ADAVANCED TECHNOLOGY ADOPTION AND USE IN CANADA'S TRANSPORTATION SECTOR

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INTRODUCTION

Enterprises operating in the transportation sector increasingly compete along global production and supply chains. To be successful, enterprises must continuously retool, upgrade, and adopt advanced technologies to gain or maintain a competitive edge. Given the transportation sector's critical role in facilitating economic trade, understanding its adoption of advanced technology can serve to assess both innovation and economic growth. Despite this importance, data pertaining to the adoption of advanced technology by transportation enterprises in Canada has, until now, remained largely limited. The 2014 Survey of Advanced Technology (SAT) addresses this data gap by providing information on the extent to which Canadian transportation enterprises use advanced technologies (see textbox).

This paper examines the adoption rates of advanced technologies by the Canadian transportation sector and its industries against the average rate across all surveyed industries. After presenting the adoption rates of the most widely adopted technologies, the paper compares transportation with 7 other sectors of the Canadian economy. Next, attention shifts to the objectives that transportation enterprises set by adopting advanced technology, as well as the obstacles that were faced, and what measures they took to overcome them. The paper concludes by pointing to future advanced technologies, such as electric vehicles, autonomous transportation, Smart Cities, and others, which are poised to impact the transportation sector. And this impact will create new challenges and opportunities for transportation enterprises.

The Survey of Advanced Technology collects information on the extent to which Canadian enterprises use such technologies. For 2014, almost 12,000 enterprises from 87 industry groupings were surveyed. The Transportation sector consists of enterprises classified by the North American Industry Classification System to transportation and warehousing industries (NAICS 48-49).

An enterprise is the organizational unit of a business that directs and controls the allocation of resources relating to its domestic operations, for which consolidated financial and balance sheet accounts are maintained, and from which a consolidated financial position for the unit can be derived.

An advanced technology is one that performs a new function or significantly improves an existing function performed by a more commonly used technology. For the 2014 survey, 41 advanced technologies were selected and divided into four distinct technology groups:

1. Advanced logistics (material handling, supply chain and logistics),
2. Advanced business intelligence,
3. Advanced design and fabrication (design, information control, processing and fabrication),
4. Advanced green technology.

For more information on the Survey of Advanced Technologies, see Statistics Canada (2015).

MATERIAL HANDLING, SUPPLY CHAIN AND LOGISTICS TECHNOLOGIES

The first group of technologies measured by SAT was Advanced Material Handling and Logistics, which included 8 technologies such as automated storage and retrieval systems, bar coding and, Customer Relationship Management. At the national level, the transportation sector most widely reported the use of transportation management systems (TMS) such as route optimization, vehicle dispatching and cost minimization. Just over one-third (34.4%) of transportation enterprises have adopted TMS, more than three-times the adoption rate across all industries surveyed (Figure 1).

In particular, nearly 6 in 10 enterprises within the rail transportation sub-sector adopted and used TMS nationwide, almost double the value reported for the transportation sector as a whole. TMS is especially important for rail transportation companies that need to coordinate the movement of enormous volumes of freight, often as part of an intermodal shipment, across the country. The next two sub-sectors leading the adoption of TMS were transit & ground passenger transportation, and truck transportation, with reported adoption rates of 36.7% and 36.6% respectively.

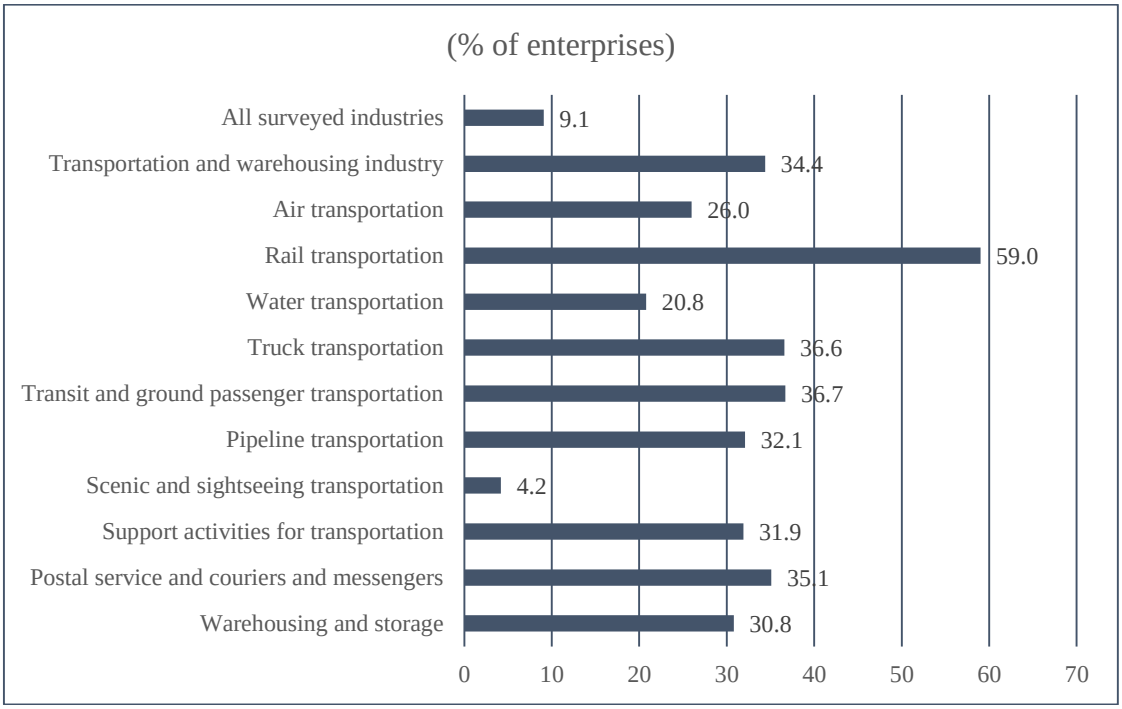

Figure 1: **Adoption of transportation management systems, selected industries, Canada 2014**
Source: Statistics Canada, CANSIM table 358-0402

BUSINESS INTELLIGENCE TECHNOLOGIES

The second group of technologies was Advanced Business Intelligence Technologies, which assist with the generation, collection, and analysis of business data. This includes, for example, executive dashboards for analytics or decision-making, software for large-scale data processing (e.g., Hadoop), and software as a service (SaaS) (e.g., cloud computing). The most widely adopted business intelligence technology across the transportation sector was live stream processing technology or real-time monitoring, reported by 17.3% of transportation enterprises (Figure 2). This adoption rate was higher than the national level of 13.1% across all surveyed industries, suggesting that transportation enterprises place extra importance on this business intelligence technology.

Within the transportation sector, some industries reported above average rates of adoption for live stream processing technology or real-time monitoring: pipeline transportation (24.3%), truck transportation (20.8%), and warehousing and storage (18.7%). Three other industries reported adoption rates above the national average: postal service and couriers and messengers (15.8%), support activities for transportation (15.4%), and air transportation (13.4%). Support activities for transportation consists of several types of industries including freight forwarders and marine shipping agents.

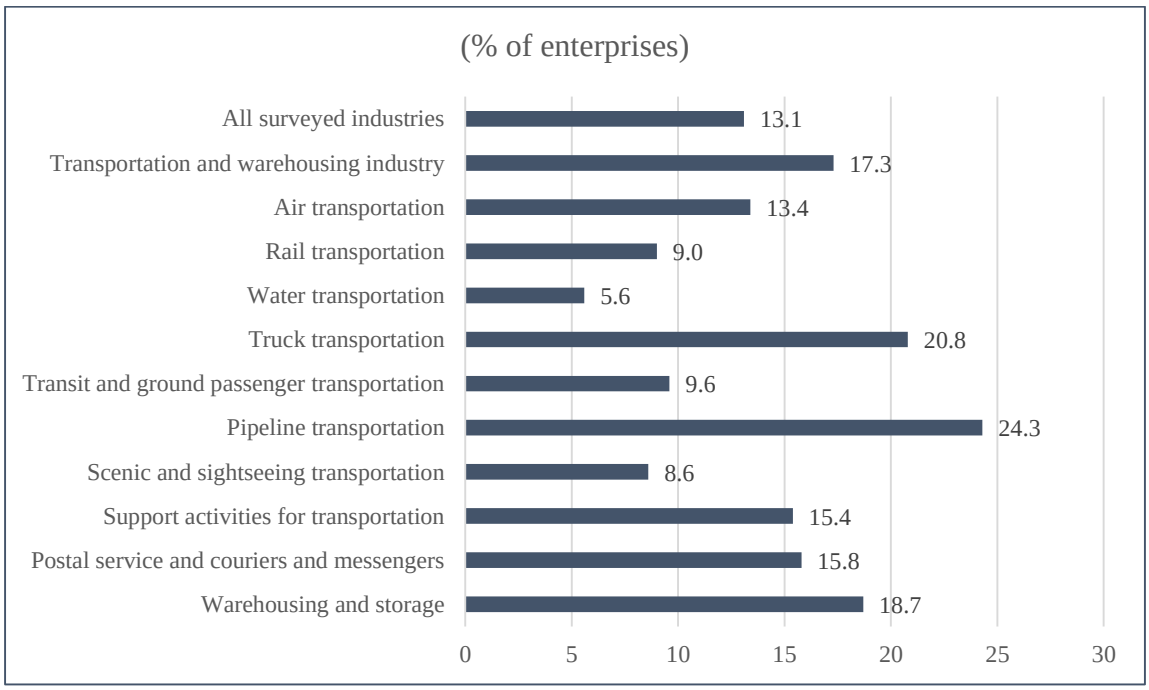

Figure 2: Adoption of live stream processing / real-time monitoring, selected industries, 2014
Source: Statistics Canada, CANSIM table 358-0403

DESIGN, INFORMATION CONTROL, PROCESSING AND FABRICATION TECHNOLOGIES

The next group of advanced technologies consists of 24 technologies associated with design, information control, processing, or fabrication; examples of these technologies include: Enterprise Resource Planning (ERP), automated systems for inspection (e.g., laser-based, X-ray, or sensor-based), and wireless communications for production. The transportation sector's highest reported adoption rate from this advanced technology group was 17.3% for intercompany computer networks, including extranet and electronic data interchange (EDI). However, this level of adoption was lower than the 21.4% reported across all surveyed industries at the national level (Figure 3).

While the transportation sector as a whole reported a below average level of adoption of intercompany computer networks, there were many cases where this technology clearly plays a significant role in their operations. Pipeline transportation, for instance, led the adoption of this technology with nearly 40% of all enterprises reporting its use. Followed closely were the rail transportation, and warehousing and storage sub-sectors, reporting intercompany computer networks adoption rates of 28.3% and 28.1% respectively.

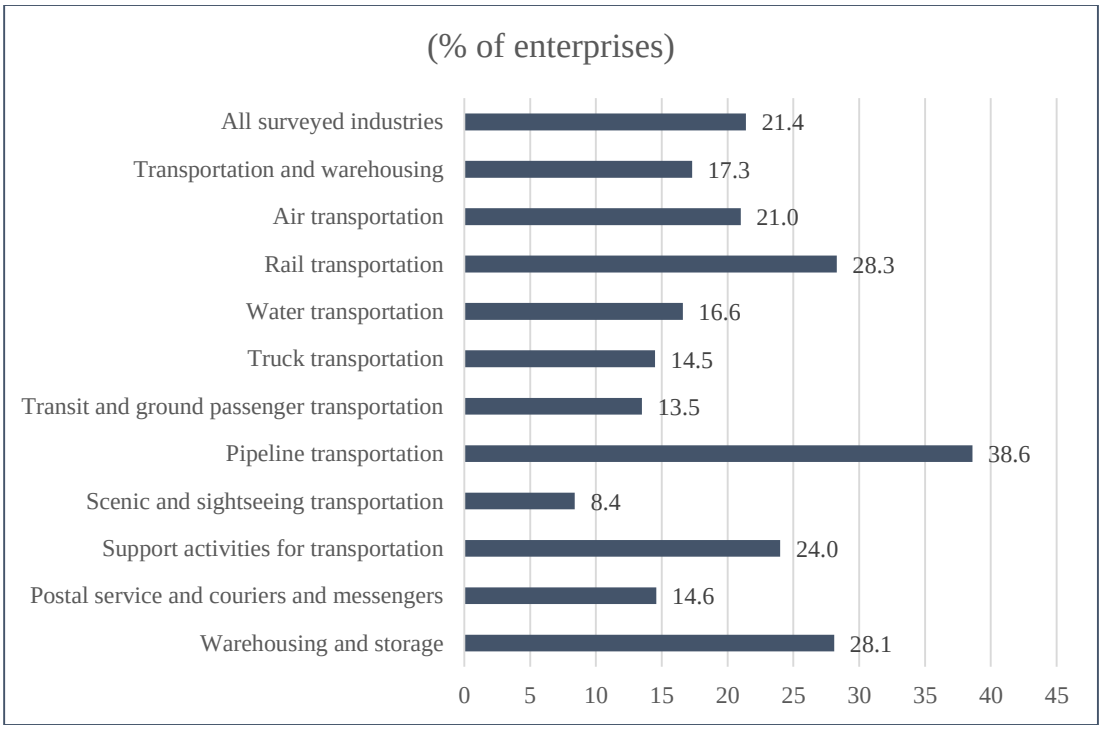

Figure 3: Adoption rate of intercompany computer networks, selected industries, Canada
Source: Statistics Canada, CANSIM table 358-0404

GREEN TECHNOLOGIES

The final group of advanced technologies measured by SAT were Green Technologies, which broke down into four distinct sub-groups: air or emission technologies, energy technologies (e.g., ISO 50000), water technologies, and waste technologies. Not surprisingly, the most widely adopted advanced green technology across the transportation sector was air or emission technologies, reported by 12.2% of enterprises. Of note, this reported adoption rate nearly tripled the national level of adoption of 4.6% across all surveyed industries.

Adoption of air or emissions technologies within the transportation sector, however, varied widely from a high of 25.7% among enterprises engaged in pipeline transportation, to a low of 3.2% among enterprises in the scenic & sightseeing transportation sub-sector. Two other sub-sectors reported a rate higher than the sector-wide adoption rate for air or emission technologies: truck transportation (16.0%) and water transportation (15.3%).

HOW DOES THE TRANSPORTATION SECTOR STACK UP?

Prima facie, at the national level the transportation sector appears to be a laggard in the adoption of advanced technologies**.** Indeed, on average more than 63% of enterprises across all surveyed industries used at least one technology identified as 'advanced', compared with just over 53% across the transportation sector alone (Statistics Canada, 2015). Only the forestry and logging sector reported a lower overall rate of adoption across all four advanced technology groups. However, this result may not tell the full story, as many of the technologies that the transportation sector did adopt, were adopted more frequently than in other sectors (Table 1).

Table 1: Adoption of selected technologies by sector, Canada 2014

Advanced Technology	NAICS Sector	Adoption rate (%)
Transportation management system	Professional, scientific and technical services	2.3
	Transportation and warehousing	**34.4**
	Retail trade	4.6
	Wholesale trade	12
	Manufacturing	7.9
	Utilities	13.6
	Mining, quarrying, and oil and gas extraction	11.4
	Forestry and logging	5.8
	All surveyed industries	**9.1**
Live stream processing technology or real-time monitoring	Professional, scientific and technical services	14.5
	Transportation and warehousing	**17.3**
	Retail trade	14.1
	Wholesale trade	10.6
	Manufacturing	10.9
	Utilities	31.7
	Mining, quarrying, and oil and gas extraction	16.5
	Forestry and logging	3.5
	All surveyed industries	**13.1**
Intercompany computer networks, including extranet and electronic data interchange (EDI)	Professional, scientific and technical services	15.4
	Transportation and warehousing	**17.3**
	Retail trade	18.7
	Wholesale trade	29.3
	Manufacturing	25.9
	Utilities	37.7
	Mining, quarrying, and oil and gas extraction	21.1
	Forestry and logging	3.9
	All surveyed industries	**21.4**
Air or emission technologies	Professional, scientific and technical services	0.7
	Transportation and warehousing	**12.2**
	Retail trade	2.5
	Wholesale trade	2.4
	Manufacturing	8.4
	Utilities	14.2
	Mining, quarrying, and oil and gas extraction	8.7
	Forestry and logging	5.7
	All surveyed industries	**4.6**

Source: Statistics Canada, CANSIM tables 358-0402, 358-0403, 358-0404, 358-0405

As expected, the transportation sector as a whole adopts the advanced logistics technology - TMS - more than any other industry sector measured by SAT. Among business intelligence technologies, the transportation sector's adoption rate of live stream processing or real-time monitoring was second only to the utilities sector. However, from the advanced design, information control and fabrication technology group, the transportation sector reported a below average adoption rate overall.

In terms of intercompany computer networks (including EDI), it was widely adopted across all sectors including transportation. EDI is an important element of logistics or the application of information and communications technologies to the physical distribution of product. Lastly, the transportation sector led six of the other sectors with above average adoption of air or emissions advanced green technologies.

OBJECTIVES, OBSTACLES AND MEASURES TAKEN

Lowering operating costs was the primary objective reported in adopting advanced technology by all surveyed industries and by the transportation sector. In addition, transportation firms considered meeting regulatory standards and improving organization flexibility as other key objectives for advanced technology adoption. The adoption of air or emissions technologies by transportation enterprises may reflect both a cost reduction objective (i.e. fuel efficiency) as well as compliance with new or anticipated regulations.

Mismatches between the skills needed by enterprises and employee training, as well as employees' resistance to change were the most common obstacles faced by enterprises from all surveyed industries that adopted an advanced technology. The transportation sector was no exception as, across the four advanced technology groups, the most widely reported obstacle was employees' resistance to change, followed by lack of employee training, and difficulty in recruiting qualified staff. This implies a critical human resources dimension underlies the adoption of these technologies.

Across all surveyed industries, enterprises reported that they most frequently mitigated these obstacles to adopting advanced technology by offering advanced training, and hiring consultants or subcontracting for short-term needs. The result was similar for the transportation sector as a whole, as enterprises reportedly offered training as needed by their organization to avoid the obstacles to technology adoption, followed closely by hiring consultants to fulfill short or long term needs. These findings suggest an area that requires further investigation.

DISCUSSION

In summary, more than 6 in 10 (63%) enterprises in industries covered by the 2014 Survey of Advanced Technology used at least one technology identified as 'advanced.' The adoption rate ranged from slightly more than 60% of small enterprises (10 to 99 employees) to over 90% for large enterprises (250 or more employees). In the transportation and warehousing sector, about 54% of the enterprises reported using at least one advanced technology in 2014. If focussing only on the large enterprises however, the adoption rates for transportation enterprises increased to 92%.

Moreover, the adoption of certain technologies in specific transportation industries was more prevalent. For example, more than one third (34.4%) of transportation enterprises reported using Transportation Management System technologies, with the railway industry reporting the highest rate (59.0%). Similarly, pipeline transportation (24.3%), truck transportation (20.8%), and warehousing and storage (18.7%) all reported average rates of adoption for live stream processing technology or real-time monitoring, higher than the national level of 13.1% across all surveyed industries.

Like all surveyed industries, transportation enterprises identified training and a lack of human resources skills as obstacles to adopting advanced technologies. Finding ways of overcoming these obstacles will be critical since the coming decade will witness increasing industry disruption and widespread technological change; some have even dubbed it the 'fourth industrial revolution' (Schwab, 2016). Through continued innovations in autonomous and electric vehicles, new regulations for the sharing economy and Smart Cities, increased emphasis on energy conservation, and further reductions in greenhouse gas emissions, the transportation sector will be under constant pressure to adapt. By examining SAT data, we gain a better understanding of the extent to which transportation enterprises have adopted advanced technologies as well as the obstacles they face. It is imperative to understand and mitigate such obstacles so that enterprises operating in the transportation sector can compete successfully along global production and supply chains.

REFERENCES

Schwab, K. (2016). *The Fourth Industrial Revolution: what it means, how to respond.* World Economic Forum. Retrieved January 14, 2016 from: http:///www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond:

Statistics Canada (2015). *Survey of Advanced Technology, 2014. The Daily*. Retrieved February 19, 2016 from: http://www,statcan.gc.ca/daily-quotidien/151211/