TRANSPORT & *LOGISTICS:*
the International Journal
ISSN 2406-1069

Article history:
Received 24th June 2024
Accepted 26th June 2024
Available online 30th June 2024
DOI: 10.46544/TNL.v24n56.09

Article citation info: Sekelová, I., Korba, P., Koščáková, M., Tymofii, V., Evaluation of MRO Markets' Growth and Average Hourly Rate of Aircraft Mechanics. Transport & Logistics: the International Journal, 2024; Vol. 24, No. 56, https://doi.org/10.46544/TNL.v24n56.09

Evaluation of MRO Markets' Growth and Average Hourly Rate of Aircraft Mechanics

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Abstract:
The aviation industry is required to cope with several challenges in the course of the next few years. Firstly, recovering from the impacts of COVID-19, dealing with initiatives for the reduction of CO_2 and among others shortage of qualified personnel. A study was administered to identify whether the regions with developing MRO markets reach comparable average hourly rates at the job position of aircraft mechanic in 2022 and in 2027. The gathered data in our study were processed by the means of statistical software Jamovi, which allowed us to evaluate if there is a significant difference between the average hourly rate of individual regions. Results show that the income in Eastern Europe and Latin America is currently significantly lower and is expected to be significantly lower in 2027 when compared to other regions, such as North America or Western Europe. This paper demonstrates the potential for the development of MRO facilities in Slovakia, because of its geographical position and significantly lower average hourly rate.

Key words:
maintenance and repair organization, growth, average hourly rate, aircraft mechanics

Introduction

Aviation stands in front of several challenges that are to be overcome in the following decade. Whether in the form of persisting negative effects of the COVID-19 pandemic or in the form of possible restricted growth resulting from the initiatives to reduce emissions, all of them have to be addressed. Additionally, increasing labor and material costs, shortage of qualified employees or congested airspace may be mentioned as long-term challenges. The aviation industry tries to comply with the national green action plans with the implantation of sustainable aviation fuels and more efficient aircraft. Achieving these goals requires the modernization of the current fleet worldwide.

Despite the possible future limitations in growth, aviation is still a rapidly growing industry that reflects the increased need for pilots, air traffic controllers, cabin crew, and

undoubtedly aircraft mechanics. Boeing's forecast predicts the need for around 620,000 new qualified aircraft mechanics in the next 20 years worldwide (Boeing, 2021). Aircraft maintenance represents one of the biggest costs for airlines, in fact, it represents around 15% of all airline's operating costs (IATA, 2022). A significant amount of operating costs is represented by labor and material costs. These expenses are becoming more and more elevated over time, which pushes some airlines into outsourcing their maintenance.

The cost is the primary reason for outsourcing aircraft maintenance. Some airlines outsource maintenance because of their goal to reduce expenses, but it is the only option for some start-ups or low-cost airlines, as they do not have the resources to establish their own maintenance program (McFadden, M., Worrells, D., 2012). It is expected that 70% of maintenance is outsourced (Weaver, J., 2008), while some percentage is also represented by outsourcing to foreign repair stations. One of the biggest benefits of outsourcing to foreign countries is a considerably lower cost of labor.

Regions with developing aviation industries have been the most common regions for MRO (maintenance, repair, and overhaul) outsourcing also thanks to their low labor costs. However, these regions' aviation industries are continuously growing and becoming more competitive. The growing local demand for maintenance continuously increases labor costs. The aviation industry and thus the MRO market are continuously growing despite the temporal setback caused by the pandemic of COVID-19. The short-term decline in demand for aircraft maintenance during the pandemic was the result of reduced flying, which consequently led to employment reductions. However, the long-term shortage of workforce in aircraft maintenance is forecast to grow (ATEC, 2021).

Climate change represents another challenge for aviation. Many initiatives of the European Union and other countries in the form of the Paris Agreement are aimed at achieving climate goals, which should result in limiting climate change (United Nations Climate Change, dátum neznámy). At present aviation accounts for 2.3% of emissions which is significantly lower when compared to the emissions from road transportation. However, the continuously increasing use of electric or hybrid cars will significantly reduce road transportation emissions in the next decade. Even though aircraft designers are attempting to reduce aviation emissions, implementing inventions such as using hydrogen or electric energy as the primary power source will require more than one decade. The accessible option can be the use of sustainable aviation fuels, which will have to be supported to a certain extent by governments in order to make it more profitable for the airlines to use instead of standard aviation fuel (Wyman, 2022b).

The COVID-19 pandemic had a significant impact on the development of the maintenance, repair, and overhaul markets, as well as the growth of the fleet. However, the response of individual regions to the pandemic varied. A study conducted in May 2020 (Farooq, U., Nasir, A., Bilal & Bashir M.F. , 2022) found that more developed regions were more affected than developing regions, which suggests that some regions may experience slower growth than before the pandemic. Nonetheless, some regions and countries, such as China, were able to achieve their pre-pandemic fleet size by the beginning of 2021. In addition, the Eastern Europe region exceeded its pre-pandemic size in June 2021 (Prentice, B., DiNota, A., Costanza, D., Reagan, I., Franzoni C., Stelle, M., 2022a).

The growth and development of the market are not solely influenced by the pandemic; rather, it is influenced by several factors. These factors include cost, workforce, geographic presence, quality, technological advancement, and certification, which can create opportunities or threats to market development. Opportunities can arise from technological advancements, such as automation and predictive maintenance, as well as an increase in fleet orders or new airlines entering the business. Conversely, threats to market development include postponing non-essential maintenance, a limited workforce, or lengthening scheduled

maintenance checks due to aircraft advancements (Nam, S., Choi, S., Edell, G., De, A., Song, W-K., 2023).

The shortage of aircraft mechanics is caused by several factors: the aging global population, lower wages, and fewer benefits (Wyman, O., 2017). Additionally, due to COVID-19 the aviation sector was almost entirely shut down, which may discourage new potential aviation workers from entering the industry (Wyman, 2022b). The Aviation Technician Education Council (ATEC) estimates around a 13% increase in the mechanic population in the next 20 years, nevertheless even this projected increase will not satisfy the needs of commercial aviation in 2041 (ATEC, 2021). The continuous need for skilled aircraft mechanics in the next two decades is also forecast by Boeing's outlook (Boeing, 2021). According to the survey (Prentice, B., DiNota, A., Costanza, D., Reagan, I., Franzoni C., Stelle, M., 2022a), 80% of North American responders reported that they find it challenging to employ a skilled aircraft mechanic, the number is lower in Europe representing 65% of European responders.

The aim of our study is to evaluate and compare the average hourly costs for the job of aircraft mechanics in various regions and countries worldwide. The reason is to determine the countries and regions with the highest and lowest average hourly rate and therefore demonstrate the regions that could be used for the outsourcing of aircraft maintenance. It provides a look into the position of Eastern Europe in the MRO market and an analysis of the possible future opportunities for Slovakia.

1 Methods and methodology

The aviation industry has been one of the fastest-growing industries in recent years. As a result, the demand for qualified aircraft mechanics has also increased significantly. The role of aircraft mechanics is critical as they are responsible for inspecting, repairing, and maintaining aircraft to ensure safe and efficient operations. With the rising demand for aircraft mechanics, the importance of understanding the average hourly rates in different countries and regions becomes even more crucial.

The objective of our study is to evaluate and analyze the average hourly rate for the job of aircraft mechanic in different countries and regions. The authors believe that even though the average hourly rate of aircraft mechanics in Eastern Europe is about to raise it is still significantly lower than in the regions of North America and Western Europe. This study demonstrates what are differences between regions and countries in relation to average hourly rate of aircraft mechanics. According to this information, we can suppose which regions could be expected to become popular for the outsourcing of aircraft maintenance. Outsourcing together with the growth of local markets contribute to the demand for skilled aircraft mechanics in the future.

Data collection was performed by the means of a website database powered by the Economic Research Institute called Salary Expert (Economic Research Institute, 2022). The pay at the position of aircraft t mechanic varies according to the years of experience of the individual. The average hourly rate was taken into account and local currencies were converted to USD according to the exchange rate valid on 2 May 2022.

Countries that represent each region were based on the location of big MROs according to various sources. For Eastern Europe, we chose Poland, Hungary, Estonia, Bulgaria, and the Czech Republic (Adams, Ch., 2018). Western Europe is represented by Spain, France, Germany, Ireland, and the United Kingdom (Pozzi, J., 2019). The North America region is composed of two countries United States of America and Canada. Countries representing Latin America were chosen based on Airbus Global Market Forecast

(Panel, P., 2016), namely, Mexico, Brazil, Chile, Costa Rica, and Panama. Lastly, the Asia-Pacific region in this article consists of China, Indonesia, Japan, Singapore, and Thailand (Mordor Intelligence, 2021). Middle East region is represented by United Arab Emirates, Saudi Arabia, Pakistan, Israel, and Iraq. These countries foster large MRO facilities and our dataset did not contain other countries from this region, which may be viewed as a possible limitation of study. As well, we did not obtain sufficient data about the Africa region, at the same time, this region is not expected to increase in demand for aircraft mechanics in the same amount as in the regions under study according to (Boeing, 2021) (Prentice, B., DiNota, A., Costanza, D., Reagan, I., Franzoni C., Stelle, M., 2022a), which is the reason why it is exempt from the study.

In our study, descriptive and inferential statistics are used to evaluate the data. Descriptive statistics provides the possibility to summarize and analyze data under study. For determining and generalizing data about the regions, we chose to use the median. The median is the figure which is situated in the middle of the data set, it separates the lower figures and higher figures. The median is especially important when there is a great range of figures in the dataset because the arithmetic mean can skew the results (Thompson C.B., 2009).

For example, it is possible that in this study five countries that are observed would have the following average hourly rate $3, $4, $5, $10, and $25. The arithmetic mean of these would be $9, which does not reflect the majority of the values in the dataset. But the median of the same data set is $5, which gives a better representation of most of the values. If the range of the values in the dataset is not so wide apart, the mean and the median are also closer to each other. To illustrate, if the average hourly rate in five countries of one region would be $9, $10, $11, $12, and $14, the arithmetic mean would be $11, and the median would be also $11.

In the evaluation of the gathered data, we also used inferential statistics, thanks to which we can determine with relative certainty whether there is a significant difference between the average hourly rate of regions. Since we were comparing more than 2 groups and our sample complied with the requirements for the parametric method, we used One-Way ANOVA with the appropriate Post-Hoc Test. The accepted value of p that indicates significance is determined as $p < .001$. The calculations of appropriate mathematical statistics were performed via the program Jamovi.

2 Results

Figure 4 shows an average hourly rate for the job position of an aircraft mechanic. The figure contains the average hourly rate that is valid in 2022 and also a forecast provided by the Economic Research Institute on how the rates are going to increase in 5 years. The highest average hourly rate is $31, and it is present in the region of North America (N.A.), namely in the United States of America. The projection in this country for 2027 stands at an average of $37 per hour.

On the other hand, the lowest average hourly rate is $3 per hour in Pakistan, $4 per hour in India, and $5 per hour in Bulgaria. Despite being countries with the lowest average hourly rate, they are expected to achieve the highest increase in pay. The highest increase percentage of average hourly rate among the studied countries is estimated in Bulgaria achieving 84%, achieving $9 per hour in 2027. Pakistan is estimated to reach the second-highest increase after Bulgaria by 72%. However, the lowest expected hourly pay in 2027 is going to be in Pakistan coming up to $5. The increase in the average hourly rate in India is expected to be 68%, resulting in $6 per hour in 2027.

As demonstrated in Figure 1 the biggest differences in hourly rates are in the Asia-Pacific region, which is one of the fastest-growing aviation markets that will also require an increase in the region's fleet (Airbus, 2022), which is directly linked to the MRO market development. The lowest average hourly rate increase is 13% which is expected in Spain, raising the average hourly rate from $19 to $21, and in Japan resulting in the increase of $3 per hour coming up to $25 per hour in 2027.

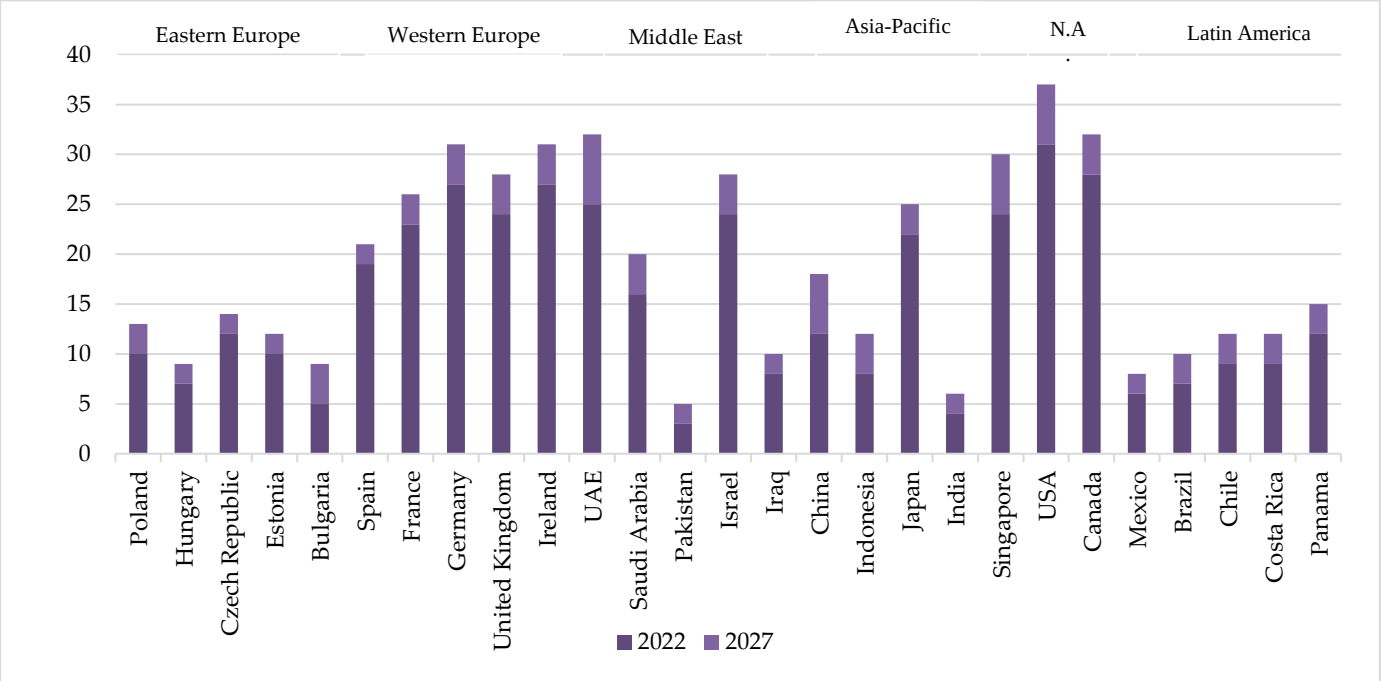

***Fig.1** Hourly rate in different countries in USD.*

Figure 2 features the ranking of countries with the highest average hourly pay in 2022 and Figure 3 the lowest. Regarding the highest-paying countries, the increase rate is quite similar, with the exception of the United Arab Emirates which is expected to reach 28%, making it the third highest-paying country in 2027. All other countries are from North America or Western Europe regions, which was expected based on the size of the MRO markets in these two regions. The presence of the United Arab Emirates in this figure serves as proof that the Middle East is a new fast-growing region in maintenance.

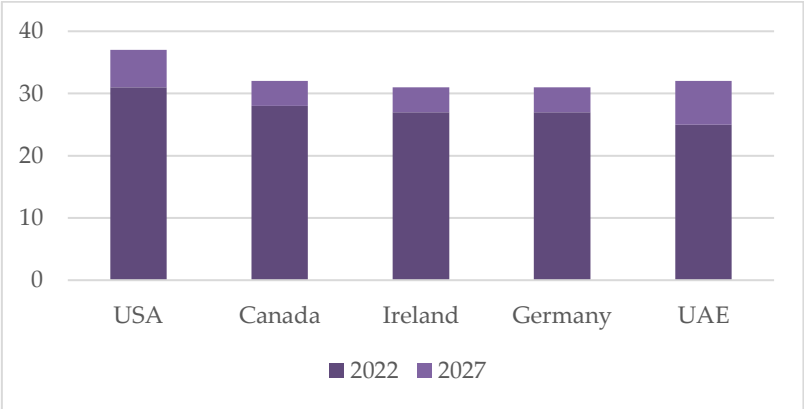

***Fig.2** Highest paying countries.*

Countries classified as the lowest paying are from Eastern Europe, Latin America, and the Middle East. We can see that the increase rate in the lowest-paid countries vastly differs

for each country, resulting in consequent changes in the ranking for the lowest or highest average hourly rate for 2027. The increase rate for Bulgaria is estimated at 84%, making it the third lowest-paid country in 2027. On the other hand, the lowest percentage of increase rate is estimated for Mexico (27%).

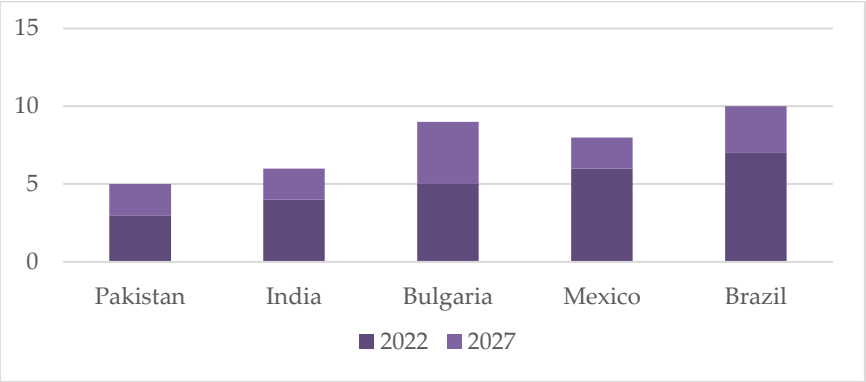

Fig.3 *Lowest paying countries.*

Table 1 we can see the descriptive statistics data, namely mean, skewness, and Shapiros-Wilk normality test. We chose to use the median as a measure of central tendency because of its resistance to extreme values. Our sample meets the requirements of the Shapiro-Wilk Normality test for the data in 2022 (p = 0.539) and also year 2027 (p = 0.458), while the skewness of both groups of data is also in the allowed range between -1 and 1.

Tab. 1 *Descriptive statistics*

Descriptive statistics	Region	2022	2027
Median	Eastern Europe	10	12
	Western Europe	24	28
	Asia-Pacific	12	18
	North America	29.5	34.5
	Latin America	9	12
	Middle East	16	20
Skewness	Eastern Europe	-0.477	-0.197
	Western Europe	-0.822	-0.992
	Asia-Pacific	0.181	-0.0448
	North America	NaN	NaN
	Latin America	0.606	0.118
	Middle East	-0.260	-0.150
Shapiro-Wilk p	Eastern Europe	0.656	0.257
	Western Europe	0.394	0.363
	Asia-Pacific	0.494	0.921
	North America	NaN	NaN
	Latin America	0.685	0.872
	Middle East	0.477	0.673

Figure 4 shows the data from Table 1, it portrays the median of each region's average hourly rate. Each country is expected to achieve a different percentage of increase, the highest increase in percent is estimated in the Asia-Pacific and Latin America region and it is to be an increase of 33%. It is followed by a 25% increase in the Middle East, 20% in Eastern Europe, 17% in Western Europe, and a 16% increase in North America. In Figure 7, we can observe that the lowest average hourly rates are present in Latin America, with around $9 per hour, followed by Eastern Europe and Asia-Pacific, the former at $10 per hour and the latter at $12 per hour. They are followed by the Middle East region with $16 per hour. Two leading regions with the highest hourly rate are Western Europe at $24 and North America at $31.

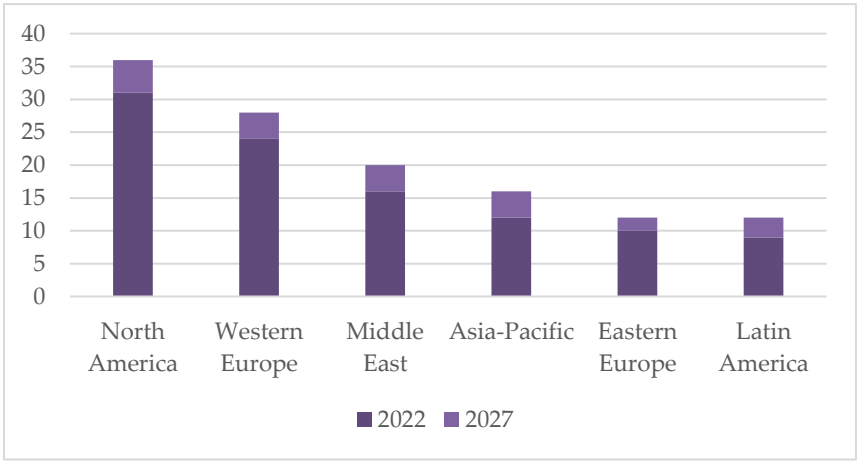

Fig.4 *Average hourly rate in regions*

The increase in the average hourly rate expected in 2027 is different in each region, while North America and Western Europe should experience the lowest increase rate. However, in these regions, the expected average hourly rate in 2027 will be the highest among other regions. The projections predict that the Middle East will become the third highest-paying region above Asia-Pacific, Eastern Europe, and Latin America. The two highest increase rate is observed in Asia-Pacific and Latin America regions, however, even such high increase rates are not going to change the ranking of the highest-paying regions in 2027. In Figure 4 we can see that there is a significant difference between the first two highest-paying regions and the rest of the world. Due to countries with remarkably lower average hourly income, like India or Pakistan, we used median in our calculations instead of arithmetic mean, because it gives us the possibility of coping with extreme values in data.

In order to find out whether the differences between the average hourly rates of the individual regions are significant, it is important to calculate the data with mathematical statistics. In our study, we used a parametric method, namely, One-Way ANOVA. Our data set complied with the requirements for this method, however, the desired homogeneity was not achieved (p = 0,002), which is the reason why we used Welch's method which does not assume equal variances, seen in Table 2. This decision also influenced the choice of the Games-Howell Post-Hoc Test, which is used for unequal variances.

Tab. 2 *One-way ANOVA (Welch's) for average hourly rate in 2022*

	F	df1	df2	p
2022	28.5	5	7.39	< .001

Table 3 shows the comparison of the median average hourly rate in all regions, the value of $p < .001$ indicates that the differences between the regions will be significant. Since we are comparing more than two groups, the appropriate Post-Hoc Test had to be calculated with Games-Howell correction in order to eliminate the type 1 error rate. Tab. 4 features the Post-Hoc Tests after correction. After careful examination of the data in the following table, we can determine that the average hourly rates in Eastern Europe and Latin America are significantly lower than in Western Europe and North America. The Asia-Pacific and Middle East region does not show significant difference with either of the other regions. According to these findings, the average hourly rate in North America, Western Europe, Asia-Pacific, and Middle East regions do not differ significantly, while Eastern Europe and Latin America differ from other regions, we do not observe a significant difference between them.

Tab. 3 *Post-Hoc Test for One-way ANOVA for average hourly rate in 2022*

		Eastern Europe	**Western Europe**	**Asia-Pacific**	**North America**	**Latin America**	**Middle East**
Eastern Europe	p-value	—	< .001	0.790	0.015	1.000	0.719
Western Europe	p-value		—	0.302	0.307	< .001	0.481
Asia-Pacific	p-value			—	0.087	0.758	1.000
North America	p-value				—	0.025	0.154
Latin America	p-value					—	0.690
Middle East	p-value						—

To determine whether the situation is going to change in the next five years based on the projected increase rate in the average hourly rate, we had to calculate the data with the same inferential statistics method. We decided to use the parametric One-Way ANOVA method, even though homogeneity for the sample 2027 was not achieved ($p = 0.006$). Other requirements were fulfilled, which is why we used Welch's One-Way ANOVA and Games-Howell correction for unequal variances.

Tab. 4 *One-way ANOVA (Welch's) for average hourly rate in 2027*

	F	**df1**	**df2**	**p**
2027	32.2	5	7.40	< .001

The value of p in Table 4 determines that there is a significant difference between the average hourly rates that are expected in 2027. Tab. 5 shows that Eastern Europe is to have a significantly lower average hourly rate than Western Europe and North America which is the same situation as it was in 2022 but is to be less significant. There is no significant difference

observed between Eastern Europe and Latin America. The average hourly pay in Latin America is to be similar to Eastern Europe, thus significantly lower than in Western Europe and North America, but slightly less significant than in 2022. Regarding the Middle East and Asia-Pacific regions they are not showing any significant difference in relation to other regions, however their average hourly rate is getting more insignificant in relation to both higher paying regions (Western Europe, North America) and lower-paying regions (Eastern Europe, Latin America).

Tab. 5 *Post-Hoc Test for One-way ANOVA for average hourly rate in 2027*

		Eastern Europe	**Western Europe**	**Asia-Pacific**	**North America**	**Latin America**	**Middle East**
Eastern Europe	p-value	—	0.002	0.666	0.020	1.000	0.706
Western Europe	p-value		—	0.460	0.199	0.002	0.661
Asia-Pacific	p-value			—	0.101	0.671	1.000
North America	p-value				—	0.014	0.196
Latin America	p-value					—	0.710
Middle East	p-value						—

3 Discussion

One of the continuously growing expenses are beside fuel costs represented by labor costs (Prentice, B., DiNota, A., Costanza, D., Reagan, I., Franzoni C., Stelle, M., 2022a). It is true that the average hourly rate is going to increase in all of the regions, in some more than in other. The emerging MRO markets are Asia-Pacific, the Middle East, and also Eastern Europe according to the forecast about the growth of the fleet and consequent spend on MRO. The difference in average hourly rate is however still observable between the regions of North America, Western Europe, and the rest of the world. Even though the average hourly rates in the other regions are increasing, according to our study, these two regions are still going to have significantly higher pay than Eastern Europe and Latin America. No change is observed in regard to the Asia-Pacific and Middle East regions as their average hourly rate is insignificant in 2022 and also projected to be insignificant in 2027 in relation to other regions.

Over the last years, markets in Asia-Pacific and Middle East regions are emerging, in contrast to the past years, it is now becoming less advantageous to outsource maintenance to these regions because of significantly lower wages, as the MRO companies are getting more and more business opportunities locally within the country, they are located in. However, not all countries have an average hourly rate similar to the calculated region's median. For example, Pakistan and India are the lowest paying countries which are estimated to reach a

high increase in the average hourly rate and remarkable growth of their markets in the next decade.

In recent years, the Eastern European MRO market has been facing some challenges in form of growing expenses. A significant part of maintenance costs is represented by labor, fuel, and material costs, unfortunately, there is an expected increase of the material price by around 5% (Wyman, 2022b). In addition, labor costs are showing a growing tendency over the years to come (Adams, Ch., 2018). Despite, the raising wages in this region, the average hourly rate in Eastern Europe is going to be significantly lower than in North America or Western Europe in 2022 and according to the projected average hourly rate also in 2027. According to our study, the hourly average rate in Eastern Europe is comparable to Latin America in both years. The results show that Eastern Europe is still an attractive region for outsourcing maintenance in terms of labor costs.

The hourly average rate in Slovakia is $11 (Economic Research Institute, 2022), which is slightly above the average for Eastern Europe. There are several MROs in Slovakia that provide different types of services; however, they are mostly located in the western part of the country. Aicraft maintenance has to performed according to certain standards to ensure safety. These standards come from international organizations and they are accessible in the English language (Nam, S., Choi, S., Edell, G., De, A., Song, W-K., 2023). Therefore, the overall need for qualified and skilled aircraft mechanics also encompasses the knowledge of English, which is inevitable in aircraft maintenance, as manuals are written exclusively in English (Friginal, Mathiews, Roberts, 2020). After searching for vacancies for the job position of aircraft mechanic at Slovak MROs websites (Aeroengineers International, dátum neznámy) and the Slovak job portal Profesia from companies Air Explore (Air Explore, s.r.o., 2022) and Austrian Airlines Technik (Austrian Airlines Technik - Bratislava s.r.o., 2022), we concluded that companies that are hiring aircraft mechanics require a good command of English at level A2, B1, or B2 according to the Common European Framework of Reference for Languages. This demand copies the recommended level of language command based on the Slovak project funded by the European Social Fund focusing on the National occupation system (Ministry of Labour, Social Affairs and Family of the Slovak Republic, dátum neznámy). According to our study, Slovakia may be seen as an ideal location for maintenance outsourcing, as the labor costs are not that high and at the same time geographically is Slovakia located on a crossroad between Western and Eastern Europe and Northern and Southern Europe. We see potential opportunities for the Slovak MRO market, however, the knowledge of proper English may present an issue, as the options for attending training in the English language are limited, not only in Slovakia but also in other countries, as training is standardly performed in the official language of the country (C. Drury, J. Ma, C. Marin, 2005).

4 Conclusions

The pandemic of COVID-19 strongly influenced the aviation industry, and some countries and regions are going to recover from its impacts longer than others. The pandemic was only one of the challenges that the aviation industry has to face in the coming years. Challenges consist of the pressure to use of more sustainable fuels and limit the carbon footprint of aviation or increasing costs of material wages, and shortage of qualified personnel.

The possibilities of how to approach the shortage in personnel are several, such as the increase in prices of maintenance or the longer turnaround time for scheduled maintenance. The increased prices for maintenance can cause the augmentation of outsourced maintenance

to foreign countries, as in some countries prices for labor are significantly lower than for example in the United States of America, Canada, Germany or Ireland.

By outsourcing maintenance to countries with lower average hourly rates airlines can reduce their costs for maintenance. However, incomes are not increasing only in North America and Western Europe regions, but worldwide. Countries in the Asia Pacific that are predicted to reach great development like China or India, will consequently increase the average hourly rate of aircraft mechanics. Despite the growth in these regions, the expected income in 2027 is still significantly lower than in North America or Western Europe. Eastern Europe is ranked as the second-lowest paying region, with a projected growth of 5.5% of the region's fleet in the next decade. Growth of the fleet is directly connected to the growth of the MRO market such high fleet growth projections are also expected in China (5.4%) and India (7.8%).

According to our study, a difference in the average hourly rate between Latin America and Eastern Europe is observed as insignificant. However, average hourly rates in these two regions are significantly lower than in North America or Western Europe. Latin America is expected to achieve only 1.3% growth of the fleet in the next decade which makes it one of the slowest-growing markets. On the other hand, Eastern Europe with one of the highest projected growth and together with significantly lower labor costs can be a region with many future MRO opportunities. Despite the growth in other regions, the expected income in 2027 is to be significantly higher in North America or Western Europe than in Eastern Europe or Latin America.

The position of Slovakia in the MRO market provides a lot of potential in the coming years. There are several MRO facilities already located in this country. The average hourly rate and the location of the country seem favorable for the development of further MRO providers. Further research can address the importance of English in aircraft maintenance, which is evident, therefore there is a need to focus on the possibility of aircraft mechanics' training in English for preparing a skilled and qualified workforce that is able to ensure safety.

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