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Analysing Winter Olympic Medals Through Economic Variables: A Comprehensive Examination

Ekonomik Değişkenler Açısından Kış Olimpiyat Madalyalarının İncelenmesi: Kapsamlı Bir İnceleme

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ABSTRACT

The impact of economic development holds considerable significance across various domains, including the realm of sports, which has been extensively explored in existing literature. To establish this relationship between Olympic performance and economic factors, an examination was conducted on the medals obtained by countries during Winter Olympic Games spanning the game period from 1960 to 2018. The results of the Pedroni cointegration test signify the presence of a robust co-integration relationship across all test statistics conducted The Panel ARDL analysis reveals that Real GDP emerges as the singular influential factor affecting countries' medal scores in the long term, achieving statistical significance at the 1% level. Additionally, labor compensation exerts a discernible impact, albeit at a 10% significance level. Notably, in the short term, none of these variables exhibit any influence on medal scores, a finding corroborated by the results from the panel PMG analysis. Furthermore, among all variables examined, only Real GDP demonstrates Granger causality concerning medal scores. In contrast, none of the other variables exhibit a Granger causative relationship with medal scores. This profound insight underscores the specific and substantial role played by Real GDP in shaping the dynamics of medal scores, highlighting its unique influence on medal success.

Keywords: Economic growth, olympic, olympic medals, olympic performance, winter olympic games

ÖZ

Ekonomik kalkınmanın etkisi, spor alanı da dahil olmak üzere çeşitli alanlarda büyük önem taşımaktadır. Bu nedenle mevcut literatürde kapsamlı bir şekilde incelenmiştir. Olimpik performans ile ekonomik faktörler arasındaki ilişkiyi kurmak amacıyla, 1960'tan 2018'e kadar Kış Olimpiyatlarında ülkelerin kazandığı madalyalar incelenmiştir. Pedroni eşbütünleşme testi sonuçları, gerçekleştirilen tüm test istatistiklerinde güçlü bir eşbütünleşme ilişkisinin varlığını göstermektedir. Panel ARDL analizi, uzun vadede ülkelerin madalya skorlarını etkileyen tek faktörün reel GSYİH olduğunu ve bu etkinin %1 düzeyinde istatistiksel olarak anlamlı olduğunu ortaya koymaktadır. Ayrıca, iş gücü tazminatının da %10 anlamlılık düzeyinde belirgin bir etkisi bulunmaktadır. Kısa vadede ise, bu değişkenlerin hiçbiri madalya skorları üzerinde bir etki göstermemekte olup, bu bulgu panel PMG analizi sonuçlarıyla da desteklenmektedir. Ayrıca incelenen tüm değişkenler arasında yalnızca reel GSYİH madalya skorlarına ilişkin Granger nedenselliği göstermektedir. Diğer değişkenlerin hiçbirinin madalya skorları ile Granger nedensel bir ilişkisi bulunmamaktadır. Bu derinlemesine analiz, madalya skorlarının dinamiklerini şekillendirmede reel GSYİH'nin belirgin ve önemli rolünü vurgulamakta olup, madalya başarısı üzerindeki benzersiz etkisini gözler önüne sermektedir.

Anahtar Kelimeler: Ekonomik büyüme, olimpiyat, olimpiyat madalyaları, olimpiyat performansı, kış olimpiyat oyunları

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Introduction

The participation in sports contributes to both physical and mental development, and it occurs through active and passive engagement. This leads to individuals' development and gathering within the sports community. Therefore, participation in sports activities is of great importance. In terms of sports participation, the Olympic Games, which is the largest mega sports event, reveals the most decisive aspects of active or passive participation statistically (Buts et al., 2013; Gratton et al., 2000; Kasimati & Dawson, 2008). Therefore, the economic, environmental, cultural, and political impacts of mega sports events are inevitable (Scandizzo & Pierleoni, 2018). Based on these effects, it becomes clear that there is no single factor determining the success of major sports events like the Olympic Games.

According to the assumption put forward by sports economists, a country's Olympic performance is directly related to its economic resources and their utilization (Andreff, 2013). Shasha et al. (2022) conducted an Olympic evaluation with economic, demographic, geographic, and social factors using Quantile and Tobit approaches and cross-sectional data analysis, suggesting that per capita income and the number of athletes are not significantly associated with success. However, while Hoffmann et al. (2004) stated that economic and demographic variables have a significant impact, they also mentioned that state policy will only have a small effect on the medals won. In addition, the study on economic determinants of success in Olympic Games examined the relationship between population, per capita income, and medals using the Poisson Regression model, suggesting that economic factors are associated with medal outcome, particularly when the country is the host (Makiyan & Rostami, 2021; Lui & Suen, 2008). The success achieved in international sports organizations has mainly focused on four factors: population size, gross national product, hosting, and political regime (Knuepling & Broekel, 2022).

Countries invest a significant amount of money to compete with other nations, but there is no evidence of how successful their policies will be. It is evident that there are macro-level variables apart from politicians that determine success. Among these macro-level variables, economic prosperity, population, geographical diversity, urbanization, political and cultural systems emerge (De Bosscher et al., 2006). Additionally, the relationship between the number of medals and economic power and population at the macro level is highly valuable (Seiler, 2013; Tcha & Perchin, 2003). While it is commonly believed that the population size plays a significant role in winning medals, this is not accurate. This is because if population size were a determining factor, countries like China and India would have more medals (Bernard & Busse, 2004). When looking at the number of medals won, it can be observed that the United States, a wealthy country, has won over 100 medals in some games, while developing countries have fewer medals (Forrest et al., 2017). In addition to the indicators affecting the number of medals won in the Olympics, socio-economic variables (Johnson & Ali, 2004), population, unemployment rate (Vagenas & Vlachokyriakou, 2012), host effect (Rewilak, 2021; Csurilla & Fertő, 2022) geographical factors (Hoffmann et al., 2004; Otamendi & Doncel, 2014), education (Noland & Stahler, 2016a, 2017), economic effect (Makiyan & Rostami, 2021) and income level (Noland & Stahler, 2016b) are also seen to play a significant role.

Therefore, an in-depth examination of national income is necessary (Bernard & Busse, 2004; Rathke & Woitek, 2007). Gross national product provides a significant advantage in terms of participation and success in games in nations with higher population (Johnson & Ali, 2000; Rathke & Woitek, 2007; Andreff, 2008; Makiyan & Rostami, 2021). In particular, the fact that 15 European countries, including advanced countries such as Germany, Finland, France, the United Kingdom, Austria, Slovenia, etc., have a value-added contribution of 324 billion euros for sports indicates the importance placed on achieving success (Dimitrov et al., 2006). Yet, the primary source of Olympic performance remains unknown. Hence, factors such as i) income inequality, ii) technological advancement, iii) working hours, and iv) gross national product are considered to influence medal attainment. The only tangible evidence in determining the relationship between sporting development and economic variables lies in the medals won. Therefore, it is crucial for the International Olympic Committee (IOC) to investigate the origins of medals awarded to high-performing athletes.

The primary aim of this research is to investigate the economic variables influencing success in the Olympic Games, which have a long history dating back to antiquity. This study is one of the few that elucidates the connection between economic variables and Olympic medals.

The remainder of the paper develops as follows: in the first section, the focus is on elucidating the relationship between Olympic medals and countries' economic performance. The significance of this relationship in the existing literature is emphasized, underscoring the importance of further investigation. Moving on to the second section, the methodology and data employed in the study are introduced. Descriptive statistics are provided for the series, shedding light on the temporal progression of both countries' medal counts and economic performance. This section aims to gain valuable insights into the medal counts and economic performance of the countries under analysis. The third section presents the empirical results derived from the selected econometric method. These results serve as evidence of the outcomes obtained through the analysis. By employing a rigorous econometric approach, the study strengthens the reliability and validity of its findings. The last section encompasses the discussion of the study's findings and their implications. This section provides a comprehensive overview of the research outcomes, offering insights into the broader implications of the relationship between Olympic medals and economic performance.

Methodology and Data

Methodology

The influence of economic variables on the medal performance of utilized countries are defined as:

$$MEDALS_{it} = \beta_0 + \beta_1(RGDP)_{it} + \beta_2(LABOR)_{it} + \beta_3(TFP)_{it} + \beta_4(HOURS)_{it} + \epsilon_{it}$$

Where Medals meaning total score of medals in Olympic games, RGDP stands for real GDP, LABOR is for labor share, TFP is for total factor productivity and HOURS is for Average annual hours worked by persons engaged. i stands for countries and t for times.

This study employs a variety of methodologies to explore the interrelationships among variables. The initial step involves assessing the cross-sectional dependency of variables using several tests, including the Breusch-Pagan LM test, Pesaran scaled LM test, Bias-corrected scaled LM test, and Pesaran CD test. Subsequently, the Pesaran CIPs test, as proposed by Pesaran (2007), is applied to ascertain the stationarity of series in the presence of cross-sectional dependencies among variables.

The analysis proceeds to investigate the presence of cointegration among variables using the Pedroni cointegration test introduced by Pedroni (2004). While identifying cointegration is pivotal, this study delves further into understanding the impact of variables on medal scores. This exploration is conducted through panel ARDL/PMG analysis, enabling the unveiling of both short-term and long-term effects. Finally, the study explores the causal relationships among variables using the Dumitrescu-Hurlin Panel Causality Test, a method developed by Dumitrescu and Hurlin (2012). This comprehensive analytical approach offers a nuanced understanding of the intricate relationships and dynamics among the studied variables, providing valuable insights into the underlying mechanisms governing the phenomena under investigation.

Data

In this study, data spanning from 1960 to 2018 pertaining to winter games on available dates was utilized. The selection criteria for countries were stringent, considering only those nations that had won at least one medal in every winter game encompassed within the study period. Consequently, a limited pool of countries emerged, consisting of just nine nations: Austria, Canada, Finland, France, Germany, Italy, Norway, Sweden, and the United States, all of which met the medal-winning criterion from 1960 to 2018.

This focused approach, although narrowing down the participating countries significantly, enabled the application of rigorous econometric techniques. The specifics of the Winter Olympic Games, including the year and location, are meticulously detailed in Table 1 for reference.

Table 1
Year and place of winter olympic games

Year	Place	Year	Place
1960	Squaw Valley	*1992*	Albertville
1964	Innsbruck	*1994*	Lillehammer
1968	Grenoble	*1998*	Nagano
1972	Sapporo	*2002*	Salt Lake City
1976	Innsbruck	*2006*	Turin
1980	Lake Placid	*2010*	Vancouver
1984	Sarajevo	*2014*	Sochi
1988	Calgary	*2018*	Pyeong Chang

It is noteworthy that the Winter Olympic Games hosted in Beijing in 2022 were excluded from the analysis due to the unavailability of data in the Penn World Table prepared by Feenstra, Inklaar & Timmer (2015) beyond 2019. Consequently, the study concentrated on analyzing the data from a total of 16 winter games spanning the period from 1960 to 2018.

Table 2
Description of variables

	Variables	Explanations	Data Source
1	***MEDAL***	Total score of Medal (3*Gold, 2*silver, 1*bronze)	Olympics.com
2	***RGDP***	Real GDP at constant 2017 national prices (Logarithm)	PWT
3	***LABOR***	Share of labor compensation in GDP at current national prices	PWT
4	***TFP***	TFP (Total Factor Productivity) at constant national prices (2017=1)	PWT
5	***HOURS***	Average annual hours worked by persons engaged	PWT

PWT: Penn World Table

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

The data utilized in this study is meticulously detailed in Table 2. To ensure a comprehensive understanding of the economic dynamics in the countries under scrutiny, a diverse range of economic variables has been incorporated into the analysis. This broad selection was made in recognition of the intricate economic structures of these nations; relying on a limited set of variables might not suffice to capture the complexity of their economies.

To gauge the multifaceted nature of these countries, an extensive exploration of numerous variables was undertaken. The medal data was sourced from olympics.com, where the total score was calculated using the formula: Total Score = (Gold Medals * 3) + (Silver Medals * 2) + (Bronze Medals * 1). This calculated total score was adopted as the medal variable in this research.

The variables used in this study focuses on the impact on economic variables on medal scores of countries which are economic growth, labor share, total factor productivity and average annual hours worked by persons. Technology is added into analysis as an important factor for medal score because of that sports technology encompasses the deliberate utilization of specialized tools and cutting-edge technologies by athletes to enhance their training and competitive environments, optimizing tasks and improving overall athletic performance through efficient and effective means (Omoregie, 2016). Hence, the technology variable is measured as total factor productivity.

Additionally, economic growth is another variable which can have remarkable effect on medal scores of countries because of the fact that the rise of GDP per capita enables countries to afford to train athletes better, provide better medical care, and send a larger group of athletes to the Olympic Games (Bian, 2005).

Additionally, share of labor compensation and average annual hours worked variables are also added into analyses because of the fact that share of labor compensation can be beneficial indication of inequality in the countries. Inequality can have both economic and social results, hence, the impact of inequality on countries economic performance is well-studied in economic literature. However, the rise in inequality may have far-reaching consequences. The high costs associated with athlete training can pose a considerable challenge for talented individuals from underprivileged backgrounds, impeding their capacity to invest in enhancing their skills, hence, this financial impediment further compounds the pre-existing disparities in Olympic performance, perpetuating unequal opportunities for athletes based on their socio-economic status (Kufenko & Geloso, 2019).

Additionally, working hours can have fundamental impact on Olympic scores as the fact that some of athletes can work in companies and prepare for Olympic games as well. In this case, the preparation of these athletes with too much working hours can be obstacle for them to win medals. For the case of both have to work and train such as Nathalie Marchino Oly (Colombia) for Rugby Sevens, Lanni Marchant (Canada) for Athletics, Paul Adams Oly (Australia) for Shooting (Olympics.com).

Furthermore, the economic variables employed in the analysis were derived from the Penn World Table prepared by Feenstra, Inklaar & Timmer (2015). These variables encompassed Real GDP at constant 2017 national prices (in logarithm), share of labor compensation in GDP at current national prices, total factor productivity (TFP) at constant national prices (with 2017 as the base year), and average annual hours worked by persons engaged. These variables were chosen to assess the impact of economic factors on the performance of countries in the Olympic Games, providing a nuanced perspective on the interplay between economic indicators and medal success.

Furthermore, Figure 1 serves as a visual representation illustrating the mean values of the variables utilized in this study across different time periods. Examining the countries included in this study, it is evident that their medal scores remained relatively low with significant fluctuations prior to 1992. Subsequently, there was a notable increase in medal scores until 2002, followed by fluctuations in subsequent years.

In terms of economic indicators, Real GDP and Total Factor Productivity (TFP) exhibited a consistent upward trend over time. Conversely, average working hours exhibited a steady decline. Notably, labor compensations reached their peak before 1980, sharply decreasing thereafter with pronounced fluctuations observed, indicating a gradual decline in compensation rates over time. This graphical representation offers a clear overview of the evolving trends in these variables, providing valuable insights into the changing dynamics of the countries under study.

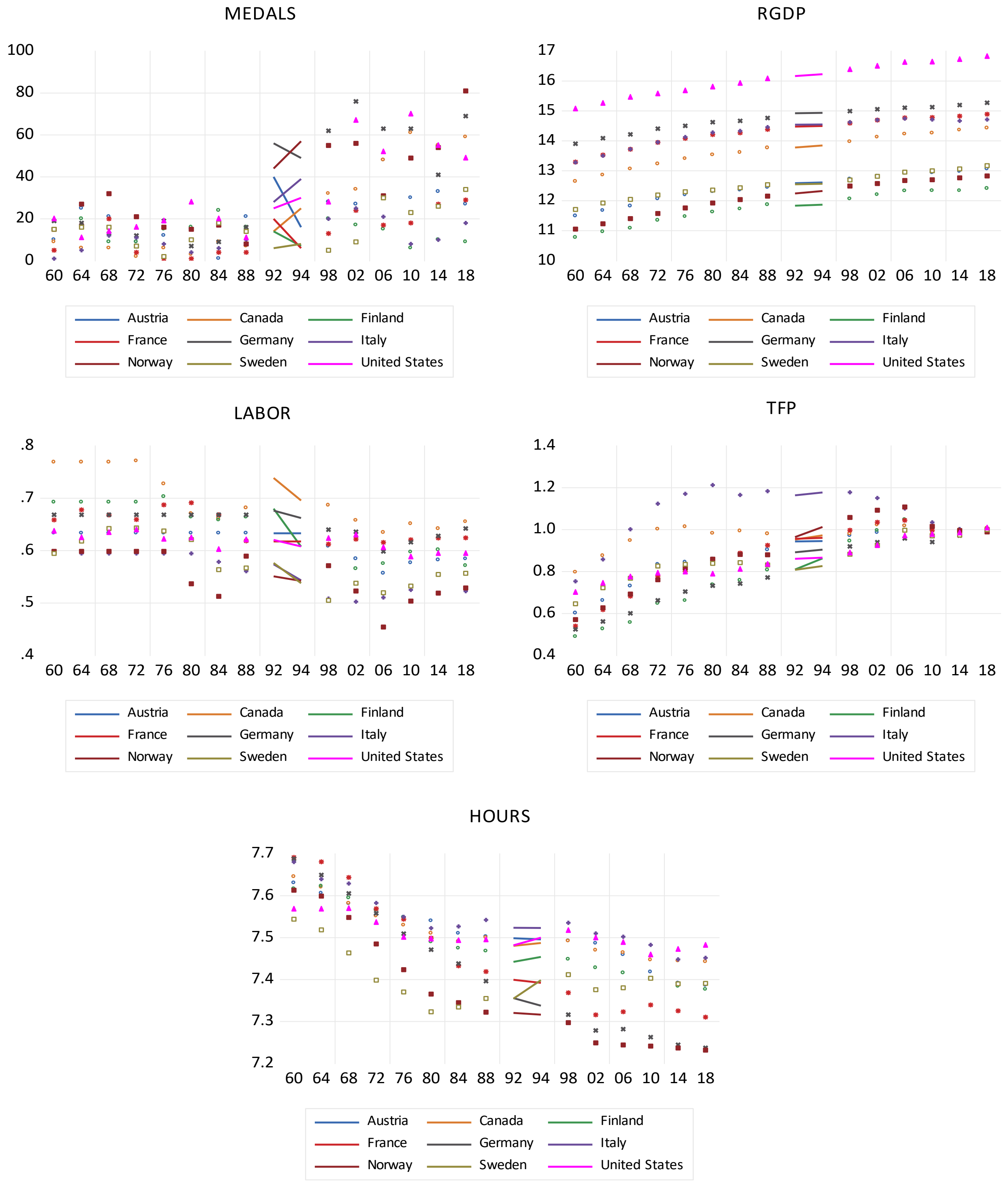

Figure 1. *Visualization of variables*

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

Table 3 provides a comprehensive overview of the variables incorporated in the analysis, offering detailed descriptive statistics. These statistics include key measures such as the mean, standard deviation, minimum, and maximum values of each variable in the study. This tabular representation not only offers a snapshot of the central tendencies and variabilities within the dataset but also serves as a fundamental reference point for understanding the range and distribution of the variables under scrutiny.

Table 3
Descriptive statistics of variables

Variable	Obs	Mean	Std. dev.	Min	Max
MEDAL	144	23.34028	18.6522	1	81
RGDP	144	13.5473	1.439163	10.77505	16.81765
LABOR	144	.6162724	.0589054	.454113	.7709072
TFP	144	.891225	.155246	.4890219	1.211855
HOURS	144	7.464394	.1085663	7.231664	7.690961

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

Moreover, the relationships among variables are illustrated through a correlation matrix visualization, accompanied by scatter plots. This approach effectively captures the year-over-year correlations among the variables under investigation. Figure 2 serves as a visual representation, providing a clear and insightful depiction of the correlations existing among the variables, further enriching the analytical depth of this study.

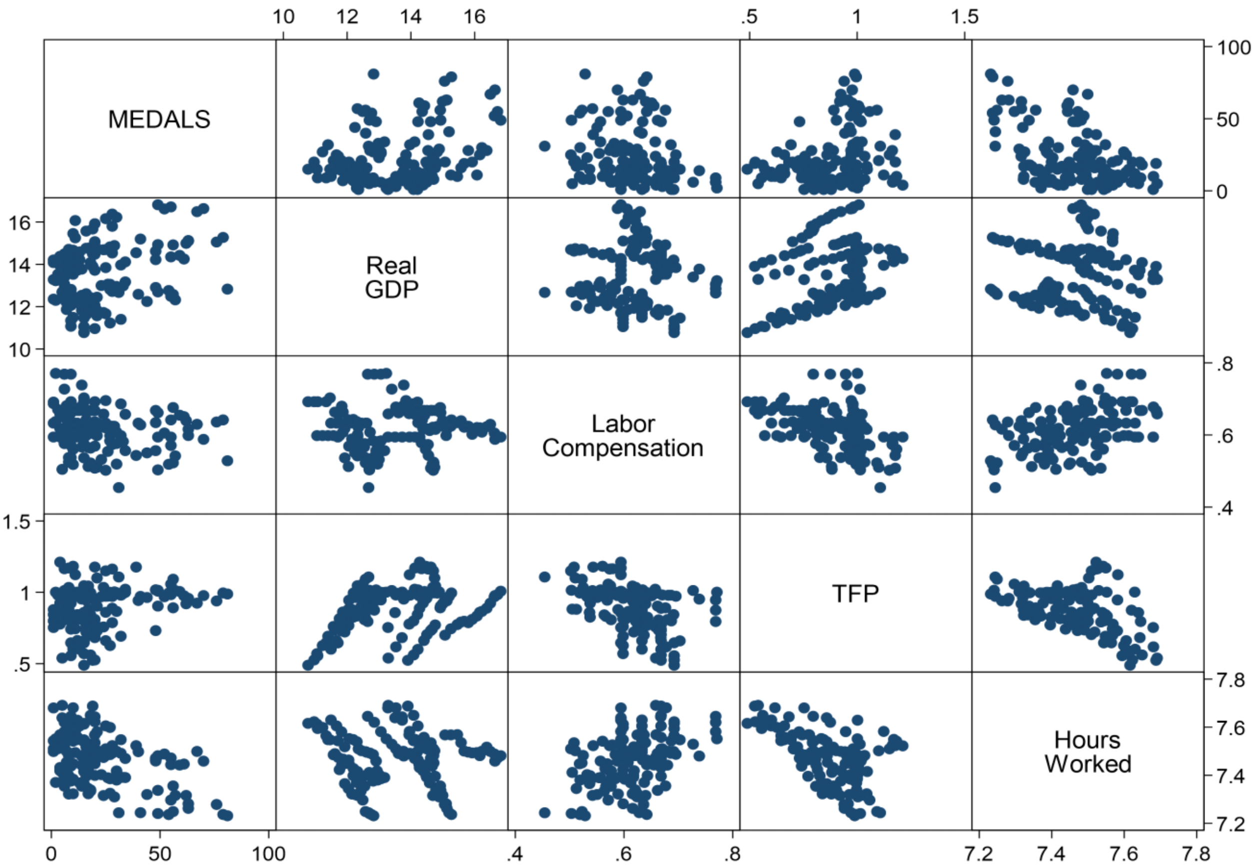

Figure 2. *Correlation matrix*

Furthermore, to enhance clarity and precision in visualizing the correlation degree among variables, a heat map is employed to represent the correlation matrix. Figure 3 depicts the correlations among variables using this heat map approach, where blue areas signify negative correlations. In contrast, the spectrum from white to pink illustrates positive correlations, with white indicating lower correlations and pink indicating higher positive correlations.

The correlation matrix analysis reveals significant patterns. Specifically, Medal scores exhibit positive correlations with Real GDP and total factor productivity. Conversely, labor share and average working hours demonstrate negative correlations with the medal scores of countries participating in winter games. These findings provide valuable insights into the intricate relationships between economic variables and medal success, shedding light on the multifaceted dynamics at play in the context of this study.

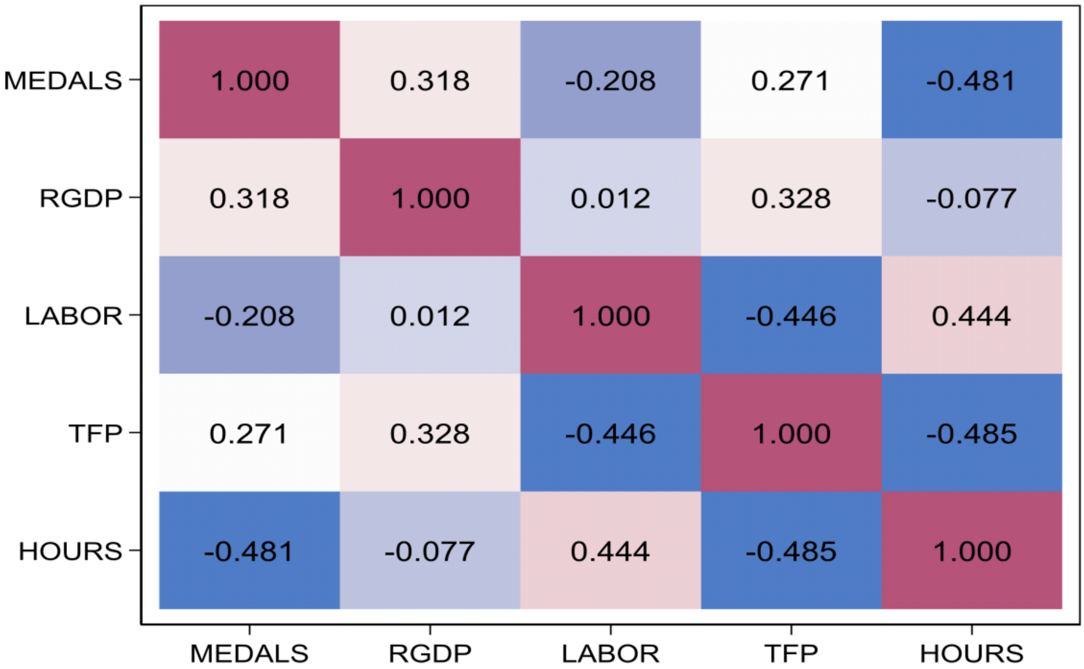

Figure 3. *Heat map correlation matrix*

To initiate the panel data analysis, the initial step involves assessing the cross-section dependency of the series, as it is indicated in Table 4. Various tests, including Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM, and Pesaran CD tests, are utilized for this purpose. The results from these tests uniformly indicate the presence of cross-section dependency. Consequently, the subsequent step involves conducting unit root tests, tailored to the identified cross-section dependency, ensuring a methodologically rigorous approach in the analysis.

Table 4
Cross-Section dependency test

Test	MEDAL	RGDP	LABOR	TFP	HOURS
			Statistics		
Breusch-Pagan LM	170.9598	562.2707	307.5216	390.9511	461.0737
Pesaran scaled LM	15.90516	62.02159	31.99913	41.83139	50.09541
Bias-corrected scaled LM	15.60516	61.72159	31.69913	41.53139	49.79541
Pesaran CD	8.739963	23.71041	17.24493	19.21188	21.26794

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

The stationarity levels of the variables are determined using the CIPS unit root test introduced by Pesaran (2007). All series are subjected to testing under both constant and constant & trend options, examining both levels and first differences. The outcomes reveal that Medal is stationary at the level, indicating it as I (0). Conversely, all other series exhibit unit roots at their initial levels. However, after taking the first difference, all series achieve stationarity across all options. Consequently, it can be concluded that, except for Medal, all other variables are integrated of order one (I (1)), while Medal stands as a non-stationary variable (I (0)).

Table 5
Unit root test results

Variables	**Level**		**Difference**	
	Constant	***Constant & Trend***	***Constant***	***Constant & Trend***
MEDAL	-2.939***	-2.931**	-4.204***	-4.153***
RGDP	-1.683	-2.363	-3.683***	-3.960***
LABOR	-2.096	-1.956	-3.228***	-3.091**
TFP	-1.469	-1.552	-2.563***	-2.918**
HOURS	-2.268*	-1.884	-3.149***	-3.440***

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

Moreover, the investigation delves into the co-integration relationships among variables using the Pedroni co-integration test, as proposed by Pedroni (2004). The results of this analysis are meticulously presented in Table 6. According to the Pedroni cointegration test results, cointegration is affirmed for all the test statistics conducted. The findings conclusively demonstrate that the medal score exhibits a co-integration relationship with Real GDP, labor compensation, total factor productivity, and average annual hours worked by individuals. These insights shed light on the intricate long-term relationships between medal success and these key economic factors, contributing substantially to the depth of our analysis.

Table 6
Pedroni cointegration results

	Statistic Tests	**Statistics**	**P-Value**
Between-dimension	**Group rho-Statistics**	3.0857	.0010
	Group PP Statistics	-6.1568	.0000
	Group ADF Statistics	-5.1606	.0000
Within-dimension	**Panel -Statistics**	-4.0831	.0000
	Panel rho Statistics	2.1580	.0155
	Panel PP Statistics	-6.4844	.0000
	Panel ADF Statistics	-5.2325	.0000

In this study, the Pooled Mean Group (PMG) estimation technique, as introduced by Pesaran et al. (1995) and Pesaran et al. (1999), is employed. This method enables the exploration of both short-term and long-term influences of variables on medal scores. The distinctive feature of the panel Autoregressive Distributed Lag (ARDL) model lies in its ability to accommodate both stationary (I (0)) and non-stationary (I (1)) time series data, facilitating a rigorous empirical examination.

The results, presented in Table 7, reveal that only Real GDP significantly influences medal scores of countries in the long run at a 1% significance level, with labor compensation exhibiting an influence at a 10% significance level. However, in the short run, none of the series exhibit an influence on medal scores according to the panel PMG results. It is noteworthy that the error correction variables are negative and significant, as it is expected. Therefore, the sole long-term influence on medal scores is attributed to Real GDP, while no short-term effects from any variables are observed in this analysis.

Table 7
Short and long run dynamics based on Panel ARDL/PMG model

	Coefficient	Std Error	Z	*p*-Value
		Long-run		
RGDP	49.25123	12.94316	3.81	.000
LABOR	139.1698	79.65433	1.75	.081
TFP	-37.53819	33.87505	-1.11	.268
HOURS	63.78218	52.86245	1.21	.228
		Short-Run		
EC	-.530685	.0630587	-8.42	.000
RGDP	-20.7801	31.99109	-0.65	.516
LABOR	-38.22834	45.92463	-0.83	.405
TFP	61.77867	38.25621	1.61	.106
HOURS	39.29615	101.1861	0.39	.698
Constant	-620.3366	78.55567	-7.90	.000

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged **EC**: Error Correction

The final econometric approach in this study is centered around causal analysis, with a specific reliance on the panel causality analysis developed by Dumitrescu and Hurlin in 2012. This study scrutinized the causal relationships and directional connections between variables by implementing the Dumitrescu-Hurlin Panel Causality Test, with lag selection determined using the Akaike Information Criterion (AIC) and 1,000 bootstrap replications employed to ensure robust results. Notably, this test serves as an enhanced and more nuanced iteration of Granger causality, allowing for a comprehensive examination of the intricate interrelationships among the variables under investigation.

Table 8
Dumitrescu-Hurlin panel causality test

H0	W-bar	Z-bar	Z-bar p-value	Z-bar tilde	Z-bar tilde p-value	Causality
RGDP does not Granger-cause MEDAL	13.6985	13.1029	.0180	4.0145	.0180	YES
LABOR does not Granger-cause MEDAL	8.6304	6.8958	.0860	1.8027	.0860	NO
TFP does not Granger-cause MEDAL	3.3738	5.0355	.1060	3.2771	.1060	NO
HOURS does not Granger-cause MEDAL	2.0881	2.3082	.3790	1.3389	.3820	NO

MEDAL: Total score of Medal **RGDP:** Real GDP at constant 2017 national prices **LABOR**: Share of labor compensation **TFP** : Total Factor Productivity **HOURS**: Average annual hours worked by persons engaged

The comprehensive outcomes of this analysis have been thoroughly documented in Table 8. The results distinctly indicate that among all variables examined, only real GDP demonstrates Granger causality concerning medal scores. None of the other variables exhibit a Granger causative relationship with medal scores. This discerning finding sheds light on the specific influence of real GDP on medal success, emphasizing its unique and significant role in shaping the dynamics of medal scores.

Conclusion

Olympic events and other mega sports events are highly important for economic development and sustainability (Aygün et al., 2023). Many scientists have conducted studies on the factors underlying Olympic success. While it is particularly accepted that economic size is important in Olympic success, it has also been stated that population, gross national product, and the number of athletes play a role in winning medals (Moosa & Smith, 2004; Lui & Suen, 2008). In addition to these factors, it is observed that being the host country (Johnson & Ali, 2004; Csurilla & Fertő, 2023; Singleton et al., 2024), national policies (Bian, 2005), traditions (Otamendi & Doncel, 2014), and gross national product (Csurilla & Fertő, 2022) are significant factors in medal outcome. Factors influencing the number of medals has been the subject of extensive discussion in the literature. Directing our attention to the Winter Olympic Games, our investigation reveals a discernible correlation between economic variables and medal success. The recognition of economic variables as a significant indicator of athlete performance hinges on the availability of financial resources, facilities, policies, and athlete support systems. It is believed that countries with a higher gross national product and more comprehensive sports policies will achieve greater stability in medal outcome. Therefore, the examination of economic indicators in relation to Olympic performance and medal outcome is a significant factor for the development of new sports policies in nations and for the formation of an informed sports culture aimed at performance and success improvement.

The results of the Pedroni cointegration test highlight a strong co-integration relationship evident in all test statistics conducted, establishing a robust connection between medal scores and crucial economic indicators such as Real GDP, labor compensation, total factor productivity, and average annual hours worked by individuals. An extensive examination of the Panel ARDL outcomes reveals that Real GDP emerges as the primary factor positively influencing countries' medal scores in the long term, achieving statistical significance at the 1% level. Additionally, labor compensation exerts a discernible influence, albeit at a 10% significance level. Interestingly, in the short term, none of these variables show any noticeable impact on medal scores, a conclusion supported by the results of the panel PMG analysis.

A noteworthy revelation from this study is that among all the variables analyzed, only Real GDP demonstrates Granger causality concerning medal scores. In contrast, none of the other variables exhibit a Granger causative relationship with medal scores. This significant insight underscores the specific and substantial role played by Real GDP in shaping the dynamics of medal scores, highlighting its distinctive influence on medal success.

These findings contribute to our understanding of the intricate interplay between economic development and sports performance, providing valuable insights for policymakers and stakeholders aiming to enhance national sporting achievements. Future research in this field may expand the analysis to encompass additional economic variables and explore the impact of specific policies and investments in sports infrastructure on Olympic outcomes. In addition to examining the Olympics from an economic standpoint, it is recommended to adopt a broader perspective that encompasses socio-economic, demographic, and other relevant variables. Given the comprehensive nature and extended time span covered in this study, it holds the potential to provide theoretical support and guidance for future research endeavors.

Etik Komite Onayı: Bu çalışmada yazarlar tarafından insan katılımcılarla gerçekleştirilen herhangi bir çalışma içermemektedir.
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