Evaluating the impact of automation in long-haul trucking using USAGE-Hwy

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- https://www.mercedes-benz.com/en/innovation/autonomous/the-long-haul-truck-of-the-future/

Introduction:

- “Already, companies have made fully autonomous beer deliveries and struck alliances to operate ATs jointly. The rigs these companies are using are typically new medium- and heavy-duty trucks, outfitted with lidars, sensors, and other technology to allow the vehicle to operate without human intervention. Basic versions of the kit cost as little as $30,000; high-end packages might cost $100,000.” (Chottani et al. 2018:4)

Introduction:

"Tech startup TuSimple has been carrying mail in autonomous semi-trucks between Phoenix and Tucson for "several weeks" with little fanfare.
Since May 2019 the autonomous trucks have been making the 115 mile journey on Interstate 10 …
TuSimple and UPS are testing what is called **"Level 4" autonomous technology, meaning that the truck's on-board computer is in control during the entire drive**.
However, current federal laws require that people are in the truck at all times, so the trucks have a driver and an engineer in them while on Arizona roads."
https://www.azmirror.com/2019/08/16/autonomous-semi-trucks-arizona-ups-tusimple/

Introduction:

- We focus on automation in the long-haul trucking industry, assuming it will be among the first to be impacted because:
  1. Current driving automation system development focuses on limited access highways because they are a less-complex environment than surface streets;
  2. Unlike the short-haul segment, the long-haul segment involves long periods of uninterrupted highway driving;
  3. Long-haul drivers have fewer non-driving responsibilities than short-haul drivers

- We will use the dynamic USAGE-Hwy CGE model to simulate the impact of the adoption of automation in long-haul trucking over the period 2020-2050

Introduction:

- Adoption of automation in long-haul trucking will be modelled as a series of shocks to:
  - Labor saving technical change
  - Cost of adopting automation
  - Fuel cost savings
  - Capital-saving technological change
  - Fatalities and safety costs

- We are interested in the impact on real output and welfare, and any notable industry-level impacts

- **What is the impact of automation on employment**? Will there be job losses due to the replacement of truck drivers with technology?

Truck transport in USAGE-Hwy:

Table 1.1: Truck Transport industries in USAGE-Hwy v1.1 ($m)						
NAICS industry	Intermediate inputs	Compensation of employees	Gross operating surplus	Taxes	Value of industry output	Value of commodity sales
484 For-hire truck transportation	156,224	90,051	52,920	8,040	307,235	320,016
47OT.484 In-house truck transportation	175,978	86,338	50,738	0	313,054	313,054

- Not all employees are long-haul truck drivers
- What component of "Compensation of employees" will be impacted by the introduction of driverless trucks?

Number of long-haul truck drivers:

	484 For-hire truck transportation	47OT.484 In-house truck transportation	
All employees	1,476,970		
Heavy and Tractor-Trailer Truck Drivers	880,710	919,600	1,800,310
Long-haul truck drivers	453,742	74,763	

- Mean annual wage in Industry 484 is $46,340, and of Truck drivers is $46,230, so 59.5% [= 46230·880710 / 46340·1476970] of "compensation to employees" goes to Truck drivers
- Gittleman and Monaco (2020:16-18) use data from the 2002 Vehicle Inventory and Use Survey to conclude that 51.52% and 8.13% of all "Heavy and Tractor Trailer Drivers" employed in the for-hire trucking and private trucking sectors were long-haul truck drivers

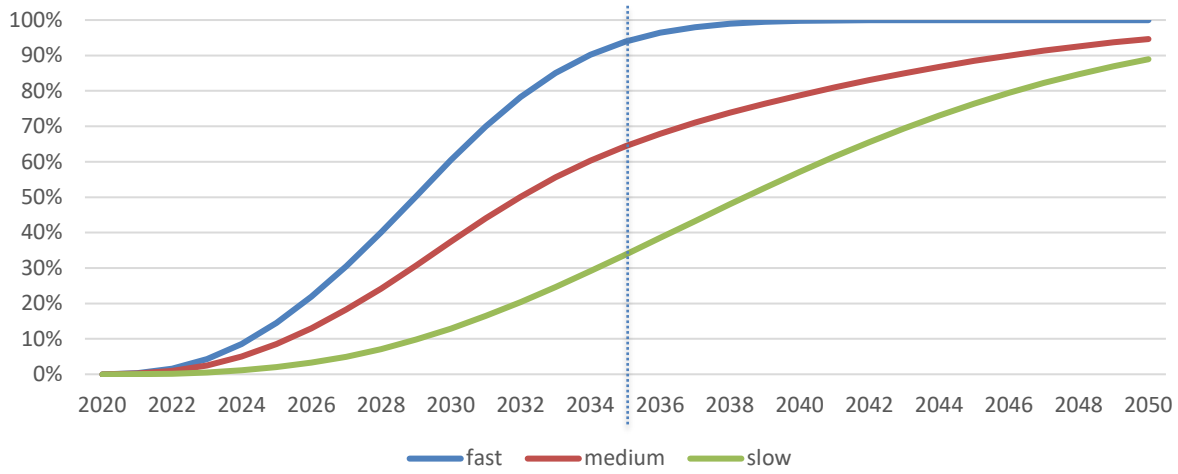
Adoption of automation technology:

- We suppose that the first firms in the trucking industry begin adopting automation in long-haul trucking starting in 2021
- The rate at which firms adopt automation will be affected by a number of factors
- To reflect the uncertainty around these factors, we consider three separate time paths that dictate the share of the trucking industry that begins to adopt automation in long-haul trucking over a period of 30 years: 2020-2050
- After 10 years from when the technology becomes available and is taken up by the first adopters, about 95%, 60% and 30% of trucking firms will have begun adopting automation in long-haul trucking under the “fast”, “medium” and “slow” scenarios, respectively

Adoption of automation technology:

- The typical useful life of tractors in the long-haul segment is approximately nine years.
- On average, in any given year, any firm that has begun adopting automation technology will convert 1/9th of its fleet
- Share of the fleet of long-haul trucks in the trucking industry that will have been converted to accommodate automation is plotted in Chart 2.1a

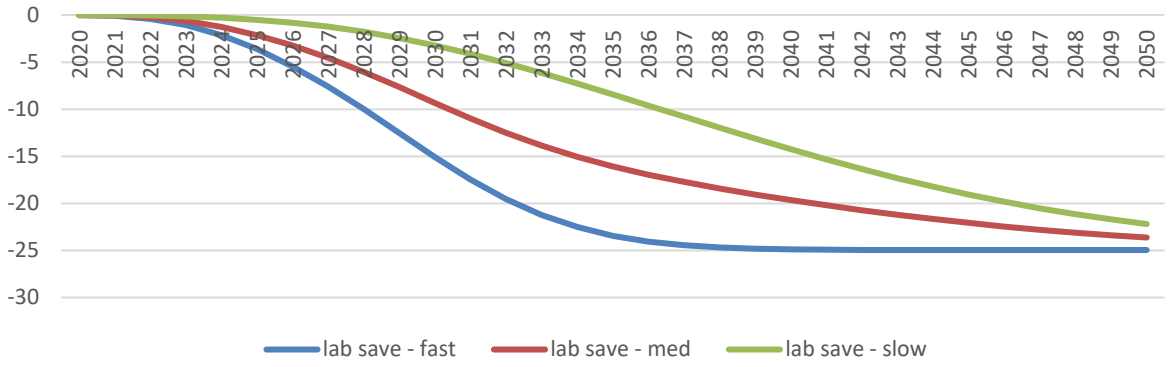
Chart 2.1a: Share of industry fleet with driverless tech



Labor saving technical change:

- Fewer drivers will be needed, so automation in long-haul trucking will have a positive impact on labor productivity
- A labor productivity **improvement** is represented by a **negative** value for labor-saving technical change: Less labor is required to produce the same level of output given use of other inputs
- labor-saving technical change shock is derived by multiplying the adoption rates by the share of employment accounted for by long-haul truck drivers

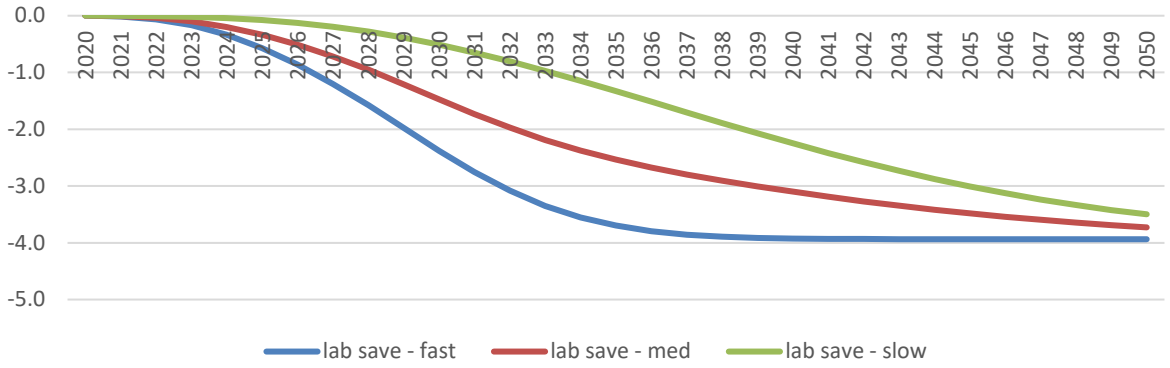
Chart 2.2a: Labor saving technical change in TruckingServ
(% relative to baseline)



Labor saving technical change:

- Where does -25% come from?
  - 59.5% of “compensation to employees” to Truck drivers
  - 51.52% of “Heavy and Tractor Trailer Drivers” were long-haul truck drivers
  - McKinsey (2015) estimates maximum automation potential in Heavy Truck and Tractor-Trailer Operators is 81.4%
  - 59.5% · 51.52% · 81.4% = 25%. In In-house trucking, 59.5% · 8.13% · 81.4% = 3.9%

Chart 2.2b: Labor saving technical change in InHTruck
(% relative to baseline)

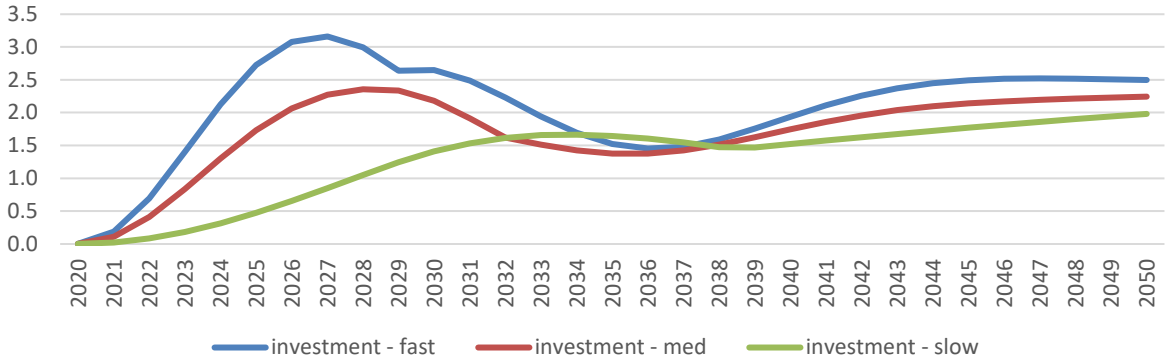


Cost of adopting automation:

- Estimate the cost of replacing the current fleet of two million tractor-trailers in the United States (McKinsey Global Institute 2017:79) with one where all trucks are fitted with the technology to allow for autonomous operation
- "… new trucks would be outfitted with lidars, sensors, and other technology to allow the vehicle to operate without human intervention ... high-end packages might cost $100,000" (Chottani *et al*. 2018:4)
- To reflect the idea that early adopters of new technology face higher adoption costs than late adopters, assume that this per-truck cost falls over time to a minimum of $50,000
- Over 2020-50, we assume that the size of the fleet of long-haul trucks follows the US DoT increase in Truck vehicle-miles-travelled - assuming that the existing fleet is fully utilized

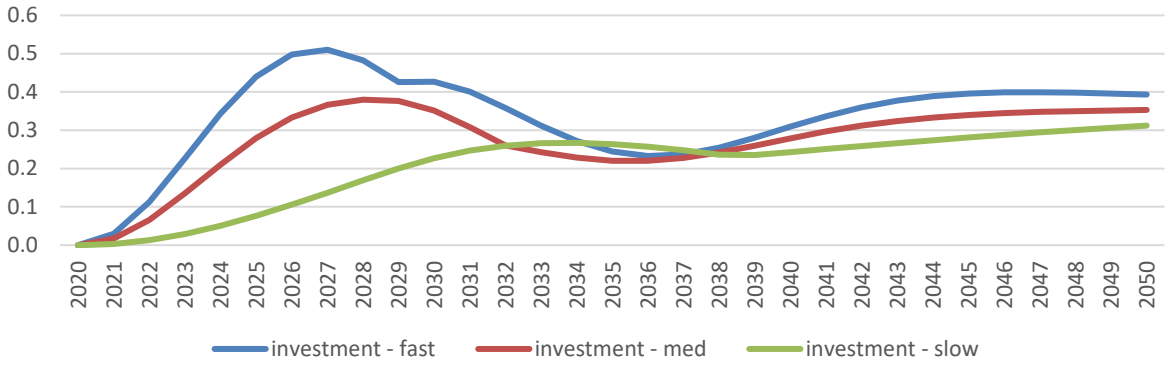
Cost of adopting automation:

Chart 2.3a: Cost of adopting automation in TruckingServ (% relative to baseline)



- By 2050 shock is 2.5%: 1/9 · # of trucks (1,056,242) · [TruckServ share (0.86)] · [$50k per truck] / [Investmt in TruckServ ($203b)]

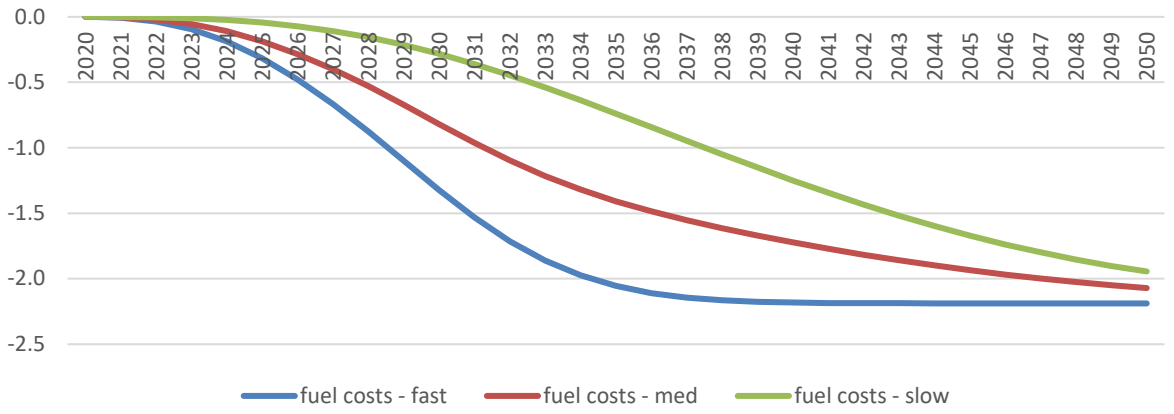
Chart 2.3b: Cost of adopting automation in InHTruck (% relative to baseline)



Fuel cost savings:

- Driving automation could decrease fuel costs by optimizing throttle and brake controls to minimize fuel burn
- Estimated fuel savings using a speed limiting device or truck platooning (USDoT (2016) and Shladover *et al*. (2018)) suggest 5.22% fuel savings
- When converting whole fleet, the fuel-saving shock is -2.19% [= -100 · 0.0522 · 0.5152 · 0.814] in TruckingServ and -0.35% [= -100 · 0.0522 · 0.0813 · 0.814] in InHTruck

Chart 2.4a: Fuel saving in TruckingServ (% relative to baseline)



Capital-saving technological change:

- Driverless trucks can be operated for longer hours than trucks with drivers who need mandated rest periods and can only work for a mandated number of hours without interruption
- Following McKinsey (2018:19), we assume capital-saving technological change of 45%

Fatalities and safety costs:

- By eliminating driver-related factors, automation could reduce crashes, eliminating an estimated 155 fatalities and $97.8m in safety costs in 2017
- Each fatality is valued at $9.6m, following US DoT guidance on Value of Statistical Life
- Introduced safety cost savings as reduced purchases of medical services by the household sector

Fatalities and safety costs:

Chart 2.6a: Change in fatalities (# relative to baseline)

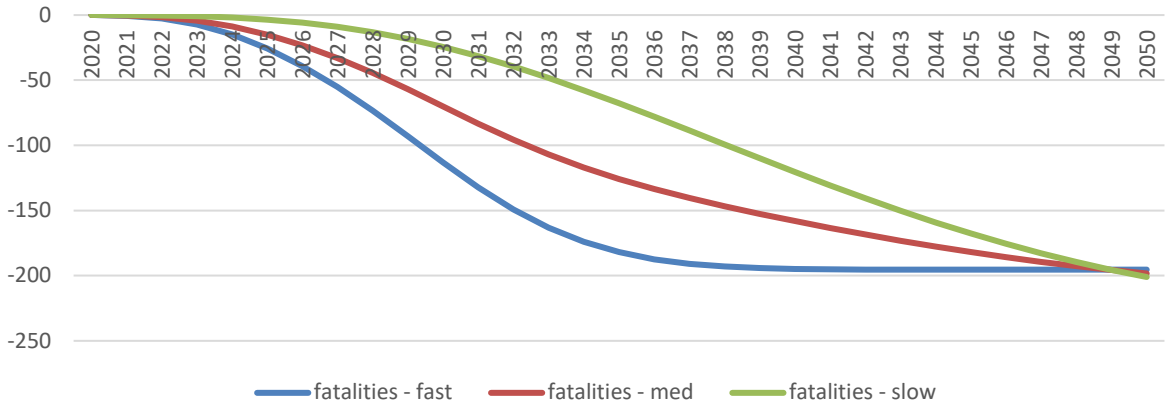
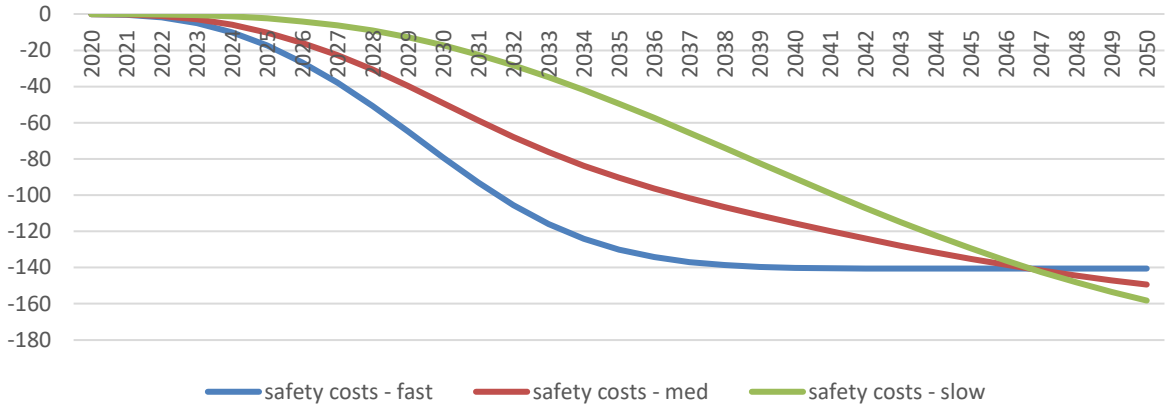
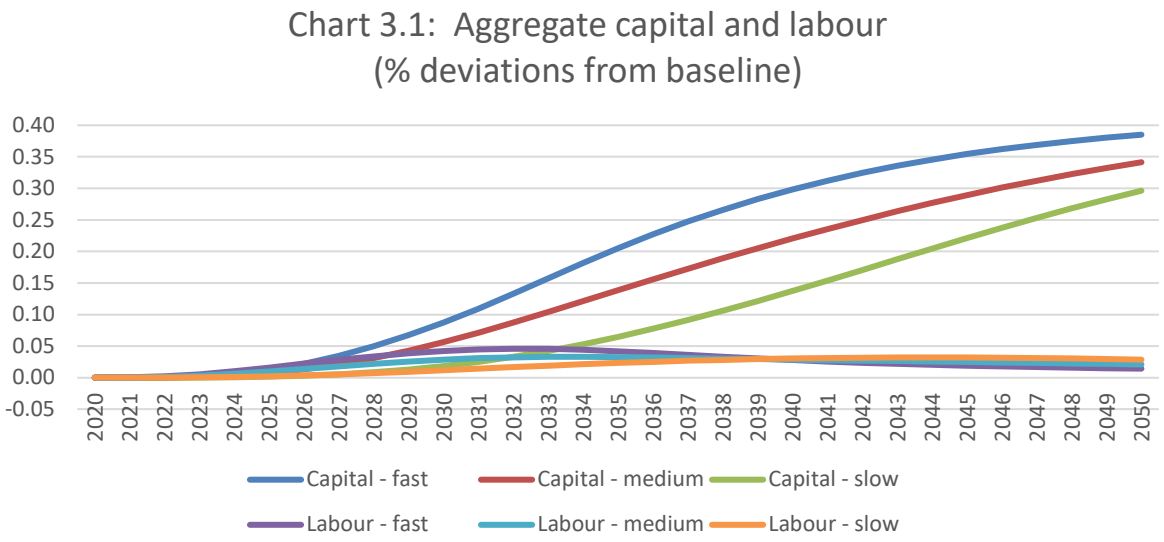


Chart 2.6b: Reduction in safety costs ($m relative to baseline)

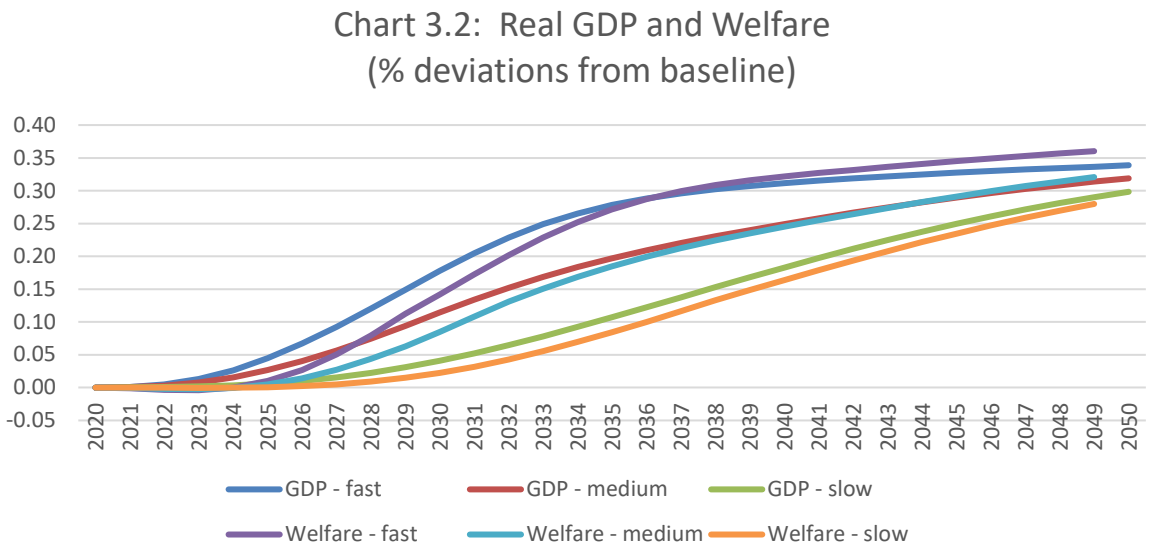


Results – primary factors:



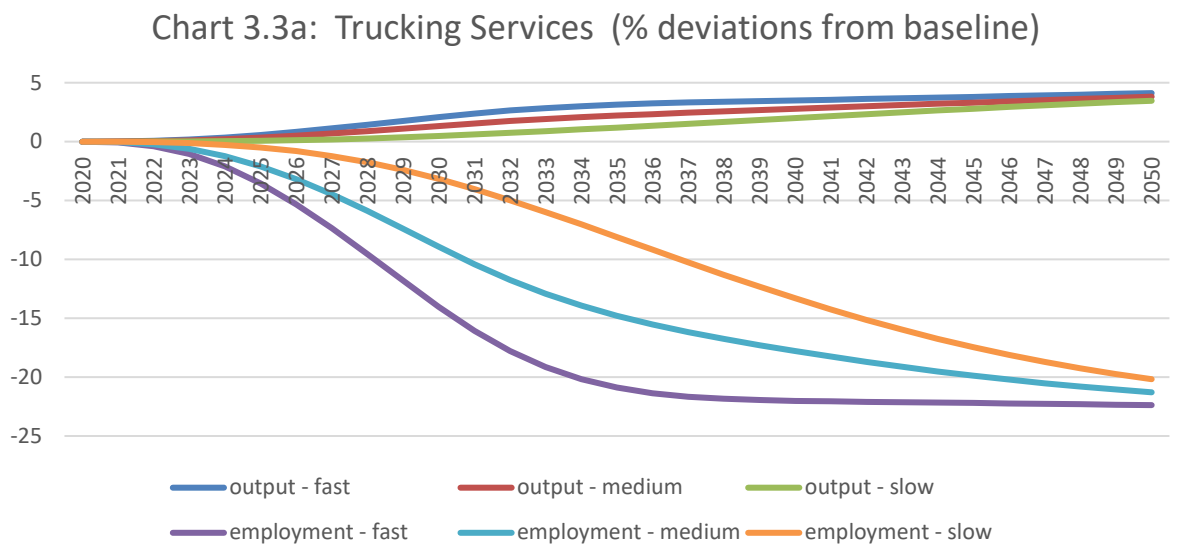
- Investment in automation stimulates capital, which rises almost 0.4 per cent above baseline by 2050
- More capital means increase in labour demand which reaches 0.05 per cent above baseline around 2032 under “fast” scenario
- Slower adoption rates implies slower and steadier growth in capital and labour

Results – real GDP and welfare:



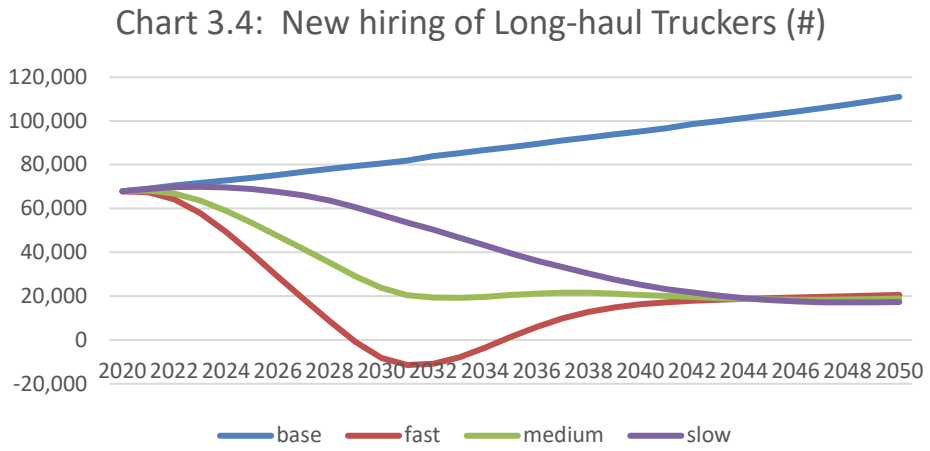
- Real GDP and welfare increase by around 0.35 per cent relative to baseline, about $68b of 2019 GDP
- Capital contributes about 0.12 per cent of this increase in real GDP
- Most (0.2 per cent) comes from labour-, capital- and fuel-saving technical change

Results – industries:



- Output of for-hire trucking increases by about 4 per cent relative to baseline
- Automation reduces employment in Trucking Services industry by over 20 per cent
- In-house trucking increases by about 0.5 per cent
- Substitution away from other transport, mostly rail (-6 per cent) water (-2.7 per cent) and air (-0.6 per cent)

Results – number of long-haul truckers:



New hiring(t) = employment(t) – employment(t-1) · (1 - turnover rate)

- Turnover rate is 10.5 per cent, employment is about 560k in 2020
- Baseline hiring rises from 69k in 2020 to over 110k by 2050
- Maximum automation potential is 81.4 per cent, so by 2050, there is still demand for about 20k long-haul truck drivers
- But under “fast” adoption scenario, new hiring is negative over 5-year period 2029-2034, reaching minimum of -11k
- Annual turnover of short-haul drivers is about 135k in 2020

Conclusions:

- Automation in long-haul trucking offers the opportunity for:
  - Increases in Welfare and real GDP
  - More efficient and safer trucking services
  - Without loss of employment