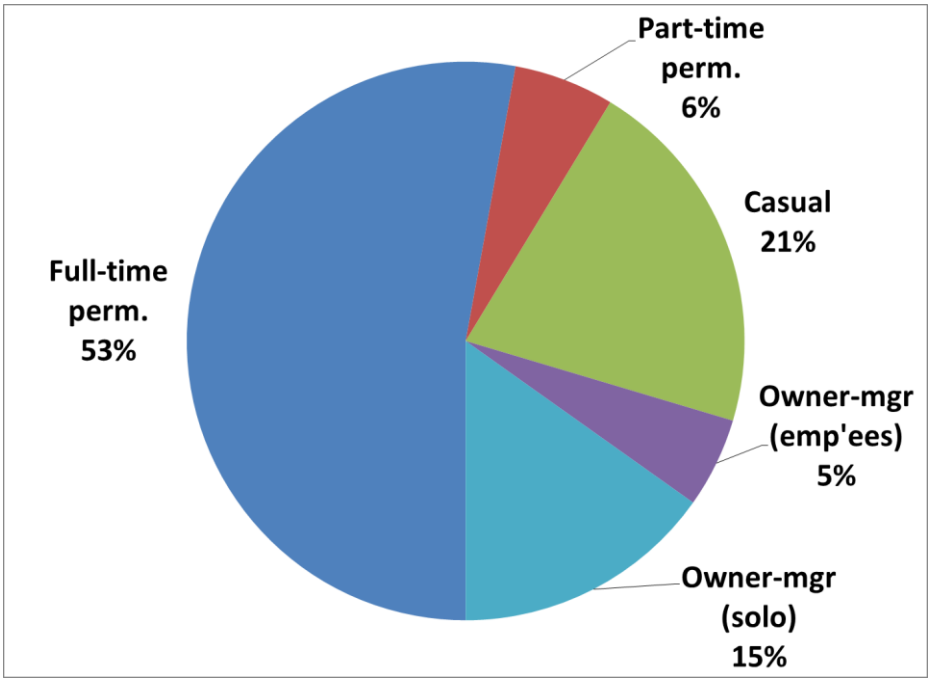


Source: ABS Catalogue 6291.0.55.003, Table 19; 4-quarter moving average.

A significant proportion of those working part-time in the transportation sector, would like to work more hours. The ABS defines the underemployment rate as the proportion of total employed persons in an industry who would prefer to work longer hours. In the transportation industry, underemployment has grown by about half since 2011 (Figure 10). This group of underemployed workers constitutes a significant pool of underutilised labour that could be more fully engaged in work if demand for their services strengthened.

The growth of part-time work is just one dimension of the broader phenomenon of non-standard work which has come to dominate labour market developments in Australia's overall economy – and the transportation sector has not been exempt from this trend. Figure 11 breaks down total employment in the sector into various classifications of job type. The traditional standard job – full-time, permanent, year-round, with normal benefits and entitlements – now accounts for barely over half (53 percent) of all transportation employment. The rest of the workforce occupies positions that embody one or more dimensions of what has come to be known as insecure or precarious employment.

Figure 11. Transportation Employment by Job Type, 2016



Source: Authors' calculations from ABS Catalogue 6291.0.55.003.

A small proportion of transportation employment consists of permanent part-time paid employment; while these workers do not have access to full-time incomes, they at least enjoy an ongoing employment status and likely reasonably regular hours of work. In contrast, one in five employed people in the transportation sector now

occupies a casual position, in which there is no presumption of ongoing engagement and no access to traditional entitlements like paid leave (for holiday, illness, etc.). Most of those casual workers work part-time hours. Finally, the remaining fifth of employed transportation workers are self-employed. A minority of those operate genuine small businesses which employ other individuals. But three-quarters of self-employed transportation workers, in contrast, have no employees other than the proprietor: they consist of self-employed owner-operators and other independent contractors. Many of these workers are largely indistinguishable from employees: they are dependent on a specific company for their work, but do not have the same stability, protection, and benefits as regular paid employees. Hence these individuals face significant insecurity in hours of work, income, and tenure, depending on market conditions in their respective segments of the sector.

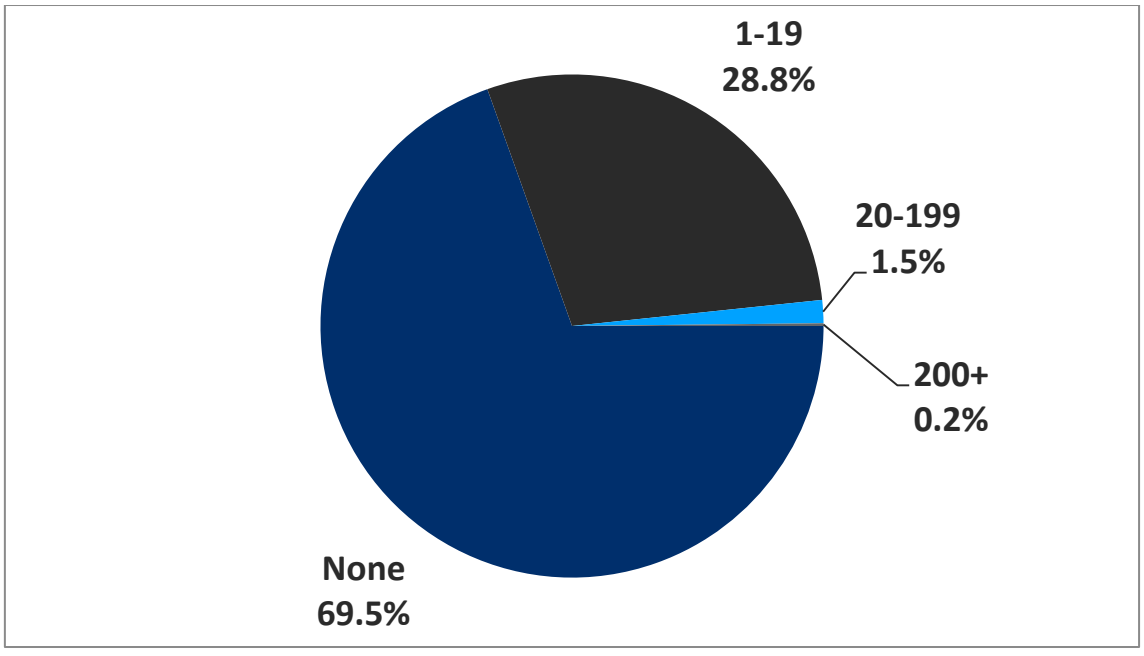
With almost half of all transportation workers thus experiencing some dimension of precarity in their work situations, job quality in the broader sector faces significant challenges. Income levels are lower and more volatile for casual, part-time, and own-account self-employed individuals; they are less likely to accumulate adequate contributions to superannuation funds, and less likely to be able to accumulate other financial resources to see them through retirement or other periods without income. Abundant research (see, for example, Independent Inquiry Into Insecure Work, 2012; and Lewchuk et al., 2015) indicates that insecure or precarious work arrangements impose additional stress on workers and their families, which can translate into poor outcomes in physical, mental, and familial well-being.

Other research has also associated insecure or transitory work practices with a range of other negative outcomes in the areas of skill acquisition, retention and turnover of employees, and health and safety outcomes. In a road transportation context, for example, Thornthwaite and O'Neill (2016) find a negative correlation between self-employment or independent-contractor arrangements and health and safety practices. Owner-operators are found to work longer hours but receive less income, and are often not compensated for many ancillary tasks (including time in queues, loading, and maintenance). Their research also indicates that owner-operators experience negative health and safety risks, including less access to regular rests, and a lower perceived ability to refuse unsafe loads. More broadly, the rise of insecure work arrangements has raised a range of important issues regarding job stability and quality, and the social costs that are encountered because of shrinking access to steady, reliable, high-quality employment. The evidence clearly suggests that the transportation sector has not been immune to those challenges.

A related change in the quality of employment has been the erosion of union membership and collective bargaining coverage in the transportation sector – a trend

which reflects both the direction of industrial relations policy at the aggregate level (which has resulted in a less amenable legal and regulatory climate for union activity), and the shift in employment within transportation toward more precarious work forms (where collective bargaining is rare). Latest ABS data indicates that about 28 percent of workers in the broader transportation industry are union members (authors' calculations from ABS Catalogue 6310.0). Union density is highest in the rail and marine modes, but lower (below 20 percent) in road transportation. While union membership is proportionately stronger in transportation than in the overall economy, it has declined steadily over the last 15 years (from around 36 percent at the turn of the century). Collective bargaining coverage has also declined, with a growing proportion of paid employees now compensated according to the minimum standards of the Modern Awards system. (In addition, of course, the growing share of independent or self-employed workers are not even covered by those provisions, which do not apply to self-employed workers.) These trends are relevant for TWUSUPER not only because the erosion of collective bargaining undermines the quality and stability of transportation jobs; moreover, the traditional connection between industry super membership and union membership implies an additional challenge for the fund to maintain its relative membership presence across a sector that is gradually being de-unionised.

Figure 12. Transportation Businesses by Number of Employees, 2016



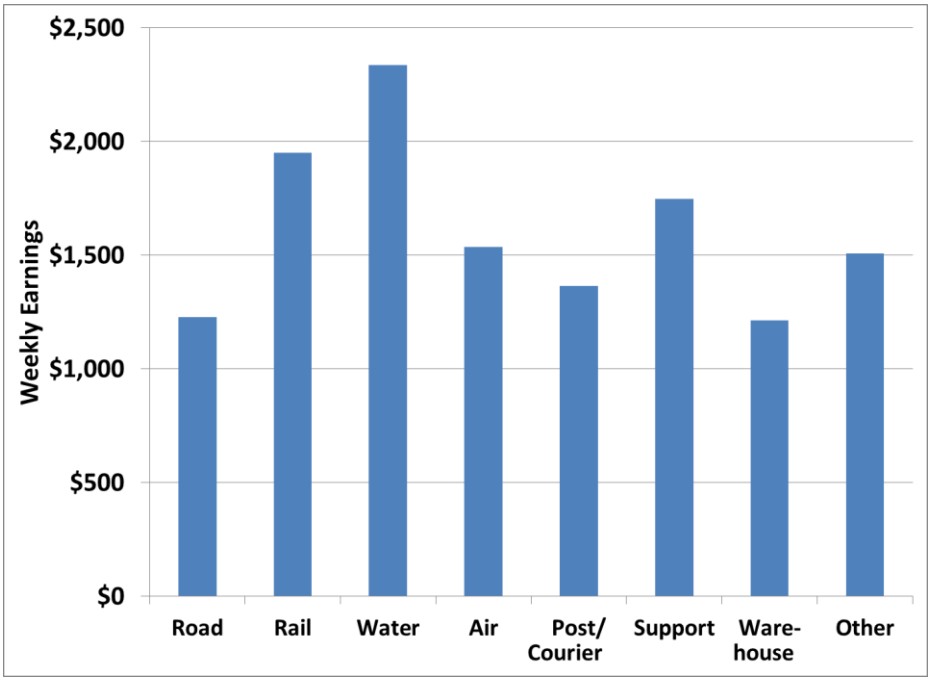
Source: Authors' calculations from ABS Catalogue 8165.0.

Another indicator reflecting the growth of non-standard employment in transportation, is the growing concentration of employment in the sector within very

small businesses. There are over 130,000 businesses operating in the transportation services and related sectors of the economy. But about 70 percent of these firms are sole proprietorships with no employees (Figure 12). Most of the rest are businesses with under 20 employees. Less than 2 percent of firms have over 20 employees, and less than 0.2 percent (or just 234 transportation companies in total, across all modes) have over 200 employees. This fragmentation of the transportation industry into very small businesses further complicates efforts to improve the stability of work, reinforce quality and safety standards, and broaden coverage of core entitlements like superannuation benefits. Moreover, the rate of exit and turnover for small firms is very high, making it all the more difficult to establish best practices and sustain them over time.

We conclude this description of the existing transportation workforce, by reviewing indicators regarding compensation patterns in the sector. Average weekly earnings (for all workers, including part-time employees) across transportation are close to $1500 per week, or just over $75,000 per year. That is more than 20 percent higher than average weekly earnings (again, for all workers, including part-timers) in the economy as a whole. Some of that difference is attributable to the greater proportion of full-time work in the transportation sector, but some to the productivity and challenges of work in the industry, and some to the role of unions and collective bargaining in lifting compensation norms across the sector.

Figure 13. Weekly Earnings by Transportation Sub-Sector, 2016



Source: ABS Catalogue 6306.0, Table 14.

Figure 13 illustrates the diversity of compensation across the various sub-sectors of transportation work. The highest earnings are generated in the marine and rail sub-sectors, reflecting the concentrated nature of production in larger enterprises in those modes, higher union density, and other factors. The road transportation and warehouse sections of the industry offer the lowest weekly earnings (around $1200 per week for both), reflecting a more competitive, fragmented industry structure and the dominance of smaller businesses (including sole proprietorships).

In the transportation sector as a whole, labour costs account for about 22 percent of the total cost of delivered services, and just over one half of total value-added within the sector (authors' calculations from ABS Catalogue 5209.0.55.001, Table 5). The labour cost share in sector output has been stable over the last two decades (ABS Catalogue 5260.0.55.002, Table 19). This indicates that labour compensation has maintained broad pace with measured changes in productivity.

In summary, transportation is an important employer, and will remain one. The overall demand for transportation services has grown, relative to other parts of the economy; demand growth for public transportation services has been especially steady in the face of urbanisation and related trends. And even in more traditional occupations (including drivers and operators), employment growth has been relatively strong. The industry's unique demographic characteristics – with a relatively older, overwhelmingly male, and less formally educated workforce – constitute both a challenge and an opportunity as the sector prepares for the changes ahead. In addition to the ageing of its workforce, the transportation sector has experienced recent challenges in job quality and stability, mostly associated with the expansion of non-standard employment (including part-time, casual, self-employed, and contractor positions). Despite these challenges, compensation in the industry remains modestly higher than in many other sectors of the Australian economy, reflecting a range of factors including the demanding nature of transportation work, the accumulated job-specific human capital of many transportation workers, and the influence of unions and labour regulations in setting and maintaining standards.

V. Disruptor #1: Technological Innovation

There has been an immense outpouring of public discussion, and public concern, in recent years regarding the impacts of ongoing technological change on employment. Some research has suggested that 40 percent or more of all jobs are highly vulnerable to automation and computerisation in coming decades; we will consider those findings, and their relevance to the transportation sector, in more detail below. Some observers even suggest that work can no longer be the primary means for people to support themselves – leading to all sorts of unusual policy responses ranging from taxing robots (Delaney, 2017) to the provision of universal basic income to all people, whether they are working or not (Arthur, 2016).

Of course, this general fear of technological unemployment is not new. Since the industrial revolution, workers have quite understandably worried what would happen to their jobs when machines can do their work faster, cheaper, or better. Previous periods of accelerating technological change were also associated with waves of public concern about unemployment; even relatively recently, futurists predicted that technology would make work largely obsolete (for example, Rifkin, 1995).

Conventional market-oriented economists have typically downplayed concerns over mass unemployment: the automatic workings of supply and demand forces, they suggest, should ensure that any labour displaced by new technology is automatically redeployed in some other, more appropriate endeavours. And the increase in general productivity will ensure that people are better off in the long run. The focus of policy, according to this view, should be limited to facilitating transition through retraining and mobility assistance, allowing displaced workers to move more easily into the better, alternative occupations that automatically open up. However, there are ample reasons to doubt this complacent conclusion. In reality, labour markets do not function so smoothly or efficiently: unemployment and underemployment can persist for long periods of time, displaced workers may not be successful in transitioning into appropriate alternative roles, and income losses from restructuring can be both substantial and long-lasting. So workers are not unreasonable to worry that rapid technological change may indeed undermine the careers they have built, and that they and their families may suffer significant economic harm from the coming changes.

At the same time, however, historical economic experience also gives cause to question ultra-pessimistic forecasts of mass technological unemployment. In practice,

previous waves of technological change have not been associated with long-lived unemployment, for a range of reasons. The labour-displacing effects of new technology are typically offset, in whole or in part, by other factors: including new work associated with the development, production, and operation of new technology itself; new tasks that become conceivable only as a result of new technology; historic reductions in average working hours (a trend which has stalled in recent years); and the capacity of active macroeconomic policy to boost aggregate labour demand to offset unemployment when needed. Many jobs (especially in various human or personal service occupations) are not so amenable to automation in the first place.

So there is little reason to conclude that "work will disappear" – even in sectors, like transportation, which seem ripe for the application of labour-saving or labour-replacing technologies. But this does not mean we should be complacent about the problems and risks posed to workers by accelerating technological change. Instead, our response to those challenges should be grounded in a more balanced and complete assessment of what new technology actually means for work and jobs.

Remember, too, that technology is not the only force of change buffeting the transportation industry – and may not even be the most important factor behind the significant changes in job quality and stability that are already visible in the sector (as documented above). As noted, the organisation of transportation work is also changing dramatically, with the shrinking importance of traditional "standard" employment (full-time, permanent, year-round jobs with entitlements) and the growth of alternative arrangements (part-time, casual, self-employed, and contractors) marked by generally higher degrees of instability and precarity. Numerous other factors will also disrupt transportation work, including:

- Environmental pressures, as the transportation industry adapts to the increasingly binding constraints of climate change and other environmental challenges.
- Globalisation, as Australian transportation providers confront an increasingly integrated global marketplace, and competitive pressure from foreign providers.
- Fiscal pressures, as cash-strapped governments aim to recoup a greater share of transportation-costs from providers and users, and mobilise resources to fund massive required investments in transportation infrastructure.
- Demographic pressures, as an ageing population shifts its consumption patterns in line with consumer life cycles and preferences – and as the transportation sector faces its own demographic challenge (as reflected in the ageing of its own workforce).

Amidst all of these complex and overlapping sources of change, it would be a mistake to focus solely or unduly on technology as the only "disruptor." Moreover, it is wrong to interpret technology itself as some exogenous, incontrollable force. After all, what we call "technology" is actually the composite of human knowledge about how to produce more advanced goods and services, using better tools and techniques. Innovation involves putting human ingenuity to solving certain problems (so-called "mission-based innovation," as termed by Mazzucato, 2011), based on particular identified concerns and interests. Technology, therefore, is neither "autonomous," nor neutral: the problems we turn our creative attention to, reflect the concerns and priorities of those sponsoring the innovation.

Nevertheless, keeping this caution in mind, it is certainly clear that the transportation industry will be one of the most-affected sectors of the economy by coming waves of innovation and automation. How the sector prepares itself for this change, and manages it, with due attention to the interests of all stakeholders, and the overarching goal of maximising the broader economic and social benefits generated by transportation services (not simply minimising their costs), will shape both the quantity and the quality of transportation work in the decades ahead.

This section will review new directions in innovation activity, explaining why their potential effects on work may be more dramatic than previous waves of technology. It will catalogue some of the important ways that future technology is likely to impact the production and delivery of transportation services. Finally, it will identify factors which will facilitate and accelerate this change, and also the numerous factors which are likely to inhibit or slow it.

NEW FRONTIERS IN AUTOMATION

Predictions that machines and robots will "destroy" large numbers of jobs, and impoverish the people who used to perform them, have been made for hundreds of years – dating back to the advent of the spinning jenny and steam power in the early days of the industrial revolution. It is a historical fact that these past waves of innovation did not produce mass technological unemployment as a lasting economic outcome. To be sure, unemployment is a chronic problem in market economies, but it has not been consistently correlated with technology; to the contrary, in some instances (such as the postwar decades, or the 1990s) waves of technology and innovation, by sparking stronger surges in business investment, have been associated with relatively stronger job-creation and *lower* unemployment. So we should be cautious about jumping to very pessimistic conclusions that future technology will displace masses of workers and cause widespread unemployment.

On the other hand, there are also some clear ways in which the current wave of technological change is indeed "different" from those that preceded it, and hence that the labour market impacts could be less sanguine (Dunlop, 2016). More specifically, current innovations in computing and automation are proving capable of undertaking whole new sets of tasks, that in the past were not amenable to machine-aided production. Table 5 illustrates the expanded scope for labour-saving or labour-replacing automation.

Table 5
The Growing Reach of Automation

Type of Task➔ **Form of Work⬇**	**Routine**	**Non-Routine**
Manual	Routine/ Manual	Non-Routine/ Manual
Cognitive	Routine/ Cognitive	Non-Routine/ Cognitive

Source: Adapted from Autor et al. (2013).

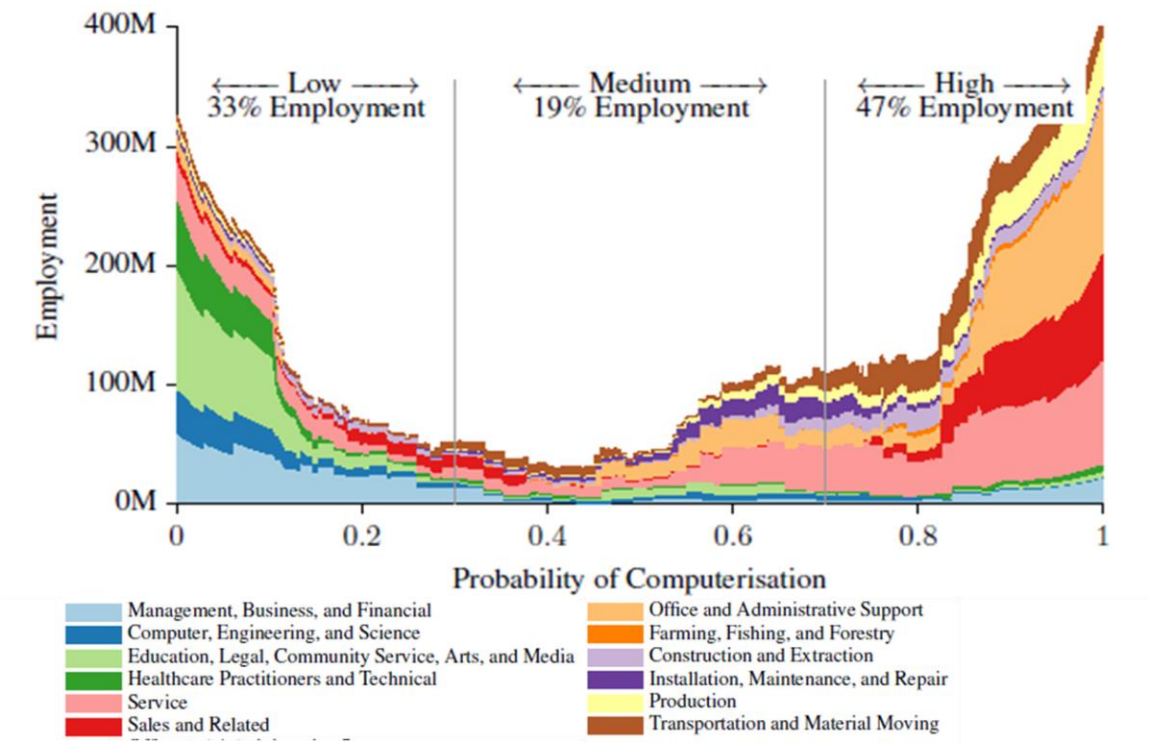
Computing power continues to become dramatically less expensive, as the technology of microchips and processing continues to advance exponentially. There is nothing new about this trend – famously reflected in "Moore's Law" (Moore, 1965), which predicted a doubling in the circuit capacity of processors every two years. What has changed, however, is the applicability of this ever-cheaper computing power to entire new categories of work. Traditionally, computer-assisted automation required the programmer to be able to specify very precise tasks, in a controlled environment. The programming code could direct the machine to perform an intricate and complex set of functions, directed by an increasingly detailed set of data and prompts. But the functions being automated had to be routine and precisely described. These functions could include manual tasks (involving the movement of objects) or cognitive (involving the manipulation of data). But in either case, automation was only accessible to routine and replicable functions. This set of tasks is illustrated in the middle column of Table 5.

The current wave of automation, in contrast, still facilitated by ongoing reductions in the cost of computing power (and exponential increases in the capacity of computers), is allowing computing power to be applied to the mechanisation of *non-routine* tasks. In other words, the scope of automation is extending rightward in Table 5, to address non-routine tasks that require judgment, flexibility, and decision-making capacity, in

the face of non-controllable or unpredictable environments and stimuli. These new applications which extend the scope for computer-controlled work include machine learning (ML), data mining, machine vision, computational statistics, artificial intelligence (AI), and mobile robotics. In every case, computers are informed by analyses of large databases of past experience, to develop the capacity to make best judgments in the face of unpredictable circumstances. This allows them to undertake non-routine functions, again covering both manual and cognitive tasks. Tasks in the right-hand column of Table 5 (non-routine manual and cognitive jobs) now face the prospect of partial or complete automation.

Since machine learning and other new computing strategies allow for a wider range of tasks to be computerized, economists are now considering the resulting expanded potential impacts on employment patterns. One approach, pioneered by Frey and Osborne (2013, 2016) has been to conduct detailed skills audits of various occupations, to simulate their amenability to computerisation. These audits analyse the specific task content of different jobs, and develop judgments on the extent to which they could be automated on the strength of new capacities to apply computer capacities to non-routine functions.

Figure 14. Vulnerability of U.S. Occupations to Computerisation.



Source: Frey and Osborne (2013).

This approach underpins the now-famous finding that close to half of jobs in the U.S. economy are highly vulnerable to computerisation. Frey and Osborne's mapping of occupations is illustrated in Figure 14. In this figure, jobs are arrayed from left to right according to increasing vulnerability to computerisation. Occupations are grouped into broad sectoral categories by colour code. (The transportation and material handling industries are coded brown in this illustration.) Occupations with likelihood of computerisation exceeding 70 percent are classified as "highly vulnerable," while those with likelihood under 30 percent are considered to have low vulnerability, and those between 30 and 70 percent as having medium vulnerability. The area under the top line within each category represents the total number of jobs reflecting that range of vulnerability to computerisation.

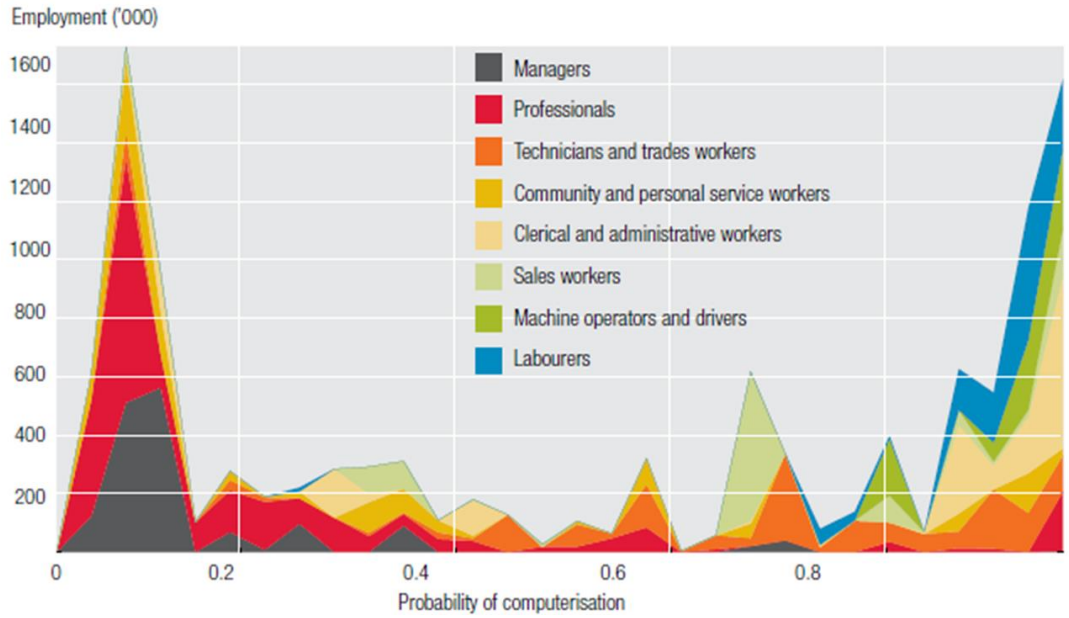
Frey and Osborne find that 47 percent of all jobs face a 70 percent or higher likelihood of computerisation. This does not mean that 47 percent of jobs will disappear: there are many countervailing forces that will tend to create other work, as the process of automation unfolds. First, there will be new jobs associated with the design and engineering of the new technology, and new jobs created by virtue of the expanded capacity of new technology to produce a broader range of goods and services. Even within functions that have been automated, a continuing demand for labour will be experienced, associated with the operation and maintenance of the new machinery. Finally, there are many prerequisites and hurdles that will be encountered (including challenges in job design, infrastructure, training, and regulation) before the potential for computerisation becomes a reality (we will discuss these hurdles in the context of the transportation sector further below). But as an indicator of the large number of workers in an industrial economy whose work lives are likely to fundamentally changed by the new wave of automation, the Frey and Osborne results are insightful, and have sparked a significant literature extending and replicating their results.

It is worth emphasizing additional findings of the Frey-Osborne analysis. First, most jobs tend to experience either a high vulnerability to automation, or a low vulnerability; there are relatively fewer jobs in "the middle" (and this explains the U-shape of the overall map). Second, there are clear differences between sectors which seem highly vulnerable to computerisation (including transportation, sales, office and administration, and general service functions), and others which are characterised by less vulnerability (including caring and human services such as education and health care, management, and technical functions). Third, there is no obvious or consistent correlation between the "skill" or qualifications of specific jobs, and their vulnerability to automation. There are many traditionally high-skill occupations whose functions will soon be automable (such as certain medical, legal, engineering, and other highly-qualified jobs). And there are many jobs considered "low skill" (or at least requiring

relatively fewer formal qualifications) that are less likely to be computerised (including many support functions in human services, and many hospitality and personal service jobs). So it is wrong to assume, as often occurs in popular discourse, that only "low skill" jobs will be affected by automation, nor to conclude that the way to "protect oneself" against technological displacement is simply to acquire new skills.

In an Australian context, researchers at the Committee for Economic Development of Australia (Durrant-Whyte et al., 2015) mapped the Frey-Osborne results onto the set of Australian occupations. They came to a similar conclusion regarding the potential expansion of computerisation and automation to a broader set of jobs (not surprisingly, since the range of jobs in Australia's economy is not fundamentally different from that typical of other industrial countries). The ranking of Australian occupations according to degree of vulnerability to computerisation is illustrated in Figure 15, which replicates the U-shaped Frey-Osborne findings (although their results are less finely disaggregated).

Figure 15. Vulnerability of Australian Occupations to Computerisation.



Source: Durrant-Whyte et al. (2015).

The Frey-Osborne findings have sparked a large body of subsequent research (see Dunlop, 2016; Bowles, 2014; Autor, 2015; Brynjolfsson and McAfee, 2014; Manyika et al., 2017; and Graetz and Michaels, 2015 for useful overviews of this growing body of research). Some studies have disputed the dramatic Frey-Osborne conclusion that up to half of existing jobs could be subject to computerisation and automation. For example, a major OECD study (Arntz et al., 2016) considered the likelihood of

automation based on a task-based rather than occupation-based mapping of current work. Because specific jobs within given occupations generally incorporate a heterogeneous mixture of specific tasks, it may not be possible to automate an entire job – even though some or many of the specific tasks associated with that job can be automated. Using this approach, they find that only 9 percent of existing jobs in industrial countries are automable, since some occupations considered "highly vulnerable" to computerisation according to the Frey-Osborne approach nevertheless incorporate a significant share of tasks and functions that are not as amenable to machine-learning technologies and other innovations. However, it may be that it will simply require additional reorganisation and redefinition of jobs (creating a smaller number of jobs oriented reconstituted from various hard-to-automate tasks) to allow the full potential of computerisation to thus be realised, and hence the more cautious OECD finding should not be a cause for complacency.

APPLICATIONS OF NEW AUTOMATION TECHNOLOGY IN TRANSPORTATION

It is immediately apparent from Figure 14 that transportation is one of the industries most vulnerable to labour-saving or labour-replacing automation and computerisation. The expanded application of programming and computerisation to tasks involving judgment and responses to uncertain environments, seems inherently relevant for many transportation-related occupations – including driving, of course, but other transportation-related functions as well. As the authors themselves put it bluntly, "Our model predicts that most workers in transportation and logistics occupations, together with the bulk of office and administrative support workers, and labour in production occupations, are at risk [of computerisation]" (Frey and Osborne 2016, p. 48).

Frey and Osborne (2016) also developed a detailed occupational breakdown of vulnerability to computerisation, based on their function-based analysis. Table 6 excerpts their estimated probabilities of computerisation for several transportation occupations. The potential for driverless technology has been much discussed in the media and policy discussions, and it is certainly true that many driver and operator functions face a high degree of automability. Railroad and heavy truck drivers face the highest vulnerability in this regard, due to the enhanced controllability of the driving environment in those applications. Indeed, the implementation of driverless vehicles in carefully controlled public transit, industrial or trunk road settings is already occurring. Drivers who need to exert greater flexibility and judgment in their work (including smaller truck, delivery truck, marine and airline operators) would seem to face a less extreme, but still significant, vulnerability to computerisation.

Table 6 Probability of Computerisation, Transportation Occupations			
Occupation	**Probability**	**Occupation**	**Probability**
Commercial pilots	55%	Transportation attendants	75%
Transit & railroad police	57%	Heavy truck drivers	79%
Transportation & distribution managers	59%	Railroad brake / signal / switch operators	83%
Motorboat operators	62%	Railroad conductors	83%
Bus drivers	67%	Industrial truck drivers	93%
Postal mail carriers	68%	Locomotive engineers	96%
Light truck & delivery drivers	69%	Driver sales workers	98%
Aircraft mechanics	71%	Shipping & receiving clerks	98%
Bus & truck mechanics	73%	Cargo & freight agents	99%
Source: Adapted from Frey and Osborne (2016).			

However, it is not just drivers and operators in the transportation industry whose functions would seem amenable to automation and computerisation. Other support and ancillary functions are also fertile ground for the application of labour-saving and labour-replacing technologies. Indeed, cargo agents, clerks, and sales workers face the highest likelihood of automation (98 percent or more) of any transportation-related occupations. Drivers and operators, recall, account for less than half of total transportation employment (Figure 5 above). So it is important not to place undue focus on the potential for automating driving, which has captured so much public attention; in fact, stakeholders must be cognizant of the probability of automation across all aspects of transportation work.

Regarding the introduction of driverless vehicle systems in particular, the transition to these technologies will be incremental in nature, as firms, workers, customers and governments alike adapt to the new potential of these systems, and make the necessary investments (in capital, skills, infrastructure, and regulation) required to implement them. The Society of Automotive Engineers (SAE International, 2016) has developed a six-tier ranking of automated driving functions and capacities, which recognises the incremental adoption of these technologies; this framework is illustrated in Figure 16.

Figure 16. Six Tiers of Autonomous Driving

Tier	Level	Steering, speed, signal	Monitor & respond to environment	Fallback dynamic tasks	Context (ODD)
0	No automation	☺	☺	☺	
1	Driver assistance	☺	☺	☺	Limited
2	Partial automation	☺ 🚗	☺	☺	Limited
3	Conditional automation	🚗	🚗	☺	Limited
4	High automation	🚗	🚗	🚗	Limited
5	Full automation	🚗	🚗	🚗	Unlimited

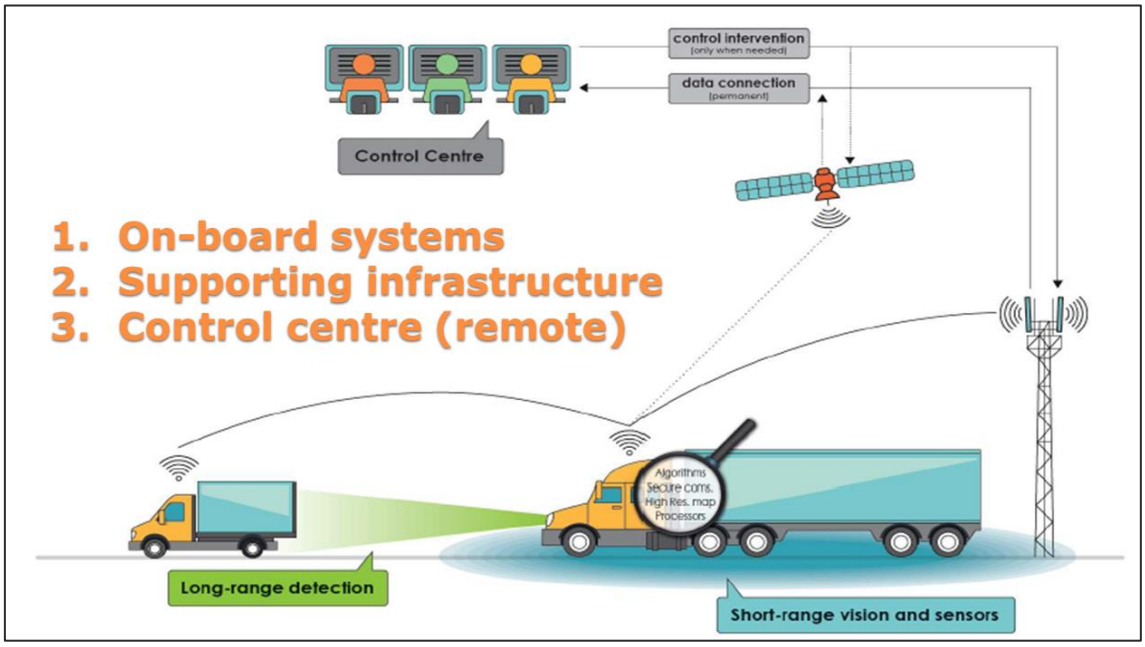
Source: Adapted from SAE International (2016). Human face icon indicates manual performance; car icon indicates automated functions.

The distinction between manual and automated performance of specific tasks is represented by the thick dotted line. Steering, speed control, and signaling functions are the easiest tasks to automate – and some applications (in industrial vehicles, intercity truck fleets, and other settings) already incorporate these applications. The expansion of automation to situations requiring more judgment, monitoring of an uncontrollable environment, and quick responses to changing stimuli will be more challenging. The completeness of the "Operational Design Domain" (ODD) governing the operation of automated driving systems is a final step in the evolution toward fully automated driving systems; the ODD is the set of parameters within which an automated vehicle is designed to safely operate (including which types of roads, which regions or areas, which speeds, and under which weather or lighting conditions). Only once the ODD has expanded to cover the full range of circumstances encountered in normal driving (rather than narrower, more controllable or predictable sub-environments), will vehicles be capable of fully automated operation.

Moreover, the equipment and infrastructure required in order to organise and implement driverless vehicle systems are complex, expensive, and challenging. Figure 17 illustrates the major components required for an integrated driverless system for heavy intercity trucks – which will be one of the first applications of driverless methods in commercial use. Even though the fleet of vehicles in such applications will be

limited, and the set of roads which they would utilise (and hence the corresponding ODD) also constrained, the viability of such systems will nevertheless require huge investments in developing compatible roadway, communication, and control systems – investments that will certainly extend well beyond the capacities of any individual firm. The on-board systems required to operate an automated vehicle, and communicate with fleet managers and controllers, are just the most obvious of these components. The road and associated infrastructure must be constructed according to the specifications of automated systems. And an overall network for reliable, instantaneous communication with fleet-specific and general-use control centres will also have to be in place. In short, it will take much more than just the development of driverless vehicles, for these systems to be able to operate in a real-world context.

Figure 17. Components of Driverless Vehicle Systems



Source: Adapted from International Transport Forum (2016).

Driverless technologies have attracted most of the public attention (and concern) regarding the application of new computing powers in transportation. But there are numerous potential applications of machine-learning, artificial intelligence, and other dimensions of the new wave of technology in the transportation sector, in addition to driving and operating vehicles. Indeed, incremental applications of new-generation computing technologies will likely be realised more immediately in ancillary, management, and data-related functions, rather than in driving. These applications of automation do not require the same all-encompassing advances in infrastructure, regulation, and public acceptance as do driverless vehicle technologies; hence they can be implemented more immediately within individual businesses, with relatively little

inhibitors or public attention. Some of the more imminent of these incremental applications (some of which are well on the way to widespread use) include:

- Position , localization, and mapping capacities and functions.
- Monitoring and surveillance technologies to track vehicle and staff locations.
- Assisted driving, sensing, and perception supports, short of fully automated driving systems.
- Connected vehicle technology allowing better coordination and communication across fleets.
- Big data analytics, deep learning, and the use of algorithms (in planning routes, service, and customer contacts).
- Extensive computerisation in data management, including by drivers (such as paperless document systems).
- Advanced data systems to enhance security and privacy standards in transportation.

AUTOMATION IN CONTEXT

Of course, the potential disruptive effects of new technologies on employment patterns in the transportation industry have captured much attention and generated much concern. But at the same time, it is important to take due account of the many potential economic, social, and human benefits of the application of new technologies in the transportation sector. Automation in transportation offers many potential advantages and benefits – depending on how innovation is managed, and how stakeholders are supported in the process of adapting to the coming changes.

Some of the most important of these potential benefits include:

- Improved safety, with successful driverless systems promising as much as an 80 percent reduction in accidents.
- Greater fuel efficiency, resulting from improvements in both vehicle operation and traffic planning and management.
- Improved capacity for efficient traffic management (including route selection, traffic signals coordination, and more responsive vehicle-to-vehicle interactions).
- Reduced greenhouse gas emissions, arising from improved fuel efficiency.
- General transportation cost reductions arising from lower fuel costs, reduced travel times, and reduced labour costs.
- Enhanced mobility for people with disabilities.

- Potential improvements in job quality, since some of the most challenging or mundane features of transportation work (such as long-haul highway driving) could be automated.

Of course, the extent to which these benefits can be attained, and shared across transportation stakeholders, depends on how new technology is implemented and managed, and on how existing participants in the industry are protected and supported to adapt to the change and undertake revised or new roles. Moreover, the benefits derived *internally* by individual companies may differ from the broader or *external* benefits generated for the sector (and society) as a whole, and this may impede the decisions by individual companies to invest in new technologies. For example, broad impacts like improved safety or reduced congestion are hard to quantify and evaluate from the perspective of an individual firm's capital spending choices.

The pure technology of vehicle automation (and the computerisation of related and ancillary transportation functions) is progressing more rapidly than expected. But this does not imply that these systems will find rapid adoption and acceptance in real-world practice. Keep in mind that even though scientists and programmers understand how to operate driverless vehicle technologies (as has been demonstrated in several trials and demonstrations, such as reported in an Australian context by Zito, 2015), there are many other barriers to its full implementation, including:

Regulation: Government regulators will need to develop new rules and systems for achieving compatibility in driverless systems, safety and reliability, and other goals. The Australian Driverless Vehicle Initiative (2016) has catalogued the regulatory requirements in the Australian case; there will certainly be major implications of new technology for instruments such as the Heavy Vehicle National Law.

Infrastructure: Investments in common-use roadways, communication systems, vehicle-to-vehicle interfaces, and other components of driverless systems will be extensive – and expensive.

Proof of safety: Before they are deployed in widespread use, much greater research and experimentation will be required to demonstrate the reliability and safety of driverless systems.

Security: In addition to safe operation, driverless and partially automated systems will need to implement strong measures to protect the integrity of information and operating systems against threats such as hacking, hijacking, and terrorism.

Social acceptance: Independent of the evidence base for reliability and safety of driverless systems, the traveling public will need to be convinced that they are acceptable.

Regional impacts: Australia's regional communities have strong relationships with their regionally-based carriers, and will want to see those regional providers play an ongoing role in the face of technological change (and its potentially centralising impact on industrial structure).

Capital investment: Firms participating in driverless systems (and other new technologies) will need to make extensive investments in new capital equipment, software and programming, communications and data systems, and training. Given the dispersed, fragmented structure of the transportation industry (described above), dominated by a large number of very small firms, financing these investments will be challenging.

Management adequacy: A related constraint is the capacity of management (especially in smaller firms) to oversee the implementation and operation of sophisticated systems.

Lag times to phase in new equipment: The cost of new investments, and the complexity of their introduction and operation, will require significant lag times before they are in widespread use. Business typically introduces new technologies in an incremental, step-by-step manner; major changes never happen overnight.

Insurance: Automated and driverless systems introduce a whole new set of risks and potential liabilities; the development, costing, and marketing of new insurance products to address these risks will also take time.

For all of these reasons, even though the technology of driverless vehicles has been proven possible, it will take many years before these systems are in widespread use in real-world applications. Even the inertia of transforming vehicle fleets, introduces considerable time delays. For example, the U.S. heavy vehicle fleet consists of 3.5 million licensed Class 8 vehicles on the road today. Given that large fixed capital investment, and the dispersed structure of ownership in the industry (requiring tens of thousands of individual companies to adjust their capital spending plans in response to new technological possibilities), it will take many years before autonomous vehicles come to represent a significant share of the overall fleet. One prominent forecast suggests that the U.S. trucking industry could be purchasing some 60,000 autonomous-capable heavy trucks per year by 2035 (Hawes, 2016). But at that pace, it would take ten further years before the technology reached even 10 percent penetration of the overall national fleet.

This inherent time lag in the widespread introduction of new vehicles is readily apparent in the analogous and surprisingly slow adoption of hybrid and electric passenger vehicles in the mass consumer market: this technology is proven, their economic payback in a range of uses is certain, and they face relatively modest challenges of regulatory approval and consumer acceptance. Yet even 15 years after initial commercial production, they still account for a tiny share (less than 3 percent) of vehicles on the road in most industrial countries (Japan being an exception; see German, 2015). In short, the time lags associated with transition in the industry's capital stock – let alone the technical, regulatory, infrastructure, and social barriers to widespread adoption of driverless technologies – could prove more daunting and time-consuming than some of the more bullish forecasts about technological change in transportation typically assume.

Another factor creating time lags in transportation automation is the challenge of redesigning and reassigning jobs. The implementation of automated systems may replace some, but not all, of the functions performed by a human worker. As noted above, few existing jobs could have all of their requisite tasks automated. So the process of deploying automated technology, and harvesting the resulting labour savings, involves several steps. First, programmers must identify and disaggregate all of the specific tasks in a job. Then they develop and apply machine systems that can perform some of those tasks, at least as well as humans. But there will still be an inventory of remaining tasks which machines cannot yet satisfactorily perform; those must be organized into restructured jobs that are still performed by humans. Those restructured jobs likely will consist of some previous non-automable tasks, combined with specific new tasks that have arisen as a result of the application of automated technology in other tasks (such as monitoring, servicing, or controlling new machinery and systems). Facilitating this restructuring of tasks into a new portfolio of jobs will require considerable management attention and experimentation.

All of these inhibiting factors suggest that forecasters should use extreme caution in projecting that the advent of new technology will lead to the dramatic near-term displacement of labour. It will take considerable time for these applications to be refined, tested, proven, adequately regulated, invested, and implemented. The technologies themselves will stimulate the creation of new work, in various ways: including designing, engineering, operating, and maintaining the technology, as well as performing new functions which only become possible because of the capacities of the new technology. Many jobs (and some elements in almost all jobs) are very difficult to automate. And presumably, macroeconomic policies (including fiscal and monetary policy tools at the disposal of governments and central banks) should respond if technologically-driven job displacement were to become significant (although the

effectiveness of such interventions depends on the willingness of policy-makers to respond quickly and adequately to emerging macroeconomic challenges).

One important piece of evidence suggesting that the pace of employment disruption from technological change may be slower than many observers anticipate, comes in the form of aggregate data regarding the productivity of labour across the industrialised economies. Keep in mind that if technological labour displacement were to reach dimensions anything like those implied by the Frey-Osborne analysis, this would imply an approximate doubling of aggregate labour productivity (such that existing output could be produced with barely half the existing workforce, consistent with the elimination of 47 percent of jobs). For this to occur within a medium-run timeframe (of, say, ten years) would require a dramatic acceleration of recorded productivity growth – to in the order of 10 percent per year (a rate which has never been observed, on a sustained basis, in recorded history).

Yet curiously, realised productivity growth has been *slowing*, not accelerating, in most industrial economies – including Australia. Average labour productivity growth in the decade ending in 2016 in Australia was just 0.9 percent per year, less than half the rate of growth experienced in the previous decade (authors' calculations from OECD, 2017). Across the major industrial economies, the rate slowed to just 0.5 percent per year over the same period (down from 1.9 percent in the previous decade). Various factors explain the slowdown in productivity growth despite the labour-saving potential of many modern innovations. These include sustained conditions of macroeconomic stagnation, weak business capital spending, weak wage growth, and other factors (Baker, 2015). But the data are clear that the widespread fear that large numbers of workers will be fully displaced into unemployment by the application of computers and robots, is not yet being realised.

We therefore conclude our review of the technological changes affecting Australia's transportation industry, reaching a more nuanced and complex position than is typically expressed in breathless media reports about the advent of dramatic new technologies. To be sure, computers and other machines are becoming capable of performing a much broader range of tasks – including those involving judgment, flexibility, and responses to uncontrollable environments. And transportation as a sector seems particularly vulnerable to the application of those technologies. At the same time, there are many prerequisites and barriers that must be negotiated before we see the widespread use of many of those technologies in real-life applications. And there will be other sources of continuing or new demand for labour (including in transportation), that will mute or offset at least some of the displacing effects of new technologies when they are deployed.

None of this gives reason for complacency: huge changes are coming in the nature of transportation work, and not solely because of technology. But the extreme pessimism of some forecasts of mass technological unemployment in the sector, and in the economy as a whole, are not credible, and should not guide the sector's planning and preparations.

VI. Disruptor #2: Changes in Work Organisation and Employment Relationships

We have emphasised from the outset of this report that technology is not the only force driving fundamental change in the nature of transportation work. Major changes in the organisation of work – including the nature of the relationships between workers and their employers, and relations within and between firms in the overall transportation supply chain – are also leading to a fundamental restructuring of work. These changes raise challenges for the quality and stability of work that may be as dramatic as, and are certainly more immediate than, the challenges arising from new waves of technological innovation. Moreover, the interaction between changes in technology and changes in work organisation can be hard to identify and disentangle. This section will consider these ongoing changes in work organisation, their historical context, and the potential responses that transportation stakeholders, regulators, and governments could take to manage those changes in ways that preserve the quality and stability of transportation work.

THE RISE OF "GIG" JOBS

The growing importance of irregular and independent work in the broader economy has generated considerable speculation regarding the future of the very concept of "employment." The economy of tomorrow, it is breathlessly suggested, will not consist of "jobs," but rather consecutive and repeating "gigs." Workers will perform a series of one-off tasks, coordinated through on-line digital platforms, and compensated by the job through digital transfers. Buyers and sellers can meet more easily than ever, and a global digital marketplace will facilitate flourishing exchange – but perhaps also a ruthless race to the bottom, as individuals compete in a larger, more unified market to support themselves. How will the traditional benefits and protections of paid employment survive in this brave new digital world?

The growth of the so-called "gig economy," typified by isolated independent workers often recruited and managed through on-line platforms, poses fundamental challenges to the traditional model of employment, and to traditional methods for regulating work and ensuring minimum standards. It is not clear that existing labour regulations apply to independent workers (and in some cases it is explicitly clear that they do not)

– let alone that those rules can be effectively enforced in a free-wheeling, digital economy. In some cases, evading traditional regulations and employment responsibilities is part of the rationale for the growth of independent-contractor-style practices in the first place.

The transportation sector has been an important site for the development of digitally-based "gig" business models. After all, the most famous (or infamous) platform business – the Uber ride-sharing service – is a provider of transportation services. (Curiously, Uber's owners deny that they are in the transportation business, claiming rather that they simply provide "information services": a fiction invented to sustain the company's efforts to evade coverage by existing regulations on taxi and limousine services; see Lien, 2016.) The growth of other platform-based transportation businesses (including ride share, courier and delivery services, and intercity parcel and freight delivery) has raised concerns that the transportation sector could be more broadly disrupted by the phenomenon of digital platform intermediation. In other cases, transportation services could be a collateral victim of disruptions to the businesses of existing transportation customers: for example, the growth of on-line retailing could undermine demand for existing transportation providers (such as bulk shippers for large retail chains), at the same time as stimulating demand for others (namely small courier and delivery services).

Some perspective is needed to better understand what is actually new about digital platform businesses, and to distinguish between the technical innovations which they utilise and the changes in work organisation which those business models also introduce. In fact, the major organisational features of digital platform work are not new at all. These practices have been used regularly in competitive labour markets for hundreds of years; it's just that past incarnations of these practices could not use digital methods for organising, supervising, and compensating the work. And it is a mistake to view the growth of insecure or precarious work practices (or "gigs") as solely or mostly resulting from technology. Instead, the growing precarity of jobs, including those associated with digital platforms, reflects the evolution of social relationships and power balances, as much as technological innovation in its own right. A more grounded analysis of the social and regulatory dimensions of technology and work organisation must be developed, in order to arrive at a more holistic and balanced understanding of the rise of platform work, its consequences, and its potential remedies.

Digital platform businesses perform some kind of matching function, connecting participants who subsequently engage in exchange (directly or indirectly). Advances in the technology of networking and matching thus underpin the development of far-reaching marketplaces represented by the more successful digital platforms

(Productivity Commission, 2016). Once a particular platform reaches a critical mass of scale and scope, strong economics of scale (since larger networks have a great advantage over smaller ones) reinforce its growth. Matching platforms come in two broad categories: those facilitating the exchange of assets, and those facilitating actual work and production (Farrell and Grieg, 2016). The clients of asset-trading platforms (such as eBay) undertake to buy or sell items which have already been produced. Other than the (modest) incremental value-added provided by the intermediary (eBay), there is no production involved in this exchange; they are, in essence, a centralised, digitised version of a gigantic yard sale.

In contrast, digital platforms which facilitate actual work and production will likely exert a more important influence on employment and production across several broad sectors of the economy, including transportation and delivery (as discussed), odd jobs and miscellaneous tasks, and many forms of digital work (such as programming, writing, translating, or design). Work performed through this class of digital platform generally incorporates the following broad characteristics:

- Work is performed on an on-demand or as-needed basis. Producers only work when their services are immediately required, and there is no guarantee of ongoing engagement.
- Work is compensated on a piece-work basis. Producers are paid for each discrete task or unit of output, not for their time.
- Producers are required to supply their own capital equipment. This typically includes providing the place where work occurs (their home, their car, etc.), as well as any tools and equipment utilised directly in production. Because individual workers' financial capacity to invest in capital is limited, the capital requirements of platform work (at least the capital used directly by workers) are usually small.
- The entity organising the work is distinct from the end-user or final consumer of the output, implying a triangular relationship between the producer, the end-user, and the intermediary.
- Some form of digital intermediation is utilised to commission the work, supervise it, deliver it to the final customer, and facilitate payment.

Regarding this latter characteristic of "gig" jobs (digital management and intermediation), the reality is that most jobs in a modern economy are digitally managed in some dimension. This makes the dividing line between "gig" jobs and traditional employment rather imprecise. Consider, for example, the situation of casual on-call workers in a restaurant. They work on a shift-to-shift basis, now knowing when or if they will be called back in to work. Their irregular schedules are typically organised through e-mail or SMS-based communication systems – some of which are automated or semi-automated (thus saving the manager the trouble of making

repeated phone calls to organise the roster). So even digital intermediation itself is not completely novel or "game-changing," and has already been applied in many other contexts.

Certainly the other characteristics typically associated with "gig" work are not unprecedented, either. The practice of on-call or contingent labour – employed only when it is directly needed – has been common for hundreds of years. In an Australian context, a famous example is the former practice of dockworkers lining up each morning (for example, along Sydney's "Hungry Mile") in hopes of attaining employment that day. Home-based work, and other ways in which workers supply their own capital equipment, has occurred in many applications and contexts – from the "putting out" system of manufacturing textile products and simple housewares in the early years of the industrial revolution, to the important role played by owner-operators in many modern industries (including transportation, resources, and fisheries).

Piece-work compensation systems, meanwhile, also have a long and uneven history. Employers have often favoured this strategy for tying compensation directly to output (thus shifting responsibility for managing work effort and productivity onto the workers themselves). Yet at the same time, the use of piece-work is also constrained by numerous well-known difficulties, including:

- They are hard to apply in situations which require an emphasis on quality, not just quantity of output (this includes many service sector activities).
- They are hard to apply in cases where work is performed jointly by teams or larger groups of workers, not individuals.
- They are hard to apply in jobs which require complex or flexible work, and require the worker to exercise judgment.
- It is often difficult to negotiate the sharing of productivity gains attained under piece-work systems; if employers simply "re-rate" the jobs (so as to capture most or all of those productivity gains), then the incentive effect of the piece-work system is ultimately negated.

For all of these reasons, piece-work compensation models have not found favour in most jobs, and their resurgence in the context of digital platform models should not be assumed to reflect a universal trend.

Finally, the triangular relationship which is created in a "gig" business between the worker, the ultimate end-user of their services, and a separate platform business which functions solely as an intermediary, is also very familiar from economic history. Past examples include labour hire services, "gang-masters," and other intermediaries.

The core problem associated with this triangulated model of employment – namely, that it is unclear who is the actual "employer," an ambiguity which opens the possibility to various negative practices and outcomes – is also well-known, and has been addressed by regulatory initiatives in many jurisdictions (such as Australia's existing rules regarding "sham contracting," and more recent initiatives to regulate labour hire businesses).

Several factors can be identified as facilitating the current growth of platform-based businesses – and the expansion of precarious forms of employment (including independent contracting, self-employment, and casual jobs) more generally. To be sure, technology plays a role: more in facilitating new models of management, rather than in altering the fundamental nature of work and production itself (a distinction that will be considered further below). Broader economic conditions also play a role. In particular, the chronic existence of a large pool of underutilised labour (represented by high levels of unemployment, underemployment, and marginally attached non-employed) facilitates insecure staffing strategies on the part of employers. If they were not confident that incremental labour resources could be quickly and confidently recruited whenever needed, then employers would face greater compulsion to offer more secure and permanent jobs. The flip side of the same coin is the pressure that workers feel in a chronically weak labour market to accept any work available, no matter how insecure or irregular. If they had access to more permanent, predictable, and better-paying work opportunities, there is little doubt that many or most workers currently offering their services through digital platforms would choose a more stable form of employment.

The chronic weakness in labour markets in recent years (especially severe since the Global Financial Crisis of 2008-09) has therefore contributed to the expansion of non-standard or precarious employment arrangements, through a process of cumulative causation. An initial shortage of jobs reshapes the interactions between workers and employers, allowing employers to recruit sufficient labour despite offering unpredictable and insecure arrangements. The success and replicability of this strategy in turn leads employers to expand their use of flexible staffing models, including through new business tools and practices (such as outsourcing labour hire, using automatic or digital rostering systems, and more) organised to optimise the use of irregular work. This in turn further reduces the pressure for employers to offer permanent, full-time positions – which reinforces the initial weakness in aggregate labour demand that sparked the initial shift in practices.

Another factor facilitating the expansion of precarious work practices (including "gigs") has been the generally passive, inconsistent application of traditional labour regulations and standards. In some cases (such as independent contractors in the

Australian context; see Johnstone and Stewart, 2015), existing regulations (like minimum wage laws, collective bargaining rights, and other minimum standards) explicitly exclude non-standard workers. Regulators have been slow to recognise the risks posed to the quality of work by the expansion of precarious work and the resulting avoidance of traditional labour regulations; they have failed to adapt regulatory models to encompass workers in these growing categories of nominally independent labour. In other cases, the applicability of existing regulations is uncertain; but regulators have still been slow to test the robustness or applicability of existing laws. In still other cases, it is clear that existing regulations should protect contingent or "gig" workers, yet the widespread non-enforcement of those rules undermines their real-world effect. The epidemic of wage theft documented in numerous Australian franchise-based businesses in recent years, which have avoided paying even minimum wages to thousands of employees, is a good example of this regulatory failure (see Thornthwaite, 2017).

These facilitating conditions – chronic excess supply in labour markets, and a passive stance on the part of regulators – have not always been present. Hence, the trend toward precarious work has not been uniform through history. For example, in earlier decades, labour markets were tighter, and employers could not be so confident about recruiting contingent labour while offering inferior security or compensation. Similarly, in past periods policy-makers and regulators were more pro-active and ambitious in their efforts to establish (and enforce) minimum standards to lift job quality, support wage growth, and achieve a more equitable, inclusive distribution of income. Those factors explain why earlier (pre-digital) forms of precarious work (such as labour hire and home work) became much less common in the decades following the Second World War. In those years, strong labour demand conditions and a more active regulatory stance underpinned the emergence of the "standard employment relationship" (marked by permanent, year-round paid employment with basic benefits and entitlements) as the dominant norm of work. The fact that insecure forms of work and employment have resurged in recent years, reflects those evolving economic and political dimensions of the labour market and labour regulation – not just the advent of digital technologies.

DISENTANGLING TECHNOLOGY AND WORK ORGANISATION

In sum, we should greet the supposed "novelty" of gig-style employment practices with a certain scepticism. To be sure, modern technologies have allowed the application of these tried-and-true insecure employment strategies to a new set of

functions and circumstances. But the actual nature of the production process undertaken as part of modern "gig" businesses does not typically change; and the use of modern technology is largely limited to facilitating work organisation, management, and compensation (as opposed to changing the way actual work is performed). And these changes in work organisation should be analysed and understood in the context of the often-conflicting economic and social interests which motivate the various participants in the employment relationship.

The blurred overlap between new forms of technology, and new employment relationships, can be considered further using the well-known case of Uber (and similar businesses like Lyft). These businesses are displacing traditional taxi work on the strength of an effective digital dispatch system – whereby clients can hail a ride (and pay for it) through an app on their smart phones, with useful features that include being able to track the location of their car on-line. Drivers are not considered employees of Uber, but rather as self-employed independent contractors (although that status is being contested through legal action in several countries). Uber sets the fare; collects payment from the customer (through its app – cash payments for Uber rides are not permitted in most jurisdictions); supervises and where necessary disciplines and discharges drivers; and then pays drivers a portion of revenue based on pre-determined distance and time factors.

It is important to note that the actual work involved in the production of the service is no different from a traditional taxi: a worker collects a passenger and delivers them to a chosen destination. The on-line hailing app is more convenient, for many users, than traditional systems (such as manually hailing a taxi, or phoning a dispatch office). But it is certainly possible to imagine traditional taxi services using similar web-based dispatch systems, without adopting the same labour practices as Uber. (In fact, many taxi companies have indeed implemented these dispatch technologies already.) The disruptive effect of Uber's business model on taxi work cannot therefore be ultimately attributed to its technology.

What really distinguishes Uber from traditional taxi companies, therefore, is the organisation of work within its business. Uber drivers provide their own vehicles, pay for all related expenses (including amortization, fuel, and maintenance), and are compensated by Uber on a per-fare basis (with no guarantee of hourly or daily income). Uber drivers incur the full costs of operating their vehicle (like traditional owner-operators), but also lose the fees deducted from their fare revenue by Uber (like waged taxi drivers). This model has allowed Uber to appropriate profits from provision of a taxi-like service, but without the capital outlays associated with either owning or operating vehicles, or purchasing licenses/medallions. Its centralised control over its proprietary dispatch application, which drivers need to find customers, is the

basis for its claim to this revenue – just as the merchant's centralised capacity to connect home-made consumer goods with final purchasers was the basis for its claim to a profit margin under the putting-out system of the industrial revolution. Perhaps, then, the "gig" economy is not so novel after all.

An apt analogy, and timely warning, is provided to transportation providers by the disruption and turmoil that has been experienced in the conventional taxi industry following the rapid expansion of Uber and other ride-sharing services. The taxi industry's efforts to stop Uber's market expansion on the basis of arguments rooted in protecting incumbent providers have been generally unsuccessful – even though credible arguments were made that the ride-sharing industry benefited from regulatory loopholes and other advantages not available to traditional providers (and hence that competition was not occurring on a level playing field). Instead, the industry's response to the challenges posed by new business models must be rooted in its reputation for quality, reliable, and safe service (and that reputation has to be strengthened, of course, with consistent efforts to improve the industry's performance); its demonstrated track record in adopting new technologies to improve customer service and reduce costs; and its commitment to a broader vision of a socially responsible and beneficial transportation industry. Otherwise, the story of Uber's conquest of conventional taxi services is likely to be repeated in other transportation segments (such as new web-based platforms being developed to deliver packages, food, long-haul freight, and more). The incumbent industry must be ready to respond to these new entries by proving that it offers a superior level of service, safety, and community accountability.

THE FUTURE EVOLUTION OF WORK ORGANISATION IN TRANSPORTATION

As described in detail in Section IV of this report, non-standard or precarious forms of employment are already very common in the Australian transportation industry. Solo self-employment (whereby the proprietor has no other employees) and casual work account for over one-third of all work. Permanent part-time employment and self-employment by proprietors with employees (whose businesses, consequently, are larger and likely more stable than sole proprietorships) account for another significant proportion of the industry's overall workforce. Barely half of transportation workers currently fill permanent, full-time, paid jobs.

For all of the reasons listed above, that shift to non-standard forms of employment and quasi-employment is likely to continue in coming years, absent major changes in the direction of business strategy, macroeconomic conditions, and regulatory stance.

The development of new platform-based business models is still in its early stages. There are other instances where the application of matching systems to transportation services will likely increase the preponderance of "gig" jobs in transportation. For example, several businesses are developing platform-based systems for coordinating delivery of individual freight loads or courier deliveries, using a web-based intermediary or bid-based system (in which individual carriers match loads to their intended routes and available capacity). These models hold some potential for enhanced efficiency in real economic terms – if these platforms can reduce the incidence of deadhead hauling, for example. But they would also introduce a more transparent and unforgiving incarnation of competition, undoubtedly putting downward pressure on service rates; the outcome would likely be effective wages, working hours, and other conditions that fall below accepted minimum standards. (The incompatibility of bid-based digital platforms with minimum wage standards and other traditional regulations is highlighted by Kaine, 2017.)

Other changes in the corporate structure of transportation services could arise from new forms of partnership between transporters, shippers, intermediary firms (including digital or data services), and possibly even manufacturers of transportation equipment – who could partner with the developers of new digital apps to "lock in" a market for their specific brand of transportation equipment. Nascent examples of these business models are visible in emerging partnerships between automobile manufacturers, ride-sharing services, and early adopters of driverless vehicle services. New production technologies (such as driverless systems, drone-based delivery, and other automated forms of transportation) will overlap with new business models, to generate a multi-dimensional disruption in existing practices that will challenge existing transportation suppliers – as well as challenging traditional models for supporting incomes and working conditions.

But technology is not the only driving force in this continuing shift toward more fragmented and competitive industrial structure, and a more contingent and unstable organisation of work. Continuing weak labour market conditions facilitate the process, too: by ratifying firms' adoption of contingent staffing strategies, and undermining workers' ability to demand greater stability in their employment relationships. Similarly, the stance of regulatory agencies to the recognition and enforcement of minimum standards throughout the supply chain, regardless of the specific ownership structures associated with various stages of work, has been ambivalent. On the one hand, Australia has led important regulatory innovations in attempting to strengthen regulatory standards in the face of vertical disintegration in the supply chain. For example, NSW Occupational Health and Safety rules regarding responsibility for long distance truck driver fatigue apply not just to immediate employers, but also to freight

brokers, clients, and shippers (Quinlan and Sokas, 2009). This vision of supply-chain-wide regulation also motivated the initial development of the Road Safety Remuneration Tribunal (although subsequent policy decisions have reversed those innovations). In general, the expansion of non-standard or contingent work, the fragmentation of inter-firm relationships, and the development of a more intense intermediation between end-users and direct producers has been associated with the erosion of regulatory protection for the quality of work. On the other hand, a clear recommitment by government and regulators to extend the traditional protections associated with employment to all producers, and fairly enforce those protections regardless of the business structure of the producing firm, would certainly give pause to those who seek to utilise digital platforms and other business tools to avoid the impact of traditional employment responsibilities and standards.

VII. Scenario Analysis: Where is Transportation Headed?

On the basis of these detailed analyses of the coming impact of both technological change and changes in the organisation of work on the transportation sector in Australia, we will now endeavour to develop an integrated depiction of potential future trajectories for transportation employment. There is no disagreement that dramatic technological changes in key elements of transportation work are coming, and the pure technology of those systems is advancing faster than traditional expectations. However, considerable uncertainty lingers regarding the pace and scope of real-world implementation of these innovations: including delays and barriers associated with regulation, consumer acceptance, infrastructure, capital investment, management capacity, and more. Even once these innovations are implemented in practice, an additional dimension of uncertainty exists regarding the likely scale of their impact on the quantity and nature of transportation employment. To be sure, some jobs will be replaced by technology; but a larger number will be changed by technology. Some new jobs will be created, to develop, manage, operate, and maintain new equipment and systems – and others will be created to fill new demand arising from the capacity of new technology to produce a broader range of services and functions. Still other jobs won't really be changed at all by technology.

At the same time as technology is advancing quickly (and being implemented in practice less evenly and certainly), changes in work organisation, employment relationships, and business models within the transportation sector are continuing. These changes are already very evident across many aspects of transportation provision, and may in the end prove to be the bigger disrupter for the industry and its workers. The extent to which work in transportation continues to shift toward non-standard, contingent, and digitally intermediated forms of work depends on several factors, including technology, the macroeconomic condition of labour markets, and the stance of policy-makers and regulators toward the standards and conditions associated with these structures.

DEMAND AND EMPLOYMENT FORECASTS

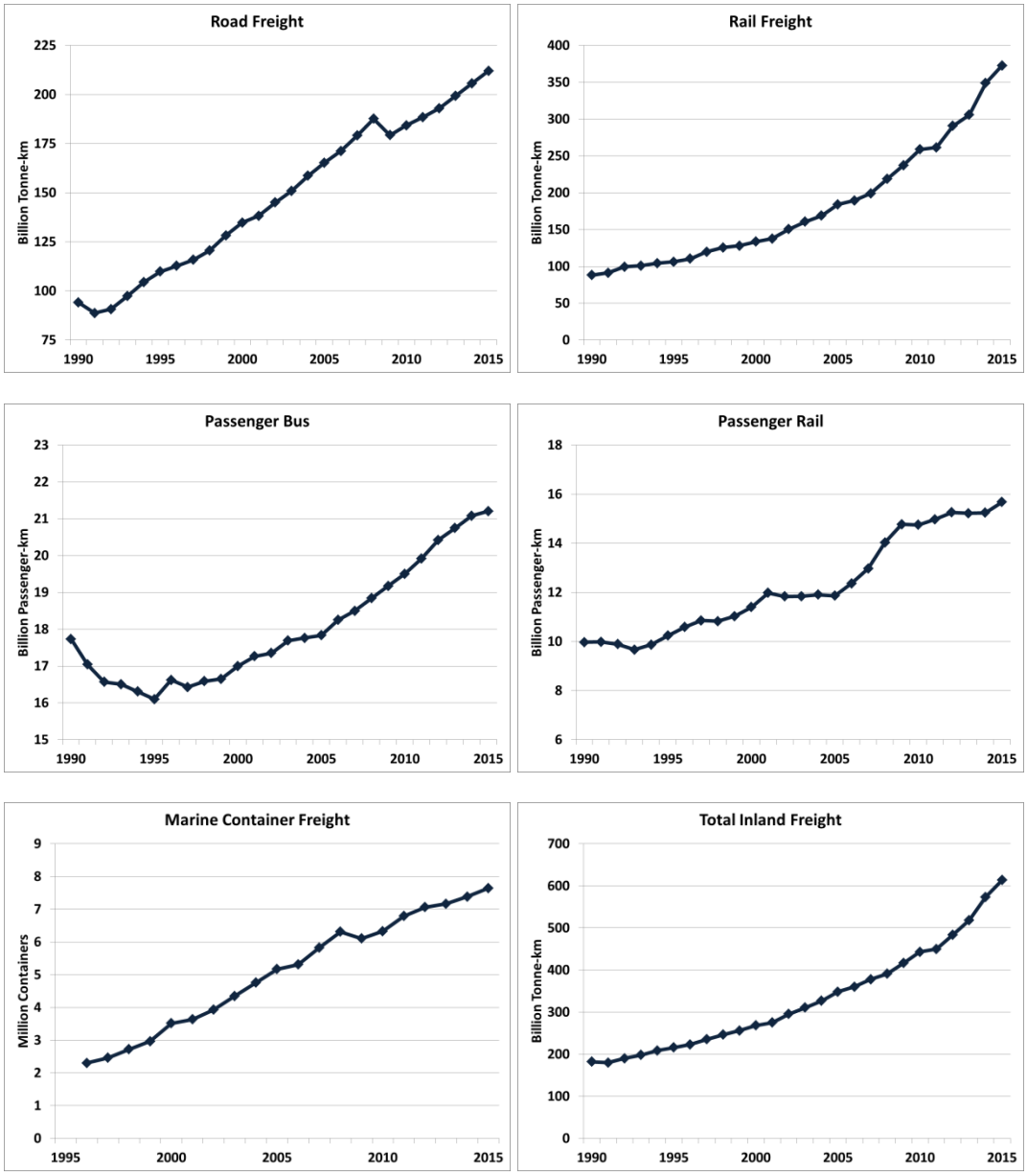
There is one dimension to the forecasting exercise that is relatively certain: there is little doubt that Australians' demand for transportation services in the general sense will continue to grow, and likely at a faster pace than the economy as a whole.

Transportation services demonstrate an income elasticity of demand in excess of unity, implying that consumers tend to purchase relatively more transportation services as their income grows – for both business and personal purposes. They demand a greater range of consumer goods (including those which must be delivered from far away), and they demand greater quantities of personal travel (including tourism). The increasing length and complexity of industrial supply chains (including global supply chains) will foster increased demand for transportation as a business input. Fundamental drivers such as population growth, economic growth, and rising incomes ensure that overall demand for transportation services will expand robustly in coming years. Factors such as energy prices, environmental concerns, and infrastructure constraints will certainly influence the quantity and structure of this demand, but the overall trajectory is certainly a positive one. This stable and ongoing growth in the overall demand for transportation services will be important in buffering the disruptive impact of changes in technology and work organisation on employment patterns: it is certainly easier to adapt to change in the context of a growing industry, than one that is shrinking.

The National Transport Commission (2016) has developed a series of forecasts of overall transportation demand, based on economic inputs, demographic projections, and other fundamental drivers. This forecast anticipates growth in total domestic passenger travel of 19 percent over the coming decade. Their forecasts anticipate even faster growth (26 percent over the same period) in the aggregate demand for domestic freight transportation. So the overall volume of transportation services production will certainly continue to expand in the years ahead. This forecast is certainly reasonable in light of the strong demand growth that has characterised most segments of the transportation industry over the past quarter-century (as summarised for selected modes in Figure 18, for example).

Various agencies have also attempted to develop more specific forecasts of employment over coming years in various transportation occupations and modes. These forecasts take as inputs conventional projections of population growth (in the range of 1.5 percent per year), economic growth (expected to equal about 2.5 percent per year in real terms), and gradually increasing real income levels. However, none of these occupational projections attempts to incorporate the effects of the bigger changes in transportation technology that we have considered above. In this regard, they should be considered as “status quo” forecasts, that in essence assume a continuation of current practices and trends, without attempting to incorporate larger disruptions that we know are on the horizon.

Figure 18. Demand Growth by Transport Mode, 1990-2015.



Source: Authors' calculations from International Transportation Federation and BITRE (2016) data.

The Commonwealth Department of Employment's most recent forecast of occupational employment growth (Australia Department of Employment, 2016) projects a relatively robust and optimistic trend for employment in the transportation industry. Total transportation employment is expected to increase by 8.5 percent over the coming five years (faster than it increased in the past five years, as reported in Figure 6 above). Ironically, this forecast anticipates stronger job-creation in some of the very functions which are believed to be especially vulnerable to technological displacement according to the Frey-Osborne analysis reported above; for example, the

Department foresees a large increase in employment in transport and dispatch clerks. The details of this projection of transportation occupations are summarised in Table 7.

Table 7

Occupational Employment Projections, Australia Transportation

Dept. of Employment (2016) *5 years*		**Transport and Logistics Industry Skills Council (2013)** *5 years*	
Truck drivers	+5.9%	Road transport	+17.2%.
Transport & dispatch clerks	+19.1%	Rail transport	+13.1%.
Delivery drivers	+17.4%	Water transport:	+16.4%.
Train and tram drivers	+10.2%	Air transport	+7.2%.
Bus and coach drivers	+1.0%	Support services	+1.1%.
Marine transportation	-6.5%	Warehouse/storage	-1.9%.
Air transport professionals	-7.9%	Postal, courier, delivery	-4.8%
Total transportation	**+8.5%**	**Total transportation**	**+5.1%**

Source: Adapted from Australia Department of Employment (2016) and Long and Shaw (2013).

A second detailed employment forecast has been generated by the Transport and Logistics Industry Skills Council (Long and Shaw, 2013). This forecast is disaggregated according to mode of transport, rather than occupation. It also contains some surprising and counter-intuitive projections (and is also summarised in Table 7). Total transportation employment is expected to expand by over 5 percent in 5 years. One of the most vibrant expected sources of new work, curiously, is water transportation (which, as noted in Figure 4 above, has experienced by far the largest employment losses of any segment of transportation). Road transportation is expected to grow

vibrantly, as well – while employment is expected to decline in warehouse and courier functions.

These occupation- or mode-specific job projections should be interpreted with considerable caution. It is clear that they have not attempted to model the likely effect of paradigm-shifting changes in technology or firm structure that are already visible in the sector. Of course, it is not possible to develop point estimates of such far-reaching structural changes: any systemic shift causes unpredictable changes in relationships between variables, which make backward-looking forecast models (such as these) highly uncertain.

SCENARIO ANALYSIS

For this reason, instead of attempting to posit specific point estimates of future employment trends in transportation services, we will instead develop a set of broad composite scenarios of likely patterns of technological and organisational change in the sector – and then ascribe broad probabilities of likelihood to each one. This approach has been preferred in management strategy, planning, and other forward-looking applications, where the inherent uncertainty of point estimates provides little confidence for the users of forecasts (Schoemaker, 1995).

We consider three broad composite scenarios of coming change in transportation work:

i) Steady implementation of change (50%):

In this scenario, expect widespread, balanced adoption of labour-saving and labour-replacing technologies. For example, in the realm of driverless road transport, expect widespread Tier 3 and 4 driverless automation within 15 years. Associated investments in infrastructure, new capital, and skills will impose significant burdens on governments, regulators, and businesses. While the implementation of technology on this pace will result in significant changes in the allocation of specific jobs, overall employment across transportation as a whole is not dramatically affected, and may even continue to grow – albeit more slowly than the economy, population, and overall transportation output. The impacts of change on the existing workforce are relatively manageable, with appropriate attention from all stakeholders to appropriate adjustment and training supports. Workforce adjustment in this scenario is assisted by the demographic profile of the industry, since at least one-third of the existing workforce will be retiring in the course of the 15-year adjustment period.

ii) Faster implementation of change (35%):

In this scenario we expect large but uneven outbursts of technological change and business disruption within a shorter time period, perhaps as quickly as 5 years. In reference to the extent of driverless technology, in this scenario far-reaching applications of Tier 4 or even higher dimensions of vehicle automation are possible within a decade. Obviously, with faster technological and organisational change, the impacts on the existing transportation workforce are more immediate, and more difficult to manage. In this scenario, measurable amounts of technological unemployment are likely to arise among transportation worters, requiring active adjustment measures to assist non-retiring workers to find new vocations.

iii) Deferred change (15%):

It is also possible that change may be implemented in real-world transportation applications more slowly than expected. Technological, regulatory, or social barriers could restrict the application of game-changing transportation technologies, resulting in a slower phase-in and more gradual impacts on transportation workers. In this scenario, expect it to take 25 years or longer for the widespread adoption in practice of Tier 3 or 4 driverless systems. Policy-makers should not be lulled into complacency, however, even under this relatively more gradual trajectory of change: the sector will still face significant requirements for training and retraining, workforce adjustment, and regulatory adaptation, including those arising from the continued expansion of non-standard or precarious employment practices.

VIII. Preparing for Change

Among these broad scenarios, there is no case in which thorough-going technological change, and equally far-reaching changes in work organisation and employment relationships, can be prevented or avoided. Historical experience suggests that epochal shifts in technology and other dimensions of work can indeed be managed without destroying (economic) value and (social) values. All stakeholders – including employers, workers and their unions, customers and shippers, governments and regulators, financiers and investors, and training and education institutions – have a role to play in preparing the sector to make the most of the change ahead. To be sure, this means acknowledging that change is inevitable, but recognising equally that it will be shaped by the choices and actions of industry participants and broader social and governmental forces. Moreover, preparing to manage change will be more successful if it is done jointly by stakeholders through multi-partite processes of analysis, deliberation, and decision-making – rather than being driven solely by the individual actions and preferences of particular interests within the sector.

SIX RECOMMENDATIONS FOR THE SECTOR

We identify six sets of pro-active measures through which transportation stakeholders could prepare to minimise the costs, and maximise the benefits, of the coming disruptions:

i) *Facilitating Mobility*: It is clear that some existing transportation jobs will be eliminated by new technologies, others will be significantly changed. But there will also be significant new work associated with the advent of new technologies. An obvious response to this challenge will be to assist existing workers to fill those new positions which arise in the course of technological change. This means providing notice, support, and access to training and adjustment programs, so that workers can adapt their capacities in line with the emerging opportunities. Financial support from employers and governments will be important in this regard, given the already-precarious incomes of many transportation workers. A crucial challenge confronted in this effort to facilitate mobility within the sector is the advanced age and limited formal qualifications of many transportation workers. As noted above, transportation workers on average are much older, and possess fewer formal post-school credentials, than workers in other sectors. Training and adjustment programs for transportation need to take account of this reality, and tailor their offerings to fit the needs of older workers with less formal qualifications. Many older workers will be keen to learn new

skills and fill new positions; but at the same time, the challenges of this adjustment will simply be beyond the personal capacities of some older workers, who will instead need to be supported in transitions to early retirement (discussed below).

ii) *Establishing Benchmarks for Skills and Qualifications*: New technology-intensive jobs in transportation arising from the application of new technologies will require a wide-ranging suite of new skills – including design, programming, operation, data management, and more. The more that the specific requirements and certifications associated with those skills can be formalized and regulated, the higher-quality and more stable will be the resulting jobs in these vocations. Sector stakeholders should work closely with existing bodies (such as the Australian Industry Standards body, TAFEs, and others) to specify and catalogue the requirements for these new jobs. Transferable certifications will assist workers and employers alike in identifying and acquiring needed suites of skills, and developing a ready supply of qualified workers who can work in different firms and sub-sectors. And the sector can work with training institutions (with a likely focus on TAFEs, given their superior scope and capabilities for planning) to develop made-to-measure programs, so that those emerging recognized qualifications can be attained by new entrants and retrained employees alike. Better integration between the vocational education system, regulators, and employers across the sector would help to attain greater clarity and consistency on the skill sets, qualifications, and career paths that will define the transportation jobs of the future. Strengthening the use of high-quality apprenticeships in the industry is another critical dimension of preparing for new skills requirements.

iii) *Facilitating Decent Retirement*: The advanced age of many transportation workers (as noted in Figure 8 above, about one-quarter of the workforce is over the age of 55, and hence eligible to retire within the next decade) can be an advantage in a time of transition. Downsizing or restructuring of employment patterns can be managed in part by facilitating the exit from the sector by workers who are not interested or able to undertake retraining and adjustment. Bridging benefits and early retirement incentives, with government support, could help to ease this transition to retirement for many workers, and avoid involuntary job losses that would otherwise occur. TWUSUPER can play an important independent role in this process, by investigating the possibility for special early retirement options, developing innovative new products that meet the needs of older transportation workers, disseminating information and counselling to affected groups of workers, and similar initiatives.

iv) *Negotiating Technological Change*: Adaptation to change is more feasible and successful when all parties to the change have a genuine say in how it is implemented and managed. In this regard it is important for all transportation stakeholders to commit to a process of information sharing, consultation, and negotiation over the

process of technological change. Workers and their unions should be notified of company plans for new technologies, even at the conceptual stage of planning. Discussions should occur within workplaces regarding the timing, scope, and effects of new investments in technology. Opportunities should be provided for early input from workers regarding how change will be managed; often innovation programs will be all the stronger thanks to the ideas and concerns expressed by workers. Collective bargaining should be expanded to include the terms of technology and its application, providing an opportunity for employers and unions to dialogue and come to agreement over the main features of technological change (including fiscal allocations for training and adjustment programs, rules regarding mobility to new positions, and other dimensions of workplace technological change).

v) *Building Consensus Across Stakeholders*: A related recommendation for dealing with coming disruption is for stakeholders to adopt a multi-partite, sector-wide approach to analysing the coming challenges, and developing inclusive sector-wide responses. Resistance to change will naturally be intensified when it is forced on those who may be disadvantaged by it. A better approach is to undertake social dialogue among all participants in the industry, to maximise the benefits of change, reduce costs – and share both costs and benefits fairly. An optimal approach would be to establish multi-partite forums (engaging business, workers and their unions, government, regulators, training institutions, financial institutions, and others) to help build relationships among stakeholders, identify future needs, and imagine and implement initiatives to facilitate necessary investments and adjustments. As discussed further below, TWUSUPER has a unique capacity to facilitate this sort of sector-wide dialogue, given its history as a successful meeting place for diverse stakeholders from across the sector.

vi) *Protecting Standards and Benefits*: As discussed in Section VI of this report, significant changes in work organisation and employment relationships are challenging traditional methods for establishing and maintaining minimum standards of job quality, entitlements, and compensation. To some extent, a desire to evade those traditional responsibilities and requirements has in fact motivated employers to utilise non-standard forms of employment more intensively. This “non-level playing field” disadvantages both workers filling non-standard roles (who are denied access to normal protections and entitlements, ranging from coverage by minimum wage laws to superannuation contributions), as well as those in traditional employment situations (whose employment security and relative bargaining power are undermined by the shift toward more precarious employment practices). Transportation stakeholders must recognise the consequences of this trend, and accept that traditional standards and entitlements should be available to all workers in the industry – including those in

non-standard, independent, or even "gig"-type employment situations. Regulatory benchmarks and corporate accountability should apply right through the supply chain. And innovative policies and regulatory tools will be required to achieve a more level playing field in standards and entitlements – including providing dependent contractors with fair protections and entitlements (equivalent to those available to traditional paid employees). Some promising Australian experience in this regard has introduced the concept of "supply chain regulation," through which responsibility for the maintenance of basic standards is applied across the full chain of responsibility, not just to the business entity nominally employing an individual. These initiatives (which to date have been concentrated on workplace health and safety issues) should be reviewed, and their potential extension to other regulatory issues (like minimum wages) actively considered. Other methods for extending basic protections and entitlements (including coverage by superannuation benefits) to workers in non-standard jobs should also be considered. TWUSUPER has a special responsibility in this regard, given its overarching mission to enhance retirement security for all transportation workers (including those in non-standard jobs).

BEST PRACTICES IN INDUSTRIAL ADJUSTMENT

Unfortunately there have been many episodes of restructuring, downsizing, or outright closure of industries in Australia's recent past – including the shutdown of most of the textile, clothing, and footwear (TCF) industry in the early 1990s; the closure of major automobile manufacturing facilities (recently culminating in the cessation of vehicle assembly); the closure of major primary metal facilities in various communities; and present downsizing in the mining industry. There may be lessons arising from these painful experiences for the transportation industry, as it negotiates the coming years of innovation, disruption, and restructuring.

A wide body of Australian research has endeavoured to investigate the impacts of these episodes of industrial restructuring on the basis of surveys of displaced workers, and other data sources (see, for example, Armstrong et al., 2008; Barnes, 2016; Callan and Bowman, 2015; and Weller, 2009). Of particular note here is published work tracking displaced workers from the TCF restructuring, and from the Mitsubishi auto factory closure in SA in 2008. Valuable new research is being undertaken at present by researchers in Melbourne (on the auto layoffs), Wollongong (on displaced steel workers), and the University of Queensland (on displaced coal miners). In addition, there is considerable international research available regarding the long-run economic, social, and regional effects of industrial restructuring.

This extant research highlights several broad common elements in the labour market experience of displaced workers, including:

- The effects of retrenchments are worse when they are large, when they occur in regional locations (where fewer alternative jobs are available), and when they occur with short notice.
- The effects of retrenchments are generally worse for workers who are older (above 45), have fewer recognized degrees or qualifications, and who may have poorer English or numeracy skills. It is wrong to assume these workers are "unskilled": they likely have decades of experience, but tied to a particular job or company (and hence not valued or recognized by other employers). This issue, as noted above, is especially relevant for the transportation sector, given the advanced age and relatively few formal qualifications of many transportation workers.
- Retrenchments are not limited to large industrial facilities. Service sectors can also experience high rates of job loss due to retrenchments (including transportation), although those retrenchments may be more dispersed across businesses and regions (which is a benefit).
- A "1/3 – 1/3 – 1/3" pattern of transition experience seems to be validated in various settings. Roughly one-third of displaced workers find decent/comparable work, one third are placed into inferior or precarious work (including part-time, casual, or self-employment), and one-third don't work again (retiring, remaining unemployed, moving onto disability pension, or otherwise leaving the workforce).
- Adjustment to major closures is very difficult in conditions of generalized economic and labour market weakness. When there are few job vacancies, and a general trend to overqualification (that is, people with training whose work does not use their full capacity), then the idea that workers' adjustment can be facilitated solely through more training alone is not convincing. At best, the more marketable displaced workers will get ahead of someone else who was also seeking work – so on a net social basis there is no improvement (although some specific individuals displaced by the original restructuring may end up better off). Policies promoting training and retraining, therefore, need to be accompanied by measures to increase the total amount of work available.
- Australia's vocational training and employment services sectors are among the most fragmented and chaotic of any industrial country. Responsibility for both functions has been largely assigned to private providers, with little coherent planning or consistency in the services offered. Thus, addressing restructuring by simply allocating public funds to private training and placement agencies has generally proven ineffective.

Research into industrial restructuring in Australia and other countries also suggests several key principles and best practices that should be reflected in any sector planning for employment transitions:

- Management of transitions is more effective when there is ample notice of the timing of closures. This allows workers and their families to prepare for the event, including taking advantage of opportunities in intervening years. It also allows human resource managers to anticipate and smooth adjustments in the workforce.
- Mobility across locations provides another important buffer in managing transition effects. If there is a single closure to be managed, then all of the workers in that facility will be impacted immediately, with no ability to share the adjustment burden across a greater population. Some may qualify for early retirement and other opportunities, but many will not and hence involuntary redundancies will be likely. When transition can be managed across several locations, however, or even across several firms, then there are greater opportunities for taking advantage of cross-location demographic differences and the staggered timing of closures.
- One key advantage in planning for transition in transportation is the relatively advanced age of much of the workforce. When combined with appropriate incentives and supports for early retirement (such as income bridging or other guarantees) this can reduce the number of involuntary redundancies. And when access to early retirement incentives is offered across several different facilities or firms in different communities, then the potential for using demographic transition to smooth the industry's overall adjustment is magnified accordingly.
- The need for long-term transition planning, and for an integrated multi-location approach, both highlight an underlying need for greater coordination of sector-wide transitions. If transition planning is limited to individual facilities or fragmented private firms, each seeking to minimise their own corporate exposure during the transition, then transition decisions may be atomistic, potentially contradictory to efforts by other industry stakeholders, and ultimately ineffective.

The lessons learned from these other experiences with broad industry-wide restructuring, therefore, reinforce our general support, noted above, for multi-partite sector-wide transition planning in the transportation sector. Developing forums for dialogue that engage all stakeholders, and establishing bodies and agencies with the capacity to make decisions regarding training, adjustment, infrastructure, and other matters with whole-sector implications, will enhance the capacity of the transportation industry to prepare for coming changes in a consistent, integrated, and effective manner.

IX. Conclusion

This review has highlighted some daunting challenges and uncertainties facing transportation work in Australia. Accelerating technological change is one driver of that change. But other factors are also shaping and reshaping the whole sector, and the lives of the people who work in it. Significant among them is the trend toward non-standard or precarious forms of employment, which have significantly affected the stability and quality of work. But many other forces are at play, as well, including environmental, demographic, and fiscal pressures that will also affect the production and sale of transportation services, and which have not been considered in detail in this report.

However, amidst all this flux and uncertainty, there are several sources of stability and continuity in transportation industry which can impart a certain confidence to stakeholders as they prepare for the coming changes. Transportation is a crucial contributor to Australia's economic performance and quality of life; that importance is experienced broadly through the whole economy, not just within the transportation sector itself, and this gives transportation providers a legitimate platform from which to demand the attention and support of broader government and regulatory structures. Moreover, the overwhelming evidence is that the core demand for transportation services in Australia will continue to grow relatively strongly – faster than population growth and the economy as a whole. Hence the structural economic and social importance of transportation is not in question. All that is in question is how the sector is managed, in the face of coming change and disruption. Will the potential of the transportation sector to generate wide-ranging economic and social benefits be optimised through measures that lift the quality and productivity of work, invest in the capacity and continuity of the workforce, and ensure that the industry's value is recognised and sustained? Or will the key decisions affecting the industry be guided by narrower cost-minimisation criteria, according to which unconstrained market forces will be empowered to lead change in the interest of particular firms and investors?

Transportation work will not "disappear." But it will change significantly. And not solely because of technology. Working pro-actively to lift and stabilise the quality of transportation jobs is important to maximising the net social benefits of this vital sector. It is also important to the future success of TWUSUPER.

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