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A QUALITATIVE STUDY ON THE EXPLORATION OF SAFETY HAZARDS RELATED TO THE OUTSOURCING OF AIRCRAFT MAINTENANCE¹

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ABSTRACT

This study sets out to investigate the hazards, root causes and outcomes associated with the outsourcing of aircraft maintenance, and to investigate how and why these hazards compromise safety. For the purpose of the study, questionnaires consisting of open-ended questions were used to collect qualitative data from technicians and engineers who participate in outsourcing processes, and who were selected through purposive sampling. An inductive qualitative analysis method was used to analyze the qualitative research data. The research results suggest that airlines see the outsourcing of aircraft maintenance to another party as an effective way of reducing costs. With cost being the main factor in the selection of a maintenance, repair and overhaul (MRO) company, MRO providers are under serious pressure to reduce costs as this is the major competitive advantage in the MRO market. These factors create a wide range of safety hazards. Furthermore, outsourcing causes disorganization in the production of aircraft maintenance activities and in the organizational structure of parties. This also gives rise to safety hazards.

Key words: Outsourcing, Aircraft Maintenance, Aviation Safety, Safety Hazards.

JEL Codes: R41, J28, L93, M55

HAVA ARACI BAKIM FAALİYETLERİNDE DIŞ KAYNAK KULLANIMIYLA İLGİLİ EMNİYET TEHLİKELERİNİN BELİRLENMESİNE YÖNELİK NİTEL BİR ÇALIŞMA

ÖZ

Çalışmada hava aracı bakım faaliyetlerinin dış kaynaklardan tedarik edilmesi durumunda bu yöntemle özgü olarak ortaya çıkması muhtemel emniyet tehlikeleri, söz konusu tehlikelerin kaynaklarının ve sonuçlarının neler olabileceği, emniyeti neden ve nasıl tehdit edecekleri araştırılmıştır. Çalışmada açık uçlu anketler aracılığıyla, amaçlı örneklem yoluyla seçilmiş bu sürece hakim olan teknisyen ve mühendislerden nitel veri

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toplanmıştır. Veriler tümevarımsal nitel analiz yöntemiyle analiz edilmiştir. Havayolu işletmelerinin bakım faaliyetlerini dış kaynaklardan tedarik etme maliyetleri azaltmanın önemli bir aracı olarak gördükleri, MRO'ların sunacağı fiyatın en önemli seçim ölçütü olduğu, MRO pazarında fiyatın temel rekabet aracı olduğundan MRO'ların önemli maliyet azaltma baskılarına uğradıkları ve bunların çeşitli emniyet tehlikeleri yarattığı tespit edilmiştir. Ayrıca dış kayna kullanımı bakım faaliyetlerin üretilmesi süreçlerinin ve bu faaliyetleri üreten örgütsel yapıların parçalanmasına neden olarak emniyet tehlikeleri yaratmaktadır.

Anahtar Kelimeler: *Dış Kaynak Kullanımı, Hava Aracı Bakım Faaliyetleri, Havacılık Emniyeti, Emniyet Tehlikeleri.*

JEL Kodları: *R41, J28, L93, M55*

1. INTRODUCTION

Increased competition on a global scale in the airline industry and diminishing profit margins have led airlines with high operational costs to adopt new management approaches. One of these approaches is reducing costs by focusing on core competencies and outsourcing the operations that remain out of the scope of its field of operation (Doganis, 2006). Outsourcing aircraft maintenance provides the advantages of primarily lowering costs, boosting effectiveness and efficiency, enhancing core competencies, and gaining competitive advantages (Ghobrial, 2005: 463-470; Quinlan et al., 2013: 284). Therefore, a growing number of airlines today opt for the outsourcing of aircraft maintenance, which is a highly specialized field of operation (FAA, 2009: 2; Czepiel, 2003: 2-1; Rieple and Helm, 2008: 281).

The effectiveness of aircraft maintenance affects aircraft productivity, direct operating costs, on-time performance and undoubtedly the aviation safety of airlines. When aircraft maintenance, a critical function of an airline, is not conducted as part of the organizational hierarchy, the hierarchical control of the airline regarding safety is likely to reduce (Rieple and Helm, 2008:281; Drury and Guy, 2010:126; Ghobrial, 2005:470-473). Consequently outsourcing inherently poses potential hazards that may adversely impact aviation safety (Quinlan et al., 2013). A lower level of aviation safety performance not only jeopardizes expected outcomes of air transport, but also engenders substantial costs in economic and social terms. Furthermore, outsourcing does not remove the accountability of airline organizations with regard to ensuring safety. Safety accountability cannot be transferred to MRO providers (Czepiel, 2003:21). The 1996 crash of ValuJet Flight 592 attracted the attention of regulatory authorities and researchers by creating the idea that outsourcing maintenance poses certain potential hazards (Drury and Guy, 2010:130).

The aim of this study is to identify potential hazards that are likely to have a negative impact on aviation safety, how and why these hazards arise, and how and why these hazards affect aviation safety. A secondary aim of the study is to discover which hazards have the greatest potential to compromise aviation safety. The findings may contribute to the development of risk-mitigating measures and to the enhancement of safety.

2. LITERATURE REVIEW

Aircraft maintenance is one of the fields of operation that has a significant impact on aviation safety. Human beings who are prone to error carry out maintenance planning and practice. Human error may reduce the reliability of aircraft systems and create safety risks. Factors that affect human performance are similar regardless of whether aircraft maintenance operations are carried out in-house by the airline itself or by another MRO organization. However, it is asserted that hazards are likely to occur if an airline chooses outsourcing, and thereby losing control over a field of operation that has a direct impact on safety (Drury and Guy, 2010:126; Sedatolite et al. 2012). Organizations that resort to outsourcing lose control over certain factors within their organizational context. When aircraft maintenance operations, which include critical processes regarding safety, are carried out by an outside organization, there is a need for effective planning, coordination, communication and auditing between service provider and buyer (Useem and Harder, 2000:29). When the effectiveness of these operations decreases for any reason, various hazards inevitably occur. Previous research has generally concentrated on a loss of control over aircraft maintenance operations and problems related to coordination and communication required between two organizations that have shared the aircraft maintenance production function.

Drury and Guy (2010) contend that the need for coordination in outsourcing requires effective communication, and that even minor flaws in communication may impair the exchange of information between organizations. MROs need to communicate with several airlines to exchange information. As the number of airlines to which they provide maintenance services increases, communication inevitably becomes more complicated. In this respect, any problems that are likely to arise in the exchange of information have the potential to directly influence safety. Drury and Guy (2010) argue that documentation procedures in outsourcing are prone to errors, and that violations may occur as the airline has only limited control over quality assurance practices in the MRO. Moreover, given that MRO providers carry out maintenance operations for various types of aircraft, the wide variety and large volume of documentation may also pose a significant safety hazard. Monaghan (2011), Czepiel, (2003)

and Franco (2008) deal with the fact that regulatory authorities cannot adequately audit MRO providers outside the country. The rationale behind foreign-based outsourcing of maintenance is a greater cutting of operational costs. In other words, airlines see outsourcing as a tool for achieving lower operational costs.

Czepiel (2013) asserts that the quality assurance teams and aircraft maintenance technicians of airlines that outsource maintenance operations have greater commitment to safety than the staff of MRO providers.

Quinlan et al. (2013) who conducted one of the most comprehensive studies on whether outsourcing aircraft maintenance operations cause safety hazards, report that disorganization, (i.e. division of maintenance operations between two organizations), causes flaws in communication and information exchange, impairment in the quality and quantity of training and supervision/oversight, breakdowns in procedures and safety critical systems and, as a result, a malfunctioning of the safety management system (SMS) in general. According to Quinlan et al. (2013), other potential hazards include failure in regulatory oversight of MRO providers and financial pressure on outsourcing organizations as well as the MRO providers.

Murray (2009) in the United States conducted another relevant study. The research sought to understand the relationship between outsourcing aircraft maintenance and passengers perception of aviation safety, and whether outsourcing aircraft maintenance is a factor that affects passenger's airline preference. The results indicate that passengers find airlines that do not outsource aircraft maintenance safer than other airlines, are willing to pay higher ticket fares to airlines that do not outsource maintenance operations, and tend to prefer airlines that do not outsource maintenance operations. Passengers also believe that maintenance quality is impaired when airlines resort to outsourcing for maintenance operations. These findings are noteworthy.

In another study conducted in the United States, McCamey (2010) focused on the relationship between outsourcing of aircraft maintenance and job satisfaction of maintenance personnel. The study shows that the motive behind the desire of airlines to outsource aircraft maintenance is to achieve a cost advantage. However, because of outsourcing, aircraft maintenance technicians and safety professionals of airlines are made unemployed. The study underlines that outsourcing may lead to a general dissatisfaction among aviation professionals and thereby, reduce employee motivation as well as reducing the competitive advantage of an airline, with indirect negative effects on aviation safety.

McCamey et al. (2009) carried out research in Norway to investigate problems created by outsourcing maintenance operations in the airline industry. The results suggest that airlines do not make thorough analyses of technical conditions and competencies of maintenance organizations, that technicians employed in MRO providers are not as competent or equipped as professionals employed within an airline, and that quality and safety professionals in MRO providers have insufficient knowledge of procedures. The researchers note that there is a need to develop an effective communication mechanism, detect factors that are likely to affect safety, and audit outsourcing processes effectively to ensure the success of outsourcing. The study further recommends that the performance of auditors and professionals involved in outsourcing must be monitored more closely in order to enhance safety in outsourcing.

3. METHODOLOGY

This study is based on qualitative research design, which ensures multidimensional and in-depth exploration and understanding of a problem or a subject (Creswell, 2013) considering that qualitative research provides an effective way of detecting specific hazards caused by outsourcing. Qualitative data was collected by means of a questionnaire consisting of open-ended questions. The qualitative research data was analyzed through the inductive method; a qualitative analysis method (Patton, 2002). Inductive analysis requires extracting patterns (categories) and themes based on a single data set (Patton, 2002). One crucial step of inductive analysis is data coding (Glesne, 2013). Codes are names or labels that allow researchers to draw inferences from raw data or turn raw data into explanatory units. These codes may be in the form of words, sentences or paragraphs (Miles and Huberman, 1994). The purpose of coding is to bring together interrelated codes in order to generate a common idea, and hence, to obtain more comprehensive themes through inductive progress (Creswell, 2013).

Airlines and their aircraft maintenance departments, certified in accordance with regulation SHY-145, are organizations which fall under the scope of this study. Purposive sampling was used to select participants from these organizations. Participants included engineers, technicians and managers that facilitate communication and coordination, in other words those who function as airline representatives, between an MRO and an airline. They take part in maintenance processes to ensure that maintenance procedures are completed appropriately when maintenance activities, such as C and D checks, engine maintenance and structural repairs are outsourced. Participants were expected to have thorough knowledge of the processes. Table 1 presents demographic data related to those participants who completed the questionnaire.

Table 1: Demographic Data Related to Survey Participants

	Women	Men			
Gender	2	22			
	20-30	31-40	41-50	51-60	61 and Over
Age	4	15	4	1	0
	Undergraduate	Master Degree	PhD	Other	
Education	17	2	0	5	
	0-5	6-10	11-16	17-22	23 and Over
Length of Experience	4	8	5	2	5
	Documentation Engineer	Systems Engineer	Maintenance Planning Engineer	Chief Engineer	Director of Engineering
Position	2	2	4	1	3
	Quality SMS Director	Technical Training Chief	Maintenance Director	Aircraft Technician	
	1	1	1	9	

Qualitative research is advantageous especially when the theoretical literature that prepares the ground for a research topic is inadequate (Creswell, 2002:35). For the purpose of this study, the researchers developed a questionnaire consisting of open-ended questions in order to obtain in-depth knowledge of the research topic. Where questions were not structured, a participant was able to answer questions freely, allowing researchers to get unexpected and unplanned replies and thus to have in-depth knowledge of the topic. The open-ended questions were sent to participants e-mail addresses. The questions formulated in accordance with research questions and sent to participants are as follows:

What do you think are the factors (problems) that are likely to affect aviation safety when aircraft maintenance operations are outsourced? Please explain and justify your answer. Why do these factors (problems) affect aviation safety (What makes them affect aviation safety)?

Which of the factors you mentioned are the most important? Please list them in order of importance and explain your reasoning.

27 participants completed and returned questionnaires. As three of these were incomplete, only 24 questionnaire forms were included in the study. To begin with, each of the

two researchers read the 24 questionnaire forms three times individually, trying to understand the participants responses. With a view to strengthening the validity of the study, the researchers first coded the data individually, and then came together to discuss the codes. They agreed upon a final list of codes following a conferring process. The researchers worked individually to inter relate codes in order to obtain categories from the codes, and themes from the categories. Analyses of two researchers were compared. The researchers then discussed differences in the analyses and came to an agreement on the final list. Another researcher, specializing in qualitative research, also participated in this process as an observer and consultant.

4. FINDINGS AND DISCUSSION

4.1. Hazards of Outsourcing Aircraft Maintenance

The codes that point to specific safety hazards of outsourcing aircraft maintenance were interrelated through inductive thematic analyses to obtain subcategories, categories, and finally three comprehensive themes. These components are presented in Table 2.

Table 2: Themes and Categories

1.Airline’s View of Outsourcing as a Cost Reduction Tool
1.1.Considering maintenance cost as the main criterion in selecting an MRO provider
1.2.Putting time pressure on the MRO provider
1.3.Disregarding unscheduled maintenance requirements detected by the MRO provider
2.Price is the major factor ensuring competitive advantage for MRO providers
1.1.Seeking to reduce stock costs
2.2.Seeking to reduce workforce costs
1.2.1.Employment of unqualified personnel
1.2.2.Inadequate number of approving personnel
1.3.Efforts to enhance productivity
1.3.1.Increasing workforce productivity
1.3.2.Efforts to increase maintenance slots
1.4.Seeking to reduce equipment costs
1.5.Seeking to create economies of scale and scope
1.5.1.Search to provide maintenance for different types of aircraft
1.5.2.Pressure to find new customers (rapid certification)
1.5.3.Search for customer loyalty
3.The function of production is shared between two organizations
3.1.Decreased control of airlines over maintenance
3.1.1.Emergence of information asymmetry
3.1.2.Decrease in effectiveness of airline’s quality assurance function
3.1.3.Decrease in effectiveness of SMS
3.2.Outsourcing requires effective communication and coordination
3.2.1.Supply problems between MRO provider and customer airline
3.2.2.Problems in the transfer of maintenance work packages
3.2.3.MRO provider’s insufficient knowledge of maintenance procedures
3.2.4.Division of the function of up-to-date documentation and record keeping
3.2.5.Problems regarding safety reporting between airline and MRO provider
3.2.6.Problems regarding the quality and quantity of representatives
3.3.An MRO provider sees accountability as a secondary function
3.4.Differentiation in organizational cultures

4.1.1. Airlines View of Outsourcing as a Cost Reduction Tool

One main finding of the qualitative data analysis is that airlines see outsourcing as an effective tool for cost reduction, and generally resort to outsourcing for this reason. This finding is compatible with the findings of other studies mentioned in the literature review section. When the only or the major criterion for resorting to outsourcing is cost reduction, certain factors that compromise safety are likely to emerge. An airline that outsources aircraft maintenance for cost reduction purposes may put time, cost pressure on an MRO, and tend to ignore unscheduled maintenance tasks noticed during this maintenance process. The categories that led researchers to this theme in inductive analysis are explained below.

4.1.1.1. Considering Maintenance Cost as the Main Criterion in Selecting an MRO Provider

Inductive qualitative analysis suggests that the major criterion considered by airlines in selecting an MRO provider is the cost of aircraft maintenance service introduced by MROs. The exclusion of other criteria, e.g. effectiveness of maintenance operations, safety performance, effective quality assurance and a safety management system, qualitative and quantitative sufficiency of human resources and maintenance equipment, is a factor that potentially compromises safety. P20, P18 and P12 commented on this as follows:

P20: Airline representatives should not put pressure on MRO providers to lower extra costs that arise in routine procedures. If extra findings cause delay in base maintenance, this brings further pressure on MRO providers. Generally, when an extra defect is detected in visual inspection, the airline representative objects to the finding and tries to have it cancelled on the grounds that it was not included in the visual inspection package. The pressure related to costs leads to certain concessions. An MRO provider generally gives in to pressure and cancels the finding. A lowcost maintenance invoice is a factor that prevents customer attrition, and guarantees the following C check reservation.

P18: Contracting out maintenance to a third party may sometimes provide organizations with monetary gain, but safety is questionable in this case. You probably know the proverb: "If you buy cheaply, you pay dearly."

P12: Airlines want cheaper maintenance. They send aircraft to maintenance service providers where quality is questionable.

4.1.1.2. Putting Time Pressure on the MRO Provider

Lower maintenance service cost is a significant factor that affects airlines' MRO provider selection. When airlines choose MRO providers, taking account of maintenance

service cost, they put time pressure on MROs during the process of both contract making and maintenance operations. P9 and P19 made the following comments about time pressure:

P9: Aircraft operators' organizations that own the aircraft, limit the time allocated for maintenance, and speed up maintenance operations inevitably leads to errors...

P19: Time limitations insisted on by aircraft operators cause MROs to work hastily and make errors, and to leave maintenance incomplete, but report as if it was complete.

It is not unexpected that airlines, seeing outsourcing as a cost reduction tool, want maintenance work packages to be completed rapidly so that they can start operational flights. Daily and annual utilization of aircraft is a major indicator of aircraft productivity (Belobaba, 2009). In order for airlines to lower unit costs, aircraft, with high purchase and operational costs, must be operating and hence producing rather than remaining idle on the ground.

Pressure on MRO providers to speed up maintenance creates time pressure on MRO technicians and managers. Time pressure is not only a significant stress factor, but also a potential cause of error as it impairs attention, perception and decision-making skills (ICAO, 2002; ICAO, 2003; UK CAA, 2002). Furthermore, when accompanied by other negative factors, such as low safety commitment, time pressure is likely to cause violations (Reason, 2008; UK CAA, 2002; Hobbs, 2008). P2, P5 and P16 pointed out the impact of time pressure on MRO providers:

P5: Another hazard is that an MRO provider tries to meet the deadline rather than achieve quality objectives when maintenance a completion date is predetermined. This may cause errors and impairment of quality assurance in maintenance operations.

P2: Among the most important problems are putting time pressure on staff and punishing them when human error occurs.

P16: 'Commercial and time pressure' placed on MRO providers by airlines: Maintenance contracts signed with an MRO provider generally includes rates per man hour. When there is a finding that may take time to address, consent of the customer is required. At this point, the customer's attitude towards aircraft maintenance is important. It is important whether the airline principally prioritizes safety or economy. Time is essential for an airline with a weak fleet. Airlines that do not have substitute aircraft in their fleets may have difficulty when ground time due to maintenance extends. This may have negative effects on the finances and prestige of the organization. In such a case, the airline may prefer another MRO provider

for subsequent maintenance. Time pressure also affects the MRO provider. Personnel working for the MRO provider may feel under different types of pressure.

4.1.1.3. Disregarding Unscheduled Maintenance Requirements Detected by the MRO Provider

Participant's accounts suggest that airlines that outsource scheduled maintenance of aircraft may disregard unscheduled maintenance requirements that become apparent during checks and inspections in order to lower costs and make aircraft ready for flight as soon as possible.

Detecting unscheduled maintenance requirements may seem to favor an MRO provider as this increases their revenue. However, airlines may prefer to change the MRO provider for the next maintenance check as they generally aim to operate aircraft as soon as possible and reduce maintenance costs. On the other hand, for an MRO provider, taking aircraft with maintenance completed from hangar and acquiring additional slots for other aircraft means a potential increase in revenue. The findings of the qualitative analysis suggest that both parties have agreed upon a silent compromise for the disregard of 'unscheduled maintenance requirements'. P20 and P16 drew attention to this issue with the following statements:

***P20:** Under today's circumstances, where all sorts of costs have been minimized, package contracts are signed for scheduled maintenance in base maintenance. On the one hand, MRO providers try to gain extrafinancial advantage from maintenance requirements not included in the package through hourly payment per person and materials used. On the other hand, airline representatives try to force MRO providers not to find extra requirements and not to increase maintenance costs. If extra findings cause delay in the completion of maintenance, this leads to further pressure on MRO providers. Generally, when an extra defect is detected through visual inspection, the airline representative objects to the finding and tries to have it cancelled on the grounds that it was not included in the work packages. The pressure related to costs leads to certain concessions. An MRO provider generally gives in to pressure and cancels the finding. Low cost of maintenance is a factor that prevents customer attrition, and guarantees the following C check reservation.*

***P16:** Maintenance contracts signed with an MRO provider generally include rates per man hour. When there is a finding that may take a long time to address, consent of the customer*

is required. At this point, the customer's attitude towards aircraft maintenance is important. It is important whether the organization principally prioritizes safety or economy.

4.1.2. Price is the Major Factor Ensuring Competitive Advantage for MRO Providers

At this point, we should remember the theme outlined earlier. Research findings suggest that the motive behind outsourcing maintenance operations is to lower maintenance costs, and maintenance fee is the major criterion in the selection of an MRO provider. An increasing number of airlines outsourcing maintenance to lower their costs cause an upsurge in the number of, and competition among, MRO providers in the market. An analysis of the qualitative data shows that maintenance cost has become a crucial competitive tool in the MRO market. MRO providers offering lower prices to survive in a fiercely competitive environment need to reduce costs and provide service to a greater number of customers in order to make profits. The concern for increasing the amount of production on the one hand and doing this at the lowest cost on the other hand may cause safety hazards. Five areas that make up this category are explained below.

4.1.2.1. Seeking to Reduce Stock Costs

Airlines are required to possess adequate spare parts for the aircraft in their fleets and to keep them maintained in accordance with regulations. The success of stock management plays a crucial role in completing maintenance operations on time and raising aircraft productivity by reducing the time during which aircraft remain idle for maintenance. Stock costs constitute a substantial part of maintenance costs. Given that stock management requires specialization and is quite costly, airlines also resort to outsourcing for stock management (Trebilcock, 2007 cited in McFadden and Worrels, 2012:65).

However, MRO providers may not have adequate spare parts in their facilities in order to lower stock costs. Rather, they get support from airlines or order spare parts when required. However, this may cause delays in the completion of maintenance tasks. Therefore, inventory management is another factor that may put pressure on MRO providers (McFadden and Worrels, 2012:65). Furthermore, in case of any problem in the supply of spare parts, technicians may reuse parts removed from another aircraft. This finds support in the following statement of P2:

Using adequate/high-quality materials (certified and kept under appropriate conditions) is of particular importance. However, when stocks are unavailable, malfunctioning/broken parts (especially consumable materials) are reused. An aircraft may be retained in maintenance facilities for hours or even days on the pretext that spare parts are not available.

4.1.2.2. Seeking to Reduce Workforce Costs

Qualitative data analysis shows that MRO providers also strive to reduce workforce costs. This is mainly due to efforts to reduce maintenance costs in general. What underlies MRO providers' vigorous efforts to lower costs is the fact that maintenance cost is the major competitive advantage on the market. Competition based on the cost of maintenance and the search to reduce costs manifest in the form of efforts to lower workforce costs. A workforce is a significant cost item in maintenance services. Trying to lower workforce costs makes MRO providers reduce the number of qualified approved personnel and to recruit auxiliary technicians for lower wages. P2, P4, P6 and P15 said the following related to labor force costs:

***P2:** As the cost of C/S personnel is high, MRO providers tend to recruit NON C/S personnel. Not recruiting adequate numbers of experienced and qualified personnel to reduce costs... Paying per man hour works in the planning process, but in reality, requires more man hours and may cause human errors.*

***P4:** Not employing qualified personnel in maintenance organizations (MRO providers) is one of the most frequently encountered challenges today. Unqualified personnel provide service for lower wages, but not having the required license and training and not having a good command of English means that unqualified personnel cannot always understand technical documents thoroughly. Because they lack proficiency in English, they learn the job via a master-apprentice relationship. In the event of a problem, they fail to produce solutions and complete a task erroneously or incompletely, thinking that 'nothing bad would happen'. Therefore, the major factor that determines the quality of work in maintenance organizations (MRO providers) is the capability of employees.*

***P6:** MROs reduce the number of qualified (C/S) personnel and increase the number of non C/S personnel to minimize personnel costs.*

***P15:** Lack of capable and experienced personnel has serious negative effects on safety even when correct tool/equipment is available.*

MRO providers are obliged to lower costs to offer lower prices in order to attract customers that prioritize lower fees in the MRO market marked by fierce competition. For this purpose, rather than increasing the number of qualified personnel, they tend to use existing technicians not equipped with adequate knowledge, experience or competency as approving personnel. P6 and P9 explained this as follows:

P6: MROs reduce the number of qualified (C/S) personnel and increase the number of non C/S personnel to minimize personnel costs. Because workload is heavy, maintenance tasks are often completed by unqualified personnel.

K9: An MRO provider can authorize unqualified personnel to take responsibility in aircraft maintenance.

The concern to lower costs in aircraft maintenance may cause problems related to the quality and quantity of human resources that, as a result, compromises aviation safety. Human action is the major factor that threatens aviation safety. This may lead to significant safety hazards. Furthermore, cuts in technician's wages to lower costs may reduce motivation and hence reduce performance. Low performance is a safety hazard as it raises the possibility of errors being made and violations occurring.

4.1.2.3. Efforts to Enhance Productivity

Productivity enhancement is an important means of lowering costs. For MRO providers operating under the pressure of lowering costs, enhancement of workforce productivity means conducting more maintenance tasks with the same number of personnel or conducting the same maintenance tasks with fewer personnel. Both options increase workload and thus the fatigue and chronic stress felt by maintenance technicians, and are likely to cause human error to arise from attention deficit or loss of situational awareness. Heavy workload is reported to be among the causes of short circuits and violations (UK CAA, 2002). Given that the price of maintenance is a significant competitive tool, there is a need to enhance the amount of production rather than increase prices in order to raise an organization's revenue. Carrying out additional work using the same number of personnel means increasing their workload. Findings suggest that MRO providers try to enhance workforce productivity in order to lower costs and thereby increase revenue.

Another finding of qualitative data analysis is that MRO providers seek to increase the number of slots available for a certain period. This also refers to attempts to enhance productivity not only of the workforce but also of facilities and equipment used in the

maintenance procedures, and has the potential to cause problems as outlined above. P20 and P23 drew attention to the adverse effects of productivity enhancement efforts:

P20: Contracted organizations generally offer maintenance services with a minimum number of personnel in order to minimize costs and achieve profit. In this case, the airline cannot monitor or control human fatigue levels under time pressure and their effects on safety.

P23: There is certainly a need to remove cost and time pressure in base maintenance. MRO providers must unquestionably address any problem that affects safety.

4.1.2.4. Seeking to Reduce Equipment Costs

MRO providers seek to reduce costs in order to increase profit since maintenance price is the major competitive tool in the market. Fierce competition among MRO providers and the tendency of airlines to select MRO providers that offer lower prices are factors that put MRO providers under pressure to lower costs. The findings suggest that offering lower prices is an important way to find customers. The qualitative data analysis shows that MRO providers tend to renounce equipment required for maintenance with a view to lowering costs. MRO providers tend not to use equipment except such equipment as required by regulation. Low quality or insufficient equipment may impair maintenance effectiveness, and create a safety hazard. P15 said the following about a reduction of equipment costs:

From the perspective of MRO providers: MROs may also outsource both tools/equipment and, in some cases, technical support (aircraft technicians or engineers). Tools and equipment used by MRO providers must fulfill international standards and requirements, and be approved appropriately after undergoing periodic checks and tests. Providers must ensure that they have access to supplies whenever they need them. The use of tools and equipment that do not meet standards may impair maintenance procedures and affect safety.

P24 also confirms the presence of a safety hazard:

Not using appropriate technical tools and materials and conducting maintenance with the use of tools and materials not specified in technical manuals are factors that threaten safety. Likewise, if an MRO provider's facilities are not in proper condition or maintenance facilities are colder, warmer, more humid or dustier than they should be, employees as well as aircraft systems are negatively affected. This impairs the quality of maintenance.

4.1.2.5 Seeking to Create Economies of Scale and Scope

Qualitative data analysis indicates that MRO providers seek to create economies of scale and scope in order to reduce maintenance costs and, by so doing, to attract more customers. Economies of scale mean reducing unit costs by increasing production (Hanlon, 2007:76-77). For an MRO, this refers to producing more maintenance and providing service to a greater number of customers over a certain period. Efforts to simultaneously increase workforce productivity and production inevitably lead to an increase in the workload of technicians. Moreover, efforts to produce more maintenance services and open up new slots for a greater number of aircraft in a certain period of time result in a speeding up of maintenance activities, and overlooking or disregarding problems. Early or on-time return of aircraft from MRO providers is a profitable and desirable situation for airlines as well.

Economies of scope mean diversifying products within an organization to lower costs (Hanlon, 2007:77). The rationale behind MRO providers' efforts to have the authority to provide maintenance services for different types of aircraft and different parts of aircraft creates economies of scope and reduces costs. Holding the authority to provide maintenance to several types of aircraft at the same time causes an increase in the workload of personnel with regard to functions, such as quality assurance, SMS, documentation, record keeping, stock management, reliability and validity of maintenance equipment and facilities and technician training, as well as a complication of processes. Efforts to speed up maintenance authorization for a new type of aircraft may also create a safety hazard.

Qualitative data analysis further shows that MRO providers seek to retain customers to take advantage of economies of scale and scope and to increase revenue. Fulfilling the demand of customers for lower costs and shorter periods of maintenance are factors that are likely to put MRO providers under time pressure and encourage them to ignore unscheduled maintenance requirements. P9's metaphor of mass production in factories refers to the search for economies of scale and scope:

Employees in MRO's generally work with the mentality of a factory, and fail to estimate problems that are likely to occur due to errors. Thus, it is inevitable that many problems occur after maintenance is completed. Especially problems due to incorrect or incomplete assembly...

4.1.3. The Function of Production is Shared between Two Organizations

Aircraft maintenance is the most fundamental component required by an airline to produce flight services. An airline cannot operate an aircraft before maintenance operations have been conducted. In other words, without maintenance, it is not possible to fly an airplane. Sharing the function of production between two organizations is a natural outcome of

outsourcing. Analysis of qualitative data obtained from participants indicates that this may potentially threaten aviation safety for several reasons. This significant finding is not surprising for the researchers. As mentioned in the section covering literature review, several studies conducted in the airline industry and other sectors report that outsourcing splits the organizational function of management, impairs the integrity of production, and poses a potential threat to safety (Ghobrial, 2005: 470-473; Rieple and Helm, 2008: 281; Drury and Guy, 2010: 126; Sedatolite et al., 2012; Quinlan et al., 2013). Results compatible with the literature have been obtained, not because the researchers made deductive research based on the literature, but because they detected problems caused naturally by outsourcing. This indicates the high validity and reliability of this research. Making use of the capability of qualitative research to address all aspects of a topic profoundly, the authors have conducted an inductive qualitative analysis to obtain themes from codes with a view to showing why dividing the production function between two organizations creates a safety hazard.

4.1.3.1. Decreased Control of Airlines over Maintenance

Due to outsourcing, maintenance operations (a significant component in the provision of air transportation service) are removed and distanced from the organization. Therefore, a natural outcome of outsourcing is that airlines lose some of their control over maintenance operations.

The qualitative data that led the researchers to this conclusion are given below:

- The emergence of information asymmetry derived from outsourcing.
- Airline control over maintenance only through documentation and records,
- A decrease in airline effectiveness of quality assurance and SMS functions,

Problems related to the quality and quantity of airline representatives who are responsible for the control of maintenance tasks performed by MRO providers.

Information asymmetry is present when two parties do not possess the same amount of information in a shared process (Mishra et al. 1998: 277). One natural outcome of outsourcing is that a service providing organization has more information than a service purchasing organization (Heide, 2003: 19). In such a case, an airline contracting out maintenance to an MRO provider is inevitably faced with uncertainty with regard to effectiveness and compliance with regulation of maintenance operations. There would be no uncertainty if maintenance tasks were performed in-house. The uncertainty is likely to mask the need for safety enhancement and an aviation organization's opportunity to correct any irregularities. This is obviously a

safety hazard. Qualitative data obtained from the participants also confirms that outsourcing of maintenance causes information asymmetry. P12 and P19's statements are shown below:

P12: They report to have completed some important tasks, but they have not. They tend to disregard some minor work, or work that takes a short period.

P19: As airline is mainly accountable as an operator for maintenance, an MRO organization may leave out or leave incomplete some maintenance tasks that threaten safety (e.g. control, testing, changing parts). The MRO provider may report that it has conducted some maintenance tasks although it has not.

The theory of transaction cost economics (TCE) shows that outsourcing may engender information asymmetry, and this asymmetry may cause moral hazard from the perspective of a service provider (Heide, 2003: 19; Guldbrandsen et al., 2017: 4; Aubert and Rivard, 2016). If an MRO provider uses information asymmetry (a condition in its favor) as a moral hazard, it gives rise to a hazard that compromises safety.

Participants report that when maintenance operations are contracted out, the effectiveness of the quality assurance function of airlines decreases. Outsourcing distances maintenance from organizations, and makes it harder for airlines to perform audits on another organization. Participants complain that airlines cannot effectively control whether MRO providers ensure up-to-date record-keeping, audits are less likely to detect problems when performed outside the organization, and audits are solely based on documentation and records. These findings also point to a reduced effectiveness of SMS. Both quality assurance and SMS functions are shared between two organizations. The main goals of quality assurance are determining to what extent maintenance operations comply with regulations and the provision of feedback and solutions to problems, if any. The purposes of technical regulations regarding maintenance are to remove safety hazards and to reduce safety risks. The main functions of an SMS are to measure safety performance, to monitor safety performance over time, to estimate future performance values and to find safety-related solutions after identifying root causes, as well as removing safety hazards and reducing safety risks. The damage to these functions is undoubtedly a hazard in itself.

Qualitative data collected from participants suggests that airlines are involved in maintenance processes through the reports from their representatives or MRO providers, rather than from the performance of on-site auditing P3 draws attention to this issue saying:

Personnel of an MRO provider may not have thorough knowledge of maintenance quality. At this point, it is necessary for MRO providers to have well-functioning in-house quality audit processes, and that our quality assurance departments audit outsourcing processes effectively.

P7 also emphasizes auditing problems that arise when certain maintenance operations are outsourced to an MRO provider:

Lack of quality control: We outsource the maintenance/manufacturing of parts of main units. There is a need for close contact, like the one between parents and children. Neither heavy oppression nor extensive freedom... The organization to which a maintenance service is outsourced must have a common understanding of the culture with the main organization.

P20 and P23's explanations relating to a decrease in airline effectiveness in quality assurance and SMS functions are quoted below:

P20: In outsourcing, it is not possible to control and actively follow the human factors in aircraft maintenance. Contracted organizations (MROs) conduct maintenance with the minimum number of personnel to achieve minimum costs and to make profit. The customer airline cannot monitor and actively control human fatigue against time pressure and its effect on safety. Quality audits are never comprehensive enough to reveal these details.

P23: Control of procedures by quality departments alone does not ensure the monitoring of safety.

4.1.3.2. Outsourcing Requires Effective Communication and Coordination

The qualitative data analysis suggests that there may be problems related to communication and coordination between the two organizations during the outsourcing process, and that this may cause hazards that threaten safety. What underlies these problems is undoubtedly the split of the production function between two organizations due to outsourcing and an impairment of the integrity of production and organizational functions of management.

For instance, participants report that they are frequently faced with problems related to on-time, complete and accurate communication of maintenance work packages and technical documents by airlines to MRO providers. This is severe problem that is likely to compromise aviation safety. Furthermore, during the production of maintenance services, MRO providers need to communicate with maintenance, quality assurance, the safety management system, the finance and human resources department of other organizations (including aviation authorities),

spare part providers and customer airlines. Another point mentioned by participants is that communication between quality assurance and the SMS departments of two organizations weakens because of outsourcing. Outsourcing, causing disorganization and complication in all these processes, is likely to produce hazards. Drury and Guy (2010: 127) argue that if maintenance operations are conducted in-house, an aviation organization is faced with fewer communication and co-ordination problems between sub-departments of an organization.

For safe, on-time and successful completion of maintenance operations, there is a need for an effective supply chain mechanism between MRO provider and customer airline, considering that the production function is divided between at least two organizations and between two locations. An effective supply mechanism requires effective communication and co-ordination. Errors and delays in the supply process may place time pressure on both organizations. Such problems are less likely to occur if maintenance operations are conducted in-house.

Another challenge concerns the accurate and complete keeping and transfer of records related to maintenance operations. When an airline decides to change its MRO provider or conduct maintenance in-house, there may be problems related to the transfer of previous maintenance records into the system or the integration of different systems.

Data obtained from the participants indicates that an MRO provider may not have sufficient knowledge of maintenance procedures followed by the customer airline. This is mainly because the maintenance service production function is shared between two organizations. Furthermore, the need for many different customer airlines' procedures at the same time may inhibit MROs having a thorough knowledge of them. Flaws and errors regarding the knowledge and implementation of maintenance procedures potentially threaten aviation safety. P11, P1 and P24's statements regarding this are provided below:

***P11:** In scheduled maintenance, when an MRO provider does not have full knowledge of an airline's procedures and directives, there may be misunderstanding or incomplete fulfillment of work orders.*

***P1:** Procedures pertaining to the airline and time wasted and malpractices that are likely to arise when procedures are not fulfilled thoroughly through outsourcing: There may be delays and hence time wasted due to operational planning. Malpractices may also cause delays as well as a loss of man-hours because of recovery procedures performed up until or after an airplane is returned to the airline.*

P24: An MRO provider needs to have a full knowledge of and be able to implement fully the procedures in the organization that outsource aircraft maintenance. Otherwise, malpractices are likely to arise and have negative effects on safety.

The fact that outsourcing entails effective communication and co-ordination makes the system vulnerable to problems related to safety reporting between customer airline and MRO provider. These problems undoubtedly impair the effectiveness of the SMS.

In order to increase their chances of success in communication and co-ordination with an MRO, airlines assign representatives to control the processes of the MRO provider. However, participants questioned the quality and numbers of representatives. Data analysis suggests that airlines outsourcing maintenance operations to lower costs are reluctant to assign technicians and engineers in sufficient numbers and quality in the MRO provider. “*If the carrier does not send representatives to an MRO provider, serious problems may arise,*” said P12. P19’s statements related to this problem are as follows:

Maintenance contracts may guarantee that representatives of an airline play an effective role in maintenance tasks conducted in an MRO. Meetings must be held frequently to monitor the process.

4.1.3.3. An MRO Provider Sees Accountability as a Secondary Function

Participants argue that MRO technicians are not as eager as in-house technicians of airlines when performing maintenance operations. The researchers contend that this may be traced back to inequality of safety accountability between parties. Airlines have primary accountability in the safe transport of passengers and freight. Accountability cannot be transferred to other departments or organizations. MRO providers certainly have accountability with regard to ensuring safety. However, the accountability of airlines (as the owner of transport service) is primary in legal terms and in the eyes of MRO providers. Some participants mention that MRO providers are not as willing as airlines to keep up-to-date documentation and to make use of official and valid documents in maintenance procedures. Two examples are provided below:

P6: When maintenance is outsourced, MRO providers, unfortunately, do not take good care of customers’ airplanes. In other words, airplanes are treated like step children, with no diligence. Thus, there are problems related to performing the job appropriately and monitoring performance. These cause serious threats to safety.

P8: The most important thing is TRUST, I believe. I do not have trust in outsourcing. People do not care about what does not belong to themselves.

P19: As an airline is the main accountable operator for maintenance, an MRO organization may leave out or leave incomplete certain maintenance tasks that threaten safety (e.g. control, testing, changing parts).

4.1.3.4. Differentiation in Organizational Cultures

The analysis of data obtained from the participants shows that an airline and an MRO may have different organizational cultures. When differences turn into problems of incompatibility, hazards appear that threaten safety. Although airlines and MRO organizations operate in the same industry, there are probably differences in core competency, safety commitment and management policies. Differences in organizational culture derive from the fact that the production function is split between two organizations.

Data suggests that the technician turnover rate is higher in MRO providers. This may indicate that technicians do not develop a sense of organizational belonging. If MRO technicians are not as diligent as airline technicians, with respect to taking technical documents as a reference, voluntary reporting and avoiding violations, this may cause safety hazards. If reporting violations, one of the indicators of a strong positive safety culture, is seen as a valuable act for safety enhancement in one organization, but as ‘squealing’ in the other organization, reporting is encouraged in the former, but punished in the latter. The discrepancy is likely to cause profound problems that threaten safety. P2 provided detailed explanations regarding this:

P2: Creating time pressure on employees and punishing errors are among the most significant flaws. This means encouraging employees to hide errors, and I believe, is one of the biggest enemies of ‘SAFETY’.

P2: An airplane in the organization where I work was taken to a large MRO provider for a scheduled C check. Two days after it was brought back, a breakdown in the fire extinguishing system occurred. In the controls we performed, we found that the fire extinguisher tube was empty. Our flight crew had not reported that they had used the fire extinguisher tube. After a detailed examination, it was detected that there was an external intervention press switch for the tube. In short, the tube exploded during maintenance or testing, and the error was concealed from senior administration without being reported. Not being aware of the importance of fire extinguisher points due to lack of training and not reporting errors for fear of being punished points to pressure from administration, and not taking documents as a

reference means that personnel fulfill duties haphazardly. This specific case is a good, but a bitter example.

4.2. Importance Rating of Outsourcing Hazards

In the questionnaire, the participants were also asked to identify which hazards were likely to have the greatest negative impact on aviation safety. However, the participants did not make a rating when replying to the open-ended questions. This is why, the authors examined how many participants mentioned a specific code extracted from their statements (some of these codes were then formulated into categories and themes) to rate the importance of hazards. The five most important safety hazards are presented in Table 3.

Table 3: Importance Rating of Safety Hazards

Theme No	Safety Hazards	Frequency	Level
3	Seeing accountability as a secondary function of an MRO provider	10	1
1	Time pressure on an MRO provider	9	2
2	Lack of qualified technicians in an MRO provider	9	2
3	Decrease in effectiveness of an airline's quality assurance function	9	2
3	MRO provider's insufficient knowledge of maintenance procedures	7	3
1	Price as the major selection criterion	7	3
2	Insufficient number of technicians in an MRO provider	6	4
2	Employment of unqualified personnel	6	4
3	Decrease in a sense of belonging among MRO technicians	5	5
3	Airline's decreased control over maintenance	5	5
3	Problems in the transfer of maintenance packages	5	5
3	Effective communication required in outsourcing	5	5

Safety hazards that rank in the top five include codes and categories that fall under all three themes. However, the most commonly referred to hazards are related to the theme of 'the division of the production function between two organizations'. This finding supports the fact that, as a natural outcome of outsourcing, there is disorganization of roles in the production function of an airline and the organizational function of management. This provides strong evidence to the finding that the disorganization caused by outsourcing has the potential to produce safety hazards.

Furthermore, the code of 'considering the maintenance fee as the main criterion in selecting an MRO provider', seen as a safety hazard in its own right and developed into a

category as it encompasses other codes, was also mentioned frequently by participants. This finding supports the theme that ‘Airlines’ View of Outsourcing as a Cost Reduction Tool’. The high frequency of this code draws attention to the presence of such a problem and to the fact that this is an important safety hazard caused by outsourcing. The codes frequently mentioned under the theme that ‘price is the major factor ensuring a competitive advantage for MRO providers’ point to problems pertinent to human resources management in MRO providers: *a lack of qualified technicians in an MRO provider; insufficient numbers of technicians in an MRO provider; and employment of unqualified personnel*. Inductive qualitative data analysis shows that, as price is a significant competitive advantage, MRO providers are under cost-related pressures and try to reduce workforce costs in order to achieve lower costs.

4.3. Examining the Relationship Between Themes

Competition has been increasing and has become global in air transport. One of the most significant reasons for this is the liberalization of economic regulations in the domestic and international airlines market (Odoni, 2009). One important outcome of liberalization is that airlines determine air fares freely in consideration of market dynamics. This has led to increased price competition in the market. This has also brought about the business model of low-cost carriers, which is a breakthrough in the airline business (Lenartowicz et al. 2013; Pearson and Merkert, 2014). The entry, success of, and growth in numbers of low-cost carriers into the market are factors that increase price competition in the market (Hanaoka et al., 2014). Increased competition and the significant role of price in competition make airlines implement policies that lower costs and develop core competencies. In this respect, airlines outsource maintenance operations. The relationship among three themes obtained as a result of the inductive analysis of qualitative data is presented in Figure 1. The qualitative analysis results support previous findings in the literature. Airlines see outsourcing maintenance operations as an effective tool for reducing costs. The main motivation behind outsourcing is to reduce costs.

The fact that an increasing number of airlines outsource greater numbers of maintenance operations to reduce costs elevates the number of MRO providers that enter the market and increases competition among MRO providers (Vieira and Loures, 2016). The findings of the qualitative data analysis suggest that airlines, whose main motivation for outsourcing maintenance operations is to lower costs, expect low prices and speed in maintenance services purchased from MRO providers operating in a market where competition has been increasing. The main criterion that plays a role in the selection of MRO providers is low cost. Another important criterion that airlines consider is speed in completing maintenance services. These

demands make maintenance price the major competition tool among MRO providers and put them under pressure to produce low-cost, but accelerated, aircraft maintenance services. The present research shows that such pressure has the potential to produce diverse safety hazards.

Achieving low costs is undoubtedly the goal of all business organizations. However, the cost reducing pressure to which MRO providers are exposed has the potential and strength to create safety hazards. For instance, undesirable safety situations are likely to occur when MRO providers, endeavoring to lower workforce costs to offer lower prices to airlines, recruit personnel that do not meet qualitative or quantitative needs and increase the workload of personnel in order to reduce costs by increasing productivity.

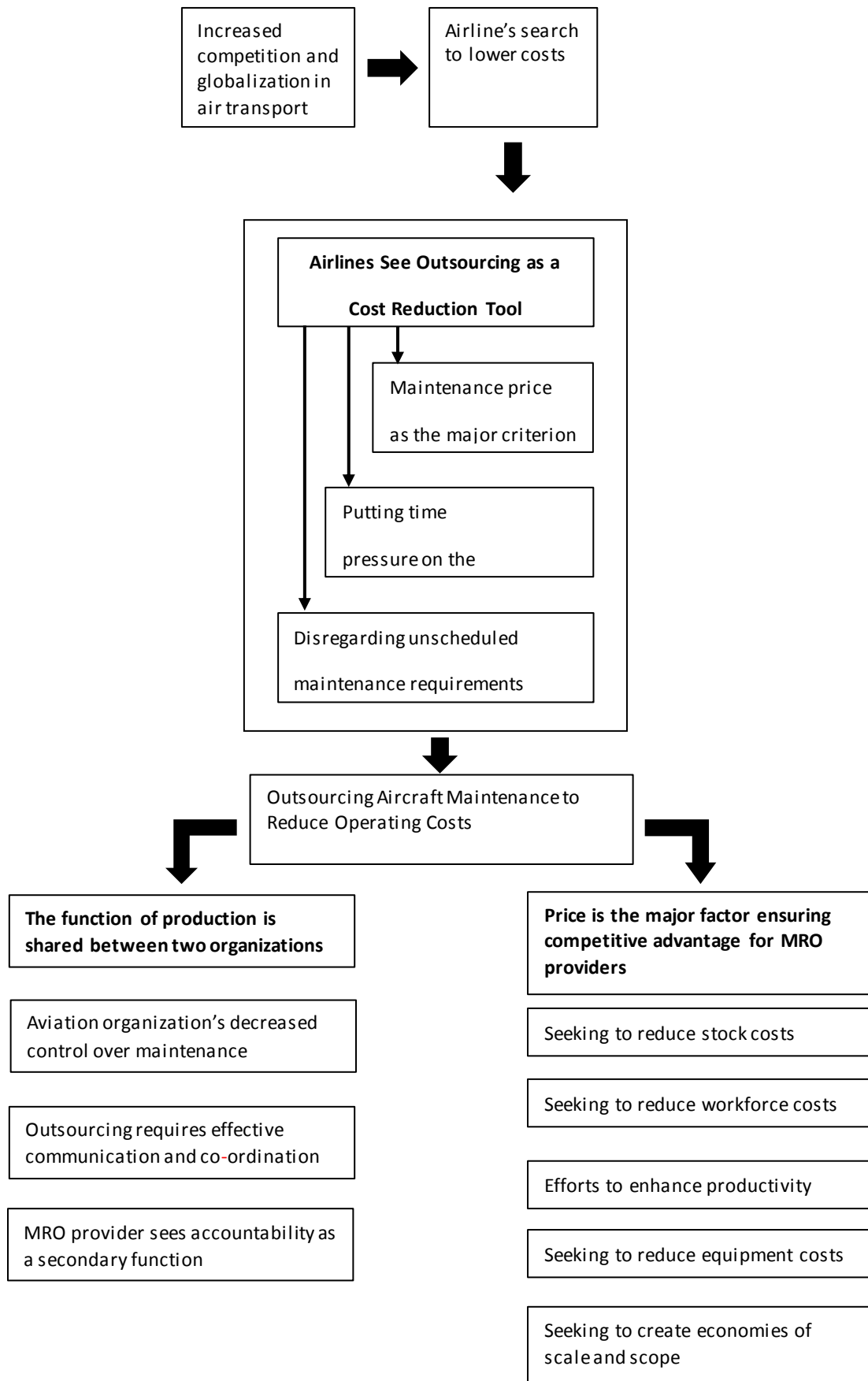


Figure 1: Relationship Between Themes

Another finding of the research is that outsourcing causes disorganization in the production of operations and in the organizational structure. This finding is significant for those in other sectors and fields of operation. The distinction is that airlines outsource a critical field of operation that has a direct impact on aviation safety. Reduced control of airlines over these critical processes may cause safety hazards. Disorganization in processes and structures require effective communication and co-ordination. However, since achieving this is difficult, disorganization becomes another source of safety hazards in the aviation industry. There is also disintegration in accountability. Accountability not distributed equally between parties becomes a safety hazard. Disorganized processes and structures pose another source of safety hazards when there is incompatibility between the organizational cultures of parties.

5. CONCLUSION

This study, based on a qualitative research design, attempts to answer whether specific safety hazards occur when airlines outsource maintenance operations to MRO providers rather than conduct them in-house, what the sources and outcomes of the hazards are, and how and why these hazards constitute a threat to safety.

The study has shown that airlines see outsourcing of maintenance operations as an important tool for achieving lower costs. Given that the main motivation of airlines is the lowering of costs, they naturally expect lower prices and speed in maintenance services. This makes maintenance price and duration the major criteria in the selection of MRO providers. As a result, MRO providers are under serious pressure to reduce costs and to provide accelerated services. MRO providers under the pressure of cost and time seek to reduce stock, workforce and equipment costs, and to enhance the productivity of workforce and facilities at the expense of an increasing workload. The results suggest that reducing the quality and quantity of technicians, with the intention of lowering workforce costs, in particular brings about a significant safety hazard. Regardless of quality and quantity problems, the effort to produce more work in a shorter period alone is an important safety hazard. All these factors may lead to human errors and violations. Cuts in stocks and equipment may also compromise safety. Further efforts to lower costs, by making different maintenance activities for different types of aircraft, searching for customer loyalty, and pressure to gain new customers, also constitute threats to aviation safety.

Another significant result of this study is that outsourcing causes disorganization in the production of maintenance services and the organizational structure of parties that produce these services. This decreases the control of airlines over maintenance operations, and makes

maintenance prone to errors as the process requires effective communication and co-ordination. The study further shows that MRO providers do not embrace the maintenance process fully as they see accountability as a secondary function. Another natural outcome of the division of production function between two organizations is that a differentiation in organizational culture may cause incompatibility with regard to safety culture, which inevitably creates safety hazards.

Airlines that desire to outsource maintenance operations, and civil aviation authorities that are responsible for ensuring safety, are recommended to take risk-mitigation measures in consideration of the hazards list obtained by this study.

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