

CRANFIELD UNIVERSITY

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European Airline Pilot Commuting
Stress and Pilot Performance Implications

School of Aerospace, Transport and Manufacturing
Safety and Accident Investigation

Doctor of Philosophy
Academic Year: 2016–2022

Supervisor:
Dr Graham Braithwaite
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ABSTRACT

The airline pilot's profession is a highly challenging and ever-changing environment requiring constant safety-related decisions made by the pilots themselves to ensure the high standards of the aviation safety system. In an otherwise highly regulated European aviation safety system, the effects of "pilot commuting" remain a potential blind spot, even though commuting and its consequences are representing a risk for the safety of the European air transport system.

This research explores commuting stress, pilot performance, locus of control, turnover intention and safety behaviour in connection to the European pilot commuting process. Variables involved in the commuting process are established and analysed. A Europe-wide airline pilot study sent out to over 15,000 European airline pilots resulted in 1,461 usable questionnaires to examine European airline pilot commuting data for the first-time. Statistical analysis reveals that commuting is a standard behaviour of many European pilots. More than half of the European airline pilots declared themselves as active commuters by the definition of this research. The statistical analyses are based on structural equation modelling and partial least square (PLS)-structural equation modelling (SEM). These analyses reveal the interaction of commuting stress, turnover intention, locus of control, safety behaviour and resulting professional pilot performance. A predictive model has been developed which explains mediating and moderating effects on respective variables. The findings shed new light on the professional pilot performance of commuter, non-commuter and intermediate housing commuter pilots in Europe. Which were in contrast with what was anticipated from the research literature. This research identified a significant predictability and interaction between commuting stress, safety behaviour, and turnover intention. It also highlights that locus of control has a predictive quality regarding commuting stress. Applying the theoretical framework of Sloan and Cooper (1986) on pilot performance and the maximum adaptation model (Hancock and Warm, 2003), a new European airline pilot commuting model using PLS-SEM predictive qualities was developed.

This research allows a deep insight into commuting risks in terms of optimal pilot commuting distances and times and resulting pilot performance. It offers an important and, until now, neglected contribution to the European aviation safety system. A comparative three-group analysis observed that non-commuters exhibited the lowest

stress levels, while commuters experienced moderate stress due to commuting. Pilots who used intermediate housing facilities reported the highest stress levels among the three groups. Moreover, the analysis revealed that European airline pilots engaged in commuting exhibited significantly better subjective performance when compared to their non-commuting counterparts. Furthermore, the results indicate that commuters who utilize intermediate housing exhibit a significantly increased tendency to deviate from standard procedures on an individual basis, likely due to their unique commuting needs.

This model presents a foundation for innovating and implementing new strategies in managing European airline pilot commuting, duty scheduling, and base assignments, suggesting a positive direction for change based on these research findings.

Keywords: pilot commuting, pilot performance, occupational commuting, commuting stress, locus of control, turnover intention, safety behaviour.

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Furthermore, I want to thank the circle of friends involved in this process for the discussions about this topic and the valuable contributions to various levels of this dissertation. Throughout this journey I felt a deep connection to my Alma Mater Cranfield University and especially the Institute of air accident and safety investigation. The guiding questioning and consistent support of my Ph.D. adviser team, for most by Prof Dr Graham Braithwaite and Dr Robert Mayer increased my awareness to follow the way of their established and highly appreciated academic research to reach out and achieve the Ph.D. level. A significant contributing during difficult times offers me the academic chair of the review process Prof Mark Jolly who supported and encouraged me about the importance of some necessary academic reviews. I want to give him a high respect and many thanks for this “quality assurance” feedback and support in the annual reviews. In the depth of statistical analyses, it was immense helpful and constructive to rely on the tutoring, insight and checking support of Angela Schoibl from Salzburg University and Vesna Rodić Lukić, based at the University of Novi Sad. This was especially true when unexpected and new statistical results required statistical error analysis. Thank you for your insights and lecturing. I would like to emphasise in particular that the overwhelming return of individual European airline pilots surveys made the most significant contribution to this research showing and proving that commuting is an integral part of the life of European airline pilots. I sincerely hope and I am confident that this research will be an important contribute to the safer and more responsible conduct of commuting in the specific pilot commuting background. And I am glad that this study offers profound analysis and a solid foundation for legislative processes and discussions on European airline pilot commuting.

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LIST OF ABBREVIATIONS

ALPA	Air Line Pilots Association
AVE	Average variance extracted
BALPA	British Airline Pilots' Association
CBD	Central Business District
CRM	Crew Resource Management
CURES	Cranfield University Research Ethics System
DLR	Deutsches Zentrum für Luft- und Raumfahrt
EASA	European Union Aviation Safety Agency
HTMT	Heterotrait–monotrait
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
PLS	Partial least square
RMSE	Root mean square of errors
SEM	Structural equation modelling
SOP	Standard operating procedure
US	United States
VIF	Variance inflation factor

CHAPTER 1: INTRODUCTION

1.1 Statement of the Problem and Research Interest

It has been established in scientific research and is agreed in academia that commuting causes stress and that fatigue compromises task performance and affects on-the-job decision making. Multiple factors, including sleep deprivation, can lead to fatigue and subsequently influence performance. Moreover, stress (both positive and negative—eustress and distress) can lead to fatigue. Thus, a logical way to examine stress and fatigue is to first investigate factors that cause stress. Then to establish the connection of these factors with commuting, and subsequently determine how stress from commuting influences professional performance on commuting days (Costa, Pickup Z and Martino, 1988; Hennessy and Jakubowski, 2008; Hassan, 2014; Karasek, 1979; Novaco, Gonazalez and Gonzalez, 2009; Olsson et al., 2013; Ory et al., 2004; Roma and Hursh, 2012; Sloan and Cooper, 1986; Turgeman-lupo and Biron, 2017; Voydanoff, 2005).

In the aftermath of the crash of Colgan Air Flight 3407, the United States (US) National Research Council (National Research Council of the National Academies [NRCNA], 2011a) was prompted by the US Congress to investigate the 'effect of commuting on pilot fatigue'. In its report, the NRCNA (2011, p.4) highlighted that 'commuting might have contributed to fatigue'. The council concluded that: 'There is potential for pilots to become fatigued from commuting. However, there is insufficient evidence to determine the extent to which pilot commuting has been a safety risk in part because little is known about specific pilot commuting practices and in part because the safety checks, balances, and redundancies in the aviation system may mitigate the consequences of pilot fatigue' (NRCNA, 2011, p.4). When the NRCNA addressed the US airline pilot commuting situation, it did not empirically examine the variables that influenced the pilot commuting situation (actual commuting distances & times) and decision-making process. Moreover, they did not undertake research on the influence of commuting on pilots' performance.

1.2 Research Rationale

The aviation industry claims that air travel is the safest means of transport in the world and is legally mandated to actively manage imminent threats and risks to the aviation

system. A thorough safety management system is a fundamental element of every commercial aircraft operation and for many years, European aviation legislation has required operators to implement a fatigue risk management system to manage fatigue threats that might arise in a specific airline operator's system. The European Union Aviation Safety Agency (EASA) *Implementation Guideline Material on Fatigue Risk Management Systems* (International Air Transport Association [IATA], 2011) specifies that pilot commuting is a threat to aviation safety. However, it leaves the mitigation of this threat to individual pilots.

The author conducted empirical research for his MSc degree (Friesacher, 2016) on European airline pilots' commuting processes, which provided the only primary empirical data available at this time in Europe regarding how European airline pilots commute to their home base and return to their place of residence. The MSc investigated various issues, including the frequency of pilot commutes, motivations for pilot commutes, the reduction of work commitments in connection with pilot commutes and the stress levels generated by commutes from a pilot's place of residence to the home base. These findings were derived from a comprehensive survey that revealed that commuting causes stress, and pilots compensate in various ways to integrate commuting into their lives. To expand this MSc research, the current study sought to research and statistically predict the stress generated by this commute and determine how pilot performance is influenced by the commuting process, and how this is affected by a range of variables (time, distance, mode of transport, age, rank, etc.). Moreover, this PhD research aimed to determine how pilots' commuting processes influence their turnover intention, locus of control and safety behaviour. This study examined the stress variable and factors that cause stress during the commuting process, as well as its influence on pilot performance. This approach advances the literature. The isolated domains of commuting research, fatigue research, pilot performance measurements and subsequent turnover intention are associated with the stress experienced during the commuting process. This research advances knowledge and places these variables of commuting stress in the direct context of pilot performance to advance aviation safety and generate further knowledge to extend fatigue management.

1.3 Research Significance

In its report on the US airline pilot commuting situation, the NRCNA (NRCNA, 2011b, p. 2) stated that ‘there are no comprehensive data on the frequency of pilot commuting, the lengths of commutes, or such trip characteristics as the transportation modes used in commuting’. Moreover, the ‘pilots experience domicile changes or how such changes affect pilot commuting behavior’ (National Research Council of the National Academies, 2011, p. 2). These statements are not only true in relation to the current US airline pilot commuting situation. EASA has identified pilot commuting as a safety risk (EASA, 2020a). As a potential threat to the safety of European aviation, EASA identified that commuting generates ‘stress at an individual level’ (EASA, 2022). No data, except for those obtained from the author’s empirical European airline pilot commute research, are available to characterise the European airline pilot commute situation and practices. This applies to the same extent to the subjectively experienced stress that this commute generates and the way subjective pilot performance is influenced by these commuting practices. Thus, this research provides an empirical analysis of the commuting process to develop an understanding of European airline pilot commuting and its influence on subjective stress, subjective pilot performance, turnover intention and safety behaviour.

1.4 Research Objectives

Based on the literature review findings and identified research gaps, the following research objectives were developed to enhance and contribute knowledge regarding European airline pilot commuting.

Objective 1

To identify and validate factors affecting European airline pilots’ commuting variables based on different commuting and non-commuting pilot groups.

Objective 2

To develop an understanding of the European airline pilot commute process and factors that influence commuting.

Objective 3

To identify the influence of independent and dependent commuting factors on European airline pilots' commuting processes.

Objective 4

To develop an understanding of how pilots perceive different factors of commuting.

Objective 5

To make recommendations for the pilot commuting process to minimise the impact on pilot performance.

1.5 Hypotheses and Research Questions

Nine hypotheses were formed based on the broader theory-based systematic literature review and empirical research to accommodate the novel approach of the current study and test the relationships between pilots' commuting stress, turnover intention and safety behaviour as aspects of pilot occupational performance.

H1: European airline pilots' commuting stress (CS) does not have an impact on self-reported pilot performance (PP) levels, independent of demographic and organizational factors. Shown as null hypothesis – H0.

H2: European airline pilots' commuting stress (CS) does not have an impact on safety behavior (SB). Shown as null hypothesis – H0.

H3: European airline pilots' commuting stress (CS) does not have a positive relationship with turnover intention (TI). Shown as null hypothesis – H0.

H4: European airline pilots' commuting distance and time do not moderate the relationship between commuting stress (CS) on turnover intention (TI) and pilot performance (PP). Shown as null hypothesis – H0.

H5: The frequency of commute does not moderate the effect of locus of control (LC) on commuting stress (CS) among European airline pilots. Shown as null hypothesis – H0.

H6: The use of intermediate housing facilities at the home base for commuting pilots is a positive moderator of the relationship between commuting stress (CS) and pilot performance (PP). Shown as null hypothesis – H0.

H7: European airline pilots' commuting mode choice positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H0.

H8: European airline pilots' commuting travel time does not moderate the relationship between commuting stress (CS) and safety behavior (SB) levels. Shown as null hypothesis – H0.

H9: European airline pilots' commuting travel time positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H0.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Many risks have been appropriately addressed and managed in the development of current aviation safety management systems. The aviation industry has been at the forefront of development and achievements in system safety for many years. The result is a mature safety system that is a role model to many other domains. Although well-established safety parameters have been demonstrated by the aviation safety system over recent decades, the safety research process is ongoing. This process will enable further improvements to system variables including a combination of data analyses that add to the development to an already excellent safety system. In this context, aviation safety research is undergoing a change process from being a reactive safety system—where learning from accidents and their ensuing investigations contribute to improving system safety—to a prognostic, big data analysis-based safety system that identifies risk and implements mitigation processes and procedures proactively. This is the scientific field in which this study is situated and seeks to provide further substantial input (Ablitt, 2016; EASA, 2017; Esmaeili, Hollowell and Rajagopalan, 2015; Waller and Fawcett, 2013).

It is broadly agreed that a pilot's job is one of the most stressful and demanding occupations in the aviation industry (Bennett, 2018; Butcher, 2002; Hancock and Szalma, 2013; Homan, 2002). When entering an aircraft for a flight, passengers expect an unfatigued, well-rested and unstressed cockpit crew to deliver a safe service. However, this is often not the case due to various factors and pilot job specialities directly connected to the pilot profession. One of these is that the majority of European airline pilots commute to work and this has a direct influence on pilots' on-the-job performance during their cockpit duties (Bennett, 2003, 2014). According to the central working thesis of this study and continuing from previous investigations, this commuting stress has the potential to jeopardise and influence aviation safety. Given that pilot commutes—both before and after flight duty—can be time consuming and stressful, there is the potential for pilot commutes to significantly adversely affect safety.

Pilot commuting remains one of the least understood aspects of aviation. However, researchers have recognised the experience as a potential source of stress (Evans and Wener, 2006; Feng and Boyle, 2014; Hennessy and Jakubowski, 2008; Second, 2016; Voydanoff, 2005) and believe that commuting might affect pilots' overall professional performance (Borghini et al., 2014; Caldwell, 2012; Chandramohan, 2008). Given that commuting is the link between individuals' private and professional lives, it is very difficult to find one method of commuting that is appropriate for all. Unique aspects of airline pilots' commuting approaches make it different from general, occupational commuting. Multiple variables influence airline pilots' commuting decisions and models, including airline-based policies, career progression (Akgüç, Beblavý and Simonelli, 2018; Chen and Silverthorne, 2008; National Research Council of the National Academies, 2011b), changes in aircraft type (Bennett, 2018; Sloan and Cooper, 1986) changes in airline operations (Butcher, 2002; Caldwell, 2001) (short-/long-haul operation), subsidised or free commuting (National Research Council of the National Academies, 2011a), hub or low-cost airline business models and duty scheduling (Caldwell, 2012; Stojković and Soumis, 2001).

The diverse and individual range of commuting scenarios often conflicts with airlines' stringent legal duty time regulations and mandatory fatigue risk management systems. The responsibility for managing this conflict is held by pilots at the personal micro level, as discussed in the EASA *Fatigue Risk Implementation Guide*, and the aviation industry is not actively managing this risk (IATA, 2011). The combination of these diverse parameters influencing the pilot commuting process has been examined in a pan-European context, as aviation is a cross-border, international domain and some pilot commuting processes are also cross-border and international. The commuting literature (Green, Hogarth and Shackleton, 1999; Koslowsky, 1997; Koslowsky et al., 1989.; Novaco, Gonazalez and Gonzalez, 2009; Stutzer and Frey, 2007) examines general European population commuting processes, the different modes of transport used (Legrain, Eluru and El-Geneidy, 2015; Murphy, 2009), and the stress generated by the need to commute (Koslowsky, 1997; Krausz, Koslowsky and Aizer, 2008). Various models, such as the impedance model (Novaco, 1990), have been deployed to understand the commuting process and investigate commuting time and distance, the mode of transport used, travel impedance and the resulting stress. To build this research on a solid theoretical foundation, this research followed Baumeister and

Leary (1997), who stated that a literature review is a valuable theory-building technique that may also serve a hypothesis-generating function. Following Cooper (1988), this research conducted an outcome-focused literature review, as 'an outcomes-oriented review may help identify a lack of information on a particular research outcome, thus establishing a justifiable need for an outcome study'(Randolph, 2009, p. 2). Randolph (2009, p.4) further stated that: 'the literature review process will be (a) a rationale for conducting the review; (b) research questions or hypotheses that guide the research; (c) an explicit plan for collecting data, including how units will be chosen; (d) an explicit plan for analyzing data; and (e) a plan for presenting data.' As part of this approach, steps (a) and (b) are followed in this research and ongoing presentation for data collection and filtering is defined, as is data presentation.

2.2 Commuting

For this research, the definition of commuting was taken from the Eurostat Labour Force Survey (Eurostat, 2013) to produce a definition that reflects a European commuting approach, as this research investigated European airline pilot commutes. The definition is as follows: 'Commuting is defined in relation to each person's main place of residence, with commuters exercising their occupation in a region (national or international) other than the one in which they reside. Commuters should return, on average, at least once a week to their main place of residence from the region where they are working' (Eurostat, 2016, p.18). European airline pilot commuting is substantially different from general population commuting as explained in the following sections.

2.2.1 General Population Commuting

Commuting is a transport process that uses time and a specific mode of transport to connect a person's place of residence and workplace. Geurs and van Wee (2004) defined connectivity as a measure between two points; travel time can be used as a defining variable for this measurement. Various general population studies have researched different commuting variables, such as travel impedance, travel time, commuting distance, modes of transport, active/passive engagement (Paez and Whalen, 2010), commuting stress (Costa et al., 1988; Hennessy and Jakubowski, 2007; Kanter, 2016), life satisfaction (Legrain et al., 2015; Stutzer and Frey, 2007,

2008), commuting distance (Clark et al., 2003; Green et al., 1999; Sandow et al., 2014) and work performance (Hennessy and Jakubowski, 2007; Kanters, 2016; Roma and Hursh, 2012; Zhou et al., 2017). Interestingly, only very limited research has focused on occupation-specific commuting results in the interactions between occupation-specific agendas of commuting mode/time, commuting stress and occupation-specific performance results. In the current study, domain-specific (aviation) research was combined with pilot occupation-specific commuting mode/time, resulting in subjectively generated commuting stress, to generate a prediction quality for pilot occupation-specific on-job performance.

2.2.1.1 Commuting Distance

Commuting distance is a highly objective measurement, unlike commuting time. It reflects a highly individual measure that differs from any individual commute. It does not deliver a reliable measurement of connectivity, as it has to be in direct connection with the mode of transport and the resulting travel time. This results in a personal and economic threshold to determine the impossibility of daily commuting that might force commuters into a long-distance, irregular commuting style and possible second home lifestyle (Green, Hogarth and Shackleton, 1999). Green et al. (1999) stated that lengthy weekly commutes might substitute a migration tendency and result in longer commuting distances and commuting times. Enjoyable long-distance commutes can constitute a clear line between the place of residence and workplace, and the commute can have positive utility for the commuter. Commuting time can be used sensibly for enjoyment and relaxation (Sandow et al., 2014).

2.2.1.2 Commuting Time

Commuting time is dependent on the distance travelled and mode of transport used, and is moderated by delays or problems encountered on the travelling route or travelling mode. Nonetheless, there are clear statistical measures available for average European commuting times (Eurostat, 2016). US vales reflect that, on average, individuals travel 46.2 minutes per day for work-related travel (Amponsah-Tawiah, Annor and Godfred Arthur, 2016). Amponsah-Tawiah et al. (2016) found that workers commute for an average of 4–10% of their waking time on workdays.

2.2.2 Airport Accessibility

Airport accessibility is a vital parameter in pilot commutes, given that pilots' usual point of work (except for training events or managerial duties) is directly connected to the airport. Moreover, the accessibility of an airport, whether by road or public traffic services, directly influences pilot commuting time. The spatial location of airports in the European context is largely connected to off-CBD locations. This occurs because of the particular requirements regarding airport location for safety, infrastructure, noise abatement and other conditions that airports must fulfil for environmental, legal and safety reasons. As a result of historic urban development, airports are rarely in or near a CBD in Europe. Therefore, airports require an extensive connection system with public and private accessibility infrastructure to fulfil economic and access requirements. European airports are mostly connected to and served by rail infrastructure to city centres, and are often connected to international long-distance railway networks (Orth et al., 2015). Percoco (2010) advanced and introduced a surface transport metric for average travel time to access airports from CBDs, focusing on surface transport modes using road traffic and rail services. A report by the German DLR, on behalf of the Directorate-General for Mobility and Transport in the European Commission, analysed accessibility of 30 major airports using multimodal access possibilities to airports in Europe. Building on these 2010 airport accessibility travel time data, the DLR elected to cross-calculate different modes of airport time accessibility from the data presented in Table 45, Table 46 and Table 47. In total, 81 time datasets were derived from the multimodal presentation travel time for access to the 30 largest European airports. The total time calculated from these data was 18:58 minutes, indicating an average cross-modal access time of 30 minutes to these airports (Reichmuth, 2010). A search of the literature did not identify more current data. Assuming that most European airline pilots do not live in CBDs, 30 minutes would not adequately encompass the average European pilot's commuting time between their place of residence and home base. Van Reeve et al. (2003) undertook a review of the accessibility of 19 European airports. The final report data were cross-calculated from 48 time datasets of airport peak and off-peak access, and the results were similar (29.3 minutes) to those found in the DLR Reichmuth (2010) data (30.0 minutes). Van Reeve et al. (2003) also investigated employee accessibility and modal split for European airports. One outcome of this research was the insight that these data were

not available off the shelf by airports nor their European representations. Better data and a more significant dataset were required, along with disaggregation of data, especially in the direction of interpretation of airport employee use of modes and airport accessibility. The study found that the insufficient data provided by participating airports did not allow them to analyse the travel or commuting behaviour of employees (Vlieger, 2003). Expanding on data from the 2019 European Foundation for the Improvement of Living and Working Conditions, data on the mean duration of one-way commuting time between work and home - based on sex and age - or 28 European Union countries, indicate that the 2015 average one-way commuting time for people aged 15–64 years was 41.9 minutes (Figure 1).

TIME	2005	2010	2015
GEO			
European Union-28 Countries	43.2	43.4	41.9

Figure 1–Mean Duration of One-way Commuting Time between Work and Home by Sex and Age. Unit: Minute; Age: 15–64; Years; Sex: All

Source: European Foundation for the Improvement of Living and Working Conditions, 2019.

2.2.2.1 Intermediate Housing During Long-term Commutes

Green et al. (1999) examined travel flows in Britain and among other countries using the European Union Labour Force Survey to identify trends in dual-career households and weekly long-distance commuting. As a result of the complexity of home and work life (Figure 2) and the interaction between these two domains, this research observed ‘disproportionately over-represented’ (Green et al., 1999) long-distance weekly commutes among highly skilled non-manual occupational groups. This weekly long-distance commute was compensated for by improved career progression and financial situations from work income, but yield the compensation on the household level and the on the partner level that left the domicile (Green et al., 1999; Stutzer and Frey, 2007). Beneficial to the long-distance commuting individual is the availability of time during the week to concentrate on work. Longer working hours in one block would allow for a longer block of free time at home as compensation. In addition, spatial separation between the place of work and home might be a desirable lifestyle choice.

Páez and Whalen (2010) researched the utility of travel in a group of university students and found three utilities - the activity at the destination, the utility of activities that can be conducted while travelling and enjoying the act of travel itself. Using the spatial divide and travel as a positive connection with the scope of family and friends, and enjoyment of travel and positive use of time (reading a book or benefitting from something one enjoys) during travel significantly decreases the subjective experience of stress, as does locus of control of the travel variables (Páez and Whalen, 2010). A stable residential situation for one's family and a stable career path for the non-commuting partner is often substituted with the disutility of a long-distance commute and overall movement of residence, which also disrupts the children's education and socialisation at the place of residence (Green et al., 1999).

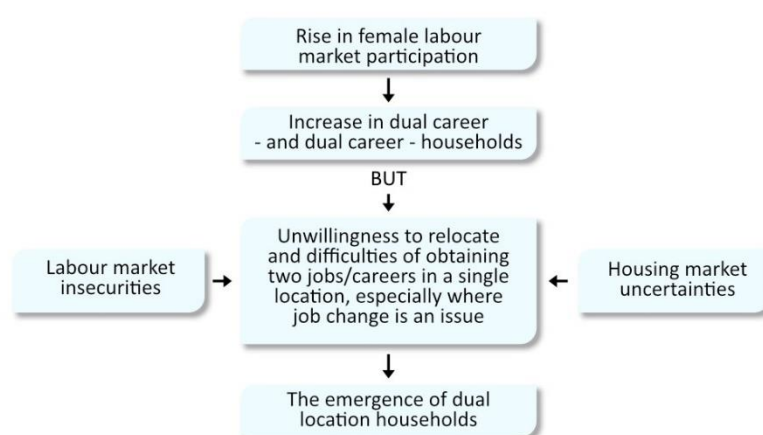


Figure 2—Long-distance Weekly Commuting and Emergence of Dual-location Households

Source: Green et al., 1999.

2.3 Airline Pilot Commuting Process

The airline pilot commute process is profoundly different from the general population commuting process because of pilot occupation-specific variables, such as infrequent commuting connected to airline crew scheduling practices and the need for housing at the crew base—considered an intermediate housing facility in this research. In addition, directly affecting the pilot commuting process is the type of airline operation. A factor adding to the need for pilot commuting is the shift from legacy airlines to low-cost carrier operations, and their scheduling policies in relation to saving on overnight

costs and per diems for pilots (Bennett, 2014; Borghini et al., 2014; Srivistava, 2011). This requires pilots to return daily to their designated home base and providing themselves with overnight accommodation at the home base, rather than scheduling them on overnight duty flight schedules. One possible outcome of this scheduling policy is more frequent commuting behaviour to save money on overnight costs by staying with friends or family during duty, resulting in reduced time for sleeping. Therefore, the change from legacy hub airline business models to low-cost operations may aggravate the commuting process if the pilot does not have a place to sleep at the crew base and is forced to use an intermediate housing facility at the home base to accommodate resting requirements (Cooper and Sloan, 1985; Stephen Sloan and Cary Cooper, 1986a, 1986b, IATA, 2022; Jimenez and Suau-Sanchez, 2020; Markopoulos and Hesse, 2021).

Legacy hub airlines tend to schedule airline pilots for chain flights, and frequently use night stop duty rotations. This scheduling policy relieves airline pilots of the need to find their own resting facilities, as the airline operator provides crew resting facilities and hotels at the operator's expense (EASA, 2020; Lee and Kim, 2018a; Moebus, 2008). Moreover, this scheduling policy adequately meets legal airline crew resting requirements and is covered by the required operator's fatigue risk management system. Low-cost day-trip pilot scheduling practices do not offer this coverage, as it becomes the pilot's own responsibility to ensure they have housing and sleeping opportunities and leaves open the possibility for aggravated more frequent commuting practices by individual crew members without legal or airline operator supervision (IATA, 2011; NRCNA, 2011b).

Long-haul operators implement different scheduling practices for their long-haul pilots because these pilots stay away from the home base during their operation and return after active flight duty to the home base to begin their off-period. This situation often requires long-distance commuting for long-haul pilots. Figure 66 provides an overview and general outline of the airline pilot commuting process and some influencing factors in the US airline pilot commuting situation as an example, as provided by the NRCNA (2011). As outlined in Figure 66 (Appendix D). The report of the NRCNA (2011b) discussed fatigue issues and established a proven connection between fatigue and performance. This was the first report on US airline pilot commuting, and it

incorporated an in-depth investigation of different airline business models, encompassing policies, career progression, type of operation, the connection between fatigue and performance and the prevalence of pilot commuting. Given that the report was politically prompted, the NRCNA used official US government authorities as sources of information. One of the major shortcomings of this information gathering process was how commuting distances were established. Distances were calculated based on the officially filed pilot addresses (place of pilot residence) and the operators' home bases (NRCNA, 2011a). However, this information and the calculated distance did not reflect the actual commuting situation, as real-life pilot commuting depends on multiple multi-level variables (e.g. scheduling practices, mode of airline, airline business model) in the commuting process. This report included no empirically generated data or input from US airline pilots. The NRCNA established that unpredictable commuting leads to stress, but discussed this only into connection with fatigue. It did not explore the effect of commuting on pilot performance. In a Federal Aviation Authority study, Roma and Hursh (2012) expanded on the limited systematic data on commuting issue and its variables, to include commuting time and its interaction with cabin crews' performance and fitness for duty. Another self-reported survey of US transport workers with 202 pilot respondents investigated the average one-way commute times from the place of residence to the home base, finding that 37% of workers commuted for longer than 60 minutes (Anon, n.d.; Roma and Hursh, 2012). In a discussion about the objectivity of self-reported surveys and commuting times, Roma and Hursh (2012) mentioned that self-reported measures of commute times are the best way to encompass daily variation, such as that in traffic and unforeseen circumstances. Also mentioned was the lack of subjective measurements and missing systematic data influencing the commute and on-the-job performance capacity. The NRCNA (2011a) also identified a lack of data on practices related to pilot commuting.

2.3.1 Difference in Pilot Commuting

As mentioned above, European pilot commuting is fundamentally different from regular commuting practices in Europe (e.g. irregular working hours and crew scheduling) and has historically been tightly connected to the pilot profession. Pilot commutes include a high percentage of long-distance commuting that generally exceeds 'normal' commuting distances in Europe because pilots have the possibility

of using significantly reduced flight tickets or free air transportation; thus, some pilots commute via flights. Commuting by flight gives pilots a significantly more extensive range of potential residence locations (National Academies Press, 2011). Also with regard to industry parameters such as career progression, flight route and aircraft model changes, seniority lists, crew basing policies and home base close and openings, and recent changes in airline business models from national legacy airline hub networks to low-cost point-to-point operators, mean that maintaining a stable home and residential situation has a significant effect on the wellbeing and coping strategies of European pilot corps (Caldwell, 2012; Cooper and Sloan, 1987; Hennessy and Jakubowski, 2008; NRCNA, 2011b, 2011a). In a US study entitled the 'Analysis of commute times and neurobehavioral performance capacity in aviation cabin crew', Roma and Hursh (2012, p.7) found that the 'aviation community fundamentally differs from the general population'. This outcome largely reflects the travel time of cabin crew members in the US, which are similar to those of pilots. Different from the Roma and Hursh (2012) study in terms of the commuting behaviour of cabin crew is that pilots in Europe are highly regulated and legally restricted by fatigue risk management systems required by European legislation and established by individual airlines. However, these systems are generally missing hard barriers and definitions that restrict commuting before flight duty and demand a required standard for pilots to arrive fit and well-rested for flight duty (IATA, 2011).

Pilot commuting is highly dependent on the duty schedule assigned by the airline. The commuting process ranges from infrequent—often only monthly commutes from the place of residence to the home base for long-range pilots—to more frequent, possibly daily commutes for short- and mid-range pilots. Often, pilots use a residence at the home base to arrive ahead of the flight schedule, and use this intermediate housing facility to rest and start the duty chain (National Research Council of the National Academies, 2011b). Pilots are frequently scheduled to fly duty flight chains. They may not return to the home base for some days, and then only start the commute to their residence when commencing the off-duty period (NRCNA, 2011b). As a somewhat volatile industry, airlines have benefitted more over time from these pilot commuting standards. Airlines generally do not restrict pilots' residential choices and thus do not provide relocation costs when assigning new home bases to pilots. In addition, career progression offers the pilot multiple new home base choices in an airline network not

restricted by formal residential considerations. Maintaining a stable private life and residence is crucial for stress coping among pilots (Cooper and Sloan, 1987).

2.3.1.1 Pilot Commuting Specials

The changing variables in the dynamic aviation industry frequently influence pilot commuting. The air transport industry has transformed from local primary national state airlines to a few pan-European low-cost airlines with multiple pilot bases, country affiliates and substitutes in different European countries. (Jorens and Gillis, 2015) This economic restructuring of the airline industry over recent years, including among major European airline companies, has brought significant changes in the circumstances of thousands of pilots all over Europe. Interregional and international commuting practices have changed in response to these economic changes. The industry has also seen increased route network restructuring and increased point-to-point operations from secondary non-hub airlines with flexible pan-European crew policies and inner European crew mobility. In earlier decades, strong social rights and principles of seniority among pilots put a stop to such working conditions. However, in the absence of union organisations for pilots in these pan-European companies, there is nothing hindering the current process towards worse working conditions. Additionally, the latest mergers of airlines in Europe and the drastic expansion of low-cost carriers has forced established airlines to sharpen their scheduling policies and resize their route network and business models, leading to a reduction in night stop chains to save on overnight hotel costs for crews, forcing restructuring of the European airline landscape (Caldwell, 2012; Lee and Kim, 2018b; Vejvoda et al., 2014).

2.3.1.2 Pilot Commuting Mode of Transport: Aircraft Commuting

As stated previously, Geurs and van Wee (2004) defined connectivity as a measure between two points, and travel time can be used as a defining variable in this measurement. Travel time in regard to travel distance is related to the mode of transport used, as different modes of transport require different times for different travel distances. Therefore, travel time alone does not adequately reflect the quality of a commute to cover a distance, particularly given that pilots' access to cheap or free airline tickets makes it possible for them to undertake passive long-distance commuting. Being accustomed to air commuting makes it possible to positively use passive commuting time, according to Paez and Whalen's (2010) travel utility study.

Moreover, if the pilot can travel on a confirmed seat ticket they do not have to fear being left behind because no standby seat is available. As such, as stated by the NRCNA (2011, p.25), 'the length of the commute, measured either by distance or time spent commuting, does not necessarily determine whether or not the pilot reports for duty fit and well-rested'. In contrast to the general commuting community, air-mode commuting offers European pilots an additional travel opportunity that is seldom available to the broader general public. A very limited literature focuses on this mode of commuting in general population commuting research. However, reflecting on their observations on wellbeing during commuting in the United Kingdom (UK), the Office of National Statistics (2014, p .2) stated, 'When commuting time reaches three hours or more, the adverse effects on personal well-being disappear, suggesting that the small minority of people with this commuting pattern have quite different experiences to most other commuters'. This statement supports the idea that this might include the small group of UK pilots who have cheap or free access to air travel commuting or follow infrequent long-distance commuting patterns.

2.3.1.3 Fatigue Risk Management vs. Safety Risk Management

The proposed implementation of psychological fatigue indicators identifies critical and significant risks associated with the current fatigue Risk Management System used in the European aviation safety management system. 'Fatigue is a ubiquitous phenomenon' (Fink, 2016). Pilot commuting in European aviation may have various bidirectional effects to the current fatigue risk management system and the link between fatigue and stress. (Fink, 2016) The distinction between fatigue and stress as different factors is relevant to this work, as highlighted in the study by Vagner et al. (2018). In their study, the authors emphasise the importance of considering stress as a separate risk factor. The European aviation safety regulator, EASA, prioritises fatigue risk over stress risk and emphasises the need for a broader approach to incorporating stress into a comprehensive fatigue risk management system (EASA, 2022; IATA, 2011). The development and implementation of stress management is a complex process, the nature of which is not yet fully understood. In contrast to fatigue, stress parameters are more difficult to measure and control. At the same time, stress is a critical factor affecting the performance behaviour of aviation personnel (Vagner et al., 2018; Bennett, n.d.; EASA, 2020a, 2022; Roma and Hursh, 2012; Sloan and Cooper, 1986). As prolonged stress is a possible precursor to fatigue and related

phenomena such as exhaustion, it is essential to first identify and understand the stress-inducing factors in the commuting behaviour of European pilots. In order to avoid exhaustion caused by fatigue, the next step is to manage stress appropriately (Fink, 2016; Islam, Uddin and Hasan, 2018). Fink (2016, p. 345) sees the interaction between stress and fatigue to be 'important in the development of multidisciplinary interventions' strategies. 'Fatigue can be conceptualised as an adaptive response to prolonged stress.' (Fink, 2016). The focus on "stress" rather than "fatigue" in this research is explicitly chosen to explore the precursor conditions that contribute to coping with commuting stress before reaching states of exhaustion and fatigue. By investigating stress, the research aims to identify and understand the early stages and factors that lead to stress during commuting, with the goal of developing strategies for managing or mitigating stress before it escalates into more severe conditions such as fatigue. This approach allows for early intervention and preventive measures by addressing the issue at its root, before the onset of fatigue.

Pilots are exposed to considerable stress during their professional activities. Stress can also have a positive impact on fatigue risk management, which is currently not adequately addressed. The current European fatigue risk management system only recommended that individual crew members 'arrive with sufficient time to allow adequate sleep and ensure fitness for duty' (IATA, 2011, p. 6). It neglects the possible positive benefits of commuting for European airline pilots on fatigue risk. Following on from this, Islam, Uddin and Hasan, 2018, demand that 'fatigue should be excluded from scientific discussion as it cannot be measured directly' (p.28) and it 'is difficult to define' (p.28) and expand that 'fatigue is a confusing concept and researchers should determine operationally the effect of various factors on work output' (p.28). Commuting stress is an operational factor (Islam, Uddin and Hasan, 2018) in this context and commuting stress is a precursor. Therefore, it is essential to manage the precursor (commuting stress) first, in order to avoid the exhaustion caused by fatigue (Fink, 2016).



Figure 3–EASA Safety Risk Management Process

Source: EASA, 2021.

Therefore, this study attempts to find a more specific approach to the management of fatigue and stress risks in aviation. This is done by including a known source of stress - in this specific case, the common practice of pilot commuting in Europe. EASA has taken a step in this direction by identifying commuting by pilots of European airlines in public documents as a safety risk (EASA, 2020b). In the context of the COVID-19 pandemic, ‘individual-level stress’ (EASA, 2022, p.42) was identified as a potential threat to European aviation safety. As a result, EASA now provides supporting material. This includes recommendations for pilots on how best to deal with the personal challenges of commuting (EASA, 2020b). An EASA commuter guide entitled *Together4safety* (EASA, 2020b) follows this with recommendations for commuting arrangements and changes. These current actions highlight the importance of integrating commuter stress into the existing European Plan for Aviation Safety (EPAS) as it underpins the importance of stress and stress management and coping strategies (EASA, 2020a; Flight Safety Foundation, 2020). This research, therefore, focuses on the stress generated by European airline pilots' commuting practices. Comprehensive safety management is required to integrate European pilots' commuting into EASA's overall safety risk management processes (see Figure 3).

With the data generated in this research on European airline pilots commuting, the inclusion of the commuting stress components in a comprehensive fatigue risk management system becomes essential as a precursor to fatigue prevention. The existing Fatigue Risk Management System (FRMS) consist of five components (Figure 4).



Figure 4 - Existing FRMS Components

Source: IATA, 2011 / Redesigned Friesacher.

The integration of the commuting stress component into an existing Fatigue Risk Management System (FRMS) requires the following steps and considerations:

1. Understanding Commuting Stress - Recognise how pilot commuting can contribute significantly to a European Airline Pilot's stress and fatigue levels. Factors such as distance, mode of transportation and the time taken for a pilot's commute can all have a positive or negative impact on a person's stress levels and can significantly influence the fatigue factor in one direction or another.
2. Assessment - Conduct surveys or assessments to understand the problems pilot face when commuting. This includes the length of commute times, the modes of transport used and the perceived stress associated with commuting.

3. Data Integration - Integrate commuter data into the FRMS. This includes tracking and analysing commute times and conditions to report fatigue levels. Over time, patterns may emerge that associate certain types of pilot commuting with higher fatigue levels.
4. Employee Education - Inform pilots about the impact of commuter stress on overall fatigue and give them tips to minimise stress. This could include advice on coping techniques, time management or alternative commuting options.
5. Flexible Policies - Where possible, consider introducing flexible rostering and scheduling policies.
6. Monitoring and Response - Regularly monitor the impact of pilot commuting on employee fatigue and adjust policies and strategies accordingly. This could include regular reviews of employee feedback, fatigue incidents and other relevant commuter stress data.
7. Health and Well-being Programs – Incorporate stress management and wellbeing programmes that address commuter stress. This could include access to counselling services, anonymous reporting facilities for commuting safety, optional tickets for commuter or accessible on-site rest facilities that can help mitigate the effects of commuting stress.
8. Continuous improvement - Consider the inclusion of the commuting stress component as an ongoing process. Review and update policies regularly based on new research, technological advances (like apps that track pilots' commuting stress), and employee feedback.

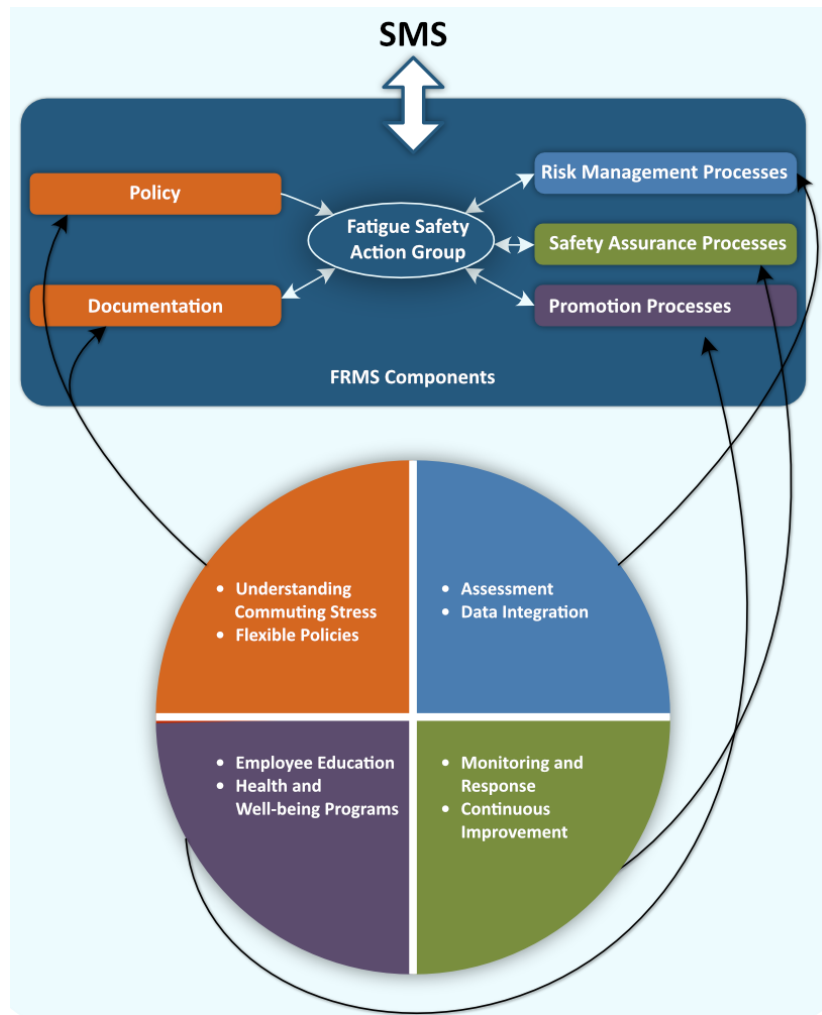


Figure 5 - Integration of the commuting stress component into an existing Fatigue Risk Management System (FRMS)

Source: IATA, 2011/ Redesigned & Expanded Friesacher.

The conceptual framework for incorporating a commuting stress component into an overall Fatigue Risk Management system is shown in Figure 5. Including a commuter stress component in an FRMS is about recognising the holistic nature of pilot well-being. A key step forward is to understand that what happens outside of work can have a significant impact on performance and safety at work. By addressing pilots commuting stress, the European aviation industry can not only improve the effectiveness of its FRMS, but also contribute to the overall health and satisfaction of their pilot workforce.

2.3.1.4 Subsidised Pilot Commuting System

European airline pilot commuting is a highly unregulated issue. Given that awareness of a commuting threat and the possible inability of a pilot to report as unfit for duty has economic importance for the airline, most operators have rules for their pilots about reporting unfit or calling in sick that are established in their operations manuals. In the context of these manuals, commuting is only vaguely covered and defined as stating that the pilot must report fit for duty. In general, commuting rules are highly subjective and difficult to verify by operators (IATA, 2011). Airlines have a system through which crew members can access significantly reduced airfare tickets for private use. Some operators have also established a commuting system, mostly defined by collective agreements or internal company rules, in which pilots travel for free on specific pre-determined commuting routes between the home base and their residence. Some operators provide tickets on a seat-available basis (standby ticket), while others provide booked seats for these flights (NRCNA, 2011b). These agreements also include—congruent with this system—the possibility of tracking pilot travel for the operator providing these tickets. However, operators do not exercise this privilege, and most do not actively manage pilot commuting as an aspect of fatigue risk management (National Research Council of the National Academies, 2011b).

2.4 Definitions

As a basis for further discussions and reflections about the literature investigated in this study, a sound definition of the variables describing pilot commuting must be established in common aviation language.

2.4.1 Place of Residence (Home)

In the literature, the place of residence is also frequently called a domicile. This refers to a principal place where a pilot lives and undertakes their private relationship activities, such as spending time with family and friends, and maintaining a social life. This place is usually the start and endpoint of a pilot's commute (EASA, 2020b; National Research Council of the National Academies, 2011a).

2.4.2 Home Base

The home base is a geospatial location to which a pilot commutes from their place of residence and where they start or end their pilot duty. It is often an airport location or an airport office location, where the pilot begins the pre-flight briefing. It should be noted that, in this study, the sometimes-lengthy time/distance from the pilot parking lot to the briefing office is not included in the commuting process time and distance measurement (NRCNA, 2011a).

2.4.3 Intermediate Housing Facility

The intermediate housing facility is a location where a commuting pilot resides during and between duty periods at the home base. Intermediate housing facilities are often used when the commuting distance or time between the pilot's place of residence and home base is too lengthy to complete during the line of duty. Using an intermediate housing facility at the home base can result in infrequent, weekly commuting practices. The form of an intermediate housing facility can range from a shared bed to a shared apartment, hotel room or fully furnished second household at the home base (EASA, 2020; NRCNA, 2011a).

2.4.4 European Airline Pilot Commuter/Non-commuter

A classification of European airline pilots' commuting needs to be made.

The classification is based on the commuting times and distances of the general population (Eurostat, 2019) and the behaviour of commuting European airline pilots. Following the approach of defining commuters and applying Eurostat (Eurostats, 2016) published statistics on commuting behaviour, 'commuting is defined in relation to each person's main place of residence with commuters exercising their occupation in a region (national or international) other than the one in which they reside. Commuters should return, on average, at least once a week main place of residence from the region where they are working.' Furthermore, Eurostat's (2016) research expands and introduces the term 'non-commuters' (Eurostats, 2016) for persons who do their work in the same region as their residence. Eurostat's (2016) definition is used as the definition of 'non-commuters' for a non-commuting European airline pilot for this research. As for the general commuting population, the daily European mean of the one-way commuting time between work and home is outlined as 41.9 minutes. An

inflection point of 44.71 minutes on average (rounded 45 minutes) of behavioural travel preferences change was also identified regarding changing the commuting situation and relocating in a big data smartcards research on commuting patterns and residential locations. (Huang et al., 2018) Deriving the commuter definition in the European context and setting of a cut-off point between European Airline Pilot commuters and non-commuters for this research is supported with

- data on the accessibility of European airports (Reichmuth, 2010a; Vlieger, 2003a)
- data on the mean duration of one-way commuting times in Europe (EUROSTAT, 2019)
- data on behavioural travel preferences change inflection point of 44.71 minutes on average (rounded 45 minutes)
- European statistics on commuting patterns (Eurostats, 2016)

A 45-minute one-way commuting time defining a European airline pilot commuter in this study is differentiating between European Airline Pilot commuters and non-commuters. According to this definition, European airline pilots classified as non-commuters may nevertheless experience fatigue and stress related to their non-commuting work travel. These European pilots, who are non-commuters by the definition of this research, may face issues such as traffic congestion, lack of public transport or other factors that may affect their pilot performance and stress levels (Koslowsky, 1997; Novaco, Gonazalez and Gonzalez, 2009). However, this is not considered and presented in the results as their work travel is not classified as commuting for this study. For this reason, it is important to consider these challenges when interpreting the results of this study with respect to the utilization of travel time, as well as the positive or negative aspects associated with this time threshold.

2.5 Stress

2.5.1 Stress Definition

A limited quantity of literature is available focusing on the occupation-specific triangle of stress, job performance and commuting of pilots. There has been some individual domain-specific research on stress, whose aim was to combine previous results with current study findings on commuting and job performance, and position these topics in a contextual and meaningful relationship. Previous research on stress and performance appears to have been inconclusive regarding the connection between stress and performance (Hunter and Thatcher, 2007). The author emphasises the outcome of Muse et al.'s (2003) meta-analysis on the stress and performance research literature in regard to the analysed period of 1975–2000, and supports the idea of a three-bladed problem. Generally, in the stress–performance literature, it appears that a negative pre-conditional relation of stress is widely evident in research, and this view is supported by a strong preference for a negative linear relationship in most studies. As a negative side-effect of this perception (Muse et al., 2003), there has been no focus on the possible positive influence of stress on performance. Also evident in most previous research on this topic is a generally weak and inconsistent definition of stress. After identifying these shortcomings (Karasek, 1979; Kavanagh, 2005; Muse et al., 2003; Sun and Chiou, 2011) and considering the pros and cons of previous research, the current study aimed to broaden the picture and achieve a more objective and realistic view on the topic. Investigating the triangle of stress–performance–commuting is required as it is an eminent aspect of work in stress conditions. For this purpose, Yerkes and Dodson (1908) inverted the ‘U-shaped theory’ of stress and defined a range of restrictions for well-established and profound stress research (Hancock and Warm, 2003; Hunter and Thatcher, 2007; Karasek, 1979; Muse et al., 2003). As a general negative connotation of stress in the literature, Muse et al. (2003) outlined a contextual range restriction: in high-stress surroundings and as a result of the fixation of research on high-stress areas, low-stress research is

possibly neglected. Therefore, Muse et al. suggested establishing weighted levels of intervals (such as low, medium and high) to minimise this range restriction.

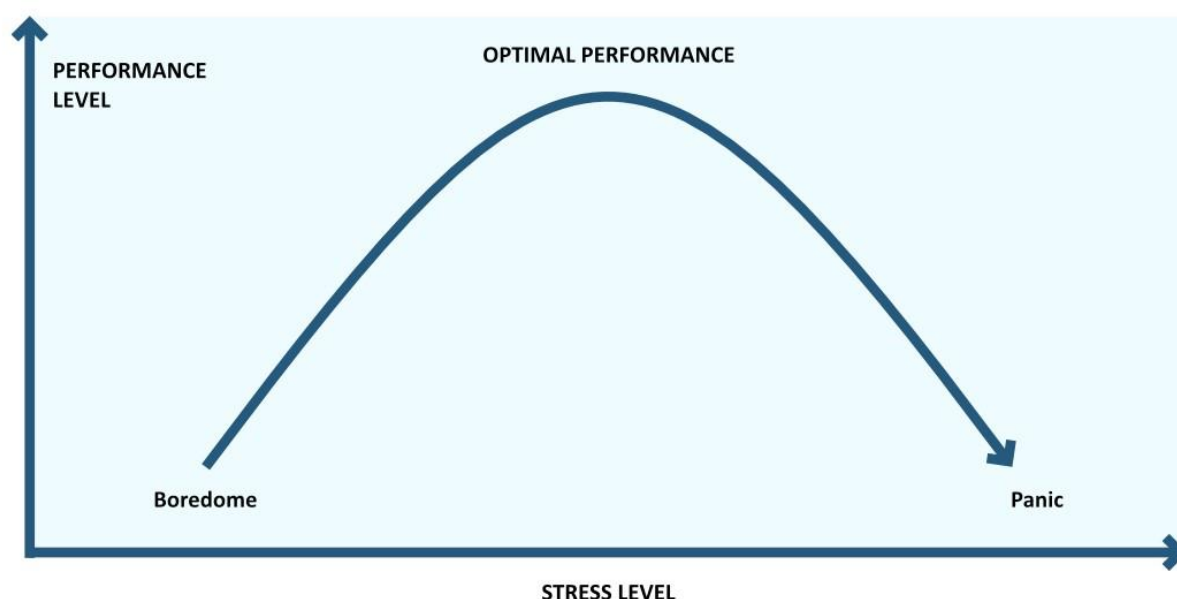


Figure 6—Yerkes and Dodson Model

Source: Homan, 2002, p. 3.

In a study on the military applicability of stress literature and stress, Kavanagh (2005, p.3) established that ‘stress is considered to have an inverted-U shaped relationship with performance—that is, performance may improve under moderate levels of stress but decline under high or constant stress’. The underlying U-shaped theory (Figure 6) of Yerkes and Dodson (1908) states that performance increases with physiological stimuli up to the point of optimal performance. After exceeding this point, performance decreases (causing a U-shape). The top of this U-shape is highly individual; however, in general, this stress shape directly influences pilot performance and situational awareness (Hornan and Sandel, 1999). A review of the literature (see Kavanagh, 2005) and its applicability to the military strongly supported the link between stress and performance and suggested that the relationship has an inverted-U shape. The current study also applied the Yerkes and Dodson (1908) theory.

The human body’s stress response can lead to stress-related diseases (Abbas, Farah and Apkinar-Sposito, 2013; Copeland et al., 2017; Sloan and Cooper, 1986), which has been a major research focus. In addition, the interaction between stress and

performance has been widely discussed in the literature, yet little aviation-specific research has been undertaken overall. Research on the commuting times and neurobehavioral performance of aviation cabin crews (Roma and Hursh, 2012), as well as scientific studies on occupational stressors among pilots (Hajjiyousefi et al., 2015) and air traffic controllers (Loewenthal et al., 2000), has mainly focused on occupational stress and stressors. A study by Copeland et al. (2017, p.2867) considered cross-sectional survey responses of college students in regard to occupational stressors, taking into account student year, social feedback conditions and social support. Moreover, Copeland et al. investigated the cognitive performance of college students in lower- and higher-stress circumstances. They also assessed salivary cortisol levels, but found no relationship between the level of cortisol in acute stress and student year level. However, they found a significant difference in student gender-related outcomes (Copeland et al., 2017). In regard to the inverted-U theory and negative linear theory, Sun and Chiou (2011, p.2867) stated that the ‘inverted-U theory of the stress–performance relation represents a merger of the negative and positive linear theories by suggesting that increasing stress is good for performance under a point, beyond which it becomes bad’. Scientific work seems ‘to prefer the contingency nature of the inverted-U theory, yet the empirical results of stress–performance research weigh heavily in favour of a negative linear relationship (Friend, 1982; Jamal, 1984; Westman and Eden, 1991, 1996). Moreover, only two stress studies have been found to support the inverted-U theory (Anderson, 1976; Srivastava and Krishna, 1991)’ (Sun and Chiou, 2011, p.2867). According to Muse et al. (2003), the ‘inverted-U hypothesis is still the most intuitively [correct]’. Therefore, in focusing on the triangle of stress–performance–commuting, the current research also used the main hypothesis of this theory.

There are multiple definitions and a vast body of research on what stress is and how it can be best described. The description by Seyle (1956, p.105) detailed a nonspecific response to any type of stimulation exposed on a human. Events or stressors can trigger such a demand. The stimulus can be a psychological or physiological (e.g. temperature, noise, vibration) external input. When an individual is exposed to a stressor, a resulting physiological or physiological response to the stress occurs. A more predictable description and expansion of Seyle’s nonspecific response approach was presented by Lazarus (1969), who defined stress as an external force putting

unusual demands or force on a person. Lazarus (1969) suggested that stress is a reaction generated by an individual rather than by the contributing circumstances. From the perspective of performing job-oriented demands, Hancock and Szalma (2008) combined the U-shaped stress theory of Yerkes and Dodson (1908) with a performance-oriented input–adaptation–output approach (see Figure 7).



Figure 7–Three-part Differentiation of the Concept of Stress

Source: Hancock and Szalma, 2008.

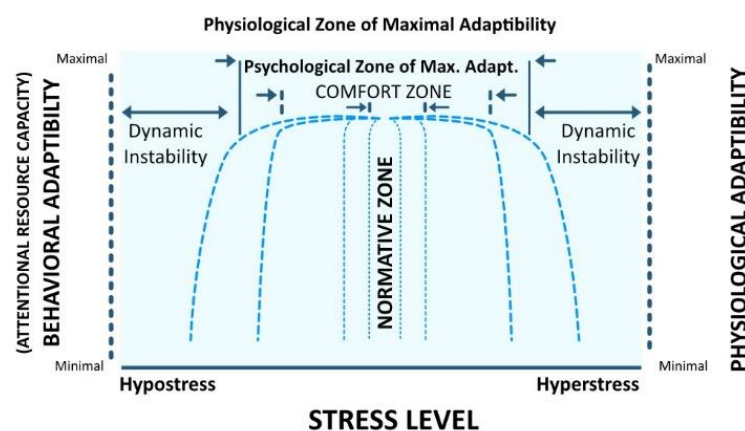


Figure 8–Extended-U Concept of Stress and Response Capacity

Source: Hancock and Warm, 1989.

As eustress, stress can be positive and a spark to enhance performance, yet it can also be challenging and demanding (distress), as a state of physical or mental suffering (Homan, 2002). Stress research (Copeland et al., 2017; Hancock and Warm, 2003; Haward, 1977; Homan, 2002; Sloan and Cooper, 1986) has led to the identification of three forms of human stress:

- Physical stress is the result of physical stressors, such as heat and cold, noise, vibrations, oxygen deficiency or other physical perceptions by the body.
- Physiological stress
- Emotional stress can be subdivided into cognitive and affective stress:
 - Cognitive stress ‘can be defined objectively as the nature of the task presented to the operator, [with] excessive cockpit workload being one of its most frequent forms’ (Sloan and Cooper, 1986, p.17). Another form of cognitive stress reflects an ‘inadequacy of information on which some critical decisions’ must be made (Cooper and Sloan, 1985).
 - Affective stress is more dangerous for the operation of machinery and on-the-job performance. Affective stress is cumulative and additive. It can result in an immediate breakdown of any acting captivity or rational behaviour.

Acute stress can be beneficial and performance enhancing, if the exposure to the stressor occurs for only a short time. However, cognitive performance is negatively affected by extensive exposure to acute stressors (Copeland et al., 2017). The human body reacts to acute stress in a broad range of ways, such as muscle tension, increased nervous system activity, nausea, psychological damage and increased heart rate (Young, 2008b). Chronic stress occurs after long-term exposure to stressors, which multiplies the short-term effects of acute stress. Health problems are common outcomes of exposure to chronic stress and can include high blood pressure, frequent sickness, a weakened immune system and cardiovascular problems. Homan (2002, p.16) explained that ‘most difficult form of stress to deal with because it tends to exaggerate the multiple effects of cumulative acute stress’. For this research and in the triangle of commuting–stress–performance in the European airline pilot context, stress occurs in reaction to commuting stressors, which are partly psychological and partly physical (heat, cold, noise, odours, etc.). However, a regularly changing environment and the need to travel between the residence and home base, with possible swap over from work into private life, can result in a form of affective chronic stress, as the pilot is exposed to commuting on a long-term basis. The empirical research in this study is connected to this constantly experienced stress.

2.5.2 Occupational Stress

Occupational stress, also frequently referred to as job stress in the literature, has been evaluated for some occupations, such as nurses (Motowidlo et al., 1986), pilots (Cooper and Sloan, 1986; Hajiyousefi et al., 2015) and aviation ground crews (Sun and Chiou, 2011), as well as in relation to work–family conflict (Cooper and Sloan, 1985; Voydanoff, 2005). However, in general, this research is occupation specific and none of the occupation-specific domains are relevant to stress in relation to commuting. In contrast, the abovementioned scientific work focused on occupational stressors, yet did not include stress-relevant factors in the commuting process.

Occupational stress is tightly connected in the literature to job performance. The resulting performance direction also forms a highly complex interrelationship in research (Sloan and Cooper, 1986). A meta-analysis report on pilot stress–performance stated that the ‘stress–performance (Young, 2008a, p.2) literature reveals a substantial body of research demonstrating that acute stress (i.e., that which arises in the context of high task demand/potentially threatening situations) can impair task performance’. Supporting this outcome, the theory of attention indicates ‘a positive association between felt job stress and job performance’ (Hunter and Thatcher, 2007, p.954). Jex’s (1998) picture of felt job stress and job performance relationships was somewhat weak and inconsistent. He expanded on inadequate connections to identify sources of stress. The current research aimed to bridge these gaps with reference to the commuting–stress–performance triangle. With this in mind, this work sought to frame and narrow research on fatigue to define a pilot commuting–stress–performance model. In their occupational stress analysis with US National Bank branch employees, Hunter and Thatcher (2007) employed the attention theory approach to focus on the task at hand to improve performance under stress. Moreover, in their Swedish army radar watching task research, Bergstrom et al. (1973) concluded that stress improved performance among 30 voluntary, filtered participants. Stress was induced in a laboratory scenario by applying strong electric shocks to the participants, which can be seen as a reservation to the procedure as physical stress was induced, but this approach lacks outside world scenarios. In contrast, in a SEM test, Sun and Chiou (2011) established that occupational stress has a negative effect on the work performance of aviation ground crew.

2.5.3 Pilot-specific Occupational Stress

Sloan and Cooper (1986) completed one of the few studies to investigate pilot-specific occupational stress factors, limited to the British pilot corps and supported by the British Airline Pilots' Association (BALPA)—an umbrella organisation for British pilots. Generally, these associations form a union for pilots' interests, which may have created a biased pre-determined mindset among the association members. With this in mind, it is also essential to note that these organisations offer the only safety-relevant backup for a national pilot corps. With their fundamental research on 'Pilots under stress', Sloan and Cooper (1986) formed the basis for pilot occupational stressors and the different interconnections between life and work stress parameters. Although they did not explicitly research commuting stress, the interactions between life and work stress and connection between these two poles, as well as the subjective pilot performance questionnaire upon which the research was founded, suggest that this work should be seen as the founding and main research (Young, 2008) on subjective pilot performance based on the stress experienced by pilots.

Further, in a sociology study of commercial pilot lifestyles, Bennett (2014, 2011) peripherally researched pilot commuting, focusing on a commuting mode, time and distance model and the use of temporary accommodation at the home base. This falls more into the realm of fatigue research than the context of stress and commuting performance that is primarily relevant to this study. The literature discussed thus far reflects a sharp divide between the source of stress and the place from which it originates—home or the workplace (Sloan and Cooper, 1986). However, the interaction between home and work is also a significant source of stress and 'of critical significance as a source of psychological stress' (Sloan and Cooper, 1986). Sloan and Cooper (1986) drew attention to this interaction and the resulting possible problematic interaction of domain rivalisation and accumulation of stress, with an interesting bias in a negative connotation of stress. Nevertheless, this research did not reflect on the bridging behaviour of commuting, with commuting not mentioned at all. Reference was only made to a 'swap over effect between home and work' (Sloan and Cooper, 1986) and differences between work and job stress. Although not explicitly mentioned, commuting connects the home and work domains. In addition, the 'level of control' (Sloan and Cooper, 1986) serves to regulate or moderate subjective experiences of stress. Sun and Chiou (2011, p.2865) found that 'stress levels among crews in aviation

industry are increasing and ... this is manifesting itself in the form of unsafe working practices, higher turnover, lower morale and poorer performance'. In this context, it is necessary to mention that reporting on general stress situations for pilots is a highly sensitive issue, as overall medical fitness is a crucial component of the daily professional business of pilots. Moreover, the highly self-regulated and self-judging mechanism of the pilot profession is geared to providing a safe and endurable status for safe aviation operations in a team. Cooperation techniques among team members, as well as CRM techniques, have long been established as a SOP in aviation (Helmreich et al., 1993). Adhering to these protocols makes it even more difficult to judge a crew partner's stress levels. If a pilot colleague is not fully aware of their cockpit partner's stress levels and the effect of stress on their operational capacity, this might be detrimental for the safe conduct of a flight. Self-reporting of crew members in the face of sanctions (e.g. 'fear of losing face in the eyes of other pilots, of being perceived as less reliable, or of being removed from flight status, for that reason pilots in such conditions, is an essential tool in an open non-punitive safety system'; Young, 2008, p. 2). In some instances, contrary to this approach to stress symptoms, a targeted SOP creating open and reliable communication is vital for a functioning cockpit and aircraft crew environment, especially during emergencies. Limitations such as pre-conditional stress and preoccupation with stressors can significantly negatively affect the communication between pilots and crew members, and skilled performance (Kavanagh, 2005). As stated by Young (2008, p.13), 'acute stress causes a narrowing of attention, which could lead to overlooking important cues to effectively resolve an emergency. Also, working memory is impaired, which impairs problem-solving and decision-making'. Given that all these limitations and threats may prevent objective pilot reports of subjective stress experiences, it seems clear that 'affective stress is the emotional experience of the pilot' (Sloan and Cooper, 1986). In this context, it is helpful to recall the cited stress theory that affective stress is cumulative and additive (Homan, 2002). Sloan and Cooper (1986) hypothesised that, based on 'the types of stress identified, it would seem that it is the affective form of emotional stress that is the more volatile and subject to the least control by the pilot'. This makes it difficult for a pilot to control the situation.

2.5.4 Commuting Stress

There is a robust literature on the commuting working population, reporting theory-based research on the effect of commuting and reflecting on various variables. General to most of this scientific work is the grounding theory of the commuting impedance model founded by Novaco et al. (1979; Schaeffer et al., 1988; Stokols et al., 1978). This research does not provide a broad picture of the topic, but limits itself to objective stressors—a combination of time and distance, according to Novaco et al. (1990). Generalising this theory suggests that commuting causes stress and that this stress is a ‘function of the degree of commute impedance which is defined as any factor that frustrates the goal of arriving at a destination, such as distance, slow speed, and congestion. Commute impedance is therefore hypothesized to cause psychologically-mediated strain, including (a) health problems, (b) decrements in performance, and (c) negative attitudes towards the experience of commuting’ (Kluger, 1998, p.148).

In researching the relationship between mode choice and commuting stress in a large sample of students and faculty staff in Canada, Legrain et al. (2015, p.149) confirmed that ‘commuting stress is caused by an interaction between objective stressors and mediators (time, control, and comfort) and subjective stressors which act as mediators (feelings, desires, and satisfaction)’. Further, a recent article by Zhou et al. (2017, p.5) on commuting stress processes and self-regulation at work pointed out that it is important to ‘define commuting stressors as conditions and events during the commute that evoke the stress process and induce strain’. As their research is limited to daily interference from the work commute, it may not be fully applicable to a long-term infrequent commute. Kluger (1998) examined the commuting impedance model and suggested that the organisational consequences of commuting are less consistent. However, he concluded that the model is ‘consistent with the proposition that some commute characteristics lead to strain, at least among commuters who drive to work. The strain has been found in physiological and somatic reactions as well as in organisational consequences such as poor task performance, tardiness, turnover, and absenteeism’ (Kluger, 1998, p.149). In Kluger’s (1998) research, the term ‘commute characteristics’ replaced ‘impedance’ and was introduced as an alternative commuting-strain model reflecting new commute variability. Kluger (1998, p.161) expanded further, stating that ‘among the possible psychological effects of variability

is reduced cognitive control, due either to a reduction in predictability, or to an increase in cognitive load, or both'. A general shortcoming of the commuting impedance model of Novarco et al. (1990) are the favourable loadings and effects of commuting on the transition from work to family domains. The boundary-spanning work–family border theory (Voydanoff, 2005) addresses these positive effects. In particular, research on long-distance commuting 'has proven that commuting can provide benefits for the individual, serving as a transition between home and work life' (Kuennen, 2012, p.46). Nomaguchi et al. (2005) found that commuting time is not related to psychological distress, and can be 'viewed both as a time constraint and as a useful transition time' (Voydanoff, 2005, p.494). In the study of Voydanoff (2005, p.494), 'commuting time was positively related to work-to-family conflict, [and] the time spent commuting also may serve as a decompression period after leaving one domain and a time for preparing to enter another'. Moreover, in a study of pilots under stress, Sloan and Cooper (1986) found that connecting to the aviation domain and stress coping possibility was one of the few directly related connections to pilot commuting; one pilot reported that, 'There is a cooling-off period in the car which is probably the main way I cope. There is a residue of time between home and work when one has time to think about things'. This statement powerfully and personally outlines what is suggested by the work–family border theory (Voydanoff, 2005). Koslowsky et al. (1995) also found that commute time can 'very well be utilised beneficially and lead to quite desirable outcomes' (Krausz, Meni Koslowsky, Asher Aizer, 2008). Voydanoff (2015, p.500) stated that boundary transitions and commuting time had 'positive relationships with work–family conflict and perceived stress'. In that work, Voydanoff (2015, p.500) also suggested 'that the time demands accompanying long commutes are more important than commuting as a period of preparation or decompression in relation to conflict and stress'. In addition, Kuennen (2012) offered the hypothesis that long-distance commuters develop new personal strategies to use travel time positively.

2.6 Pilot Performance

2.6.1 Pilot Performance Measurement

The measurement of pilot performance by airlines is highly standardised and the outcome narrowly regulated. Pilots' performance is under constant supervision via legal simulator checks every six months and a one-line check - a line-oriented

checking event to evaluate, among other factors, the CRM techniques applied in the cockpit environment (ICAO Safety Management Manual, 2009).

Subjective evaluation is a standing process as a self-centred debriefing process. The reporting system is enhanced in checking events to support self-evaluation techniques in the strict non-punitive environment of an aviation safety system (Cooper, 2000; ICAO Safety Management Manual, 2009; Lemper and Laur, 2006). Therefore, subjective pilot performance measurement (Sloan and Cooper, 1986) appears to be a valid evaluation tool. Although this measurement is retrospectively subjective, it is a highly standardised, reliable and proficient pilot professional group self-evaluation. Additionally, the medical status required by pilot certification is one of the substantial standard overall requirements for the pilot profession. Another professional speciality is that for the routine performance of the pilot profession, the pilot themselves is under constant self-evaluation in regard to whether the required standards for undertaking the flying job in an adequate way are met (Lemper and Laur, 2006). Use of established and required CRM and SOP techniques in the cockpit can also encounter shortcomings if the required standards are in jeopardy. The pilot and their self-evaluation are the last line of defence to ensure fitness for flight. One prominent event that highlights the risk of endangering the aviation system occurred on Germanwings Flight 9525, in which the first officer operated within the required standards of CRM and SOP techniques for the operation, but nevertheless performed a suicidal act that destroyed the operational aircraft and killed all occupants on board the flight.

In their study on pilot performance, Sloan and Cooper (1986, p.35) used a self-reported, retrospective questionnaire that was 'designed [so] that the pilot in the survey would find [the questionnaire] meaningful'. This item also employed a weighted design to be used individually to address pilot performance. Sloan and Cooper's (1986, p.35) research concluded that 'the final element in drawing up our portrait of the pilots is to examine their levels of performance. Pilots are subject to rigorous tests of their knowledge and flying ability. Hence all pilots in the study were performing within standards accepted by the Civil Aviation Authority.' The work further stated 'the measure we diagnosed for use in this study was not used, therefore, to identify and compare 'good' with 'bad', but 'optimal' with 'sub-optimal' performance. We are ultimately interested in which issues predict the levels of subsequent performance in

pilots.’(Sloan and Cooper, 1986, p.60). The authors of the study complained that, ‘Unfortunately the complex construction of the measure does not lend itself to meaningful simple analyses. For the present, we must be content with the conclusion that the pilots appeared to attain satisfactory levels of self-perceived performance’ (Sloan and Cooper, 1986, p.60). According to the safety system requirements, subjective measurement a satisfactory pilot performance indicates that safe conduct of a flight was achieved but an in-depth objective analysis of the flight might have indicated differently. However, Sloan and Cooper’s (1986) fundamental research on the pilot profession did not investigate the issue of pilot commuting. Although it focused on work–home relationships and stressors, this was not combined with the issue of pilot commuting. Moreover, the research was geographically focused on the UK and the participants addressed were BALPA members. This could have introduced bias among the organised pilot corps and encompassed pilots who were sensitive to professional shortcomings in the first place. In their research, Sloan and Cooper (1986) concluded that ‘pilots who are at risk are those who identify working patterns, schedules and rosters as a primary source of stress. They tend to be older pilots who are anxious about completing courses and technical and medical checks. Also important is the impact of not flying as many hours as they would have liked.’ Moreover, Sloan and Cooper (1986, p.114) stated that ‘the examination of performance is an interesting issue. The measure we used was designed by us for the study to try to achieve some quantitative assessment of performance as perceived and reported by the pilot himself ... For example, senior first officers tend to rate their performance as being higher than do captains; long-haul pilots do the same compared to short-haul pilots’.

The comments of pilots in response to the research survey sections of the original Sloan and Cooper (1986, p.167) questionnaire indicate an interesting connection between commuting, stress and the time spent travelling ‘there is a transition period in actually travelling to work. I don’t think I’m good at coping with stress in terms of reducing it but I’m good at coping in the sense of operating under it. I think it is bad often to try to reduce it because often under stress the adrenalin is going which is good.’ Moreover, the authors stated ‘it would appear that the period spent actually travelling to work helps in this mental change. Although the former quotation *is* in the context of from home to work (and not readily identifiable in the latter), one can assume

that the ‘cooling-off’ period also applies from work to home (Sloan and Cooper, 1986, p.167).’ These comments describe the value of commuting time and the positive and negative possibilities that this time offers. As stated by Amponsah-Tawiah et al. (2016, p. 104), this ‘commuting can be stressful, [and] chronic exposure to commuting stress can impair employee health and work performance’.

2.6.2 On-the-job Performance

Expanding pilot performance measures to determine the on-the-job performance of the general population may also enable a broader approach to the perception of stressors and performance issues and could be beneficial for this overall discussion. In a stress and performance review for the military, Kavanagh (2005) noted that response to stress ‘beyond simple physiological reactions’ can influence crucial performance in group-sensitive interactions and decision making, which are highly relevant in a cockpit environment. He stated that impairment is also recognisable in cognitive reactions. The schema presented in Figure 9 and Figure 10 are taken from Kavanagh (2005), and illustrate the stressor–stress–performance interaction.

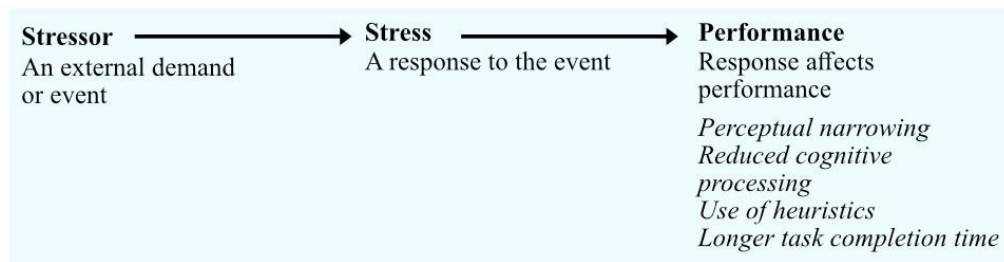


Figure 9–Stress Can Affect Performance

Source: Kavanagh, 2005.

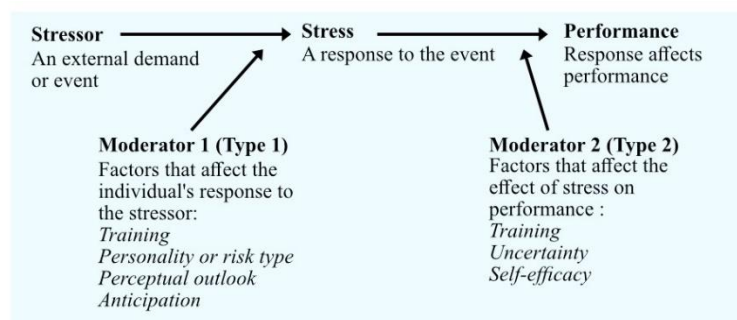


Figure 10–Moderators in the Stressor–Stress–Performance Relationship

Source: Kavanagh, 2005.

Kavanagh's (2005) indicating moderator analysis is presented in the analysis section of this thesis. This stressor–stress–performance theory presents and uses moderators that support Sloan and Cooper's (1986) research on coping mechanisms applied by pilots to cope with experienced stress. In addition, a moderating effect and acclimatisation over time, as well as an established coping scenario, can reduce the negative effect of stress on performance (Cooper and Sloan, 1987; Kavanagh, 2005). Preoccupation with stressors and constantly thinking about them, as well as spillover effects in the occupational domain, were examined by Green (1985), although he mainly focused on life stressors. The extent to which commuting is a life stressor was not addressed in Green's work.

2.7 Pilot Turnover Intention

The pilot role is a very special job situation in a highly competitive and regulated industry. Thus, employment as a pilot requires a highly diverse set of skills and the role is undertaken in a highly regulated and supervised training and checking environment. This training and checking is legally mandatory before the engagement and commencement of an active pilot position on board an aircraft. When starting work at an airline, a pilot attends numerous theoretical lectures about the company's rules and regulations. Further, it is necessary for pilots to become familiar with the operations manual of the particular airline operation. Pilots must use a type- and aircraft-specific simulator for training and checking, which familiarises cockpit crew members with the specialities of the airline operation and the SOPs, company rules and crew resource training provided by the operator (Cahill et al., 2020a; Lemper and Laur, 2006). These procedures are generally unique to each airline. Such training is time consuming and expensive. It also requires substantial effort and resources to plan, establish, maintain and fulfil the legal requirements of the standardised training and checking schedule. These obligations mean that airlines must maintain and develop a stable pilot corps to be able to deliver flight operations safely and accurately.

Another system that is used mostly by major national carriers, but is not limited to their operations, is the seniority system. Each crew member joining an airline as a pilot is given a seniority number according to the date on which they join the company. This number is essential in the pilot industry and specific to an isolated airline operation only. When leaving or resigning from an airline company, the pilot generally loses this

seniority number and the privileges connected with seniority (Gander et al., 2011; Moses and Savage, 1989; National Academies Press, 2011). Seniority generally governs career progression, such as becoming captain or senior first officer; relieving captain appointments; or gaining home base, vacation, aeroplane-type and furlough assignments. It is an essential instrument for pilot career progression and is worth a great deal to most cockpit crew members. Thus, pilots are generally reluctant to change jobs, as this is often connected with seniority loss and starting their career again at another airline operation. Generally, it is industry standard to participate in a psychological screening process when joining an airline and to show positive progression in this process before joining an airline. As a result of the bankruptcy of regional carriers in Europe over the last decade, only a few airline operators spanning the pan-European base network in their operations remain in the market. This leaves a limited choice of pan-European airlines for pilots who wish to change their job or airline operator. The available literature is scant on turnover intention in general, especially when the spotlight is advanced and connected with commuting stress or occupational performance. Turnover intention is seen as 'a conscious and deliberate wilfulness to leave the organisation' (Tett and Meyer, 1993, p.262). Some research has examined the interrelation between turnover intention in general population jobs, and in relation to commuting stress.

In their study on turnover intention, burnout and commuting stress, Amponsah-Tawiah et al. (2016) developed a novel commuting stress questionnaire, as they noted a lack of available commuting stress measuring tools. Their research indicated that 'commuting stress was significantly correlated with turnover intention ($r = 0.15$, $p < 0.05$). Commuting time was also significantly correlated with commuting stress ($r = 0.35$, $p < 0.01$)' (Amponsah-Tawiah et al., 2016, p.113). For guidance, Amponsah-Tawiah et al. (2016) established, with 363 valid respondents, that commuting stress is associated with high levels of turnover intention. This significance between commuting stress and turnover intention was also important for the European airline pilot commuting situation. Like Novaco et al. (1990), this outcome supports previous research indicating that commuting stress is connected to intention to leave a job. Novaco et al. also suggested the inter-domain transfer theory that positive or negative environmental conditions or psychological states (commuting, stress) can influence other domains. Expanding this to professional performance, Novaco and Gonzales

(2009, p.180) stated that ‘frustrating aspects of road traffic ... interfere with behavioural objectives, evoke unpleasant emotional states, and detract from efficient performance and personal satisfaction’, positioning it in correlation with commuting stress, turnover intention and occupational performance. Resigning from a position may be a coping mechanism (Sloan and Cooper, 1986) to respond to commuting stress. Novaco et al. (1990) indicated that individuals in conflict with a commuting situation tend to change their employer after 18 months. Moreover, Deding et al. (2009) established commuting distance as a variable affecting job turnover.

2.8 Locus of Control

Lack of control can be a detrimental factor in the overall rating of a travel and commuting experience, along with job performance. Particularly in an already challenging job, such as working as a pilot, accurate commute planning that leaves sufficient time to fulfil travel needs is essential to meet all requirements. Revengement and preoccupation with thoughts governing a commute situation also influence on-the-job performance because continuously needing to plan a commute can cause stress. In a study with rail commuters in the US, Evans et al. (2006) found that ‘those who perceived their commute as more unpredictable felt greater levels of stress’ (Kuennen, 2012, p.52; Lyons and Chatterjee, 2008, p.185). In particular, the unpredictability of a train commute ‘is associated with higher stress levels for commuters’ (Evans et al., 2010). Additionally, Leitch (2003) found that a number of factors cause stress that affects performance, and that people who encounter uncertainties during their commute have to spend more time finding the right response to the stress exposure they experience and must be prepared for different expected outcomes. Increasing time and effort during the commute preparation and evaluation process will have a significant effect on job task performance, can lead to worst-case preparation scenarios (Kavanagh, 2005) and generally impairs or endangers the overall positive outcome of job tasks.

2.9 Safety Behaviour

Safety management has been long established in the aviation industry and is a key factor in the safe operation of aircraft, as well as pilots’ performance. A wide body of research has established the dominating and valid position of safety management systems and how to establish a non-punitive safety climate in the aviation industry

(Cooper, 2000; Johnson, 2007; Judge and Bono, 2001; Reader, Parand and Kirwan, 2016a; Sulzer-Azaroff, 1987). Chin-Shan and Szu-Yu (2015) researched a terminal operational setting based on 430 respondents. It was found that a container terminal setting is a hazardous work environment. This has parallels in job performance in a stressful environment. The researchers saw that multiple factors of environmental stress influenced job performance. The researchers introduced the term emotional intelligence in connection with safety behaviour. It can be hypothesised that pilots have emotional intelligence based on previous pilot hiring themes and continuous on-job-evaluation themes: 'They are less likely to cut corners and undertake unsafe practices to achieve higher performance. Their emotional intelligence influences safety behaviour at work' (Chin-Shan and Szu-Yu, 2015, p.11). Chin-Shan and Szu-Yu (2015) expanded that safety behaviour is positively affected by emotional stress. An additional describing factor was used by Chen and Chen (2014), who introduced the factor of self-efficacy connected with pilot behaviour. Utilising a sample of 239 research participants, they found that 'pilots with higher self-efficacy were more motivated to perform safety behaviours, and similar results were found in prior research, which showed that self-efficacy positively influences organisational behaviours' (Chen and Chen, 2014, p.384). This is also reflected in the view of Reader, Parand and Kirwan (2016a), who described this as 'what they [pilots] do'.

Neal and Griffin (2002, p.113) used the term 'safety compliance' as a substitute for safety behaviour, and established and described the term as 'what they [pilots] actually do' (Neal and Griffin, 2002a). Further 'these behaviours include adhering to standard work procedures and wearing personal protective equipment. The term safety participation is used to describe behaviours that do not directly contribute to an individual's personal safety, but help develop an environment that supports safety. These behaviours include activities such as participating in voluntary safety activities, helping coworkers with safety-related issues, and attending safety meetings' (Neal and Griffin, 2002b, p.70). Cooper (2000, p.113) saw this approach as meaning that 'numerous definitions of safety culture abound in the academic safety literature' exist. In the highly standardised aviation and aeroplane piloting world, standardised psychological testing is used as part of most European airline pilots' hiring processes and at most airline organisations. Therefore, a quiet harmonised approach of values and harmonised organisational proceedings unique pilot of an organisation. Following

initial psychological testing, the pilot undertakes an official required safety management training course and training about the individual organisation's required standards, such as the operations manual and various parts thereof. Most organisations have established rules to deal with pilot commuting and abuse of illegal substances. This includes a radius to take residence or a minimum time to arrive at the assigned crew base to have adequate rest before commencement of flight duty. Therefore, the harmonised picture of shared safety values, a shared safety culture and shared safety behaviour is widely evident in aviation organisations and the European airline pilot corps. Research has established safety behaviour based on studies conducted in various domains outside the aviation industry (Chin-Shan and Szu-Yu, 2015; Cooper, 2000; Johnson, 2007; Neal and Griffin, 2002b; Sulzer-Azaroff, 1987). From the author's perspective it is difficult to compare between industries as few have similar, standardised promotional and legal backgrounds to aviation. Few domains outside aviation have such a strong and established history of safety record tracking, accident investigation and pre-occupational psychological testing. In a literature review conducted by Burch (2015), 'safety behaviours are seen as proximal outcomes of commuting stress'. Burch (2015) also stated that, 'one potential proximal outcome of commuting stress is risky safety behaviour while commuting', which is connected to the Wilensky (1960) 'spillover-leisure hypothesis'. It has also been theorised that spillover from commuting may happen because of safety behaviour, and may occur between the working and non-working domains.

2.10 Literature Review—Research Gaps

Very little is known about European airline pilot commuting practices and how the system mitigates threats posed by the subjective experience of commuting stress. There is a very limited literature on occupation-specific commuting. No research has investigated occupation-specific, long-distance, infrequent commuting practices or the potential for using a second housing facility at the place of occupational engagement. Therefore, the aim of this research was to expand knowledge in this area to provide insight into pilot occupation-specific commuting practices; investigate the issues of commuting stress generation and examine in detail the influence of commuting stress on on-the-job cockpit task performance and resulting turnover intention. This

research's detailed research objectives and hypotheses can be revisited at 1.4 Research Objectives and 1.5 Hypotheses and Research Questions of this work.

CHAPTER 3: RESEARCH METHODOLOGY

The aim of this research was to identify variables influencing pilots' commuting behaviour and the subsequent commuting stress generated at the pilot level that impacts their occupational performance.

The first part of this chapter is devoted to the operationalisation of variables used in the study. This is followed by the presentation of the cross-sectional survey methodology, and sampling size and method, as well as the data collection process. Survey instruments and test and survey reliability are discussed in Section 3.3. This is followed by a description of the statistical analyses and SEM employed in the research.

3.1 Theoretical Framework

The theoretical framework for this research with respect to stress and pilot performance evaluation is the Hancock and Warm (1989) maximum adaptation model that describes stress in a three-part differentiation of the concept of stress. This model strongly reflects and entails how a 'model may be elaborated to encompass the effects of stress on a wide variety of attention-demanding tasks' (Hancock and Warm, 2003). Therefore it is also highly applicable to the pilot profession and pilot performance requirements. Hancock and Warm (2008) stated that the model can be used 'at multiple levels of analysis and need not be restricted to the physiological and behavioural domains in which they were founded'. In the definition of a 'trinity of stress' (Hancock and Szalma, 2008), the commuting process can be explicitly understood in connection with pilot performance as this model was 'developed specifically for the prediction of stress effects as they relate to performance' (Hancock and Szalma, 2008). According to the trinity of stress model (Hancock and Szalma, 2008), an input is a characteristic of the physical variables in the environment. These are seldom fully reconstructable and repeatable because a time factor is represented in the assumption. A 'stress signature' (Hancock and Szalma, 2008) is therefore presented as a result of the added inputs (see Figure 11).

The inputs in the current research were measurable variables influencing commuting behaviour - time, mode, distance, frequency of commute and so on—which are deterministic.



Figure 11–Three-part Differentiation of the Concept of Stress

Source: Hancock and Szalma, 2008.

Sloan and Cooper (1986) called the stress–performance evaluation ‘coping processes’, while Hancock and Salma (1989) defined ‘pilot coping’ (Cooper and Sloan, 1987) as an adaptation process that is nomothetic in nature ‘because processes work in general in the same way for each individual’ (Hancock and Szalma, 2008). With respect to the model’s ‘goal-directed behaviour’ (Hancock and Warm, 2003), the outcome of this research is the safe conduct of a flight for the commuting and non-commuting pilot within established aviation safety or organisational aviation industry parameters. It is idiographic in nature because for this research, and the model applicability in general, each individual pilot plans their commuting process and variables independently and differently. Figure 12 describes the extended-U shape conception of stress and response capacity (Hancock and Szalma, 2008). The base level shows ‘input’ variation in stress at the maximum (hyperstress) and minimum (hypostress) levels. At the top-level plateau and apex of the extended-U shape is the area of ‘stable response in relation to the specific form of input stress’. Following the downward lines, we can see the various ‘output’ variations ‘which illustrate the breakdown in various levels of response capacity as the input stress exceeds adaptive response’ (Hancock and Szalma, 2008).

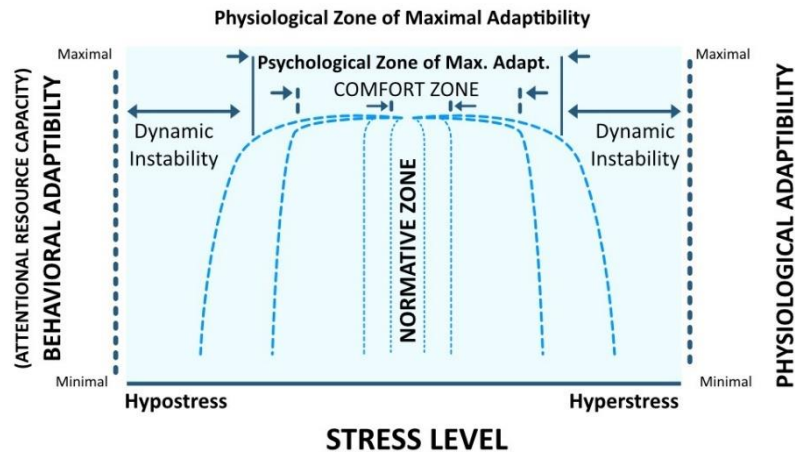


Figure 12–Extended-U Concept of Stress and Response Capacity

Source: Hancock and Warm, 1989.

Another ideal feature of the Hancock and Szalma model is that it considers a multidimensional form. It notes ‘that the proximal form of stress in almost all circumstances is the task itself’ (Hancock and Szalma, 2008). In this research, the commuting process and the subsequent variation connected to this process (commuting)—called the ‘information structure’ (Hancock and Szalma, 2008)—is represented as a vector in the model (Figure 13). The ‘temporal dimension is represented by information rate. This connotes the speed at which information and demand are presented’ (Hancock and Szalma, 2008, p.7). Typically in ‘older’ stress theories (e.g. Lazarus, 1969), the stressor is seen as a stimulus stemming from the performance task itself, while Hancock and Szalma (1989) sees the task as a broader form of input using multiple additions to the input, to form a total stress signature. Also, Sloan and Cooper (1986, 1987) expanded on the importance of compensatory processes, which Hancock and Szalma (1989) call ‘adaptation’ in this model.

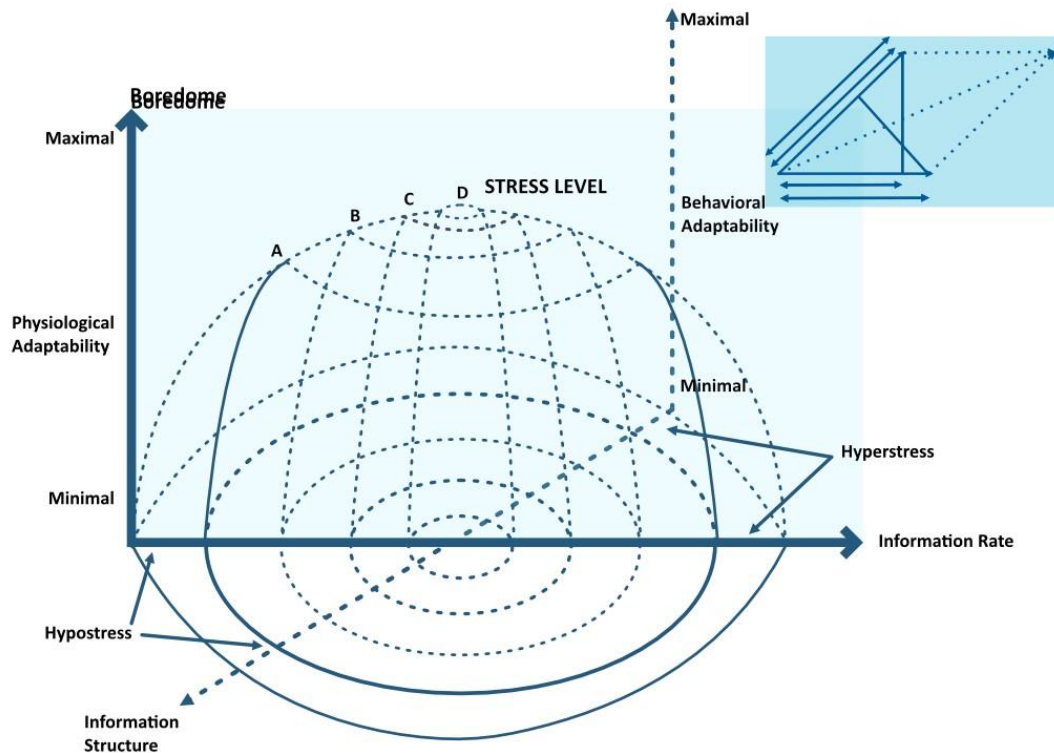


Figure 13–Extension of the Extended-U Model through the Differentiation of the Base

Source: Hancock and Szalma, 2008.

The strongly overlapping parallels of research on stress and performance of the Sloan–Cooper and Hancock–Szalma research groups broadens the basis for the application of both models, which are united in this research and applied to the influence of commuting stress on pilot performance. Integration of the Hancock and Szalma (1989) maximal adaptation model and the Sloan and Cooper (1986) approach to pilot performance measurement and coping mechanisms has generated a conceptually sound integrity and theoretically relevant model to apply to European pilot commute situation stress and its performance implications. This research focused on the Hancock and Warm model of maximum adaptation and investigated the input side (commuting stress) as the signature of stress and the output side as professional pilots' performance. Measures of adaptation can be established in relation to the Sloan and Cooper (1986) research adaptation model in their 'pilots under stress' study.

3.2 Research Strategy

The importance of data-driven research in understanding the complexities of the aviation industry is increasing. The development of modern European aviation safety plans is based on data collection to "support the management of safety risks at the European level" (EASA, 2022, p. 51). At the European level, an EASA-led initiative known as "Data4Safety" plays a crucial role in this. Data4Safety brings together partners across the European aviation community including aircraft manufacturers, airline operators, national air traffic service providers, pilots, maintenance organisations, and airports. All of these organisations have traditionally collected safety data but have tended to manage it individually (EASA, 2017).

The European approach of "Data4Safety" combines this individual data and knowledge into one large data pool in a big data environment. Analysing this big data environment requires new approaches. A "novelty is the creation of an analysis platform that will gather aviation experts from all domains and organisations in a way we have never seen before in Europe" (EASA, 2017). Analysing large amounts of data should make it possible to identify trends in European aviation safety and, based on this, to develop and continuously improve a European aviation safety strategy. Based on this approach, (McFadden and Towell, 1999, p.177), "data analysis can support vital decision-making processes and help reduce pilot-error accidents".

This study, which focuses on European airline pilots' commuting behaviours, was conducted using established research methodologies. The research strategy included a comprehensive review of existing literature, surveys with pilots, and analysis of commuting patterns and their impacts. This approach ensured a thorough and systematic exploration of the commuting process, adhering to recognized standards in research methodology. In the sense of a positivist research philosophy, this includes attempting to approach the research subject as objectively as possible and being independent of the researcher. The study aims to work out the cause-effect relationship in the commuting process of pilots of European airlines. A combination of established stress and performance theory (Hancock and Warm, 1989), the commute impedance model (Kluger, 1998), and pilot stress theory (Stephen Sloan and Cary Cooper, 1986) was applied. A new approach to understanding European airline pilots' commuting behaviour has been developed (Creswell and Creswell J. David, 2017;

Malhotra, 2017; Sahay, 2009). Derived from the literature review, this statistical survey of the commuting behaviour of European airline pilots creates a quantitative database which, following the positivistic assumption of this research approach, allows a hypothesis testing procedure to be set up.

The quantitative-deductive research approach chosen here begins with forming hypotheses and then determining the survey instruments for data collection. This approach is suitable for researching the commuting behaviour of European airline pilots because this approach is broad enough to represent a large part of the European pilot corps, and at the same time, the variables stress, and the resulting fluctuations in performance due to the commuting process can be included in the study (Creswell and Creswell J. David, 2017). A quantitative survey method was chosen to obtain the necessary information and data. This method was also helpful because a large data set of email addresses from European airline pilots could be used for this research. However, to prevent this address quota from ageing and becoming invalid, there was only a relatively short time frame available for data collection to carry out the survey (Choy, 2014).

Access to the European pilot corps for independent research is generally very limited. The method chosen by this study represented one of the few contact options through which a sufficiently large number of European pilots can be reached directly and, above all, independently of European airlines, unions and other institutions that might be influential and not unbiased in the selection of European airline pilots. Confidential and non-punitive safety systems are standard in the European aviation industry. Confidential reporting systems for aviation safety systems are the backbone of data collection for these safety systems. Another important factor in research design is audience trust and research acceptance among the invited survey participants, regulators, and those responsible for the safety of the aviation system. Therefore, this type of data collection was chosen for this study in the context of a quantitative research method. This approach has the advantages described above but differs significantly from qualitative research, such as open-ended questions or telephone interviews. Qualitative research focuses on understanding the underlying reasons, opinions, and motivations behind human behaviour, and it is conducted through methods such as interviews, observations, and focus groups. The time-consuming process of interviewing and the potentially bias-generating process of interview

interpretation were reasons for rejecting a qualitative research methodology for this study (Choy, 2014; Malhotra, 2017).

Data-driven aviation safety studies (McFadden and Towell, 1999) prefer quantitative research over qualitative methods. This is mainly because questions about flight safety are characterised by complicated relationships and patterns. Quantitative methods enable the creation of models that predict the probability of pilot error, considering both primary elements and multi-way interaction variables. This predictive ability is critical to prevent incidents in an industry where errors can have catastrophic consequences. The ability to numerically analyse performance, attitudinal, observational, and census data through statistical analysis provides a concrete way to understand and mitigate risks. The non-punitive aspects of error reporting and aviation safety concerns are crucial. Otherwise, there is a risk that many errors committed in aviation will go unreported, which would create a significant gap in the understanding of safety. Because they focus on the statistical interpretation of large data sets, quantitative approaches can help identify patterns and outliers that might indicate unreported problems. This non-punitive and proactive approach, which emphasises anonymising personnel in the data, aligns well with quantitative methods that aggregate and anonymise data to provide greater safety insights and improve overall system safety. While qualitative research delves deep into subjective standards, perceptions, and beliefs, the aviation industry often requires more objective approaches to ensure comprehensive consistency and understanding of safety-related operations. Quantitative research provides a framework for these objective standards, offering clear, number-based insights that are widely understood and applicable.

In aviation and related human factors fields, data collection for subjective attitudes is often based on employee questionnaires. These are particularly useful for capturing otherwise 'hard to measure' perceptions such as job stress and fatigue human factors (Göker, 2018) in aviation (Vredenburg, 2002), safety culture (Glendon et al., 2001), safety climate (Flin, 2007; Flin et al., 2000) and attitudes in flight operations (Sexton and Kline, 2017a), performance in flight operations (Hunter and Thatcher, 2007b), commuting, and effects of stress on work performance (Sun and Chiou, 2011b). Although so-called "soft issues", data on these areas are significant for the aviation industry (Neal and Griffin, 2002c). For example, it is critically important to understand the prevalence of stress among pilots. Measuring their impact on performance and

safety, as conducted in this study, requires a quantitative approach that ensures both accuracy and applicability of the results (Sahay, 2009). Quantitative methods, such as those used in this research on predetermined, structured topics, ensure consistency and reliability across studies, making it easier to compare data over time and across different contexts, which is vital for safety studies and regulatory compliance. The research strategy chosen in this study in no way diminishes the value of qualitative findings but rather highlights the pilots' need for standardised, proactive, and generally applicable commuting measures for pilots of European airlines.

Mixed research methods combine quantitative and qualitative approaches to provide a more comprehensive understanding of a research topic. By using mixed methods, researchers can collect data from multiple sources and triangulate findings, increasing the validity and reliability of their research. "For example, a researcher may want to both generalise the findings to a population as well as develop a detailed view of the meaning of a phenomenon or concept for individuals." (Creswell and Creswell J. David, 2017, p.50). A mixed methods approach in case of this study would have investigated the effects of pilot stress and performance. A quantitative survey could collect data on pilots' stress and performance variables, while qualitative interviews explore 'pilots' perceptions and experiences of commuting. This dual approach was not chosen for this study due to the primary aim of this research. One challenge is that mixed methods can be time-consuming and resource-intensive because researchers must collect and analyse data using multiple approaches. Additionally, integrating quantitative and qualitative data can be challenging. Researchers must ensure that the data is compatible and can be meaningfully combined. (Creswell and Creswell J. David, 2017; Malhotra, 2017; Sahay, 2009) The choice of research methods depends on the research questions and objectives and the strengths and limitations of different approaches. Given the short time frame available, the anonymity of the data providers and the broad access to the pilot corps of European airlines preferred for this research approach, a purely quantitative approach was chosen as the approach with the best possible guarantee of valid results.

3.3 Data Collection and Filtering

The development and theory-building process advanced alongside the ongoing literature review process. Initially, the scope focused on the pilot commuting process

and progressed during theory development to influencing topics and variables for theory and hypothesis development. Generally, very little literature is available on occupation-specific commuting practices. The primary scope of the majority of commuting research considers the mode of transport; form of commuting; active or passive engagement in commuting; and connection between life satisfaction, wellbeing and commuting. Influencing variables such as the cost of commuting (Morris and Zhou, 2018; Morrow, 2010; Van Ommeren and Fosgerau, 2009) and value of time (Handy and Thigpen, 2019; Markey, Ryser and Halseth, 2015a, 2015b; Paez and Whalen, 2010; Rouwendal and Nijkamp, 2004), have been thoroughly researched, but do not apply to this research on pilots' occupational commuting practices. The unique combination of and connection between the theoretical variables explored in this study has not previously been established in the literature. A systematic literature review was established to examine individual interrelated topic parameters to develop some form of connection among variables. The choice of main topics for the literature research in this study was based on categories selected 'for two primary reasons:

- they represented the primary areas of functioning affected by stress, according to the literature in this field
- they were particularly relevant to the pilot performance context and to the completion of important cockpit tasks'

(Kavanagh, 2005, p.15).

From this perspective and reflecting on the literature review, pilot commuting is associated with a range of variables including commuting, work, stress, airport location, turnover intention, safety behaviour and locus of control (Figure 14).



Figure 14–Data Collection and Filtering Keywords

Source: Friesacher.

3.3.1 Literature Review & Collection Plan

Based on the main research topics, a data collection plan was established to collect data from several databases. Keywords for the different fields were established and used for the literature search, as outlined in Figure 15.

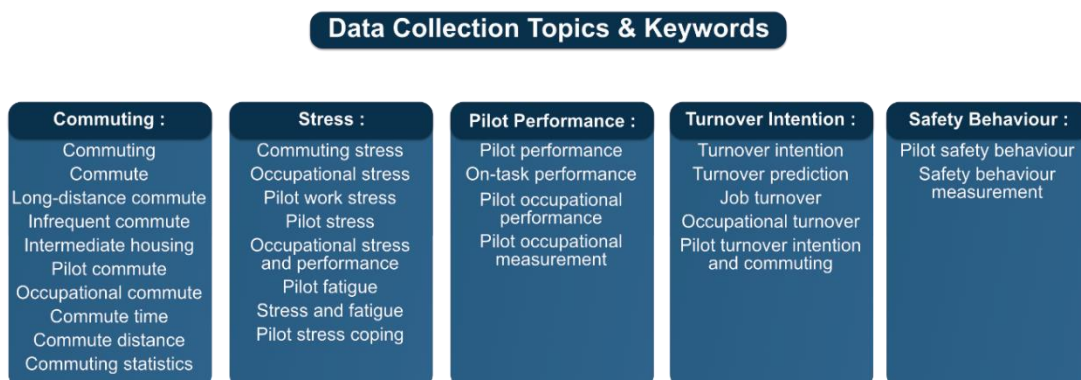


Figure 15–Data Collection Topics & Keywords

Source: Friesacher.

The literature search was conducted using three primary academic databases: EBSCO Host, ScienceDirect and ResearchGate. The search was conducted online and Google Scholar was also used to identify similar literature found in the primary search. After the initial first and second step of matrix screening, the search was conducted using reference lists from selected articles to broaden the collected literature. The matrix screen process was then applied to these articles. Noting the emphasis of Baumeister and Leary (1997), the author also investigated bordering domains such as air traffic control to find refuting or contradictory literature to eliminate bias in the selection process. The author aimed to bridge gaps in the literature to form a bias-free evaluation to discuss the broader principles of the European pilot commuting process (Baumeister and Leary, 1997). The initial selection was undertaken by applying the selection process to the filtered and generated headlines of journal articles via the academic databases used. To remove any doubt about the defined criteria for inclusion or exclusion in the selection process, a brief review of each abstract was performed and it was subsequently categorised. If the selection matrix criteria were met, the article was stored in a literature management system under the applicable domain. For the final selection of articles and second-level evaluation, a review of all filtered journal articles was performed via abstract filtering and categorisation of the matrix criteria. If it met inclusion criteria, the article was moved to the 'use' folder for in-depth analysis and referral to the final literature review. In total, 381 articles passed this first selection process.

3.3.2 Inclusion and Exclusion Criteria

The refinement of literature to use in the literature review for further theory development and evaluation involved a combination of at least three established selection criteria relating to:

- field of research
- geographic location
- relevance
- connection to research variables
- connection to two selection criteria.

When three of these parameters were met, the article was included for further evaluation and processing. Initial screening was conducted based on article titles and abstracts, and then the articles were processed for further examination of their suitability against the criteria for the research.

3.3.3 Data Analysis Plan

Forty-six documents met the inclusion criteria for the combination and support for the author's hypothesis and were further analysed to check if they offered supporting or refuting evidence. The overall literature review process was expanded to 'provide a historical account of the development of theory and research on a particular topic', as Baumeister and Leary (1997, p.312) discussed. The expansion of theory and combination to revisit and combine different research domains to enable a broader understanding of a novel hypothesised approach was undertaken to generate new perspectives and new theory, and broaden knowledge in this new field of research (Baumeister and Leary, 1997).

3.3.4 Data Presenting Plan

Randolph (2009, p.2) explained that without 'establishing the state of the previous research, it is impossible to establish how the new research advances the previous research'. The author conceptualised the presentation of the literature review research topics around the focal topic of pilot commuting. This set the current stage of research in relation to new primary data from the author's research on the European pilot commute study (Friesacher, 2015). The conceptualising topics for data presentation examined the connection between commuting, work/stress, airport location, turnover intention, safety behaviour and locus of control. Airport location was chosen to define a threshold for the pilot commuter/non-commuter time value. General commuting studies focus on the central business district (CBD) to workplace commuting time; airport geographical location and accessibility do not meet the definition of general population commuting.

3.4 Study Variables

The study relied on six exogenous variables and five endogenous variables, as well as control variables (see Table 48, Table 50 / Appendix D). Based on the literature review and research these variables were chosen for model building. Exogenous

variables in the study were commuting variables (distance, time, mode), intermediate housing, option of choice, commuting regulations and fatigue risk management. Endogenous variables were commuting stress, locus of control (for pilots using intermediate housing only), turnover intention, safety behaviour and pilot performance. Variables were measured through multiple questions and parameters used in a survey. The scientific rationale followed is presented in this chapter.

3.4.1 Commuting Stress

The maximum adaptation model (Hancock and Warm, 1989) was designed to predict the effect of stress in relation to performance. It is therefore a suitable theoretical model to include in the new framework of this research for stress, commuting and pilot performance (see Table 51 / Appendix D).

The trinity of stress model (Hancock and Warm, 1989) with definitions of all its stress signatures indicates that the 'input' reflects the whole naturalistic environment as well as subsequent information such as temperature, vibrations or noise. Hancock and Warm (1989) used the vector sum for the addition of stiffness parameters to summarise the different parameters as a stress signature. The second parameter used in the Hancock and Warm (1989) model is adaptation. Overlapping with the research of Sloan and Cooper (1986), adaptation processes expand on how the individual is coping and dealing with the imposed stress at each level: 'Such compensatory processes work in general in the same way for each individual and they are therefore nomothetic in nature' (Hancock and Warm, 1989).

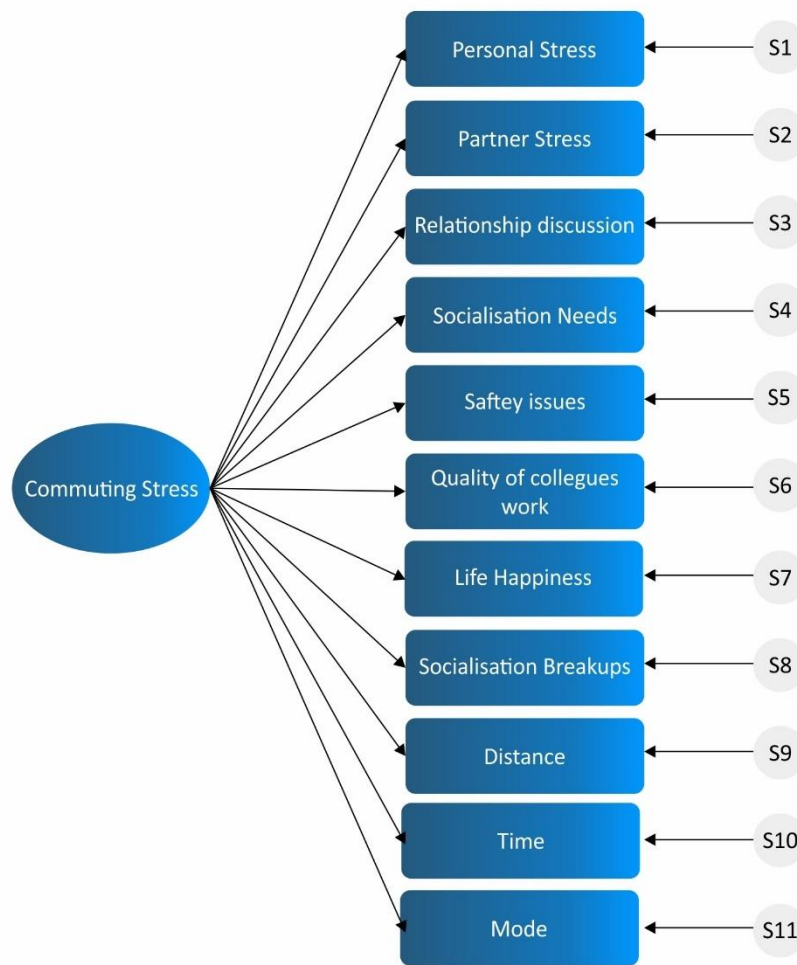


Figure 16–Measurement Model of Commuting Stress

Assigned Questions for this variable are outlined in 51 / Appendix D.

The outcome of the Hancock and Warm model indicates how the individual is dealing with the imposed stress corrected by adaptation and then setting the output. Sloan and Cooper (1986) covered this in their research as with the subjective pilot performance testing used further in this study. The two models are combined into one for this PhD research approach. Stress by itself is not necessarily a bad thing but can enhance personal performance in connection with commuting. In the commuting literature, time and distance are used mostly to measure the stress generated by commuting (Kavanagh, 2005; Koslowsky, 1997; Krausz, Koslowsky, Aizer, 2008) and form the period or distance between home and the workplace that can be positively

used as chill-down period or transition time between these two domains. Therefore, commuting by itself can be an adaptation process using time and distance. This does not necessarily generate stress, but does generate an adaptation process in the transition between these two spatial locations. Most of the commuting stress research literature uses a combination of time and distance as a negative attribute at the sociological and psychological levels (York and Press, 1995). This commuting research is solemnly directed to read professional occupational performance. Also, the commuting impedance model constructed by Novaco with respect to the valuation of time does not consider commuting impedance in association with professional performance (Novaco et al., 1979, 1990, 1991). Therefore, the author elected to generate a newly designed set of questions to measure commuting stress in this research. The stress questions were tested using Cronbach's alpha and indicated strong integrity for measuring the desired stress factor. The survey used for this European airline pilot commute research assigned the following questions to measure commuting stress (Table 51 / Appendix D).

3.4.2 Pilot Performance

Pilot performance evaluation and measurement is an important instrument in aviation safety systems. Safety evaluation combines aspects of pilot performance in a wider, more complex safety model approach, and flattens a holistic safety management and pilot safety behaviour research (Neal and Griffin, 2002b), making it a novel approach to assessing an organisation's or group's safety behaviour. The model used for testing pilot performance (Figure 17) was derived from the test developed by Sloan and Cooper (1986) and has been used and discussed in multiple studies and articles for the evaluation of pilot performance (Cuevas, 2003a; Fiedler, 2000; Lemper and Laur, 2006; Sun and Chiou, 2011; Young, 2008b). Sun and Chiou (2011) expanded on the possibility of a personal variable or personality in the coping process for occupational stress and its influence on occupational performance. Their model of occupational stress uses the mediator's coping strategies in the path influencing work performance (Sun and Chiou, 2011, p.2867). It should be underlined that their research has 'not produced a conceptually satisfying set of basic underlying dimensions that can be used to describe the performance requirements of job' (Sun and Chiou, 2011, p.2867).

Sloan and Cooper (1986) stated that, ‘it seems reasonable to conclude that there is such a thing as self-reported pilot performance and that the test appears to measure at least part of it’ (Sloan and Cooper, 1986, p.469).



Figure 17–Measurement Model of Pilot Performance

Assigned Questions for this variable are outlined in Table 52 / Appendix D.

3.4.3 Locus of Control

Actual or perceived control (Folkman, 1984; Perlmutter and Monty, 1977) is commonly mentioned in the commuting literature and is an important aspect of the commuting process itself. This is especially the case when difficulties during the commuting process become evident in unforeseen circumstances. In passive commuting mode choices the uncertainty and influence of traffic congestion and schedule delays can

create external stimuli that impose stress on the commuting individual (Krausz, Koslowsky, Aizer, 2008).



Figure 18– Measurement Model of Locus of Control

ONLY FOR Commuters / Commuters with Intermediate Housing Commuting
Assigned Questions for this variable are outlined in Table 53 / Appendix D.

3.4.4 Turnover Intention

Turnover intention has been of high interest for companies (Lambert, Lynne Hogan and Barton, 2001) and in research, but has really been set in direct connection with the pilot profession. A pilot is a very specialised and highly skilled person who has not only regularly checked their performance skills and demonstrated them in simulator checks or a form of change operator, but who has also interconnected directly with the

extensive necessity for retraining to meet the requirements of new operators, airline company standards and SOPs. These checks are also connected to the change of status from captain to first officer. Therefore, turnover, or a change in operator is a high-profile change in a pilot's career and is not only selected on the basis of career progression interests but requires an immense effort in training to achieve airline entry qualifications. Lambert et al. (2001) indicated that age, gender and educational level play a role in the decision or willingness to change jobs, while marital status does not have a large effect on turnover intention (Camp, 1994; Mueller et al., 1994; Wright and Saylor, 1992).

The inter-correlation among domains and the conflict between responsibilities and directives have been indicated to play a role in the intention to change jobs (Lambert, Hogan and Barton, 2001). Thus, it is a useful approach to apply turnover intention for the transition from work to the home domain. Expanding on Fishbein and Ajzen (1975, p.369), 'the best single predictor of an individual's behavior will be a measure of his intention to perform that behaviour'. The literature includes a turnover intention scale (TIS-6) by Roodt (2004) that has been used to investigate the intention of an employee to stay or leave an organisation (Bothma and Roodt, 2013). Using a six-item scale, the author elected to assign a turnover intention scale for the pilot occupation with items that reflect the unique factors influencing turnover in the pilot profession. The theoretical framework for development of this pilot turnover intention scale was derived from Roodt's (2004) turnover intention scale (TIS-6) and adapted for the pilot occupation and pilot-specific parameters (see Figure 19). Internal testing was conducted using Cronbach's alpha, which revealed a satisfactory Cronbach's alpha value indicating internal integrity.

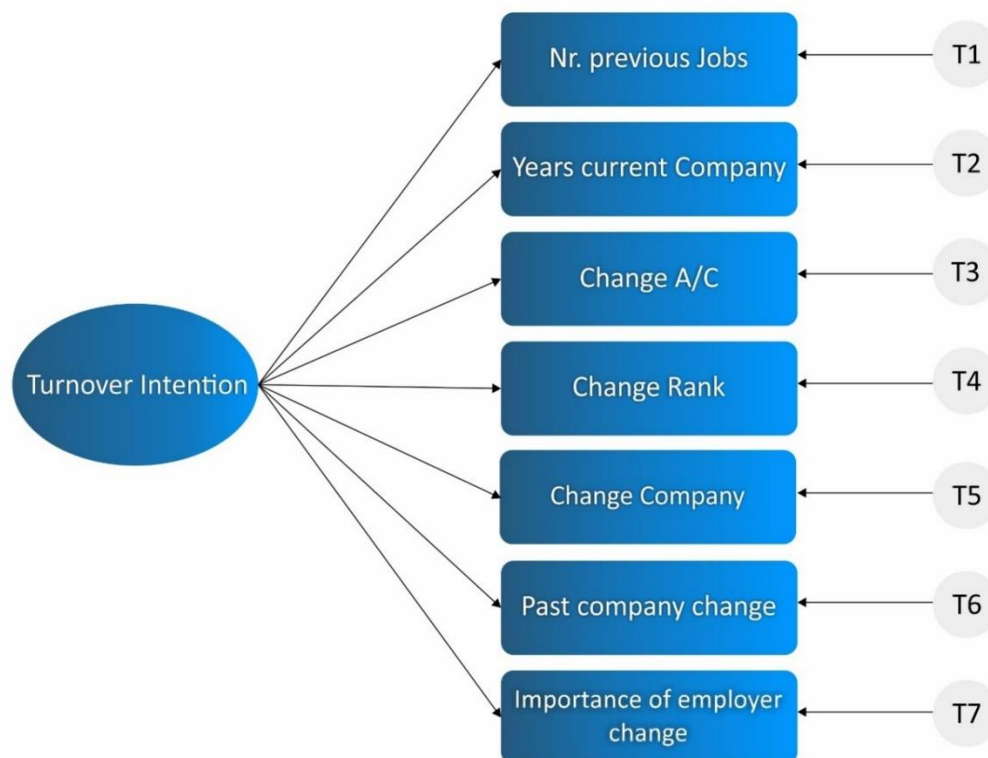


Figure 19–Measurement Model of Turnover Intention

Assigned Questions for this variable are outlined in Table 54/ Appendix D.

3.4.5 Safety Behaviour

The literature presents an unclear and imprecise picture of safety behaviour and discusses it in connection with an organisational safety climate. This connected approach unites attitude, behaviour and safety climate into a relationship for the measure of safety behaviour (Neal and Griffin, 2002b). As no clear and assessable safety behaviour survey was available for the aviation industry, most aspects of this topic were nested within a broader safety climate study in which the author used a self-developed construct (see **Figure 20**) to test subjective safety behaviour. Neal et al. (2002, p.67) saw the 'safety climate as an antecedent of safety behavior', while Cooper and Phillips (2004, p.497) emphasised the missing link 'between safety climate

and safe behaviours'. The difficulty of observing safety behaviour on an objective level complicates methodical observations as well as subjective measurements (Hoffman and Stetzer, 1996; Mohammed, 2002). A study by Mullen (2004) showed that subjective perception of the safety climate has an influence on the safety behaviour of the individual. Cooper et al. (1994) did not find a significant correlation between accidents and behavioural factors.

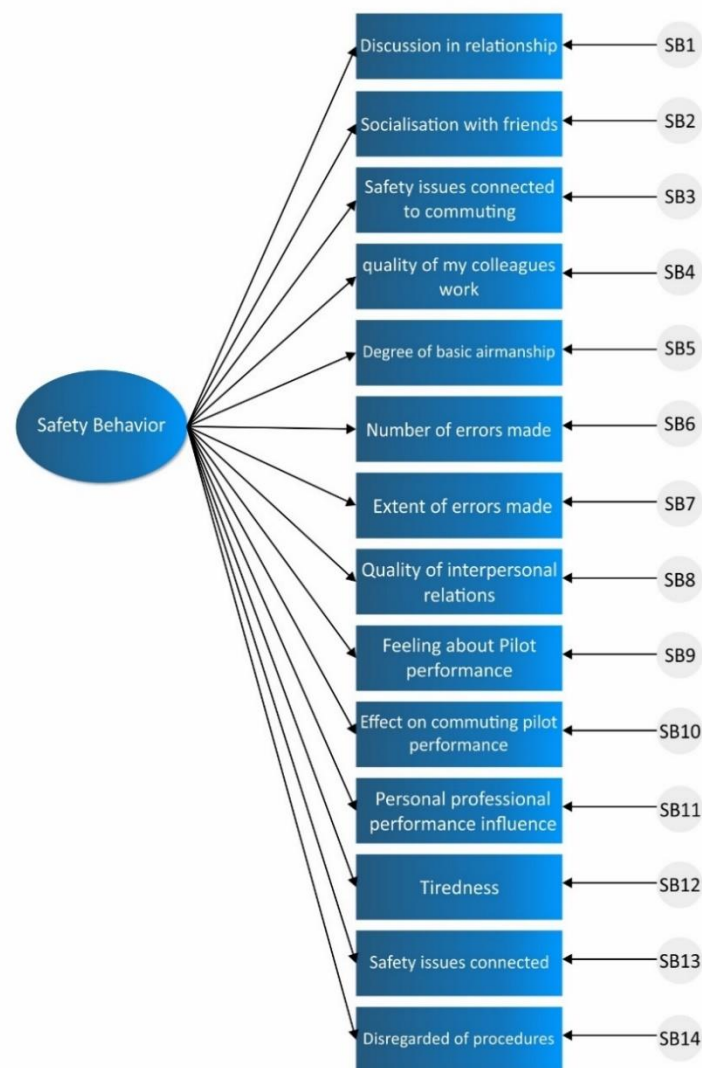


Figure 20–Measurement Model of Safety Behaviour

Assigned Questions for this variable are outlined in Table 55 / Appendix D.

3.4.6 Control Variables

Control variables used in this research are outlined in Figure 21.

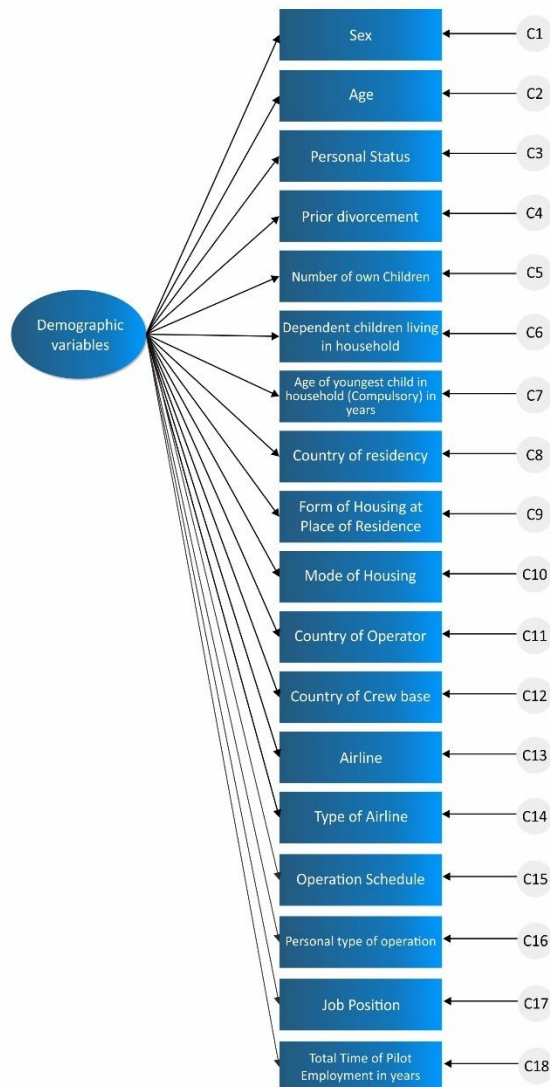


Figure 21–Measurement Model of Control Variables

Assigned Questions for this variable are outlined in Table 56 / Appendix D.

3.4.7 Commuting Variables

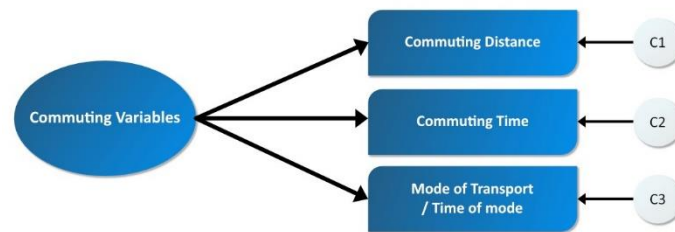


Figure 22–Measurement Model of Commuting Variables

Assigned Questions for this variable are outlined in Table 57 / Appendix D.

3.5 Sampling the European Pilot Corps and Sample Size

3.5.1 Procedure

The cross-sectional survey aimed to collect time point cross-sectional data and used the questionnaire from the initial European Airline Pilot Commute Study (Friesacher, 2014). The 2014 survey consisted of:

- 82 questions for commuters using an intermediate housing facility
- 73 questions for commuters not using an intermediate housing facility
- 56 questions for non-commuters.

The above count includes the 15 questions from Sloan and Cooper's (1986) questionnaire entitled 'The Measurement of Self-Reported Pilot Performance' that measure self-performance by pilots reporting on 15 items using a five-point scale. Rephrasing of the original Sloan and Cooper questions was only performed in the introduction part. The introduction was set in the context of pilot commuting. The text for the commuters was rephrased to:

1. Think about your last few flights recently on days where you commuted to work.
2. Consider how well or badly you performed.
Examine the list of elements below; they are different ways of assessing performance.

3. Please rate yourself on the scales by marking your answer. Remember, we are relying on you to make this as accurate of a scientific measure as possible.

The part for non-commuters was unchanged from the original version used by Sloan and Cooper (1986). An example of a stress-relevant question is, 'How satisfied are you with your life, all things considered?' (Stutzer and Frey, 2007, p.4). Responses ranged on a scale from 0 'completely dissatisfied' to 10 'completely satisfied' (Stutzer and Frey, 2007, p.4).

A new block of items about fatigue risk management, call in sick/unfit to fly and safety concerns around commuting was added to the 2020 European Airline Pilot Commute Study (research was distributed under this title). These items were:

Fatigue risk management

- I am familiar with the responsibility of my employer's fatigue risk management system.
- I think pilot commuting should be part of a fatigue risk management system.
- I consider pilot commuting as an aviation industry standard and it should be incorporated in the EASA rulemaking process.

Call in sick / unfit to fly

- I have used the 'call in sick' possibility in the past to cover for commuting issues.
- I used the 'unfit to fly' possibility to cover up commuting issues.

Personal safety concerns of commuting

- I think that commuting influences a pilot's professional performance.
- On commuting days I sometimes see some effect of the commuting on the commuting pilot performance.
- My personal professional performance has been influenced negatively by commuting issues.
- On some commuting days I am generally more tired than on other days.
- I think about the safety issues connected with my commuting.

- I have occasionally disregarded company procedures (check out procedures, etc.) to meet my commuting plans.
- I have occasionally disregarded safety issues to meet my commuting plans.

The 2020 European Airline Pilot Commute Study had a total of 120 questions. The survey flow (see Figure 23; Table 58) directed participants along one of three possible answer paths:

- commuters
- non-commuters
- commuters using intermediate housing at home base.

The layout of the 2020 European Airline Pilot Commute Study questions was devoted to the following topics:

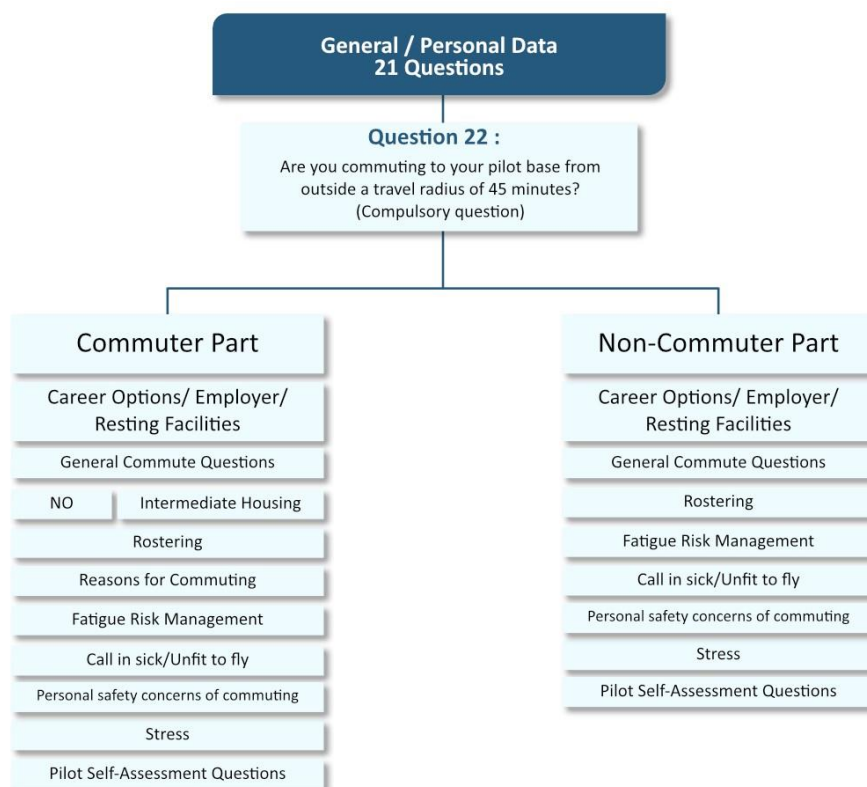


Figure 23–2020 European Airline Pilot Commute Study Outline

The Question Flow of the European Airline Pilot Commute Study 2020 is outlines in Table 58 / Appendix D.

3.5.2 Survey Distribution Limitations

A direct mail invitation was sent to individuals who declared themselves on a professional online platform (LinkedIn) as a pilot working from a list of certified European airlines. Only people who shared their email address in the public domain were able to be reached.

Also, a formal invitation letter was sent to various national Air Line Pilots Association (ALPA) member organisations (Table 1) to request the participation of ALPA members in the survey. Generally, pilot commuting is a sensitive issue with many different interests in occupational affairs. Therefore, the author elected a mixed-mode of survey invitation dissemination.

Table 1– European National Air Line Pilots Association (ALPA) member organisations

Source: European Cockpit Association, 2020 — Excerpt / Redesigned Friesacher.

Austria	Austrian Cockpit Association (ACA)
Belgium	Belgian Cockpit Association (BeCA)
Bosnia and Herzegovina	Association of Airline Pilots in Bosnia and Herzegovina (ALPAB)
Bulgaria	Bulgarian Airline Pilots Association (BUL-ALPA)
Croatia	Croatian Air Line Pilots' Association (CRO-ALPA)
Cyprus	Cyprus Airline Pilots Association (PALPU)
Czech Republic	Ceské sdružení dopravních pilotů CSA (CZALPA)
Denmark	Danish Airline Pilots Association (DALPA)
Estonia	Estonian Airline Pilots Association (Estonian ALPA)
Finland	Finnish Pilots Association (FPA)
France	Syndicat national des Pilotes de Ligne (SNPL)
Germany	Vereinigung Cockpit (VC)
Greece	Hellenic Airline Pilots Association (HALPA)
Hungary	Hungarian Airline Pilots' Association (HUNALPA)
Iceland	Félag Íslenskra Atvinnuflugmanna (FIA)
Ireland	Irish Airline Pilots Association (IALPA)
Italy	Associazione Nazionale Piloti Aviazione Commerciale (ANPAC)
Latvia	Pilots' Trade Union of Latvia (PTUL)
Lithuania	Lithuanian Airline Pilots' Association (LIT-ALPA)
Luxembourg	Association Luxembourgeoise des Pilotes de Ligne (ALPL)
FYR Macedonia	Air Line Pilot Association of the Former Yugoslav Republic of Macedonia (ALPA-FYROM)
Malta	ALPA-M
Montenegro	Montenegrin Airline Pilots' Association (MonALPA)
Netherlands	Vereniging van Nederlandse Verkeervliegers (VNV)
Norway	Norsk Flygeerforbund (NF)
Poland	Polish Airline Pilots Association (POLALPA)
Portugal	Associação dos Pilotos Portugueses de Linha Aérea (APPLA)
Romania	Romanian Airline Pilots Union (RO-ALPU)
Russia	The Cockpit Personnel Association of Russia (CPAR)
Serbia	Serbian Cockpit Association (SCA)
Slovenia	Air Line Pilots' Association of Slovenia (ALPA-SL)
Spain	Sindicato Español de Pilotos de Líneas Aéreas (SEPLA)
Sweden	Svensk Pilotförening (SPF)
Switzerland	Pilotenverband Swiss (AEROPERS)
Turkey	Türkiye Havayolu Pilotları Derneği (TALPA)
Ukraine	Ukrainian Air Line Pilots' Association (UALPA)
United Kingdom	British Airline Pilots Association (BALPA)

3.5.3 Direct Mail Invitation to European Airline Pilots

Emails were generated from the public domain and public online accessible databases from a professional occupational network (LinkedIn).

To generate contact emails for airline pilots, a set of criteria was developed by the author to meet participation qualifying criteria. The search and generation of email addresses was conducted via an advanced people search function utilising various occupational features. To be able to access email addresses, the author must be a:

- first connection
- second connection or
- group member

of the professional network.

As per the conditions of the Cranfield University ethics approval, these settings reflected and complied with the Cranfield University closed group restrictions.

A network search of European airline pilots was conducted using the following settings:

- Keyword: Pilot
- Company: Respective company name
- Employment status: Current.

Each European airline's company name was derived from a list of 115 selected European airline operators. For the 62 operators on this list a valid pilot email address could be identified from the pilot's first and last name and the airline's Internet domain. To these generated email addresses a direct invitation was sent to invite the pilot to participate in the 2020 European Airline Pilot Commute Study. Using this mode of email generation, 31,005 valid company email addresses were generated between 15 January and 20 February 2020.

3.6 Research Ethics Approval

University research ethics approval was obtained via the Cranfield University Research Ethics System (CURES) (Appendix C) approval process on 13 May 2020. No objections to the research topic or methodology were raised by the CURES board.

3.7 Data Collection

The data collection process was conducted via email invitations to participate in the 2020 European Airline Pilot Commute Study distributed to the personal work email addresses of European airline pilots. The survey was distributed between 18 May and 22 June 2020. Of the 31,005 email addresses generated during January and February 2020, many were bounced by the email server and could not be delivered to the recipient's email address. Research statistics indicated that 19,786 invitation emails could be delivered to European airline pilots' personal company email addresses.

Ten days after the initial send out of the invitation emails, a follow-up reminder was sent out to remind the pilots to participate in the study. The reason for this huge loss of email contacts was the COVID-19 crisis that impacted the aviation industry, resulting furloughs' and restrictions to work contracts in the European airline market.

A web-based survey was used for data collection on the survey provider platform Qualtrics, which administered the data collection. A dedicated email address was used to send the email invitations for participation, to the generated company email addresses. The total number of European airline pilots' responses generated during the survey collection period counted on the Qualtrics survey platform was 1,461. This reflects a response rate of 7.38%. This return rate and total number of 1,461 forms a strong statistical basis for in-depth statistical analyses given the dramatically altered and unprecedented industry problems caused by the COVID-19 crisis and the associated European airline pilot layoffs and furloughs; it reflects a strong interest in the pilot commuting topic itself.

Of the 1,461 returned surveys, 1,225 were used for statistical analyses after individual survey evaluation.

3.8 Research Survey and Reliability

The research survey was tested among a randomly selected sample of European airline pilots. Multiple changes were made to questions to provide a smoother understanding of questions and survey flow. Important was the possible use of different electronic devices, like mobile devices or fixed base computers and laptops as well as iPads, for the use of the survey and the digital presentation of the way out and do a proper indication of the display. Eleven European airline pilots tested the survey and a total of 39 recommendations were made for improvement. Twenty-three of these recommendations were implemented in the survey to improve flow, readability and survey accessibility. Most recommendations (eleven) were changes in the question wordings to rule out the misunderstanding. Three were changes in the survey flow for switching and jumping to the correct “next” question. At the same time, six questions were set to compulsory answers to obtain better statistical analysis possibilities. Furthermore, three questions were changed in the answer possibility options design to facilitate easier answering.

3.9 Statistical Analysis

In order to adequately analyse the results of statistical surveys, choosing an appropriate research approach and methodology is the crucial step to investigate the specific research question using the available data adequately. The reason for choosing PLS-SEM for this research on European airline pilots' commuting is its significant advantages compared to other analytical methods. Traditional multiple regression analyses, which have been widely used in many fields, reach their limits in the case of complex relationships between variables when the number of independent variables is high relative to the number of observations. In this case, PLS-SEM has a clear advantage over the multiple regression analysis approach for this research, as it processes high-dimensional data and provides accurate results (Fassott, Henseler and Coelho, 2016; Nitzl, 2016).

This is because PLS-SEM offers the unique ability to make predictions from the data obtained by handling small sample sizes well. Another positive factor is that PLS-SEM is suitable for working with high-dimensional and non-normal data distribution. PLS-SEM also offers a clear advantage in working with a high degree of co-linearity between the independent variables over regression analysis alternatives such as CB-

SEM (Covariance-Based Structural Equation Modelling). (Hair et al., 2014; Matthews, Hair and Matthews, 2018). For traditional multiple regression analysis, CB-SEM is a powerful method for testing complex theoretical models. However, this analysis method has some limitations regarding high-dimensional and missing data and a high degree of collinearity between the independent variables. PLS-SEM can effectively address these challenges through the use of latent variable modelling and imputation techniques (Amaro, Seabra and Abrantes, 2016; Dash and Paul, 2021; Rigdon, Sarstedt and Ringle, 2017).

3.9.1 Descriptive Analysis

Descriptive analyses were applied to describe the gathered data in different pilot group analyses investigated in the interaction of control, exogenous and endogenous variables.

3.9.2 Control Variables

Control variables are used in this section to describe the sample and its distribution among four groups for analysis: Non-commuter group analysis, Commuter group analysis, Intermediate housing commuter group analysis, Three-group analysis.

3.9.3 Exogenous Variables

Exogenous variables were used in this study to identify the following parameters: Commuting time, Commuting distance, Mode of transport, Option of choice, Commuting regulations, Fatigue risk management.

3.9.4 Endogenous Variables

Endogenous variables were used in this study to identify the following parameters: Commuting stress, Locus of control, Turnover intention, Safety behaviour, Pilot performance.

3.9.5 Structural Equation Modeling

For in-depth advanced statistical analyses, structural equation modelling was employed to explore how gathered data is in line with the theoretical developed construct of the interaction of exogenous and endogenous variables in the European airline pilot commute process. A hypothesized generic structural equation model (see

Figure 24) was generated based on a theoretical literature review and SOP standard equation model measurement models developed for commuting stress (see Figure 25), locus of control (see Figure 26), pilot performance (see Figure 27), safety behaviour (see Figure 28) and turnover intention (see Figure 29). Structural equation modelling is driven by theoretical based measurement models and control variables to investigate structural model relationships and interactions. It allows ‘advanced methods such as mediation, moderation, multi- group analysis. ‘ (Matthews, Hair and Matthews, 2018, p.1) and ‘can be applied to better understanding more complex structural measurement and path models’ (Matthews, Hair and Matthews, 2018, p.2).

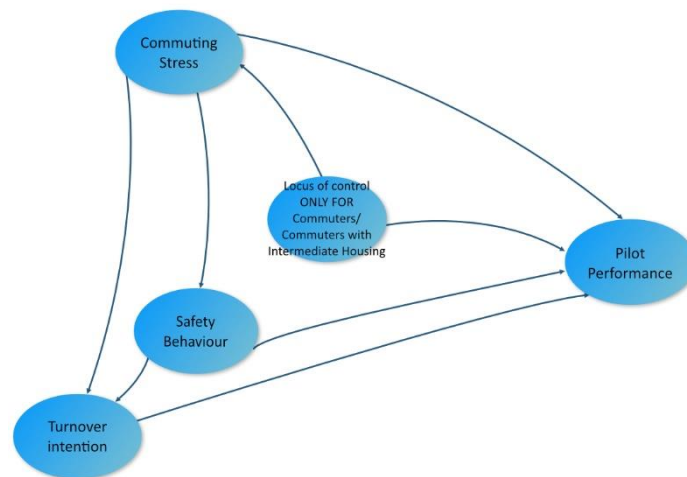


Figure 24–SEM Measurement Model of Commuting Stress and Pilot Performance

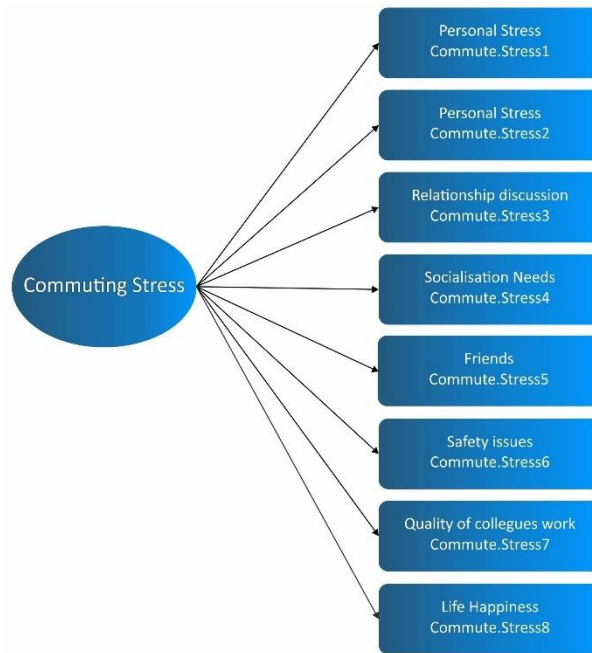


Figure 25–SEM Measurement Model of Commuting Stress (Endogenous Latent Variable)

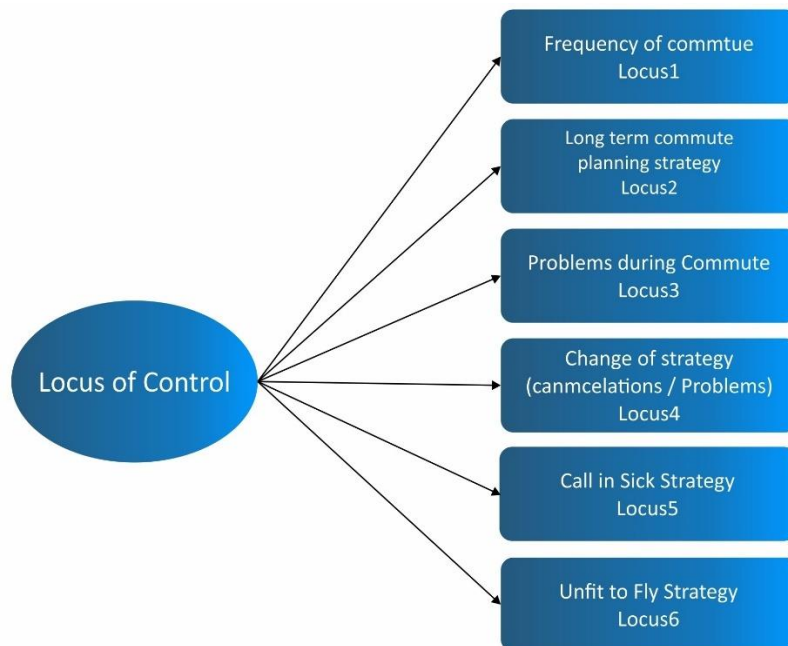


Figure 26–SEM Measurement Model of Locus of Control (Endogenous Latent Variable)

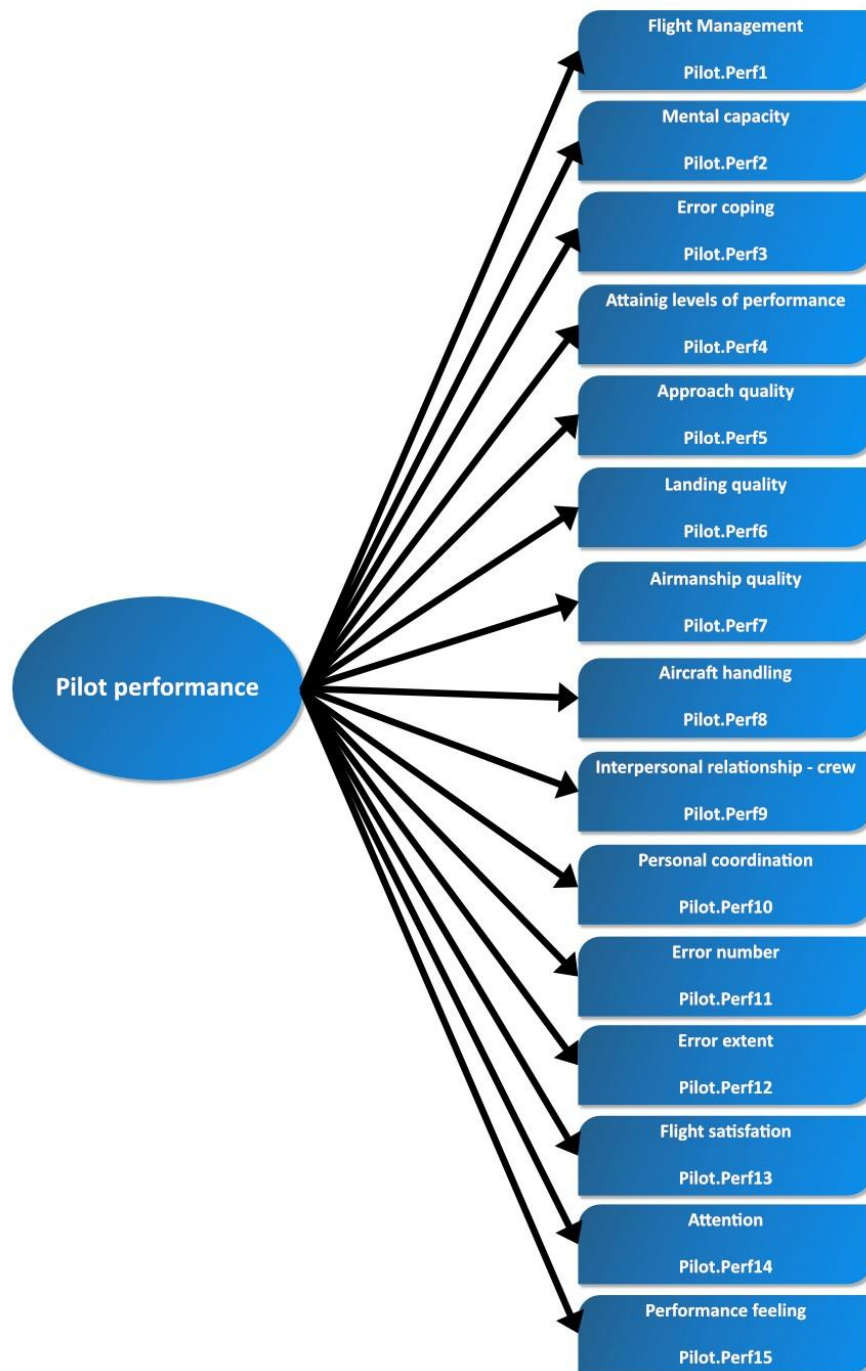


Figure 27–SEM Measurement Model of Pilot Performance (Endogenous Latent Variable)

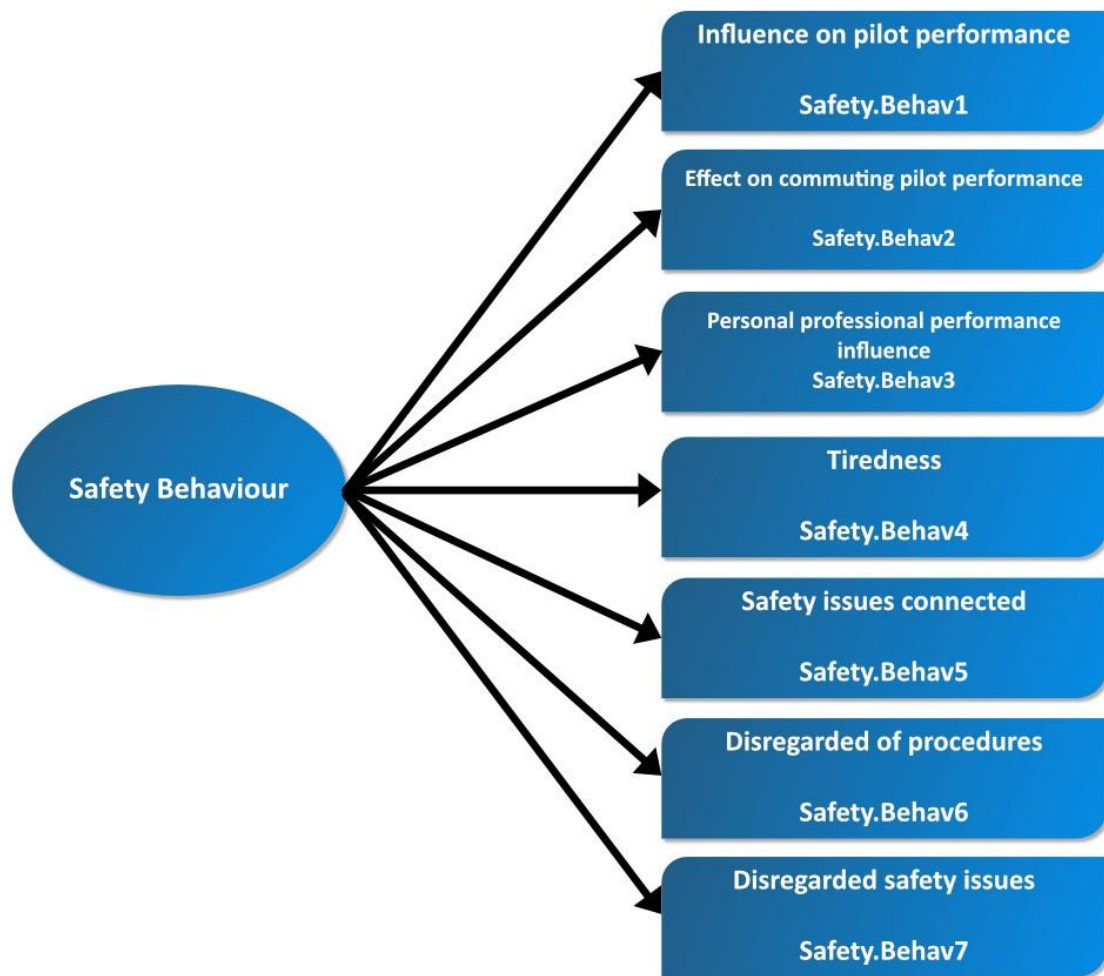


Figure 28–SEM Measurement Model of Safety Behaviour (Endogenous Latent Variable)

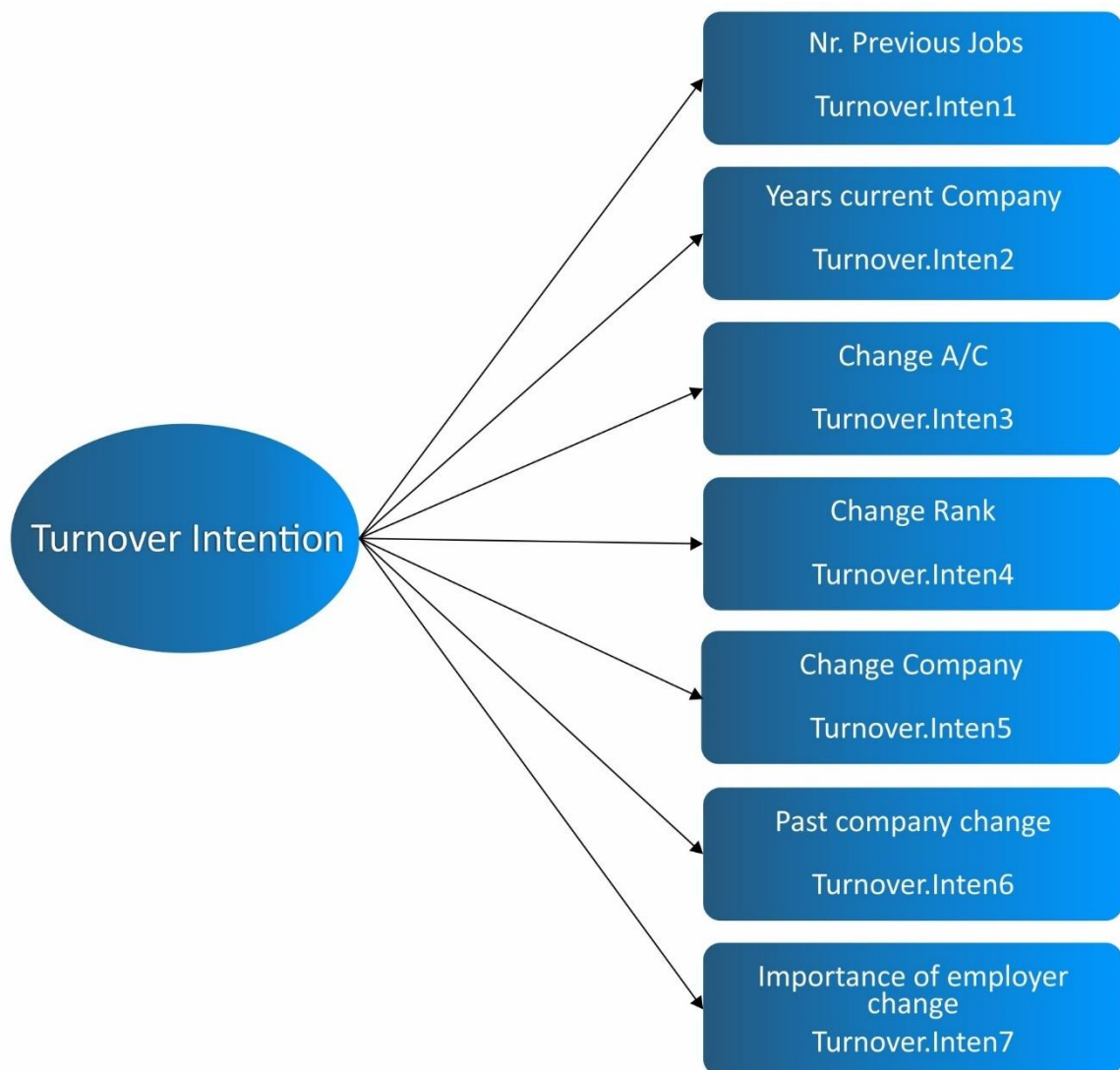


Figure 29—SEM Measurement Model of Turnover Intention (Endogenous Latent Variable)

3.9.6 Statistical Analysis Criteria

This research applied PLS-SEM. Analyses and reporting were conducted using the software Smart PLS to analyse the obtained dataset. PLS-SEM was developed by the Swedish economist Herman O. A. Wold. A combination of principal component analysis and ordinary least square regression gives PLS the powerful estimates partial model structures (Mateos-Aparicio, 2011). PLS-SEM 'is typically viewed as an alternative to Jöreskog's (1973) CB-SEM, which has numerous—typically very restrictive—assumptions' (Hair, Ringle and Sarstedt, 2011, p.4).

PLS-SEM analysis was selected to protect of constructs and identify inter-model relationships (Hair et al., 2019). PLS-SEM has been established in SEM for some time (Hair et al., 2019) and as such 'is very appealing to many researchers as it enables them to estimate complex models with many constructs, indicator variables and structural paths without imposing distributional assumptions on the data. More importantly, however, PLS-SEM is a causal-predictive approach to SEM that emphasises prediction in estimating statistical models' (Hair et al., 2019, p.3). What makes it an exciting approach for data analysis is the option to use PLSpredict, which makes it applicable 'when drawing conclusions that affect business practices and have managerial implications' (Hair et al., 2019, p.3). Hair et al. (2019) recommends that PLS-SEM should be applied especially where prediction of a theoretical framework is concerned; there are multiple inter-model relationships and theory developed based on explanatory approaches; and when a lack of normality in data distributions is a concern. A significant advantage of PLS-SEM over other Sam analysis tools is the absence of distributional assumptions (Hair et al., 2019).

A structured a four-step approach to PLS SEM analysis was recommended by Hair et al. (2019), as follows:

1. evaluation of PLS-SEM results
2. assessment of internal consistency reliability
3. assessment of the convergent validity of each construct measure
4. assessment of discriminant validity.

3.9.6.1 First Step in PLS-SEM Model Analysis

Following the recommendations of Hair et al. (2019), regarding PLS-SEM analyses procedures, a measurement model (see Figure 63) for the current dataset was examined. A reflective measurement model explanation follows, which 'involves examining the indicator loadings. Loadings above 0.708 are recommended, as they indicate 'that the construct explains more than 50' per cent of the indicator's variance, thus providing acceptable item reliability' (Hair et al., 2019, p.8).

3.9.6.2 Second Step in PLS-SEM Model Analysis

The second step involves assessment of internal consistency and reliability assessment (Hair et al., 2019). This is widely achieved using composite reliability

(Jöreskog, 1971). The higher the value, the higher the level of reliability. The literature indicates values as outlined in Table 2 for research. Higher values indicate redundancy of items, reducing the construct's validity (Diamantopoulos et al., 2012; Drolet and Morrison, 2001; Hair et al., 2019).

0.60 and 0.70	acceptable in exploratory reaserch
0.70 and 0.90	satisfactory to good
≥0.95	problematic

Table 2–Internal Consistency Reliability

Source: Diamantopoulos et al., 2012; Drolet and Morrison, 2001; Hair et al., 2019 – Excerpt / Redesigned Friesacher.

For values lower than would indicate composite reliability, Cronbach's alpha may be used for internal consistency reliability testing, using similar thresholds. Using unweighted items is generally seen as a less precise measure of reliability. 'In contrast, with composite reliability, the items are weighted based on the construct indicators' loadings and, hence, this reliability is higher than Cronbach's alpha. While Cronbach's alpha may be too conservative, the composite reliability may be too liberal, and the construct's true reliability is typically viewed as within these two extreme values'(Hair et al., 2019, p.8).

3.9.6.3 Third Step in PLS-SEM Model Analysis

The construct measure of convergent validity was the complete focus of the third step in reflective measurement model evaluation. As explained by Hair et al. (2019, p. 9), 'convergent validity is the extent to which the construct converges to explain the variance of its items. The metric used for evaluating a construct's convergent validity is the average variance extracted (AVE) for all items on each construct. To calculate the AVE, one has to square the loading of each indicator on a construct and compute the mean value. An acceptable AVE is 0.50 or higher, indicating that the construct explains at least 50 per cent of the variance of its items'.

3.9.6.4 Fourth Step in PLS-SEM Model Analysis

The term discriminant validity describes the level of construct distinction empirically proven from other constructs in the model. Individual construct AVE values can be analysed against a squared construct correlation, as explained by Fornell and Larcker (1981). Hence, this has been opposed by the lowest approach, indicating that the Fornell and Larcker (1981) construct AVE analysis did not demonstrate significantly good performance, with low indicator loadings on the construct (0.65–0.85). A heterotrait–monotrait (HTMT) ratio (Henseler et al., 2015) was introduced to replace correlations (Hair et al., 2019; Voorhees et al., 2016): ‘The HTMT is defined as the mean value of the item correlations across constructs relative to the (geometric) mean of the average correlations for the items measuring the same construct. Discriminant validity problems are present when HTMT values are high.’ (Hair et al., 2019, p.9). With different clear items in the construct and a low value of HTMT, 0.85 is susceptible to the construct. Only in cases where the structural model and subsequent constructs are similar might a higher threshold be seen as applicable, indicating the absence of discriminant validity (HTMT >0.90) (Hair et al., 2019).

3.9.6.5 Structural Model Assessment

PLS-SEM results analyse structural model assessment the precursor is the satisfactory evaluation of the measurement model. Assessment standards are measured via statistical significance, relevant path coefficients, the coefficient of determination (R^2) and the blindfolding-based cross-validated redundancy measure Q^2 . One way to assess PLS power is to use the PLSpredict algorithm via the PLS software to verify the model’s sample predictive power, which is routinely recommended (Hair et al., 2017; Shmueli et al., 2015). To rule out the possibility of biased regression results, collinearity testing must be performed before examining structural relationships. According to Hair et al. (2017, p.11), ‘this process is similar to assessing formative measurement models, but the latent variable scores of the predictor constructs in a partial regression are used to calculate the VIF [variance inflation factor] values. VIF values above 5 indicate potential collinearity issues among the predictor constructs, but collinearity problems can also occur at lower VIF values of 3-5 (Mason and Perreault, 1991; Becker et al., 2015). Ideally, the VIF values should be close to 3 and lower. If collinearity is a problem, a frequently used option is to create

higher-order models that can be supported by theory.’ Construct evaluation of R^2 values is recommended after successful collinearity testing. A model’s explanatory power, fundamentally considered in the endogenous design, is measured by R^2 values, which range from 0 to 1. The highest explanatory power is given by a value of 1.

R^2 values	Rating
0.75	Substantial
0.50	Moderate
0.25	Weak

Table 3— R^2 Value Ratings

Source: Hair, Ringle and Sarstedt, 2011; Henseler, Ringle and Sinkovics, 2009 – Excerpt / Redesigned Friesacher.

For proper predictive correctness of an applied model when testing the use of endogenous constructs, Q^2 must be greater than zero. Alternatively, a calculated Q^2 value may be substituted to prove a PLS path model’s predictive correctness (Geisser, 1974; Stone, 1974).

Q^2 value	Rating of predictive Relevance
0 - 0.24	Small
0.25 - 0.49	Medium
>0.5	Large

Table 4— Q^2 Value Rating

Source: Hair et al., 2019 – Excerpt / Redesigned Friesacher.

R^2 values represent the explanatory power of the model. Generalisation of a model’s predictive qualities regarding R^2 values is not entirely appropriate, as this only reflects

an in-sample reference (Shmueli et al., 2015). To overcome this limitation, a procedure for an out-of-sample comparison for data not used in the analysis was proposed by Shmueli et al. (2015), who termed the procedure a ‘holdout’ sample evaluation. As an option in the Smart PLS software, PLSpredict uses this out-of-sample procedure (Hair et al., 2017). When the key target construct has been selected, the Q^2 predictive statistic should be evaluated first to verify if the predictions outperform the most naïve benchmark, defined as the indicator means of the analysis sample (Shmueli et al., 2019). Hair et al. (2017) explained that ‘The prediction statistics depend on the indicators’ measurement not carry much meaning. Therefore, researchers need to compare the RMSE [root mean square of errors] (or MAE [mean absolute errors]) values with a naïve benchmark’.

‘When comparing the RMSE (or MAE) values with LM values, the following guidelines apply (Shmueli et al., 2019):

- If the PLS-SEM analysis yields higher prediction errors than the naïve LM benchmark in terms of RMSE (or MAE) for all indicators, this indicates that the model lacks predictive power.
- If the majority of the dependent construct indicators in the PLS-SEM analysis produce higher prediction errors than the naïve LM benchmark, this indicates that the model has low predictive power.
- If the minority (or same number) of indicators in the PLS-SEM analysis yields higher prediction errors than the naïve LM benchmark, this indicates medium predictive power.
- If none of the indicators in the PLS-SEM analysis has higher RMSE (or MAE) values than the naïve LM benchmark, the model has high predictive power’ (Hair et al., 2019, p.13).

For this purpose and assessment, ‘the path coefficients parallels that of the formative indicator weights. That is, researchers need to run bootstrapping to assess the path coefficients’ significance and evaluate their values, which typically fall in the range of -1 and $+1$ ’ (Hair et al., 2019; Nitzl, 2016). Following this approach and the recommendations and guidelines for PLS-SEM analyses (Dijkstra and Henseler, 2015; Fornell et al., 1988; Hair et al., 2017, 2019; Hair, Ringle and Sarstedt, 2011; Nitzl, 2016; Rigdon, 2012; Sharma et al., 2018; Shmueli et al., 2015; Voorhees et al.,

2016) the dataset was analysed following PLS-SEM criteria and predictive powers as outlined in Figure 30, applying analysis threshold values as explained by Hair (2019) (see Table 5).

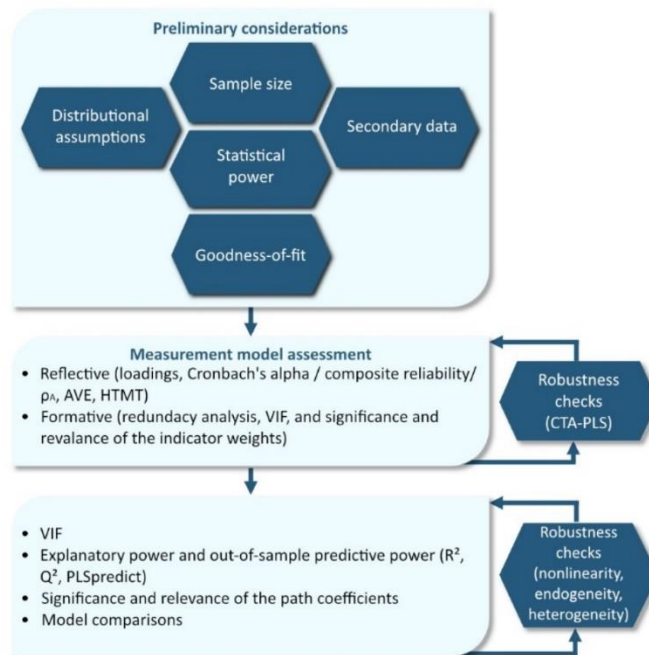


Figure 30–Aspects and Statistics to Consider in a PLS-SEM Analysis

Source: Hair et al., 2019 – Excerpt / Redesigned Friesacher.

Validity	Criteria Thresholds	Explanation
Reflective measurement models		
Reflective indicator loadings	≥ 0.708	
Internal consistency reliability		Cronbach's alpha is the lower bound, the composite reliability is the upper bound for internal consistency reliability. ρ_A usually lies between these bounds and may serve as a good representation of a construct's internal consistency reliability, assuming that the factor model is correct. Minimum 0.70 (or 0.60 in exploratory research). Maximum of 0.95 to avoid indicator redundancy, which would compromise content validity. Recommended: 0.70-0.90. Test if the internal consistency reliability is significantly higher (lower) than the recommended minimum (maximum) thresholds. Use the percentile method to construct the bootstrap-based confidence interval; in case of a skewed bootstrap distribution, use the BCa method.
Convergent validity	$AVE \geq 0.50$	
Discriminant validity		For conceptually similar constructs: $HTMT < 0.90$ For conceptually different constructs: $HTMT < 0.85$. Test if the HTMT is significantly lower than the threshold value.
Formative measurement models		
Convergent validity (redundancy analysis)	≥ 0.70 correlation	
Collinearity (VIF)		Probable (i.e., critical) collinearity issues when $VIF \geq 5$ Possible collinearity issues when $VIF \geq 3-5$ Ideally show that $VIF < 3$
Statistical significance of weights		p-value < 0.05 or the 95% confidence interval (based on the percentile method or, in case of a skewed bootstrap distribution, the BCa method) does not include zero.
Relevance of indicators with a significant weight		Larger significant weights are more relevant (contribute more).
Relevance of indicators with a non-significant weight		Loadings of ≥ 0.50 that are statistically significant are considered relevant.
Structural model		
Collinearity (VIF)		Probable (i.e., critical) collinearity issues when $VIF \geq 5$ Possible collinearity issues when $VIF \geq 3-5$ Ideally show that $VIF < 3$
R^2 value		R^2 values of 0.75, 0.50 and 0.25 are considered substantial, moderate and weak. R^2 values of 0.90 and higher are typical indicative of overfit. Values ≤ 0.90 and higher are typical indicative of overfit.
Q^2 value		Values larger than zero are meaningful. Values higher than 0, 0.25 and 0.50 depict small, medium and large predictive accuracy of the PLS path model.
PLSpredict		Set $k = 10$, assuming each subgroup meets the minimum required sample size. Use ten repetitions, assuming the sample size is large enough. Q^2 predict values > 0 indicate that the model outperforms the most naive benchmark (i.e., the indicator means from the analysis sample). Compare the MAE (or the RMSE) value with the LM value of each indicator. Check if the PLS-SEM analysis (compared to the LM) yields higher prediction errors in terms of RMSE (or MAE) for all (no predictive power), the majority (low predictive power), the minority or the same number (medium predictive power) or none of the indicators (high predictive power).
Model comparisons		Select the model that minimizes the value in BIC or GM compared to the other models in the set.
Robustness checks		
Measurement models		CTA - PLS
Structural model		Nonlinear effects Endogeneity Unobserved heterogeneity

Table 5–PLS Guide Outline

Source: Hair et al., 2019 – Excerpt / Redesigned Friesacher.

3.9.6.6 PLSpredict

Prediction is a key factor in the PLS-SEM analysis process, not only for analysing explanatory models; it is also essential to 'evaluate and improve the predictive power of explanatory model' (Shmueli et al., 2015, p.1). Expanding on tonality and seeing that the macro, micro-level discussion of far predictive far modelling in PLS-SEM using explanatory models to examine the micro-level, individual case; in this research the individual commuter and the variables involved in the micro-level commuting decision-making process (Shmueli et al., 2016). As this research aimed to build a personalised commuting prediction model it utilised PLS-SEM analysis for 'personalized predictions and recommendations' (Shmueli et al., 2015) and expanded on the willingness for occupational turnover.

Shmueli et al. (2016, p.20) reflected on 'out of sample predictions from a model and to evaluate the predictive power of explanatory models is vital to theory building and evaluation'. They observed that PLS predictive analysis is mostly used in explanatory model descriptions, as predictive evaluations will contribute significantly to macro and micro-level research and to theory enhancement (Shmueli et al., 2016, p.2). Simply relying on R^2 values when exploring explanatory models does not identify a new case in regard to out-of-sample prediction. For out-of-sample prediction of new cases the method of blindfolding (Chin, 1998) contributes a Q^2 value that identifies missing data points (Shmueli et al., 2019), allowing one to predict new out-of-sample cases. A major advantage of PLS-SEM analysis over CB SEM is the possibility of explorative and predictive analyses in PLS SEM and of generating micro-level, individual possible predictions in the explanatory process (Shmueli et al., 2019). To be able to follow this explanatory and predictive theme it is crucial to evaluate a SEM model according to the four-step analysis laid out by Hair et al. (2017) to ensure adequate data quality. Endogenous variables are crucial in the PLS predictive procedure as they constitute the fundamentals of an in-depth prediction and discussion of a PLS-SEM model.

3.9.7 Mediator Testing

Mediator testing identifies the controlling role of an external third power that has an influence on the main interaction of two variables (Krausz, Koslowsky, Aizer, 2008; Sarstedt et al., 2020). When analysing complicated interactions among latent variable constructs it is essential to analyse behaviour based on statistical models, to be able

to predict an individual case level. A construct statistically represents a relationship between individual variables and possible third-level intervening powers (Bollen, 2002) (Martínez-López Francisco et al., 2013) when evaluating not only direct relationships and their significance, as is achieved by utilising and applying mediation analysis. This brings an additional variable (mediator) into the analysis process when investigating the relationships among various variables contributing to a mediating effect (Nitzl, Roldan and Cepeda, 2016). To rule out bias, this research also investigated mediating effects that might significantly change the individual-level behaviour of structural models. This also contributed to a more in-depth analysis of the overall pilot commuting situation as it not only presents direct relationships based on theory but also expands theory above direct lines significantly cutting on possible theory bias (Nitzl, Roldan and Cepeda, 2016). Nitzl, Roldan and Cepeda (2016, p.5) explained that there 'is a methodological challenge' in 'the inclusion of a third variable that plays an intermediate role in the relationship between two variables in a model'. This makes it highly significant in the evaluation of variable interactions in a statistical model (Nitzl, Roldan and Cepeda, 2016, p.5).

3.9.8 Moderation Analysis

Moderation is a cornerstone of in-depth analysis and social science (Memon et al., 2019). It reflects a possible influence in the extent or command of a precursor on the result. It moderates the interaction when the 'relationship between an independent variable and a dependent variable changes according to the value of a moderator variable' (Dawson, 2014, p.4; Memon et al., 2019, p.3) and aims to explore how the moderation is achieved. An in-depth analysis of the literature on relevant theory will support possible moderators and enable an expansion to include theoretical moderation effects (Frazier et al., 2004). Compared with mediation, moderation effects are also becoming substantially more important in the PLS-SEM analysis process for identifying complex constructs and interactions between variables (Fassott, Henseler and Coelho, 2016).

CHAPTER 4: FINDINGS & RESULTS

4.1 Descriptive Statistics

Descriptive statistics were used to describe the dataset in various ways, following the general outline of describing the data used in the research as:

- control variables
- exogenous variables
- endogenous variables.

The abbreviations used in the following tables are defined as follows:

- All: all gathered data
- NC: non-commuters
- C: commuters
- IHC: intermediate housing commuters

IHC are part of C in the analysis process and are shown as a sub-sample of C.

The pilots' declaration as commuters or non-commuters was based on the threshold used in the survey: 56.4% of European airline pilots declared themselves as commuters on the basis that they travelled more than 45 minutes from their place of permanent residence to their pilots' base. The other 43.6% lived within a 45-minute one-way travel radius of their base (Figure 31).

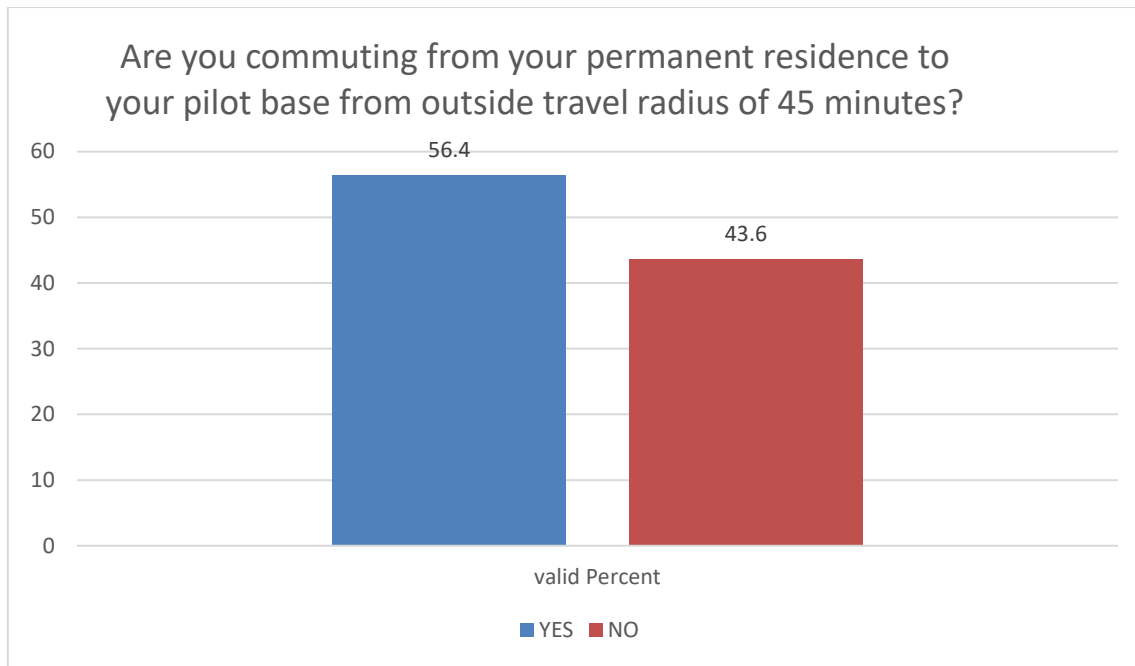


Figure 31–Declaration of Commuter or Non-Commuter

4.1.1 Control Variables

Five control variables were selected for this research (Table 6). Through this research process—as an unchanged fundament on the reflection of the dataset and as in the general commuting literature—some ‘demographic variables including mode of transportation, sex, whether or not partner or spouse works and age of the youngest child were examined as personal variables’ (Krausz, Koslowsky, Aizer, 2008, p.6). The inclusion of these variables made it possible to compare the study findings with those in the literature on general commuting in regard to stress, job turnover and professional performance research.

4.1.1.1 Gender

To establish a possible gender difference to this research, gender was included as a control variable. The International Society of Women Airline Pilots (McCarthy, 2018) reported that 5.2% of all international pilots in the industry were women. More recent data (2018) for European airlines indicated that 5.06% of European airline pilots at the time were female. Data generated by the 2020 European Airline Pilot Commute Study indicated that 7.4% of respondent pilots in all commuter groups were female (see Table 6), which was above the European airline pilot average.

Table 6—Control variables—Gender, Age, Relationship Status, Number of Children, Dependent Children in Household

	ALL		NC		C		IHC	
	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Gender	1225	100	534	100	691	100	229	100
Female	91	7.4	43	8.1	48	6.9	18	7.9
Male	1133	92.5	491	91.9	642	92.9	211	92.1
Other	1	0.1	0	0	1	0.1	0	0
Age	1225	100	534	100	691	100	229	100
18–24	50	4.1	30	5.6	20	2.9	6	2.6
25–34	359	29.3	186	34.8	173	25.0	59	25.8
35–44	37031	30.2	157	29.4	213	30.8	78	34.1
45–54	4	25.6	115	21.5	199	28.8	58	25.3
55–64	131	10.7	46	8.6	85	12.3	2	12.2
65+	1	0.1	0	0	1	0.1	0	0
Relationship status	1225	100	534	100	691	100	229	100
Single	193	15.8	105	19.7	88	12.7	22	9.6
Cohabiting	311	25.4	148	27.7	163	23.6	62	27.1
Married	671	54.8	264	49.4	407	58.9	134	58.5
Separated	14	1.1	3	0.6	11	1.6	4	1.7
Divorced	31	2.5	3	2.4	18	2.6	6	2.6
Widowed	5	0.4	1	0.2	4	0.6	1	0.4
Number of own children	1225	100	534	100	691	100	229	100
0	504	41.1	255	47.8	249	36.0	86	37.6
1-2	507	44.9	221	41.4	329	47.6	107	46.7
>3	214	14.0	58	10.9	113	16.4	36	15.7
Dependent children living in household								
0	1225	100	534	100	691	100	229	100
1-2	576	47.0	282	52.8	294	42.5	96	41.9
>3	524	42.8	203	38.0	321	46.5	105	45.9
	125	10.2	49	9.2	76	11.0	28	12.2

4.1.1.2 Age

The survey responses showed that 55.8% of participants were 35–50 years of age (see Figure 32). This age range also had the highest share of pilots who declared themselves commuters or intermediate housing commuters (C: 59.6%, IHC: 59.4%). Only 4.1% were new entries into the pilot corps, being 18–24 year of age (the age of official certification is 18 years).

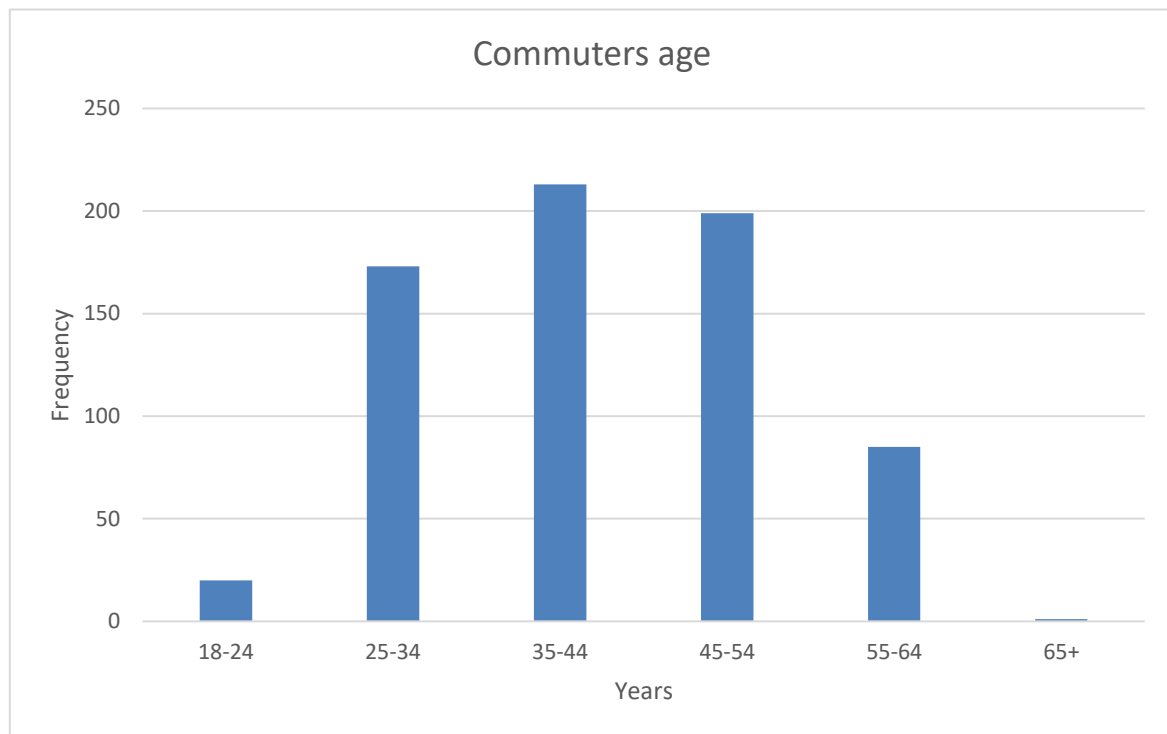


Figure 32–Age of Commuters

Compared to the available data on European Airline pilot age, the Airline pilots worldwide - average age 2016 statistics (Statista Research Department, 2023) report an average age of the European Airline pilot to be 43.7 years.

To act as a European Airline Pilot, one of the legal requirements is possessing a European Class I medical certificate (EASA, 2019). In an EASA final report on 'Age Limitations Commercial Air Transport Pilots' (EASA, 2019), the European Pilot Class I Medical Holders indicated an age distribution in this sample. The pilot sample for this report was 50101 class I medical holders, showing the age distribution outlined in Figure 33.

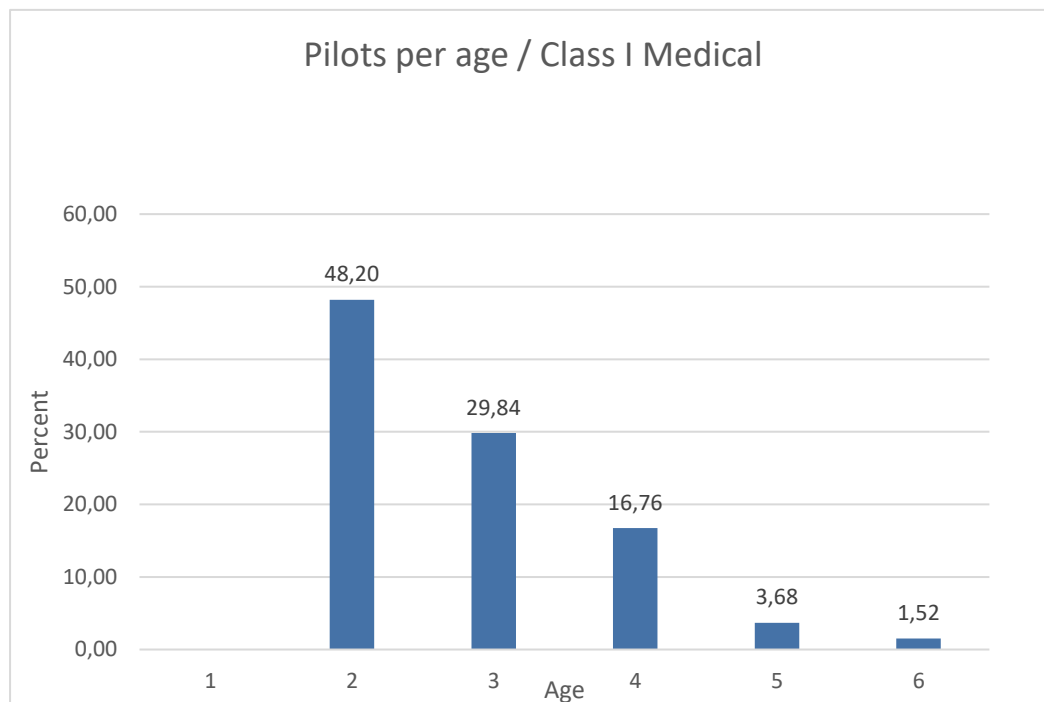


Figure 33– European Pilot Class I Medical age distribution

Source: EASA, 2019, p.22- Excerpt / Redesigned & Recalculated Friesacher.

No comparisons fitting the age categories used in this research were available in the literature review.

4.1.1.3 Relationship Status

The literature suggests that relationship status is a potential reason why pilot commuters may not permanently change their residence to be closer to their pilot base (Gutiérrez-i-Puigarnau, Mulalic and Van Ommeren, 2014; Van Der Klis and Karsten, 2009; Koslowsky, 1997; Krausz, Koslowsky, Aizer, 2008). In the dataset, it was evident that married European airline pilots had a higher tendency to declare themselves as

commuters (58.9%) or intermediate housing commuters (58.5%): fewer (49.4%) declared as non-commuters (Table 5).

4.1.1.4 Number of Own Children

The number of their own children was higher for pilots declaring themselves as commuters (64.0%) or intermediate housing commuters (62.4%), while only 52.3% of non-commuters had their own children (Table 6).

4.1.1.5 Dependent Children Living In Household

Similar to the number of own children variable is the number of children living in the household. Commuters and intermediate housing commuters tended to have more dependent children in their household (see Table 6).

4.1.1.6 Job Position

A 2016 survey study conducted by the London School of Economics and Political Science and funded by the European Commission examined the perceptions of European pilots' safety culture. The findings showed that 56% of participants declared themselves as captains and 43% as first officers (Reader, Parand and Kirwan, 2016). A similar percentage was recorded for the overall sample in the current study.

4.1.1.7 Type of Airline

In a strongly Western European-focused study on atypical employment in aviation funded by the European Commission, the European pilot corps included 45% who worked for a network airline; the second largest group (22%) indicated they flew for a low-fare airline (Jorens and Gillis, 2015). Somewhat similar results were found in the current study: 52.8% of respondents stated they flew for a legacy (network) airline and 34.7% for a low-cost operator. The minor differences between the two studies in these percentages are likely due to the fact that a higher percentage of respondents in the current study were pilots living or working in Eastern European countries.

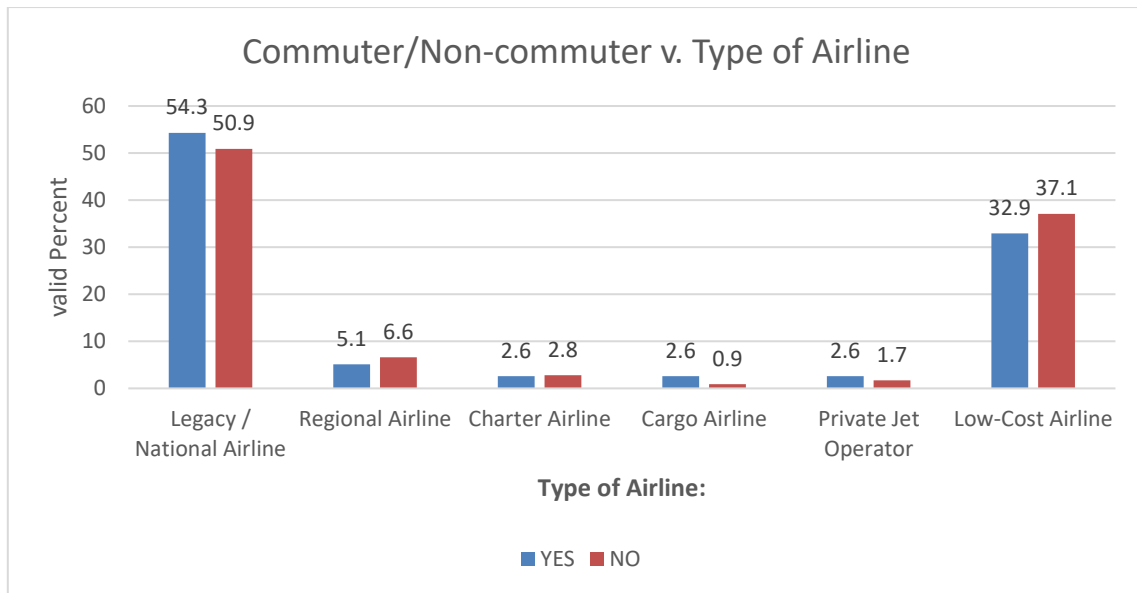


Figure 34—Type of Airline v. Commuter/Non-Commuter

4.1.1.8 Type of Operation

Similar to the type of airline is the personal declaration on the type of operation. Almost identical percentages of pilots declared they were involved in long-haul operations in the current study and the European Commission-funded study (Jorens and Gillis, 2015): 71.0% of all respondents in the latter declared they were working in medium- and short-haul operation pilots; the figure in the current study was 71.2% (Table 7). This research found a significant difference between commuter groups in the type of operation: substantially more commuters flew long-haul operations than did non-commuters or commuters with intermediate housing. Industry standards mean that long-haul pilots have greater flexibility to live further distances and travel times away from their designated home base.

Table 7–Job Position, Type of Airline, Type of Operation

	ALL		NC		C		IHC	
	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Job position	1225	100	534	100	691	100	229	100
Captain	578	47.2	238	49.2	340	49.2	127	55.5
1st Officer	400	32.7	179	32.0	221	32.0	58	25.3
SFO Officer	210	17.1	95	16.6	115	16.6	39	17.0
2nd Officer	37	3.0	22	2.2	15	2.2	5	2.2
Type of airline	1225	100	534	100	691	100	229	100
Legacy	647	52.8	272	50.9	375	54.3	92	40.2
Regional	70	5.7	35	6.6	35	5.1	11	4.8
Charter	33	2.7	15	2.8	18	2.6	1	0.4
Cargo	23	1.9	5	.09	18	2.6	4	1.7
Private Jet	27	2.2	9	1.7	18	2.6	1	0.4
Low-Cost	425	34.7	198	37.1	227	32.9	120	52.4
Type of operation	1199	100	526	100	673	100	221	100
Long-haul	298	24.9	103	19.6	195	29.0	45	20.4
Medium/short-haul	872	71.2	409	77.8	463	68.8	172	77.8
Domestic	29	2.4	14	2.7	15	2.2	44	1.8

4.1.2 Use of Intermediate Housing Facilities

The results showed that 47.5% of the participating European airline pilots had an active or past history of using intermediate housing facilities at their home base (Figure 35). Stating that using a second home away from the permanent residence is an industry standard for the European airline pilot corps. In regard to the interests and issues around long-distance commuting and of dual residents, this implies a lack of socialisation at the home base and infrequent duty scheduling issues (Green, Hogarth and Shackleton, 1999; Koslowsky, 1997; Krausz, Koslowsky, Aizer, 2008; Van Der Klis and Karsten, 2009).

Further, long-distance commuting and intermediate housing facilities at the home base open the path for a 'residential preference for accessible semi-rural areas with good communications links' (Green, Hogarth and Shackleton, 1999).

Also, regarding changes to pilots' occupational contracts and conditions, commuting and a permanent residence away from home base indicates 'there is some evidence

that residential locations are sought to maximise commuting potential and to minimise the need for future residential migration' (Green, Hogarth and Shackleton, 1999). There is also an 'impact of a move on a partner's career and the disruptive effects of a move on children's education are two of the key factors to which an unwillingness to relocate has been attributed' (Green, Hogarth and Shackleton, 1999, p.52). The use of intermediate housing facilities in particular becomes more relevant if the country of permanent residence is further away from the home base. A study conducted by the University of Gent and funded by the European Commission on atypical employment data found that 'more respondents reporting to fly for an LCC as well as those reporting to fly for cargo airline reported not to live in the country where their home base is located' (Jorens and Gillis, 2015, p.242). This indicates a strong tendency for pilots of these types of airline to use intermediate housing facilities.

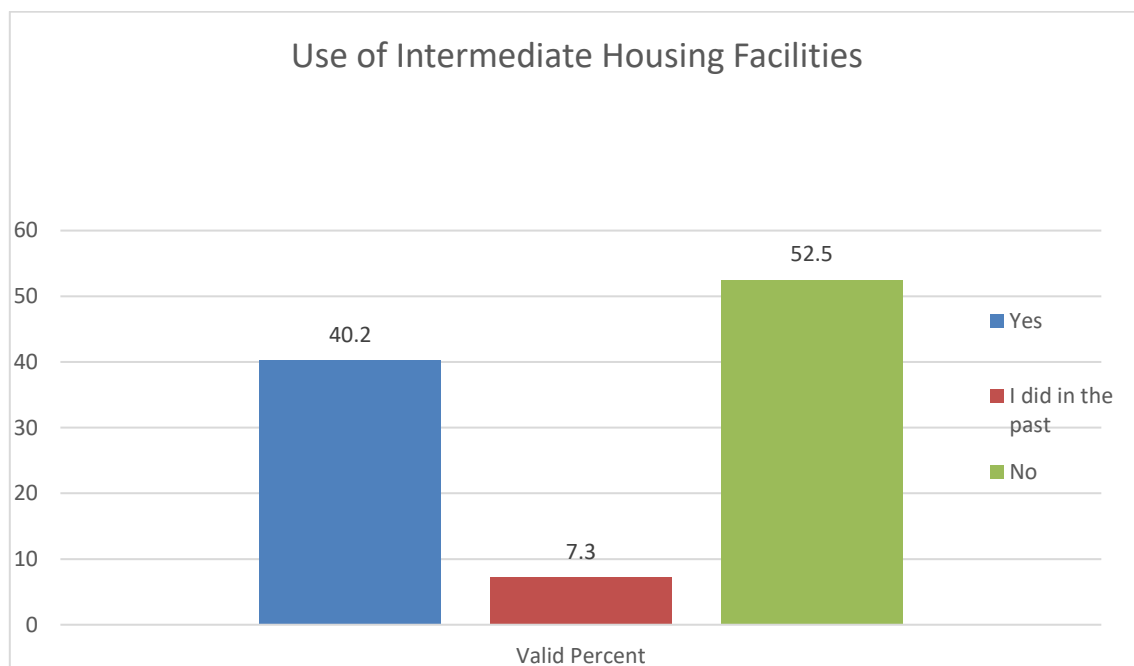


Figure 35–Use of Intermediate Housing Facilities

4.1.3 Declared Commuting Time

The latest European Union data indicate that employed people in the European Union in 2019 had an average of 25 minutes commuting time (Eurostat, 2021). A beneficial buffer time for travel between the home base and the place of residence may exist, as for 'some commuters, the travel time between work and home can be valued as free time to think, converse, sing, escape, or as a transition between work and home' (Kuennen, 2012, p.56). Further, 'travel times can be regarded as such a distance

measure' (Allroggen and Malina, 2014, p.2; Geurs and van Wee, 2004). To clearly distinguish between European airline pilot commuters and non-commuters, a visual examination of the geospatial location of airports in Europe was conducted, which showed that few airports are located in or near a city centre. Further, airport accessibility, with various modes of transport and travel times involved, is a significant point of distinction between European airline pilot commuters and non-commuters (Givoni and Vowles, 2017; Koster, Kroes and Verhoef, 2011; Reichmuth, 2010b; Reynolds-Feighan and McLay, 2006; Vlieger, 2003b; Yang, Yu and Notteboom, 2016). Unique factors associated with the airline pilot profession itself make the commuting process a highly different server and channel population commuting processes. 'Pilot commuting takes place during off-duty hours'. (NRCNA, 2011, p.17) The NRCNA in its investigation of pilot commuting took the approach that pilot commuting includes the period and the activity required of pilots from 'leaving home to arriving at the domicile (airport – in the crew room, dispatch room or designated location at the airport) and from leaving the domicile to returning back home.[...] Pilot commuting differs from the commuting of other workers in terms of frequency and variability, distance, transport modes, and time of day' (NRCNA, 2011a, p.2).

Use of a 45-minute one-way travel time declaration as the definition of a European airline pilot commuter was derived from the literature and European airline pilot accessibility (Givoni and Vowles, 2017; Koster, Kroes and Verhoef, 2011; Reichmuth, 2010; Reynolds-Feighan and McLay, 2006; Vlieger, 2003; Yang, Yu and Notteboom, 2016). US data and the literature show that 'persons who travel for work, on average 46.2 minutes per day' (El-geneidy et al., 2014). The current study used a 45-minute one-way travel radius as a realistic value based on the literature and European geospatial airport locations. Statistical analysis of data in this study indicated that 26.8% of all pilots travelled 180 minutes or more to arrive at their place of occupation. It was also observed that 46.6% of the respondent European airline pilots travelled more than 60 minutes to reach their home base and commence their occupational pilot duties (Figure 36). Van Ham (2001) commented that 'in Europe, a few studies have suggested that a 45-min trip is commonly perceived as acceptable', and that differences between European countries, and long work journeys makes it challenging to draw a definite line.

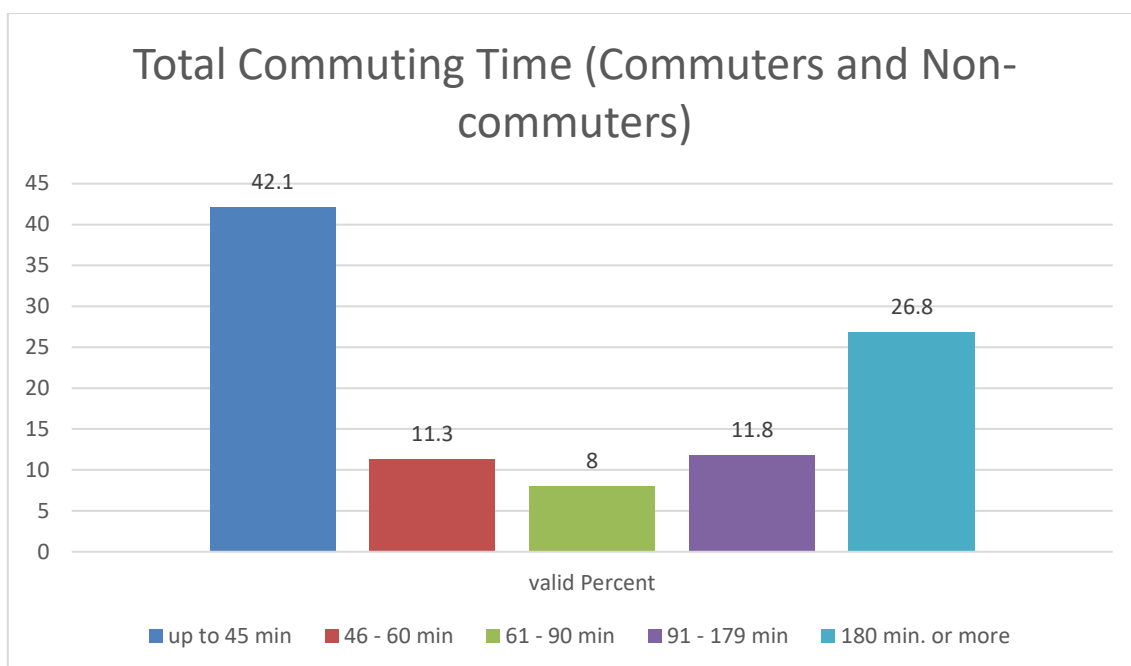


Figure 36–Total Commuting Time

4.1.4 Declared Commuting Distance

Commuting distance between the residence and home base is only one indication among others (e.g. commuting time, mode of transport) in an array of commuting variables (NRCNA, 2011a). Nevertheless, commuting distance showed a highly significant difference in the three-group analysis involving non-commuters, commuters and intermediate housing commuters (Table 8). The analysis showed that 11.9% of the commuting pilots in this study resided more than 1,500 km away from their home base (Table 9). This tremendously increases and demonstrates the need for intermediate housing at the home base: indeed, 20.7% of intermediate housing pilots indicated they had a commuting distance of more than 1,500 km. The necessity for accommodation away from the residence becomes even more evident as 63.5% of pilots in this study who declared themselves intermediate housing commuters lived more than 500 km from their residence. Overall, a total of 41% of all pilot commuters travelled a distance of more than 500 km between their place of residence and their home base, a statistic indicating that a European airline pilot is a distant-travel occupation and not only in the sense of piloting duties (see Figure 37).

Table 8—Significance Testing Commuting Distance—Three-group Analysis

Item	Group	Mean	SD	<i>p</i>
Commuting distance	C	414.06	655.782	<0.000
	NC	87.14	207.037	
	IHC	960.08	831.828	

Table 9—Commuting Time and Commuting Distance

	ALL		NC		C		IHC	
	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Commuting time (min)								
≤45	1110	100	500	100	610	100	229	100
46–60	467	42.1	413	82.6	54	8.8	8	3.5
61–90	125	11.3	33	6.6	92	15.1	5	2.2
91–179	89	8.0	11	2.2	78	12.8	10	4.4
≥180	131	11.8	9	1.8	122	20.0	50	21.8
	298	26.8	34	6.8	264	43.3	156	68.1
Commuting distance (km)								
≤45	1102	100	498	100	604	100	227	100
46–150	455	41.3	383	76.9	72	11.9	5	2.2
151–500	199	18.1	69	13.9	130	21.6	8	3.5
501–900	173	15.7	19	3.8	154	25.5	70	30.8
901–1500	124	11.3	9	1.8	115	19.0	56	24.7
1501–2500	79	7.2	18	3.6	61	10.1	41	18.1
>2500	47	4.3	0	0	47	7.8	32	14.1
	25	2.3	0	0	25	4.1	15	6.6

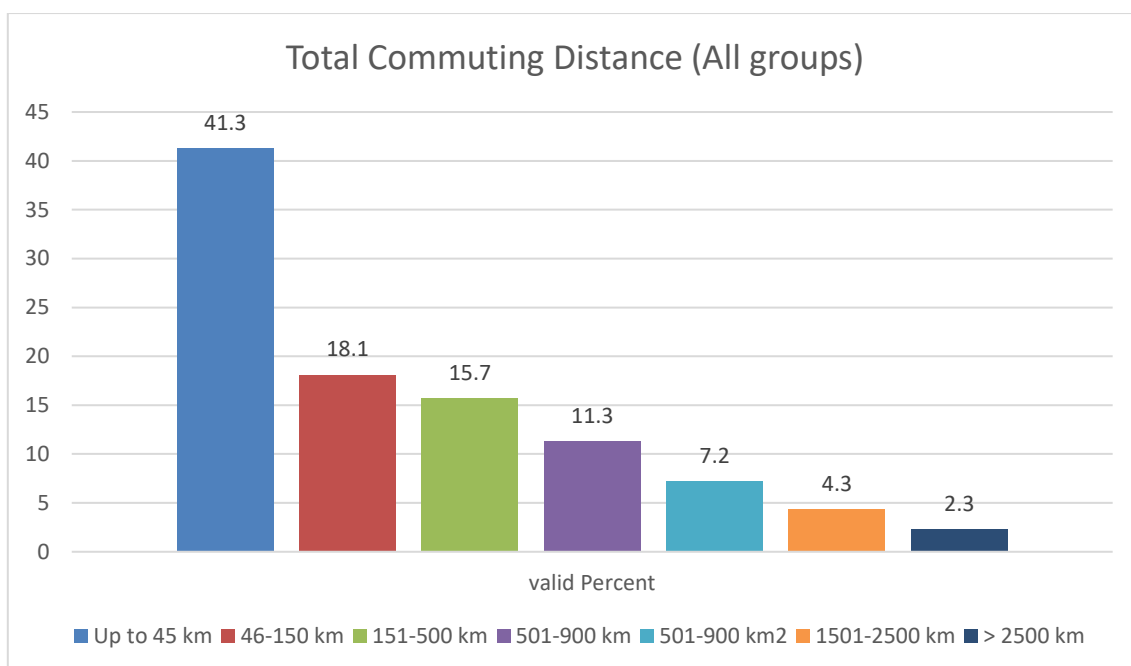


Figure 37–Total Commuting Distance

4.1.5 Declared Frequency of Commute

The frequency of commute indicates how often in a given pilot's flight schedule they commute between their place of residence and their home base. The data indicate that 30.7% of the responding European airline pilots commuted more than five times per monthly flight schedule between these two places and 17.8% indicated they commuted more than 10 times per month (see Figure 38).

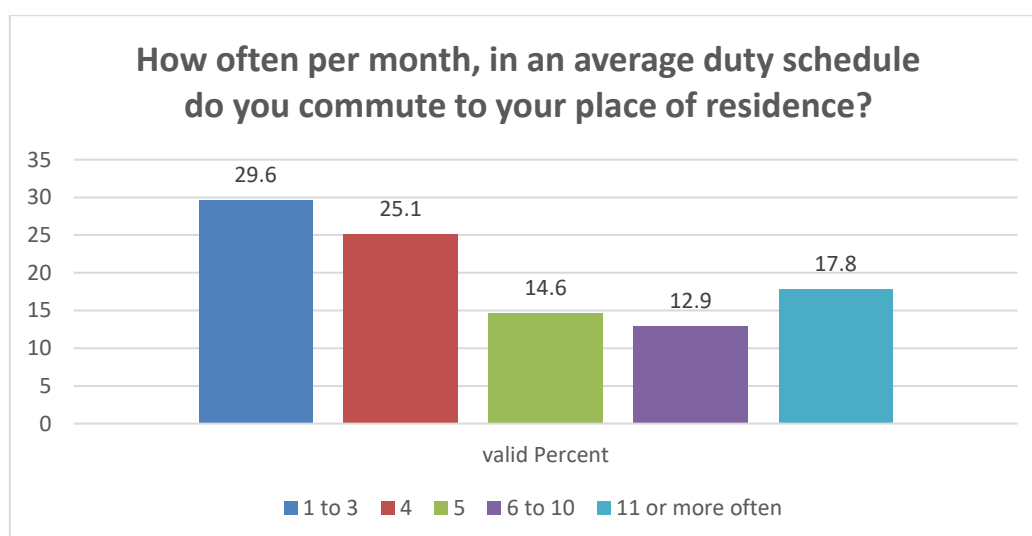


Figure 38–Declared Frequency of Commute

4.1.6 Form and Mode of Housing at Place of Residence

In terms of the form of housing, a high percentage of commuters and pilots using intermediate housing tended to reside in a house or an apartment (see Table 10). Of the commuter pilots, 59.5% compared with 44.2% of their non-commuting colleagues, declared that they lived in a house. There was also a clear preference for non-commuter pilots (50.2%) to live in apartments, relative to their commuting colleagues (38.6%).

With regard to the mode of housing, commuters and intermediate housing commuters had a solid tendency towards property ownership: 69.2% of commuters and 74.2% of intermediate housing commuters indicated this choice, while only 60.9% of non-commuters owned the property in which they lived. A significant difference was also seen in the choice to rent their property: 36.9% of non-commuters indicated this choice while this was true for only 27.1% of their commuting colleagues and 20.5% of those using intermediate housing facilities.

Table 10–Form of Housing and Mode of Housing

	ALL		NC		C		IHC	
	Nr.	%	Nr.	%	Nr.	%	Nr.	%
Form of housing at place of residence	1225	100	534	100	691	100	229	100
House	647	52.8	236	44.2	411	59.5	143	62.4
Apartment	535	43.7	268	50.2	267	38.6	81	35.4
Shared	36	2.9	24	4.5	12	1.7	4	1.7
Other	7	0.6	6	1.1	1	0.1	1	0.4
Mode of housing	1225	100	534	100	691	100	229	100
Ownership	803	65.6	325	60.9	478	69.2	170	74.2
Rent	384	31.3	197	36.9	187	27.1	47	20.5
Other	38	3.1	12	2.2	26	3.8	12	5.2

4.1.7 Declared Geographic Data of Residence and Home Base

European airline pilots' commuting is directly related to their place of residence and home base. These two locations are the critical parameter in the commuting process,

ALL			ALL		
	Nr.	%		Nr.	%
COUNTRY OF RESIDENCE	1319	100	COUNTRY OF CREW BASE	1299	100
Andorra	1	0.1	Austria	125	9.6
Austria	113	8.6	Belgium	40	3.1
Belgium	54	4.1	Bosnia and Herzegovina	2	0.2
Bosnia and Herzegovina	1	0.1	Bulgaria	6	0.5
Bulgaria	4	0.3	Cyprus	3	0.2
Croatia	3	0.2	Czech Republic	6	0.5
Cyprus	6	0.5	Denmark	8	0.6
Czech Republic	13	1.0	Estonia	6	0.5
Denmark	11	0.8	Finland	26	2.0
Estonia	9	0.7	France	156	12.0
Finland	26	2.0	Georgia	1	0.1
France	160	12.1	Germany	100	7.7
Germany	119	9.0	Greece	9	0.7
Greece	12	0.9	Hungary	16	1.2
Hungary	20	1.5	Iceland	1	0.1
Iceland	2	0.2	Ireland	7	0.5
Ireland	10	0.8	Italy	56	4.3
Italy	74	5.6	Latvia	6	0.5
Lithuania	7	0.5	Lithuania	6	0.5
Luxembourg	6	0.5	Luxembourg	9	0.7
Malta	2	0.2	Malta	2	0.2
Montenegro	1	0.1	Montserrat	1	0.1
Montserrat	1	0.1	Netherlands	84	6.5
Netherlands	90	6.8	Norway	20	1.5
Norway	16	1.2	Poland	38	2.9
Poland	34	2.6	Portugal	5	0.4
Portugal	8	0.6	Romania	52	4.0
Romania	29	2.2	Serbia	6	0.5
Serbia	8	0.6	Slovakia	2	0.2
Slovakia	4	0.3	Spain	58	4.5
Slovenia	5	0.4	Sweden	10	0.8
Spain	68	5.2	Switzerland	42	3.2
Sweden	20	1.5	North Macedonia	7	0.5
Switzerland	36	2.7	Turkey	149	11.5
North Macedonia	2	0.2	Ukraine	9	0.7
Turkey	140	10.6	UK of GB & Northern Ireland	224	17.2
Ukraine	6	0.5	Vatican City	1	0.1
UK of GB & Northern Ireland	197	14.9			
Vatican City	1	0.1			

Table 11- Geographic Data of Residence and Home Base

determining important commuting variables such as distance and time frame of commuting. This study examined the geographic information related to these two points and the resulting connection process of commuting.

As this study derives the EU definition of "non-commuters" (Eurostats, 2016) from the study of EU Labour Market and Labour force statistics, it also uses the European 'nomenclature of territorial units for statistics – NUTS' (Eurostat, 2022) as a definition for outward and inward commuting regions. The EU nomenclature of NUTS – 0 (EU-28) national countries was extended for this study to include Albania, Andorra, Armenia, Belarus, Bosnia-Herzegovina, Georgia, Montenegro, North Macedonia, Republic of Moldova, Russian Federation, Serbia, Ukraine, Vatican City as possible geographical locations for residence or home base.

Table 11 shows the number and percentage of participants in the European airline pilot commute study in 2020. The top five participating countries of residence are the United Kingdom (Great Britain and Northern Ireland), France, Turkey, Germany and Austria. In comparison, the top five countries of Crew base are the United Kingdom (Great Britain and Northern Ireland), France, Turkey, Austria and Germany.

Comparing European Labour Force Survey (LFS) data to the European airline pilot commute study, it becomes apparent that similar to this research 'Germany, Denmark, Austria and the Netherlands — where 9.0–12.0 % of the working population commuted nationally.' (Eurostats, 2016) as similarities are also shown to the LFS by this research. The European airline pilot commute study also shows that the highest intra-European commuting flows are within France, Austria, Germany and Turkey (Eurostat, 2022), which were not part of the 2016 European Labour Force Survey.

As shown in the commuting flows between countries, Figure 41.

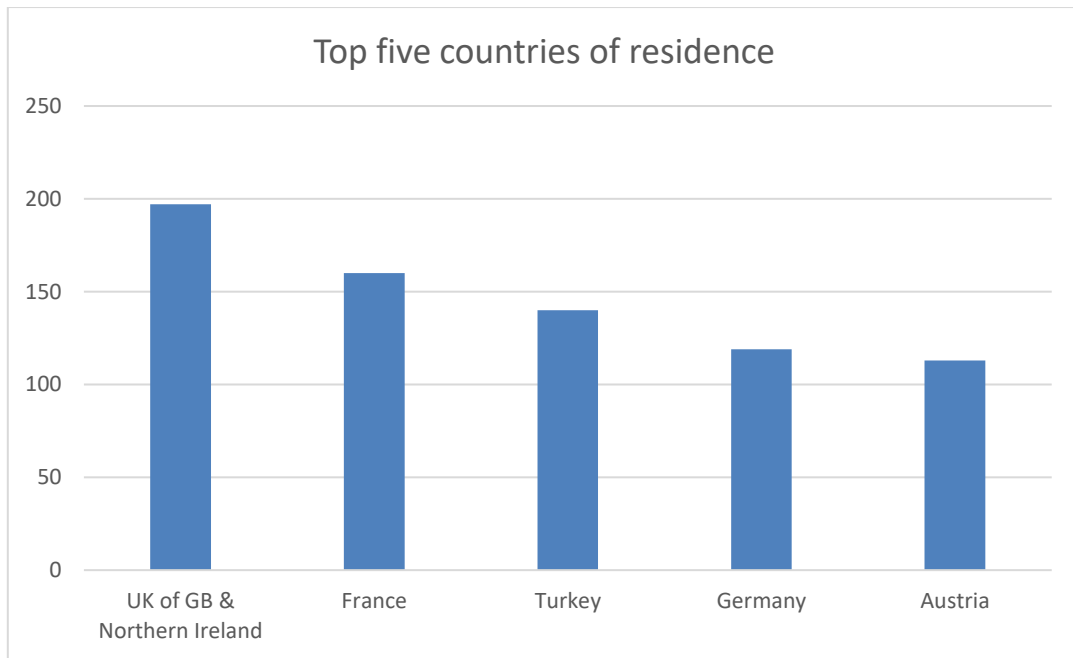


Figure 39- Top five countries of residence

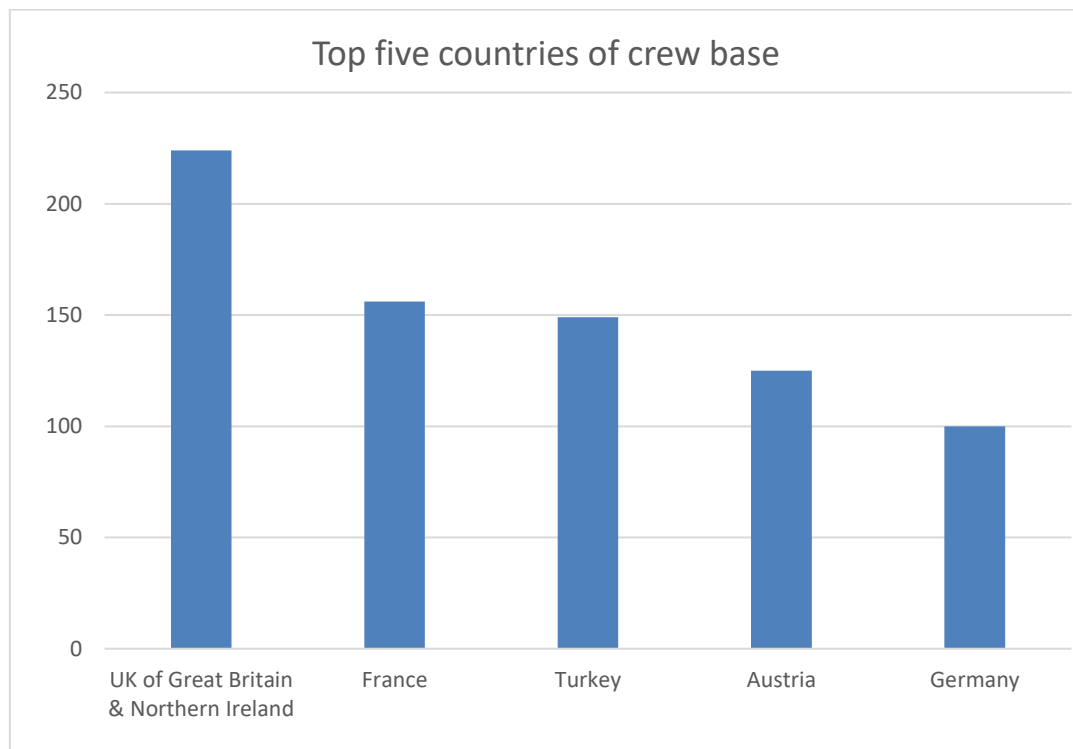


Figure 40-Top five countries of crew base

Item	ALL	Nr.	%
Top 5 European Commuters Paths			
ALL	1462	1462	100
International			
Germany – Austria		20	1.4
Italy – Romania		9	0.6
Belgium – France		8	0.5
France – Switzerland		6	0.4
France - UK of Great Britain & Northern Ireland		5	0.3
Intra-Country			
France – France		137	9.4
Turkey – Turkey		137	9.4
Austria – Austria		100	6.8
Germany - Germany		80	5.5
Netherlands - Netherlands		72	4.9

Table 12- European commuter paths - bi-direction

The general European commuting flows between countries are confirmed and similar by the general picture of the European Labour Force Survey (2016) and the European airline pilot commute study. The European Labour Force Survey (2016) also shows that the 'highest number of commuters originated from: France (438 thousand), Germany (286 thousand), Poland (155 thousand), Slovakia (147 thousand), Italy (122 thousand), Romania (122 thousand), Hungary (111 thousand) and Belgium (107 thousand)' (Eurostats, 2016). Comparing this with the findings of the European Airline Pilot Commute Study 2020 and it supports their assumption that the top five commuting flows from other European countries are from Germany, Italy, Belgium and France. The directions and destinations of these five main international commuter routes are shown in Figure 41 and visualised in Figure 42.

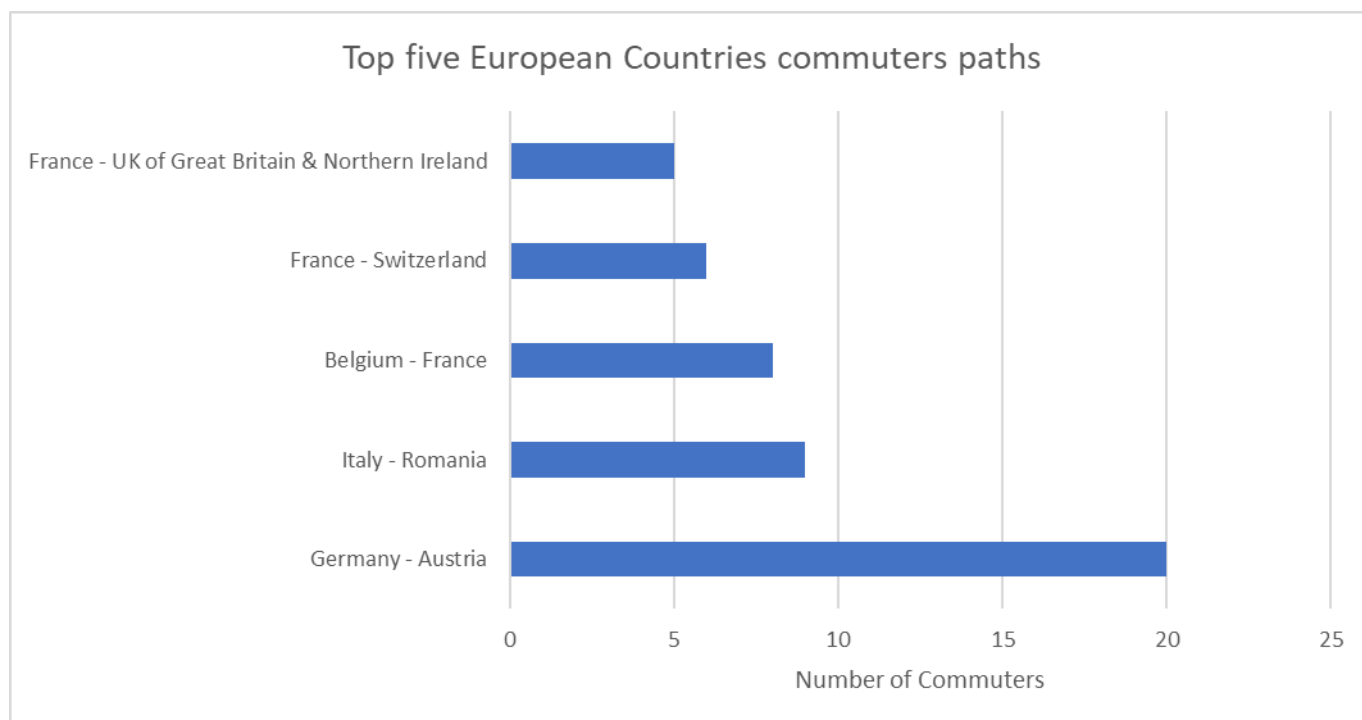


Figure 41-Top five European countries' international commuter paths of pilots in the study

Top five commuters paths



Figure 42-Visualisation of top 5 European countries' international commuters' paths

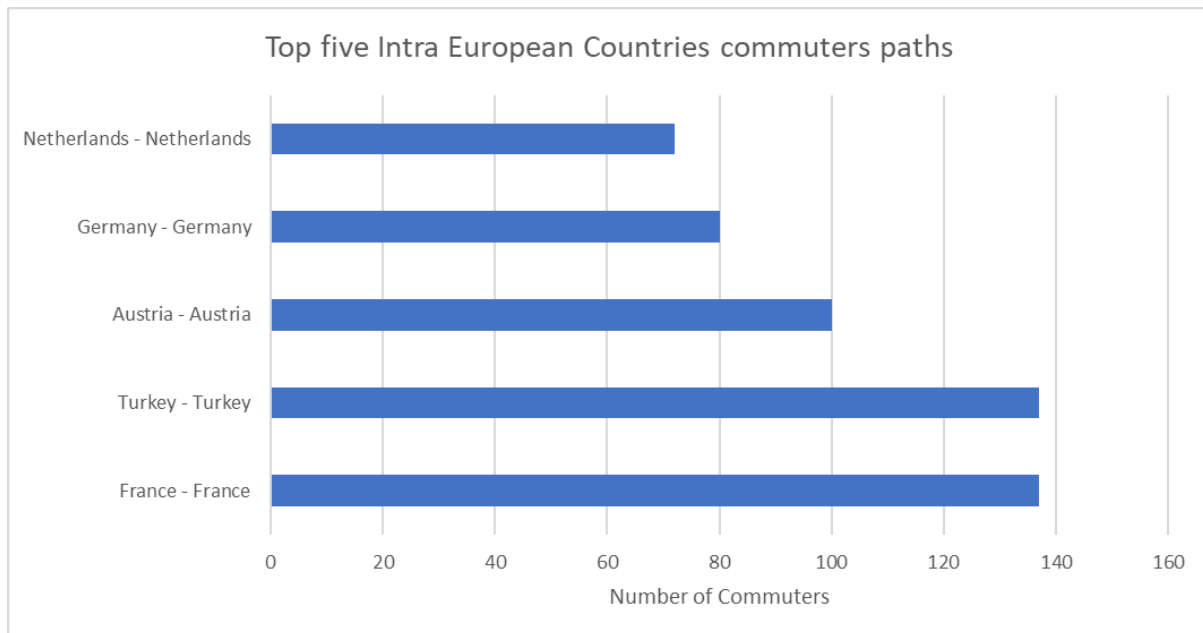


Figure 43-Top five European countries' intra-country commuter paths of pilots in the study

4.1.8 Exogenous Variables

4.1.8.1 Mode of Transport

Strongly connected to European airport connectivity issues are typical European airline pilots' commuting issue including irregular check-in times, remote location of terminal crew reporting facilities, lack of 24-hour public transport accessibility and the need to carry excessive luggage (Hickman, 2016; Murphy, 2009; NRCNA, 2011a; Reichmuth, 2010; Vlieger, 2003). The BOB airport accessibility pilot study (2003) identified a lack of employee airport occupational travel data. That study collects primary data for European airline pilots' commuting mode choice and meantime of usage for each commuting mode.

Orth, Frei and Weidmann (2015) stated that most international airports in Europe are connected to a rail service to the city centre and adjacent areas, as well as a long-distance rail service. The current study data indicated that 13.8% of the commuting European airline pilots used a train as their prevailing commuting mode choice. However, the highest percentage of the respondent European airline pilots indicated the car mode choice and active driving was their preference. Non-commuting pilots (74.2%), commuting pilots (78.5%) and pilots using intermediate housing facilities at their home base (72.1%) used active car driving, and on average these three

categories drove for 74 minutes. However, non-commuting pilots indicated that they used active car driving for 39 minutes, commuters 79 minutes and intermediate housing commuters, 102 minutes on average. In connection with the 2003 airport accessibility pilot study and the willingness to implement a green commuter plan with multiple choices for employee travel, there have been attempts to reduce commute times by more than 70% (Vlieger, 2003). Data from the European airline pilots surveyed for this research suggest that this is not possible because of the uniqueness of airline pilot commuting practices.

4.1.8.2 Mean Time of Use and Percentage of Use of Transport

Compared with the average European employee's commuting time of 25 minutes, the data in this study show that the average European airline pilot has a substantially longer commuting time. As Table 14 indicates, active car driving (Figure 45) was reported as the number one mode choice for over 70% in all groups of European airline pilots, and an average use time of 74 minutes over all groups in the study (Table 13). The second-highest mode use was a form of transport not typically available for general commuters and tightly connected to the standard of subsidised or free airline pilot crew flight tickets: the use of aircraft as a commuting mode choice.

The specifics and danger in pilot commuting to date is that 'there are no comprehensive data on the frequency of pilot commuting, the lengths of commutes, or such trip characteristics as the transportation modes used in commuting' (NRCNA, 2011a, p.2). A considerably greater distance from the place of residence to the home base is made possible by this industry-subsidised commuting system. Airline flights can be used to travel a relatively great distance in a short period, but can elevate the potential stress experienced during commuting because of airline industry special commuting benefits.

Table 13–Mode of Transport and Mean Time of Use

	NC		C		IHC	
	Nr.	min	Nr.	min	Nr.	min
	534		340		229	
Car active		39.22		79.46		102.09
Car passive		12.90		6.52		11.30
Bus/Tram/Metro active		2.64		9.52		22.49
Bus/Tram/Metro passive		17.01		11.57		11.45
Aircraft active		4.35		17.29		33.93
Aircraft passive		4.12		26.69		60.32
Train active		1.28		8.28		13.64
Train passive		7.91		22.41		34.38
Bike active		3.22		0.85		0.11
Bike passive		0.07		4.41		0
Other mode active		0.42		2.63		1.18
Other mode passive		0.21		0.66		3.34

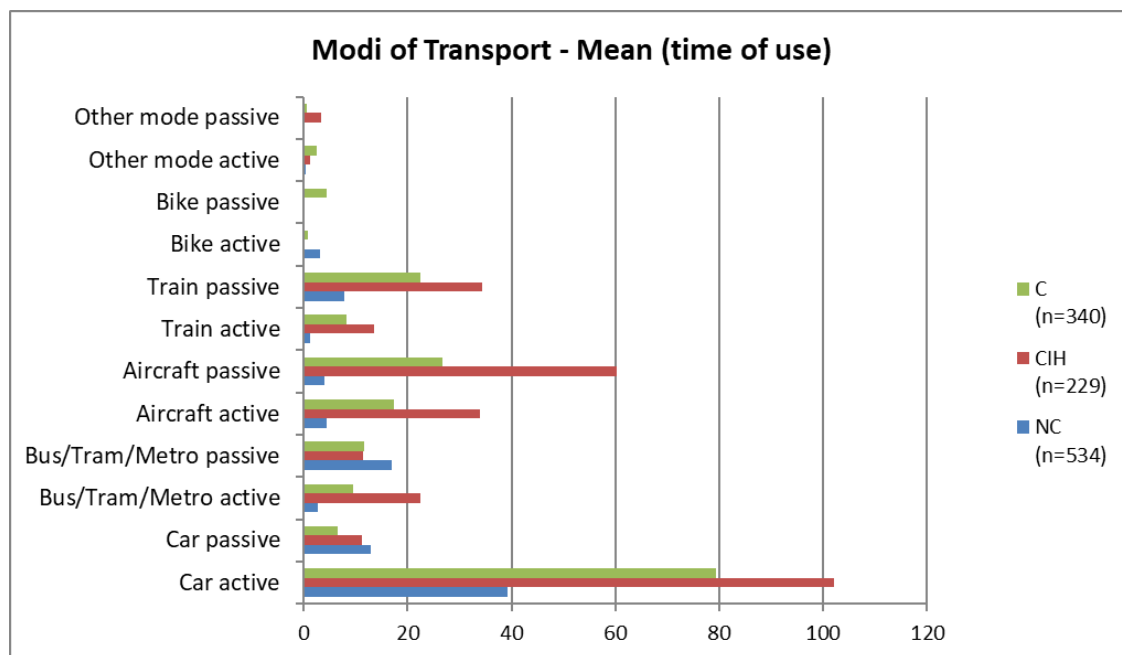


Figure 44–Mode of Transport and Mean Time of Use

4.1.8.3 Modi of Transport—Percentage of Use

Shows the statistical results of different modes of transport used.

Table 14—Mode of Transport in Percentage

	NC		C		IHC	
	Nr.	%	Nr.	%	Nr.	%
	534		340		229	
Car active		74.20		78.50		72.10
Car passive		5.20		6.20		10.50
Bus/Tram/Metro active		4.30		8.20		8.70
Bus/Tram/Metro passive		18.40		20.00		18.80
Aircraft active		3.20		14.50		23.10
Aircraft passive		3.40		20.30		51.10
Train active		2.10		6.20		5.70
Train passive		4.70		13.80		20.50
Bike active		4.10		2.60		0.90
Bike passive		0.40		0,00		0,30
Other mode active		2.40		2.60		2.20
Other mode passive		1.30		1.50		3.50

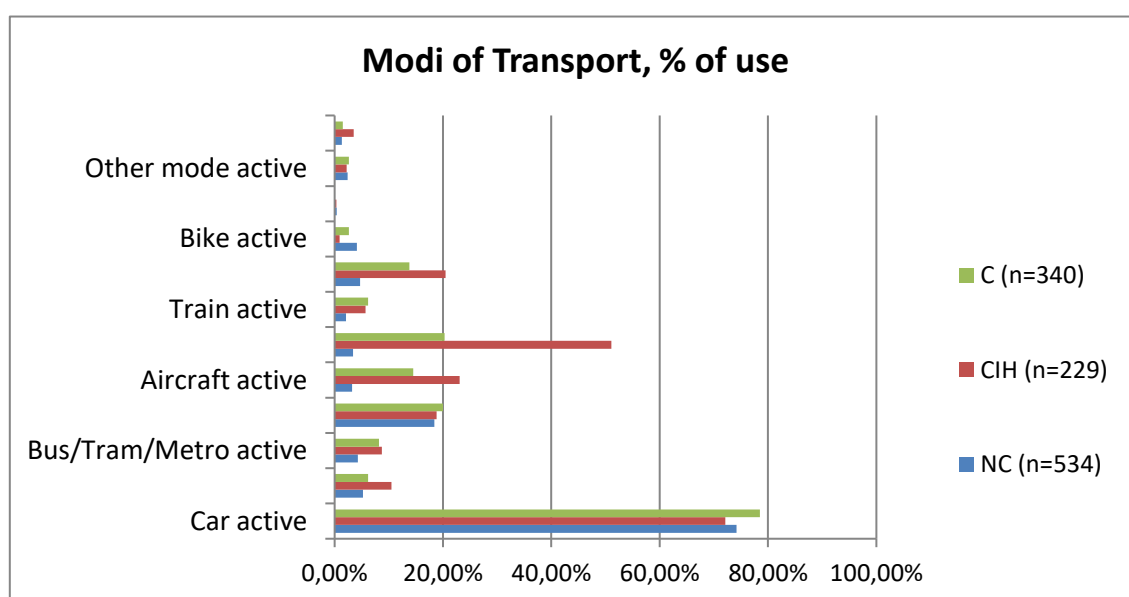


Figure 45—Mode of Transport—Percentage of Use

4.1.9 Endogenous Variables

4.1.9.1 Commuting Stress

The research literature mostly employs objective indicators of commuting stress such as time and distance when forecasting commuting stress or strain (Krausz, Koslowsky, Aizer, 20). As a mental and physical burden, commuting imposes stress on the human body (Legrain, Eluru and El-Geneidy, 2015) and humans need ways to cope with this. Sloan and Cooper in their study entitled 'Pilots under stress' (1986) suggested various approaches that can be used by pilots coping with the occupational stress associated with their profession.

Factors that help cope with perceived stressors and strengthen personal stress management include stability of the domestic relationship and home life, reason and logic, social support and domestic partner involvement (Sloan and Cooper, 1986). In a recent study on the requirements of new tools for pilots in the aviation industry, Cahill (2020) pointed out that it is essential to support 'pilot wellness and stress management' practices. Similar to Sloan and Cooper (1986), it was reported by Cahill et al. (2020a) that the transition period between home and work, and stress coping plays a crucial role in a pilot's professional life. To cope with these stressors it is necessary to expand on the importance of the interaction of performance and safety in a systematic approach to safety management (Cahill et al., 2020a). Expanding on the Hancock and Szalma (2008) 'trinity of stress' model, moderate levels of stress can contribute to heightened vigilance and improved performance on specific tasks (Kavanagh, 2005). This is applicable to professional pilot occupational requirements. In accordance with the 'input–adaptation–output model' (Hancock and Szalma, 2008), it was hypothesised that commuting can seriously influence job performance and that excessive stress during the transition period from home to work interfaces is a crucial period that might also constitute a catalysing time between these two domains. This was underlined by Koslowsky et al.'s (1995) research that demonstrated that beneficial utilisation of commuting time can be a desirable result of the commuting process (Kuennen, 2012; Sloan and Cooper, 1986; York and Press, 1995).

As part of the analysis of the data gathered in the current study, Cronbach's alpha was calculated, which produced a value of 0.931 with eight items used (Table 15). This

indicated internal consistency and proved the validity of the construct (Hair, Money and Samouel, 2007).

Table 15–Total Stress Level—Statistics General

Commuting stress	N much of Items	Valid n	Cronbach's alpha
Cronbach's alpha	8	968	0.931

Three-group analysis calculations showed a highly significant difference in total stress ($p < 0.001$) among the commuter, non-commuter and intermediate housing commuter groups.

Table 16–Total Stress Level—Statistics

Item	Group	Mean	SD	n	<i>p</i>
Total stress	C	2.9205	1.00570	313	<0.001
	NC	2.5971	1.47028	444	
	IHC	3.4218	0.83797	211	

Application of a Bonferroni post hoc test showed that all three groups differed significantly from each other in stress levels. Non-commuters had the lowest stress value, while commuters had medium stress levels and commuters using intermediate housing facilities had the highest stress levels. (see Table 16)

A between-group total stress analysis indicated significant differences between groups in the following order: IHC > NC; IHC > C; C > NC

Table 17–Total Stress–3 Group Analysis

Item total	Group comparison	Mean difference	<i>p</i>
Total stress	NC–IHC	–0.82467	0.000
	C–IHC	–0.50127	0.000
	NC–C	–0.32340	0.001

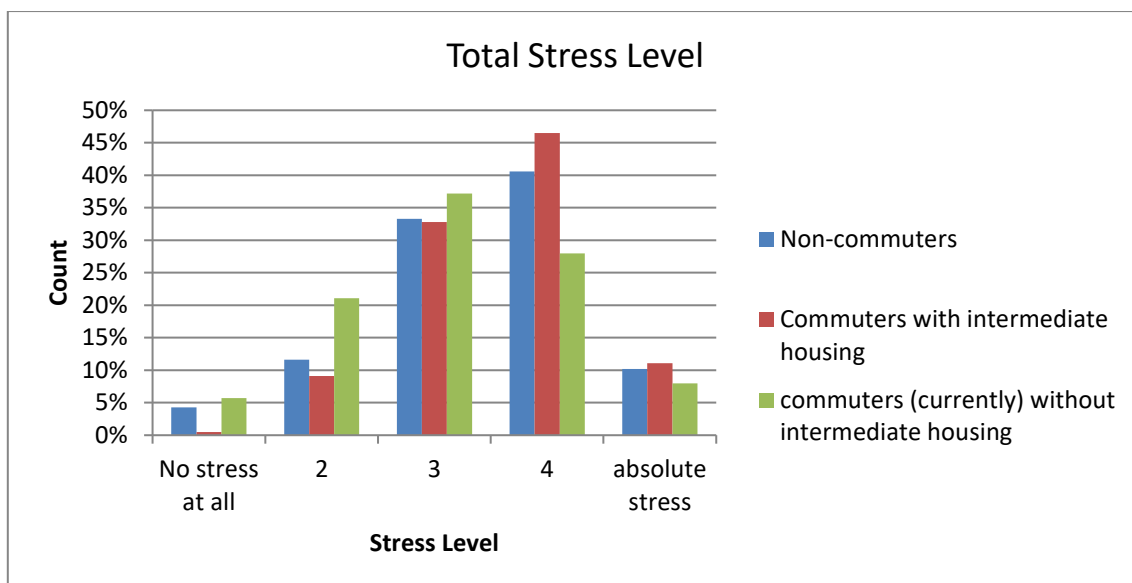


Figure 46—Total Stress Levels—Three Groups

4.1.10 Stress

4.1.10.1 Stress Commuter v. Non-commuters

To cross-tabulate commuting time and commuting stress, those two items were visually binned to create categorical variables from continuous variables. For each of the two variables, five categories were created (Table 18; Figure 47). Pearson's correlation coefficient was calculated for commuting stress and commuting time, which were weakly positively correlated. This indicates that when commuting time increases, stress rises too and vice versa.

Table 18—Commuting Time and Commuting Stress Categorisation

Item	Rating	Commuting time (min)
Commuting time	very low	<121
	low	122–171
	medium	172–241
	high	242–316
	very high	>316
Commuting stress	very low	<1.778
	low	1.779–2.444
	medium	2.445–3.000
	high	3.100–3.556
	very high	>3.556

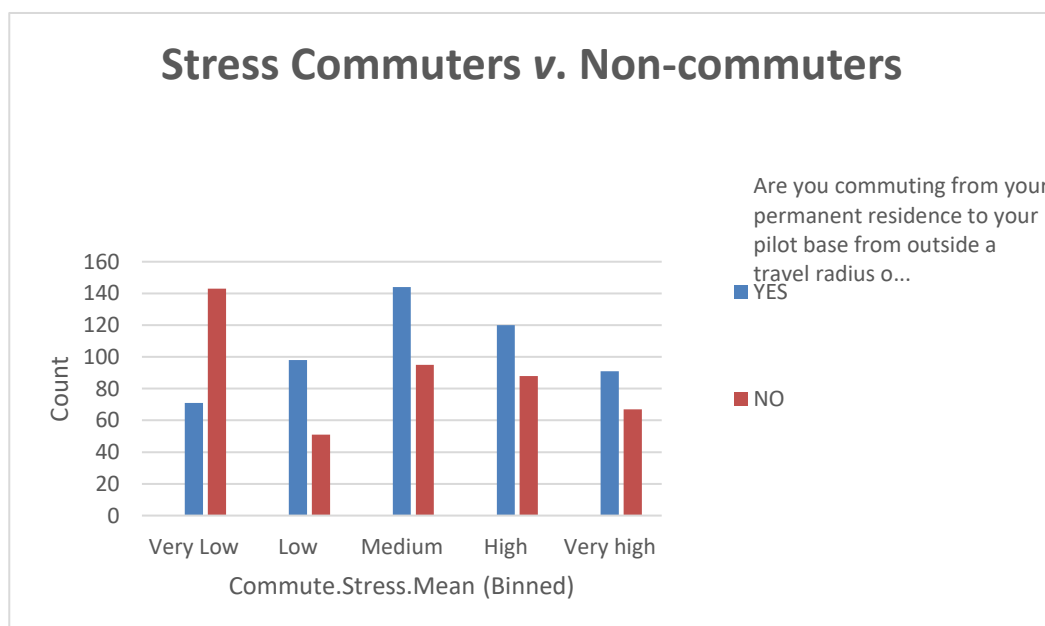


Figure 47—Stress Commuters v. Non-commuters

4.1.10.2 Stress—Commuters v. Non-commuters v. Intermediate Housing Commuters

A three-group analysis was also performed to examine more closely the positive correlation among the three groups of pilots. Again, as commuting time increased, total stress also increased (Figure 48).

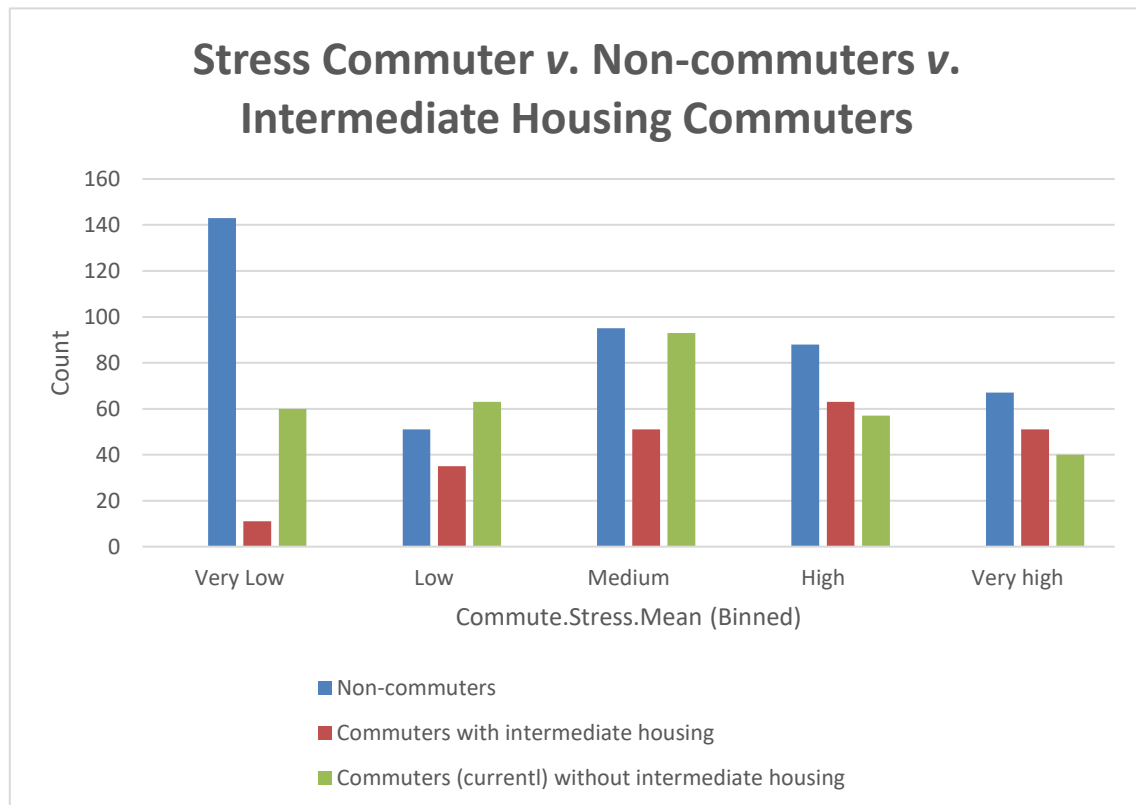


Figure 48—Three-group Analysis—Stress Commuter v. Non-Commuters v. Intermediate Housing Commuters

4.1.10.3 Stress v. Time

The relationship between commuting time and commuting stress is shown in Table 18. It was established that commuting stress and commuting time were weakly positively correlated, indicating that if commuting time increased, stress also increased. The Pearson's two-tailed correlation results identified six significant correlations between the commuting stress and commuting time categories.

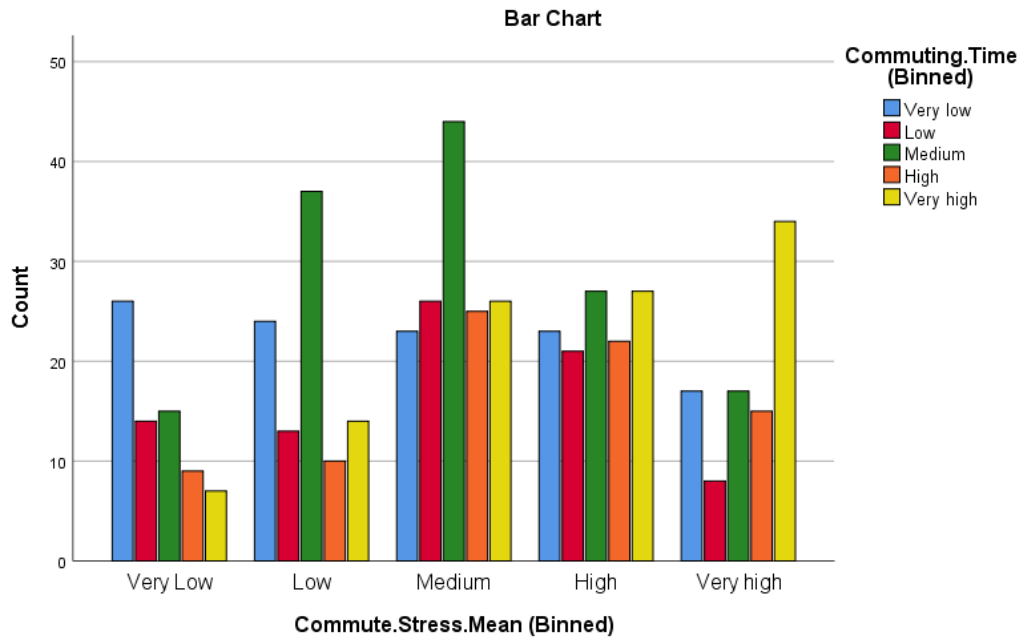


Figure 49–Commuting Stress v. Commuting Time

4.1.10.4 Commuting Stress v. Distance

The analysis showed that commuting stress and commuting distance were weakly positively correlated; that is, greater commuting distances were associated with increased commuting stress. Among other indications, Figure 50 shows that most pilots commuting 501–900 km had medium stress levels. Correlation tests were performed using Pearson’s two-tailed correlation coefficient, which revealed a highly significant correlation ($p < 0.000$) between commuting stress and commuting distance.

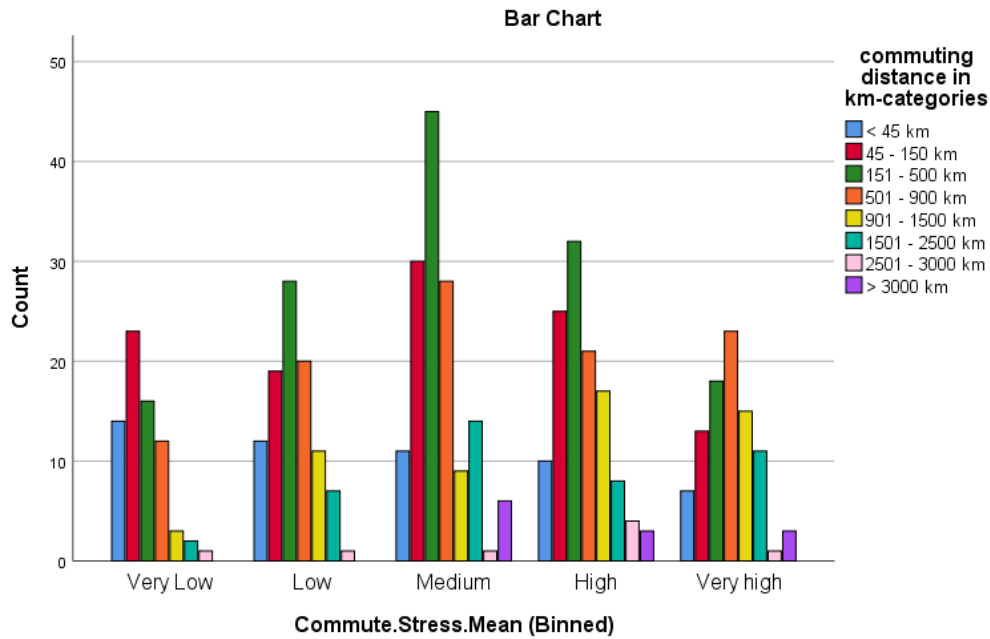


Figure 50–Commuting Stress v. Commuting Distance

4.1.10.5 Commuting Stress v. Children

Some studies hypothesise that the presence of children in a commuting household, along with the necessity for caring for those children, has an influence on the commuting decision as well as the time, distance and stress of commuting. (Gutiérrez-i-Puigarnau, Mulalic and Van Ommeren, 2014; Krausz, Koslowsky, Aizer, 2008; Ory et al., 2004; Roberts, Hodgson and Dolan, 2011).

In the current research, there was no statistically significant correlation between children and caretaking in a commuting household, and commuting stress.

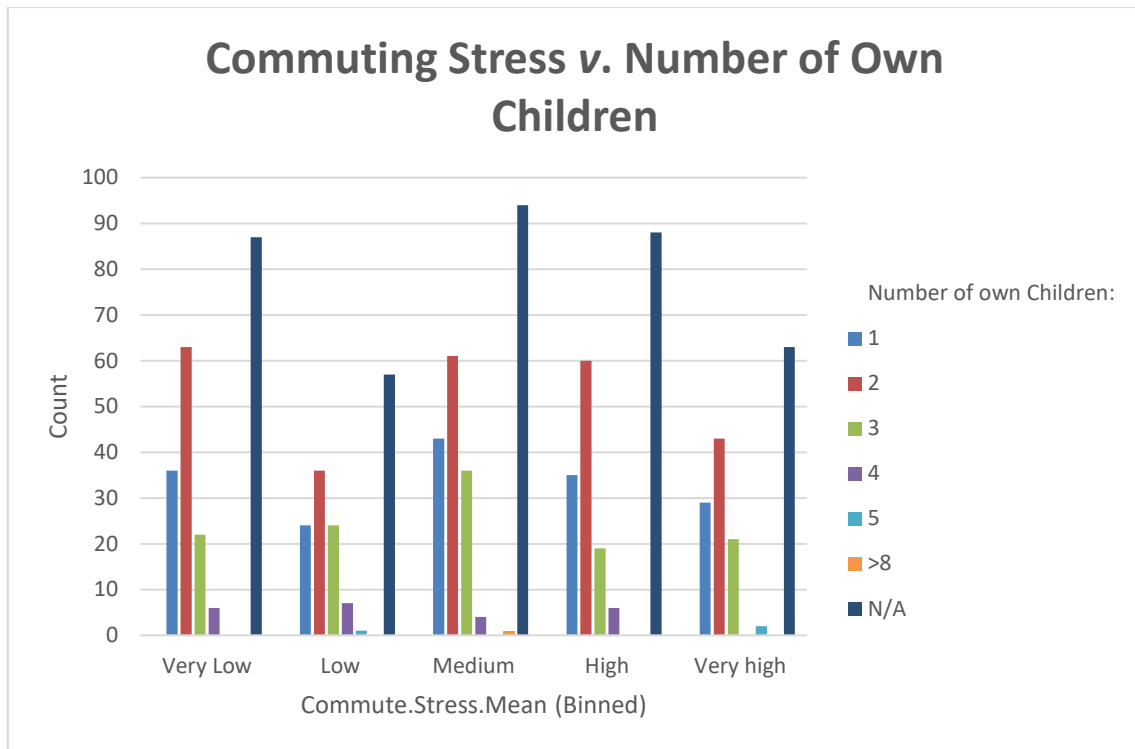


Figure 51–Commuting Stress v. Number of Own Children

4.1.10.6 Commuting Stress v. Age

The current data indicated no significant correlation between age and stress for commuting and non-commuting European airline pilots (see Figure 52).

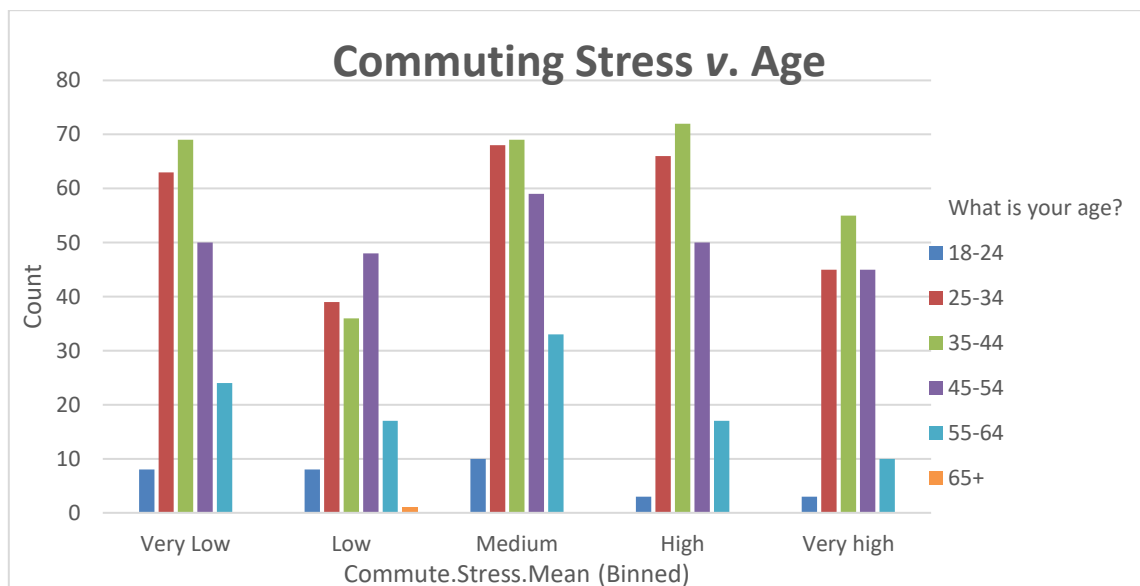


Figure 52–Commuting Stress v. Age

4.1.10.7 Commuting Stress v. Form of Housing

The results indicated no statistically significant correlation between the form of housing and commuting stress. This commuting stress distribution in regard to form of housing is shown in Figure 53.

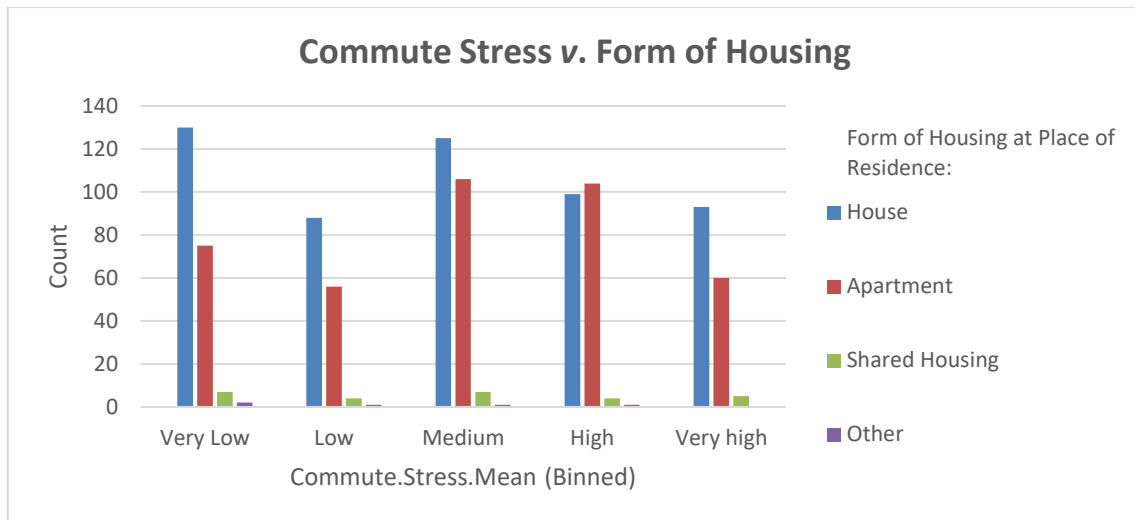


Figure 53–Commuting Stress v. Form of Housing

4.1.10.8 Commuting Stress v. Mode of Housing

Tightly connected to the form of housing is the mode of housing, which also showed no statistically significant correlation with commuting stress (see Figure 54).

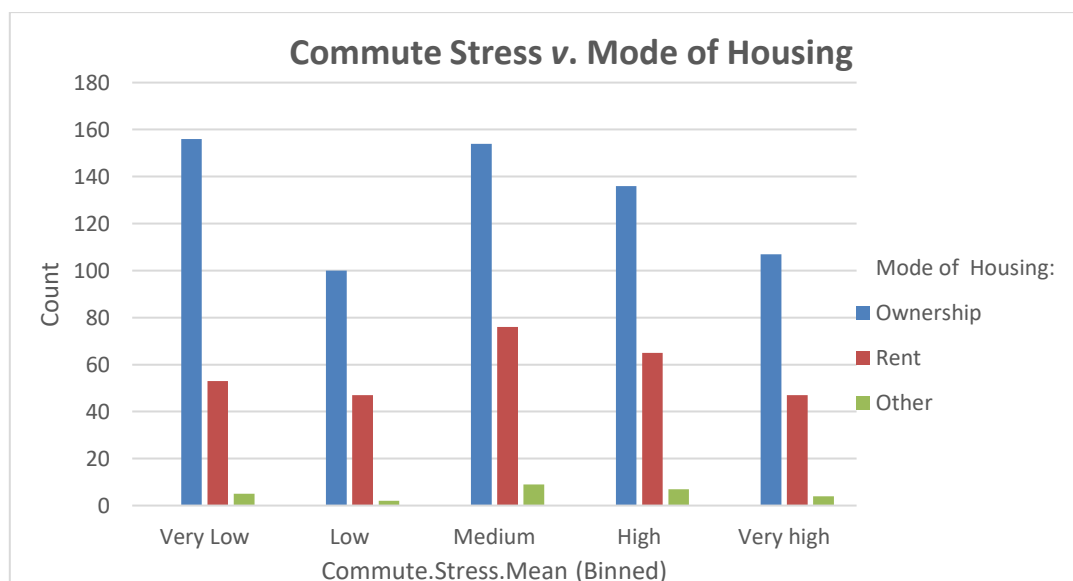


Figure 54–Commuting Stress v. Mode of Housing

4.1.11 Turnover Intention

Being an airline pilot brings with it a high level of competency and requires a high level of training including recurrent training to maintain the necessary proficiency level. In general, a frequent employment change for pilots is undesirable because the airline industry in Europe is tightly connected to seniority rules that govern benefits related to job promotions, position allocations, aircraft assignments, base assignments, holiday allocations, preferred duty scheduling and multiple other factors unique to the airline industry. Thus, turnover is not common in the aviation industry. However, the aviation sector is changing and turnover from legacy operators to low-cost operators is growing. This trend means pilots and crew members must be more flexible in terms of their base assignment and duty schedule.

Research has shown that ‘commuting stress would be related to turnover intention’ (Amponsah-Tawiah et al., 2016, p.118). The literature also indicates that commuting time and distance are strongly correlated with turnover intention (Kluger, 1998). Commuting stress is also related to commuting distance and commuting time, but primarily is seen in the literature as a predictor of turnover intention (Deding, Filges and Van Ommeren, 2009; Steinmetz, Vries and Tijdens, 2014). Zivnuska, Kiewitz and Hochwarter (2002) treated turnover intention as an outcome variable connected to performance. Their model revealed a significant relationship between the squared term for tension, and turnover intention. In the context of turnover and performance, the personal role of coping is evident in the field of commuting stress as driving the initiation of turnover (Kavanagh, 2005; Sloan and Cooper, 1986)

Table 19–Turnover Intention—Statistics General

Turnover Intention	N of Items	Valid n	Cronbach's alpha
Cronbach's alpha	5	1117	0.596

Table 20–Turnover Intention Total

Item total	Group comparison	Mean difference	p
Turnover intention	C-NC	−0.51022	0.000
	C-IHC	−0.39377	0.000

Internal consistency testing (see Table 19) using Cronbach's alpha was performed, indicating moderate usability and internal consistency. Significance levels varied and indicated that commuters had significantly lower turnover intention values than intermediate housing commuters and non-commuters in this study. Between-group analyses indicated that non-commuters had significantly higher turnover intention than commuters. A similar situation was seen with the highly significant turnover intention of intermediate housing commuters relative to that of commuters. Highly significant differences for individual items between groups are shown in Table 21.

Table 21–Turnover Intention—Items

Item	Group comparison	Mean difference	<i>p</i>
TI 2	NC–IHC	–1.89897	0.001
TI 3	NC–C	0.522	0.000
	IHC–C	0.392	0.000
TI 4	NC–IHC	0.288	0.007
	NC–C	0.317	0.000
TI 5	NC–C	0.738	0.000
TI 7	C–NC	–0.514	0.000
	C–IHC	–0.580	0.000

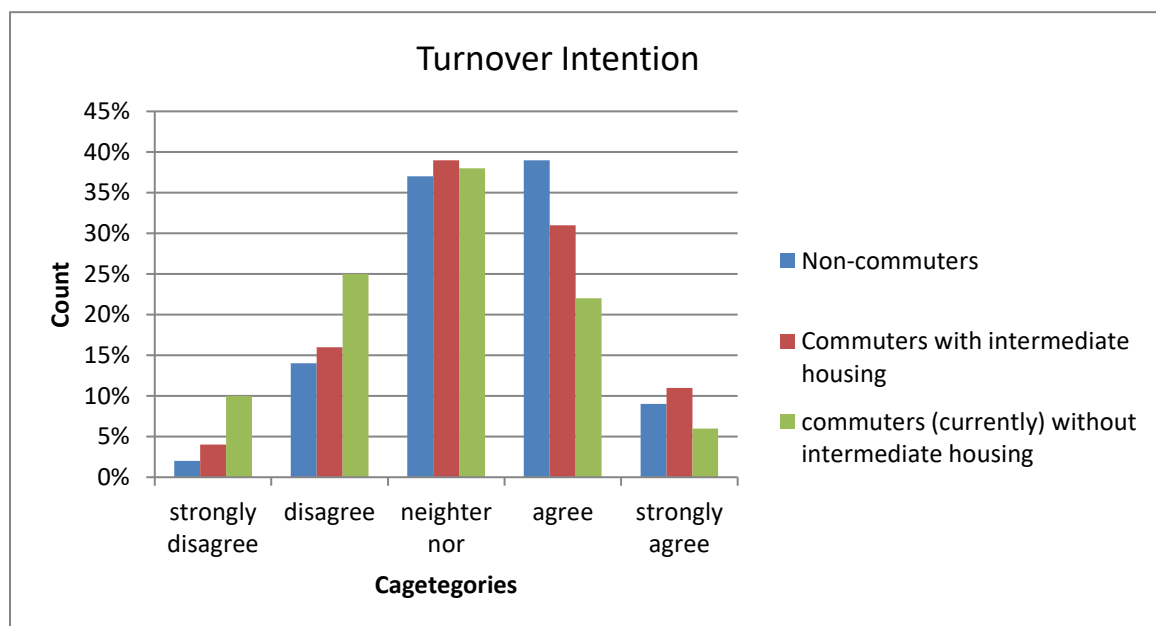


Figure 55–Turnover Intention

4.1.12 Safety Behaviour

Air travel is among the safest forms of transport and is internationally governed by a safety management system that closely monitors crew performance, and gathers duty time and fatigue levels. Nevertheless, it is crucial that an already well-working system experiences ongoing performance enhancements; therefore, it is 'critical to identify the factors that may enhance the performance of these individuals with regard to safety behaviors' (Chen and Chen, 2014, p.376).

Multiple factors have been found to be correlated with safe and reliable work, which is dependent on reliability (Sulzer-Azaroff, 1987). An established safety system and organisational safety habit and culture has been shown to be a predictor of an individual's safety behaviour in an organisation (Sunhee and Dalal, 2014). A strong corporate safety culture and climate at multiple organisational levels, and management committed to safety values fosters individual safety behaviour and reduces negative outcomes; for example, turnover intention (Sunhee and Dalal, 2014). It has been found that 'people's behaviors stem from a base of personal knowledge and values, as well as from group norms and the prevailing organizational culture' (Chen and Chen, 2014, p.376 ; Bill, 2003) that is 'leading to a restricted range of actual behaviour. The restricted range of actual safety behaviour, in turn, reduces the opportunities for dispositional factors such as conscientiousness to play a role in the prediction of safety behaviour' (Sunhee and Dalal, 2014, p.123). An established and functional corporate safety commitment and learning just-culture can build and learn from unsafe experiences, and 'that past and present contingencies' are informative about possible safety strategies (Sulzer-Azaroff, 1987). Cahill et al. (2020, p.7) stated that 'The crew are the key coordinating interface both from a flight operations and safety management' (Cahill et al., 2020a, p.7).

New approaches for entering correlated information into an organisational safety system are required to make use of modern state-of-the-art technology for critical system safety functioning and individual safety performance monitoring (Cahill et al., 2020a). The interaction and bridging of an airline pilot's private and occupational domains is the key to this research. Commuting is the connecting—sometimes catalysing time and distance—between these two domains (Cahill et al., 2020b; Cooper and Sloan, 1985; Cuevas, 2003; Sloan and Cooper, 1986). Close safety

monitoring and management of pilot commuting and their safety behaviour, in this instance ‘between life in and outside work’ (Cahill et al., 2020a) can significantly increase a system’s safety performance. Further, it has been stated that, ‘from an academic perspective they are used to provide insights into the relationships between each dimension, and how each of these interacts with outcome measures (e.g. behaviour, accident rates, etc.)’ (Cooper, 2000, p.124).

Table 22–Safety behaviour—Statistics General

Safety behaviour	N of Items	Valid n	Cronbach's alpha
Cronbach's alpha	7	1002	0.825

Safety behaviour was included in this research in the form of seven items in the 2020 European Airline Pilot Commuting Survey. To measure internal consistency, Cronbach's alpha was calculated and a value of 0.825 obtained (see Table 22). This is considered good (Hair, Money and Samouel, 2007).

Table 23–Safety behaviour—Items

Item	Group comparison	Mean difference	<i>p</i>
SB 1	NC–IHC	0.482	0.000
	NC–C	0.402	0.000
SB 2	NC–IHC	0.324	0.000
	NC–C	0.279	0.001
SB 4	IHC–NC	0.249	0.024
SB 5	IHC–NC	0.410	0.000
	IHC–C	0.229	0.048
SB 6	IHC–NC	0.311	0.007
	IHC–C	0.389	0.001

In the between-group analysis of the safety behaviour of commuters and non-commuters using t-tests for independent samples and one-way ANOVA, significant differences between groups were established for SB 1, SB 2, SB 3 and SB 4. Also as shown in Table 23 the three-group analyses produced highly significant results for the safety performance of individuals.

4.1.13 Pilot Performance

Aviation is a topic that has been extensively covered in the research literature, and abundant information is available on the subject. A un-investigated topic is pilot commuting and its possible negative effects on professional pilots' performance (NRCNA, 2011a). Little direct professional pilot research has been undertaken using field studies to investigate the effects of stress. The shortcomings of most stress–performance correlations have been tested and researched in laboratory settings utilising 'relatively naïve subjects performing rather simple tasks' (Dismukes, Goldsmith and Kochan, 2015). The skilled performance requirements of the cockpit setting are not only apparent in routine day-to-day standard operation procedure settings, but are crucial in emergencies. This involves abnormal emergency checklists and potentially out-of-the-box thinking and decision making, as well as sound crew coordination and communication (Dismukes, Goldsmith and Kochan, 2015).

In aviation mishaps, most errors (50 out of 212 in Dismukes, Goldsmith and Kochan, 2015, p.4) stem from 'inadequate comprehension, interpretation or assessment of the ongoing situation'. Therefore an in-depth understanding of how pilots live in connection to safety performance and system functioning is essential (Cahill et al., 2020b). Systematic decision making in the face of occupational stressors and the resulting performance under stress need to be fully understood and researched. Thus, it is astonishing that so few empirical data are available on highly skilled pilot performance requirements. A standardised test for measuring self-reported pilot performance developed by Sloan and Cooper (1986) was used to measure this pilot performance variable in the current study. Sloan and Cooper conceptualised that it 'seemed to be present in the items (presumably performance)'. Further, 'it seems reasonable to conclude that there is such a thing as self-reported pilot performance, and that the test appears to measure at least part of it' (Sloan and Cooper, 1986, p.469). Pilots are continuously monitoring their flying proficiency and routines when performing cockpit tasks; thus it might be concluded that certified European airline pilots are performing within required European standards. (Sloan and Cooper, 1986). Sloan and Cooper, in the design of their research, aimed to 'identify and compare "good" with "bad", but "optimal with sub-optimal performance"'. It was clear in their 1986 initial results that 'Senior first officers tend to rate their performance as being higher than do captains; long-haul pilots do the same compared to short-haul pilots' (Sloan and Cooper, 1986,

p.60). Influential personal traits of pilots include their need for control and plannability, which is reflected in the transition period and coping strategies pilots employ to deal with professional and personal stress connected with the pilot occupation. (Chandramohan, 2008)

Table 24–Pilot Performance—Statistic General

Pilot performance	N of items	Valid n	Cronbach's alpha
Cronbach's alpha	15	894	0.961

Cronbach's alpha integrity testing was performed, and a value of 0.961 was derived from the calculation, indicating excellent internal integrity (Hair, Money and Samouel, 2007).

Table 25–Pilot Performance Total

Item total	Group comparison	Mean difference	<i>p</i>
Pilot performance	NC–C	–0.21077	0.000

The total subjective pilot performance measure (see Table 25) based on 15 items showed a significant difference between commuting and non-commuting pilots. This indicated that commuting pilots had significantly better subjective performance than non-commuting pilots.

The three-group analysis involving commuters, non-commuters and intermediate housing computers enabled generalisation among groups into item significance levels as shown in Table 26. For the items in Table 26, commuters generally had significantly higher and better performance than their non-commuting colleagues at the individual item level. Two items, PP 10 and PP 13, also indicated that commuters had significantly better performance than did intermediate housing commuters. To cross-tabulate commuting time and pilot performance, these two items were visually binned (creating categorical variables from continuous variables). For each variable, five categories were created (see Table 27).

Table 26—Pilot Performance—Items

Item	Group comparison	Mean difference	<i>p</i>
PP 1	NC–C	–0.247	0.000
PP 2	NC–C	–0.199	0.011
	IHC– C	–0.249	0.008
	NC–C	–0.272	0.000
PP 3	NC–C	–0.216	0.003
PP 5	NC–C	–0.192	0.013
PP 6	NC–C	–0.239	0.001
PP 7	NC–C	–0.224	0.001
PP 8	NC–C	–0.320	0.000
PP 9	NC–C	–0.260	0.001
	IHC–C	–0.217	0.037
PP 10	NC–C	–0.1964	0.019
PP 11	NC–C	–0.25276	0.001
PP 13	IHC–C	–0.27142	0.004

Table 27—Interval / Rating Range

Item	Rating	Interval
Pilot performance	very low	<1.024
	low	1.025–0.054
	medium	–0.055–0.280
	high	0.281–0.843
	very high	>0.843

4.1.13.1 Pilot Performance Commuters v. Non-Commuters

As seen in Figure 56 in the comparison of pilot performance for commuters and non-commuters, there was a significant difference between these two groups: commuters had significantly higher and better performance than non-commuters. Analyses indicated that 62% of commuters reported that they had very high-performance levels, while only 38% of non-commuters rated themselves this way.

On the other hand, rated as very low-performance non-commuters with this rating share that 53.9% of total very low rates vice 46.1% of commuters in this very low ranking.

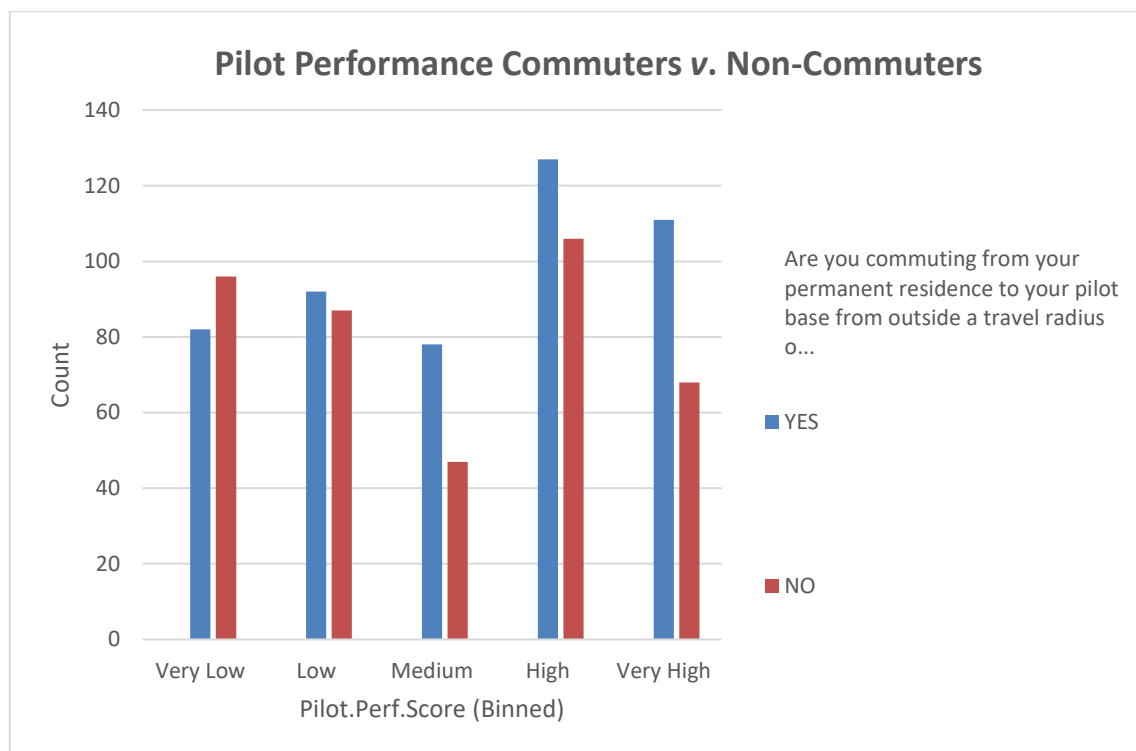


Figure 56–Pilot Performance Commuters v. Non-Commuters

4.1.13.2 Pilot Performance Commuters v. Non-Commuters v. Intermediate Housing Commuters

The three-group analysis also revealed that the significant difference among all groups was due to non-commuters. Figure 57 illustrates the significant differences between the three groups as presented in Table 26 for individual items.

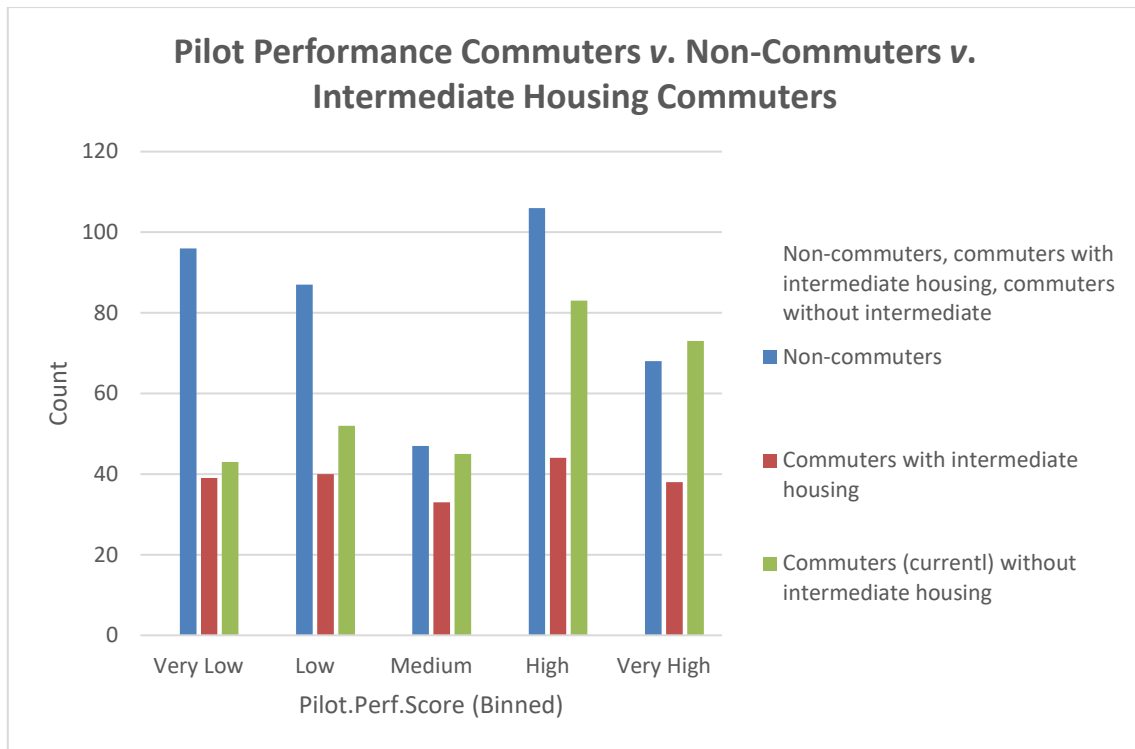


Figure 57–Pilot Performance Commuters v. Non-Commuters v. Intermediate Housing Commuters

4.1.13.3 Pilot Performance v. Commute Time

Statistical analyses indicated that the pilots who rated their performance as high had a medium commute time. Pilots rating their performance as very low in the main had very high commuting times (see Figure 53). In these analyses, there was a significant negative correlation between pilot performance and commute time, indicating that a higher commuting time results in a lower performance.

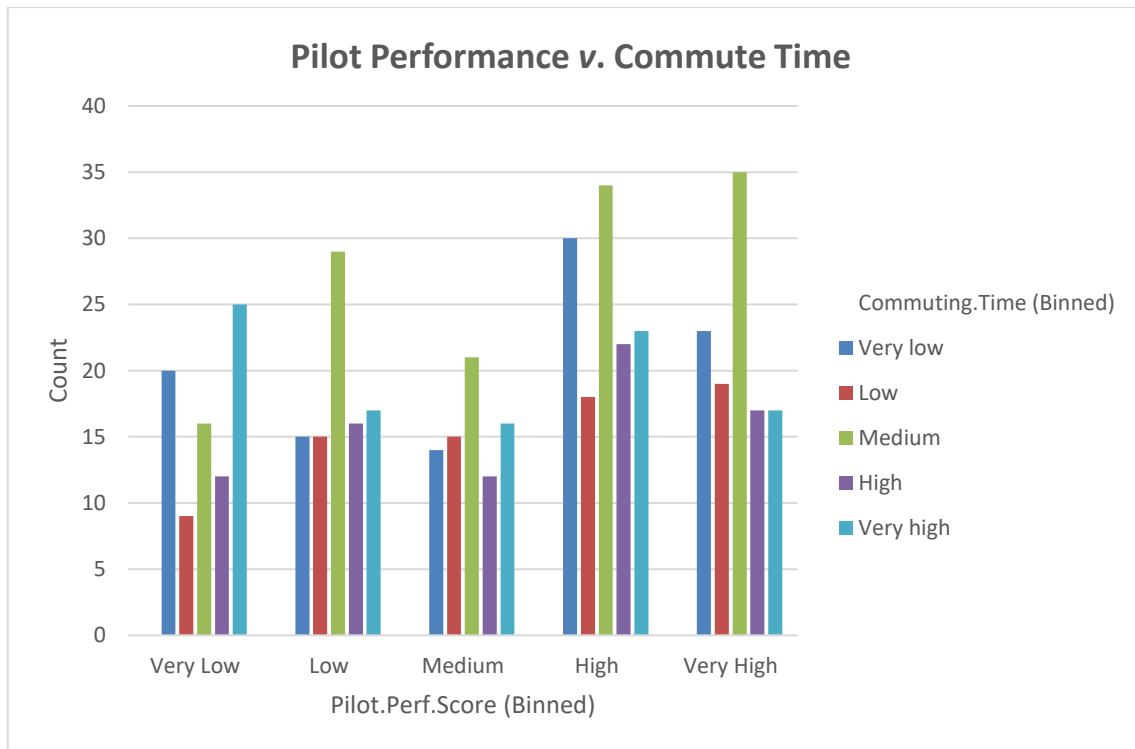


Figure 58–Pilot Performance v. Commute Time

4.1.13.4 Pilot Performance v. Commute Distance

A correlation between pilot performance and commuting distance was revealed via a significant two-tailed Pearson’s correlation coefficient value of 0.049. In Figure 59, it is apparent that among the group of pilots with very high pilot performance scores, the majority had a commuting distance of 151–500 km; this was also true for the group of pilots with very low pilot performance scores.

The analysis results indicated that pilot performance and distance were negatively correlated, meaning that as the commuting distance increased, performance decreased, and vice versa.

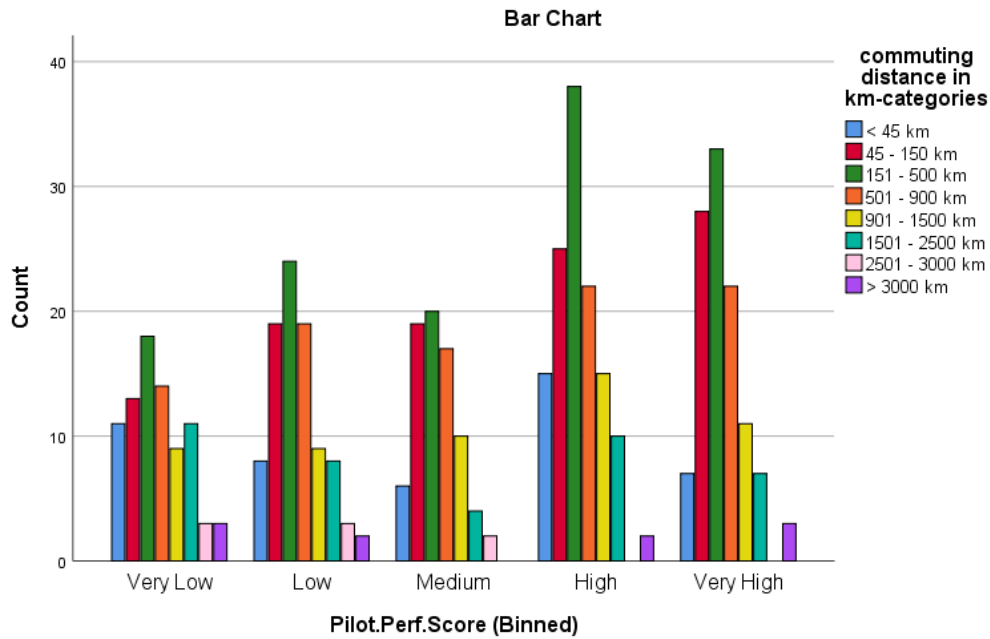


Figure 59–Pilot Performance v. Commute Distance

4.1.13.5 Pilot Performance v. Age

Pearson’s correlation coefficients for pilot performance v. age were significant ($p = 0.016$; two-tailed). Thus, pilot performance and age were positively correlated, indicating that the performance of older pilots was better, and vice versa.

Figure 60 indicates that pilots who had a very high pilot performance score were mostly in the 45–54-year age group, while pilots with very low pilot performance scores were mostly 35–44 years old.

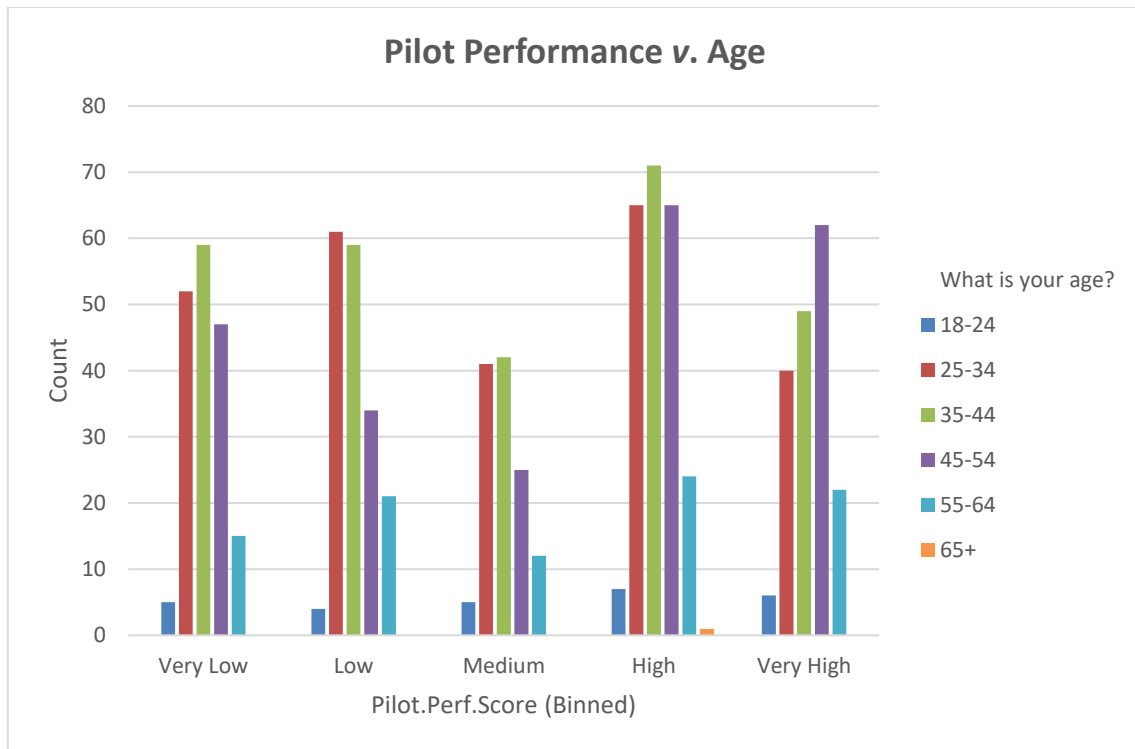


Figure 60–Pilot Performance v. Age

4.1.13.6 Pilot Performance v. Children

According to calculations and analyses, there was no particular pattern to the relationship between pilot performance and having children. The Pearson's correlation coefficient for pilot performance and number of children was not statistically significant.

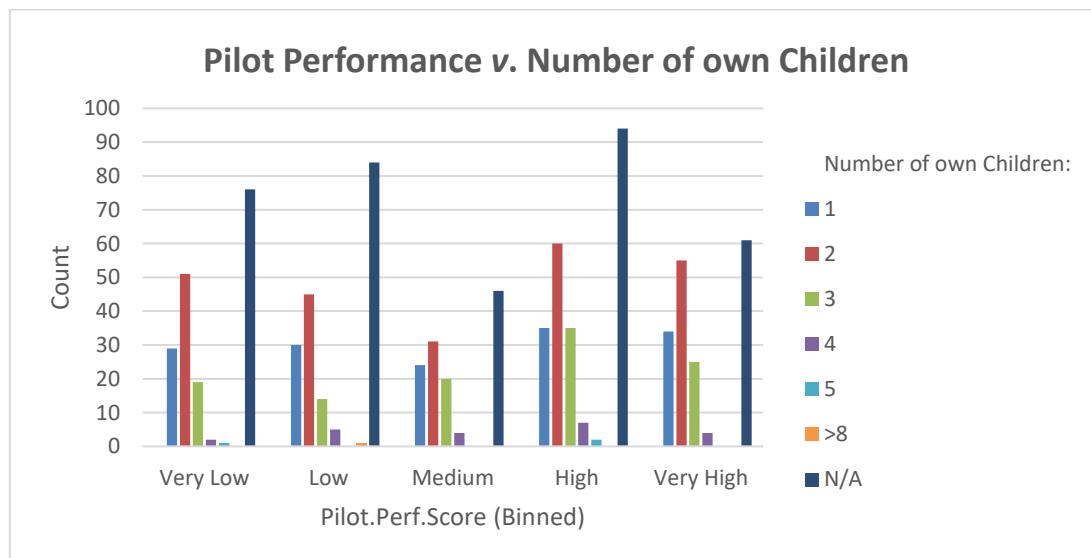


Figure 61–Pilot Performance v. Number of own Children

4.1.13.7 Pilot Performance v. Form of Housing, and Pilot Performance v. Mode of Housing

Neither calculations nor analyses revealed a significant correlation between pilot performance and either the form or mode of housing.

4.1.14 Locus of Control

As seen in the context of this research, external locus of control was established by Sposato, Röderer and Cervinka (2012) as a predictor variable for commuting stress in regard to the duration of the commute and how mode-choice and other variables are predictable.

According to the social theory of Rotter (1954), locus of control (LOC) can be divided into an internal and external locus of control. Missing or low locus of control heightens the probability of negative effects on job functioning (Kavanagh, 2005) and one study, 'internal locus of control directly affected pilot safety operation behaviour' (You, Ji and Han, 2013, p131). In a study of accounting professionals in Taiwan, Chen and Silverthorne (2008) established that locus of control predicts work behaviour, while Hancock and Szalma (2008) identified a significant culture-dependent issue in their research regarding open, active or intrinsic, passive, personal orientation. In a review of stress and performance, Kavanagh (2005) examined the possibility of a significant disturbance effect of stress on job performance because of lack of control and the individual's psychological efforts to compensate for this state, because 'lack of control can be a negative moderator, one that increases the negative effects of stress on performance' (Kavanagh, 2005).

Table 28—Locus of Control Statistics

Locus of control	N items	Cronbach's alpha
Cronbach's alpha	4	0.543

Table 29—Locus of Control—Group Difference

Item total	Comparison group	Mean difference	<i>p</i>
Locus of control	C-IHC	−0.14919	0.000

Using Cronbach's alpha testing for internal integrity, LOC 1 was found to significantly reduce the internal integrity value. For this reason, it was removed from further analysis, raising Cronbach's alpha value to 0.543 (see Table 28).

Analysis of the locus of control variable at the four-item level revealed no significant difference among non-commuters, commuters or intermediate housing commuters at the individual item level. Important in this context is that the 'call in sick' and 'unfit to fly' options were not misused in the European airline pilot commuting, given that statistical analysis found no group difference. The only significant three-group analysis result was between commuters and intermediate housing commuters. The total four-item analysis showed lower locus of control for commuters compared with intermediate housing commuters.

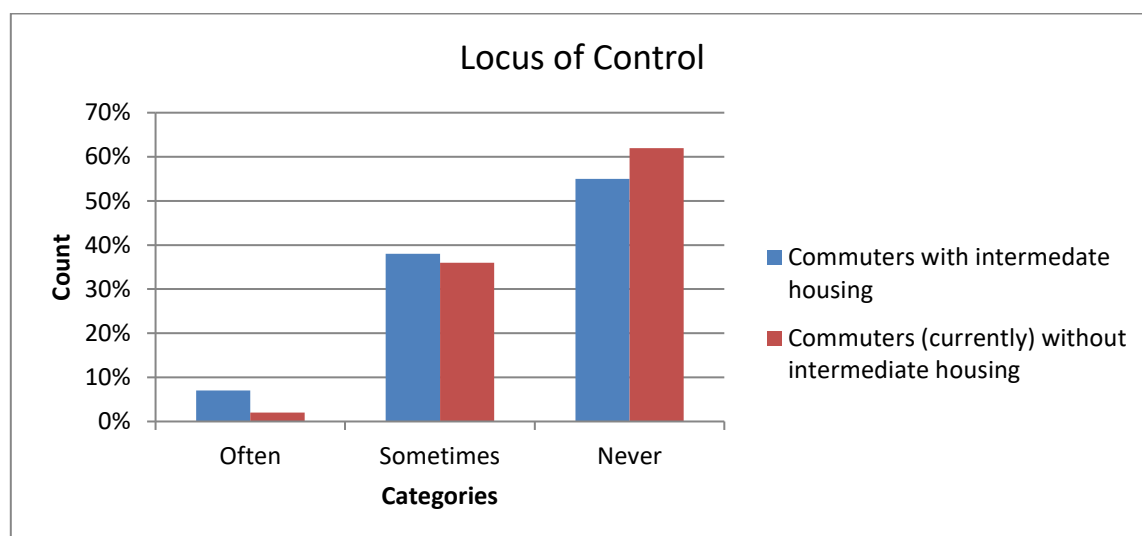


Figure 62–Locus of Control

4.2 Structural Equation Modelling Analysis

4.2.1 First Step in PLS-SEM Model Analysis

Following the outlined procedure, showed that several items had loading below the recommended value of 0.708 (Table 30). These values (shown in red in Table 30) were excluded from further analysis to achieve good reliability and validity of the used constructs.

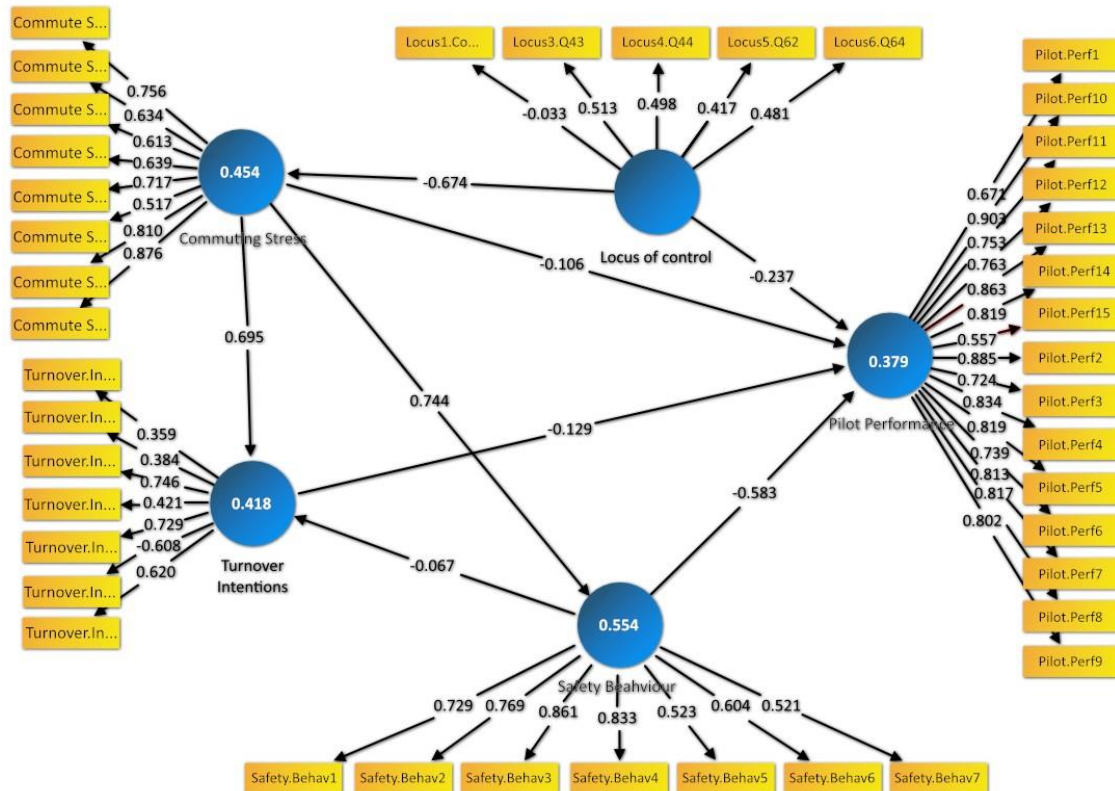


Figure 63–Generic Structural Equation Model

	Commuting Stress	Locus of Control	Pilot Performance	Safety Behaviour	Turnover Intentions
Commute.Stress1	0.756				
Commute.Stress2	0.634				
Commute.Stress3	0.613				
Commute.Stress4	0.639				
Commute.Stress5	0.717				
Commute.Stress6	0.517				
Commute.Stress7	0.81				
Commute.Stress8	0.876				
Locus1.Comm.Per.Mon.Interval		0.033			
Locus3.Q43		0.513			
Locus4.Q44		0.498			
Locus5.Q62		0.417			
Locus6.Q63		0.481			
Pilot.Perf1			0.671		
Pilot.Perf10			0.903		
Pilot.Perf11			0.753		
Pilot.Perf12			0.763		
Pilot.Perf13			0.863		
Pilot.Perf14			0.819		
Pilot.Perf15			0.557		
Pilot.Perf2			0.885		
Pilot.Perf3			0.724		
Pilot.Perf4			0.834		
Pilot.Perf5			0.819		
Pilot.Perf6			0.739		
Pilot.Perf7			0.813		
Pilot.Perf8			0.817		
Pilot.Perf9			0.802		
Safety.Behav1				0.729	
Safety.Behav2				0.769	
Safety.Behav3				0.861	
Safety.Behav4				0.833	
Safety.Behav5				0.523	
Safety.Behav6				0.604	
Safety.Behav7				0.521	
Turnover.Inten1.Q19					0.359
Turnover.Inten2.Q20					0.384
Turnover.Inten3.Q23.88					0.746
Turnover.Inten4.Q24.89					0.421
Turnover.Inten5.Q25.90					0.729
Turnover.Inten6.Q31.96					0.608
Turnover.Inten7.Q32.97					0.62

Table 30—Indicator Loadings—Generic Structural Equation Model Loadings

4.2.2 Second Step in PLS-SEM Model Analysis

According to the results in Table 31, two factors had composite reliability below the recommended value—namely LC (0.463) and TI (0.430)—which indicated that further modification of the model was needed. An alternative approach was employed that uses ρ_A : as explained by Dijkstra and Henseler (2015) and outlined by Hair et al. (2019, p.8), ρ_A is an ‘approximately exact measure of construct reliability, which usually lies between Cronbach's alpha and the composite reliability. Hence, ρ_A may represent a good compromise if one assumes that the factor model is correct’. According to the results shown in Table 31, LC had a ρ_A below the recommended value, which indicated that further modification of the model was needed.

Table 31–Construct Reliability and Convergent Validity

	Cronbach's Alpha	ρ_A	Composite Reliability	Average Variance Extracted (AVE)
Commuting stress	0.887	0.897	0.884	0.495
Locus of control	0.479	0.545	0.463	0.183
Pilot Performance	0.961	0.964	0.961	0.622
Safety Behaviour	0.86	0.888	0.869	0.495
Turnover Intentions	0.1	0.796	0.43	0.328

4.2.3 Third Step in PLS-SEM Model Analysis

The results shown in Table 31 indicate that LC, TI, SB and CS had values of AVE less than 0.5, so further modification of the model was required.

4.2.4 Fourth Step in PLS-SEM Model Analysis

The results shown in Table 32 indicate that discriminant validity has been achieved.

Table 32—Discriminant Validity—HTMT Ratio of Correlations

	Commuting stress	Locus of Control	Pilot Performance	Safety Behavior	Turnover Intention
Commuting stress					
Locus of Control	0.621				
Pilot Performance	0.453	0.24			
Safety Behavior	0.746	0.604	0.583		
Turnover Intentions	0.639	0.415	0.358	0.451	

A revised structural equation model (see Figure 64) was obtained, satisfying both convergent and discriminant validity, and construct reliability (Figure 59). To meet this requirement, several iterations and deletion of items were necessary. The locus of control variable did not achieve validity and reliability in any way, so only one item remained for this factor.

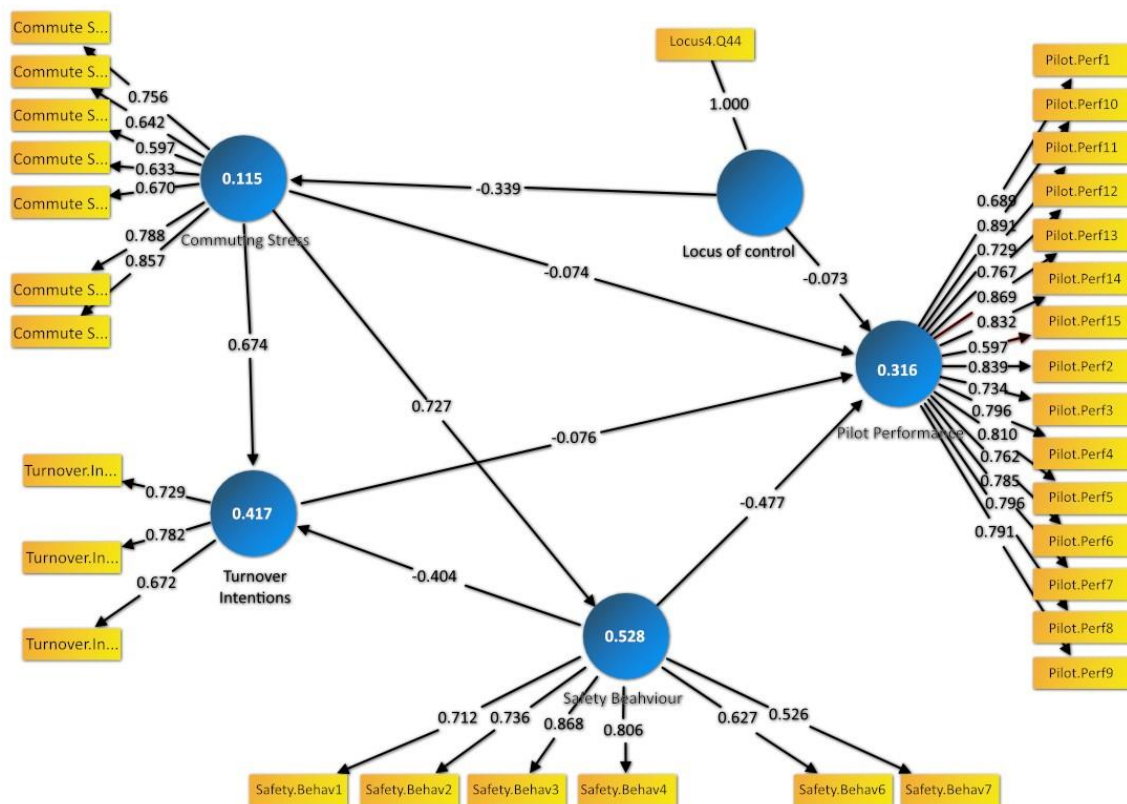


Figure 64—Revised Structural Equation Model

4.2.5 Assessment of the Reflective Measurement Model—Revised Model

The results obtained from data analysis showed that outer loadings were not all above 0.708, but this did not affect reliability and validity (see Table 33).

The results in Table 34 show that all factors achieved good composite reliability. They all had Cronbach's alpha above the recommended value and pA at the recommended level. Factors had AVE values above the recommended value of 0.5. Accordingly, it was concluded that reliability and convergent validity had been achieved.

Table 33—Indicator Loadings—Final Model

	Commuting stress	Locus of Control	Pilot Performance	Safety Behaviour	Turnover Intentions
Commute.Stress1	0.756				
Commute.Stress2	0.642				
Commute.Stress3	0.597				
Commute.Stress4	0.633				
Commute.Stress5	0.67				
Commute.Stress7	0.778				
Commute.Stress8	0.857				
Locus4.Q44		1			
Pilot.Perf1			0.689		
Pilot.Perf10			0.891		
Pilot.Perf11			0.729		
Pilot.Perf12			0.767		
Pilot.Perf13			0.869		
Pilot.Perf14			0.832		
Pilot.Perf15			0.597		
Pilot.Perf2			0.839		
Pilot.Perf3			0.734		
Pilot.Perf4			0.796		
Pilot.Perf5			0.81		
Pilot.Perf6			0.762		
Pilot.Perf7			0.785		
Pilot.Perf8			0.796		
Pilot.Perf9			0.791		
Safety.Behav1				0.712	
Safety.Behav2				0.736	
Safety.Behav3				0.868	
Safety.Behav4				0.806	
Safety.Behav6				0.627	
Safety.Behav7				0.526	
Turnover.Inten3.Q23.88					0.729
Turnover.Inten5.Q25.90					0.782
Turnover.Inten7.Q32.97					0.672

Table 34—Construct Reliability and Convergent Validity

	Cronbach's Alpha	ρ_A	Composite Reliability	Average Variance Extracted (AVE)
Commuting stress	0.879	0.884	0.875	0.504
Locus of Control	1	1	1	1
Pilot Performance	0.959	0.961	0.959	0.612
Safety Behavior	0.857	0.878	0.864	0.52
Turnover Intentions	0.77	0.776	0.772	0.531

Table 33 presents the HTMT ratio of correlations. All were below the recommended value of 0.85, and HTMT was significantly lower than the threshold value, indicating discriminant validity had been achieved (see Table 34).

Table 35—Discriminant Validity—HTMT Ratio of Correlations

	Commuting stress	Locus of Control	Pilot Performance	Safety Behavior	Turnover Intention
Commuting stress					
Locus of Control	0.341				
Pilot Performance	0.438	0.07			
Safety Behavior	0.714	0.19	0.552		
Turnover Intentions	0.645	0.289	0.317	0.46	

Table 36—Significance of HTMT

	Original Sample (O)	Sample Mean (M)	Bias	2.50%	97.50%
Safety Behavior -> Commuting stress	0.714	0.713	-0.002	0.655	0.776
Turnover Intentions -> Commuting stress	0.645	0.643	-0.002	0.57	0.716
Safety Behaviour -> Pilot Performance	0.552	0.554	0.001	0.461	0.618
Turnover Intentions -> Safety Behaviour	0.46	0.458	-0.002	0.36	0.554
Pilot Performance -> Commuting stress	0.438	0.439	0.002	0.347	0.515
Locus of Control -> Commuting stress	0.341	0.34	0	0.246	0.423
Turnover Intentions -> Pilot Performance	0.317	0.317	0	0.225	0.415
Turnover Intentions -> Locus of Control	0.289	0.289	0.001	0.202	0.367
Safety Behaviour -> Locus of Control	0.19	0.188	-0.002	0.092	0.291
Pilot Performance -> Locus of Control	0.07	0.08	0.01	0.036	0.137

4.2.5.1 Structural Model Assessment

As Table 37 shows, VIF values less than 5. According to Hair's (2017) explanation, this means there is no issue with collinearity in the presented structural model.

The results in Table 38 indicate that all endogenous constructs had Q^2 values >0 , supporting the model's predictive relevance.

Table 37–Collinearity Testing

	VIF
Commute.Stress1	2.52
Commute.Stress2	3.171
Commute.Stress3	2.729
Commute.Stress4	2.098
Commute.Stress5	1.775
Commute.Stress7	1.496
Commute.Stress8	2.376
Locus4.Q44	1
Pilot.Perf1	2.849
Pilot.Perf10	3.341
Pilot.Perf11	2.375
Pilot.Perf12	2.235
Pilot.Perf13	3.006
Pilot.Perf14	3.48
Pilot.Perf15	1.684
Pilot.Perf2	2.517
Pilot.Perf3	2.723
Pilot.Perf4	2.447
Pilot.Perf5	4.021
Pilot.Perf6	3.941
Pilot.Perf7	3.673
Pilot.Perf8	4.126
Pilot.Perf9	2.305
Safety.Behav1	3.142
Safety.Behav2	3.676
Safety.Behav3	3.577
Safety.Behav4	2.11
Safety.Behav6	1.633
Safety.Behav7	1.587
Turnover.Inten3.Q23.88	1.587
Turnover.Inten5.Q25.90	1.699
Turnover.Inten7.Q32.97	1.493

R^2 values represent the explanatory power of the model. Generalisation of a model's predictive qualities regarding R^2 values is not entirely appropriate, as this only reflects an in-sample reference (Shmueli et al., 2015). To overcome this limitation, a procedure for an out-of-sample comparison for data not used in the analysis was proposed by Shmueli et al. (2015), who termed the procedure a 'holdout' sample evaluation. As an option in the Smart PLS software, PLSpredict uses this out-of-sample procedure (Hair et al., 2017).

Table 38— Q^2 Values

	SSO	SSE	$Q^2 (=1-SSE/SSO)$
Commuting stress	3409	3208.586	0.059
Locus of Control	487	487	
Pilot Performance	7305	6036.878	0.174
Safety Behavior	2922	2224.948	0.239
Turnover Intentions	1461	1182.021	0.191

The results presented in Table 39 show that some PLSpredict Q^2 values are less than zero, indicating that the model does not outperform the most naïve benchmark. As predictive relevance was not confirmed, the items in red font were deleted.

Table 39–PLSpredict Q² Values

PLS	RMSE	MAE	MAPE	Q ² _predict	LM	RMSE	MAE	MAPE	Q ² _predict
Commute.Stress1	1.137	0.897	infinite	0.068	Commute.Stress1	1.137	0.898	infinite	0.067
Commute.Stress4	1.199	0.921	infinite	0.074	Commute.Stress4	1.199	0.921	infinite	0.074
Commute.Stress5	1.299	1.076	infinite	0.045	Commute.Stress5	1.301	1.079	infinite	0.043
Commute.Stress3	1.411	1.201	infinite	0.07	Commute.Stress3	1.412	1.196	infinite	0.07
Commute.Stress8	1.304	1.09	infinite	0.073	Commute.Stress8	1.304	1.09	infinite	0.072
Commute.Stress2	1.381	1.13	infinite	0.058	Commute.Stress2	1.382	1.131	infinite	0.057
Commute.Stress7	1.236	1.017	infinite	0.02	Commute.Stress7	1.237	1.019	infinite	0.019
Pilot.Perf8	0.838	0.591	18.038	0.001	Pilot.Perf8	0.839	0.591	18.043	-0.001
Pilot.Perf15	0.845	0.651	21.394	0.002	Pilot.Perf15	0.846	0.652	21.413	-0.001
Pilot.Perf3	0.817	0.596	18.449	-0.007	Pilot.Perf3	0.815	0.593	18.387	-0.002
Pilot.Perf5	0.86	0.613	19.344	-0.005	Pilot.Perf5	0.859	0.609	19.24	-0.004
Pilot.Perf14	0.919	0.713	24.166	-0.002	Pilot.Perf14	0.92	0.713	24.206	-0.004
Pilot.Perf2	0.916	0.757	25.481	0.002	Pilot.Perf2	0.917	0.757	25.475	0
Pilot.Perf6	0.89	0.675	21.158	0	Pilot.Perf6	0.891	0.676	21.186	-0.002
Pilot.Perf12	0.863	0.636	20.12	0.005	Pilot.Perf12	0.863	0.639	20.166	0.005
Pilot.Perf4	0.915	0.744	25.136	0.005	Pilot.Perf4	0.915	0.741	25.034	0.004
Pilot.Perf9	0.896	0.655	20.485	-0.001	Pilot.Perf9	0.896	0.652	20.417	-0.003
Pilot.Perf11	0.91	0.761	25.798	0.003	Pilot.Perf11	0.911	0.761	25.776	0.001
Pilot.Perf1	0.777	0.547	16.892	-0.008	Pilot.Perf1	0.775	0.545	16.841	-0.004
Pilot.Perf13	0.919	0.685	22.568	0.004	Pilot.Perf13	0.92	0.685	22.557	0.002
Pilot.Perf7	0.832	0.592	18.059	0	Pilot.Perf7	0.832	0.589	17.986	-0.001
Pilot.Perf10	0.934	0.741	24.19	0.004	Pilot.Perf10	0.935	0.74	24.14	0.003
Safety.Behav4	1.173	0.983	44.628	0.024	Safety.Behav4	1.175	0.985	44.72	0.021
Safety.Behav7	0.944	0.752	49.987	0.01	Safety.Behav7	0.947	0.754	50.102	0.004
Safety.Behav6	1.274	1.063	63.281	0.029	Safety.Behav6	1.275	1.069	63.582	0.028
Safety.Behav2	1.131	0.94	41.789	0.014	Safety.Behav2	1.131	0.948	42.016	0.013
Safety.Behav1	1.205	1.007	46.101	0.002	Safety.Behav1	1.204	1.018	46.381	0.004
Safety.Behav3	1.247	1.058	52.889	0.015	Safety.Behav3	1.247	1.061	53.097	0.014
Turnover.Inten3.Q23.88	1.213	1.004	49.863	0.042	Turnover.Inten3.Q23.88	1.211	1.008	49.838	0.045
Turnover.Inten5.Q25.90	1.314	1.146	61.758	0.05	Turnover.Inten5.Q25.90	1.309	1.133	60.778	0.058
Turnover.Inten7.Q32.97	1.273	1.057	50.457	0.024	Turnover.Inten7.Q32.97	1.275	1.056	50.367	0.022

After deleting those items, PLSpredict Q² values were re-calculated and some Q² values were less than zero, indicating that the model does not outperform the most naïve benchmark. As predictive relevance still was not confirmed, one more item was deleted. Following this necessary modification, the model was tested again and the model that achieved predictive relevance is shown in Figure 65.

Table 40–PLSpredict Values

PLS PREDICT				
	RMSE	MAE	MAPE	Q ² _predict
Commute.Stress3	1.412	1.202	Infinite	0.07
Commute.Stress8	1.303	1.09	infinite	0.073
Commute.Stress4	1.2	0.921	infinite	0.073
Commute.Stress2	1.381	1.13	infinite	0.057
Commute.Stress5	1.299	1.075	infinite	0.044
Commute.Stress1	1.136	0.897	infinite	0.067
Commute.Stress7	1.238	1.018	infinite	0.02
Pilot.Perf2	0.916	0.755	25.418	0.002
Pilot.Perf11	0.91	0.76	25.734	0.003
Pilot.Perf12	0.862	0.637	20.118	0.007
Pilot.Perf10	0.934	0.739	24.121	0.004
Pilot.Perf15	0.845	0.651	21.371	0.002
Pilot.Perf13	0.919	0.684	22.502	0.004
Pilot.Perf8	0.838	0.598	18.205	0
Pilot.Perf4	0.914	0.742	25.064	0.006
Safety.Behav7	0.944	0.752	49.986	0.01
Safety.Behav2	1.131	0.94	41.796	0.014
Safety.Behav4	1.174	0.983	44.658	0.023
Safety.Behav3	1.246	1.058	52.893	0.015
Safety.Behav1	1.205	1.007	46.109	0.002
Safety.Behav6	1.274	1.062	63.275	0.029
Turnover.Inten5.Q25.90	1.314	1.146	61.76	0.05
Turnover.Inten3.Q23.88	1.214	1.005	49.887	0.042
Turnover.Inten7.Q32.97	1.273	1.057	50.428	0.024

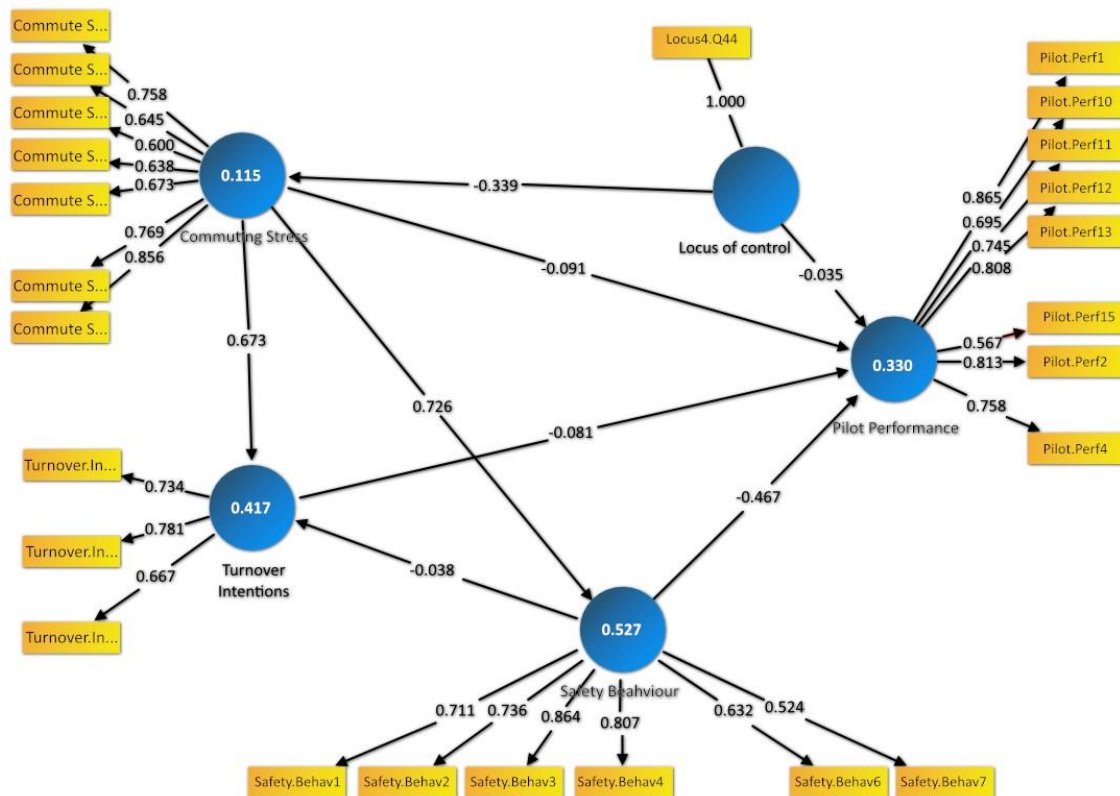


Figure 65–Final Structural Equation Model

The final model's PLS predict Q^2 values were all greater than zero, indicating the model's superiority over a naïve prediction. (Hair et al., 2019) The PLS-based prediction yielded more accurate out-of-sample predictions (i.e. more minor prediction errors) **for the majority of indicators** of pilot performance. The model has **medium predictive power** for pilot performance (Table 41). With established explanatory and predictive power of the model, checking for the relevance of path coefficients and the model's statistical significance constitutes a model closing evaluation process. Four paths of the final model were significant (see Table 42). The most substantial impact in the model was that between CS and SB (0.726), and the weakest was between LC and CS (–0.339).

Table 41–PLSpredict Final Model

PLS					LM				
	RMSE	MAE	MAPE	Q ² _predict		RMSE	MAE	MAPE	Q ² _predict
Commute.Stress5	1.3	1.076	infinite	0.044	Commute.Stress5	1.301	1.08	infinite	0.042
Commute.Stress3	1.412	1.202	infinite	0.07	Commute.Stress3	1.412	1.197	infinite	0.069
Commute.Stress2	1.382	1.13	infinite	0.057	Commute.Stress2	1.382	1.132	infinite	0.056
Commute.Stress7	1.237	1.018	infinite	0.019	Commute.Stress7	1.237	1.019	infinite	0.02
Commute.Stress8	1.304	1.09	infinite	0.073	Commute.Stress8	1.304	1.089	infinite	0.072
Commute.Stress1	1.137	0.898	infinite	0.066	Commute.Stress1	1.138	0.898	infinite	0.066
Commute.Stress4	1.2	0.921	infinite	0.073	Commute.Stress4	1.2	0.921	infinite	0.072
Pilot.Perf13	0.92	0.686	22.542	0.002	Pilot.Perf13	0.921	0.686	22.584	-0.001
Pilot.Perf12	0.863	0.686	20.136	0.006	Pilot.Perf12	0.864	0.686	20.192	0.004
Pilot.Perf11	0.911	0.761	25.767	0.001	Pilot.Perf11	0.912	0.762	25.805	0
Pilot.Perf10	0.935	0.74	24.139	0.002	Pilot.Perf10	0.936	0.741	24.179	0
Pilot.Perf2	0.917	0.756	25.436	0.001	Pilot.Perf2	0.917	0.757	25.481	0
Pilot.Perf15	0.846	0.651	21.386	0.001	Pilot.Perf15	0.847	0.652	21.42	-0.001
Pilot.Perf4	0.915	0.742	25.066	0.004	Pilot.Perf4	0.916	0.742	25.059	0.002
Safety.Behav2	1.13	0.94	41.773	0.013	Safety.Behav2	1.131	0.948	42.023	0.012
Safety.Behav1	1.205	1.007	46.103	0.001	Safety.Behav1	1.204	1.018	46.407	0.004
Safety.Behav3	1.246	1.057	52.855	0.014	Safety.Behav3	1.247	1.061	53.064	0.014
Safety.Behav6	1.276	1.062	63.288	0.03	Safety.Behav6	1.274	1.068	63.538	0.029
Safety.Behav7	0.944	0.752	49.996	0.01	Safety.Behav7	0.947	0.754	50.1	0.004
Safety.Behav4	1.173	0.983	44.681	0.024	Safety.Behav4	1.175	0.985	44.703	0.021
Turnover.Inten5.Q25.90	1.315	1.147	61.834	0.05	Turnover.Inten5.Q25.90	1.31	1.134	60.851	0.058
Turnover.Inten5.Q25.90	1.214	1.005	49.893	0.042	Turnover.Inten5.Q25.90	1.211	1.009	49.85	0.046
Turnover.Inten5.Q25.90	1.275	1.058	50.488	0.024	Turnover.Inten5.Q25.90	1.276	1.056	50.399	0.022

Table 42–Path Significance

Paths in the model	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values	Significance
Commuting stress -> Pilot Performance	-0.091	-0.087	0.094	0.974	0.33	No
Commuting stress -> Safety Behaviour	0.726	0.727	0.029	24.869	0.000	Yes
Commuting stress -> Turnover Intentions	0.673	0.674	0.075	8.965	0.000	Yes
Locus of Control -> Commuting stress	-0.339	-0.338	0.043	7.898	0.000	Yes
Locus of Control -> Pilot Performance	-0.035	-0.036	0.05	0.695	0.487	No
Safety Behaviour -> Pilot Performance	-0.467	-0.471	0.068	6.835	0.000	Yes
Safety Behaviour -> Turnover Intentions	-0.038	-0.037	0.084	0.448	0.655	No
Turnover Intentions -> Pilot Performance	-0.081	-0.081	0.073	1.108	0.268	No

4.2.6 Commuting Stress -> Safety Behaviour

The significant path for commuting stress to safety behaviour in the final peerless prediction model indicates a positive prediction quality and influence on the resulting safety behaviour of the pilot in connection with commuting. Also, in their 1986 research, Sloan and Cooper reflected on the commuting process as a change process from the home to the work domain. Their research established for the first time that the direct connection between commuting stress and safety behaviour changes has a predictive quality. In 2020, Cahill et al. addressed this in their research, fostering and

calling for a new quality and new approach to safety behaviour in relation to a pilot's professional tasks and home domain. According to the definition used in this research this refers to the commuting process and the binding paradigm between the life and work domains. Thus Cahill et al. (2020, p.1) findings of 'healthy behaviours, which in turn strengthens a pilot's resistance to stress' support the current findings. Further, a 2011 report initiated by the NRCNA (2011a) shows that personal practices play a role in pilot behaviour at an individual level (NRCNA, 2011b). The significant change in personal safety behaviour demonstrated by the current research and prompted by commuting stress also supports the findings of a study on Chinese airline pilots where the researchers commented 'that stress levels among crews in the aviation industry are increasing and that this is manifesting itself in the form of unsafe working practices' (Sun and Chiou, 2011, p.2865) The current research shows that commuting and the stress generated by commuting (distress or eustress) has a significant impact on a pilot's safety behaviour. Moreover, as Chin-Shan and Szu-Yu (2015, p.10) showed in their Chinese airline pilot study that 'job stress as a critical factor impacting on human safety behaviour'. It was apparent in research conducted by Loewenthal et al. (2000) to address stress, job dysfunction and air traffic incidents in airline pilots, that safety behaviour and change prompted by commuting stress influenced flying incidents. Commuting stress significantly influences personal safety behaviour, which is significant for pilots' professional ability to respond to in-flight challenges, emergencies and day-to-day general, adequately established safety practices and SOPs. Any deviation may endanger the safe conduct of the flight, and thus standardised safety practices have been established in the aviation industry.

As established by this research, commuting stress has a significant impact on individuals' safety behaviour. An 'individual's ability to respond efficiently and effectively' (Hancock and Szalma, 2008) may be jeopardised in a standardised system because 'stress has been identified as a factor with antecedent causes and behavioural consequences (Motowidlo, Packard and Manning, 1986)' (Chin-Shan and Szu-Yu, 2015, p.10). Hancock and Warm (1989) established in their maximum adaptation model that narrowing both personal attention—by leaving relevant tasks aside—and channel perception can significantly endanger the cockpit and pilot environment, as well as pilot cockpit task requirements.

4.2.7 Commuting Stress → Turnover Intention

The PLS-SEM analysis identified a significant positive link between commuting stress and turnover intention. Further, commuting stress was found to have predictive power for turnover intention. This is consistent with the literature, including a study by Amponsah-Tawiah, Annor and Godfred (2016) that investigated the link between commuting stress and turnover intention. They found that commuting stress at first affects a person's job appreciation (Amponsah-Tawiah, Annor and Godfred, 2016). In their research on pilots under stress, Sloan and Cooper (1986) emphasised that a stable working environment and job security are strong precursors of safe operation and performance in the pilot profession. It appears that turnover intention is a highly delicate and difficult decision in a pilot's life. A change of employer or airline is directly connected to the need for intensive retraining, checks of the individual pilot and loss of company seniority, resulting in a potentially more unstable life and flying pattern (Ancel et al., 2015; Bennett, 2003; National Academies Press, 2011; Sloan and Cooper, 1986; Williams and Cooper, 1998). Undoubtedly, commuting is highly stressful and can impact personal health and work performance (Keller, 1984; Kluger, 1998; Novaco, Gonzalez and Gonzalez, 2009). In general, commuting studies not limited to the pilot profession have established that absenteeism is a precursor of later turnover intention. Such absenteeism might also be a unique coping mechanism widely seen in pilots with commuting stress (Amponsah-Tawiah, Annor and Godfred, 2016; Sloan and Cooper, 1986). Commuting in itself was found by Novaco et al. (1991) to be a precursor for employees leaving their jobs. Commuting variables such as distance and time were found by Van Ommeren (2009) to be a motivator for turnover intention, as that research established that commuting stress is significantly correlated with turnover intention, as is commuting time.

The bordering domains transfer between work and home domains and the bridging commute and resulting spillover have a modest positive or negative effect on the commuting experience (Burch, 2015; Hennessy and Jakubowski, 2007; Novaco, Gonzalez and Gonzalez, 2009). This is highly applicable to the pilot professional and commuting experience. This coping mechanism (Cooper and Sloan, 1987; Sloan and Cooper, 1986) and time bridging effect can generate positive or negative stress and outcomes.

4.2.8 Locus of Control -> Commuting Stress

The special connection and significant path established between locus of control and commuting stress shows that the subjective control and ruling variables of the commute have a highly significant predictive quality in regard to commuting stress. It is important to understand from the system perspective the overall influence of locus control and associated parameters on the pilot's experience (Cahill et al., 2020b). Lack of control for a pilot over their commute directly influences their level of commuting stress, as established by this research and consistent with Gottholmseder et al.'s (2008) research on self-perceived stress. Multiple variables governing a pilot's commute and commuter mode choices—as well as the influence of commuting time arising from the choice of an active or passive mode of commuting—make pilot commutes more or less predictable. This predictability and locus of control, along with possible hindering variables, appear to be factors driving commuting stress, supporting findings in the general commuting literature (Amponsah-Tawiah, Annor and Godfred, 2016; Koslowsky, 1997; Krausz, Koslowsky and Aizer, 2008; Novaco, Gonazalez and Gonzalez, 2009; NRCNA, 2011b).

4.2.9 Safety Behaviour -> Pilot Performance

The aviation system strongly depends on adherence to SOPs and the procedures laid out in organisation manuals for airline operators (Helmreich et al., 1993; Sexton, Thomas and Helmreich, 2000). Therefore, pilot safety behaviour and the resulting pilot performance are crucial parts of the overall aviation safety system. Moreover, this research established safety behaviour as a precursor to pilot performance, with significant predictive power regarding this factor. Previous research has indicated that new approaches are required to address and predict pilot performance for modern, changing pilot living environments and working conditions (Cahill et al., 2020b; Cooper and Sloan, 1987; Foyle et al., 2012; Sloan and Cooper, 1986). Currently, operators rely on occupational performance monitoring to observe performance change and problems that reduce operational pilot performance (Butcher, 2002; Helmreich et al., 1993; Hennessy, 2008; Sexton and Kline, 2017). This procedure and performance monitoring systems in themselves are considered a source of stress for most pilots because failure and possible non-compliance with a SOP can have a punitive effect on a pilot's career and subsequent medical qualification checks, as discussed by

Sloan and Cooper (1986) and shown in Bennett's (2003) study of the pilot's lifestyle. Bennett (2014) concluded that a 'pilot's performance is an emergent property of multiple interconnected factors. Although the aviation safety culture is highly non-punitive, Sexton (2017) confirmed that pilot performance is related to the safety culture of a carrier, and its organisational structure and level. Personal traits and personality have been intensely examined in connection with individual coping mechanisms and performance issues from a pilot performance perspective (Sloan and Cooper, 1986; Cooper and Sloan, 1987; Cuevas, 2003). Although the current research focused on commuting stress and pilot performance, the aviation industry is still highly focused on pilot performance evaluation via simulator assessment and evaluations of workload and cockpit tasks (Stein, 1984). This neglects highly relevant pilot coping mechanisms (Cahill et al., 2020; Cooper and Sloan, 1985, 1987; Cuevas, 2003b; Kanters, 2016; Novaco, Gonazalez and Gonzalez, 2009; Sloan and Cooper, 1986; Sun and Chiou, 2011; Williams and Cooper, 1998) and commuting coping strategies that are connected not only to safety behaviour and pilot performance, but also to overall human wellbeing.

4.2.10 Mediator Testing

Analysing the overall picture of the present research model variables of commuting stress, locus of control, turnover intention, safety behaviour and pilot performance, highlights the significant influence of the prediction model and the influences and moderating aspects of the pilot commuting process. This focus on the independent and dependent variables of the pilot commuting process is a novel approach and has contributed significantly to the overall understanding of safety performance in light of pilots' lifestyles. This interaction and mediating concept support and feed into discussions of general population commuting (Krausz, Koslowsky and Aizer, 2008).

Table 43—Mediator Testing Path Significance

Paths in the model	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values	Significance
Locus of Control -> Commuting stress -> Safety Behaviour -> Pilot Performance	0,115	0,116	0,022	5,278	0,000	YES
Locus of Control -> Commuting stress -> Turnover Intentions	-0,228	-0,228	0,037	6,149	0,000	YES CS In mediator between LC and TI
Locus of Control -> Commuting stress -> Safety Behaviour	-0,246	-0,246	0,032	7,733	0,000	YES CS is mediator between LC and SB
Commuting stress -> Safety Behaviour -> Pilot Performance	-0,338	-0,342	0,052	6,549	0,000	YES SB is mediator between CS and PP

4.2.11 Locus of Control -> Commuting Stress -> Turnover Intention

The relationship between the independent variable locus of control and the dependent variable turnover intention was established by this research to be mediated by the experience of commuting stress. This suggests that the pilot's subjectively experienced control over the frequency of their commute, commuting mode choice and commuting time as independent variables add up to the locus of control experience. This has a mitigating effect via the experience of commuting stress, resulting in significant mediation in turnover intention (see Table 44). This finding supports that of a study by Chen and Silverthorne (2008), who saw locus of control as a 'predictor of work-related behaviour in several areas' (Chen and Silverthorne, 2008, p.579) in regard to job stress, which might be related to the commuting stress of this research. Following this approach to locus of control, 'individuals with a higher internal locus of control are more likely to have lower levels of job stress and higher levels of job performance and satisfaction' (Chen and Silverthorne, 2008, p.572). This appears reasonable given the results of statistical analyses in the current research that established the mediating role of commuting stress on the locus of control and turnover intention, as well as the increase in turnover intention with an increase in commuting stress.

4.2.12 Locus of Control -> Commuting Stress -> Safety Behaviour

Expanding on their locus of control research, Chen and Silverthorne (2008) found that 'little or no research has focused on the potential impact of being part of a profession rather than just as an employee' (p.572), which influences the personal, micro-level behaviour rather than the overall, macro-level industry—in this research, the European pilot corps. Nevertheless, and even more importantly, it is evident that focusing on the

results of a micro-level statistical data analysis of commuting stress as a mediator significantly influences locus of control's influence on safety behaviour. This study has established for the first time a statistical basis for influences on European airline pilots' safety behaviour. This is entirely in line with research conducted on container terminal operations by Chin-Shan and Szu-Yu (2015), who used the term 'emotional intelligence' regarding safety behaviour and established 'a moderating role in the relationship between job stress and self-reported safety behaviour' in their research model. (p.10) In a study of Chinese pilots in 2013 it was found that 'locus of control directly affected pilot safety operation behaviour' (You, Ji and Han, 2013, p.131), which suggested that the precursor for this research is mediating evaluation of commuting stress on the influence of locus of control on safety behaviour. You, Ji and Han (2013) explained that 'locus of control primarily influences safety operation behaviour indirectly by affecting risk perception' (p.131), which is essential in the evaluation of locus of control and subsequent commuting stress generation, as presented in this research.

4.2.13 Commuting Stress → Safety Behaviour → Pilot Performance

Statistical analyses in this research showed that safety behaviour is a mediator between commuting stress and pilot performance. Different approaches can be taken to reduce the influence of stress on pilots. Important to the pilot profession is their overall execution of skilled performance and the overall safe conduct of flight operations, which is highly dependent on a pilot's decision-making process. Given that 'few studies have examined the skilled performance of expert pilots under well-controlled conditions' (Dismukes, Goldsmith and Kochan, 2015, p.2). the finding in this study that safety behaviour mediates pilots' performance deepens insight into the stress–performance relationship involved in the highly skilled pilot occupation. The European airline pilot environment presents a highly stressful situation connecting the home domain and work domain via a commuting process that is strongly connected to the pilot's coping capability and thus a positive or negative outcome (Cooper and Sloan, 1987; Hancock and Szalma, 2008; Kavanagh, 2005; Sloan and Cooper, 1986). This research used descriptive analyses to show that commuting pilots had significantly higher and better performance over non commuting pilots. Therefore, the coping process and the spillover from commuting stress in the work domain is mediated by safety behaviour. Therefore, safety behaviour in this mediation analysis

had a positive impact on subsequent pilot performance. The coping mechanisms and spillover effects of positive stress associated with pilot commuting, and the utilisation of commuting time, improved subsequent pilot performance. Bennett (2014) explained that 'it is important to take an interest in pilots' lives because of what happens outside the airport. Media influences the quality of flight deck labour, and because accidents are low probability but high consequence'.(Bennett, 2014, p.268) Similarly, Hennessy (2008), in a study of drivers' stress and performance found that 'workplace attitudes, behaviour, and performance can be influenced by a commute' (p.264). Grzywacz and Marks (2000) reported that a spillover may have positive outcomes for both work and family, while 'a stressful commute can spill over to impact performance in subsequent environments' (Hennessy and Jakubowski, 2008, p.1). The current research has established a clear cause–effect relationship between commuting stress and safety performance, as well as pilot performance.

4.3 Moderator Testing

Testing of theory depends strongly on moderating variables and the influence of a theoretical construct. The interaction between an independent variable and a dependent variable is influenced by a moderating variable, and moderation testing shows the level and degree of influence on the theory of this construct. To analyse this construct, moderator testing must be well grounded in a substantial literature and theoretical background, which are fundamental to evaluation of this moderation effect. Also, moderator testing outcomes may be challenging to interpret and must be based on the theoretical background (Hair et al., 2017; Memon et al., 2019).

4.4 Hypothesis Testing

Based on the theoretical background developed from the literature review, this research formed hypotheses that were tested to understand the interactions among dependent and independent variables as well as moderating variables in the framework of commuting stress, pilot performance, turnover intention and locus of control, in regard to the moderating variables of commuting distance, commuting time, frequency of commute, intermediate housing facilities and commuting mode choice. These were tested against the theoretical literature review findings (with results summarised in Table 44).

H1: European airline pilots' commuting stress (CS) does not have an impact on self-reported pilot performance (PP) levels, independent of demographic and organizational factors. Shown as null hypothesis – H0.

This hypothesis is supported as CS has no significant impact in either direction on subjective PP, with demographic and organisational factors being equal. The alternate hypothesis is accepted ($\beta = -0.86$; $p = 0.367$).

H2: European airline pilots' commuting stress (CS) does not have an impact on safety behavior (SB). Shown as null hypothesis – H0.

This hypothesis is rejected by statistical analyses indicating that European airline pilot CS positively impacts SB. The alternate hypothesis is accepted ($\beta = .726$; $p < 0.001$).

H3: European airline pilots' commuting stress (CS) does not have a positive relationship with turnover intention (TI). Shown as null hypothesis – H0.

A high CS value indicates an increase in the willingness of a European airline pilot to change jobs, thus increasing TI. With a value of $\beta = 0.673$; $p < 0.001$, this hypothesis is rejected. The alternate hypothesis is supported ($\beta = .673$). This supports the theoretical background literature as outlined in the literature review chapter of this thesis.

H4: European airline pilots' commuting distance and time do not moderate the relationship between commuting stress (CS) on turnover intention (TI) and pilot performance (PP). Shown as null hypothesis – H0.

This was formulated for statistical moderation testing and was split for separate evaluation of commuting time and distance. This meant that the hypothesis is only partially rejected, as outlined below.

It was established that commuting distance negatively moderates the effect of CS on TI ($\beta = -0.416$; $p < 0.001$), indicating that an increase in commuting distance negatively impacts the relationship between commuting distance and TI, meaning that TI increases.

Unlike commuting distance, commuting time is not a moderator of the effect of CS on TI ($\beta = 0.015$; $p = 0.711$). That is, an increase in commuting time does not moderate the relationship between CS and TI, according to this analysis. Further, commuting time is not a moderator of CS on subjective PP ($\beta = -0.016$; $p = 0.417$). Nor do commuting time and commuting distance moderate the direct path of CS to subjective PP. Commuting distance is not a moderator on the effect of CS on PP ($\beta = 0.390$; $p = 0.434$). These findings lead to support the hypothesis that commuting time influences the relationship between CS and subjective PP. The alternate hypothesis is partially supported.

H5: The frequency of commute does not moderate the effect of locus of control (LC) on commuting stress (CS) among European airline pilots. Shown as null hypothesis – H0.

As indicated by the descriptive statistics and analyses in this research, the declared frequency of commute between the home base and place of residence showed that 30.7% of the declared pilot commuters commuted more than six times in an average duty schedule per month. In-depth analysis and hypothesis testing showed that the frequency of commute does not influence or moderate the relationship of locus between control on commuting stress; thus, this hypothesis is supported ($\beta = .054$; $p = .931$). The alternate hypothesis is rejected.

H6: The use of intermediate housing facilities at the home base for commuting pilots is a positive moderator of the relationship between commuting stress (CS) and pilot performance (PP). Shown as null hypothesis – H0.

The use of intermediate housing facilities is moderator of CS on PP ($\beta = -.361$; $p = 0.452$). This hypothesis is supported. The alternate hypothesis is accepted.

H7: European airline pilots' commuting mode choice positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H0.

Commuting mode choice is, not moderator of CS $\rightarrow$ PP, each of transport mode (car; bike; bus, train, air, other) were tested, as moderator and none, of them were statistically significant moderators. This hypothesis is rejected. The alternate hypothesis is supported.

H8: European airline pilots' commuting travel time does not moderate the relationship between commuting stress (CS) and safety behavior (SB) levels. Shown as null hypothesis – H0.

Commuting time positively moderates the positive effect of CS → SB. This hypothesis is rejected. The alternate hypothesis is supported ($\beta = -.050$; $p = 0.031$). The approach taken to test this hypothesis derived from the literature review and theoretical modelling that showed intermediate housing residents at the home base can establish a similar setting to non-commuting European airline pilots. Descriptive statistical analyses showed that 40.2% of declared European airline pilot commuters utilise a form of intermediate housing facilities at their home base. Their travel time was similar to that for non-commuting European airline pilots. Further, the three-group analysis of commuting pilots, non-commuting pilots and committing pilots using intermediate housing facilities identified a large number of significant differences in performance level; in particular, total subjective PP calculations established that non-commuting pilots significantly outperform commuting pilots.

H9: European airline pilots' commuting travel time positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H0.

Not statistically significant in either direction on CS → PP, ($\beta = -.016$; $p = .417$). This hypothesis is supported. The alternate hypothesis is rejected.

	Hypotheses	Result	Rejected/ Supported
H1	European airline pilots' commuting stress (CS) does not have an impact on self-reported pilot performance (PP) levels, independent of demographic and organisational factors. Shown as null hypothesis – H_0 .	CS has no significant impact in either direction on subjective PP ($\beta = -0.86$; $p = 0.367$).	Supported
H2	European airline pilots' commuting stress (CS) does not have an impact on safety behaviour (SB). Shown as null hypothesis – H_0 .	CS have positive impact on SB (.726; $p < 0.001$).	Rejected
H3	European airline pilots' commuting stress (CS) does not have positive relationship with turnover intention (TI). Shown as null hypothesis – H_0 .	CS have a positive impact on TI (.673; $p < 0.001$).	Rejected
H4	European airline pilots' commuting distance and time do not moderate the relationship between commuting stress (CS) on turnover intention (TI) and pilot performance (PP). Shown as null hypothesis – H_0 .	Commuting distance <u>negatively</u> moderates the effect of CS on TI (-0.416; $p < 0.001$). Commuting time <u>is not a moderator</u> of the effect of CS on IT (0.015; $p = 0.711$). Commuting time <u>is not a moderator</u> of CS on subjective PP (-0.016; $p = 0.417$). Commuting distance <u>is not a moderator</u> on the effect of CS on PP (0.390; $p = 0.434$).	Rejected
H5	The frequency of commute does not moderate the effect of locus of control (LC) on commuting stress (CS) among European airline pilots. Shown as null hypothesis – H_0 .	Frequency of commute is not moderator of relationship LC - CS (.054; $p = .931$).	Supported
H6	The use of intermediate housing facilities at the home base for commuting pilots is a positive moderator of the relationship between commuting stress (CS) and pilot performance (PP). Shown as null hypothesis – H_0 .	The use of intermediate housing facilities is moderator of CS on PP (-.361; $p = 0.452$).	Supported
H7	European airline pilots' commuting mode choice positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H_0 .	Commuting mode choice is, not moderator of CS $\rightarrow$ PP. Each of transport mode (car bike, bus, train, air, other) were tested as moderator and none of them were statistically significant moderators.	Rejected
H8	European airline pilots' commuting travel time does not moderate the relationship between commuting stress (CS) and safety behaviour (SB) levels. Shown as null hypothesis – H_0 .	Commuting time positively moderates the positive effect of CS $\rightarrow$ SB (-.050; $p = 0.031$).	Rejected
H9	European airline pilots' commuting travel time positively moderates the positive effect of commuting stress (CS) on pilots' performance (PP) levels. Shown as null hypothesis – H_0 .	Not statistically significant in either direction on CS $\rightarrow$ PP, (-.016; $p = .417$).	Supported

Table 44–Summary of Hypothesis Testing Results

CHAPTER 5: CONCLUSION

This chapter provides an in-depth discussion of the theoretical and methodological framework and the contributions of this research, along with reflections on the research objectives. The chapter closes by outlining the limitations of this research and future research recommendations.

5.1 Discussion Related to Research Objectives

5.1.1 Objective 1–To identify and validate European airline 'pilots' commuting variables based on different commuting and non-commuting pilot groups

This study is the first of its kind on the subject. It shows that it is common in the airline industry for European airline pilots to commute more than 45 minutes to work in order to start their flight duty. The majority (56.4%) of European pilots who participated in this empirical study described themselves as commuters in the sense of the definition used in this research. This result also highlights the importance of identifying the crucial factors in the commuting process of European airline pilots. Only this understanding, the establishment of which is the focus of this work, makes it possible to expand the established safety management system in air transport to include this safety-relevant aspect and to develop it in the sense of a more comprehensive approach. The study showed that the profession of European airline pilots is still dominated by men (92.5 % men, 7.4 % women). However, the following result is significant for the general validity of the statements made in this paper: as far as the proportion of commuters is concerned, there is no significant difference between male and female pilots.

Objective 1 of this research was to identify and validate European airline pilot commuting variables based on different commuting and non-commuting pilot groups. For this, it was necessary to work out a crucial distinguishing feature for commuting: The use of an intermediate housing facility close to the work base, i.e. a 'second home' away from the main private residence at home. This research found that 40.2% of participants use intermediate accommodation close to the workplace. These intermediate housing facilities are mainly used when the commuting time or distance is too far for commuting between the place of work and the actual place of residence. Forty-seven-point five percent of the participating European pilots in this study actively

use or have used such a kind of intermediate housing or stopover accommodation. This indicates a responsible approach to personal fatigue and commuter risk management. This study was thus able to distinguish between the different commuter and non-commuter pilot groups and identify certain behaviours and patterns in their commuting behaviour. Commuting variables such as commuting distance, commuting time and frequency of commute were tested and found significant, validated and statistically checked. In the three-group analysis involving commuters, intermediate housing commuters, and non-commuters, the distance to work indicated a highly significant difference. Sixty-three and a half percent of pilots who declared themselves as intermediate housing commuters lived more than 500 km from their residences. 20.7% of intermediate housing pilots indicated a more than 1,500 km distance.

5.1.2 Objective 2–To develop an understanding of the European airline pilot commute process and factors that influence commuting

Understanding the European airline pilot commuting situation requires an in-depth characterisation of the European aviation industry and the changes taking place in that industry. Commuting has become essential for pilots in this rapidly changing situation to support more flexible working conditions and pilot contract scenarios. The personal situation of the European pilot and their form and mode of housing has become relevant because a permanent change in residence also has a detrimental impact on the individual pilot's overall social situation and well-being. Sixty-three and a half percent of the intermediate housing commuters among the European airline pilots in this study commuted more than 501 km one-way. With regard to the frequency of monthly commuting and the total time spent on commuting, there was a significant difference in commuting distance and commuting time among the three pilot groups of commuter pilots, intermediate housing commuters, and non-commuter pilots analysed here. This is related to the different modes of transport used: About 75% of all three groups actively travelled by car between their place of residence and their home base.

This study reveals the need to take a much broader perspective on the integrated variables. This is particularly important in relation to pilot job performance. This research identified significant predictability and interaction between commuting stress, safety behaviour, and turnover intention. It also highlights that locus of control has a

predictive quality in regard to commuting stress resulting from the commuting process and the utilisation of different forms of transport according to the distance and time involved in the commuting process itself. Further, it is possible to predict safety behaviour and subsequent subjective performance of commuting and non-commuting pilots.

5.1.3 Objective 3–To identify the influence of independent and dependent commuting factors on European airline 'pilots' commuting processes

5.1.3.1 Exogenous Variables/Independent Variables

- **Commuting distance and commuting time**

Commuting time and distance are tightly connected to the mode of transport used. The subtractive personal choice of the individual pilot is also directly connected to the stress signature (Hancock and Warm, 1989) experienced during the commuting process, which is connected to levels of performance and commuting stress. Turnover intention is also influenced by commuting time and distance. This research identified a correlation between commuting time and commuting stress. The importance of this finding is evident given that 26.8% of the respondent European pilots travelled more than 180 minutes between the place of residence and the home base.

- **Mode of transport**

The European pilot corps is in general, connected to the workplace through cars as a transport mode. Of the European airline pilots in this study, 74.9% (averaged across commuter groups) drove a car to commute between their residence and home base. Among the group of pilots using intermediate housing facilities, by far the highest proportion (51.1%) chose to fly as a passenger to commute between their home base and place of residence. Also connected to the mode of transport, is time of use of the selected mode of transport. Use of a car as an active driver was by far the leading mode in this study, in regard to the mean time of use (rounded to 74 minutes); followed by air travel as a passenger (rounded to 30 minutes mean time of use) in all three groups. Only 13% of the European airline pilots surveyed in this study chose the train to travel to the home base.

- **Intermediate housing**

Forty-seven and a half percent of the European pilots in this study used intermediate housing facilities at their home base. As time and commuting distances increase, so too does the use of intermediate housing facilities. A highly significant difference was found in the three-group analysis of commuters, intermediate housing commuters, and non-commuters, in that the mean commute distance for commuters using intermediate housing facilities was 960 km—more than twice the distance of a "normal" pilot commuter (414 km). This resulted in commuting pilots experiencing the highest overall stress levels among the three groups.

5.1.3.2 Endogenous variables

- **Pilot performance**

An established subjective pilot performance measurement questionnaire (Sloan and Cooper, 1986) was used to achieve this research's overall subjective pilot performance measurement objectives. The descriptive analysis of pilot performance results from a total of 15 item calculations revealed the surprising result that commuting European airline pilots had significantly better subjective performance than non-commuting pilots. This suggests a positive influence of the commuting process and possible positive utilisation of commuting time and distance between work and home as a form of cognitive coping process. In contrast to the commuting stress results is that pilot performance is positively correlated with the commuting process itself. However, this only applies if the commuting process is not too long. This study shows a negative correlation in the sense that longer commute distances reduce performance. Therefore, this study concludes that commuting between 172- and 241-minutes results in the best-reported pilot performance.

- **Safety behaviour**

In this research significant differences were found at the individual item level between non-commuters and commuters, especially in regard to the influence of fatigue on professional pilots in connection to safety behaviour. An in-depth three-group analysis revealed significant differences between intermediate housing commuters and non-commuters and intermediate housing commuters and commuters regarding "disregard

of procedures" at the individual item level. This shows that intermediate housing commuters have a significantly higher willingness to disregarding procedures at the individual level, which is related to their commuting needs. This may indicate that infrequent commuting is a feature for intermediate housing commuters. This research revealed safety breaches by members of this group to meet their personal commuting-requirements. This was also evident in the item of safety issues (SB 5), where intermediate housing commuters had a significantly higher propensity for safety breaches than commuters and non-commuters. The PLS-SEM analysis identified safety behaviour as a significant predictor of subsequent pilot performance. This was supported by the findings of mediator testing, where safety behaviour was established as a mediator in commuting stress and pilot performance. This supports the importance of personal safety behaviour as a catalyst in the pilot commuting process. Pilot personal safety behaviour, including when embedded in the general cockpit and flight crew environment, was established as being used or modified in the European airline pilot commuting process at a measurable and significant level.

- **Commuting stress**

The statistical analyses employed in this research revealed a significant difference in total commuting stress levels between non-commuters and intermediate housing commuters; commuters and intermediate housing commuters; and non-commuters and commuters. Overall, non-commuters had the lowest stress values while commuters had a medium level of commuting stress and pilots utilising intermediate housing facilities had the highest stress level in this three-group comparison. It was found that there was a low positive correlation between commuting stress and commuting time. Raising commuting time raised commuting stress. Further, a highly significant correlation was found between commuting stress and commuting distance in the three-group analysis. Predictive qualities were established in regard to this commuting process in terms of dependent, endogenous variables. The fatigue risk management system implemented in Europe is insufficient to adequately address the interactions involved in the pilot commuting process. This research established that the prediction quality of commuting stress depends on the endogenous variables of turnover intention and safety behaviour. This underlies the fact that commuting stress has significant prediction value for how pilots behave in regard to safety behaviour,

and that commuting stress significantly influences and predicts whether a pilot is willing to change their employer or airline operator. Surprisingly no significant predictive quality was seen on the path of commuting stress to pilot performance. This supports Sloan and Cooper's (1986) findings on pilots' stress coping strategies, which included no significant prediction capability for the influence of pilots' stress coping mechanisms on pilots' performance. Prediction quality was, however, established by this research on the path of safety behaviour to subsequent pilot performance. Mediation testing on the relationship between commuting stress, safety behaviour and pilot performance showed that safety behaviour is a mediator between commuting stress and pilot performance. This indicates that a change in safety behaviour significantly mediates the path of commuting stress to pilot performance. Therefore, the qualifying mediator in this connection was established as safety behaviour. Commuting stress of the European pilot corps had no statistically significant correlation with the presence of children living in the household. Also, the age of commuting European airline pilots had no significant relationship with commuting stress, indicating that the maturity or age of a European airline pilot does not influence the commuting stress signature they experience according to this analysis.

- **Turnover intention**

This research established that commuting pilots have a significantly lower tendency to change jobs than do intermediate housing commuters and non-commuting European airline pilots. This is also evidence that non-commuting European airline pilots have a significantly higher turnover intention than commuting European airline pilots.

Locus of control

This research found a significant difference in locus of control between commuters and pilots using intermediate housing facilities. The latter group experienced a significantly higher locus of control in the commuting process than did commuters. Significant predictive quality was established for locus of control in regard to commuting stress, in that a higher locus of control lowers commuting stress. Mediation testing of locus of control further showed its significance in safety behaviour and commuting stress as a mediator in this relationship. Similar significance was found in the relationship between locus of control and turnover intention, of which commuting

stress was a mediator. This is important as control is fundamental in a pilot's professional daily routine and an essential requirement in the pilot's commuting process.

5.1.4 Objective 4–To develop an understanding of how pilots perceive different factors of commuting

In this research's moderation testing of the effect of commuting stress on pilot performance, with demographic factors as moderators, no significant impact was found on this path. Unlike commuting time, commuting distance was found to negatively moderate the effect of commuting stress on turnover intention. Focusing on the spatial geolocal aspect of the distance between home base and place of residence commuting time negatively impacts the effect of commuting stress on safety behaviour. This research also found that the frequency of the European airline pilot commute - how often they commute (30.7% declared they commuted more than six times, and 17.8%, eleven times, per duty month) - influences the relationship between locus of control and commuting stress. However, this effect is not significant. Thus, the theory that the more often one commutes, the more locus of control determines commuting stress, cannot be supported based on the findings. Interestingly, choice of the mode of commuting transport (car, bike, bus, train, air, other) had no significant moderating effect on commuting stress and pilot performance. This is relevant to locus of control in the present research, where this transition period (locus of control) showed that commuting stress is a mediator between locus of control and turnover intention, as well as safety behaviour. This indicates that the degree of commuting stress mediates this relationship in the transition period, and suggests it is possible for a pilot to use this transition period to cool off and cope with inter-domain requirements.

5.1.5 Objective 5–To make recommendations for the pilot commuting process to minimise the impact on pilot performance

Over fifty-six percent (56.4%) of the European airline pilots participating in this study described themselves as commuters according to the definition used in this research. In the group of commuters with very high and high subjective performance, the commute time of most pilots was between 172 and 241 minutes. This indicates that this commute time between home and work represents an optimal commute time in

terms of the pilot's subjective performance. In terms of commuting distance between these two areas, participants with very high (29.7%) and high (29.9%) pilot performance indicated that they had a total commute distance from 151 to 500 km total, suggesting that this is the optimal travelling or commuting distance between the home and work areas in terms of subjective pilot performance. Analysing the age of commuting European airline pilots in relation to pilot performance revealed that the majority (34.6%) of European pilots with a very good rating were aged between 45 and 54 years, and 27.9% of pilots with a good rating was in this age range. The analysis of pilot performance in relation to the number of children in the household, and the type and form of housing did not show any significant correlation with these variables. The results of this research show the following optimal commuting conditions in relation to the subjective performance of European airline pilots:

- 151–500 km
- 45–54 years of age

In order to improve the safety of the European aviation system, the following recommendations are made:

Legislative European Level – European Aviation Safety Agency (EASA): EASA is recommended to integrate pilot commuting considerations into its Fatigue Risk Management Systems (FRMS) and general safety risk management processes. This integration is crucial for recognizing and mitigating the stress associated with pilot commuting, which poses a potential threat to European aviation safety. The implementation of this recommendation should begin immediately and be completed within 24 months. This period allows for adequate policy development, stakeholder consultation, and regulatory changes.

Accident Investigation Authorities Level: Pilots' commuting time should be included as part of the duty time in accident and incident investigations. This recommendation necessitates an expansion of the relevant EU regulations. Including commuting time will provide a more comprehensive understanding of the factors contributing to accidents and incidents, acknowledging commuting as a potential risk factor. The process to implement this change should start and conclude within 12 months, ensuring a timely integration into investigative protocols.

Operators – Airline Level: Airlines are advised to develop and implement a strategy for sustainably integrating commuting into work processes and to carry out awareness-raising measures for European airline pilots. Effective commute management and pilot training can mitigate fatigue-related risks, enhancing the safety and well-being of pilots and passengers. These strategies should be developed and implemented within the next 12 months to address the risks associated with commuting promptly.

Pilot Union Level - European Cockpit Association: The European Cockpit Association is encouraged to advocate for the inclusion of commuting time in the overall calculation of a pilot's duty time and for the adaptation of rest time regulations accordingly. This inclusion ensures that pilots receive sufficient rest, reducing fatigue and enhancing safety. Efforts to influence policy and practices in this regard should be intensified over the next 12 months to align with broader industry changes.

European Airline Pilot Level – Individual Level: European airline pilots are urged to raise their awareness of the impact of commuting on their health and safety. Individual awareness is essential in managing personal risks associated with commuting. This initiative should be prioritized and implemented within the next six months, as changes in individual behaviour can swiftly influence the overall safety culture.

Threat and Error Management (TEM) Briefings: It is recommended that commuting considerations for European airline pilots be included in TEM briefings. This inclusion aims to increase crew awareness and promote identifying and mitigating immediate threats related to commuting stress. Integrating these factors into TEM briefings ensures that all crew members are cognizant of potential stressors and can act to maintain safety. This integration should be implemented immediately and completed within the next two months, as it can immediately impact flight safety.

These recommendations are explicitly aimed at regulatory bodies, airline operators, pilot unions, and individual pilots. They include a range of operational measures, policy changes and individual awareness-raising initiatives to recognise and mitigate the risks associated with pilot commuting. The proposed timetables proposed a structured framework for prioritization and implementation, ensuring a systematic approach to improving aviation safety.

5.2 Limitations

A limitation inherent in cross-sectional data collection and research is the potential inability to substantiate distinct conclusions. Therefore validation testing was performed using pilot sample groups before administering the survey, and a self-reported survey was used in this PhD research for the data collection process. It is important to note that the accuracy and quality of self-reported surveys depend on the participants' retrospective recall and judgement. Additionally, the survey was conducted during the COVID-19 pandemic, which severely impacted the aviation industry. A considerable number of European airline pilots have not been actively flying duty schedules or were laid off from the pilot occupation because of route network re-dimensioning and the breakdown of the European aviation system. COVID-19 was presented in the survey introduction. The introduction referred to a reference month prior to the COVID-19 time and set this as an observation and research timeframe for the pilots to use in the survey. Care was taken to avoid bias when selecting pilots from major European airlines and low-cost carriers for the survey. A comprehensive convenience sampling method ($n > 31,000$) was used and a list of European airlines and pilots was compiled from an public internet domain. To be included in the sample, pilots had to declare themselves on a professional online platform (LinkedIn) as a pilot working for a European airline. One limitation of using this generation method is that only people who declared themselves as pilots of a European airline on this specific online platform could be reached and invited to participate in this study. Nevertheless, it was possible to generate a large sample to gain meaningful and important insights from the 1,461 returned surveys. Exploring the relationship in a novel construct of commuting stress and the closely related issues of pilot performance, locus of control, turnover intention and safety behaviour, the developed construct might impose the restriction of construct validity. Measuring the interactions between constructs and variables does not remove the possibility of the existence of other influencing variables that were not part of the developed measurement model.

5.3 Future Research

In the process of this research and reflecting on its empirical results, it was evident that the commuting process in itself – the time and distance involved – is a critical vehicle in regard to pilot performance. This research suggests that a significant change in pilot performance occurs during the commuting period between the work and home domains. Future research needs to address this use of time and find out what happens during this transition from work to home and vice versa, and how this transition period can have such an impact on pilot performance. As this research was affected by the COVID-19 pandemic, changes in the commuting patterns of European airline pilots and any thresholds changes should be considered in future studies.

5.4 Contributions

By establishing novel PLS-SEM model data showing interactions between variables in the European airline pilot commute process and situation, this research significantly contributes to the European aviation safety research literature. The findings raise awareness of stress generated by the pilot commuting process and establish that the European airline pilot commuting process, contrary to previous assumptions, also positively influences self-reported pilot performance. This research changes the pre-conditional assumption that commuting is merely a burden and not beneficial to overall employment. European airline pilots generate a positive outcome for their subjective pilot performance by utilising the time during the transition between the work and home domains to beneficially influence their occupational duty. Commuters make a significant micro-level contribution to raising European airline performance safety standards in the European airline pilot corps. The research focus of this thesis is to bring pilot commuting behaviour to the attention of aviation authorities and airlines. This work has shown that although aviation authorities and airlines are addressing the issue of fatigue risks, they are doing so only very superficially and by no means adequately addressing and managing the pilot commuting process.

This research takes a broader and more inclusive approach, which makes it an important contribution and expands the current fatigue risk management research. This study reveals that even European airline pilots who are not considered commuters may experience fatigue and stress due to their work-related travel,

indicating a crucial finding to take into account. These European pilots who are non-commuters by the definition of this research may face issues such as traffic congestion, lack of public transport or other factors that may affect their pilot performance and stress levels. However, this is not considered and presented in the results as their work travel is not classified as commuting for this study. EASA has taken a step in this direction by identifying commuting by pilots of European airlines in public documents as a safety risk. In the context of the COVID-19 pandemic, 'individual-level stress' was also identified as a potential threat to the safety of European aviation. This outcome underlines the importance of integrating commuting stress into the existing European plan for aviation safety (EPAS). Comprehensive safety management is required to integrate European pilots' commuting into the fatigue risk management framework and the overall EASA safety risk management processes. Based on the results of this research it is also recommended that the broader aviation system safety management network establishes and implements a sound framework for managing commuting. As one result, EASA now provides supporting material. This includes recommendations for pilots on how best to deal with the personal challenges of commuting. These current actions highlight the importance of integrating commuter stress into the existing European Plan for Aviation Safety (EPAS). Comprehensive safety management is required to integrate European pilots' commuting into the fatigue risk management framework and into EASA's overall safety risk management processes. This work makes equally clear that previous approaches to fatigue risk management, both in the US and in Europe, do not do justice to the highly complex interactions in the pilot commuting process. In the context of this research, it was found that the quality of the prediction of commuter stress depends on the endogenous variables of turnover intention and safety behaviour. This highlights that commuter stress has significant predictive value for pilot safety behaviour and that commuter stress significantly influences and predicts a pilot's willingness to change employer or airline. This research offers EASA data to incorporate the results as a safety issue into European Plan for Aviation Safety (EPAS) and to establish practical, suitable corresponding mitigation actions. This work's ultimate goal is to understand the influence and safety issues of commuting and overcome its potential impact on flight safety. It is essential to incorporate the insights and results from this research on European Airline Pilot Commuting on a macro

industry level. And implement these findings in the European Plan for aviation safety (EPAS) for relevant changes for aviation industry.

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Glossary of Key Terms

European Airline Pilot

For the definition of this research, a European Airline Pilot is a pilot engaged in flying operational duty as a professional pilot for an operator in the field of a Legacy / National Airline, Low-Cost Airline, Regional Airline, Charter Airline, Cargo Airline or Private Jet Operator.

Home Base

The home base is a geospatial location to which a pilot commutes from their place of residence and where they start or end their pilot duty. It is often an airport location or an airport office location, where the pilot begins the pre-flight briefing. (NRCNA, 2011a).

Intermediate Housing Facility

A facility at home base to be used for rest and sleep. It can range from a shared bed to a shared apartment, hotel room or fully furnished second household. (EASA, 2020; NRCNA, 2011a).

Place of Residence (Home)

A principal place where a pilot lives and undertakes their private relationship activities, such as spending time with family and friends and maintaining a social life. This place is usually the start and endpoint of a pilot's commute. (EASA, 2020b; National Research Council of the National Academies, 2011a)

APPENDICES

Appendix A - European Airline Pilot Survey 2020

Start of Block: Welcome Message

Q1

Dear

appreciated

Colleague,

Thank you for deciding to participate in our research! **Because of the COVID-19 impact on aviation and all our professional life and routines, please take the unaffected aviation reference month of**

JULY 2019

as the basis for your professional life and as the reference for your participation in the survey.

End of Block: Welcome Message

Start of Block: Biographical Data

Q2 What is your gender?

Male / Female / Other

Q3 What is your age?

18-24 / 25-34 / 35-44 / 45-54 / 55-64 / 65+

Q4 Which of the following best describes your relationship status?

Single / Cohabiting / Married / Separated / Divorced / Widowed

Q5 Dependent children living in household:

N/A / 1 / 2 / 3 / 4 / 5 / 6 / 7 / +8

Q6 Number of own Children:

N/A / 1 / 2 / 3 / 4 / 5 / 6 / 7 / >8

Q7 Age of youngest Child in household (in years)

N/A / <1 / 1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10 / 11 / 12 / 13 / 14 / 15 / 16 / 17 / 18 / >18

End of Block: Biographical Data

Start of Block: Housing

Q8 Country of residency:

Albania / Andorra/Armenia / Austria / Belarus / Belgium / Bosnia and Herzegovina / Bulgaria / Croatia / Cyprus / Czech Republic / Denmark / Estonia / Finland / France / Georgia / Germany / Greece / Grenada / Hungary / Iceland / Ireland / Italy / Latvia / Liechtenstein / Lithuania / Luxembourg / Malta / Monaco / Montenegro / Montserrat / Netherlands / North Macedonia / Norway / Poland / Portugal / Republic of Moldova / Romania / Russian Federation / San Marino / Serbia / Slovakia / Slovenia / Spain / Sweden / Switzerland / Turkey / Ukraine / UK of GB & Northern Ireland / Vatican City

Q9 Form of Housing at Place of Residence:

House / Apartment / Shared Housing / Other

Q10 Mode of Housing:

Ownership / Rent / Other

End of Block: Housing

Start of Block: Geographical Information

Q11 Country of Operator:

Albania / Andorra/Armenia / Austria / Belarus / Belgium / Bosnia and Herzegovina / Bulgaria / Croatia / Cyprus / Czech Republic / Denmark / Estonia / Finland / France / Georgia / Germany / Greece / Grenada / Hungary / Iceland / Ireland / Italy / Latvia / Liechtenstein / Lithuania / Luxembourg / Malta / Monaco / Montenegro / Montserrat / Netherlands / North Macedonia / Norway / Poland / Portugal / Republic of Moldova / Romania / Russian Federation / San Marino / Serbia / Slovakia / Slovenia / Spain / Sweden / Switzerland / Turkey / Ukraine / UK of GB & Northern Ireland / Vatican City

Q12 Country of Crew base:

Albania / Andorra/Armenia / Austria / Belarus / Belgium / Bosnia and Herzegovina / Bulgaria / Croatia / Cyprus / Czech Republic / Denmark / Estonia / Finland / France / Georgia / Germany / Greece / Grenada / Hungary / Iceland / Ireland / Italy / Latvia / Liechtenstein / Lithuania / Luxembourg / Malta / Monaco / Montenegro / Montserrat / Netherlands / North Macedonia / Norway / Poland / Portugal / Republic of Moldova / Romania / Russian Federation / San Marino / Serbia / Slovakia / Slovenia / Spain / Sweden / Switzerland / Turkey / Ukraine / UK of GB & Northern Ireland / Vatican City

Q13 What Airline do you work for? (Two letter Code) Please enter - if not available please enter N/A**Q14 Type of Airline:**

Legacy-National Airline / Low-Cost Airline / Regional Airline / Charter Airline / Cargo Airline / Private Jet Operator

Q15 Operation Schedule:

Schedule / Non-Schedule

Q16 Personal Type of Operation:

Longhaul OPS / Mid & Shorthaul OPS / Domestic only

Q17 Job Position:

Captain / First Officer / Senior First Officer / Second Officer

Q18 Total Time of Pilot Employment in years:

0 5 10 15 20 25 30 35 40 45 50

Q19 Number of previous pilot Jobs:

0 2 4 6 8 10 12 14 16 18 20

Q20 Years with current employer:

0 5 10 15 20 25 30 35 40 45 50

Q21 Approximate Total Flight Time:

0 12500 25000

End of Block: Geographical Information

Start of Block: Commuter / Non - Commuter Divider

Q22

Are you commuting from your permanent residence to your pilot base from outside a travel radius of 45 minutes?

Pilot Base is the place where you are based according to your employment contract. The place where you start and end your work obligation.

YES / NO

End of Block: Commuter / Non - Commuter Divider

Start of Block: Commuter Part

Q23 I would change my type of aircraft to be based closer to my place of residency?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q24 I would change my position (First Officer/Captain or vice versa) to be based closer to my place of residency?

e.g. Upgrading to commuter – Downgrading to Homebase

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q25 I would change my employer to be based closer to my place of residency?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q26

Would you like to reduce your work hours/days (part-time employment) to accommodate your commuting?

I think about a permanent reduction / I think about a temporary reduction / I reduced the work hours in the past / I have reduced it / I'm not interested in reducing it

Skip To: Q28 If Q26 = I think about a permanent reduction

Skip To: Q28 If Q26 = I think about a temporary reduction

Skip To: Q27 If Q26 = I reduced the work hours in the past

Skip To: Q27 If Q26 = I have reduced it

Skip To: Q28 If Q26 = I'm not interested in reducing it

Q27 To what percentage did you reduce your working obligation/month?

0 25 50 75 100

Q28 Does your employer offer different cockpit crew bases?

Yes / No

Q29 Does your employer offer commuting benefits?

Yes / No

Skip To: Q31 If Q29 = No

Skip To: Q30 If Q29 = Yes

Q30 Which benefits are these?

(Multiple answers are possible)

Discounted travel tickets / Free travel tickets / Preferred rostering / Rostering bidding systems / Commuting contract / Other / None

Q31 Did you change your employer because of residential issues?

Yes / No, I think about it / No, there is no need for change

Q32 How important is the residential issue for changing the employer?

Very important / Somewhat important / Neither important nor unimportant / Somewhat unimportant / Very unimportant

Q33 Are you on a waiting list to be based closer to your place of residence?

Yes / No

Q34 Do you have a commuting history in your past pilot career?

Yes / No

End of Block: Commuter Part

Start of Block: Commuting TIME / DISTANCE

Q35 How far is your residence from your pilot base (in KM):

0 2000 >4000

Q36 How far is your residence from your pilot base in travel time:

Time in hh:mm

Q37 Are you using multiple forms of transport to commute to your pilot base (Car, Train, Bus, Aircraft, etc.)?

On a regular commute to your pilot base from your place of residence which form of transport do you use active or passive and what is the approximate time spent on each mode of transport

Active means as a driver of a car for example;

Passive means as a passenger of a bus for example

Please enter time in format hh:mm

Car / Bus / Tram / Metro / Aircraft / Train / Bike / Other

MINUTES (Passive /Active)

End of Block: Commuting TIME / DISTANCE

Start of Block: Resting Facilities

Q38 Does your employer offer resting facilities at your home base?

Yes / No / Not Sure

Skip To: Q39 If Q38 = Yes

Skip To: End of Block If Q38 = No

Skip To: End of Block If Q38 = Not Sure

Q39 What best describes the form of these resting facilities?

Crew Lounge / Sleeping Chairs / Hotel Room / Flat separate beds / Resting Rooms / Shared Room at Crew Base / Other

Q40 Are these resting facilities free of charge?

Yes / No / Not Sure

Q41 Are these resting facilities permissible for overnight stay?

Yes / No / Not Sure

End of Block: Resting Facilities

Start of Block: Frequency of Commute

Q42 How often per month, in an average duty schedule do you commute to your place of residence?

1/2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/ 19/20/21/22/23/24/25/>25

Q43 How often do you experience problems in your commute?

(Traffic jams, Delays, Flight Cancellations, No Seat available, etc.)

Always / Almost Always / Often / Sometimes / Never

Q44 How often do you have to cancel/change your commute plan?

Always / Almost Always / Often / Sometimes / Never

End of Block: Frequency of Commute

Start of Block: Commuting Costs

Q45 Does your Employer provide you with free commuting tickets?

Yes / No / Not Sure

Q46 Approximately how much money do you spend per month on commuting?

Please specify amount in EUROS

0-50 / 51-100 / 101-150 / 151-200 / 201-250 / 251-300 / 301-400 / 401-500 / 501-600 / 601-700 / 701-800 / 801-900 / 901-1000 / >1000

End of Block: Commuting Costs

Start of Block: Intermediate Housing Facility Separator Question

Q47 Do you use an intermediate housing facility at your home base?

An intermediate housing facility is a place in your use where you regularly stay at your home base. (eg. room or shared apartment at your home base)

Yes / No / I did in the past

End of Block: Intermediate Housing Facility Separator Question

Start of Block: Intermediate Housing

Q48 What form of intermediate housing do you use?

Flat-Apartment / House / Hotel Room

Q49 Are you sharing the intermediate housing facilities with other people?

Yes / No

Skip To: Q50 If Q49 = Yes

Skip To: Q51 If Q49 = No

Q50 With how many other persons are you sharing your intermediate housing facility?

0/1/2/3/4/5/6/7/8/>9

Q51 How many nights on average do you stay in your intermediate housing facility per month?

0/1/2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/ 19/20/21/22/23/24/25/26/27/28/29/30/31

Q52 Do you have to pay for the use of intermediate housing at your home base?

Yes / No

Skip To: Q54 If Q52 = No

Skip To: Q53 If Q52 = Yes

Q53 Approximately how much is the cost of your intermediate housing facilities per month?

Please specify amount in EUROS

0-50 / 51-100 / 101-150 / 151-200 / 201-250 / 251-300 / 301-400 / 401-500 / 501-600 / 601-700 / 701-800 / 801-900 / 901-1000 / 1001-1100 / 1101-1200 / >1200

Q54 How far is your intermediate housing from your pilot base (in KM):

0 125 >250

Q55 How far is your intermediate housing from your pilot base in travel time:

Time in hh:mm

Q56 Are you using multiple forms of transport to commute to your pilot base (Car, Train, Bus, Aircraft, etc.)?

On a regular commute to your pilot base from your intermediate housing which form of transport do you use active or passive and what is the approximate time spent on each mode of transport

Active means as a driver of a car for example;
Passive means as a passenger of a bus for example

Please enter time in format hh:mm

Car / Bus / Tram / Metro / Aircraft / Train / Bike / Other
MINUTES (Passive /Active)

End of Block: Intermediate Housing

Start of Block: Commuting Rules & Regulations

Q57 Does your employer have procedures/protocols in their operations manual in place for pilots commuting to their base?

Yes / No / Not Sure

Q58 Does your employer / rostering department know that you are commuting to work?

Yes / No / Not Sure

End of Block: Commuting Rules & Regulations

Start of Block: Fatigue Risk management

Q59 I am familiar with my responsibility, in regards to commuting in my employer's Fatigue Risk Management System?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q60 I think pilot commuting should be a mandatory managed part of a Fatigue Risk Management System?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q61 I consider pilot commuting an aviation industry standard, and it should be regulated by EASA rules?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

End of Block: Fatigue Risk management

Start of Block: Call in sick / Unfit to fly

Q62 I have used the "Call in Sick" possibility in the past to cover for commuting issues?

Always / Often / Sometimes / Rarely / Never

Q63 I have declared myself "Unfit to Fly" because of commuting issues.

Always / Often / Sometimes / Rarely / Never

End of Block: Call in sick / Unfit to fly

Start of Block: Personal safety concerns of commuting

Q64 Safety concerns of commuting

Totally agree / Agree / Neither agree - nor disagree / Disagree / Totally disagree / Not applicable

I think that commuting negatively influences a pilot's professional performance
On commuting days I sometimes see some negative effect of the commuting on the commuting pilot performance
My personal professional performance has been influenced negatively by commuting issues
On some commuting days I am generally more tired than on other days
I think about the safety issues connected with my commuting
I have occasionally disregarded Company Procedures (Check out Procedures, etc.) to meet my commuting plans
I have occasionally disregarded Safety issues to meet my commuting plans

End of Block: Personal safety concerns of commuting

Start of Block: STRESS Commuters

Q65 How do You feel about your commute?

Totally agree / Agree / Neither agree - nor disagree / Disagree / Totally disagree / Not applicable

Commuting impose stress on my life
Commuting imposes stress on my partner
Commuting leads to discussions in my relationship
Commuting limits the socialization time with my friends
Friends turned away from me because of my commuting/time issues
Commuting makes me think about the safety issues connected to my commuting
I think that commuting negatively influences the quality of my colleagues work
Commuting negatively influences my overall happiness

Q66 How satisfied are you with your life, all things considered?

completely dissatisfied

completely satisfied

End of Block: STRESS Commuters

Start of Block: Commuting Reasons

Q67 Your reasons for commuting?

Totally agree / Agree / Neither agree -nor disagree / Disagree / Totally disagree

My housing situation / cost of housing influences the decision to commute
My family situation influences the decision to commute

Q68

What is your main reason for commuting?

Higher income / Cheaper housing at place of residency / Social bands at place of residency / Better life quality at place of residency / Family situation / Other (please specify)

Q69 Do you consider relocating to your crew base?

Yes / No

Skip To: Q70 If Q69 = Yes

Skip To: End of Block If Q69 = No

Q70 Relocation considerations?

Never			Neutral				For Sure			
0	1	2	3	4	5	6	7	8	9	10

Do you consider relocating closer to your crew base
Will you be relocating closer to your crew base in the future

End of Block: Commuting Reasons

Start of Block: Pilot Self Assessment Commuters

Q71 Pilot Self Assessment

Think about your flights on days where you commuted to work.

1. Consider how well or badly you performed.
2. Examine the list of elements below; they are different ways of assessing performance.
3. Please rate yourself on the scales by marking your answer.

Remember, we are relying on you to make this as accurate of a scientific measure as possible.

The answers are 100% anonymous and confidential

-2 -1 0 1 2

Being ahead of the game:

Behind for 100% of flight Ahead for 100% of flight

Q72

Excess mental capacity:

No excess capacity during flights Plenty of excess capacity during flights

Q73

Coping with things that go wrong:

Coped very unsatisfactorily Coped very satisfactorily

Q74

Attaining self-set levels of performance:

Did not attain self-set of performance for flights Attained self-set levels of performance for flights

Q75

Smoothness and accuracy of approaches:

Very unsmooth & inaccurate approaches Very smooth & accurate approaches

Q76

Smoothness and accuracy of landings:

Very unsmooth & inaccurate landings Very smooth & accurate landings

Q77

Degree of basic airmanship exhibited:

Very low degree of basic airmanship Very high degree of basic airmanship

Q78	Overall smoothness of flights:	
	Very unsmooth	Very smooth
Q79	Quality of interpersonal relations with aircrew:	
	Low and unsatisfactory Quality	High and satisfactory quality
Q80	Degree of mental and physical coordination:	
	Very low degree of coordination	Very high degree of coordination
Q81	Number of errors made:	
	Relatively high number	Relatively low number
Q82	Extent of errors made:	
	Relatively high importance	Relatively low importance
Q83	Satisfaction with flights generally:	
	Very low degree of satisfaction	Very high degree of satisfaction
Q84	Ability to divide attention:	
	Very low ability	Very high ability
Q85	Many pilots when asked to assess the quality of their performance reply that it is "just a feeling" - can you assess yourself on a scale in this way?	
	Very poor	Very good

End of Block: Pilot Self Assessment Commuters

Start of Block: Intermediate Housing - NO Answer

Q86 Does your employer have a rostering systems incorporating crew commuting?

Yes / No / Not Sure

End of Block: Intermediate Housing - NO Answer

Start of Block: NON Commuter - Commuter Variables

Q87

Did you change your employer in the past to be based closer to your place of residency?

Yes / No

Q88 I would change my type of aircraft to be based closer to my place of residency?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q89 I would change my position (First Officer/Captain or vice versa) to be based closer to my place of residency?

e.g. Upgrading to commuter – Downgrading to Homebase

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q90 I would change my employer to be based closer to my place of residency?

Strongly agree / Agree / Neither agree nor disagree / Disagree / Strongly disagree

Q91 Would you like to reduce your work hours/days (part-time employment)?

I think about a permanent reduction / I think about a temporary reduction / I reduced the work hours in the past / I have reduced it / I'm not interested in reducing it

Skip To: Q93 If Q91 = I think about a permanent reduction

Skip To: Q93 If Q91 = I think about a temporary reduction

Skip To: Q92 If Q91 = I reduced the work hours in the past

Skip To: Q92 If Q91 = I have reduced it

Skip To: Q93 If Q91 = I'm not interested in reducing it

Q92 To what percentage did you reduce your working obligation/month?

0 25 50 75 100

Q93 Does your employer offer different cockpit crew bases?

Yes / No

Q94 Does your employer offer commuting benefits?

Yes / No

Skip To: Q95 If Q94 = Yes

Skip To: Q96 If Q94 = No

Q95 Which benefits are these?

(Multiple answers are possible)

Discounted travel tickets / Free travel tickets / Preferred rostering / Rostering bidding systems / Commuting contract / Other / None

Q96 Did you change your employer because of residential issues?

Yes / No, I think about it / No, there is no need for change

Q97 How important is the residential issue for changing the employer?

Very important / Somewhat important / Neither important nor unimportant / Somewhat unimportant / Very unimportant

Q98 Do you have a commuting history in your past pilot career?

Yes / No

End of Block: NON Commuter - Commuter Variables

Start of Block: Commuting Time / Distance NON - Commuters

Q99 How far is your residence from your pilot base (in KM):

0 500 >1000

Q100 How far is your residence from your pilot base in travel time:

Time in hh:mm

Q101 Are you using multiple forms of transport to commute to your pilot base (Car, Train, Bus, Aircraft, etc.)?

On a regular commute to your pilot base from your intermediate housing which form of transport do you use active or passive and what is the approximate time spent on each mode of transport

Active means as a driver of a car for example;

Passive means as a passenger of a bus for example

Please enter time in format hh:mm

Car / Bus / Tram / Metro / Aircraft / Train / Bike / Other

MINUTES (Passive /Active)

End of Block: Commuting Time / Distance NON - Commuters

Start of Block: Commuting Regulations Non-Commuters

Q102 Does your employer have procedures/protocols in their operations manual in place for pilots commuting to their base?

Yes / No / Not Sure

Q103 Does your employer have a rostering systems incorporating crew commuting?

Yes / No / Not Sure

End of Block: Commuting Regulations Non-Commuters

Start of Block: Stress NON - Commuters

Q104 How do you feel about your work travel?

Totally agree / Agree / Neither agree - nor disagree / Disagree / Totally disagree / Not applicable

Commuting impose stress on my life

Commuting imposes stress on my partner

Commuting leads to discussions in my relationship

Commuting limits the socialization time with my friends

Friends turned away from me because of my commuting/time issues

Commuting makes me think about the safety issues connected to my commuting

I think that commuting negatively influences the quality of my colleagues work

Commuting negatively influences my overall happiness

Q105 How satisfied are you with your life, all things considered?

completely dissatisfied

completely satisfied

End of Block: Stress NON - Commuters

Start of Block: Pilot Self Assessment Non Commuters

Q106 Pilot Self Assessment

Think about your flights on days where you commuted to work.

1. Consider how well or badly you performed.

2. Examine the list of elements below; they are different ways of assessing performance.

3. Please rate yourself on the scales by marking your answer.

Remember, we are relying on you to make this as accurate of a scientific measure as possible.

The answers are 100% anonymous and confidential

-2

-1

0

1

2

Being ahead of the game:

Behind for 100% of flight

Ahead for 100% of flight

Q107	Excess mental capacity:	No excess capacity during flights	Plenty of excess capacity during flights
Q108	Coping with things that go wrong:	Coped very unsatisfactorily	Coped very satisfactorily
Q109	Attaining self-set levels of performance:	Did not attain self-set of performance for flights	Attained self-set levels of performance for flights
Q110	Smoothness and accuracy of approaches:	Very unsmooth & inaccurate approaches:	Very smooth & accurate approaches:
Q111	Smoothness and accuracy of landings:	Very unsmooth & inaccurate landings	Very smooth & accurate landings
Q112	Degree of basic airmanship exhibited:	Very low degree of basic airmanship	Very high degree of basic airmanship
Q113	Overall smoothness of flights:	Very unsmooth	Very smooth
Q114	Quality of interpersonal relations with aircrew:	Low and unsatisfactory quality	High and satisfactory quality
Q115	Degree of mental and physical coordination:	Very low degree of coordination	Very high degree of coordination
Q116	Number of errors made:	Relatively high number	Relatively low number
Q117	Extent of errors made:	Relatively high importance	Relatively low importance
Q118	Satisfaction with flights generally:	Very low degree of satisfaction	Very high degree of satisfaction
Q119	Ability to divide attention:	Very low ability	Very high ability
Q120			

Many pilots when asked to assess the quality of their performance reply that it is "just a feeling" - can you assess yourself on a scale in this way?

Very poor

Very good

End of Block: Pilot Self Assessment Non Commuters

Show OFF:

We thank you for your participation!

&

For adding valuable information to our scientific research regarding European Airline Pilot Commuting.

Thank you for adding safety to our sky!

Please commute responsibly!

Yours sincerely,

Capt. Thomas M. Friesacher, MSc

Cranfield University, UK

www.pilot-commute.eu

Appendix B – Participant Consent Form

The participant confirms thorough the online participation in agreeing to participate in the *European Airline Pilot Commute Study – Time Series Follow Up Study 2020*.

Researcher: Thomas M. Friesacher, MSc

Researcher's contact details: Cranfield University
Martell House
Safety and Accident Investigation Centre
PhD Office
University Way
Cranfield, Bedford MK43 0TR
United Kingdom
Email:

University supervisor: Professor Dr Graham Braithwaite, Cranfield University

The participant understands that all personal information provided will be treated with the strictest confidence that all data remains anonymous.

Data will be used for research purposes; it will not be possible to identify any specific individual from the data reported as a result of this research.

The raw data will be accessible only to the researcher. All data collected will be stored in accordance with the UK Data Protection Act (1998) on a secure server located in the European Union, and at the researches secure and password protected Server accessible to the researcher only.

The participant is free to withdraw from this project at any stage during the online session by merely closing the browser. The participant also understands that it is possible to withdraw the provided data for a period of up to 7 days from the date of participation if the participants IP Address is provided, as after this time, the IP address will be removed. It will not be possible to identify individual data from the aggregated results.

Although you are free to decline to answer any questions for reasons of privacy, we would appreciate a response to all questions to generate maximum benefit from the research.

The participant confirms to have read and completely and fully understands the information provided via the electronically assessable participant consent form and therefore gives consent to taking part in this research.

Appendix C – CURES Approval



13 May 2020

Dear Capt Friesacher ,

Reference: CURES/11010/2020

Title: European Airline Pilot Commuting

Stress Aggregation and Pilot Performance Implications

Thank you for your application to the Cranfield University Research Ethics System (CURES).

We are pleased to inform you your CURES application, reference CURES/11010/2020 has been reviewed. You may now proceed with the research activities you have sought approval for.

If you have any queries, please contact CURES Support.

We wish you every success with your project.

Regards,

CURES Team

Appendix D – Tables & Figures

Rank	Airport	Airport distance	Reference point City Center	Shortest time travel - rail	Shortest time travel - bus	Travel time car/Taxi
1	London Heathrow	29.6	Waterloo Station	00:58	00:40	0:39
2	Paris Charles de Gaulle	21.2	Gare du Nord	00:28	01:13	0:22
3	Frankfurt	15.3	Hauptbahnhof	00:11	00:43	0:16
4	Madrid	16.0	Abcha	00:49	00:30	0:17
5	Amsterdam	20.6	Centraalstation	00:17	00:56	0:21
6	Rome Fiumicino	41.0	Termini Station	00:30	01:10	0:50
7	Munich	38.3	Hauptbahnhof	00:40	-	0:36
8	London Gatwick	45.5	Waterloo Station	00:42	01:05	0:59
9	Barcelona	13.4	Sants	00:17	00:30	0:19
10	Paris Orly	23.2	Gare du Nord	00:37	00:30	0:32
11	Dublin	13.1	Heuston Station		00:45	0:20
12	Palma de Mallorca	9.7	Placa Espanya		00:31	0:12
13	London Stansted	59.5	London Waterloo	01:06	01:45	1:02
14	Zurich	10.3	Hauptbahnhof	00:11	00:29	0:13
15	Copenhagen	13.2	Central Station	00:13	00:41	0:16
16	Manchester	15.5	Piccadilly Station	00:14	00:20	0:19
17	Vienna	21.7	Sudbahnhof	00:25	00:44	0:23
18	Oslo	50.1	Sentral stasjon	00:19	00:43	0:41
19	Mian Malpensa	50.6	Centrale	00:49	00:50	0:46
20	Brussels	13.7	Centraal	00:20	00:53	0:17
21	Stockholm Arlanda	42.0	Central Station	00:20	00:30	0:33
22	Dusseldorf	10.3	Hauptbahnhof	00:06	00:27	0:22
23	Athens	40.8	Larissis Station	00:42	-	0:39
24	Berlin Tegel	11.4	Hauptbahnhof		00:20	0:18
25	Lisbon	7.5	Santa Apolonia		00:39	0:14
26	Helsinki	19.3	Main Station		00:35	0:21
27	Hamburg	11.4	Hauptbahnhof	00:25	-	0:22
28	Malaga	10.2	Maria Zambrano	00:12	00:20	0:15
29	Prague	18.7	Hlavni Nadrazi		00:30	0:28
30	Geneva	6.3	Gare de Comavin	00:07	00:19	0:10

Table 45–Airport Accessibility by Rail for the 30 Largest Airports in the European Economic Area + Switzerland (2008)

Source: (Reichmuth, 2010) – Excerpt / Redesigned Friesacher.

Airport	Privat Car travel time - off peak	Privat Car travel time - peak	Metro Line to city center - Travel time	Rail express link - Travel time
	min.	min.	min.	min.
Amsterdam Schiphol airport	20	35		19
Barcelona Airport	20	30		25
Berlin-Schoenfeld airport	20	30		31
Bologna Marconi airport	15	30		
Brussels airport	22	42		20
Copenhagen Kastrup airport	20	20		13
Dublin Airport	20	30		
Dusseldorf airport	10	20		11
London Heathrow airport	60	80	47	16
Lyon-Saint Exupery airport	30	35		-
Madrid Bajanas airport	20	35	20	
Malaga airport	15	30		15
Manchester airport	20	30		20
Milan Malpensa airport	44	60		40
Munich airport	30	40		40
Paris Charles de Gaulle airport	42	55	39	
Toulouse Blagnac airport	15	20		
Vienna airport	20	40		25
Warsaw Okecie airport	15	40		

Table 46—Information Collected for All Airports—Excerpt I / Redesigned Friesacher

Source: (Vlieger, 2003b) – Excerpt / Redesigned Friesacher.

Airport	Bus City Centre - Travel time
	min.
Amsterdam Schiphol airport	30
Barcelona Airport	35
Berlin-Schoenefeld airport	
Bologna Marconi airport	30
Brussels airport	25
Copenhagen Kastrup airport	25
Dublin Airport	30
Dusseidorf airport	
London Heathrow airport	55
Lyon-Saint Exupery airport	30
Madrid Bajanas airport	30
Malaga airport	20
Manchester airport	25
Milan Malpensa airport	60
Munich airport	45
Paris Charles de Gaulle airport	50
Toulouse Blagnac airport	20
Vienna airport	30
Warsaw Okecie airport	40

Table 47—Information Collected for All Airports—Excerpt II

Source: (Vlieger, 2003b) – Excerpt / Redesigned Friesacher.

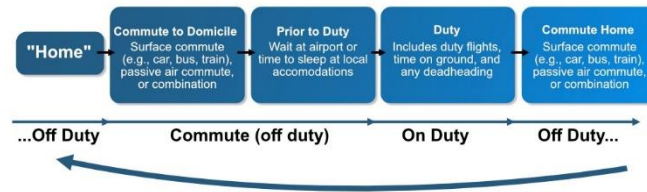


Figure 66—Outline of the Pilot Commuting Process

Source: National Research Council of the National Academies, 2011b - Excerpt / Redesigned Friesacher.

Latent	Indicator	Attribute	Measurement	Operationalization	Literature
Commuting Variables	Commuting distance	Exogenous		KM	developed from Novaco, Gonazalez and Gonzalez (2009), Koslowsky (1997)
	Commuting time	Exogenous	Metric	hh:mm	developed from Novaco, Gonazalez and Gonzalez (2009), Koslowsky (1997)
	Mode of transport / Time of mode	Exogenous		Mode/hh:mm	developed from Koslowsky (1997) , Orth,Frei and Weidmann (2015), Ettema et al. (2010)
Intermediate Housing	Form of housing	Exogenous	Nominal	Mode Choice	developed from Bennett, S.A. (2014)
	Sharing of intermediate housing	Exogenous	Nominal	Yes/No	developed from Bennett, S.A. (2014)
	Nr. of persons sharing	Exogenous	Metric	Number	developed from Bennett, S.A. (2014)
	Nr. of nights at intermediate housing	Exogenous	Metric	Number	developed from Bennett, S.A. (2014)
	Pay for housing	Exogenous	Nominal	Yes/No	developed from Bennett, S.A. (2014)
	Cost of housing	Exogenous	Ordinal	Amount	developed from Bennett, S.A. (2014)
Option of Choice	Option of choice used call in sick	Exogenous	Ordinal/Quasi	Likert Scale	developed from Jorens and Gillis, 2015; Reader, Parand and Kirwan, 2016;
	Option of choice used unfit to fly	Exogenous	Metric	Likert Scale	developed from Jorens and Gillis, 2015; Reader, Parand and Kirwan, 2016;
Commuting Regulation	Employee Commuting Procedures	Exogenous	Nominal	Yes/No/Not sure	developed from Bennett, S.A. (2014); Bennett, S.A. (2011); Cooper and Sloan, 1985;
	Status of knowledge employer/commuter	Exogenous	Nominal	Yes/No/Not sure	developed from Bourgeois-Bougrine, 2020; Reader, Parand and Kirwan, 2016; IATA, 2011
Fatigue Risk Management	Familiarity	Exogenous		Likert Scale	developed from Bourgeois-Bougrine, 2020; Reader, Parand and Kirwan, 2016; IATA, 2011
	Mandated System	Exogenous		Likert Scale	developed from IATA, 2011; EASA, 2017
	Industry Standard	Exogenous	Ordinal/Quasi	Likert Scale	developed from IATA, 2011; EASA, 2017; Jorens and Gillis, 2015
	System Responsibility	Exogenous	Metric	Likert Scale	developed from IATA, 2011; EASA, 2017
	Commuting mandatory managed system	Exogenous		Likert Scale	developed from IATA, 2011; EASA, 2017

Table 48—Operational Definitions of Study Control Variables

Latent	Indicator	Attribute	Measurement	Operationalization	Literature
Demographic Variables	Sex	Control	Nominal	Male, Female	developed from Sloan and Cooper, 1986; Bennett, S.A. (2011)
	Age	Control	Metric	Years	developed from Sloan and Cooper, 1986; Bennett, S.A. (2011)
	Personal status	Control	Nominal	Selection of Status	developed from Sloan and Cooper, 1986; Bennett, S.A. (2011)
	Prior divorcement	Control	Nominal	Yes/No	developed from Sloan and Cooper, 1986
	Number of own Children	Control	Metric	Selection of number	developed from Schwanen, Dieleman and Dijst, 2004; Sloan and Cooper, 1986
	Dependent children living in household	Control	Metric	Selection of number	developed from Sloan and Cooper, 1986
	Age of youngest Child in household (Compulsory) in years	Control	Metric	Selection of years	developed from Sloan and Cooper, 1986
	Country of residency	Control	Nominal	Selection of country	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Form of Housing at Place of Residence	Control	Nominal	Selection of mode	developed from Green, Hogarth and Shackleton, 1999; Lorenz, 2018; Sloan and Cooper, 1986
	Mode of Housing	Control	Nominal	Selection of mode	developed from Green, Hogarth and Shackleton, 1999; Lorenz, 2018; Sloan and Cooper, 1986
	Country of Operator	Control	Nominal	Selection of country	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Country of Crew base	Control	Nominal	Selection of country	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Airline	Control	Nominal	Typing of two letter code	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Type of Airline	Control	Nominal	Selection of choice	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Operation Schedule	Control	Nominal	Selection of choice	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Personal Type of Operation	Control	Nominal	Selection of choice	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Job Position	Control	Ordinal	Selection of choice	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Total Time of Pilot Employment in years	Control	Metric	Selection of years	developed from Sloan and Cooper, 1986; Jorens and Gillis, 2015
Commuter / Non commuter	Time	Control	Nominal	Yes/No	developed from Sloan and Cooper, 1986; Bennett, S.A. (2011); EASA, 2020
Intermediate Housing	Divider Question	Control	Nominal	Yes/No	developed from Bennett, S.A. (2014); Sloan and Cooper, 1986; NRCNA, 2011a
Locus of Control	Approximate Total Flight Time in total hours	Control	Ordinal	Selection of hours	developed from Bennett, S.A. (2014); Sloan and Cooper, 1986; NRCNA, 2011a

Table 49—Operational Definitions of Exogen Variables

Latent	Indicator	Attribute	Measurement	Operationalization	Literature
Locus of Control	Frequency of commute	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	developed from You, Ji and Han, 2013; Bennett, S.A. (2014);
	Long term commute planning strategy	Endogenous			developed from Venus et al., 2022; Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986; Bennett, S.A. (2014)
	Problems during Commute	Endogenous			developed from Ye and Titheridge, 2017;
	Change of strategy (cancellations/problems)	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Call in Sick Strategy	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016;
Turnover Intention	Unfit to Fly Strategy	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	developed from Jorens and Gillis, 2015; Reader et al., 2016;
	Number previous pilot jobs	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Years current employer	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Change of aircraft - willingness	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986;
	Change of position - willingness	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986;
Commuting Stress	Change of employer - willingness	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	developed from Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986;
	Change of employer - history	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986;
	Change of employer - residential	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016; Sloan and Cooper, 1986;
	Feeling about commute	Endogenous			developed from Bennett, S.A. (2014); Sloan and Cooper, 1986; Cooper and Sloan, 1985;
	Stress on life	Endogenous			developed from Bennett, S.A. (2014); Sloan and Cooper, 1986; Cooper and Sloan, 1985;
Safety Behaviour	Stress on partner	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Discussions in relationship	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Socialisation time friends	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Friends turned away	Endogenous			developed from Cooper and Sloan, 1985; Bennett, S.A. (2014)
	Safety issues connected	Endogenous			developed from Jorens and Gillis, 2015; Reader et al., 2016
Safety Behaviour	Quality of colleagues work	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	developed from Reader et al., 2016; Sloan and Cooper, 1986; Jorens and Gillis, 2015
	Life happiness	Endogenous			developed from Olsson et al., 2013; Stutzer and Frey, 2008; Lorenz, 2018; ONS, 2014
	Feelings about commute	Endogenous			Sloan and Cooper, 1986;
	Discussions in my relationship	Endogenous			Sloan and Cooper, 1986;
	Socialisation time with my friends	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Safety issues connected to my commuting	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a total number or likert scale	Sloan and Cooper, 1986;
	Quality of my colleagues work	Endogenous			Sloan and Cooper, 1986;
	Degree of basic airmanship	Endogenous			Sloan and Cooper, 1986;
	Number of errors made	Endogenous			Sloan and Cooper, 1986;
	Extent of errors made	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Quality of interpersonal relations	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a likert scale ranging from "-2" via "0" to "+2" - Scale taken from original Sloan & Cooper test (1986)	Sloan and Cooper, 1986;
	Feeling about pilot performance	Endogenous			Sloan and Cooper, 1986;
	Influences a pilot's professional performance	Endogenous			Sloan and Cooper, 1986;
	Effect on commuting pilot performance	Endogenous			Sloan and Cooper, 1986;
	Personal professional performance influence	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Tiredness	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a likert scale ranging from "-2" via "0" to "+2" - Scale taken from original Sloan & Cooper test (1986)	Sloan and Cooper, 1986;
	Safety issues connected	Endogenous			Sloan and Cooper, 1986;
	Disregarded of procedures	Endogenous			Sloan and Cooper, 1986;
	Feelings about commute	Endogenous			Sloan and Cooper, 1986;
	Discussions in my relationship	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Socialisation time with my friends	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a likert scale ranging from "-2" via "0" to "+2" - Scale taken from original Sloan & Cooper test (1986)	Sloan and Cooper, 1986;
	Safety issues connected to my commuting	Endogenous			Sloan and Cooper, 1986;
	Quality of my colleagues work	Endogenous			Sloan and Cooper, 1986;
	Degree of basic airmanship	Endogenous			Sloan and Cooper, 1986;
	Number of errors made	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Extent of errors made	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a likert scale ranging from "-2" via "0" to "+2" - Scale taken from original Sloan & Cooper test (1986)	Sloan and Cooper, 1986;
	Quality of interpersonal relations	Endogenous			Sloan and Cooper, 1986;
	Feeling about pilot performance	Endogenous			Sloan and Cooper, 1986;
	Influences a pilot's professional performance	Endogenous			Sloan and Cooper, 1986;
	Effect on commuting pilot performance	Endogenous			Sloan and Cooper, 1986;
Safety Behaviour	Personal professional performance influence	Endogenous	Ordinal/ Quasi Metric	Pilots are invited to indicate their extent to which they experience the question or make use of the indicated variable using a likert scale ranging from "-2" via "0" to "+2" - Scale taken from original Sloan & Cooper test (1986)	Sloan and Cooper, 1986;
	Tiredness	Endogenous			Sloan and Cooper, 1986;
	Safety issues connected	Endogenous			Sloan and Cooper, 1986;
	Feelings about commute	Endogenous			Sloan and Cooper, 1986;
	Discussions in my relationship	Endogenous			Sloan and Cooper, 1986;

Table 50—Operational Definitions of Endogen Variables

Nr. Question	
Q65/104	<p>How do you feel about your commute?</p> <ul style="list-style-type: none"> • Commuting imposes stress on my life. • Commuting imposes stress on my partner. • Commuting leads to discussions in my relationship. • Commuting limits the socialisation time with my friends. • Friends turned away from me because of my commuting/time issues. • Commuting makes me think about the safety issues connected to my commuting. • I think that commuting negatively influences the quality of my colleagues' work. • Commuting influences my overall life happiness.

Table 51–Assigned Commuting Stress Questions

Nr. Question	
Q71/Q106	<p>Pilot self assessment :</p> <ul style="list-style-type: none"> • Commuting imposes stress on my life. • Commuting imposes stress on my partner. • Commuting leads to discussions in my relationship. • Commuting limits the socialisation time with my friends. • Friends turned away from me because of my commuting/time issues. • Commuting makes me think about the safety issues connected to my commuting. • I think that commuting negatively influences the quality of my colleagues' work. • Commuting influences my overall life happiness.

Table 52–Assigned Pilot Performance Questions

Nr. Question	
Q42	How often per month, in an average duty schedule do you commute to your place of residence?
Q43	How often do you experience problems in your commute? (traffic jams, delays, flight cancellations, no seat available, etc.)
Q44	How often do you have to cancel/change your commute plan?
Q62	I have used the 'call in sick' possibility in the past to cover for commuting issues.
Q63	I have declared myself 'unfit to fly' because of commuting issues.

Table 53–Assigned Locus of Control Questions

Nr. Question	
Q19	Number of previous pilot jobs?
Q20	Years with current employers?
Q23/Q88	I would change my type of aircraft to be based closer to my place or residence
Q25/Q90	I would change my employer to be based closer to my place of residence
Q31/Q96	Did you change your employer due to residential issues?
Q32/Q96	Did you change your employer due to residential issues?
Q32/Q97	How important are residential issues for changing your employer?
Q34/Q98	Do you have a commuting history in your past pilot career?
Q35/(Q54)/Q99	How far is your residence from your pilot base (in km)?

Table 54–Assigned Turnover Intention Questions

Nr. Question	
Q65/Q104	<p>How do you feel about the commute?</p> <ul style="list-style-type: none"> • Commuting imposes stress on my life. • Commuting imposes stress on my partner. • Commuting leads to discussions in my relationship. • Commuting limits the socialisation time with my friends. • Friends turned away from me because of my commuting/time issues. • Commuting makes me think about the safety issues connected to my commuting. • I think that commuting negatively influences the quality of my colleagues' work. • Commuting influences my overall life happiness.
Q85/Q120	<p>Many pilots when asked to assess the quality of their performance replied that is 'just feeling'; can you assess yourself on a scale in this way?</p>
Q64	<p>Safety concern about commuting :</p> <ul style="list-style-type: none"> • I think that commuting negatively influences a pilot's professional performance. • On commuting days I sometimes see some negative effect of the commuting on the commuting pilot performance. • My personal professional performance has been influenced negatively by commuting issues. • On some commuting days I am generally more tired than on other days. • I think about the safety issues connected with my commuting. • I think that commuting negatively influences a pilot's professional performance. • I have occasionally disregarded company procedures (check your procedures, etc.) to meet my commuting plans. • I have occasionally disregarded safety issues to meet my commuting plans

Table 55—Assigned Safety Behaviour Questions

Nr. Question	
Q2	What is your gender?
Q3	What is your age?
Q4	Which of the following best describes your relationship status?
Q5	Dependent children living in household
Q6	Number of own children
Q7	Age of youngest child in household (in years), country of residence
Q8	Country of residence
Q9	Form of housing at place of residence
Q10	Mode of housing
Q11	Country of operator
Q12	Country of crew base
Q13	What airline do you work for?
Q14	Type of airline
Q15	Operation schedule
Q16	Personal type of operation
Q17	Job position
Q18	Total time of pilot employment in years
Q21	Apporximate total flight time

Table 56—Assigned Control Variables Questions

Nr. Question	
Q35/Q99	How far is your residence from your pilot base (in km)?
Q36/Q100	How far is your residence from your pilot base in travel time?
Q37/Q54/ Q101	Are you using multipte forms of transport to commute to your pilot base (car, train, bus, aircraft, etc.)?

Table 57—Assigned Commuting Variables Questions

Standard: Welcome Message (1 Question)
Standard: Biographical Data (6 Questions)
Standard: Housing (3 Questions)
Standard: Geographical Information (11 Questions)
Standard: Commuter/Non–Commuter Divider (1 Question)

Branch: New Branch

If

If Are you commuting to your pilot base from outside a travel radius of 45 minutes? Pilot Base is... YES Is Selected

Block: Commuter Part (12 Questions)
Standard: Commuting Time/Distance (3 Questions)
Standard: Resting Facilities (4 Questions)
Standard: Frequency of Commute (3 Questions)
Standard: Commuting Costs (2 Questions)
Standard: Intermediate Housing Facility Separator Question (1 Question)

Branch: New Branch

If

If Do you use an intermediate housing facility at your home base? An intermediate housing facility... Yes Is Selected

Standard: Intermediate Housing (9 Questions)
Block: Commuting Rules & Regulations (2 Questions)
Standard: Fatigue Risk Management (3 Questions)
Standard: Call in Sick/Unfit to Fly (2 Questions)
Standard: Personal safety Concerns of Commuting (1 Question)
Block: Stress Commuters (2 Questions)
Block: Commuting Reasons (4 Questions)
Block: Pilot Self-Assessment Commuters (15 Questions)

Branch: New Branch

If

If Do you use an intermediate housing facility at your home base? An intermediate housing facility... No Is Selected

Or Do you use an intermediate housing facility at your home base? An intermediate housing facility... I did in the past Is Selected

Standard: Intermediate Housing–NO Answer (1 Question)
Standard: Fatigue Risk Management (3 Questions)
Standard: Call in Sick/Unfit to Fly (2 Questions)
Standard: Personal Safety Concerns of Commuting (1 Question)
Standard: Stress Commuters (2 Questions)
Standard: Commuting Reasons (4 Questions)
Standard: Pilot Self-Assessment Commuters (15 Questions)

Branch: New Branch

If

If Are you commuting to your pilot base from outside a travel radius of 45 minutes? Pilot Base is... NO Is Selected

Standard: Non-Commuter–Commuter Variables (12 Questions)

Standard: Commuting Time/Distance Non-Commuters (3 Questions)

Standard: Commuting Regulations Non-Commuters (2 Questions)

Standard: Fatigue Risk Management (3 Questions)

Standard: Call in Sick/Unfit to Fly (2 Questions)

Standard: Personal safety concerns of commuting (1 Question)

Standard: Stress Non-Commuters (2 Questions)

Standard: Pilot Self-Assessment Non-Commuters (15 Questions)

Table 58–European Airline Pilot Commute Study 2020 Question Flow