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Examining the socio-economic variables and basic skills provision in navigating the challenges of the Fourth Industrial Revolution: A case study of long-distance truck drivers in South Africa

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Background: This study investigated the impact of socio-economic variables influencing the provision of basic skills for navigating the challenges of the Fourth Industrial Revolution (4IR).

Objectives: The study aims to describe the variables underpinning this study, using statistical analysis and quantitative measurement as displayed in Table 1. It also investigates the role of socio-economic variables, using a Chi-Square test and Multinomial Logistic Regression techniques, in the provision of basic skills for handling direct and indirect challenges of the 4IR. Further, it attempts to provide recommendations, based on research findings, on strategies for ensuring that long-distance truck drivers are well-equipped with the necessary skills for meeting the demands of the 4IR.

Method: The study utilised a quantitative research method. A multinomial regression model was used to describe long-distance truck driver data collected in South Africa. A total of 314 participants completed the questionnaire.

Results: Results revealed that variables such as driver's education level, frequency of route usage, company type, and driver's work location are significant predictors in predicting whether a given truck driver possesses basic skills for handling the challenges of the 4IR. This finding holds significant practical implications, as it allows for targeted interventions and tailored strategies aimed at effectively addressing the identified predictors to encourage the desired response of having long-distance truck drivers equipped with essential 4IR skills.

Conclusion: This study contributes to the body of knowledge regarding factors affecting long-distance truck drivers in getting basic 4IR skills essential for them to properly implement new technologies arising in the haulage trucking industry.

Contribution: It documents the experiences of long-distance truck drivers in the face of newly emerging technologies in the transport industry.

Keywords: long-distance truck drivers; fourth industrial revolutions; socio-economic factors; challenge; essential skills; migrants; transportation networks.

Introduction

The purpose of this study is to investigate the impact of socio-economic variables influencing the provision of basic skills for navigating the challenges of the Fourth Industrial Revolution (4IR). The World Economic Forum (WEF) (2018) defines the term 4IR) as a transformative era marked by the convergence of technologies that dissolve the boundaries separating the physical, digital, and biological realms. In this era, innovations like artificial intelligence (AI), the Internet of Things (IoT), and biotechnology are intertwining to reshape industries, societies, and the way people live and work including long-distance truck drivers. The WEF's definition of 4IR implies that its impact on long-distance truck drivers is multifaceted as it can impact the work of long-distance truck drivers physically (through technological advancements in the physical work environment), digitally (through digital tools for efficiency and connectivity), and biologically (through initiatives to address the biological well-being of the workforce).

Understanding the situations of long-distance migrant truck drivers in the context of 4IR is important. Migrant long-distance truck drivers were chosen in this study for several reasons.

Firstly, studying long-distance truck drivers specifically those who are African migrants offers inimitable acumens and perceptions within the context of the South African landscape and the 4IR. Taking a cue from Munnik and Veenstra (2020), migrant truck drivers face additional vulnerabilities compared to South African drivers. To this effect, understanding their unique experiences provides classical views of broader social justice and migrant labour issues which are related to 4IR. Also, the study took into consideration the diversity of experiences of African migrants such as seeking better economic opportunities or escaping political and economic quagmire in their home countries (Mhandu & Mugambiwa 2021; Mhandu, Ojong & Muzvidziwa 2018). As such the study opines that examining these diversities provides a nuanced understanding of how technology intersects with labour and migration patterns in a globalised world. Migrant truck drivers often have connections to communities both in their home countries and in the regions where they work. Understanding their experiences can elucidate the socio-economic impact of their migration on both sending and receiving communities. This understanding is essential for crafting inclusive policies that address the needs of all stakeholders. In South Africa, long-distance trucking is central to the global supply chain. As migrants contribute significantly to these supply chains, they have remained an under-researched group. Studying their skills needs in the context of 4IR provides insights into the broader implications of global trade and transportation networks.

This article presents three crucial results. Firstly, it presents the role of education level as a key social factor in determining the provisioning of basic skills for handling the challenges of the 4IR. Particularly, the findings presented in this article were consistent in the way the lack of basic 4IR skills coincided with the level of attainment reported by drivers. Surprisingly, the findings revealed that truck drivers with certificate, diploma and Matric (Grade 12) or ordinary level qualifications had a 70% and 64%, respectively, lower chance of acquiring basic skills for handling 4IR challenges relative to their counterparts with degree. The authors expected the odds of observing 4IR-skills-equipped truck drivers with certificates or diplomas to be relatively lower than truck drivers with Matric (Grade 12) or ordinary level qualifications. Secondly, the article presents key economic factors that determine a driver's acquisition of basic 4IR skills. The findings revealed how drivers who used the JHB-Durban route at least once a week reportedly had lower odds of being neutral about the provision of basic skills for handling 4IR challenges compared to truck drivers who used the same route daily.

Thirdly, the article presents findings that reveal the importance of work location as a crucial factor that influences truck driver acquisition of 4IR basic skills. Particularly, this article shows that KwaZulu Natal (KZN) province, as a registered work location for long-distance truck drivers, had a lower chance of acquiring basic skills for handling 4IR challenges compared with other provinces such as Gauteng, Mpumalanga, Limpopo, Western Cape, and Northern Cape.

This article contributes broadly to the scientific body of knowledge which seeks to explore and examine the factors that influence the acquisition of basic skills for handling 4IR challenges by long-distance truck drivers. The article contributes to the effective planning, design, and implementation of training intervention programmes for truck driver upskilling in areas of 4IR technological tools and digital platforms. The contribution of this study informs policy and legal frameworks on skills development within the working environment, including policy design on long-distance truck drivers' education, as well as informing aspects of the Labour Act, for example, study leaves, time and days, and others.

The rest of this article is organised as follows: Section 2 presents an extensive review of existing literature, offering a comprehensive analysis of prior research and scholarly contributions in the field. Section 3 presents a detailed exposition of the data sources and research methodologies employed in the study, facilitating a clear understanding of the research approach. In Section 4, research findings are discussed, offering a comprehensive analysis and interpretation of the study's results and their implications. Section 5 provides concise concluding remarks summarising the key insights and implications drawn from the study, offering closure to the research.

Problem statement

The 4IR has presented a change in the global economy. According to the European Commission (2017), the 4IR presents a paradigm shift driven by technological innovations in labour markets. Although 4IR has presented many opportunities, Autor (2015) opines that disparities in access to basic skills and socio-economic factors pose significant challenges to equitable participation in the digital age. In the era of 4IR, there is a gap in understanding the socio-economic factors of basic skills provision and its effects on addressing inequalities.

The effects of the 4IR in the trucking industry materialise when truck drivers are introduced to tech-induced challenges which, as a result, alter their lives and work formats. The challenges of the 4IR materialise physically, digitally, and biologically. Consequently, truck drivers, particularly long-distance truck drivers, ought to be provided with essential skills for navigating the direct and indirect challenges posed by the introduction of technology and other computer-based systems in the trucking industry (Bessen 2019; Chetty, Friedman & Hendren 2018; World Economic Forum 2018). The 4IR has posed substantial challenges to long-distance truck drivers in South Africa acutely in terms of basic skills. This argument finds complementarity in Bessen (2019) who argues that truck drivers face a plethora of challenges in integrating digital platforms, automated vehicles and technological competencies to navigate the challenges of the 4IR in a rapidly changing landscape. Taking a cue from Chetty et al. (2018), as the

transport industry experiences digital transformation characterised by improvements in logistics technology, automation and in some instances route optimisation, long-distance truck drivers in South Africa face a serious need to improve their digital literacy and technological proficiencies to maintain relevance. This article argues that addressing the intricate challenges faced by long-distance truck drivers requires tailored skill provision programmes that allow them to navigate the complexities of 4IR.

It is therefore crucial for companies and organisations interested in the work of long-distance truck drivers to understand driver- and work-related factors that influence the provision of basic skills to long-distance truck drivers to facilitate the planning, design, and implementation of intervention programmes including the development of strategies to ensure that such interventions are properly implemented This study aims to investigate the socio-economic factors that influence truck drivers' acquisition of skills essential for handling the direct and indirect challenges of the 4IR. Against this backdrop, the purpose of this study is to investigate the impact of socio-economic variables influencing the provision of basic skills for navigating the challenges of the 4IR. To achieve this purpose, a quantitative statistical-based research design was used to interrogate Southern African migrant long-distance truck drivers' data.

Aim of the study

This study aims to quantitatively investigate the impact of socio-economic variables influencing the provision of basic skills for long-distance truck drivers to navigate the challenges of the 4IR in South Africa.

Objectives of the study

The specific objectives of the study were:

To comprehensively describe key socio-economic variables (age, company type, education level, routes among others) underpinning this study, using statistical analysis and quantitative measurement to ensure a thorough understanding.

To investigate socio-economic variables' role in providing basic skills for handling direct and indirect challenges of the 4IR using chi-square tests and multinomial logistic regression techniques.

To provide recommendations, based on research findings, on strategies for ensuring that long-distance truck drivers are well-equipped with the necessary skills for meeting the demands of the 4IR.

Literature review

The 4IR significantly affects all aspects of life including education, employment, family, and international migration (Xu, David & Kim 2018). Substantial evidence from Li, Hou and Wu (2017) as well as Romney and Steinhart (2018) indicates that the 4IR is not limited to industrial production. Rather, it is present in all fields of society and enables diverse innovation through digital technology. According to Manyika et al. (2017), 4IR consists of new developments in information technologies coupled with the Internet, automation of tasks, robotisation, and many other advances in manufacturing and transport.

Technology has created innovative interventions, enormous wealth, and undesired disruptions in the labour market. According to Frey and Osborne (2017), the pace of technological development/advancement is increasing, and the 4IR has disrupted the labour market making workers redundant. There are a plethora of ways by which new technologies have exposed workers, including truck drivers, to the risk of automation. These factors include a low level of education and training, a low degree of adaptation to automation, and low communicative cognitive skills (Manyika & Sneader 2018; World Bank 2019; Zervoudi 2022). More accurately, Zervoudi (2020) further argues that highly educated workers are less likely to be threatened by automation than low-specialised employees. Consequently, automation results in a decline in employment in low-income service industries (Frey & Osborne 2017). In other employment sectors, the 4IR exacerbated income inequality. Evidence can be drawn from a study conducted by Frey and Osborne (2017) which concludes that income inequality caused by the 4IR and rapid technological progress in developing countries has increased since 1999. Complementary analysis is also provided by Deloitte (2018) who argues that the adoption of automation and new technologies such as AI in South Africa might drive social turmoil and increase income inequality.

With the advent of the 4IR, there is fear that automation and digitisation will most likely drive to the 'End of Work'. This argument finds complementarity in Frey and Osborne (2017:255), who anticipate the possibility of human factor replacement by machines and robots because of the 4IR resulting in a probable 'creative disaster'. The impact of the 4IR on the labour market is evidenced by an ongoing decline in the manufacturing industry and the decline in a plethora of routine jobs (Autor & Dorn 2013; Frey & Osborne 2017). With the use of the Internet, new technology and data sources require workers to employ adaptive adjustment of relevant technological indicators in the changing nature of work. The main argument herein is that digitisation results in far-reaching changes to business models.

Literature has shown different challenges and opportunities experienced by truck drivers in South Africa in the context of the 4IR. To some extent, the 4IR has opened doors for new roles and professions within the trucking industry. The necessary skills to deal with advanced technologies and maintain autonomous vehicles have opened new opportunities (Kern 2021). In the United States, this shift in technology has also created opportunities for truck drivers to become entrepreneurs and establish their businesses (Shoag, Strain & Veuger 2021). In Southern Africa, there are practical innovations that are being piloted. For example, Kenya, and Mozambique are piloting a mobile-based digital payment system called M-PESA to promote financial

inclusion and reduce transaction costs (Jack and Jill Foundation, n.d.). However, in South Africa, advanced technologies have created a plethora of challenges for long-distance truck drivers. As an illustration, Sutherland (2020) opines that automation in long-distance trucking is a primary challenge faced by South African truck drivers. In addition, Kern (2021) adds that technological advancement led to the development of self-driving trucks, which will likely replace human drivers. Technological advancements such as integrated systems, AI, and robotics automate various functions previously performed by truck drivers, such as navigation and delivery (Gittleman & Monaco 2020; Viktor & Szeghegyi 2022; Xu et al. 2018). These technological advancements will threaten job security for many South African truck drivers.

PwC (2016) cited new technology among the top four challenges the transportation and logistics companies must confront for the industry sector to fully prepare itself to handle potential future risks and opportunities of the 4IR. The report acknowledges that digital and lack of digital training thereof remains the biggest challenge for the transport sector. Kuteyi and Winkler (2022) underscore the importance of offering human capital training when adopting and introducing digital technologies.

de Winter et al. (2023) explored the challenges faced by truck drivers in the era of technological advancement and revealed that the vehicle technology received mixed reactions from the truck drivers with some drivers praising vehicle technology from a safety and fuel-saving perspective while raising concerns about reliability and intrusiveness. The conclusions reached by de Winter et al. are important to this study because they reinforce the underlying hypothesis for this study that truck drivers face daily challenges thereby reaffirming the need to undertake research work on long-distance truck drivers to build understanding and knowledge to inform the process of effect necessary industry improvements. Some of the specific challenges the truck drivers face in the context of 4IR include automation and job displacement, job insecurity, and safety concerns regarding autonomous vehicles.

Truck drivers also face the challenge of adjusting to the continuously changing technological environment. These adjustments may include the need for truck drivers to adopt advanced driver assistance systems (ADAS) as well as other digital tools for optimising driver efficiency, for example, enhanced tracking systems, digitised flows of information, AI and automated route monitoring and camera surveillance systems to ensure that drivers remain observant of traffic laws and regulations (Kuteyi & Winkler 2022). Researchers have reported potential benefits of new technologies such as safety and security offered by systems like Autonomous Emergency Braking (AEB) and Lane Departure Warnings (LDW) (Hickman et al. 2015; Teoh 2021). Despite the potential for truck drivers to enjoy all these benefits, researchers have warned that introducing new technologies to the transport sector can generate driver resistance especially when drivers are not properly equipped with essential skills for using such technologies (Jaller, Otero-Palencia & D'Agostino 2022; Van Fossen et al. 2022).

Schuster et al. (2023) emphasise the need for the transport sector to receive wider adoption of new technology by older workers as a prerequisite for attracting new drivers in the now 4IR-impacted transport industry. Further, Schuster and collaborators underscore the need to implement training programmes that target drivers to equip them with essential skills that will prepare them for an autonomous future. To this effect, the importance of skills training for long-distance truck drivers cannot be undermined. It enhances safety, efficiency, and adaptability within the trucking industry. Tay et al. (2021) underscore that skills training equips long-distance truck drivers with the ability to positively respond to technological advancements and the changing nature of work in the transportation sector. Ahmed, Yang and Gaweesh (2019) add that new training skills contribute to the establishment of soft skills that assist in effective conflict resolution and create a positive representation of trucking.

Data and methods

Data collection

The study utilised a quantitative research method. Bryman (2012) states that one of the most important advantages of quantification is that it brings objectivity and accuracy as there are fewer variables involved and the data collected is close-ended. As informed by Ryan (2006), the researchers employed reductionism as a means of statistically validating the various ways in which long-distance truck drivers have been disadvantaged by lack of adequate training during the 4IR. A probability simple random sampling was used. Initially, the questionnaire targeted 500 participants. The justification for such a big sample size was grounded in the researchers' desire to build a data bank that could be used for further research projects. However, only 314 participants completed the questionnaire, making a response rate of 62.80%. This valuable data were gathered through a meticulously designed research questionnaire, which was distributed online via the WhatsApp platform. The questionnaire was designed using Kobotoolbox. The target population comprised long-distance Southern African migrant truck drivers operating along the N1 (Johannesburg to Beitbridge border) and N3 (Johannesburg to Durban) highways. The total number of long-distance truck drivers is unknown.

The questionnaire was distributed online using WhatsApp. The research was cleared by the Research Ethics Committee of the University of Johannesburg. The questionnaire was administered in December 2022 and April 2023, with invitations disseminated through WhatsApp platforms. Collecting data in December was a limitation of the study because the majority of the manufacturing industries were closed, and most truck drivers were on holiday. For this

reason, the data collection period was extended to April 2023. The researchers got WhatsApp numbers for targeted sample elements from their network of connections as they are also Zimbabwean migrants staying in Johannesburg and Durban. In March 2023, the response rate was still low (63 participants) and the researcher (first author) adopted a new strategy of visiting truck stops around Durban Harbour, and the abovementioned N1 and N3 routes. Apart from the truck stop, participants were also found at the Freight distribution centres and warehouses as well as online forums and communities. This significantly raised the response rate from 63 to 314 participants. The rationale for selecting the survey design was informed by the researchers' desire to observe scores and patterns across the dataset to show how numerically significant the working-class long-distance truck drivers' plight is. A simple random sampling was used. The study focused on migrants from Southern African countries namely Botswana, Lesotho, Malawi, Mozambique, Swaziland, Zambia, and Zimbabwe. Migrant long-distance truck drivers who are not citizens of the abovementioned countries were deliberately excluded from participating in this study. Also, long-distance truck drivers who are South African citizens were excluded from participating in the study. However, this aspect appeared to be very sensitive and excluding other long-distance truck drivers from the study would potentially result in conflicts. The researchers thus recorded this as a limitation of the study. The research process adhered to ethical standards and received clearance from the University of Johannesburg ensuring the integrity and compliance of the study. The ethical considerations namely informed consent, confidentiality, voluntary participation, and anonymity were observed throughout the research process. This was done to adhere to ethical norms of research and to protect the dignity and welfare of research participants.

Validity was ensured in this work by piloting the questionnaire to 20 long-distance drivers to ascertain the clarity of instructions and questions (Mogire, Kilbourn & Luke 2023). Further, validity of research findings was also ensured through validation of the research questionnaire as necessitated by undertaking extensive research (Jensen 2003). Reliability was ensured by making sure that relevant information was gathered from long-distance truck drivers while also ensuring that variables were properly formulated to minimise ambiguity (Cizek 2009).

Data analysis

Harding (2018:21) defines data analysis as a 'process of inspecting, cleansing, transforming, and modeling data to discover useful information, informing conclusions, and supporting decision-making using multiple approaches and diverse techniques'. In pursuit of our predefined objectives, a comprehensive data analysis was conducted on the dataset of long-distance truck drivers. This analytical process involved a range of statistical techniques, including descriptive statistics, frequency distribution tables, chi-square tests, odds ratios, and the application of a multinomial regression model. These diverse analytical tools were harnessed to scrutinise the data thoroughly and derive meaningful insights that form the foundation of the findings presented in this study. To achieve the aim and objectives as outlined earlier, data analysis was performed on the long-distance truck drivers' data. Descriptive statistics, frequency distribution tables, chi-square tests, odd ratios, and multinomial regression models are used to analyse the data and deduce the insights which informed the document of the findings of this study.

Ethical considerations

Ethical approval to conduct this study was obtained from the University of Johannesburg Faculty of Humanities Research Ethics Committee. (No. REC-01-283-2022).

Results

Distribution of the research variables

Figure 1 presents a visual summary of the variables and responses under examination. The figure provides valuable insights into the distribution of responses, including their proportional representations.

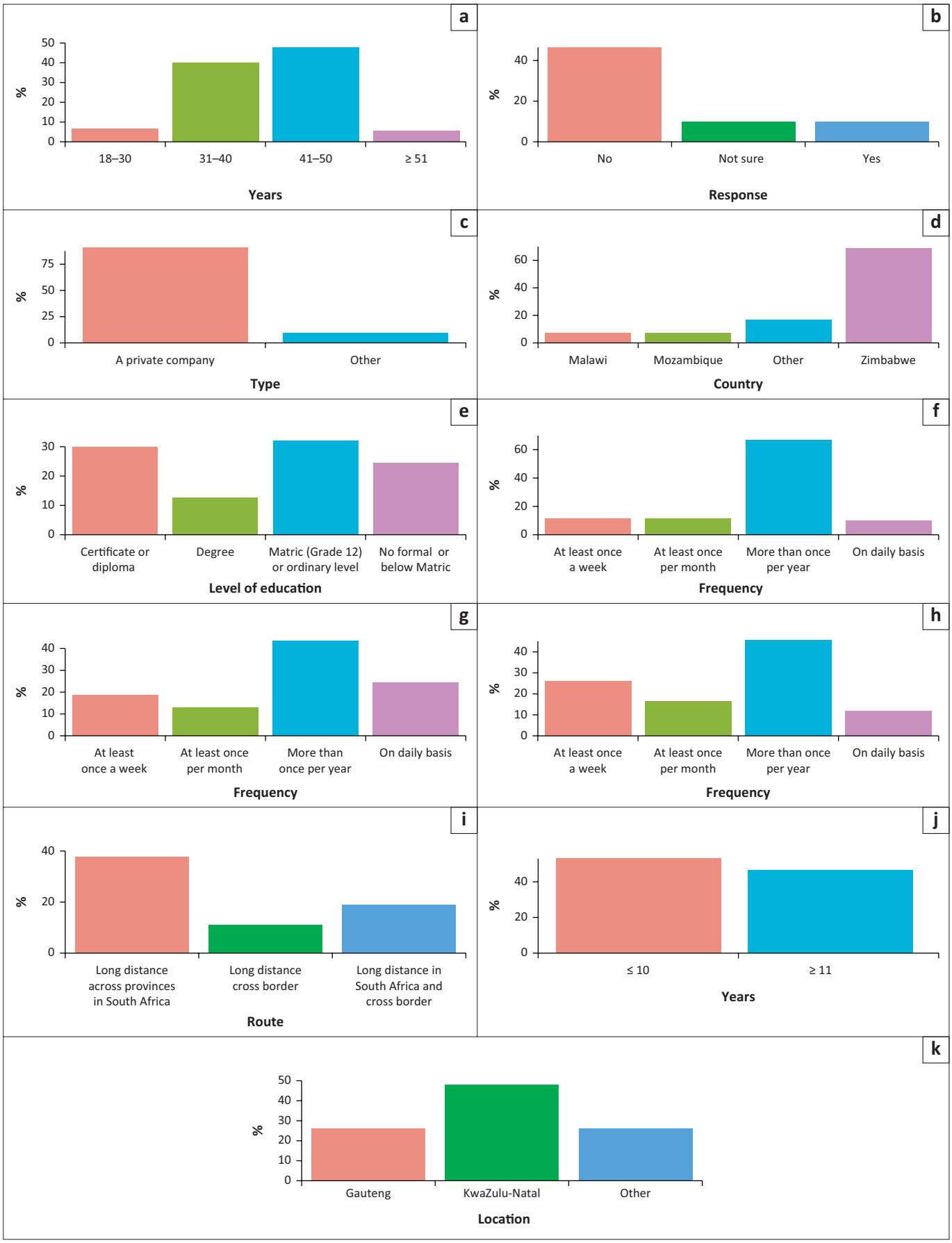
Chi-Square test for associations

Tests for association revealed that company type (Private or Other) significantly influenced several dependent variables. Table 1 presents chi-square results showing results of variables whose associations with company type are statistically associated with the company type.

The Chi-square tests reveal significant associations between company type and various variables, including basic skills, received training in the 4IR, training provision, and training in intelligent transport systems (ITS). This indicates that participants' responses to these variables are strongly influenced by the type of company they belong to.

Multinomial Regression Model

Multinomial logistic regression is a statistical model used to analyse the relationship between a categorical dependent variable with more than two categories and one or more independent variables (Mwenda, Wanjoya & Waititu 2015). In the context of the present study where the dependent variable Y has categorical responses (No, Not Sure, and Yes) and multiple independent variables X, the multinomial logistic regression is the most preferred model. A multinomial logistic regression model seeks to model the probability of each category of the dependent variable as a function of the independent variables using the softmax function. Under the multinomial regression modeling technique, each category of the dependent variable is compared to a reference category (alternatively, the base category). The model works by estimating coefficients for each independent variable for each category of the dependent variable which allows for an understanding of how each independent variable affects the likelihood of each category relative to the base category.



JHB, Johannesburg.

FIGURE 1: Bar graphs showing the distribution of variables: (a) Age; (b) basic skills; (c) company type; (d) country origin; (e) education level; (f) JHB-Cape Town route; (g) JHB-Durban route; (h) JHB-Musina route; (i) Main routes; (j) work experience; (k) work location.

TABLE 1: Chi-square results for variables statistically associated with company type.

Dependent variable	Chi-square	*df*	*p*
Do you have the basic skills to respond to the direct and indirect challenges posed by the Fourth Industrial Revolution?	11.722	6	< 0.05
Did you receive any training on the Fourth Industrial Revolution at work or new technologies at work?	14.127	4	< 0.05
Did your company provide training to navigate the effects of the Fourth Industrial Revolution in the past 3 years till to date?	17.034	6	< 0.05
Received training in Intelligent transport systems, including automated warehouses area of the Fourth Industrial revolution (Yes/No)	14.963	4	< 0.05

Model setup

The variables that we used to build the multinomial regression model are described below:

Dependent variable:

Do you have the basic skills to respond to the direct and indirect challenges posed by the 4IR? (No = 0, Not Sure = 1 or Yes = 2).

Explanatory variables (all are indicator variables):

1. : age_18–30 years
2. : age_31–40 years
3. : age_41–50 years
4. : country_origin2_Zimbabwe
5. : work_experience_<= 10 years
6. : work_location_Gauteng
7. : work_location_KwaZulu-Natal
8. : education_level_certificate or diploma
9. : education_level_matric/grade 12/ordinary level
10. : education_level_no formal/below matric
11. : main_routes_Long distance across provinces in South Africa
12. : main_routes_Long distance cross border
13. : JHB_Musina_At least once a week
14. : JHB_Musina_At least once per month
15. : JHB_Musina_More than once per year
16. : JHB_Cape Town_At least once a week
17. : JHB_Cape Town_At least once per month
18. : JHB_Cape Town_More than once per year
19. : JHB_Durban_At least once a week
20. : JHB_Durban_At least once per month
21. : JHB_Durban_More than once per year
22. : compay_type_A private company

Overall, the explanatory variables for the multinomial regression model prior to converting them to indicator variables include age, country of origin, work experience, work location, education level, main route, JHB-Musina/Beitbridge, JHB-Cape Town, JHB-Durban, and company type.

Model results

The results presented in Appendix 1 convey two messages. Firstly, it displays significant and insignificant predictors for estimating log odds of observing 'not sure' instead of observing a 'no'. As presented in Appendix 1, three variables are significant predictors of the model for predicting the log odds of observing the response outcome 'not sure' given that response outcome 'no' has occurred. The significant predictor variables are 'work location-Gauteng', 'JHB to Musina/Beitbridge – at least once a week', 'JHB to Durban – more than once per year'. Secondly, the table displays significant and insignificant predictors for predicting the log odds of observing 'Yes' rather than 'no' as response to the dependent variable. Seven indicator variables are significant predictors namely 'work location – KwaZulu-Natal', 'education level – certificate or diploma', 'education level – matric/grade 12/ordinary level', 'education level – no formal/below matric', 'main routes – long distance across provinces in South Africa', 'JHB to Durban-more than once per year', 'company type – private company'. Identifying significant predictors has strong implications for effectively targeting planned training programmes aimed at providing basic 4IR skills to long-distance truck drivers.

Discussion of findings

The first objective of this study was to describe the socio-economic variables of the primary data underpinning this study. To this end, F igure 1 describes the socio-economic variables to respond directly to this objective . As clearly shown in Figure 1, the majority of truck drivers who responded to the survey had no essential 4IR skills. The majority of truck drivers are aged between 41 and 51 years old, employed by private companies with Zimbabwe as their country of origin. Further, majority of drivers were educated up to matriculate level or equivalently ordinary level. The majority of truck drivers drove across South Africa as well as cross-border. The truck drivers reported that they frequently used JHB-Cape Town, JHB-Musina, and JHB-Durban routes for a number of times exceeding once per year. The majority of these truck drivers worked in the KwaZulu-Natal province and their level of experience was nearly shared equally between those with less than 11 and those with greater than 11 years of experience. The implication of these findings is that the majority of truck drivers require training interventions to ensure that they are equally equipped with essential skills for handling challenges associated with the 4IR revolution.

The second objective of this study was to investigate the role of socio-economic variables in the provision of basic skills for handling direct and indirect challenges of the 4IR. Chi-square test and multinomial logistic regression results have been presented to respond effectively to the second objective of this study. Particularly, chi-Square test revealed that company type influenced possession of basic skills to handle direct and indirect challenges of 4IR among long-distance drivers including receipt of training on 4IR and ITS as well as provision of training by companies. The implication of this finding is that company type is a significant predictor of variables related to the possession of basic skills, provision of training on 4IR, and ITS. This means that interventions seeking to address gaps in equipping truck drivers with

basic 4IR skills including skills in integrated transport systems must be informed by company type to ensure that they achieve maximum impact possible. Particularly, multinomial regression results revealed that truck drivers who worked for private companies were less likely to possess basic skills for navigating through the challenges associated with the 4IR.

The findings of this study revealed that 'Gauteng work location' is a significant predictor for estimating the conditional probability of observing 'Not sure' given that the response outcome 'No' has occurred. The multinomial regression model reports a statistically significant coefficient of 0.4454 for the indicator variable 'Gauteng work location' at a 10% level of significance ($Z = 1.859$, $p < 0.1$). This means that the log-odds of observing 'Not sure' rather than a 'No' is 56% higher for long-distance truck drivers located in Gauteng than truck drivers from other provinces (in this case, other provinces refer to Free State, Western Cape, Northern Cape, Limpopo etc). In other words, truck drivers from Gauteng province are more likely to be unsure of having received training in essential 4IR skills relative to truck drivers from other provinces. The implication of this finding is that it may be used to target truck drivers for purposes of equipping them with essential 4IR skills.

The model also reveals that the indicator variable 'JHB to Musina route at least once a week' is a significant predictor of the log-odds of observing 'Not sure' rather than a 'No'. In particular, the model reports a statistically significant coefficient value of −0.7002 at a 5% level of significance for the indicator variable 'JHB to Musina route at least once a week'. The value is negative meaning that switching the indicator variable to 1 reduces the log odds of observing 'Not sure' instead of a 'No'. The negative coefficient of −0.7002 means that the log-odds of observing the response outcome 'Not sure' rather than a 'No' is nearly 50% lower for truck drivers who use 'JHB-Musina route at least once a week' than truck drivers who use 'JHB-Musina route on a daily basis'. This finding suggests that truck drivers who drive along the JHB-Musina route daily were more likely to reveal that they had not been provided with basic skills to equip them to effectively respond to direct and indirect challenges of the 4IR. The increased likelihood of long-distance truck drivers who frequent the JHB-Musina route denying receipt of essential 4IR skills underscores the necessity for training in fundamental 4IR skills within this group of long-distance truck drivers. In other words, keeping drivers on the road daily leaves drivers with no time to attend 4IR skills training programmes.

The findings of this study reveal that the indicator variable 'JHB to Durban – more than once per year' is a significant predictor in a model for predicting the log-odds of observing the response outcome 'Not sure' instead of a response outcome 'No'. Particularly, the model reports a positive and statistically significant coefficient value of 0.5179 for the indicator variable 'JHB to Durban – more than once per year' is 0.5179 ($Z = 2.001$, $p < 0.05$). This means that the log-odds of observing 'Not sure' rather than 'No' is approximately 68% higher for truck drivers who use the JHB to Durban route on a frequency exceeding once per year compared to truck drivers who use the JHB to Durban route daily. This finding implies that the odds of observing a 'No' rather than 'Not sure' is lower among truck drivers who use the JHB to Durban route daily compared to drivers who use 'JHB to Durban – more than once per year'. Therefore, it is imperative to transition the prevalent state of uncertainty among truck drivers utilising the JHB-Durban route more than once a year into a state of affirmative confirmations.

The findings of this study reveal that the indicator variable 'KwaZulu-Natal work location' is a significant predictor of the logistic model predicting the log-odds of observing the response outcome 'Yes' instead of the response outcome 'No'. For instance, the model reports a negative and statistically significant coefficient value of −0.5053 for the indicator variable 'KwaZulu-Natal work location' ($Z = -1.760$, $p < 0.1$). The log-odds value of −0.5053 means that the odds of observing 'Yes' rather than 'No' are 40% lower for truck drivers whose work location is KZN compared to long-distance truck drivers stationed in other provinces. In other words, this finding suggests that the odds of observing a 'Yes' response rather than a 'No' response are higher for other provinces compared to the KZN work location. The significance of this finding lies in its potential to target truck drivers from KZN for tailored training programmes addressing the 4IR basic skills gap among long-distance truck drivers. This approach optimises the utilisation of available training resources, thereby amplifying the impact of training programmes through precise targeting of beneficiaries.

The findings of this study revealed that the level of education possessed by long-distance truck drivers is a significant predictor in predicting log odds of observing a 'Yes' rather than a 'No'.

For instance, the model reports a negative and statistically significant coefficient value of −1.1983 for the indicator variable 'certificate or diploma education level' ($z = -4.532$, $p < 0.05$). This implies that having attained a certificate or diploma level of education significantly influences log odds of observing the response outcome 'Yes' rather than 'No'. Specifically, the finding reveals that the log odds of observing 'Yes' over 'No' are 70% lower for truck drivers with a certificate or diploma qualification than truck drivers who are degreed. Similarly, a negative and statistically significant coefficient value of −1.0205 is reported for the indicator variable 'matric/grade 12/ordinary level education level' ($z = -4.029$, $p < 0.05$). This means that the odds of observing 'Yes' rather than 'No' is 64% lower for truck drivers with matric/grade 12/ordinary level qualification compared to truck drivers with a degree education level.

The model reports a statistically significant log-odds value of −1.1871 at the 5% level of significance. The log-odds value of −1.1871 means that the odds of observing a response outcome 'Yes' rather than 'No' is 69% lower for truck drivers with no formal or below Matric qualification compared to truck drivers with a degree qualification. These findings carry significant implications for guiding the planning, design, and execution of training initiatives tailored to equip long-distance truck drivers with fundamental 4IR skills. Such programmes aim to enhance their ability to adeptly navigate challenges posed by the 4IR in the course of their duties, ensuring they remain effective and efficient in their roles.

The findings of this study also revealed that the variable 'main routes' was a significant predictor of predicting the log-odds of observing a 'Yes' rather than a 'No'. The model reports a statistically significant coefficient value of −0.4055 ($z = -1.780$, $p < 0.05$). The log-odds value of −0.4055 means that the odds of observing 'Yes' rather than 'No' is 33% lower for cross-border truck drivers than truck drivers who drive long-distance in South Africa and cross-border. This finding suggests that truck drivers exclusively engaged in cross-border routes may have limited access to opportunities for acquiring training in essential 4IR skills, unlike their counterparts who operate partially within South Africa and partially cross borders. This identified discrepancy in access to 4IR training between exclusively cross-border truck drivers and those with mixed routes underscores the need for policy interventions aimed at ensuring equitable access to training opportunities across all categories of truck drivers. Consequently, policymakers should consider implementing targeted initiatives to provide comprehensive 4IR skill training to cross-border drivers, thereby fostering a more inclusive and prepared workforce within the transportation sector.

The research findings show that there are statistically significant differences between truck drivers who drive along the JHB to Durban route more than once per year and those who drive the same route daily. The model reports a statistically significant coefficient value of −0.9211 for the indicator variable 'JHB to Durban – more than once per year' ($z = -2.788$, $p < 0.05$). The log-odds value of −0.9211 means that the odds of observing 'Yes' rather than 'No' is nearly 60% lower for truck drivers who use JHB to Durban for a frequency exceeding once per year than truck drivers who use JHB to Durban on a daily basis. In other words, truck drivers who ply the JHB-Durban route daily are highly likely to have been provided with basic skills that capacitate them to handle direct and indirect challenges of the 4IR relative to truck drivers who ply the same route more than once per year. The practical implication of this finding suggests an opportunity to develop strategies aimed at equipping all truck drivers traversing the JHB-Durban route with fundamental 4IR skills, regardless of the frequency of their route utilisation.

Finally, the findings of this study showed that the nature of companies where truck drivers worked influenced whether they admitted to having been equipped with basic skills for the 4IR or otherwise. A statistically significant coefficient of indicator −0.4183 is reported for 'private company' indicator variable. The log-odds value of −0.4183 means that the odds of observing 'Yes' rather than 'No' is nearly 58% lower for truck drivers working for private companies than truck drivers working for other companies such as non-profit organisation (NPO), community-base organisation (CBO), government, and public entities. The observed disparity in the reported incidence of truck drivers employed by private companies who claim to possess basic 4IR skills underscores the need for targeted training interventions to address this discrepancy between private enterprises and other organisational structures. This calls for a nuanced approach to policy formulation wherein the government may seek to refine the National Skills Development Policy to incentivise both private and non-private entities to prioritise the provision of fundamental 4IR skills. Such alignment with National Development Strategies is crucial for fostering holistic economic, social, and political advancement.

Recommendations

The third objective of this study relates to the need to recommend strategies for ensuring that long-distance truck drivers are well equipped with skills necessary for them to meet the demands of the 4IR. Consequently, on the basis of the findings established in this study, this article presents the following recommendations:

- This study reported that truck drivers from Gauteng are more likely to be unsure/neutral with regards to the status of having been provided with basic skills to handle 4IR changes. Neutrality may mean either a 'Yes' or 'No'. It is therefore recommended that training interventions on 4IR basic skills target truck drivers from Gauteng province as there lies enough room for change in the perceptions of drivers through providing training on basic 4IR skills to ensure that truck drivers in Gauteng are well equipped with the skills required of them to navigate through the direct and indirect changes of the 4IR. The same recommendation also extends to truckers who ply JHB to Musina daily and JHB to Durban more than once per year.
- We recommend that trucking companies allocate financial resources to support truck drivers who wish to pursue further education. This recommendation is based on a compelling finding that highlights the educational qualifications of truck drivers, revealing that truck drivers with a degree level of education had higher odds of having provided with basic skills relative to truck drivers with education level lower than degree level, including those with no formal education, only a Matric, or certificates and diplomas.
- We recommend that the trucking industry establish collaborations with organisations like the African Unite Borders Bus Trucks Association (AUBBTA) to enhance the preparedness of cross-border truckers in dealing with

the evolving challenges presented by the 4IR. This recommendation is rooted in a noteworthy finding indicating that cross-border truck drivers exhibit a lower likelihood of possessing the essential skills required when compared to their counterparts who operate on both local and cross-border routes.

- We recommend the conducting of qualitative research to allow for in-depth investigation of the identified significant variables such as work location, education level, main routes, and company classification. It is our understanding that this proposed type of research will enable the discovery of nuanced factors within these identified variables thereby assisting in providing valuable insights into why they are influential in predicting truck drivers' admission to receiving basic training in 4IR skills.

Conclusion

In this study, we used a multinomial regression model to describe long-distance truck driver data collected in South Africa. The goal was to understand participants' socio-demographic variables that influence the assimilation of basic skills necessary for handling the direct and indirect challenges of the 4IR. The study revealed that work location, education level, main routes, JHB-Durban route, and company classification variables are significant predictors for estimating the log odds of truck drivers acknowledging receipt of basic training in 4IR skills. These findings have practical implications on policy formulations as well as on planning, design, and implementation of training interventions targeted at equipping long-distance drivers with essential 4IR skills. Governments must prioritise the provision of training to long-distance truck drivers to enable small trucking companies to adopt 4IR technologies. Through initiating and supporting 4IR skills provision training programmes, long truck drivers from small transport companies may end up becoming more receptive to new technologies characterising the trucking industry. This study contributes to the body of knowledge regarding factors affecting long-distance truck drivers in getting basic 4IR skills essential for them to properly implement new technologies arising in the haulage trucking industry. This quantitative study opens space for future qualitative research as it allows researchers to document the experiences of long-distance truck drivers in the face of newly emerging technologies in the transport industry.

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Competing interests

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Authors' contributions

J.M. was responsible for research instrument design, diligent data collection, ensuring data validation, and contributed significantly to the writing process. M.C.M. played a pivotal role in the project's conceptualisation, conducted extensive writing, contributed to the methodology design, performed data analysis, created visualisations, and developed essential software components. K.B. was responsible for checking the article to be submitted, giving substantive input for all the sections, and making corrections where necessary.

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Data availability

There is no restriction of data available. We confirm that there are no web links for publicly available dataset.

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Appendix 1

TABLE 1-A1: MNLogit regression results.

Basic_skills = 1 (Not Sure)	coefficient	std err	z	P > |z|	[0.025	0.975]
Constant	-1.8676	0.206	-9.073	0.000	-2.271	-1.464
age_18–30 years	0.1423	0.273	0.521	0.603	-0.393	0.678
age_31–40 years	0.2572	0.452	0.569	0.569	-0.628	1.143
age_41–50 years	-0.0154	0.451	-0.034	0.973	-0.900	0.869
country_origin2_Zimbabwe	-0.0993	0.208	-0.478	0.633	-0.507	0.308
work_experience_<= 10 years	-0.0093	0.198	-0.047	0.962	-0.398	0.379
work_location_Gauteng	0.4454	0.240	1.859	0.063*	-0.024	0.915
work_location_KwaZulu−Natal	0.4070	0.257	1.581	0.114	-0.098	0.912
education_level_certificate or diploma	0.1341	0.391	0.343	0.732	-0.632	0.900
education_level_matric/grade 12/ordinary level	0.1872	0.395	0.474	0.636	-0.587	0.962
education_level_no formal/below matric	0.1984	0.385	0.515	0.606	-0.556	0.953
main_routes_Long distance across provinces in South Africa	0.2484	0.235	1.057	0.291	-0.212	0.709
main_routes_Long distance cross border	0.1765	0.213	0.827	0.408	-0.242	0.594
JHB_Musina_At least once a week	-0.7002	0.290	-2.417	0.016**	-1.268	-0.132
JHB_Musina_At least once per month	-0.4128	0.263	-1.571	0.116	-0.928	0.102
JHB_Musina_More than once per year	-0.2473	0.258	-0.959	0.338	-0.753	0.258
JHB_capetown_At least once a week	0.2964	0.293	1.012	0.311	-0.277	0.870
JHB_capetown_At least once per month	0.4058	0.281	1.444	0.149	-0.145	0.957
JHB_capetown_More than once per year	0.2266	0.337	0.673	0.501	-0.434	0.887
JHB_Durban_At least once a week	0.1690	0.256	0.659	0.510	-0.334	0.672
JHB_Durban_At least once per month	0.2630	0.239	1.099	0.272	-0.206	0.732
JHB_Durban_More than once per year	0.5179	0.259	2.001	0.045**	0.011	1.025
company_classification_A private company	0.0964	0.210	0.459	0.647	-0.316	0.509
Basic_skills = 2 (Yes)						
Constant	-2.1337	0.242	-8.808	0.000	-2.608	-1.659
age_18–30 years	0.2418	0.268	0.903	0.367	-0.283	0.767
age_31–40 years	-0.2720	0.415	-0.656	0.512	-1.085	0.541
age_41–50 years	-0.3335	0.407	-0.819	0.413	-1.132	0.465
country_origin2_Zimbabwe	-0.0075	0.240	-0.031	0.975	-0.478	0.463
work_experience_<= 10 years	-0.2084	0.211	-0.990	0.322	-0.621	0.204
work_location_Gauteng	-0.3504	0.253	-1.384	0.166	-0.847	0.146
work_location_KwaZulu-Natal	-0.5053	0.287	-1.760	0.078*	-1.068	0.057
education_level_certificate or diploma	-1.1983	0.264	-4.532	0.000**	-1.717	-0.680
education_level_matric/grade 12/ordinary level	-1.0205	0.253	-4.029	0.000**	-1.517	-0.524
education_level_no formal/below matric	-1.1871	0.303	-3.922	0.000**	-1.780	-0.594
main_routes_Long distance across provinces in South Africa	-0.4055	0.228	-1.780	0.075*	-0.852	0.041
main_routes_Long distance cross border	-0.1633	0.235	-0.696	0.487	-0.623	0.297
JHB_Musina_At least once a week	0.0242	0.349	0.069	0.945	-0.661	0.709
JHB_Musina_At least once per month	-0.2027	0.306	-0.662	0.508	-0.803	0.398
JHB_Musina_More than once per year	-0.1771	0.349	-0.507	0.612	-0.861	0.507
JHB_capetown_At least once a week	0.0974	0.271	0.359	0.719	-0.434	0.628
JHB_capetown_At least once per month	-0.2469	0.278	-0.887	0.375	-0.792	0.299
JHB_capetown_More than once per year	-0.1772	0.336	-0.528	0.598	-0.835	0.481
JHB_Durban_At least once a week	-0.2028	0.269	-0.755	0.450	-0.730	0.324
JHB_Durban_At least once per month	-0.0754	0.228	-0.331	0.741	-0.522	0.371
JHB_Durban_More than once per year	-0.9211	0.330	-2.788	0.005**	-1.569	-0.274
compay_classification_A private company	-0.4183	0.173	-2.420	0.016**	-0.757	-0.080

Note: Pseudo R-squared : −0.1745, Log-Likelihood: −210.66, LL-Null: −255.20, LLR *p*-value: 6.846e-05.
*, significant at 0.1; **, significant at 0.05.