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# NAŠE GOSPODARSTVO

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## Naslov uredništva

Maribor, Razlagova 14, Slovenija, telefon: +386 2 22 90 112

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## Editorial and administrative office address

Maribor, Razlagova 14, Slovenia, phone: +386 2 22 90 112

E-mail: [our.economy@um.si](mailto:our.economy@um.si)

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# Carbon Credits and Crude Oil: An Investigation of the Price Returns Interaction in the International Market

André Assis de Salles,<sup>\*</sup> Renato Barros Lima

Universidade Federal do Rio de Janeiro, Escola Politécnica, Av. Athos da Silveira Ramos 149, 21941-909 Rio de Janeiro, Brazil

as@ufrj.br, relima222@poli.ufrj.br

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## Abstract

This paper aims to verify the relationship between the international markets for crude oil and carbon credits. We studied the returns of prices practiced in these markets, focusing on the transmission of shocks between oil prices and carbon credit prices. The methodological approach used financial econometrics to study these variables' risk and return relationships. Besides causality and cointegration hypothesis tests, the VECM and GARCH models were estimated. There is a short- and long-term interaction between these variables. The volatility models show a significant association between the volatilities of the two variables of interest. Fossil fuels, mainly crude oil, generate energy that has substantial restrictions. At the same time, the carbon credits market has shown significant growth that can contribute to the use of energy from fossil fuels with parsimony and responsibility. Studying these variables and their interactions contributes to understanding the importance of the carbon market.

## Introduction

Once it is an essential production factor for economic activity and development, the energy sector is prominent in economies. Aside from concerns about the economic development of national economies, world leaders have been faced with the alarming speed of climate change. In this context, fossil fuels, mainly crude oil, stand out as an energy source with a significant share in the energy matrix of national economies.

Since the end of the last century, concern about global warming has been the subject of establishing global policies that can control climate change. This concern with the problem of global warming gave rise to the Climate Convention, signed by representatives of the countries that participated in the Rio 92 Conference, resumed and ratified from the Kyoto Protocol in 1997, as mentioned in work by Guðbrandsdóttir and

<sup>\*</sup> Corresponding author.

Haraldsson (2011). Global incentive policies seek to slow global warming by reducing and controlling the emission of greenhouse gases, which have energy from fossil fuels as one of the primary emission sources. Among the fruits of this concern about global warming is the incentive to produce energy from renewable energies and the growth of the carbon credits market. These credits allow the emission of CO<sub>2</sub> from fossil fuels into the atmosphere, increasing the cost of using this energy source. The work of Kanamura (2021) highlights the importance of the carbon market as an essential tool for reducing CO<sub>2</sub> emissions and solving the problem of global warming.

Many studies have been done on the behaviour of carbon credit prices traded in organized markets in recent decades using econometric methods developed. Among other studies, we can mention that of Paoletta and Taschini (2008), Bens and Truck (2009), Daskalakis et al. (2009), Feng et al. (2011), and Dutta (2018). The work of Tian et al. (2016) should be highlighted once pointing out that the European Union Emissions Trading Scheme (EU ETS) is the largest carbon market in the world economy. Thus, the primary reference for the price of carbon emissions worldwide. Many research studies have focused on the recent development of the carbon credit market, such as the work of Guðbrandsdóttir and Haraldsson (2011) and Michaelowa et al. (2019). These works highlight that the negotiation of these credits has been implemented in four phases of the development of this market. Phase 1, demarcated from 2005 to 2007, corresponded to the preparation phase for commercialization. Following the implementation in Phase 1, Phase 2 began in 2008 and ran until 2012. With Phase 2, the necessary conditions for advancement were created. In negotiation, such as data records, emission limits by companies, and provision of licenses for CO<sub>2</sub> emissions. From 2013 to 2020, it corresponded to Phase 3 when implementing market reforms, backloading, stability reserve, and emission limits. Phase 4 began in 2021, seeking greater market control and experiencing significant growth in carbon credit negotiations and prices charged.

An exciting aspect of organized commodities markets is financialization. D'Ecclesia et al. (2014) highlight that the financialization of commodity markets uncovers a new class of assets to make up investors' portfolios. This financialization occurs in energy markets, particularly the crude oil market, as mentioned in Salles et al. (2022) and previously observed by Tang et al. (2012). In work on the carbon market, Kanamura (2021) points out similarities

between the carbon credit and financial markets, emphasizing the financialization of the carbon market.

Therefore, considering finance theory, studying the behaviour of price returns and the volatility of the carbon credit and crude oil markets and their interactions is analogous to financial assets. Estimating and predicting returns and price volatility of financial assets and commodities is at the heart of modern finance theory. Estimates of returns, volatilities, and correlations between financial assets are necessary for pricing these assets and their derivatives, optimizing portfolios, managing risks, and implementing hedging operations. Therefore, for more excellent knowledge of the markets for crude oil and its derivatives, gas, carbon credits, and renewable energy, it is essential to study the foundations of finance theory, particularly market finance, to support decision-makers besides the formulators of economic policy in general and energy policy in particular, as well as the direct participants of these markets, such as consumers, investors, hedgers, arbitrators, and speculators.

The object of study of this work refers to the issue of the transmission of shocks from crude oil prices to carbon credit prices and vice versa, allowing inferences to be obtained about the dynamic relationship between these variables of interest, essential for agents' economic interests involved in the oil and gas sector. Seeking to investigate how much the carbon credits market should be more or less attractive for the economic agents mentioned. Furthermore, it is necessary to understand how the prices of fossil fuels have been related to those of carbon credits, a relevant issue for economic agents involved directly or indirectly with the fluctuation of these prices.

This work uses a methodological approach based on data science, particularly methods based on financial econometrics, to study the risk and return relationship in the international markets for crude oil and carbon credits. Furthermore, we sought to verify the interaction between prices charged in the crude oil and carbon credit markets. More specifically, the interaction between the time series of returns on Brent oil prices traded on the international market and the returns or variations in carbon credit quotes traded on the first maturity of the futures market for these credits traded on the European market, that is mainly benchmark of the world market.

In addition to this introduction, this work is structured as follows. The next section presents the methodological

approach to achieving the objectives mentioned earlier. Moreover, this section describes the sample or data set used, while the following section analyses the results obtained by implementing the proposed methodology to the data. At the end of this paper, the last section deals with the final comments on the research, followed by the bibliographic references list used in the study.

## Methodology and Data

### Applied methodological approach

This section initially describes the price and returns variables of the interest time series. In these descriptions, in addition to the graphs that allow visualization of the behaviour of these variables in the period studied, statistical summaries and statistical tests of the hypotheses of the assumptions of normality, stationarity, autocorrelation, and homoscedasticity were prepared. Thus, statistical tests of the hypothesis were carried out: Jarque-Bera (JB) to normality, Augmented Dickey-Fuller (ADF) to stationarity, Ljung Box to non-autocorrelation, and White to homoskedasticity. These tests were referenced in Gujarati and Porter (2011) and Wooldridge (2011), as well as in the applications shown by Salles and Campanati (2019) and Salles et al. (2021).

The crude oil and carbon credit price returns cointegration hypothesis was tested in a subsequent stage. In this way, we verify whether it is possible to infer that the returns from crude oil prices and carbon credit quotes share the same stochastic properties in the long term. Among the tests of the cointegration hypothesis tests available in the econometric literature, two tests should be cited: Engle and Granger (1987) and Johansen and Juselius (1990). The Engle and Granger test, as described in Gujarati and Porter (2011), is based on unit root tests, in particular, on the Dickey and Fuller or Dickey and Fuller stationarity tests augmented for the linear combination of two series non-stationary storms once the cointegration test suggested by Johansen and Juselius (1990) makes it possible to verify the cointegration hypothesis for stationary time series. Thus, in this work, the test used to verify the hypothesis of cointegration of the time series of price returns of the two variables of interest was that of Johansen and Juselius (1990), concomitantly with the implementation and estimation of vector autoregressive models (VAR). Estimating VAR models is crucial for studying the stochastic relationship between these time series and, in particular, the causality between these series.

In addition to the cointegration test described, the methodological approach uses vector autoregressive or VAR models, as defined by Gujarati and Porter (2011). The VAR models, presented in the literature by Sims (1980), consider all variables involved as endogenous. In other words, they do not distinguish between endogenous and exogenous variables, which allows the study of the relationship between two or more stochastic variables and concerning innovations or shocks that one variable can transmit to another, as well as their causal relationship in the short and long run observed by Granger (1969). Brooks (2014) has added that autoregressive models are those in which the most recent values that the variable assumes depend only on the values assumed in past periods added to an error. The VAR model can be described through equations that relate the variables of interest to the lagged values of the variable itself and another variable of interest in the case of bivariate models. Thus, the VAR model can be described by the following system of equations, in the particular case of a VAR model of order 1, or VAR (1):

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3 Z_{t-1} + \varepsilon_{1t} \quad (1)$$

$$Z_t = \beta_4 + \beta_5 Z_{t-1} + \beta_6 Y_{t-1} + \varepsilon_{2t} \quad (2)$$

$Y_t$  and  $Z_t$  are stationary variables, and  $\varepsilon_{1t}$ , and  $\varepsilon_{2t}$  are stochastic terms, impulses or innovations, orthogonal with an expected value equal to zero.

If the two variables cointegration hypothesis is not rejected, the VAR model must be modified to consider the error correction mechanism. Therefore, the model to be estimated to study the relationship between the two variables must be a vector autoregressive model with error correction (ECM) or the VEC or VECM model. Therefore, once the non-rejection of the cointegration hypothesis is confirmed, the VECM model is indicated to examine the causal relationships between the two variables in question. In the bivariate case, the simplest form of the VECM is a linear combination between the variables  $Y_t$  and  $Z_t$  (see Salles and Almeida (2017) described as follows:

$$Y_t = \beta_1 + \beta_2 ECM + \beta_3 Y_{t-1} + \beta_4 Z_{t-1} + \varepsilon_{1t} \quad (3)$$

$$Z_t = \beta_5 + \beta_6 ECM + \beta_7 Z_{t-1} + \beta_8 Y_{t-1} + \varepsilon_{2t} \quad (4)$$

From the estimation of the VAR model or the VECM model, one can obtain the impulse response function and the decomposition of the variance of the variables under analysis. According to Brooks (2014), the impulse response function estimates the responsiveness of a variable to shocks in other variables belonging to the VAR model. For each variable in each equation separately, a

shock is applied to the error, and the effects on the VAR system are perceived over time.

In turn, variance decomposition is a method for examining the dynamics of the VAR system and differs slightly from the impulse response function. The decomposition allows us to observe the participation of the variations of each variable in the variations of other variables of interest. In the case of the model discussed here, with two variables of interest, the variance of each variable in each period of the time series studied is decomposed into two distinct causes associated, respectively, the variable itself and the other variable of interest.

For a considerable knowledge of the price and the returns on these prices, another necessary inference is the estimation of the volatilities of the return time series studied. According to Gujarati (2019), price return variability or volatility can be defined as the price fluctuations of an asset in a given period, the variability of that asset's prices. Financial time series such as financial asset and commodity prices present marked variability with periods of turbulence caused by exogenous events such as news and extraordinary economic events. The variance over time, known as conditional variance, is used to measure this variability. This measure considers the history of the price time series as well as the heteroscedastic character of the financial series, thus having an autoregressive conditional heteroscedasticity that can be obtained using an autoregressive conditional heteroscedastic model or ARCH. The development of the ARCH model, presented in the econometric literature by Engle (1982), allows the explanation of volatility through the square of the stochastic terms of the mean of the observations of a given financial time series. As noted by Engle (2004), the development of the model became necessary to validate the hypothesis that the unpredictability of inflation originates from economic cycles, a factor of uncertainty that interferes with investor behaviour. Thus, to obtain inferences about the volatility of the crude oil price return series and the returns on CO<sub>2</sub> emission credit quotes, heteroscedastic autoregressive volatility models were estimated from the ARCH class of models, presented by Engle (1982) and described in more detail in Bollerslev (2008) and Brooks (2014). Some models of this class, ARCH, GARCH, and EGARCH, estimated for this work, are briefly presented below.

In its simplest form, the heteroscedastic conditional autoregressive model – ARCH for estimating the variance

$\sigma_t^2$  can be described in its ARCH( $p$ ) form by the following expression:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_t^2 + \dots + \alpha_p \varepsilon_{t-p}^2 \quad (5)$$

From the model presented by Engle (1972), a generalization was presented by Bollerslev (1986) called GARCH, where the conditional variance is also dependent on previous lags  $q$  and in its general form of a GARCH( $p, q$ ) can be described as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^p \beta_j \sigma_{t-j}^2 \quad (6)$$

One of the main restrictions of GARCH models is the premise of symmetry, that is, the imposition of volatility having a symmetrical response to positive and negative shocks. However, in general, a negative shock to financial time series returns causes a more significant increase in volatility than a positive shock of the same magnitude in the case of returns from financial asset, commodity, and equity markets, where such asymmetries are typically attributed to the leverage effects, a fall in the value of a company's shares causes the company's debt-to-equity ratio to increase. Thus, Nelson (1991) proposed that the EGARCH model or Exponential GARCH should consider asymmetries between returns and volatility. Through the EGARCH model, given the transformation of the dependent variable using  $\ln$ , the variance  $\sigma_t^2$  is positive even with negative parameters. In its general form, EGARCH( $p, q, r$ ) can be described according to the following expression:

$$\ln \sigma_t^2 = \alpha_0 + \sum_{j=1}^p \beta_j \ln \sigma_{t-j}^2 + \sum_{i=1}^q \alpha_i \left| \frac{\varepsilon_{t-i}}{\sigma_{t-i}} - E \left( \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \right) \right| + \sum_{k=1}^r \gamma_k \frac{\varepsilon_{t-i}}{\sigma_{t-i}} \quad (7)$$

It must be highlighted that model selection criteria are necessary for estimating both vector autoregressive and volatility models. Thus, in addition to checking the sum of squares of errors or stochastic terms, this work used information criteria according to the description presented in Gujarati and Porter (2011). As noted by Gujarati and Porter (2011), among the many model selection criteria, the Akaike information criterion (AIC) and the Schwarz information criterion (BIC) can be highlighted.

The section below describes the data that comprise the sample used in this work.

## Sample and Data

The primary data used are the weekly closing prices, in US\$, from February 2009 to August 2022, of the two

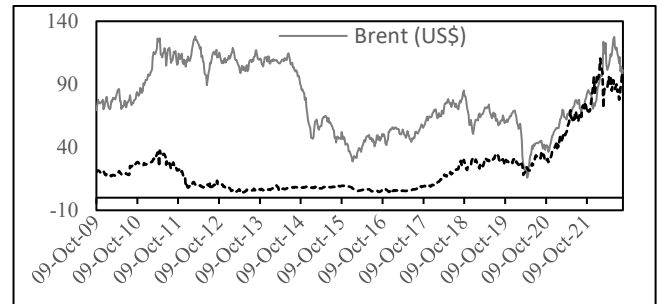


variables of interest: Brent oil price and carbon credit price from the EU Trading System (EUETS). It is a sample of 656 observations of the weekly closing quotations obtained from the daily data collected. The crude oil prices were collected from the EIA, the North American government energy agency, and quotes from the EU Trading System (EUETS) carbon credit price indicator were collected from the Invest.com website. Figure 1, shown below, presents plots of the time series of the closing prices of carbon credit, the first futures, and the closing prices of Brent crude oil in the spot market in the period studied.

From Figure 1, it is possible to check the joint evolution of their prices and the difference between the prices of these two commodities. Prices appear to be decoupled until the end of 2017 or halfway through Phase 3 of carbon market development. Before the start of Phase 4, following the Covid-19 pandemic decree, prices decreased sharply due to the slowdown in global economic activity. In the following period, there were

significant joint increases in oil prices and carbon credits until mid-2022, when the two price series shifted or distanced, approaching a negative association.

**Figure 1**  
Brent Oil Price and Carbon Credit Price



Source: Authors' own elaboration based on the investing.com

Table 1 shows the statistical summary of the price time series and their returns and the results of the statistical hypotheses test of normality, stationarity, and autocorrelation.

**Table 1**  
Statistical Summary of Weekly Price and Returns

	BrentPrice	CarbonPrice	BrentRet	CarbonRet
Mean	77.5145	23.2855	0.0006	0.0024
Median	73.3800	17.6400	0.0038	0.0053
Maximum	128.0800	110.4256	0.2704	0.4201
Minimum	15.8700	3.9735	-0.3464	-0.6491
Std Deviation	26.4045	22.5142	0.0514	0.0820
Skewness	0.1171	1.8527	-0.4601	-1.1662
Kurtosis	1.8348	5.9094	9.6713	13.3607
JB test	38.6077	606.6579	1239.6510	3081.6210
(p value)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
ADF test	-1.5956	-0.0055	-20.8860	-20.3374
(p value)	0.4843	0.9962	0.0000	0.0000
Q(30)	14517.00	14652.22	76.1605	41.3104
(p value)	(0.0000)	(0.0000)	(0.0000)	(0.0819)
Observations	656	656	656	656

Source: Authors' own elaboration based on the investing.com

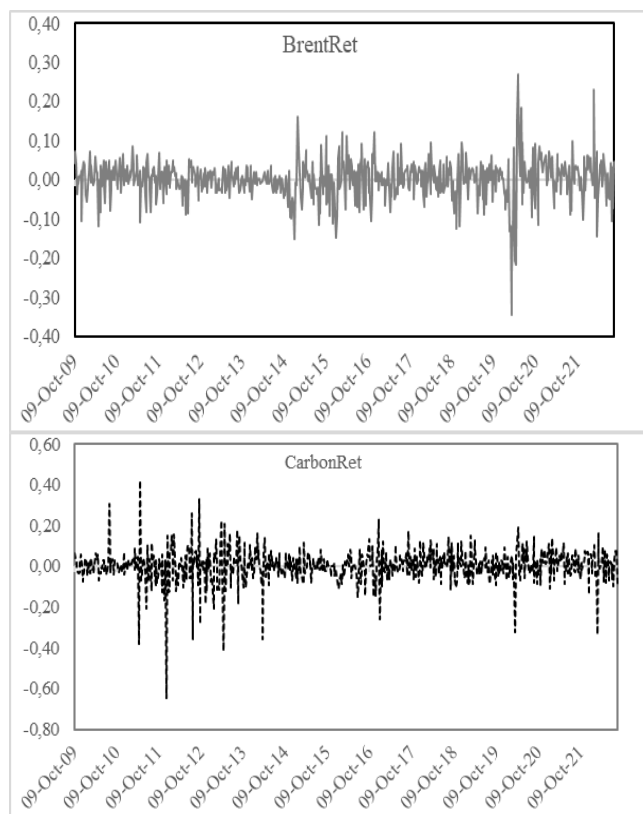
From the price time series, the time series of price returns in period  $t$  were obtained through the following expression  $R_t = \ln(P_t / P_{t-1})$ , where  $R_t$  represents the return in period  $t$  and  $P_t$  the price in period  $t$ . Price returns, both from oil and carbon credits, make it possible to obtain the vector autoregressive and volatility models estimates that are subject of the methodological approach of this research. It can be observed that the average return on carbon credit was higher than the average return on oil prices. The same happens with volatility when observing the standard deviation and the relative variability given by the coefficient of variation. The estimates of the asymmetry and kurtosis coefficients show that the return

series differs from a normal distribution, which the Jarque-Bera test confirms. Unlike what was observed for the weekly price series, the stationarity hypothesis of the weekly return series cannot be rejected. It is verified that the null hypothesis of the time series of returns does not present evidence of autocorrelation.

In Figure 2, where the time series of returns are presented, it can be seen that the volatility of crude oil price returns, given by the Brent type price, increased from 2014 onwards. Another increase in intensity occurred when the Covid-19 pandemic was declared. Regarding carbon credit prices in the period before Phase

3 until 2014, at the beginning of Phase 3, volatility was higher, and there was a peak in volatility with the decree of Covid-19 pandemic.

**Figure 2**  
Carbon Credit and Brent Price Returns



Source: Authors' own elaboration based on the investing.com

Furthermore, as shown in Table 2, White's heteroscedasticity test does not allow the acceptance of

the null hypothesis of homoscedasticity for the time series of price returns from oil prices and returns from carbon emission credit prices. These results justify the use of heteroskedastic models to estimate the return series' volatilities, which will be shown in the following section, as well as the estimates of the proposed autoregressive vector model.

**Table 2**  
White Test for Heteroscedasticity

Variable	BrentRet	CarbonRet
White test	-20.3374	-20.8860
(p value)	0.0000	0.0000

Source: Authors' own elaboration

### Results and Discussion

Given the econometric literature, it is possible to infer the variable interaction referring to causality in the sense of Granger. Thus, tests of the causality hypothesis were carried out between the returns on Brent crude oil prices and the returns on carbon credit quotes from the first traded futures of the EU ETS.

Table 3 shows the results of the Granger causality hypothesis tests for eight lags of two null hypotheses:  $H_{01}$ : CarbonRet does not cause BrentRet and  $H_{02}$ : BrentRet does not cause CarbonRet. These statistical tests of hypotheses carried out with the time series of returns meet the crucial assumption of stationarity. Table 3 shows the F-statistics with the corresponding p-values in parentheses, calculated in EViews.

**Table 3**  
Granger Causality Tests

Lags	2	5	10	20	30	40	50	60
$H_{01}$ : CarbonRet does not cause BrentRet	3.976 (0.019)	3.912 (0.002)	2.225 (0.015)	1.536 (0.064)	1.214 (0.203)	0.982 (0.504)	1.043 (0.399)	0.964 (0.556)
$H_{02}$ : BrentRet does not cause CarbonRet	5.102 (0.006)	2.342 (0.040)	1.855 (0.049)	1.502 (0.074)	1.073 (0.364)	0.952 (0.557)	0.983 (0.510)	0.888 (0.710)

Source: Authors' own elaboration based on the investing.com using EViews software

It can be inferred that the Granger causality hypotheses test cannot be accepted for  $H_{01}$  and  $H_{02}$  in the short term or with 20 lags, or 20 weeks, with a significance level greater than 6%. For high lags, more than 30 weeks, the tests indicate acceptance of the two hypotheses,  $H_{01}$  and  $H_{02}$ .

Other tests were carried out to make it possible to proceed with the inferences and analyze the interaction between the variables of interest in this research. Initially, the cointegration hypothesis test between the time series of variations in oil prices and carbon credits traded in international markets, concomitantly with implementing a bivariate autoregressive vector model, was done. From the cointegration hypothesis tests, it can be inferred that the time series of the returns of crude oil prices of the Brent type and the returns of the carbon

credit quotation indicator in the international market share the same properties stochastic in the long run.

Thus, using the method proposed by Johansen and Juselius (1990), the bivariate autoregressive vector model with error correction, or the VECM model, was implemented. With the results of the VECM model estimates, shown in Table 4 below, inferences were made about the causal relationship between the mentioned time series of returns and about how the variation in prices practiced in the crude oil market is absorbed in the variations in prices charged in the carbon credit market and vice versa.

Table 4 presents the two VECM model estimation equations, with the estimated parameters and their respective standard errors and t-statistics. With these

**Table 4**  
VECM Model Estimation Results

Parameter	Estimates	Std Error	t-statistic
$\beta_1$	0.0133	0.0097	1.3765
$\beta_2$	-0.4257	0.0367	-11.6141
$\beta_3$	-0.0225	0.0286	-0.7861
$\beta_4$	0.2733	0.0134	20.4468
$\beta_5$	-0.0826	0.0505	-1.6336
$\beta_6$	0.0557	0.0394	1.4135
Determinant Residual Covariance (DRC) = 2.22e-05			
Equation 1	$BrentRet_t = \beta_1 (BrentRet_{t-1} - 0.4421 CarbonRet_{t-1}) + \beta_2 BrentRet_{t-1} + \beta_3 CarbonRet_{t-2}$		
R-Squared = 0.1935	Mean Dependent Variable = -3.65E-05		
Adjusted R-Squared = 0.1911	Std Error of Dependent Variable = 0.0651		
Std Error of Regression = 0.0546	Sum Squared Resid = 2.2331		
F-Statistic = 78.1124	Akaike Criterion = -2.8327		
Equation 2	$CarbonRet_t = \beta_4 (BrentRet_{t-1} - 0.4421 CarbonRet_{t-1}) + \beta_5 CarbonRet_{t-1} + \beta_6 BrentRet_{t-2}$		
R-Squared = 0.5731	Mean Dependent Variable = -0.0002		
Adjusted R-Squared = 0.5718	Std Error of Dependent Variable = 0.1234		
Std Error of Regression = 0.080	Sum Squared Resid = 4.2454		
F-Statistic = 437.0540	Akaike Criterion = -2.1902		

Source: Authors' own elaboration based on the investing.com using EVIEWS software

results, it could be inferred that the VECM model was satisfactorily estimated, confirmed by the Determinant Residual Covariance (DRC) close to zero and an AIC close to -5.03. However, not all estimated parameters are statistically significant in an adequate form.

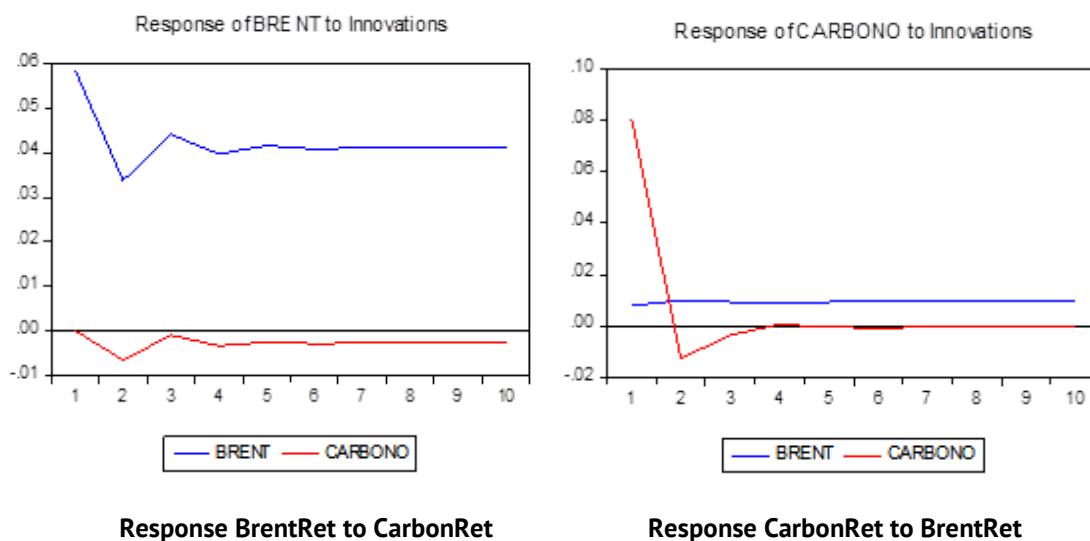
From these results, significance tests of the coefficients

$\beta_1$  and  $\beta_4$  of the error correction mechanisms implemented and presented in Table 4, with the non-rejection of the hypothesis of statistical significance, indicate a long-term relationship between the variables *BrentRet* and *CarbonRet*. Resulting in a chi-square test statistic with 2 degrees of freedom given by 420.43 and a p-value close to zero; the null hypothesis of the Wald

test of these coefficients was not accepted, that is, the population coefficients are significant or differ from zero, confirming a long-term relationship between the variables *BrentRet* and *CarbonRet*. The short-term relationship is also confirmed since the significance of the coefficients indicates that this hypothesis cannot be rejected. Another essential inference concerns the

Granger causality test. The Granger causality test hypothesis points to the non-rejection of bidirectional causality between the two indicators, confirmed by the Wald exogeneity test. In short, it can be inferred that there is a short- and long-term interaction between the two variables studied.

**Figure 3**  
Impulse Response Function Results



**Response BrentRet to CarbonRet**

**Response CarbonRet to BrentRet**

Source: Authors' own elaboration based on the investing.com using EViews software

**Table 5**  
ARIMA-GARCH Model Estimation Results: The BrentRet variable

Brent Volatility – Normal – Error Distribution									
Volatility Model/Mean Model no intercept	ARMA(1,1)	AR(1)	MA(1)	C	Volatility Model/Mean Model with intercept	ARMA(1,1)	AR(1)	MA(1)	C
ARCH (1)	-3.2915	-3.280	-3.278	-	ARCH (1)	-3.2887	-3.2775	-3.276	-3.2716
GARCH (1,1)	-3.3860	-3.3874	-3.3873	-	GARCH (1,1)	-3.3829	-3.3844	-3.3843	-3.3845
E-GARCH (1,1,1)	<b>-3.3915</b>	-3.3927	-3.3927	-	E-GARCH (1,1,1)	-3.4073	-3.4081	-3.4078	<b>-3.4090</b>
T-GARCH (1,1,1)	-3.4052	-3.4050	-3.4047	-	T-GARCH (1,1,1)	-3.4026	-3.4022	-3.4018	-3.4020
Brent Volatility – Student t – Error Distribution									
Volatility Model/Mean Model with intercept	ARMA(1,1)	AR(1)	MA(1)	C	Volatility Model/Mean Model no intercept	ARMA(1,1)	AR(1)	MA(1)	C
ARCH (1)	-3.3712	<b>-3.3693</b>	-3.3684	-3.3650	ARCH (1)	-3.3708	-3.3671	-3.3657	-
GARCH (1,1)	-3.4401	-3.4399	-3.4395	-3.4378	GARCH (1,1)	-3.4407	-3.4399	-3.4394	-
E-GARCH (1,1,1)	-3.4647	-3.4637	-3.4415	-3.4398	E-GARCH (1,1,1)	<b>-3.4435</b>	-3.4425	-3.4419	-
T-GARCH (1,1,1)	-3.4623	-3.4618	-3.4611	-3.4599	T-GARCH (1,1,1)	-3.4648	-3.4637	-3.4218	-

Source: Authors' own elaboration based on the investing.com using EViews software

From the VECM estimation, impulse response functions were obtained for these variables, which show the magnitude of shocks in one of the variables absorbed by the other variable and their persistence over time. The graphs shown in Figure 3 allow us to observe how and

when the response occurs or with what lag one variable affects the other, that is, the responses of the variation of the *CarbonRet* variable to the variation of the *BrentRet* variable and vice versa, with up to ten lags.

**Table 6**  
ARIMA-GARCH Model Estimation Results: The CarbonRet variable

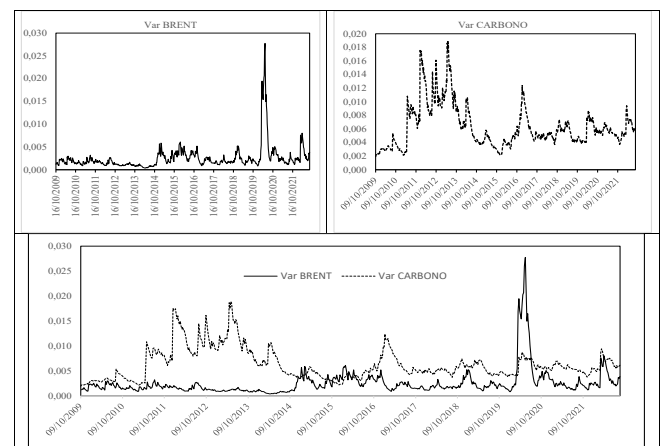
Carbon Volatility – Normal – Error Distribution									
Volatility Model/Mean Model no intercept	ARMA(1,1)	AR(1)	MA(1)	C	Volatility Model/Mean Model with intercept	ARMA(1,1)	AR(1)	MA(1)	C
ARCH (1)	-2.1994	-2.1997	-2.200	-	ARCH (1)	-2.1989	-2.1989	-2.1997	-2.2019
GARCH (1,1)	<b>-2.2528</b>	-2.2518	-2.2507	-	GARCH (1,1)	-2.2548	-2.2539	-2.2534	-2.2527
E-GARCH (1,1,1)	-2.2585	-2.2535	-2.2501	-	E-GARCH (1,1,1)	-2.2575	-2.5484	-2.2521	<b>-2.2545</b>
T-GARCH (1,1,1)	-2.2611	-2.2613	-2.2265	-	T-GARCH (1,1,1)	-2.2609	-2.2608	-2.2606	-2.2592
Carbon Volatility – Student t – Error Distribution									
Volatility Model/Mean Model with intercept	ARMA(1,1)	AR(1)	MA(1)	C	Volatility Model/Mean Model no intercept	ARMA(1,1)	AR(1)	MA(1)	C
ARCH (1)	-2.4756	-2.4729	-2.4733	-2.4734	ARCH (1)	-2.4700	-2.4686	-2.4685	-
GARCH (1,1)	-2.5082	-2.5043	-2.5041	-2.5018	GARCH (1,1)	-2.5043	-2.5005	-2.4994	-
E-GARCH (1,1,1)	-2.5113	-2.5094	<b>-2.5096</b>	-2.5067	E-GARCH (1,1,1)	<b>-2.5084</b>	-2.5064	-2.5056	-
T-GARCH (1,1,1)	-2.5112	-2.5090	-2.5079	-2.5055	T-GARCH (1,1,1)	-2.5073	-2.5047	-2.5027	-

Source: Authors' own elaboration based on the investing.com using EViews software

Thus, ARIMA-GARCH models were estimated to estimate the volatility of returns on Brent crude oil prices in the international market. The results listed in Table 5 show that, among the models estimated for the *BrentRet* variable, the volatility model that presented the best performance was the ARMA(1,1)-EGARCH(1,1,1) model, without intercept for the mean with errors distributed according to Student's t probability distribution and AIC close to -3.4435.

For the *CarbonRet* variable, the same ARIMA-GARCH models were estimated, the results of which are listed in Table 6. Among the estimated models for the *CarbonRet* variable, Table 6 shows the volatility model that presented the best performance the MA(1)-EGARCH(1,1,1) model with errors distributed according to Student's t probability distribution and the Akaike criterion close to -2.5096. From these results, the risk of the studied variables and their relationship or contagion can be measured.

**Figure 4**  
Results of the Volatility Models of the BrentRet and CarbonRet Variables



Source: Authors' own elaboration

Figure 4 shows the graphical results obtained with the selected volatility models of the *BrentRet* and *CarbonRet*

variables. It can be observed that there is a significant association between the volatilities of the two variables of interest: *BrentRet* and *CarbonRet*. It is verified that the association between the volatilities of these variables shows the existence of heteroscedasticity in the covariances. In the middle of carbon credit negotiation Phase 3, a more explicit association between volatilities begins the phenomenon of spillover volatility. It could be observed that volatility contagion decreased at the beginning of 2017 and 2019. Besides that, noteworthy that after the COVID-19 pandemic was declared, volatilities took off, showing a sharp increase in the volatility of oil prices, not accompanied by carbon credit prices that showed a significant decrease in volatility contagion.

### Conclusion and Final Comments

This research focused on studying the return and risk of commodity prices, which is of fundamental relevance for global policies to reduce and control the emission of greenhouse gases directly responsible for the acceleration of global warming. Fossil fuels, mainly crude oil, generate energy that has substantial restrictions. At the same time, the carbon emission credits market has shown significant growth that can contribute to using energy from fossil fuels with parsimony and greater responsibility. Studying the risk and return of these variables and their interactions contributes to understanding the importance of the carbon market. Given the financialization of energy markets, it was possible to verify the interdependence between the returns on carbon credit prices and the returns on crude oil prices through a methodology based on financial

econometrics. In this way, tests of the causality and cointegration hypotheses were carried out and the interdependence of these time series of returns using bivariate autoregressive and volatility models.

The results indicate an interaction between the variables studied. It should be noted that during the period studied, two important events occurred that caused significant interference in price returns and the volatility of the variables studied here: the decree of the Covid-19 pandemic and the military conflict between Russia and Ukraine. Therefore, these reservations must be made to the results obtained.

Following this research, the dynamic correlation behaviour of these time series of interest must be studied based on the estimation of a multivariate models. Just as the study of the interaction of the two variables must continue through multivariate volatility models to expand the observation of the dynamics of volatility contagion or the risk of the assets studied, the volatility estimates must be studied more extensively to allow for more accurate inferences regarding their long-term association or cointegration.

Furthermore, it is suggested that the interaction of carbon credit prices and volatility with other variables associated with the global energy market and the performance of national, developed, and emerging capital markets, as well as the global capital market, be studied. These studies related to the capital market should allow inferences about the interaction of the carbon credit market and the performance of productive activities in the global economy.

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# Emisijski kuponi in surova nafta: raziskava interakcije med ceno in donosi na mednarodnem trgu

## Izvleček

Namen tega prispevka je preveriti interakcijo med mednarodnimi trgi surove nafte in emisijskimi kuponi. Preučevali smo donosnost cen, ki veljajo na teh trgih, pri čemer smo se osredotočili na prenos šokov med cenami nafte in cenami emisijskih kuponov. Za preučevanje razmerja med tveganjem in donosnostjo teh spremenljivk smo uporabili finančno ekonometrijo. Poleg testov hipotez o vzročnosti in kointegraciji smo ocenili tudi modela VECM in GARCH. Med spremenljivkami obstaja kratkoročna in dolgoročna interakcija. Modeli nestanovitnosti kažejo pomembno povezavo med nestanovitnostmi obeh spremenljivk, ki sta predmet zanimanja. Fosilna goriva, predvsem surova nafta, proizvajajo energijo, ki ima precejšnje omejitve. Hkrati je trg emisijskih kuponov pokazal znatno rast, ki lahko prispeva k varčni in odgovorni rabi energije iz fosilnih goriv. Proučevanje teh spremenljivk in njihovih medsebojnih vplivov prispeva k razumevanju pomena trga ogljika.

**Ključne besede:** kredit za emisije ogljika, cena surove nafte, model VECM, modeli nestanovitnosti



# From Theory to Practice: Incentives for Managers and Professionals

Branka Zolak Poljašević,<sup>a</sup> Nemanja Berber<sup>b</sup>

<sup>a</sup>University of Banja Luka, Faculty of Economics, Majke Jugovića 4, 78 000 Banja Luka, Bosnia and Herzegovina

<sup>b</sup>University of Novi Sad, Faculty of Economics Subotica, Segedinski put 9-11, 24000 Subotica, Serbia

branka.zolak-poljasevic@ef.unibl.org, nemanja.berber@ef.uns.ac.rs

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## Abstract

Although, in theory, a considerable amount of literature emphasizes the significance of employee incentive pay, there is not much empirical research indicating their dispersion in practice. The primary purpose of this study is to explore the level of implementation of various incentives in three countries: Slovenia, Serbia, Bosnia and Herzegovina. The research was conducted on a sample of 321 companies. Data for this study were extracted from the CRANET dataset. The latest data collection cycle was conducted in 2021-2022. In addition to descriptive statistics, the Pearson Chi-Square Test and Cramer's V test were used to test hypotheses. The research results indicate a statistically significant difference in using most observed compensation elements among the observed countries. The study contributes to compensation management literature by presenting empirical data regarding the degree of implementation of various compensation instruments in three observed countries.

## Introduction

Compensation or rewards include various elements of material and non-material nature that employees receive for their work. Given that the amount and the structure of total rewards directly influence the attitudes and behaviour of employees, it is in the interest of every employer to use reward systems as a tool to achieve organizational business goals. Academics would argue that rewarding employees is one of human resource management's most important activities (HRM) activities.

Numerous studies conducted in the last two or three decades confirm the multiple significance of incentive reward systems. Compensation is essential in attracting potential employees and maintaining high performance and work motivation (Fay & Thompson, 2001). Additionally, compensations affect employee satisfaction (Siems et al., 2012; Mudor & Tooksoon, 2011; Judge et al., 2010), organizational behaviour (Gupta & Shaw, 2014), and organizational performance (Chen

\* Corresponding author.

& Huang, 2009; Subramony, 2009; Gooderham et al., 2008).

Contemporary organizations recognize that a more complex reward system, including a diverse compensation package, constitutes a strong motivational factor for employees, giving the organization a greater chance to achieve its business goals (Zolak Poljašević et al., 2017). Many organizations rely on various incentive pay and benefit package practices to align employee motivation and behaviour with the desired organizational outcomes (Nyberg et al., 2013; Gerhart et al., 2009; Dulebohn & Werling, 2007).

However, in HRM, theory and practice often differ (Timming & Macneil, 2023). There are numerous criticisms that management research is often disconnected from professional practice (Aguinis & Cronin, 2022; Wood & Budhwar, 2021), is highly theoretical, and is methodologically complex. On the other hand, academics (Fletcher et al., 2020; Purcell, 2014; Guest, 2014) criticize practitioners as being 'too often reductionist, normative, and instrumental' (Timming & Macneil, 2023, p.593). This gap between the HRM theory and practice should not be ignored, especially considering contextual influences. Namely, modern principles and the theoretical basis in the HRM field originated in developed Western countries. At the same time, the HRM practice in some other countries significantly deviates from these theoretical postulates. An example is the former socialist countries of Central and Eastern Europe (CEE). Generally, Western human resource management practices in transitional regions are improper due to local institutional and legal systems and a lack of transparency in the often politicized decision-making process (Horwitz, 2011).

In this paper, we aim to explore the dispersion of various forms of incentives in the context of three CEE countries that share a common socialist heritage but which have experienced different levels of alignment with the Western philosophy of management and HRM practices. In this context, three CEE countries were selected as the subject of the analysis: Serbia, Slovenia, Bosnia, and Herzegovina. The main goal of the analysis is to identify the level of use of five different types of incentives in the observed countries and to determine differences among them regarding compensation practices. The data used in the analysis were drawn from the large international CRANET database, which is the result of data collection on HRM practices in over 40 countries worldwide (Zolak Poljašević & Vučenović, 2023; Prince et al., 2020; Farndale et al., 2019; Berber & Slavić, 2018, Berber et

al., 2017). This paper applied descriptive statistical methods, Pearson Chi-Square Test (Franke, Ho & Christie, 2012) and Cramer's V Test (Okeke Charles, 2019), on a sample of 321 companies. Comparative studies of this kind are valuable as they provide an overview of employee reward practices, reveal potential gaps between theory and practice, and point toward desirable directions for developing this field.

The structure of this paper follows the standard IMRAD form. The first section, following the introduction, provides the theoretical background of the research, describing the theoretical significance of employee incentive rewards. The second part describes the CRANET methodology and the research sample. Subsequently, the research results, discussion, and conclusions are presented.

## Theoretical Background

Compensation management is a process that aims to reward employees fairly and consistently. Rewarding employees is crucial in an organisation's efforts to gain a competitive advantage, attract and retain human resources, and encourage employee development (Berber et al., 2017). Developing an incentive reward system is a challenge for the management of any organization. For this purpose, companies often use various forms of incentives because the traditional reward system in which salaries play a dominant, and often the only role, faces numerous challenges (Zolak Poljašević et al., 2017; Štangl Šušnjar & Berber, 2014; Ilić et al., 2012).

Incentives represent a significant segment of material rewards. They are determined based on the contribution of an individual or a group of employees to achieve organizational goals. The essence of incentives lies in stimulating work performance by establishing a clear and direct connection between the reward and work results. In practice, various types of incentives are used as strategic tools to encourage employee motivation and satisfaction (Heywood & Wei, 2006), productivity at work (Lazear, 2000), positive attitudes, and work intensification (Ogbonnaya et al., 2017; Vlaev et al., 2019), and organizational commitment (Bayo-Moriones & Larazza-Kintana, 2009). Additionally, incentive pay practices are a good instrument for attracting and retaining employees (Diaz-Fernandez et al., 2013) and for aligning employee and stakeholder interests (Nyberg et al., 2018).

In HRM literature, incentives can be classified in various ways depending on whether they are tied to individual,

group, or organizational performance. Performance-based pay and individual bonuses are most commonly used at the individual level. At the organizational unit or team level, group bonuses are utilized, while at the organizational level, there are organizational bonuses as well as profit or stock sharing, which employers can use in the case of achieving certain organizational-level metrics (Prince et al., 2020). Yang (2019) observes that most organizations use combinations of incentive practices to address different goals and balance pay with performance. For the purposes of this research, five types of incentives were analysed: performance-related pay, bonuses based on individual goals, bonuses based on team goals, bonuses based on organizational goals, and non-monetary incentives.

Usually, companies from different countries adopt different combinations of incentive practices because incentives are context-dependent. Many factors, such as national regulations, the state of the labour market, social and political trends, and economic development, influence the preferred combination of incentives at the country level. Numerous studies indicate the influence of national culture on preferred incentive practices in different countries (Prince et al., 2016; Prince et al., 2018; Prince et al., 2020). Hofstede's cultural dimensions - power distance, individualism, masculinity, and uncertainty avoidance (Hofstede, 1984) - are also linked to preferred forms of employee reward (Gooderham et al., 2018; Frank et al., 2015). This study will analyze the dispersion of different forms of incentives in three CEE countries that share a common socialist heritage, namely Slovenia, Serbia, Bosnia, and Herzegovina. During the socialist period, the reward system in CEE countries was characterized by several key features, such as 'centrally planned wages, significant variable payments, and a wide variety of benefits' (Berber et al. 2017, p. 1665). Today, this region cannot be seen as a homogeneous entity, and the reward practices in these countries cannot be viewed as a uniform model. Therefore, this study starts with the following hypotheses:

*H1: A statistically significant difference exists in performance-related pay use among observed countries, regardless of their common socialist heritage.*

*H2: There is a statistically significant difference in the use of bonus on individual, team, and organization level among observed countries, regardless of their common socialist heritage.*

*H3: There is a statistically significant difference in the use of non-monetary incentives among observed countries, regardless of their common socialist heritage.*

The defined hypotheses were tested using the appropriate statistical analysis according to the presented methodology.

### Methodology and Sample

We used data from the latest CRANET research from 2021 to investigate the compensation systems in the selected countries. CRANET research is conducted cyclically for several years to gather a representative sample across multiple countries. CRANET research is conducted according to the same methodology in 40 countries of the world to enable comparison of data on HRM practices. It is designed to draw representative samples from each country (Steinmetz et al., 2011; Cited in Prince et al., 2020). Despite certain methodological limitations, CRANET research is very important because it has provided continuous empirical data on developing HRM practices in member countries for three decades. The questionnaire comprises closed-ended questions, meaning respondents were expected to choose from the provided options. The questionnaire was filled out by HR managers in organizations employing more than 100 employees. In this research, a total of 321 companies from Slovenia, Serbia, Bosnia, and Herzegovina were examined.

**Table 1**  
Sample structure per countries

	Frequency	Percent
Bosnia and Herzegovina	47	14.6
Serbia	106	33.0
Slovenia	168	52.3
Total	321	100.0

Source: Authors based on CRANET 2021 database

As shown in Table 1 most companies operate in the service sector, about 70%, while the rest (30%) are in the manufacturing sector. About 60% work in the private sector and 40% are in the public sector.

In CRANET methodology, each incentive scale is composed of binary items (1 = yes, 0 = no). Respondents were expected to indicate whether they use the observed incentives separately for four categories of employees: managers, technical/professional, clerical, and manual staff. In this paper, only two categories of employees were observed: managers and technical/professional staff. The analysis was conducted in two phases. In the first phase, a descriptive analysis

was performed to assess the level of use of different incentive pay practices in the observed countries. In the second phase, the Pearson Chi-Square Test (Franke, Ho & Christie, 2012) and Cramer's V coefficient of association (Okeke Charles, 2019) were applied to test the hypotheses, i.e., to determine statistical differences in the level of application of three different forms of incentives among the observed countries, including pay for performance (H1), bonus (H2) and non-monetary incentives (H3). Research data were analyzed using SPSS software.

## Results

The data analysis in this study begins with descriptive statistics, aiming to illustrate the prevalence of various forms of employee incentives in the observed companies. The results are presented separately for each country and according to two basic categories of employees: managers and professionals.

According to the data in Table 2 there is evidence that bonus based on individual goals is mostly used in all

**Table 2**

The percentages of the companies that use different incentive pay practices

	Performance related pay	Bonus based on individual goals	Bonus based on team goals	Bonus based on organizational goals	Non-monetary incentives
Managers					
Bosnia and Herzegovina	34.0%	46.8%	21.3%	23.4%	34.0%
Serbia	69.8%	72.6%	53.8%	63.2%	53.8%
Slovenia	39.3%	43.5%	16.1%	34.5%	31.5%
TOTAL	48.6%	53.6%	29.3%	42.4%	39.3%
Professionals					
Bosnia and Herzegovina	40.4%	40.4%	19.1%	14.9%	36.2%
Serbia	69.8%	67.0%	55.7%	51.9%	42.5%
Slovenia	41.1%	47.0%	16.7%	31.5%	35.1%
TOTAL	50.5%	52.6%	29.9%	35.8%	37.7%

Source: Authors based on CRANET 2021 database

**Table 3**

Pearson Chi-Square Test and Cramer's V test for performance related pay

Chi-Square Test (Managers)*				Symmetric Measures (Managers)			
	Value	df	Asymp. Sig. (2-sided)		Value	Approx. Sig.	
Pearson Chi-Square	28,913 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.213	0.001
Likelihood Ratio	29.501	2	0.000		Cramer's V	0.213	0.001
N of Valid Cases	321			N of Valid Cases	321		
Chi-Square Test (Professionals)**				Symmetric Measures (Professionals)			
Pearson Chi-Square	23,696 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.272	0.000
Likelihood Ratio	24.199	2	0.000		Cramer's V	0.272	0.000
N of Valid Cases	321			N of Valid Cases	321		

a. 0 cells (0%) have expected count less than 5. The minimum expected count is 22.84 (\*) and 23.28 (\*\*).

Source: Authors based on CRANET 2021 database

countries for both groups of employees (53.6% and 52.6%, respectively), accompanied by performance related pay (48.6% and 50.5%, respectively). In managers

and professionals' case, the smallest percentage of companies offers bonus based on team goals (29.3% and 29.9%, respectively).

As shown in Table 2, companies in Bosnia and Herzegovina mostly use individual bonuses (46.8% of companies) for managers and professionals. Besides individual bonus there is performance related pay (40.4% in both cases). In Serbia, for managers, companies mostly use individual bonuses (72.6% of companies), and for professionals, performance-related pay (69.8%). In Slovenia, for managers and professionals, companies mostly use individual bonuses (43.5% and 47% of companies, respectively).

For hypotheses testing, the Pearson Chi-Square Test and Cramer's V Test of the strength of association were utilized, and the results are presented below in Tables 3-5.

As shown in Table 3, there is statistically significant association between the use of Performance-related pay for managers and the company's country of origin ( $p < 0.001$ ). Also there is a statistically significant association

between the use of Performance-related pay for professionals and country of origin of the company ( $p < 0.001$ ). The Cramer's V test of the strength of association shows that the strength of association between the variables is 0.213 ( $p < 0.001$ ) for managers and it is 0.272 ( $p < 0.001$ ) for professionals, which are moderate associations (Table 3) (Pallant, 2009, 221). We can see that Bosnia and Herzegovina shows the smallest percentage of companies that offer this kind of rewards to their employees, and those companies in Serbia use performance-related pay more than other countries, for both groups of employees.

The results of the Pearson Chi-Square Test and Cramer's V Test provide sufficient evidence to confirm the first hypothesis (H1), which states that there is a statistically significant difference in the use of bonus on individual, team, and organization level among observed countries, regardless of their common socialist heritage.

**Table 4**

Pearson Chi-Square Test and Cramer's V test for bonus on individual, team and organization level

Chi-Square Test (Managers)* - Individual goals				Symmetric Measures (Managers) - Individual goals			
	Value	df	Asymp. Sig. (2-sided)		Value	Approx. Sig.	
Pearson Chi-Square	23,280 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.269	0.000
Likelihood Ratio	23.979	2	0.000		Cramer's V	0.269	0.000
N of Valid Cases	321			N of Valid Cases		321	
Chi-Square Test (Professionals)** - Individual goals				Symmetric Measures (Professionals) - Individual goals			
Pearson Chi-Square	13,683 <sup>a</sup>	2	0.001	Nominal by Nominal	Phi	0.206	0.001
Likelihood Ratio	13.902	2	0.001		Cramer's V	0.206	0.001
N of Valid Cases	321			N of Valid Cases		321	
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 21.82 (*) and 22.26 (**).							
Chi-Square Test (Managers)* - Team goals				Symmetric Measures (Managers) - Team goals			
	Value	df	Asymp. Sig. (2-sided)		Value	Approx. Sig.	
Pearson Chi-Square	46,317 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.380	0.000
Likelihood Ratio	45.075	2	0.000		Cramer's V	0.380	0.000
N of Valid Cases	321			N of Valid Cases		321	
Chi-Square Test (Professionals)** - Team goals				Chi-Square Tests (Professionals) - Team goals			
Pearson Chi-Square	50,182 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.395	0.000
Likelihood Ratio	48.784	2	0.000		Cramer's V	0.395	0.000
N of Valid Cases	321			N of Valid Cases		321	
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 13.76 (*) and 14.06 (**).							
Chi-Square Test (Managers)* - Organisational goals				Symmetric Measures (Managers) - Org. goals			
	Value	df	Asymp. Sig. (2-sided)		Value	Approx. Sig.	

**Table 4**

Pearson Chi-Square Test and Cramer's V test for bonus on individual, team and organization level (cont.)

Pearson Chi-Square	30,009 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.306	0.000
Likelihood Ratio	30.347	2	0.000		Cramer's V	0.306	0.000
N of Valid Cases	321			N of Valid Cases		321	
Chi-Square Test (Professionals)** - Organisational goals				Symmetric Measures (Professionals) - Org. goals			
Pearson Chi-Square	22,188 <sup>a</sup>	2	0.000	Nominal by Nominal	Phi	0.263	0.000
Likelihood Ratio	23.022	2	0.000		Cramer's V	0.263	0.000
N of Valid Cases	321			N of Valid Cases		321	

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 19.91 (\*) and 16.84 (\*\*).

Source: Authors based on CRANET 2021 database

In the case of bonus based on individual goals, there is a statistically significant association between the use of bonus based on individual goals for managers and the company's country of origin ( $p < 0.001$ ). Results shown in Table 4 indicate the same results for professionals and the company's country of origin ( $p < 0.001$ ). These results are shown in Table 4. The Cramer's V test of the strength of association indicates that the strength of association between the variables is 0.269 ( $p < 0.001$ ) for managers and 0.206 ( $p < 0.001$ ) for professionals, which are moderate associations (Table 4). We can see that Bosnia and Herzegovina shows the smallest percentage of companies that offer this kind of reward to their employees and that companies in Serbia use this kind of compensation more than other countries for both groups of employees.

In the case of bonus based on team goals, Table 4 presents a statistically significant association between the use of bonus based on team goals for managers and the company's country of origin ( $p < 0.001$ ). Also there is a statistically significant association between the use of Bonus based on team goals for professionals and the country of origin of the company ( $p < 0.001$ ). The Cramer's V test of the strength of association shows that the strength of association between the variables is 0.380 ( $p < 0.000$ ) for managers and 0.395 ( $p < 0.001$ ) for professionals, which are moderate associations. We can see that companies from Slovenia show the smallest percentage of offering this kind of rewards to their employees, and those companies in Serbia use this kind of compensations more than other countries, for both groups of employees.

In the case of bonus based on organisational goals, there is a statistically significant association between the use of bonus based on organizational goals for managers and country of origin of the company ( $p < 0.001$ ). Also there is a statistically significant association between the use of Bonus based on organizational goals for

professionals and country of origin of the company ( $p < 0.001$ ). The Cramer's V test of the strength of association shows that the strength of association between the variables is 0.306 ( $p < 0.001$ ) for managers, and it is 0.263 ( $p < 0.001$ ) for professionals, which are moderate associations. We can see that Bosnia and Herzegovina shows the smallest percentage of companies that offer this kind of rewards to their employees and that companies in Serbia use this kind of compensations more than other countries, for both groups of employees.

The presented results confirm the second hypothesis (H2), which states a statistically significant difference in the use of performance-related pay among the observed countries, regardless of their common socialist heritage.

In the case of Non-monetary benefits, data in the Table 5 shows that there is a statistically significant association between the use of non-monetary benefits for managers and country of origin of the company ( $p < 0.001$ ), but not for professionals and country of origin of the company ( $p > 0.005$ ). The Cramer's V test of the strength of association shows that the strength of association between the variables is 0.210 ( $p < 0.001$ ) for managers, which is moderate. These results are shown in Table 5. We can see that Slovenia shows the smallest percentage of companies that offer this kind of rewards to their employees and that companies in Serbia use this kind of compensation more than other countries, for both groups of employees.

The results of the Pearson Chi-Square Test and Cramer's V Test provide sufficient evidence to confirm only one segment of the third hypothesis (H3) related to managers as an observed category of employees. Regarding professional/technical staff, the analysis results indicate no statistically significant difference in using non-monetary incentives among the observed countries. Therefore, the third hypothesis is partially confirmed.

**Table 5**  
Pearson Chi-Square Test and Cramer's V test for non-monetary incentives

Chi-Square Test (Managers)*				Symmetric Measures (Managers)			
	Value	df	Asymp. Sig. (2-sided)		Value	Approx. Sig.	
Pearson Chi-Square	14,091 <sup>a</sup>	2	0.001	Nominal by Nominal	Phi	0.210	0.001
Likelihood Ratio	13.959	2	0.001		Cramer's V	0.210	0.001
N of Valid Cases	321			N of Valid Cases		321	
Chi-Square Test (Professionals)**				Symmetric Measures (Professionals)			
Pearson Chi-Square	1,543 <sup>a</sup>	2	0.462	Nominal by Nominal	Phi	0.069	0.462
Likelihood Ratio	1.533	2	0.465		Cramer's V	0.069	0.462
N of Valid Cases	321			N of Valid Cases		321	

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 18.45 (\*) and 17.72 (\*\*).

Source: Authors based on CRANET 2021 database

### Discussion and Conclusions

Rewarding employees undoubtedly represents one of the most important and complex human resource management activities, regardless of whether viewed from the perspective of the employer or the employee. For employees, the amount and structure of rewards directly affect the ability to maintain a satisfactory standard of living. From the employer's perspective, establishing a stimulating reward system helps the organization to attract, motivate, and retain quality human resources and achieve defined goals.

HRM theory assumes that a more complex reward system based on various incentive pay practices and benefits packages gives the organization a greater chance of achieving the desired organizational outcomes. However, in this field, theory and practice often differ (Timming & Macneil, 2023; Aguinis & Cronin, 2022; Wood & Budhwar, 2021), especially in less developed regions or countries. An example of the gap between theory and practice can be found in former socialist countries in CEE, assuming that this region cannot be considered a homogeneous entity despite their common socialist heritage.

This research provides evidence that companies from three observed CEE countries use all five forms of stimulation, which were selected as the subject of analysis in this research. As expected, the degree of use of certain incentive pay practices varies among the observed countries. However, regarding rewarding managers, the research results indicate that all three observed countries mostly use individual bonuses. Such results are consistent with similar studies conducted in

other countries (Kulak & Atay, 2020). For rewarding professionals in Serbia, Bosnia, and Herzegovina, most companies apply performance-related pay, while in Slovenia, individual bonuses are the most prevalent for this category of employees. Therefore, the practical implications of the paper lie in the fact that HR professionals responsible for an organization's compensation and benefits should carefully consider elements of their motivational package having in mind that most companies in selected countries use performance-related pay and individual bonuses. Tailoring compensation package for employees needs to include these two types of rewards beside basic pay and benefits. Pay for performance and bonuses are directly related to employees' performances, and those are seen as drivers of employees' productive behaviour. Neglecting monetary incentives could harm employees' attitudes and even behaviour, producing poor performance, which is a sensitive theme in today's unpredictable business environment, in which human resources are recognized as a driver of sustained competitive advantage.

Hypotheses testing were performed using Pearson Chi-Square Test and Cramer's V Test. Testing was done separately for three categories of incentives (pay for performance - H1, different level bonuses - H2, and non-monetary incentives - H3) and for two categories of employees (managers and technical/professional staff). In the first category of employees, the results indicate a statistical difference in applying all incentive elements among the observed countries. For professional/technical staff, this difference is shown for all incentive elements except for non-monetary incentives. Therefore, H1 and H2 are fully confirmed,

while H3 is only partially confirmed. Such results contribute to understanding the specific country context when designing incentive systems and support a divergent approach based on the hypothesis that institutional and cultural differences among countries cause national differences in human resource management practices. The paradigm of divergence is quite prevalent in Europe, as supported by the results of this research and numerous other similar studies (Berber et al., 2017; Prince et al., 2016; Prince et al., 2018; Prince et al., 2020; Drury, 2016). According to one of the CRANET reports (2011), differences in compensation elements are “based on cultural differences in the acceptance of those forms of variable pay as well as differences in business regimes” (Berber et al., 2017).

While CRANET research has numerous advantages arising from the fact that data on HRM practices are collected in more than 40 countries using the same methodology, its limitations also stem from there. Research of this kind provides the opportunity to

compare practices among countries worldwide and over time, as the research is repeated every few years. On the other hand, it does not allow more profound analysis of the observed human resource management practices, which is conditioned by the relatively simple form of the CRANET questionnaire with closed-ended questions and the principle of a single respondent per company. Specifically, in the case of incentive practices, this research allows us to observe the frequency of using certain forms of incentives in practice, but it does not answer why this is the case. The limitation in this study is also reflected in the use of simple statistical techniques to observe differences among countries. Regarding further research, CRANET provides excellent opportunities for comparative studies of different HRM practices and the field's current state. Still, more profound research that would explain the motivation and processes that have led to the current state in the field of HRM would also be helpful.

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# Od teorije do prakse: spodbude za menedžerje in strokovnjake

## Izvleček

Čeprav je v teoriji precej literature, ki poudarja pomen spodbudnih plačil zaposlenih, ni veliko empiričnih raziskav, ki bi pokazale njihovo razpršenost v praksi. Osnovni namen te študije je raziskati raven izvajanja različnih spodbud v treh državah: Sloveniji, Srbiji ter Bosni in Hercegovini. Raziskava je bila izvedena na vzorcu 321 podjetij. Podatki za to študijo so bili pridobljeni iz podatkovne zbirke CRANET. Zadnji cikel zbiranja podatkov je bil izveden v letih 2021-2022. Poleg opisne statistike sta bila za preverjanje hipotez uporabljena Pearsonov test Chi-Square in Cramerjev test V. Rezultati raziskave kažejo na statistično pomembno razliko v uporabi večine opazovanih elementov nadomestil med opazovanimi državami. Študija prispeva k literaturi o upravljanju nadomestil, saj predstavlja empirične podatke o stopnji izvajanja različnih instrumentov nadomestil v treh opazovanih državah.

**Ključne besede:** spodbude, nadomestila, kontekst države, vodstveni delavci, strokovnjaki

# EU Health Union: Legal Aspects and Digital Health

Jasmina Cvahte,<sup>\*a</sup> Andreja Primec<sup>b</sup>

<sup>a</sup>National Laboratory for Health, Environment and Food, Prvomajska 1, 2000 Maribor, Slovenia

<sup>b</sup>University of Maribor, Faculty of Economics and Business, Razlagova 14, 2000 Maribor, Slovenia

jasmina.cvahte@nlzoh.si, andreja.primec@um.si

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## Abstract

Recurrent health crises and outbreaks of infectious diseases of international concern have created a specific EU public health policy. Its role was further strengthened by the COVID-19 pandemic, which triggered the next stage in the integration process of the Member States: the European Health Union. The research is carried out using a literature review method (a review of literature and documents in the field of public health policy and the European Health Union) and a comparative-legal method for comparing EU legal acts on which the Health Union is based (endogenous comparison) and the legal acts of EU and the Republic of Slovenia (exogenous comparison). The findings are examined using a qualitative content analysis method, which allows for meaningful aggregation and use of the data under study to answer the research questions. The European Health Union builds on and extends existing areas of public health and requires greater integration between Member States. One of its most essential pillars is a single information system with a single database to improve the health of individuals, resilience to cross-border health crises, patient mobility, and joint research on the most severe diseases. Member States, including Slovenia, must follow EU public health commitments. As the Slovenian legislative proposal analysis on the digitalization of healthcare shows, this challenging task will also require respect for the institute (safeguards) of other areas of law.

## Introduction

A German proverb says that health is our greatest asset. Unfortunately, we usually only realize this when it is too late, both at the individual level and at the level of respective countries or communities of countries. Health crises and scares in the past have highlighted the importance of health and health policy, and it is only when individual crises occur that initiatives for greater cooperation to better protect against future crises begin to emerge.

\* Corresponding author.

In an era marked by intertwined global relationships, the pace at which diseases emerge and spread has accelerated to unprecedented levels. Factors such as the appearance and dissemination of novel disease agents, the forces of globalization, extensive travel, the rise of drug-resistant pathogens, and the looming specter of bioterrorism all contribute to the array of potential risks in today's world. Since viruses pay no attention to national borders, safeguarding public health necessitates collaborative efforts among various countries, organizations, and institutions (European Commission, 2022). Given the gravity of these threats, it is imperative that we not only contemplate but also actively implement healthcare strategies at the individual country, community of nations, and global scales.

When the European Economic Community was established in 1957, public health was not initially recognised as one of its fundamental pillars. Over time, however, the need for health policy at the Community level became increasingly apparent. Bucher (2022) highlights that the political recognition of public health as a goal of European integration began to emerge alongside the creation of the common market. As integration progressed, there was a growing demand to integrate different aspects of public health into EU policies. While individual Member States initially sought to retain exclusive control over healthcare, many health policy components gradually became more 'Europeanised' over time. This change was driven by the single market and the free movement of goods, people, services, and capital, which required national health systems to comply with European rules. These regulations covered areas such as the safety of medicines, the quality of blood products, health technology assessment, the digitalization of healthcare, and more. Back in 1986, the Single European Act mandated that all European policies should maintain a high level of protection for people's health.

European health policy is built on a solid collaboration between the EU institutions and the Member States, respecting the diversity of national health systems that have developed over time. As clarified by the Treaty on the Functioning of the EU, complete harmonization of health legislation at the EU level is not feasible. Instead, the EU can offer support when needed.

According to Bucher (2022), the most straightforward way to conceptualize health policy is through two key pillars: public health and healthcare. Public health encompasses many areas, including health information systems for monitoring people's well-being, health

promotion, disease prevention, handling health crises, and health protection through regulation. In the European Union, public health serves a dual role, addressing the care and treatment of individuals' health and preventive measures (such as joint procurement of vaccines, epidemic surveillance and response, and the secure supply of blood products). Therefore, it covers both curative and preventive aspects. Public health activities are promoted by the European Commission and the Directorate-General for Health (DG Sante). They are a mixture of binding legal acts in specific areas (e.g., control of substances of human origin), supporting activities (e.g., joint procurement such as vaccine procurement during the pandemic), and health recommendations (Greer et al., 2022).

The second pillar, healthcare, covers the organization of national health systems (hospitals, public health organizations), the financing of health services for citizens, the organization of access to these services, and the conditions for training and employment of health professionals. Health systems in each Member State are part of the social protection system, which has evolved and reflects the cultural, economic, and social characteristics of each Member State. As a result, they differ significantly from one Member State to another in terms of financing, service structure, and regulation (Federal Ministry of Health, 2016). Given these differences, the growing inequalities in access to health services, the lack of agreed funding, etc., the EU could achieve much more through greater integration in the field of health. The need for cooperation was further stimulated by the COVID-19 pandemic, which showed that no single country can tackle such cross-border challenges and problems alone (Fraundorfer & Winn, 2021). This is why the call for a European Health Union (European Commission, 2022) was first highlighted in the speech of the President of the European Commission in October 2020. Historically, this represents the next stage in the integration process of the Member States.

As the central research question, we emphasize the impact of healthcare reform or the establishment of the European Health Union on EU health policy and, consequently, healthcare systems within Member States. To address this, we will examine the EU's legislative framework, which laid the foundation for the European Health Union. The latter primarily relies on regulations which, in the classification of legal sources in the European Union, fall under secondary sources of law. Regulations are acts of unification, meaning they bring uniformity to the law in member states, as opposed to directives, which merely harmonize it (Bratina et al.,

2018). This highlights the EU's dedication to the importance of reforming health policy. We will specifically focus on one of the main pillars of the Health Union - the European Health Data Space. Therefore, as our second research question, we have posed the question of how Slovenia is adhering to the requirements of the European Health Union in the digitalization of healthcare systems or whether it is following the requirements for creating the European Health Data Space. To find the answer, we will compare the EU acts with the Healthcare Digitalisation Bill in Slovenia, which is currently under consideration in the National Assembly of the Republic of Slovenia.

### Literature Review

This section overviews key literature, research, and policy documents on public health in the EU and the European Health Union.

The idea of a health union emerged in 1952 when the first European Coal and Steel Community was established. Still, it did not develop further because of security and economic union priorities. Health remained on the sidelines, and the EU has no standard body or institution in public health (Nabbe & Brand, 2021).

The scope of public health for which the EU is responsible has evolved over the years (Greer & Jarman, 2021). The Maastricht Treaty of 1992 established that the EU should be more competent in health, and environmental and consumer protection legislation was introduced accordingly. The Amsterdam Treaty of 1997 (which came into force in 1999) established new EU competencies in public health, the supply of blood products, and animal and plant health policies that affect public health. The next step in public health protection was the control of agriculture and the food system, and in 2002, the European Food Safety Authority was established. The Lisbon Treaty of 2007, according to Bucher (2022), set essential parameters in the field of public health and requirements for the unification of safety standards in specific areas.

European public health law and policy began to develop as a distinct field about 20 years ago. Fraundorfer & Winn (2021) note in their study that the development of a common European public health policy has been strongly influenced by emerging health crises and outbreaks of infectious diseases (anthrax, SARS) of international proportions. Nabbe & Brand (2021) also note that past health crises have demonstrated the importance of joint action to prevent health crises. As a result, the European

Centre for Disease Prevention and Control (ECDC) was established in 2005 to operate at the EU level. The European Commission has taken on an informal role as the focal point for public health protection, coordinating communication and activities to improve pandemic preparedness.

Between 2007 and 2017, the EU started promoting cross-border healthcare cooperation through various projects. Schmidt et al. (2022) analyzed 400 incentives and projects from this period. They found that in most cases, geographical and cultural-social factors, rather than economic ones, were decisive for cooperation and that further cooperation between Member States would positively impact the development of the Health Union and the improvement of public health policy. The need to develop an information system that enables sustainable and integrated health data in the EU was highlighted in a study by Bogaert & Van Oyen (2017). eHealth can benefit patients, doctors, and the health system (Ardielli, 2020). A common information system would allow better and more extensive data sharing, enabling better and more comparable research, international comparisons, and national and European health surveillance (Bogaert & Van Oyen, 2017).

In responding to the pandemic, the EU has already acted as a supranational organization, bringing together the leading institutions in positive cooperation. Pre-existing crisis response and communication programmes were used, and significant policy decisions were made without lengthy public consultations. Quaglia & Verdun (2023) assess that the EU response was highly successful in terms of three criteria - perception of potential threats, mobilization of scarce resources, and legitimacy of the response - and could lead to greater integration. The pandemic demonstrated that such shocks can contribute to further progress in developing the EU and its institutions.

The Bucher study (2022) also pointed out that the EU could benefit significantly from greater integration in public health. The EU has increased the scope for intergovernmental cooperation on public health threats by establishing the European Health Emergency Preparedness and Response Authority (HERA). The study suggests that this cooperation should be further strengthened to include issues like the fight against antimicrobial resistance. The study also indicates that the EU should better organize, coordinate, and unify knowledge on health protection measures and more systematically introduce legislation on public health policies. Support for developing digital services in public

health or developing a European Health Data Space is highlighted as very important, as this will be the central infrastructure for future health research.

Fraudorfer & Winn (2021) emphasize that the European Health Union aims to strengthen preparedness for pandemics and international health crises. This includes improving and reinforcing existing measures developed in response to past crises, supporting the European Medicines Agency (EMA) and the ECDC authorities, and establishing a new agency called HERA. These three organizations will focus on improving pandemic preparedness, surveillance, and control and ensuring medical countermeasures under the supervision of the European Commission. Nabbe & Brand (2021) also emphasize that to build a robust health union, it is essential to strengthen existing agencies' roles (ECDC and EMA) and establish a new one to cover preparedness for future crises, improved response, surveillance, and data exchange.

A common health information system and a single health data space are also crucial to the European Health Union. In 2021, the EU launched a joint action for a European health data space - Towards the European Health Data Space (TEHDAS). The effort brings together 22 Member States and four other European countries. The joint action aims to support the European Commission in establishing the European Health Data Space. To realize the full potential of health data, in May 2022, the EU presented the Proposal for a Regulation on the European Health Data Space (COM(2022) 197/2), in which it

- supports individuals to take control of their health data;
- supports the use of health data for better healthcare, research, innovation, and policy-making;
- enables the EU to fully exploit the potential of secure and reliable exchange, use, and secondary use of health data (European Commission, 2023).

The European Health Data Space (EHDS) is one of the key foundations of the European Health Union and the first EU common data space in a specific domain. It is based on strict requirements for data protection, interconnectivity, and security, including cybersecurity, which are crucial for the trust of EU citizens and the stability of the project. It brings together national organizations responsible for eHealth and tasks related to patient access to health data. The European Health Data Space proposal would replace Article 14 of the CBHC Directive with an entirely new set of binding rules for using and reusing health data. Given the highly

sensitive nature of data relating to an individual's health, the European Health Data Space must fully comply with all the requirements of the General Data Protection Regulation (GDPR) and the EU Data Protection Regulation (EUDPR) (European Commission, 2023).

Slovenia also follows the trend of digitalizing healthcare and unifying information systems to make EU data more consistent and accessible. In January 2023, the Ministry of Health (2023) presented the Strategy for the Digitalisation of Healthcare in Slovenia for 2022–2027. Through the strategy, Slovenia aims to enable better control of the digital healthcare system and simplify the flow of data for better patient care. The main goal is that by 2027, eHealth will be patient-centered and enable better health for all Slovenian citizens. Patients are placed at the centre; work is being done to enhance the connectivity of existing information systems and databases, ultimately leading to greater efficiency and better control and management of the healthcare system. This has been followed by the Healthcare Digitalisation Bill of June 2023, which brings essential innovations for patients and healthcare professionals to make the healthcare system work more efficiently (Ministry of Health, 2023).

The final steps towards the completion of the European Health Union will be the legislative acts adopted at the end of 2022 (presented in more detail in the next section), which will provide the legal framework for improving the EU's capacity in the key areas of prevention, preparedness, surveillance, risk assessment, early warning and response to current health problems and the health of EU citizens, as well as to cross-border health crises (European Commission, 2022).

## Methodology

The study will use qualitative research methods. Data collection will be carried out using the technique of reviewing existing literature and documents to provide an overview of the literature, the legal framework, and the opinions of individual researchers on the European Health Union and the development of EU public health policy. We will examine the EU legal framework through a comparative legal analysis, comparing the EU legal acts on which the Health Union is based (Pavcnik, 2020). The comparison will be twofold, with an endogenous aspect, as it will take place within the framework of EU law, and an exogenous dimension, as we will also make comparisons of the Proposal for a Regulation on the European Health Data Space of 3 May 2022, resulting from the European Data Strategy, with Slovenian

legislation, more specifically with the Slovenian Healthcare Digitalisation Bill of June 2023. We will further explore the findings using the qualitative content analysis method, which allows for a meaningful synthesis and use of the data studied to provide answers to the research questions (Yin, 2009). In addition, we will synthesize the findings to provide solutions to the research questions. Data are collected from official and public EU (Eur-lex) and Slovenian (gov.si and pirs) websites.

## Results and Discussion

Our literature review has revealed that EU legislators have enacted various legislative acts to strengthen the European Health Union, as outlined in Table 1. Notably, these legislative measures primarily aim to enhance the authority of existing health agencies, thus emphasizing the EU's engagement in public health and reinforcing its preparedness for potential future health crises.

**Table 1**

Basic legal acts for the establishment of the European Health Union

Title of the act	Date of adoption	Main orientations
Regulation on a reinforced role for the European Medicines Agency	1/3/2022	Build a strong European Health Union; Enhance the role of the EMA in crisis preparedness and management for medicines and medical devices; Facilitate a coordinated response to public health crises at the EU level; Enable faster authorization of medicines.
Regulation on serious cross-border threats to health	23/11/2022	A preparedness planning system and a more comprehensive threat monitoring system; Establishing an early warning and response system; Improving capacity for accurate risk assessment and targeted response; Establishing mechanisms for joint procurement of medical countermeasures; Common action at the EU level is possible to address future cross-border health threats.
Regulation amending the Regulation establishing a European Centre for Disease Prevention and Control (ECDC)	23/11/2022	The primary purpose is to enable the ECDC to identify, assess, and report on current and emerging threats to human health promptly; To make recommendations on measures to control disease outbreaks; To provide state-of-the-art epidemiological surveillance of infectious disease outbreaks based on common standards and definitions; To operate an early warning and response mechanism; To establish a network of reference laboratories for crisis consulting on emerging pathogens.
Regulation on a framework of measures for ensuring the supply of crisis-relevant medical countermeasures in the event of a public health emergency at the Union level	24/10/2022	Improve the EU's rapid response capacity to crises; Establish a Health Crisis Board; Rapidly coordinate the supply of and access to medical countermeasures at the EU level; It enables the activation of the instruments of the network of 'ever-warm' production capacities for vaccine and medicine manufacturing (EU FAB) and emergency research and innovation plans, as well as access to their funding; Ensure the development and equitable distribution of key medical countermeasures to fill gaps in their availability and accessibility.

Source: Authors' own elaboration

Table 2 shows the main areas of public health policy before and after the creation of the European Health Union. We can see that all areas will be strengthened, with particular emphasis on developing information

systems and databases to allow the free flow of health data and thus better patient mobility, joint research on the most severe diseases, increased resilience to cross-border health crises, etc.



**Table 2**  
Overview of public health policy areas

Public health area	Before the Health Union	After the creation of the Health Union
Healthcare information systems	eHealth; voluntary database; no links between Member States' systems	A common European health data space; A better basis for public health policy-making; Benefits for human health
Use of health data for research purposes (secondary use)	Very poorly or not used	In our opinion, developing the common health data space will significantly enhance this potential.
Health promotion and disease prevention	Common databases for communicable disease surveillance; Screening tests	further strengthened by the Cancer Plan; More integrated options to fight non-communicable diseases, antimicrobial resistance, and health inequalities; Reinforced by increased powers for the ECDC; Included in at least 20% of the resources of a new health programme
Prevention and control of cross-border threats		Strengthened by the new authority HERA and increased powers for ECDC
Prevention and management of health crises		Strengthened by the new authority, HERA
Patient mobility	It is also supported through eHealth; it is not 100% operational due to poor connectivity between eHealth systems	It will be improved through better information flow within the common health data space
Free movement of healthcare personnel	Secured through the free movement of workers	Secured through the free movement of workers
Ensuring standards for quality and safety in the field of health (human samples, organs, animals, plants, medical products, and devices)	Unified EU standards based on the Lisbon Treaty	Common standards of healthcare will further enhance this to reduce health inequalities.

Source: Authors' own elaboration

As shown in Table 2, the common health information system will be an essential part of the European Health Union. It will be based on the common Health Data Space, which the EU intends to establish through a regulation proposed by the Commission in May 2023. Slovenia follows the EU requirements for the digitalization of healthcare through its Healthcare Digitalisation Bill.

Table 3 shows the main highlights of the Proposal for a Regulation on the European Health Data Space and the Healthcare Digitalisation Bill. We note that the Healthcare Digitalisation Bill follows the Proposal for a Regulation on the European Health Data Space in several areas. It aims to put in place a central collection of all health data, promotes the exchange of health data for healthcare (patients and healthcare professionals will

have access to the data), and provides access to health data for secondary use. In particular, there is a strong emphasis on strengthening the right of individuals to access their health data and facilitating the free flow of such data, which is also one of the priorities of the Proposal for a Regulation on the European Health Data Space.

The Legislative and Legal Service and the Information Commissioner provided their opinions on the Bill. The Legislative and Legal Service (2023) assessed the Bill for its compliance with the constitution, legal system, and legislative and technical aspects. At the same time, the Information Commissioner expressed various concerns regarding the Bill.

The Bill is characterised by ambiguity, uncertainty, and even unconstitutionality in some parts. In the opinion of

**Table 3**

Comparison between the Proposal for a Regulation on the European Health Data Space and the Healthcare Digitalisation Bill

Proposal for a Regulation on the European Health Data Space	Healthcare Digitalisation Bill
It is based upon: General Data Protection Regulation (GDPR), proposed Data Governance Act, draft Data Act, Directive on the security of network and information systems	Transposition of Directive 2011/24/EU on the application of patient's rights in cross-border healthcare, as last amended by the Regulation on Health Technology Assessment in December 2021
To establish a single market for digital health services	Setting up a wholly state-owned company to develop and maintain the central electronic health system
To strengthen the rights of individuals to control their health data and to support the free flow of such data	Putting the patient at the centre of healthcare, enabling individuals to access their health data, special care for digitally illiterate persons
To promote the exchange of health data for healthcare purposes	All health records will be collected in digital form in a national single health card, an obligation of all providers to transmit documents to a central electronic health record
To facilitate access to health data and promote secondary use for research, innovation, and policy-making purposes.	Data is accessible through a central health information system; access will be available to patients and healthcare professionals
To allow for innovative health products and services based on health data use and secondary use of health data.	Data control facilitates health policy planning; access to health data for research, innovation, policy-making, official statistics, patient safety and regulatory activities will be provided.

Source: Authors' own elaboration

the Legislative and Legal Service (2023), the Bill is vague and indefinite about processing, the purposes of processing and storage of personal data, the scope of data to be collected, the entire data flow of processing and collection of data, further processing and storage of data. This raises doubts as to its compliance with Article 38 of the Constitution of the Republic of Slovenia (Right to protection of personal data) and Article 34 of the Constitution of the Republic of Slovenia (Right to personal dignity) (Constitution of the Republic of Slovenia, 1991). In addition, the Bill does not specify who is responsible for managing the Central Health Information System (only who should implement it) and does not define the relationship between database controllers.

According to the Information Commissioner (2023), the stakeholders' tasks, responsibilities, and competencies (National Institute of Public Health and Health Insurance Institute of Slovenia, Ministry of Health) are insufficiently defined.

A significant dilemma arises in particular about establishing the Central Health Information System operator, a legal entity governed by public law and a

limited liability company. It is, therefore, a new legal form of organization. In the opinion of the Legislative and Legal Service (2023), this chosen legal form is poorly explained. Aspects such as controlling the company's activities, its purpose and activities, and its relationship with the Ministry are also insufficiently specified. In the part where the tasks to be performed by the operator are described, it is clear that they partly overlap with the functions already performed by the National Institute of Public Health. The Information Commissioner (2023) also points out that a large amount of personal data will be managed by a company that could operate as a private entity, which would pose a significant risk to the rights of individuals, as private entities are subject to different conditions and requirements regarding the protection of personal data. All this makes it necessary to reconsider the provisions relating to the Central Health Information System operator.

The Healthcare Digitalisation Bill is still under consideration in the National Assembly and is awaiting approval. In any event, it will have to be reviewed and amended by MPs in light of the concerns expressed by the Legislative and Legal Service and the Information Commissioner.

## Conclusion

The COVID-19 pandemic has revealed that the EU's mechanisms for dealing with health threats are generally inadequate, and these issues will likely worsen in the future if the EU does not take action. Cooperation is essential to effectively address emerging challenges in the future. Consequently, the EU has initiated the establishment of a robust European Health Union, which aims to unite Member States in preparing for and responding to health crises and collaborating to enhance prevention, treatment, and follow-up.

In response to the first research question, our research demonstrates that creating the European Health Union will strengthen the EU's role in public health policy. While health systems will continue to vary among Member States, this reform will grant the EU a more prominent position as a supranational authority. It will achieve this by expanding the authorities of key agencies (EMA, ECDC, HERA), implementing health and global strategies, and establishing a more comprehensive European health data infrastructure. By comparing the main features of the four fundamental acts adopted to establish the European Health Union, we have illustrated that they represent a significant enhancement and improvement in public health policy when contrasted with the situation before the creation of the European Health Union.

One of the key issues was the creation of a common health data space, which will be one of the main building

blocks of the European Health Union. In particular, common rules must be established on the information base and the data format to be collected. Only mutually comparable data can provide a reasonable basis for making the right decisions about individual health and a reasonable basis for making the right decisions in the field of public health policy.

The second research question focused on whether Slovenia meets the European Health Data Space requirements. The survey found that with the latest legislative proposals in the field of public health policy, Slovenia is also following the EU's lead and working to improve the digitalization of healthcare, establish a network of reference laboratories as proposed by the EU, and increase preparedness for possible future health crises. The digitalization of healthcare, which has been increasingly emphasized in recent months, will significantly impact the quantity and quality of health data. Policymakers have also realized that only good, consistent data can provide a reasonable basis for sound policy decisions. While the Bill is still under review and will need to be adapted in the light of the opinion of the Legislative and Legal Service and the Information Commissioner, we remain optimistic that decision-makers will be able to amend it appropriately. As we have shown, there are many benefits to be gained from digitalizing healthcare, both in terms of public health policy and at the level of individuals and their health.

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# Zdravstvena unija EU: pravni vidiki in digitalno zdravje

## Izvleček

Ponavljajoče se zdravstvene krize in izbruhi nalezljivih bolezni mednarodnih razsežnosti so privedli do oblikovanja posebne politike EU, politike javnega zdravja. Njeno vlogo je še dodatno okrepila pandemija COVID 19, ki je sprožila naslednjo stopnjo v integracijskem procesu držav članic: Evropsko zdravstveno unijo. Raziskavo smo izvedli z metodo literarnega pregleda (pregled literature in dokumentov na področju politike javnega zdravja in Evropske zdravstvene unije) ter s primerjalno-pravno metodo, s katero bomo medsebojno primerjali pravne akte EU, na katerih temelji zdravstvena unija (endogena primerjava) ter pravne akte EU in RS (eksogena primerjava). Ugotovitve smo proučili z metodo kvalitativne analize vsebine, ki omogoča smiselno združevanje in uporabo proučevanih podatkov za pridobivanje odgovorov na raziskovalna vprašanja ter jih z metodo sinteze strnili v odgovor na raziskovalni vprašanji. Evropska zdravstvena unija vsebinsko nadgrajuje in razširja obstoječa področja javnega zdravja ter od držav članic zahteva večjo stopnjo integracije. Eden njenih pomembnejših stebrov je enoten informacijski sistem z enotno bazo podatkov, ki bo omogočal izboljšanje zdravja posameznikov, odpornost na čezmejne zdravstvene krize, mobilnost pacientov ter skupne raziskave najtežjih bolezni. Zavezam EU na področju javnega zdravja morajo slediti države članice, vključno s Slovenijo. Kot izhaja iz analize slovenskega zakonodajnega predloga s področja digitalizacije zdravstva, bo pri tej zahtevni nalogi morala spoštovati tudi institute (varovala) drugih pravnih področij.

**Ključne besede:** Evropska zdravstvena unija, javno zdravje, evropski podatkovni prostor, zdravstveni informacijski sistem, zakonodajni okvir

# Wage Function Estimation of Estonia and Latvia

Gašper Kolar,<sup>a</sup> Nejc Fir<sup>b</sup>

<sup>a</sup> Master Student at the University of Maribor, Faculty of Economics and Business, Razlagova 14, 2000 Maribor, Slovenia

<sup>b</sup> PhD Student and Teaching Assistant at the University of Maribor, Faculty of Economics and Business, Razlagova 14, 2000 Maribor, Slovenia

gasper.kolar@student.um.si, nejc.fir@um.si

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## Abstract

The study of wage determinants goes back to the beginning of economic science, with theoretical and empirical foundations providing the basis for the specification of a model of the wage function. Using the OLS method, we study the determinants of real wages for Estonia between 2006Q3 and 2022Q3 and Latvia between 2004Q1 and 2022Q3. The lagged dependent variable exerts the most considerable impact on real wages, i.e., real wages in the preceding quarter. We find that unemployment has a relatively larger impact on real wage dynamics than real productivity in the Latvian than in Estonian model. In the Estonian model, real productivity has a relatively stronger impact than unemployment in explaining real wages. In both countries, changes in real productivity impact real wages with a one-quarter lag. The findings on the relative influence of real wage determinants guide economic policymakers in targeting measures that could increase real wages in both countries.

## Introduction

Estonia and Latvia are small, open economies among the developed countries. Since independence in the early 1990s, their economies have experienced periods of high growth and economic contraction and have faced several challenges. Real GDP per capita increased yearly in both economies between 2000 and 2007 (Eurostat, 2023a). The real GDP per capita growth between 2000 and 2007 results from several similar factors in both countries. Structural reforms, such as deregulating the economy and introducing progressive tax policies, which have improved the business environment, have contributed to the increase of real GDP per capita. In 2004, Estonia and Latvia joined the EU, which has led to better access to European markets, increased trade opportunities, and greater political stability.

\* Corresponding author.

This has encouraged foreign investment, which has contributed to economic growth. Between 2000 and 2007, both economies achieved an average annual economic growth rate of around 8%, the highest in the EU (Staeher, 2013).

The economic growth of Estonia and Latvia was interrupted in 2008 by the outbreak of the global financial crisis. The countries entered the financial crisis with low interest rates, high inflation rates, and balance of payments deficits. The Baltic countries, also known as the Baltic Tigers, were among the hardest hit by these conditions during the financial crisis. Estonia experienced the most significant contraction in economic activity in the fourth quarter of 2008, while Latvia experienced the most significant contraction in the first quarter of 2009. Estonia and Latvia returned to positive economic growth in 2010, but growth rates were significantly lower than in the pre-crisis period (Staeher, 2013). Real GDP per capita reached pre-crisis levels in 2013 in Latvia and in 2014 in Estonia. Nevertheless, in 2022, real GDP per capita in both countries remains far below the euro area average. It is €16,250 in Estonia (48.6% below the euro area average) and €13,320 in Latvia (57.9% below the euro area average) (Eurostat, 2023a).

The focus of this paper is on real wages in Estonia and Latvia. These grew rapidly between 2000 and 2007, by more than 10% in 2006 and 2007. Therefore, the two countries were more prone to react to adverse shocks through wage adjustments during the Great Recession. Assessments of the unsustainability of wage growth proved appropriate when real wages fell drastically during the Great Recession. Unsustainable growth was previously assessed based on higher real wage growth relative to productivity growth. Latvia, which experienced relatively higher real wage growth rates, experienced an earlier and steeper decline. During the period when real wages fell, the inflation rate was relatively lower than the fall in real wages, which meant that wages also fell in nominal terms. This is a rare occurrence, as wages are generally rigid downwards. The decrease in nominal wages was also reflected in a reduction of productivity. However, the fall in real wages in Estonia and Latvia allowed them to regain the competitiveness they had lost during the wage increases and facilitated the economic recovery. Competitiveness improved through a reduction in labour costs and, consequently, in the prices that Estonian and Latvian firms could offer on the market (Masso & Krillo, 2011). Firstly, productivity growth rates were high and relatively above the EU average in Estonia and Latvia between

2000 and 2007, while they were significantly lower between 2008 and 2022, which explains the lower real wage growth. Secondly, Estonia and Latvia's export orientation is one of the main reasons both countries exhibited lower economic growth rates during this period (Paulus & Staeher, 2022).

After more than a decade of moderate real wage growth in both countries, this was interrupted by the pandemic outbreak in the first quarter of 2020. During this period, the unemployment rate in both countries also increased slightly, with the consequences reflected in the mass of real wages. The fall in aggregate real wages was short-lived, reaching pre-pandemic levels in Estonia at the end of 2020, while in Latvia, they returned to pre-pandemic levels in mid-2021. However, it did not take long before real wages fell again. The dynamic price level increases, mainly due to energy price rises, led to a fall in purchasing power in Estonia and Latvia. In this case, nominal wages were not the main reason for this decline, as the decline in real wages was mainly due to price increases. In addition to the decline in real wages, both economies experienced decreased productivity growth in 2022 (Paulus & Staeher, 2022).

Since the transition to a market economy in the 1990s, Estonia and Latvia have successfully transformed their economies. However, they are facing new challenges in long-term development. An important factor in further development is the limitation of population migration to Western Europe. The Baltic region is one of the fastest depopulating in the world, having lost a significant proportion of its population since independence. Compared to 1990, Estonia's population has decreased by 16% and Latvia's by 28% by 2019 (Eurostat, 2020). The first wave of migration took place at independence, and the second wave after EU accession in 2004 when the migration process to Western European countries became easier. It is important to note that a significant share of migrants is part of an active population with a high level of education, so both economies have been confronted with a phenomenon known as the 'brain drain'. In recent years, Estonia has successfully curbed migration through various incentive policies and has seen population growth since 2016. Latvia has been less successful in maintaining its population (Galstyan et al., 2021).

Stable price growth is also key to the process of income convergence with more developed countries, as it enables real income growth. In recent years, the high inflation rate has led to a decline in real wages in Estonia and Latvia, because of the energy crisis. Inflation mitigation is, therefore a key current challenge for both

countries in escaping the income trap. Given the close link between real wages and productivity, productivity growth increase is also important for real wage growth in the Estonian and Latvian economies. Labour productivity in Estonia and Latvia is around 30% lower than in high-income countries. In the face of falling marginal returns to foreign investment, its future increase will be based mainly on three areas: integration into global value chains, investment in R&D and innovation, including digitization (European Bank for Reconstruction and Development, 2022).

Described dynamics of aggregate wage growth since Estonian and Latvian independence and other macroeconomic characteristics of these countries have motivated us to further research the wage determinants. To investigate the wage determinants of Estonia and Latvia, separate models for both countries have been specified to estimate wage function.

In this study, we first examined the theory of wage determinants and checked the empirical evidence to develop the real wage model, which is the paper's primary purpose. We then presented the OLS methodology, described the dataset, and presented the estimates of the wage function.

## Theoretical Framework and Empirical Evidence

Throughout the history of economic thought, many theories of wages have evolved based on different understandings of economic forces and social conditions. Adam Smith's *The Wealth of Nations* (1776) presented the foundations of theories of wages based on the supply and demand of labour (Sušjan, 2006, 58-61). Classical economists such as David Ricardo and Thomas Malthus added a pessimistic flavour to this idea, stressing that the natural price of labour refers to the minimum cost of workers' subsistence. Francis Walker put forward a new perspective on wage determination in the second half of the 19th century with his theory of bargaining. Unlike other wage theories of the period, it does not simply identify the supply and demand for labour as a determinant of wages. According to the theory, wages are determined as a result of negotiations and agreements between workers and employers, with bargaining power on the side of employers when unemployment is high and on the side of workers when unemployment is low (Sušjan, 2006, 79, 84).

Wage theory was further developed in the 19th century when the Austrian School of Economic Thought economists laid the foundations for marginal

productivity. Based on these foundations, the theory of marginal productivity was developed by several economists in the 1890s, including Philip Henry Wicksteed and John Bates Clark. According to this theory, employers will hire workers of a particular type as long as the contribution made by the marginal worker is not equal to the additional costs incurred in employing the worker. Marginal productivity theory identifies productivity as a critical determinant of wages (Sušjan, 2006, 183-184).

In the 20th century, John Maynard Keynes developed the effective demand theory. Like classical economic theory, this theory focuses on the supply and demand for labour. However, the two theories have opposing views on the relationship between wages and unemployment. Keynesian economic theory argues that a lower wage rate would lead to a lower worker income, reducing the demand for goods and services. Lower demand would then lead to an increase in unemployment, not vice versa. Therefore, the key difference between classical and Keynesian wage theory is causality (Kahn, 2022).

In the 1960s, a new trend in wage theories emerged, known as human capital theory. This theory, primarily formulated by Gary S. Becker, sees human capital as the result of an investment process. Historically, human capital theory has responded principally to the limitations of earlier wage theories. This approach has helped to explain how wages are formed in the market, focusing on workers' skills as critical determinants of wages (Bae & Patterson, 2014).

Based on wage theories, the link between wages and various factors affecting wages has been empirically investigated by several renowned economists, including Blanchflower and Oswald (1994), who estimated a wage function for the UK based on data from 175,000 workers between 1973 and 1990. They found a negative relationship between real wages and unemployment, as an increase in unemployment led to a decrease in real wages.

The link between wages and unemployment was further investigated by Gallegati et al. (2011), using the example of the US between 1948 and 2009. Using wave analysis, they found a negative relationship between wages and unemployment from 1948 to 1993, with fluctuations in unemployment explaining the major share of the wage variation. However, the negative relationship does not exist in the remaining period because wages are adjusted to low inflation rates. In the context of the European Union, the link between wages and unemployment has



been studied by Seputiene (2011). In most countries, including Estonia and Latvia, a negative relationship between the two variables can be observed between 2000 and 2010. The fall in unemployment led to an increase in real wages as workers had more bargaining power. This aligns with Philips curve idea that the lower unemployment rate aligns with the higher wage growth rate.

A negative relationship between real wages and unemployment, with a fall in unemployment leading to an increase in real wages, was also found by Apergis and Theodosiou (2008), using panel data for 10 OECD countries from 1950 to 2005. Using panel cointegration and causality tests, the study finds statistical evidence for a long-run relationship between the two variables. It supports Keynes's view that real wages fall as employment rises, probably through increased demand. Elgin and Kozubas (2013) examine the impact of unemployment and union power on wages in a sample of 31 OECD countries over 50 years between 1960 and 2009. The study is based on a model that considers labour market fractions and suggests that the wage-productivity gap is determined by workers' bargaining power and general labour market conditions. Higher unemployment reduces workers' external bargaining power with employers, forcing them to settle for lower wages.

The investigation of the link between real wages and unemployment has mainly been focused on developed countries in the 20th century. Still, economists have also recently analyzed the link between real wages and unemployment in developing countries. Examining the relationship between real wages and unemployment in South Africa, von Fintel (2017) finds that changes in unemployment do not affect real wages, while wage increases for middle- and high-wage workers increase unemployment in the region. Still, the same is not valid for low-wage workers. Wage-unemployment elasticities are only negative for the top 40% of wage earners by income. The study suggests that wage-setting institutions determine wage growth's impact on labour market outcomes. The long-run relationship between real wages and employment in South Africa between 1995 and 2019 was also analyzed by Habanabakize et al. (2019). Using causality tests, they found a one-way relationship between real wages and employment, with real wages influencing employment while employment did not influence real wages. Over the period considered, a 1% increase in real wages led, on average, to a 0.23% decrease in employment.

In the case of the Indian industry between 1998 and 2013, the relationship between real wages and unemployment has been studied by Das et al. (2017). Using time series and panel data analysis, no relationship between the two variables could be observed, suggesting that wages are not determined based on unemployment but, in many cases, are determined purely administratively and are quite rigid to labour market developments. Some studies have also examined the impact of differences in real wage growth and productivity growth on employment. Klein (2012) studied the relationship's impact on employment in South Africa and found that real wage growth outpaced labour productivity growth and increased unemployment in the region. In this case, real wages impacted unemployment trends, while unemployment did not impact real wages. Based on the empirical literature on the link between real wages and unemployment to date, we find that an increase in real wages is associated with higher labour costs, which can lead to a rise in unemployment. On the other hand, a decrease in unemployment strengthens the bargaining power of trade unions, often increasing real wages.

According to many studies, labour productivity is also an important determinant of real wages. López-Villavicencio and Silva (2011) carried out a study looking at the link between real wages and productivity. They found that wages increased in response to productivity gains, especially for permanent workers. The study's findings also further highlight labor legislation's bargaining power and influence in determining real wages. Changes in labour legislation have led to a positive link between real wages and employment in some OECD countries, such as Denmark and Italy. Sharpe et al. (2008) also highlight productivity as a key determinant of real wages. Here, changes in productivity have followed real wages more closely in the US than in Canada, where real wage growth lagged behind productivity growth between 1961 and 2007. The authors stressed that the decline in labour's share of gross domestic product over time is the reason for these dynamics. The study also explains that several other factors, including terms of trade and rising income inequality, influence the link between real wages and productivity.

Meanger and Speckesser (2011) also found that the relationship between real wages and productivity is consistent with marginal productivity theory, where an increase in productivity leads to an increase in real wages. However, the link between real wages and productivity is not always unidirectional. The study points out that the relationship between wages and productivity

is bi-directional, especially in the long run, with increases in wages leading to increases in investment to improve productivity.

The link between real wages and productivity is not always in a one-way direction. The idea that wage growth leads to productivity growth was found in a study by Narayan and Smyth (2011), who examined the link between real wages and productivity in a sample of G7 countries between 1960 and 2004. They found that a 1% increase in real wages leads to an average of 0.6% increase in productivity. Similar findings were found using Australian data between 1965 and 2007. A 1% increase in real wages in the manufacturing sector leads to productivity gains of between 0.5% and 0.8% (Kumar et al., 2012).

Many researchers have analyzed the link between real wages and labour productivity in developing countries. Tang (2014) studied the relationship between real wages and productivity in Malaysia, between 1970 and 2007. He found that changes in real wages lead to changes in productivity and that this relationship is in the form of an inverted U. When real wages increase, productivity initially increases, but further increases in wages do not lead to productivity gains but rather allow workers to have more leisure time. The study has a one-way relationship between the two variables, implying that productivity has no impact on real wages in Malaysia. That there is a long-run relationship between real wages and productivity over the period 1988-2012 in Turkey was found by Eryilmaz and Bakir (2018) based on the VECM model.

In the case of Bulgaria and Romania, Dritsaki (2016) confirms the long-run relationship between real wages and productivity. Still, the relationship is a one-way directional from real wages to productivity, meaning that an increase in real wages leads to an increase in productivity, while productivity does not impact real wages. Using Poland as a case study, Gajewski and Kutan (2021) investigate the relationship between wages and productivity, particularly in the context of multinational corporations. The findings show that sectors with larger multinational corporations tend to exhibit higher productivity growth, which is later passed on to local firms. The authors find that productivity growth increases lead to wage growth, although the impact is relatively weaker than the impact of wages on productivity.

The link between real wages, labour productivity, and employment has recently been studied by Cruz (2023) on a sample of 25 OECD countries. In his study, the author assumed that to increase real wages, productivity must first increase. For this reason, real wages have been set as the dependent variable in his model, and labour productivity and employment as independent variables. He found a long-run relationship between the variables using the dynamic ordinary least squares method and the fully modified least squares method. An increase in productivity leads to a rise in real wages, while an increase in employment leads to the opposite effect for real wages.

Table 1 summarizes the findings of the earlier presented empirical evidence.

**Table 1**

Summary of the key findings of the empirical evidence on the real wage determinants

Authors	Sample	Period	Methodology	Key findings
Blanchflower & Oswald (1994)	The UK	1973–1990	Estimation of elasticity parameters, sensitivity analysis	Negative unemployment-wage ratio; elasticity equals -0.1.
Gallegati et al. (2011)	The USA	1948–2009	Wave analysis	Negative relationship between real wages and unemployment between 1948 and 1993.
Seputiene (2011)	The EU	2000–2010	Correlations analysis	A fall in the unemployment rate leads to an increase in real wages, but an increase in real wages does not lead to a fall in unemployment.
Apergis & Theodosiou (2008)	10 OECD countries	1950–2005	Panel cointegration, causality methods	Real wages fall when employment rises, while employment does not respond to changes in real wages.

**Table 1**

Summary of the key findings of the empirical evidence on the real wage determinants (cont.)

Authors	Sample	Period	Methodology	Key findings
Elgin & Kozubas (2013)	31 OECD countries	1960 – 2009	Panel VAR	Higher unemployment leads to wage cuts, while higher union power increases wages.
von Fintel (2017)	South African Republic	2000–2004	Estimation with micro pseudo data	An increase in labour costs causes a decrease in labour demand. Collective bargaining has a significant impact on wages.
Habanabakize et al. (2019)	South African Republic	1995–2019	Autoregressive Distributed Lag model; Error Correction model; Toda–Yamamoto analysis.	Real wages have a negative impact on long-term employment rates.
Das et al. (2017)	India (manufacturing sector)	1975–2014	Data generating process; Cointegration tests	There is a negative correlation between real wages and employment, and no correlation between real wages and productivity.
Klein (2012)	South African Republic	1994–2011	Two-step cointegration	There is a link between real wages and productivity, and real wage growth is holding back employment.
Lopez & Silva (2011)	OECD countries	1985–2007	Panel VAR in causality analysis	Labor legislation is a key determinant of real wages, which can lead to a positive correlation between real wages and unemployment.
Sharpe et al. (2008)	Canada, the USA, and other high-income countries	1961-2007	Trend analysis	Wage growth has lagged behind labour productivity growth in Canada, while these trends are more aligned in the US and other high-income countries.
Meanger & Speckesser (2011)	25 countries	1995-2009	Empirical review	Productivity affects real wages, while real wages affect productivity in the long run.
Narayan & Smyth (2011)	G7 countries	1960–2004	Panel unit root tests, panel cointegration tests, and Fully Modified Least Squares method	An increase in real wages leads to an increase in productivity.
Kumar et al. (2012)	Australia (manufacturing sector)	1965–2007	Cointegration tests, Granger causality test, and structural breaks test	An increase in real wages leads to an increase in productivity.
Tang (2014)	Malaysia	1970–2007	Cointegration tests	Changes in real wages lead to changes in productivity and the price level.
Eryilmaz & Bakir (2018)	Turkey	1988–2012	Johansen and Johansen/Juselius tests of cointegration; VECM	Changes in productivity lead to changes in real wages, and crises negatively impact productivity.
Dritsaki (2016)	Romania and Bulgaria	1991–2014	Cointegration tests and Toda-Yamamoto analysis	Real wages have a one-way directional impact on productivity.

**Table 1**

Summary of the key findings of the empirical evidence on the real wage determinants (cont.)

Authors	Sample	Period	Methodology	Key findings
Gajewski & Kutan (2021)	Poland	2006–2017	GMM	Real wages are determined by marginal labour productivity. Real wages affect productivity.
Cruz (2023)	25 OECD countries	1970–2019	Dynamic Ordinary Least Squares, Fully Modified Least Squares and ARDL model	The long-term link between real wages and productivity and employment.

Source: Authors' compilation.

### Model Specification, Methodology and Dataset Description

Following the theoretical and empirical findings of the wage determinants, we have specified the model to investigate wage function. The dependent variable in the wage function is aggregate wages. To investigate the wage determinants, we have limited the research to key two explanatory variables, which are unemployment and labor productivity. As the wages in the previous period are important to explain the current level of aggregate wages, we have also included the lagged dependent variable in the model specification.

The empirical strategy for examining the real wage determinants is based on the standard methodology of wage function estimation using the Ordinary Least Squares (OLS) method. For Estonia and Latvia, separate wage functions were estimated with the same set of explanatory variables and the same functional form, enabling a direct comparison of the impacts of real wage factors between the two countries. Initially, an F-test was employed to assess the overall model fit. The rejection of the null hypothesis of the F-test confirms the existence of at least one regression coefficient different from zero. Subsequently, a t-test was used to examine the statistically significant influence of individual explanatory variables on real wages. Rejecting the null hypothesis of the t-test with the appropriate sign of the regression coefficient confirms the impact of a specific real wage factor on the dependent variable. It is also necessary to check the model specification to draw more reliable conclusions from the estimated regression models. Model specification was examined using the Ramsey RESET test, where the null hypothesis states that the specification of the baseline model is appropriate or that the model has no omitted variables while rejecting the null hypothesis requires a re-specification of the

baseline regression model. The functional form in natural logarithms of the model allows for a direct comparison of regression coefficients, as these coefficients represent partial regression coefficients or elasticities. The determination coefficients are also comparable between the models of Estonia and Latvia due to the natural logarithmic functional form. Still, it is essential to observe the adjusted determination coefficient due to different degrees of freedom (Pfajfar, 2014, 53-82, 110-124, 172, 202-207).

Confirmation of the appropriateness of the model with t-tests, F-tests, and the RESET test allows for further validation of the estimates of real wages in Estonia and Latvia. To draw reliable conclusions about real wage estimates, confirming the assumptions of the Ordinary Least Squares (OLS) method is necessary. Initially, the normal distribution of residuals was examined, as the absence of normal distribution prevents reliable inference about t and F statistics. The normal distribution of residuals was assessed using the Jarque-Bera test, which tests the null hypothesis of the normal distribution of the time series. The next assumption checked was the absence of multicollinearity. Multicollinearity among explanatory variables was examined using variance inflation factors, indicating excessive multicollinearity when their value exceeds 10. The OLS method also assumes homoscedasticity or the absence of heteroscedasticity in the model. Homoscedasticity is present when the variance of residuals does not change with the changing values of explanatory variables, and their mathematical expectation is equal to 0, otherwise, the model has heteroscedasticity. The Breusch-Pagan-Godfrey, White, and Glejser tests checked the presence of heteroscedasticity. All these heteroscedasticity tests test the null hypothesis of homoscedasticity. The last assumption checked in the OLS method is the absence of autocorrelation in the model. The absence of autocorrelation means no mutual dependence exists

between residuals in the current period and residuals in the previous period. First-order autocorrelation was examined using the Durbin h-test, as both models include a lagged dependent variable among the explanatory variables. First-order autocorrelation was also checked with the Breusch-Godfrey test, allowing for testing autocorrelation of any order under the null hypothesis of the absence of autocorrelation. The Breusch-Godfrey test was used to check first-order autocorrelation and fourth-order autocorrelation, as quarterly data were included in the analysis (Pfajfar, 2014, 393-400, 409-421, 437-439, 500-515).

To study wage determinants in Estonia and Latvia, we formulated an econometric model based on data from the Eurostat database. We have collected quarterly data for Estonia from the third quarter of 2006 to the third quarter of 2022 and for Latvia from the second quarter of 2004 to the third quarter of 2022, totalling 65 and 74 observations, respectively.

The dependent variable in the econometric models for both countries is real wages in millions of euros, calculated by deflating nominal wage data (Eurostat, 2023b) with the HICP index (Eurostat, 2023c). Due to the monthly frequency of the HICP index data with a base year of 2015, we converted the data to quarterly frequency using the simple arithmetic mean.

The explanatory variables in the econometric models for both countries include unemployment, labor productivity, and a lagged dependent variable for one quarter. Unemployment data were obtained from Eurostat (2023d) and are expressed in thousands of individuals aged 15 to 74. Labor productivity data, obtained from Eurostat (2023e), are expressed as an index with the base year of 2015 and relate to real labor productivity per hour worked. In both models, real labor productivity is specified in one-quarter lagged values. All acquired data are seasonally and calendar-adjusted.

The variables explaining the dynamics of real wages in Estonia and Latvia were determined based on theoretical considerations and a review of existing empirical literature in this field. Consistent with previous findings, we expect the explanatory variable of unemployment to have a negative coefficient in the regression estimate since its reduction leads to higher wages. Meanwhile, labor productivity is expected to have a positive coefficient in the regression estimate, as increased productivity generally results in higher real wages.

**Table 2**  
Descriptive statistics

Estonia			
	Real wages	Real productivity	Unemployment
Mean	1898.596	102.72335	53.2492
Median	1820.957	99.371	44.600
Standard Deviation	338.6454	11.48020	24.36231
Minimum	1455.595	83.463	27.00000
Maximum	2522.060	125.7930	133.7000
Latvia			
	Real wages	Real productivity	Unemployment
Mean	2279.184	95.19364	107.4627
Median	2284.839	93.55000	93.80000
Standard Deviation	478.9080	16.40301	43.64963
Minimum	1426.507	64.59400	57.20000
Maximum	3062.213	126.5210	221.6000

Source: Authors' calculations.

Table 2 presents descriptive statistics of the data included in the econometric model. The first column shows descriptive statistics for the dependent variable in the models, real wages expressed in millions of euros. We observe that real wages in Estonia fluctuated between 1,455.59 million euros and 2,522.06 million euros from the third quarter of 2006 to the third quarter of 2022. During the great recession, the lowest value was reached in the third quarter of 2010, while the highest value was recorded in the fourth quarter of 2021, indicating a 73.26% growth in real wages between the lowest and highest values. The average value of wages in Estonia over the observed period was 1,898.60 million euros, with a median of 1,820.96 million euros. On average, real wages were higher in Latvia, reaching an average value of 2,279.18 million euros from the second quarter of 2004 to the third quarter of 2022, with a median of 2,284.84 million euros.

It is essential to emphasize that these are aggregate data, with Latvia recording higher real wages due to more employed individuals and not necessarily because of higher real wages per capita or employee. The lowest value of real wages in Latvia was recorded in the first quarter of 2004, at 1,426.51 million euros, while the highest value was recorded in the third quarter of 2021 when real wages amounted to 3,062.21 million euros, representing a 114.67% increase. The volatility of real wages between the two countries can be compared by examining which standard deviation represents a larger

percentage of average values. We find that real wages in Latvia exhibited more volatility than in Estonia, in the case of Latvia, the standard deviation equals 478.91, while in Estonia it equals 338.65.

The second column presents descriptive statistics for the explanatory variable included in the econometric models, namely labor productivity per hour. In Estonia, the base index value of productivity ranged from 83.46 in the fourth quarter of 2010 to 125.79 in the fourth quarter of 2021, indicating an increase of 50.71%. Latvia shows an even larger range due to the longer observed period. The lowest productivity value was recorded in the second quarter of 2004, at the beginning of the observed period, while the highest was in the first quarter of 2021. Values ranged from 64.59 to 126.52, representing a growth of 95.87%. Similar to the data on real wages, the volatility of real productivity is relatively higher in Latvia, as indicated by a higher standard deviation.

The last column presents descriptive statistics for unemployment data, measured in thousands of persons. Estonia reached its lowest unemployment in the third quarter of 2019, at 27 thousand, while the highest value was recorded in the first quarter of 2010 at 133.7 thousand. From the highest value in 2010 to the lowest in 2019, unemployment in Estonia decreased by 79.8%. Latvia exhibited a similar trend, with the lowest unemployment rate in the fourth quarter of 2019 and the highest in the first quarter of 2010. Unemployment in Latvia ranged from 57.2 thousand to 221.6 thousand, representing a 74.19% decrease from the highest to the lowest value. The average unemployment over the observed period in Estonia was 53.25 thousand, while in Latvia, it was 107.46 thousand. Due to the different sizes of the populations in the studied countries, these data are not directly comparable, as Latvia records higher unemployment values when measured in thousands despite having the same unemployment unit. However, we can compare the volatility of unemployment by measuring the standard deviation relative to the average values. In this regard, unemployment was more volatile in Latvia than in Estonia over the observed period, as the standard deviation equals 24.36 for Estonia and 43.65 for Latvia.

### Wage Function Estimates

In this chapter, we have examined the estimates of wage function regression models for Estonia and Latvia and their consistency with the assumptions of the Ordinary Least Squares (OLS) method. Table 3 presents the wage function estimates for Estonia, covering the period from the third quarter of 2006 to the third quarter of 2022.

Meanwhile, wage function estimates for Latvia are shown in Table 4, covering the period from the second quarter of 2004 to the third quarter of 2022. In both models, the wage function is based on the same specification, including the first lag of productivity, unemployment, and the first lag of the lagged dependent variable. The selected functional form of the models is the double-logarithmic wage function, i.e., dependent and explanatory variables are expressed in natural logarithms, as it proved to be the most suitable when comparing other functional forms, and the selected explanatory variables performed best for studying the wage function.

In the case of Estonia, we can conclude that the model is statistically significant as a whole, considering the F-statistic. All regression coefficients are statistically significant at one percent, and the estimates are robust with the Huber-White and Newey-West methods. All regression coefficients reflect relationships consistent with economic theory and empirical literature. The first partial regression coefficient in the wage function estimate for Estonia is 0.279729, indicating that real wages in Estonia, on average, increase by approximately 0.28% in the current quarter if the labor productivity index increases by 1% in the previous quarter. At the same time, the values of other variables remain unchanged. The value of the second partial coefficient in the logarithmic wage function estimate for Estonia is -0.060309. This implies that real wages in Estonia, on average, decrease by approximately 0.060% if unemployment increases by 1%, and the values of other variables remain constant. The third partial regression coefficient related to real wages in the lagged quarter is 0.755573. This indicates that an increase of 1% in real wages in the previous quarter, on average, results in an increase of approximately 0.76% in real wages in the current quarter. The model explains 98.58% of the variability of the dependent variable, while the adjusted R-squared is 98.51%. Given the different degrees of freedom, the latter value is crucial for comparing both models.

If we focus on the wage function estimates for Latvia, we can determine that the model has a statistically significant F-statistic at one percent. All regression coefficients are statistically significant at 1% except for the first lag of productivity, which is statistically significant at 5%. Similarly, when considering robust estimates of standard errors, the regression coefficient for the first productivity lag is statistically significant at 5% with the Huber-White method and at 10% with the

**Table 3**  
Estimates of the wage function for Estonia

Independent variable	Coefficient	t-statistic	t-statistic (Huber White)	t-statistic (Newey-West)
Constant	0.785916	4.583074***	5.299329***	5.249810***
		(0.171482)	(0.150157)	(0.151573)
Log (Real Productivity <sub>t-1</sub> )	0.279729	5.523755***	5.842294***	6.127251***
		(0.050641)	(0.048284)	(0.046039)
Log (Unemployment <sub>t</sub> )	-0.060309	-6.367342***	-6.772216***	-6.869152***
		(0.009472)	(0.009038)	(0.008910)
Log (Real Wages <sub>t-1</sub> )	0.755573	20.13846***	22.69889***	22.82328***
		(0.037519)	(0.033186)	(0.033005)
Total observations	65	F statistic		1410.955***
R <sup>2</sup>	0.985794	Durbin-Watson statistic		1.996348
Adjusted R <sup>2</sup>	0.985095	The sum of squared residuals		0.027770

Notes: \*\*\*statistically significant at 1% significance level. \*\* statistically significant at 5% significance level. Standard errors in parenthesis. Source: Authors' estimation.

Newey-West method. All other regression coefficients are robust at 1% statistical significance. The signs of the regression coefficients are consistent with economic theory and empirical literature.

We can also explain the meaning of the obtained regression coefficients. The first partial regression coefficient, which is 0.076492, tells us that real wages in the current quarter, on average, increase by approximately 0.076% if labor productivity in the previous quarter increases by 1%, while the values of other variables remain unchanged. The second partial coefficient related to the explanatory variable unemployment is -0.125207. This means that with an increase in unemployment by 1%, real wages in Latvia

decrease by approximately 0.13% if the values of other variables remain the same. The third partial regression coefficient is 0.751447, indicating that real wages in the current quarter, on average, increase by 75.14% with a rise of 1% in real wages in the previous quarter, assuming unchanged values of other variables. The determination coefficient of the estimated double-logarithmic wage function in Latvia is 0.980794, meaning that approximately 98.08% of the variance in real wages in Latvia is explained by the explanatory variables in the model. The adjusted R-squared is about 98.00%, 0.5 percentage points less than the adjusted R-squared of the model for Estonia.

**Table 4**  
Estimates of the wage function for Latvia

Independent variable	Coefficient	t-statistic	t-statistic (Huber White)	t-statistic (Newey-West)
Constant	2.153279	8.708617***	6.665133***	6.367734***
		(0.247258)	(0.323066)	(0.338155)
Log (Real Productivity <sub>t-1</sub> )	0.076492	2.476749**	2.027854**	1.765307*
		(0.030884)	(0.037721)	(0.043331)
Log (Unemployment <sub>t</sub> )	-0.125207	-8.529752***	-6.823410***	-6.101224***
		(0.014679)	(0.018350)	(0.020522)
Log (Real Wages <sub>t-1</sub> )	0.751447	22.42820***	16.94912***	16.23272***
		(0.033505)	(0.044335)	(0.046292)
Total observations	74	F statistic		1191.554***
R <sup>2</sup>	0.980794	Durbin-Watson statistic		1.855311
Adjusted R <sup>2</sup>	0.979971	Sum of squared residuals		0.063230

Notes: \*\*\*statistically significant at 1% significance level. \*\* statistically significant at a 5% significance level. Standard errors in parenthesis. Source: Authors' estimation

We have determined that both models are suitable for further analysis, with an appropriate statistical significance of regression coefficients and robustness using the Huber-White and Newey-West methods. Additionally, the determination coefficient values are relatively high. Before moving on to checking the assumptions of the OLS method, it is essential to mention the appropriateness of the specification of both models.

We verified the specification of both wage functions using the Ramsey RESET test in Table 5, where we included squares of estimated wage function values among explanatory statistics. We do not reject the null hypothesis in both models at a 95% confidence level, indicating that both models are appropriately specified and do not require respecification. In other words, both models have no omitted variables.

**Table 5**  
Ramsey RESET test of the wage function for Estonia and Latvia

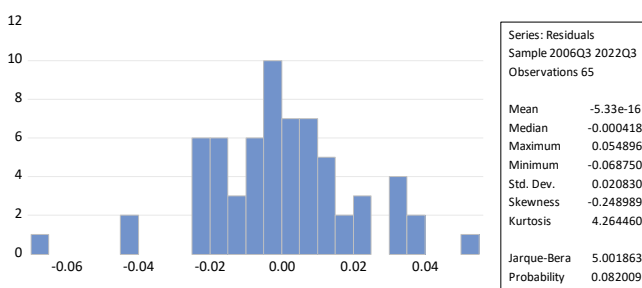
Ramsey RESET test for Estonia			
	Value	df	p-value
t-statistic	0.172364	60	0.8637
F-statistic	0.029709	(1,60)	0.8637
Likelihood ratio	0.032177	1	0.8576
Ramsey RESET test for Latvia			
	Value	df	p-value
t-statistic	1.714311	69	0.0910
F-statistic	2.938861	(1,69)	0.0910
Likelihood ratio	3.086548	1	0.0789

Source: Authors' estimation

The first of the fundamental assumptions of the OLS method that we examined is the normality of the distribution of model residuals. The fulfilment of this assumption is crucial since t- and F-statistics are based on the assumption of normality of the distribution of residuals. Figure 1 displays the histogram of residuals of the wage function for Estonia and the value of the Jarque-Bera statistic. At a 5% level of statistical significance, we can assert that the residuals of the wage function for Estonia are normally distributed, as we do not reject the null hypothesis of the Jarque-Bera test. A similar conclusion can be drawn for the wage function for Latvia, for which the estimates of the Jarque-Bera statistic and the histogram of residuals are shown in Figure 2. At a 95% confidence level, we can claim that the residuals of the wage function for Latvia are normally distributed, as we also do not reject the null hypothesis of the Jarque-Bera test.

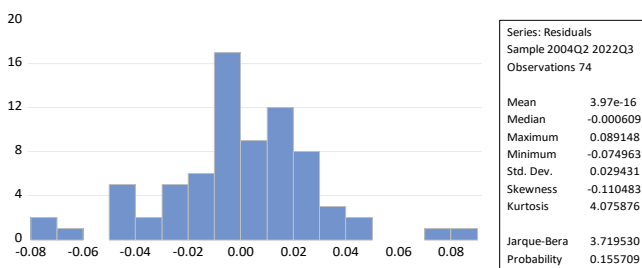
strength of multicollinearity is acceptable in the wage function models for both models.

**Figure 1**  
Histogram of residuals of the wage function for Estonia



Source: Authors' estimation in Eviews 12.

**Figure 2**  
Histogram of residuals of the wage function for Latvia



Source: Authors' estimation in Eviews 12.



**Table 6**  
Variance inflation factors of the wage function for Estonia and Latvia

	Estonia	Latvia
Log (Real Productivity <sub>t-1</sub> )	4.177831	2.332252
Log (Unemployment)	2.013629	2.431224
Log (Real Wages <sub>t-1</sub> )	2.013629	4.283019

Source: Authors' estimation.

The third assumption of the OLS method that we are testing is homoscedasticity or the absence of heteroscedasticity in residuals. All the heteroscedasticity tests assumed homoscedasticity under the null hypothesis. From the estimates in Table 7, we can conclude that we cannot confirm homoscedasticity in the wage function model for Estonia. Both the Breusch-Pagan-Godfrey and White tests for heteroscedasticity reject the null hypothesis at a 5% significance level, accepting the alternative hypothesis indicating the presence of heteroscedasticity. Both tests outweigh the Glejser test estimate, which does not reject the null hypothesis at a 95% confidence level. Based on these findings, we cannot satisfy the OLS assumption of homoscedasticity of residuals. However, we can still assert the robustness of the regression coefficient estimates to heteroscedasticity, as all regression coefficients in Table 1 are statistically significant at a 1% level, considering the adjusted standard errors with the Huber-White and Newey-West methods.

**Table 7**  
Heteroscedasticity tests of the wage function for Estonia

Breusch-Pagan-Godfrey			
			Prob. F
F-statistic	2.798823	df F (3,61)	0.0475
			Prob. Chi-Square
Obs*R-squared	7.864528	df Chi-Square (3)	0.0489
White			
			Prob. F
F-statistic	2.404461	df F (9,55)	0.0223
			Prob. Chi-Square
Obs*R-squared	18.35343	df Chi-Square (9)	0.0313
Glejser			
			Prob. F
F-statistic	1.461895	df F (3,61)	0.2338
			Prob. Chi-Square
Obs*R-squared	4.359815	df Chi-Square (3)	0.2251

Source: Authors' estimation.

The estimates for continuing the heteroscedasticity testing on the model for Latvia are shown in Table 8. We can observe that none of the three heteroscedasticity tests considered at a 5% significance level rejected the null hypothesis. This implies that the homoscedasticity of residuals is present in the wage function model for Latvia.

**Table 8**  
Heteroscedasticity tests of the wage function for Latvia

Breusch-Pagan-Godfrey			
			Prob. F
F-statistic	0.992270	df F (3,70)	0.4016
			Prob. Chi-Square
Obs*R-squared	3.018548	df Chi-Square (3)	0.3888
White			
			Prob. F
F-statistic	1.107813	df F (9,64)	0.3703
			Prob. Chi-Square
Obs*R-squared	9.974321	df Chi-Square (9)	0.3526
Glejser			
			Prob. F
F-statistic	1.373846	df F (3,70)	0.2579
			Prob. Chi-Square
Obs*R-squared	4.114779	df Chi-Square (3)	0.2493

Source: Authors' estimation.

The last assumption of the OLS method we tested is the absence of autocorrelation in the model. Due to the nature of quarterly data, we examined both first-order and fourth-order autocorrelation. Firstly, we checked first-order autocorrelation with the Durbin h test, as the model specification includes a lagged dependent variable. The Durbin h statistic for the model in Estonia is 0.0154, placing it in the interval between -1.96 and 1.96. This means that based on the Durbin h test, we do not reject the null hypothesis and can conclude that there is no autocorrelation of the first order in the model.

We also tested first-order autocorrelation with the Breusch-Godfrey test, shown in Table 9. We can observe that at a 5% significance level, we do not reject the null hypothesis, leading to the same conclusion as the Durbin h test, indicating the absence of first-order autocorrelation. The Breusch-Godfrey test was also used to check fourth-order autocorrelation, which does not reject the null hypothesis at a 95% confidence level. Therefore, we can confirm the absence of fourth-order autocorrelation. In summary, the model does not exhibit autocorrelation, confirming this assumption of the OLS method.

**Table 9**  
Breusch-Godfrey test of the wage function for Estonia

<b>Breusch-Godfrey test - Serial correlation of the first order</b>			
F-statistic	0.004503	Prob. F (1,60)	0.9467
Obs*R-squared	0.004878	Prob. Chi-Square (1)	0.9443
<b>Breusch-Godfrey test - Serial correlation of the fourth order</b>			
F-statistic	0.456731	Prob. F (4,57)	0.7671
Obs*R-squared	2.018636	Prob. Chi-Square (4)	0.7323

Notes: degrees of freedom in parenthesis.

Source: Authors' estimation.

With the Durbin h test, we also examined the first-order autocorrelation in the model for Latvia, which is 0.6499. This value also falls within the interval between -1.96 and 1.96, indicating the absence of first-order autocorrelation in the Latvian model. In Table 10, based on the Breusch-Godfrey test estimates for first-order and fourth-order autocorrelation, we can conclude that at a 95% confidence level, we cannot reject the null hypothesis. This suggests that there is no first-order and fourth-order autocorrelation in the model for Latvia.

**Table 10**  
Breusch-Godfrey test of the wage function for Latvia

<b>Breusch-Godfrey test - Serial correlation of the first order</b>			
F-statistic	0.153674	Prob. F (1,69)	0.6963
Obs*R-squared	0.164444	Prob. Chi-Square (1)	0.6851
<b>Breusch-Godfrey test - Serial correlation of the fourth order</b>			
F-statistic	0.452851	Prob. F (4,66)	0.7700
Obs*R-squared	1.976716	Prob. Chi-Square (4)	0.7400

Notes: degrees of freedom in parenthesis.

Source: Authors' estimation.

In checking the assumptions of the OLS method, we found that the assumption of homoskedasticity of residuals is not met in the wage function model for Estonia. However, the regression coefficient estimates remain robust to heteroskedasticity. On the other hand, all assumptions of the OLS method were met in the wage function model for Latvia. Based on the estimated double logarithmic wage function for Estonia, we found that the most significant impact on the movement of real wages in the current period is represented by real wages in the previous period. The same holds for the double logarithmic wage function for Latvia. This comparison of regression coefficients is possible due to both models' identical functional forms and specification. Unemployment has a relatively greater influence on the dynamics of real wages than real productivity in the

Latvian model compared to the Estonian model. Conversely, real productivity is more important in the Estonian model than in the Latvian model. Additionally, both models include the first lag of real productivity in their specifications, meaning that changes in real productivity in both countries lead to changes in real wages with a lag.

## Conclusion

In this study, we examined wage factors in Estonia and Latvia. We began by exploring the issue of aggregate wages from a theoretical perspective and then focused on empirical research related to wage function estimation. Based on theoretical and empirical considerations, we formulated a wage function model specification that allowed us to study wage determinants in both countries. We collected data on real wages, real productivity, and the number of unemployed persons from the Eurostat database, which we used in an econometric analysis with the Ordinary Least Squares (OLS) method.

The methodology for studying the wage function relied on verifying the assumptions of the OLS method using a double-logarithmic model. We initially checked the statistical significance of regression coefficients, the suitability of the model as a whole, and its explanatory power. In addition to ordinary standard errors, we examined estimates with robust standard errors using the Huber-White and Newey-West methods. We also assessed the adequacy of the model specification with the Ramsey RESET test, providing a foundation for further model investigation. The remainder of the analysis involved testing the normality of the distribution of residuals, the absence of multicollinearity in the model, the presence of homoskedasticity, and the absence of autocorrelation.

Based on the obtained estimates, the wage function model for Estonia demonstrated more than 1% statistical significance of regression coefficients and the same level of statistical significance with robust standard errors. The model also showed overall adequacy with the F test. Similarly, the wage function model for Latvia exhibited a 1% statistical significance, but the real productivity variable showed a smaller statistical significance at 5% and robustness at least 10%. Both models also demonstrated relatively high explanatory power. For both models, we confirmed the appropriateness of the specification, normality of the distribution of residuals, and absence of first and fourth-order autocorrelation. In the case of the model for Latvia, we confirmed

homoskedasticity, while the model for Estonia showed heteroskedasticity according to the tests. However, considering this unmet assumption of the OLS method in the Estonian model, it is important to consider the relatively high statistical significance of regression coefficients when using robust standard errors to account for heteroskedasticity.

We found that in both models, the most significant influence on real wages in the current period comes from the variable of real wages in the previous period. The key difference between the two countries lies in the relative importance of the other two variables in explaining real wages. In the Latvian model, unemployment has a relatively greater impact on the dynamics of real wages than real productivity. On the other hand, in the Estonian model, real productivity has a relatively greater impact than unemployment in explaining real wages. Differentiating the relative importance of real productivity and unemployment is a significant finding in our research. In both models, we also found that changes in real productivity impact real wages with a one-quarter lag. The findings of the study are consistent with empirical evidence. More specifically, the studies of Elgin and Kozubas (2013) and Seputiene (2011) have included Estonia and Latvia in their panel models, and have also confirmed the importance and influence of real labor productivity and unemployment on real aggregate

wages. However, due to the specifics of our analysis of Estonia and Latvia, it is impossible to directly compare the results of the study with the country groups in empirical evidence.

The research findings can provide guidelines for further exploring the wage function of Estonia and Latvia using additional explanatory variables and econometric methods. Policymakers in both countries can also formulate measures based on the relative importance of different wage factors. According to the findings of the study, these measures should be aimed at promoting labor productivity, among which, for example, investments in technological progress and human capital are included, since education and training of the labor force through increased labor productivity would cause the increase of aggregate wages. Similar effects on increasing aggregate wages are possible with measures aimed at reducing the number of unemployed persons. Among these measures are incentives for employment and the creation of new jobs in key sectors of both countries. Measures directed at tackling labor productivity and unemployment can also be simultaneous, as, for example, through active employment policy measures, it is possible to train individuals and increase their productivity while simultaneously providing better employment opportunities.

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# Ocena plačne funkcije Estonije in Latvije

## Izvleček

Proučevanje dejavnikov plač ima svoje zametke v samem začetku ekonomske znanosti, pri čemer nam teoretična in empirična izhodišča omogočajo temelje za specifikacijo modela plačne funkcije. Z metodo OLS smo proučevali dejavnike realnih plač na primeru Estonije v obdobju med tretjim četrtletjem 2006 in tretjim četrtletjem 2022 ter na primeru Latvije v obdobju med prvim četrtletjem 2004 in tretjim četrtletjem 2022. Največji vpliv na realne plače ima odložena odvisna spremenljivka oziroma realne plače v predhodnem četrtletju. Ugotovili smo, da ima brezposelnost v latvijskem modelu relativno večji vpliv na dinamiko realnih plač v primerjavi z realno produktivnostjo. Obratno pa ima v estonskem modelu pri pojasnjevanju realnih plač relativno večji vpliv realna produktivnost v primerjavi z brezposelnostjo. V obeh državah imajo spremembe v realni produktivnosti vpliv na realne plače z zamikom enega četrtletja. Ugotovitve o relativnem vplivu dejavnikov realnih plač omogočajo odločevalcem ekonomske politike smernice pri ciljno usmerjenemu oblikovanju ukrepov, ki bi lahko povečali realne plače v obeh državah.

**Ključne besede:** plačna funkcija, OLS, Estonija, Latvija

# Global Leading and Competencies of Global Leaders

Dorotea Markasović,<sup>a</sup> Najla Podrug,<sup>b</sup> Ana Aleksić Fredotović<sup>c</sup>

<sup>a</sup> PhD Student at the University of Zagreb, Faculty of Economics & Business, Trg J. F. Kennedy 6, 10 000 Zagreb, Croatia

<sup>b,c</sup> University of Zagreb, Faculty of Economics & Business, Trg J. F. Kennedy 6, 10 000 Zagreb, Croatia

dmarkasovic@net.efzg.hr; npodrug@efzg.unizg.hr, aaleksic@efzg.unizg.hr

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## Abstract

Global leading and leadership are two of the most relevant topics in contemporary management literature, as shown by the scientific interest and the number of papers that reflect this topic from several different points of view. This paper's purpose was to review the current research and papers published in this field in the last decade. For this purpose, visualization was done in the VOSviewer application. Findings show that the frequency of publication had doubled in the analyzed period, with the following competencies considered the most important ones for global leaders: a global mindset, emotional intelligence, high ethical standards, fairness, empowering individuals in the team, and caring for your team. The paper provides insight into general trends in research and key research conclusions that have implications and applications in the real sector. It proposes directions for future research based on detected research gaps.

## Introduction

In a world that has been, more or less deftly, navigating the nooks and crannies of the fourth industrial revolution for about a decade now, where business is done globally and in an international context, it is difficult to avoid the topic of global leading and competencies of a global leader. Numerous challenges, as well as the changes already taking place, are the causes leading to the question of global leading, what constitutes it, and what competencies should be possessed by those who aim to be recognized as global leaders. Research in this area is significant, not only in the academic community but also with implications for the entire community and practitioners.

Previous literature deals with the concept of a global leader and global leadership per se (e.g. Osland et al., 2020; Rickley, 2023; Mendenhall et al., 2012; Osland, 2017), global leadership development (e.g. Morrison, 2000), global leader attributes (Kee et al., 2017) and most

\* Corresponding author.

notably global leadership competencies (e.g. Jokinen, 2005; Cumberland et al., 2016; Bird & Stevens, 2017; Azeredo & Henriqson, 2023). Still, as Cumberland et al. (2016) emphasize, a strong focus on this topic has led to an abundance of global leadership competencies identified in the scholar-practitioner literature. There is a gap in the literature seeking more consistent comprehension of what global leadership competencies are required in diverse circumstances (Cumberland et al., 2016) and the need to simplify and synthesize existing knowledge in the field (Forsyth & Maranga, 2015).

Therefore, the purpose of this paper is to plunge more deeply into the existing literature, and based on the review of current research and bibliometric analysis to consolidate findings and provide general trends in the research on the topic of global leading and global leadership competencies in recent years in the field of economics and business. More concretely, we aim by reviewing the existing literature to determine which competencies of global leaders in the international context were detected by the authors who dealt with this topic recently, how they described global leading, and which other possible factors they connected with the adaptation of the behavior of global leaders in the international environment. Based on this, we also aim to propose directions for future research based on detected research gaps.

The paper consists of five chapters. While the first section is an introduction, the second considers the theoretical framework relevant to the research. The third section presents the methodology used, and the fourth provides the main research results. This is followed by a discussion and overview of the most important and interesting contributions to the research topic. The paper ends with the main conclusion, as well as implications of the research, as well as research limitations.

### Theoretical Framework

The theoretical framework of this topic is located in several areas – economics, psychology, and business. Because of this, it is necessary to define the basic terms and make the basic terminological distinction – leading and leadership are not synonyms. Buble (2006, 309) defines leading as one "of the managerial functions by which the manager, based on his official position, resulting from organizational structure, influences employees in such a way that they perform jobs and tasks assigned to them individually, in work groups, and in work teams." On the other hand, leadership is "the ability of managers to influence the work and organizational

behavior of employees based on their organizational power, by to motivate and inspire them with business goals and to adapt their leading and management style to the organizational culture and organizational climate" (Balog, 2021, 392).

In the global context, there is a need for increased cognitive complexity, social acuity, and behavioral flexibility because of significant diversity, more frequent and extensive boundary-crossing activities, a greater number of stakeholders that need to be taken into account when making decisions, greater complexity, competitive pressures, volatility, and pressures for ongoing change efforts (Mendenhall et al., 2012). Therefore, global leadership includes not just the traits of a traditional leader with a global mindset (Arizona State University, 2023), where global leaders' tasks refer to orchestrating multiple activities and managing interdependent relationships (Rickley, 2023). It can also be defined as operating effectively in a global environment while respecting cultural diversity (Harris, Moran, & Moran, 2004, p. 25). Mendenhall et al. (2008,17) define global leaders, as individuals who effect significant positive change in organizations by building communities through the development of trust and the arrangement of organizational structures and processes in a context involving multiple cross-boundary stakeholders, multiple sources of external cross-boundary authority, and multiple cultures under conditions of temporal, geographical and cultural complexity.

Leaders who want influence and significance in the global context need to adopt new values and master skills and competencies. In this sense, it is extremely interesting to study which competencies are considered necessary for someone to be a global leader. The collective knowledge, skills, and abilities that constitute effective organizational leadership and the essential attributes that enable leaders to carry out their duties in many cultural contexts are referred to as global leadership competencies (Akil, 2021). Both the academic community and practitioners recognize the competencies of global leaders within three key categories (Bellner, 2022): a) business and organizational acumen; b) managing people and relationships; c) managing oneself. According to Bird (2017), competencies in the first category include vision and strategic thinking and implementing and directing changes. In the second category, the most essential elements are intercultural skills and empowering others, and in the third category, the leader's character, resilience, and the development of the aforementioned global mindset (Bird, 2018).

Additionally, apart from classic leadership skills, a global leader must (Gundling et al., 2011): a) think globally and fully understand the interconnected nature and disposition of the world in which he lives; b) have a complete understanding of the global and regional business environment; c) fully understand world markets, trends and connections between them; d) understand and develop strategies for overcoming international challenges and crises; e) understand how to recognize and take advantage of international opportunities; f) recognize the importance of culture for business, human behavior, teamwork, work ethics, and goal setting; g) communicate knowledgeably and professionally with people from very different environments, social norms, languages, and with different life experiences; h) actively listen and show empathy towards those with a completely different worldview; i) have strong organizational leading skills. Bellner (2022) also emphasizes coping with challenges and recognizing and exploiting opportunities in a dynamic international ecosystem.

Giles (2016) emphasizes that research over the past few decades has shown that the most important qualities of leaders are focused on soft skills and emotional intelligence. Based on research that included 195 leaders from more than 30 global organizations, she suggests that there are five main competencies demonstrated by strong leaders: high ethical standards and enabling a safe work environment, empowering individuals and employees to self-organize, promoting connection and a sense of belonging among employees, openness to new ideas and experimentation, commitment to the professional and intellectual development of employees. Some key areas for achieving global competencies include developing a business strategy, cultural intelligence, and a global mindset. Global strategy, or the ability to employ global strategic thinking, encompasses the knowledge of how to create and maintain value beyond the borders of one's own country. A leader must understand how to align the company's strategy and structure and achieve the mission and vision that would provide a competitive advantage. Cultural intelligence includes connecting and working effectively in culturally diverse situations and the ability to cross boundaries and thrive in multiple cultures, reflecting cultural agility. Cultural intelligence implies the development of behavioral and motivational skills (Bellner, 2022). A leader with a global mindset is a leader who recognizes the need for global integration and local responsibility and works to optimize this duality. A global mindset includes an appreciation of diversity, as well as openness

to learning everywhere and from everywhere (Pucik, 2006).

However, Giles (2016) notes that although many of these abilities may seem obvious, they are not so easily mastered by leaders and underlines that the ability to improve these competencies should be the leaders' priority. Developing these competencies can be achieved through formal learning and experiential learning (e.g., accepting assignments abroad or working on a global project with international colleagues). Arizona State University (2023) provides steps and suggestions on how to prepare for the role of a global leader as effectively as possible. According to them, it is necessary to: a) improve your knowledge of the world, including geography, culture, and history (paying special attention to relations between countries as this can have a significant impact on trade, business, and interpersonal communication); b) consider learning a new language or learning basic language skills in several languages (even learning the basics can provide a more profound knowledge and understanding of the language and culture); c) consume media from around the world in order to broaden one's view of world events, everyday affairs, and cultural norms; d) read books and articles that focus on the topics of general leadership and global leadership; e) work on communication skills, including interpersonal communication, intercultural communication, and conflict resolving; f) travel abroad and certainly include some non-tourist activities in the itinerary in order to get to know the people and culture of that area; g) seek out local opportunities for action and cooperation (Arizona State University, 2023). The competencies of global leaders should be constantly improved and upgraded to meet the needs of multinational companies. The work and development of the competencies of global leaders also improve global leadership within multinational companies, which certainly spills over into the global community.

In addition, the competencies of global leaders are becoming an indispensable part of the education strategies across the European Union countries, as proposed by the Guidelines for Global Education from Lisbon in 2012 (Cabezudo et al., 2012). According to a survey conducted by Ghemawat (2012) among top managers, 76% believe that their companies should establish themselves as global leaders and maintain that status, but only 7% think they are doing it effectively. Ultimately, global leading and the competencies of global leaders become a niche for companies and institutions that provide educational services and conduct courses on this topic.



## Methodology

To review recent research and synthesize findings and provide broad trends in the field of business and economics research on the subject of global leadership and global leadership competencies the following methods were used: The methods used were: literature review, description method, compilation method, comparison method, analysis and synthesis. The collected data and their connections were analyzed using the comparison method.

The collected data were systematically prepared and processed. The first step was to collect relevant literature. The reviewed articles are available in the following databases: *Hrčak - the portal of scientific and professional journals of the Republic of Croatia* and the *Crosbi database*. Additionally, the most relevant articles were searched for in Google Scholar, Science Direct, Scopus, and Web of Science databases. The Summon tool of the Faculty of Economics in Zagreb, which integrates databases, was also used. Most relevant articles can be found in the following databases: *ProQuest Central*, *DOAJ - Directory of Open Access Journals*, *ROAD - Directory of Open Access Scholarly Resources*, and *SpringerLink Journals*. The selected articles are articles from relevant scientific journals. The articles were collected periodically from September 10, 2023, to September 24, 2023. The following terms were selected as keywords: search parameters: global leading; global leadership; global leader; leadership competencies. The selected keywords were searched for in the fields of business and economics. Additionally, the search filters applied limited the results to papers in English only and to open access works containing keywords in the work's text. "Leadership" was chosen as the subject term because leaders have followers, which is why this is the term that best fits the topic of this paper.

In the last five years, an increase in the number of studies containing given parameters can be observed, which testifies to the growth of interest in this field of research. However, in Croatia, the engagement with this topic is rather modest. The articles selected to conduct the research described in this paper were chosen according to their relevance. The reading of the titles and summaries and the manual review have resulted in 39 articles most relevant to the research topic, out of which 36 article abstracts were selected for analysis via the VOSviewer application.

## Research Results

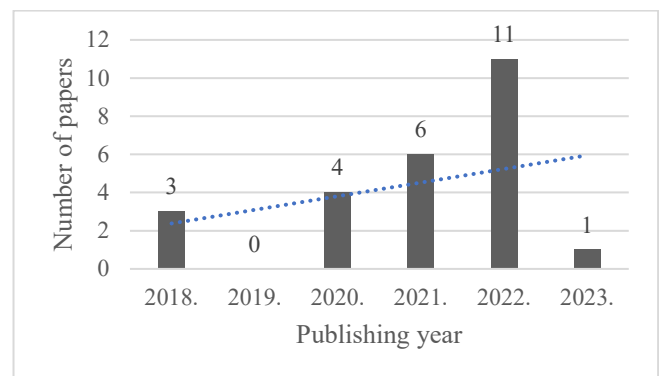
The research results were processed by first showing the frequency of publishing works corresponding to the

search results in the last five years (2018 - 2022) and the current year. Visualizations of sets of keywords were made using the VOSviewer application.

Viewing the search results per the described parameters reveals that the number of articles published in the last five years and the current one that combines considerations about global leading and the competencies of a global leader is  $n_{(5)} = 25$  (Figure 1).

**Figure 1**

Distribution of relevant scientific papers over a certain period



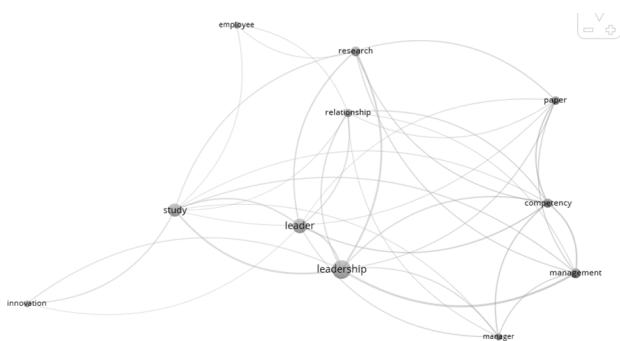
Source: Author's work

For ten years, the data are as follows:  $n_{(10)} = 39$ . There is a significant difference between the data for the number of papers published in the last 5 and 10 years - it indicates that in the last five years, the interest of the scientific community and the academic population in this topic has more than doubled. The number of research papers uniting these areas is increasing. The chart also shows the growing trend (dotted line) of researchers in this area and this topic. In 2020, four articles that matched the search criteria were published (16.00%). Most articles were published in 2022 (44.00%, 11 articles), which is understandable - the crisis caused by the COVID-19 pandemic has directed researchers into questioning the competencies of global leaders and what skills are needed to overcome the crisis with as few losses (both human and material) as possible. Also, the publication of the papers was on hold due to the complete lockdown. No scientific paper matching the given search criteria was published in 2019. In 2021, there were six articles (24.00%), twice as many as in 2018, when there were only three articles (12.00%). So far, only one article (4.00%) has been published in 2023. This year's results are slightly lower since it is not yet over.

Following this, the papers were analyzed through the VOSviewer application, which displayed keywords. In

Network Visualization, terms are represented by their grapheme and (by default) a circle. The colour of the term is determined by the cluster to which the term belongs. The meaning of the term determines the size of the circle. The greater the significance of the term, the larger the mark and circle attached to that term. The lines between terms represent connections. An example of a network visualization is shown in Figure 2. The distance between two terms in the visualization approximately indicates the connection of the terms in terms of co-citation links. The closer two terms are placed to each other, the stronger their connection.

**Figure 2**  
Visualization of the network



Source: Author's work

**Table 1**  
Clusters

Cluster	Key words
<b>Combined summaries (36 summaries)</b>	
1	Competency, management, manager, paper
2	Innovation, leader, leadership, study
3	Employee, relationship, research
<b>Summaries of papers published after January 1, 2018 (until September 24, 2023, 25 abstracts)</b>	
1	Interpersonal leadership, leadership
2	Management, paper
3	Employee, research
<b>Summaries of papers published before January 1, 2018 (11 summaries)</b>	
1	Leader, leadership, study

Source: Author's work

It is also interesting to look at the terms according to clusters. The analysis was carried out for summaries of works written before January 1, 2018, and those written between January 1, 2018 and September 24, 2023. The terms classified according to clusters are given in Table 1. It can be seen that the term "leadership" is in the first cluster for both groups of summaries while being in the second one when the summaries are combined. It is also interesting to note how the term "leader" is in the first

cluster for summaries of an older date, while it is in the second cluster when all the summaries are grouped. The term "competence" is in the first cluster in the combined summaries, whereas it does not appear in the other categories of summaries. Additionally, the term "interpersonal leadership" is found in cluster 1 of more recent abstracts, which indicates scientists' interest in this specific topic.

**Table 2**  
Terms according to the number of appearances and relevance

Phrase	Occurrence	Relevance
<b>Combined summaries (36 summaries)</b>		
Employee	15	3,43
Innovation	<u>13</u>	1,18
Management	28	1,08
Leadership	<b>95</b>	1,01
Research	26	0,86
Relationship	19	0,76
Study	49	0,66
Competency	25	0,65
Paper	19	0,53
Leader	57	0,51
Manager	14	0,34
<b>Summaries of papers published after January 1, 2018 (until September 24, 2023, 25 abstracts)</b>		
Interpersonal leadership	<u>10</u>	1,47
Paper	11	1,26
Employee	15	1,20
Leadership	<b>60</b>	0,82
Management	23	0,68
Research	17	0,56
<b>Summaries of papers published before January 1, 2018 (11 summaries)</b>		
Leadership	<u>25</u>	1,39
Study	<u>13</u>	1,27
Leader	<b>25</b>	0,34

Source: Author's work

Although the term clusters were created based on abstracts of papers, it would be interesting to expand this bibliometric analysis (carried out by network analysis) to include the papers themselves. However, even these clusters show where the focus of researchers is directed in which period. This can be confirmed by the number of occurrences of these terms and their relevance. For example, the term "leadership" appears the most in the combined summaries, as many as 95 times, while the term "innovation" appears the least in the same group, only 13 times. In summaries of papers written before January 1, 2018, it can be seen that the terms "leadership" and "leader" appear an equal number of times (25 times each), while the term that is mentioned most often in

summaries written after that date is "leadership" (60 times). The term "study" has the lowest number of appearances in abstracts written before January 1, 2018, while the term mentioned the fewest times in abstracts written after that date is "interpersonal leadership" (10 times). However, it should be noted that this term has the highest relevance rating in that group. Terms with a high relevance score tend to represent specific topics covered by the textual data, while terms with a low relevance score tend to be general and not represent any specific topic. By excluding terms with a low relevance score, general terms are filtered out, and the focus shifts to more specific and informative terms. By default, approximately 40% of terms are automatically excluded in the VOSviewer application based on their relevance score (including those with less than ten appearances) (van Eck & Waltman, 2022). By observing the results of the analysis, it can be stated that the term "leadership" has a high relevance in all analyzed categories, while the relevance ratings of the terms "leader" and "competence" are good (Table 2).

## Discussion

The results of the analyses carried out indicate that interest in the topic of global leadership has been growing in recent years. In addition, researchers are also interested in specific forms of leadership, such as responsible or interpersonal, and try to see the key competencies of (successful and "good") global leaders. Interestingly, they asserted that national culture plays a big role in the relationship between a leader and his team, that is, followers. Several analyzed papers strongly emphasize the importance of context and cultural values. Paiuc (2021) detected cultural intelligence as a key competency of inclusive leaders. With the world's multiculturalism, the workforce's migration, the ageing of the population in developed countries and other demographic problems, there are more and more companies, institutions, and organizations that are racially and ethnically diverse. This is why the role of inclusive leadership is becoming crucial. Paiuc (2021) believes that knowing how to lead and multiply the results of diverse teams in which all members support each other and feel good is a real skill but also crucial for expanding any multicultural business. Based on bibliometric analysis, he asserts that cultural intelligence is the core and drive of inclusive leadership. In addition, he also believes that cultural intelligence is the main competency for multinational and global leadership (Paiuc, 2021).

Hincapie & Sánchez (2022) have, through a bibliometric

analysis, tried to establish how important the context is regarding responsible leadership in Latin America. Responsible leadership was defined by Maak & Pless (2006). They defined responsible leadership as a relational and ethical phenomenon that occurs in social processes of interaction with those who influence or are influenced by leadership and have a stake in the purpose and vision of leadership. The article provides an overview of research on responsible leadership in Latin America. Two specific roles of the context itself (cultures and values promoted in Latin America) were determined: I) the context can act as a motivating force and have a formative role, promoting the moral development of a responsible leader; II) the context can act as a pulling force that motivates the leader to take responsibility for contributing to the society that needs it. Thus, it is clear from this that the culture and the very context in which the leader operates are extremely important for his (responsible) leadership.

Steinmann & Pugnetti (2021) examined leadership practices in Switzerland and Poland. They surveyed employees of an institution in the financial services sector with branches in both countries. They questioned the employees about their leadership expectations, experiences, and cultural values. They asserted that leadership expectations in these two locations do not differ significantly. However, their experience differs, indicating an opportunity for further development in improving management practices and leadership behaviour. In addition, they also detected several cultural dimensions (avoidance of uncertainty, collectivism versus individualism, power distance) that significantly impact leadership expectations in both countries. This research shows that the cultural assimilation of leaders into their culture, not just the organizational culture, is really important for them to be recognized as "good" leaders. Tsai (2022) proposed a theoretical framework that describes the conditions under which expatriate leaders are likely to adapt their behavior as leaders and how this behavioral adaptation is related to their effectiveness as leaders. Behavioral adaptation in a cross-cultural context is critical to effective leadership, but little effort has been made to conceptualize the relationship between behavioral adaptation and leader effectiveness. National culture was detected as a key factor influencing the behavior of leaders. The research found that leaders who perceive themselves as foreigners in the country they came to have a harder time adapting to the host country's culture. They can change and direct the behavior of subordinates and followers only to a minimal extent. The results of this research indicate a reciprocal relationship between the adaptations of leadership behavior, the

behavior itself, and the effectiveness of the leader.

As these studies indicate, the sooner the leader adapts his behavior and shows appreciation of the domicile national culture, the sooner a positive relationship between the team and the leader will develop. Ultimately, implementing the aforementioned good practices in leading and improving the competencies of (global) leaders could lead to an overall improvement in all matters of sustainable development and a fairer and more inclusive society.

Regarding specific global leadership competencies, several papers and their contributions need to be additionally discussed.

According to Shaikh et al. (2018), today, the key competencies for global leaders are personal value system, career awareness, ethical and external influences, leading change, cultural sensitivity, team building, strategic leadership, conflict management, communication skills, global leadership mindset, and emotional intelligence. In their paper, Shaikh et al. (2018) show that the personal value system variable received the lowest average score, whereas the leading change variable received the highest average score. Another important realization emerged from this research: in practice, demographic variables do not strongly influence any competencies. What was also very important was verifying the existence of correlations between managerial and leadership competencies. Shaikh et al. (2018) have determined that the correlations between these competencies were significant and high. This means that the improvement of any competency (whether managerial or leadership) has a large and positive impact on all other competencies. In practice, this implies that the levels of managerial and leadership abilities achieve a synergy of development, that is, as one skill improves, so do the others.

Lan & Hung (2018) sought to determine the most important leadership competencies in public administration in Vietnam. The results of their research, which they conducted on 529 employees in executive management functions, suggest that managers devote themselves predominantly to change management (highest average score). However, all the competencies they detected are important for the broader context of global leader competencies. They classified a total of 21 competencies into four groups: I) regional context (knowledge of local culture, knowledge of strategies and policies for local development); II) professional competencies (knowledge of organizational mission, knowledge required for work in that area); III) human

resources management (motivating employees, enabling training and personal development of employees, building a good, positive relationship with employees); IV) personal development (orientation on results, continuous learning, communication skills, decision-making, planning and organizing, change management, strategic thinking and a strategic stance in solving issues). All these competencies can be applied in the context of global leading, and are important for global leaders.

Sobratee & Bodhanya (2018) write about employers' competition for talented individuals and employees who have the competencies of global leaders. The traditional approaches to leadership have become insufficient due to rapid (knowledge-based) changes in the economy. Through their work, they wanted to create an integrative theory-based framework that can be used to identify the components that make up management and leadership. They have found that individual differences in competencies, skills, and attitudes (which ensure the development of creative and talented leaders) are not the only factor that contributes to the creation of global leaders; they emphasize that practice is also important. In this sense, they underscore the organizational culture as one of the elements that can slow down or completely prevent the implementation of innovative ideas by managers and leaders (leadership is constrained by organizational conventions). This paper suggests that leaders and managers must apply systematic thinking competencies to improve organizational performance in the rapidly changing global business environment and remain competitive.

Cahyadi & Magda (2021) considered the capability of digital leadership in G20 economies. The research is based on secondary data for 2019. Their research aimed to investigate the digital leadership capability of the G20 countries, which they defined through three variables: the global digital readiness index, the global innovation index, and the global competitiveness index. The authors have broken down these three variables into their components: the indicators they include. Digital readiness is based on the satisfaction of basic needs (one cannot talk about digitization without the most basic needs being fulfilled for the majority of the population). Also, it encompasses the expertise of human resources, the ease of doing business, direct foreign investments and state investments, an environment that encourages start-ups, technological infrastructure, and technology implementation. Innovation is influenced by institutions, human capital, and research achievements, infrastructure, market sophistication, business

sophistication, results based on knowledge and technology, and creativity. Competitiveness also refers to institutions, infrastructure, implementations of ICT, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamics, and the ability to innovate. The results of the research showed that the G20 countries can lead in the digital environment as well, although different countries achieved better results on different variables, which shows where their focus is and how their leaders think. Moreover, all three variables are positively related to each other. Digitization in leadership practice requires the research to be expanded. All of the aforementioned components should be worked on and improved for the country to be a global leader, and this is what the leaders themselves should keep in mind. Today's economic leaders must be in tune with the global mindset and support a culture of innovation.

Živković (2022) conducted a bibliometric analysis based on articles from the following databases: *Scopus* and *Web of Science*. The goal was to examine existing scientific research and develop an integrative framework explicitly focused on leadership competencies in digital transformation. The identified leadership dimensions (competencies) are: *why* (vision, innovation, flexibility); *what* (understanding the digital technologies, empowerment, collaboration); *how* (a person has several types of intelligence, for example, musical, arithmetic, spatial; experimentation, continuous learning). Živković (2022) suggests that the competency framework obtained can be used in business management, organizational development, and education.

In the end, it is evident that most of the scientific papers written at the beginning of this century mostly emphasize the same important competencies found in recent papers. In other words, it can be concluded that the set of previously recognized key competencies and the set of the most recent ones intersect to show the competencies that are also the most important ones today, namely a global mindset, emotional intelligence, high ethical standards and fairness, empowering individuals in the team, and caring for your team.

## Conclusion

The topic of global and global leadership presents a vibrant research field with an increasing interest of authors and researchers. Still, as the literature has indicated, it seems as if the field misses a certain synthesis and simplification of the main findings. Therefore, with this in mind, this paper tried to provide a

deeper insight into recent research and published papers on the topic, focusing specifically on insight regarding general trends in research on global leading and leadership competencies, as well as key research conclusions and current research gaps. The bibliometric analysis was used to address the research question of consolidation of findings and general trends in the research of global leading and global leadership competencies.

Regarding practical implications, the content provided in this paper incorporates the main findings of previous research and, as such, it may serve as a starting point for practitioners in planning different selection, training, and career development activities and for academics in starting their research. Identifying and categorizing different global leadership competencies will benefit human resource professionals and human resources development practitioners. Human resources development researchers could develop a training typology that delineates what global leadership development programs work best under what circumstances to assist practitioners with these decisions.

Therefore, it can be concluded that change like man, despite the global environment changing extremely quickly, takes place at a much slower pace. However, it is advised to confirm or refute this conclusion by considering a larger number of papers for future research. In addition, the research can be improved by determining the time frame (what is considered an "older" and what is a "more recent" paper) and by presenting predictions in the context of competencies that will be needed and valued in the future. Research limitations primarily refer to the time frame of the research, the considered time segment of the publication of relevant papers, access to certain databases, and available papers (that is, articles in open access). By refining the search and supplementing it with new keywords, for example, by narrowing the research area down by adding "intercultural context", "international", and "cultural dimensions", the results obtained would be more focused and would, possibly, show different results and stimulate new research questions. It is important to understand that though bibliometric analysis is an effective method of summarizing and synthesizing literature, it is not without limitations. In particular, the qualitative assertions of bibliometrics can be quite subjective given that bibliometric analysis is quantitative, wherein the relationship between quantitative and qualitative results is often unclear. Also, bibliometric studies can offer a short-term forecast of the research field, and thus,

making over-ambitious assertions about the research field and its impact in the long run should be avoided.

Ultimately, based on the reviewed papers, it can be concluded that there are numerous research gaps and open research questions. For example, is national culture a key factor influencing the behaviour of leaders who are younger, or come from multicultural families; whether leaders (who officially have equal competencies) are considered equally "good" in different national cultures; are modern management manuals that evaluate the competencies of managers determining the

competencies of global leaders. The references used in this analysis review are not an exhaustive list; most are drawn from journals with papers written in English. Relevant sources of information may also exist in other domains of scientific inquiry. Non-English language contributions were therefore omitted. There are still many (research) challenges, but also opportunities. Since there is a large space for potential research here, more significant scientific contributions that would combine these areas would have an echo in the business practice as well.

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# Globalno vodenje in kompetence globalnih vodij

## Izvleček

Globalno vodenje in voditeljstvo je ena izmed najbolj aktualnih tem v sodobni literaturi s področja managementa, kar se kaže v znanstvenem zanimanju in številu člankov, ki to temo obravnavajo z različnih vidikov. Namen tega prispevka je bil narediti pregled aktualnih raziskav in člankov, objavljenih na tem področju v zadnjem desetletju. V ta namen je bila izvedena vizualizacija v aplikaciji VOSviewer. Ugotovitve kažejo, da se je pogostost objav v analiziranem obdobju podvojila, za najpomembnejše kompetence globalnih vodij pa veljajo: globalna miselnost, čustvena inteligenca, visoki etični standardi in pravičnost, krepitev moči posameznikov v timu in skrb za svoj tim. Članek omogoča vpogled v splošne trende v raziskavah ter ključne ugotovitve raziskav, ki imajo posledice in uporabo v realnem sektorju, ter predlaga usmeritve za prihodnje raziskave na podlagi odkritih raziskovalnih vrzeli.

**Ključne besede:** vodenje, kompetence, globalno vodenje, globalni voditelji, bibliometrična analiza



# Overview of the Use of Eye-Tracking Technology for Monitoring Consumer Views

Anita Peša,<sup>a</sup> Marko Valčić,<sup>b</sup> Ana Maria Smokrović,<sup>c</sup> Izabela Laura<sup>d</sup>

<sup>a</sup> University of Zadar, Departement of Economics, Ulica Mihovila Pavlinovića 1, 23000 Zadar, Croatia

<sup>b</sup> University of Zadar, Maritime Department, Ulica Mihovila Pavlinovića 1, 23000 Zadar, Croatia

<sup>c</sup> OTP banka d.d. Ulica Bleiburških žrtava 17, 23000 Zadar, Croatia

<sup>d</sup> Ulica Nikole Tesle 14 J, 23 000 Zadar, Croatia

apesa@unizd.hr, mvalcic@unizd.hr, ane.zd77@gmail.com, izabela@izabelalaura.eu

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## Abstract

Eye-tracking technology has become increasingly popular in studying consumer behavior and decision-making as a part of the marketing research area. The paper highlights the importance of eye tracking in the study of consumer behavior including the use of eye tracking in virtual reality environments, the integration of eye tracking with other physiological measures, and the development of more sophisticated analytical techniques. By observing eye movements and fixations researchers can gain insight into the visual and cognitive processes underlying consumer choices. For this reason, a literature review of relevant studies provides a detailed synthesis of the development of eye-tracking experiments. This paper contributes to the latest findings on consumer behavior in the field of eye-tracking technology.

## Introduction

Visual attention is the cognitive process of concentrating on one aspect in the multitude of stimuli detected by our senses for further processing, resulting in long-term memories and ignoring the others. Attention also involves awareness of stimuli in the conscious mind and is driven by top-down (endogenous) and bottom-up (exogenous) processes. Bottom-up processes occur when vital information from the external world draws our attention, while top-down processes draw attention to information based on internal knowledge, beliefs, expectations, and goals. Attention filters most of the sensory stimuli a person faces, reducing it to a level that can be processed to fulfil whatever goal or task currently directs our activity and is extremely important in forming long-term memory (Huddleston et al., 2018).

However, attention represents a neutral function that is difficult to measure with traditional methods. Eye-tracking systems measure eye position, eye movement, and pupil size to detect zones in which the user is interested at a specific time. Several methods exist for measuring eye movement (Fakhrhosseini & Jeon, 2017).

\* Corresponding author.

Eye-tracking technology is based on decades of research on oculomotor behavior. A typical eye movement model applied to eye tracking consists of two basic concepts: fixation and saccade. The difference between fixations and saccades is in the behavior of the eyes. Human gaze at stationary objects is characterized by jumpy gazes in saccades, stopping at shorter or longer fixations. Information is processed only during fixations since the brain blocks information acquisition processes during saccades (Holmqvist et al., 2011). Empirical evidence supports that fixation on a particular item indicates that attention is being paid. Also, attention and eye movements, as well as information processing and fixation, are thought to co-occur (Sickmann & Le, 2016). This represents the operational basis for using eye tracking as a reliable tool for measuring attention.

Different eye-tracking tools allow researchers to observe and analyze subjects' visual attention and decision-making processes in real time, providing insight into how people process information and make decisions. Eye-tracking technology has the potential to shed light on how individuals direct their attention to different features of a product or service, how they process complex information, and how they integrate that information into their decision-making process. With the increasing availability and affordability of eye-tracking technology, researchers in marketing are increasingly using this method to investigate various research questions related to consumer behavior (Debertin, 2012; Sickman, 2016; Huddleston et al., 2018) This paper aims to synthesize the literature on eye tracking in applied microeconomics, highlighting its advantages and limitations and discussing its potential application in business. This review tried to demonstrate the usefulness of eye tracking in applied microeconomic research and provide guidance to researchers interested in including this method in their studies. Also, this paper represents the first phase of literature research as an introduction to the second phase, which will include a scientific experiment using eye tracking on a focus group.

The work is structured as follows: the first part provides a basic introduction to attention processes and eye-tracking technology; the second part describes the methodology, the technological background of eye-tracking is presented in part three; the fourth chapter gives a historical overview of eye-tracking, in chapter five is a literature analysis of usage eye-tracking research in retail and online; in the sixth part is conclusion and discussion given. The shortcomings of the conducted eye-tracking studies are investigated.

## Methodology

For the eye-tracking review, we researched available scientific and professional articles in the fields of marketing, market research, consumer behavior, and technology development in the field of eye-tracking. Literature was searched using an advanced search with keywords (TITLE-ABS-KEY (“eye tracking” OR “eye-tracking” OR “gaze tracking”) AND (consumer behavior OR economic behavior OR decision making OR choice OR attention OR applied microeconomics)). Web of Science, Scopus, Google Scholar, Science Direct, and APA Pysc Net databases were searched. We have narrowed our search to a time frame between 2000 and 2022. Furthermore, we found two papers from 1898, when the first device for recording eye movements was invented (Delabarre, 1898). The obtained data set consisted of 1854 works. The first stage of the data cleaning process was to remove papers based on title and abstract. After screening, we received a sample of 80 papers. The next phase involved looking at the discussions and conclusions. Excluded are articles from the field of finance, accounting, education etc. After that, a sample of 39 acceptable studies and sources that use eye-tracking (ET) as the methodology of choice in the field of consumer behavior, as well as several review papers from that field, was gained.

## The Technological Background of Eye-Tracking

Eye tracking technology is the most promising in eye movement research, visual perception, and visual attention. The eye tracking device collects data that enable conclusions to be drawn about eye fixations and saccades to a given stimulus. If the eyes stop on a particular stimulus that is captured in the foveal region, fixation occurs. The most important measures related to fixations are fixation position, number of fixations, probability of fixation, time to first fixation, duration of first fixation, and total fixation time (Duerschmid & Danner, 2018). Conversely, a saccade includes saccade amplitude (saccade length) and saccade velocity (speed of eye movement). Meißner & Oll (2017) further explain that a saccade is a rapid eye movement between two consecutive fixations during which the person is "blind". Therefore, information gathering and actual attention take place during fixation. Different combinations of fixations and saccades allow researchers to extract specific eye-tracking measurements that represent the visualization of eye movements (Meißner & Oll, 2017). Some other eye-tracking methods can be found, e.g., blink rate, saccades, and pupil dilation (Motoki et al.,

2021). Still, all of them are used to examine the visual attention of different consumers.

Eye tracking devices typically use one of two approaches: corneal reflection or pupil center corneal reflection. Corneal reflectance monitoring devices use a camera to capture an image of the eye and its surroundings. An infrared light source is used to create a reflection on the cornea, which can be tracked as the eye moves. The position of the reflection relative to the camera can be used to calculate the gaze direction. This technology is also known as the Purkinje eye-tracking method. Center-of-pupil corneal reflection tracking devices use a similar approach, but instead of tracking the reflection at the cornea, they track the position of the center of the pupil. The corneal reflection is used to calculate the position of the center of the pupil which is then used to determine the direction of gaze. Eye trackers can be used in various applications, such as user interface design, virtual and augmented reality, and market research (Bulling et al., 2014). A very intuitive visualization of eye-tracking data is a heat map that shows areas of visual interest at different thermal intensities. It shows several participants' accumulated fixations (numbers or lengths) on each stimulus area using a colour code: often red indicates many long fixations, orange-yellow for medium, and green for a few short fixations. An important tool for analyzing eye movement data is AOI (*area of interest*), which defines essential areas of the image which should be analyzed separately. AOI can be plotted on the image using eye-tracking software, and then the eye-tracking data related to the defined areas can be statistically analysed. Another option for visualizing eye-tracking data is to display fixations on a timeline. Such view diagrams show the participants' scan path and search behavior. Each fixation is shown as a dot, the number in it indicates the order in which the fixation appeared, and the diameter of the dot represents the length of the fixation (Duerrschmid & Danner, 2018).

There are usually two types of eye-tracking devices – one in the laboratory and mobile that could be used in open space. Eye tracking in the laboratory or on a computer can ensure the reliability of measurements in a controlled experimental environment. On the other hand, mobile devices offer the advantage of measuring views while shopping in a physical environment (Motoki et al., 2021).

### Historical Development of Eye-Tracking

The first eye tracker was developed at the end of the 19th century by Edmund Huey, who used iris-hole contact lenses that were connected to aluminum indicators. This

method was unpleasant to the eyes. (Huey, 1898). Delabarre (1898) invented a plaster cap that adhered to the moist surface of the eye. Attached to the cap was a wire leading to a lever that plotted the horizontal movements of the eye on the surface of the cinematographic cylinder. The subject could read the text through a hole made in the plaster cover. The plaster cap did not detach from the eye until it began to fill with tears (Płużyczka, 2018). In 1901 Dodge and Cline (1901) invented non-invasive optical eye-tracking devices. They were the first to use light that reflects from the cornea's surface and falls through the optical system onto a moving photosensitive photographic plate, thus leaving a record of the eye's movement on that plate. Dodge and Cline's device had two flaws: it registered only horizontal eye movements and required subjects to keep their heads still. US Air Force in the 1960s invented the first eye-tracking device named "oculometer". Thanks to computer algorithms, the iris was recognized on the video screen, and its geometric center and the direction in which the tested person was looking were determined (Płużyczka, 2018).

For more than 70 years, researchers have been building their systems, and it was not until the 1970s that new technologies such as infrared cameras and computers enabled the development of more sophisticated eye-tracking systems. In the 1980s, researchers began using head-mounted eye-tracking systems, allowing greater freedom of movement and more natural experiments (Duchowski, 2002). In the 1990s, the development of remote eye-tracking systems allowed researchers to monitor eye movements from a distance without needing participants to wear any equipment (Holmqvist et al., 2011).

Over the years, eye trackers have become cheaper and smaller and several commercial eye trackers are available on the market today. The most famous manufacturers of eye-tracking technology are Tobii Pro, CRG Global, MSW Research, Fieldwork Network, etc. (GreenBook, 2023). Eye-tracking technology is used in various applications, from medicine, market research, and advertising to cognitive psychology and human-computer interaction (Duchowski, 2002).

### The Use of Eye-Tracking in Applied Microeconomics

Gaze tracking is becoming an increasingly popular way to understand consumers' visual attention in retail. In this way, researchers try to gain insight into the sale of specific products or help consumers make decisions. One

of the primary uses of eye tracking in retail is to optimize store layout and product placement. A study by Orquin and Loose (2013) found that eye tracking can provide valuable insights into how consumers move through a store and which products they pay the most attention to. By analyzing fixation patterns, retailers can identify which areas of the store are most likely to attract customer's attention and can use this information to place products and promotions strategically. For example, a retailer may display high-margin items in areas with high traffic levels and fixation rates, to increase the likelihood of purchase. By analyzing gaze behavior, researchers can identify which product features are most important to consumers and which factors influence their purchase decisions. A study by Wedel and Pieters (2008) found that eye-tracking can be used to predict consumer preferences with a high degree of accuracy and can even be used to design more effective product packaging and labelling.

Also, product characteristics in the store, such as brand and popularity, influence consumer attention. The previously described experiments prove this, and in most cases, popular products are more attractive and more present in supermarkets (Bialkova et al., 2019). Meißner et al. (2019) propose the creation of virtual reality and mobile eye tracking for researching consumer behavior in retail. Eye tracking in virtual reality enables a level of control that can usually only be achieved in laboratory environments while simultaneously providing a realistic 3D experience and the freedom of movement typical of real store environments. The main argument they make for using mobile eye tracking in real-world retail settings is that attentional processes can differ significantly between the laboratory and the real world. Supermarket shoppers often make choices within seconds and consider only a few options, suggesting that retail research should investigate attentional processes at the point of sale (Meißner et al., 2019).

The main application of eye-tracking in studying consumer behavior on digital devices is to improve user interface design. A study by Thüring and Mahlke (2007) found that eye tracking can optimize website navigation, improve search functionality, and reduce user errors. They also found that eye-tracking can identify user preferences for different types of menus and navigation systems, which can help design more effective user interfaces. Another application of eye tracking in studying consumer behavior on digital devices is understanding how users process information and make decisions. A study by Tuch et al. (2012) found that gaze tracking can measure the influence of different design

elements, such as colour, font, and layout, on users' perception of a website's usability.

In online shopping, consumers' perceptions of products depend solely on their visual attention to the purchase information displayed on the screen. Consumers lack service encounters or tangible product experiences. For this reason, research into the visual behavior of consumers during online shopping is essential to help online retailers design appropriate purchase information for display on screens. Furthermore, Hwang and Lee (2020) found in their research that the small screen of a mobile device affects users' visual behavior by imposing greater visual complexity and higher cognitive load. Also, Chen et al. (2022) investigated the impact of online reviews on consumer purchases using gaze tracking. The results showed that the respondents' attention was greater for negative comments than positive ones, especially among female respondents. It was also established that consumers could not recognize false comments. The researchers suggest that marketers should pay special attention to negative comments and address them immediately.

How do consumers decide to spend their income? Which goods are bought and which remain on the shelves? The economic theory of consumer choice helps explain why consumers behave in certain ways. Different applied microeconomics studies in the marketing field try to find the best approaches to satisfy the infinite desires of modern consumers that are very demanding in this era (Debertin, 2012). Understanding consumer behavior is a central concern of microeconomics, as it plays a vital role in allocating economic resources. One of the most important aspects of consumer behavior is making purchase decisions. Eye tracking has become a valuable tool for analyzing decision-making processes in recent years. Eye tracking allows researchers to measure consumers' visual attention, providing insight into the factors influencing consumer behavior. Most eye-tracking research in this scientific field examined fixation as a primary measure of visual attention (Wedel & Pieters, 2008). Fixation can inform researchers about participants' focus, memory, preference formation, choice, and sales (Orquin & Mueller-Loose, 2013). Using eye tracking technology, Amasino et al. (2023) found that higher budgets accelerate the purchase decision process, increased attention to higher budgets increases their influence on choice, and higher budgets justify higher spending, while lower budgets reduce purchases.

One of the most prominent areas of research using eye-tracking technology in applied microeconomics is

product placement. Researchers have investigated the effects of product placement on consumer attention and choice in different retail environments. Orquin et al. (2020) investigated the impact of prominence, surface size, and product center distance on the visual attention of packaging elements. In their research, fixation is a binary variable representing whether attention appears on certain package elements. Results showed that more prominent, larger, and centrally placed package elements were more likely to be fixed. In addition, they found that images and logos on larger packages were more prominent and more centrally positioned than sustainability and nutritional information. Earlier studies have found that consumers are likelier to pay attention to and remember visually salient features, such as colours, shapes, or logos (Pieters & Warlop, 1999). Also, in their work, Puccinelli et al. (2009) investigated the influence of the environment in which products are presented on the decision-making process. They found that consumers pay more attention to prominently or centrally located products in a store or website.

Furthermore, the presence of other stimuli, such as sales promotions or competing products, also affects the allocation of visual attention and the consumer's decision-making process. This suggests that packaging and product design can significantly attract consumers' attention and influence their decision-making process. Furthermore, Bogomolova et al. (2020) tested whether the salience of a unit price label (displaying prices per unit of volume or weight) affects viewing behavior. A prominent unit price label (e.g., larger font size, colours) increased the number of fixations on the price label. Moreover, the number of fixations can be primarily attributed to highlighting the unit price in yellow and for less price-conscious consumers (Bogomolova et al., 2020). These findings suggest that visual salience is key to attracting exogenous attention.

On the other hand, gaze tracking technology has proven to be a reliable tool for measuring attention focused on a goal. Wansink and Park (2001) demonstrated that the goals and motivation of consumers can influence visual attention and the decision-making process. For example, consumers may pay more attention to features relevant to their goals or needs, such as the nutritional content of food products and environmental awareness. In their work, Chiu et al. (2023) found that reusable packaging and a monotonous logo can attract consumers' attention faster than original packaging. A uniform logo has the subtle effect of helping consumers shift their attention to the type of packaging, indirectly stimulating and enhancing the impact of visual perception on

environmental awareness and brand image. This study suggests that the company should use reusable packaging to support environmental protection and improve its brand image.

Some studies have also investigated the role of emotions on visual attention and consumer decision-making processes. Studies have found that emotional cues, such as images or slogans that evoke positive or negative emotions, can capture consumers' attention and influence their decision-making process (Pham et al., 2001). Motoki et al. investigated how random emotions affect the visual processing of food packaging (Motoki et al., 2019). Participants were randomly assigned to emotion elicitation conditions; anxiety, anger, and neutral state. In each condition, participants wrote personal experiences associated with anxiety, anger, or neutral to elicit each emotion. Afterwards, participants saw packages of healthy and unhealthy products with eye tracking. The results show that participants who felt anxious (vs. angry) showed a longer total fixation time on the junk food packages. In addition, Wedel and Pieters (2000) found that consumers tended to fixate on product features relevant to their decision, such as price and brand name. However, they also found that consumers tend to ignore features that are not relevant, such as product colour. This study demonstrated the importance of understanding which features are relevant to consumers and how visual attention can influence their decision-making.

## Conclusion and Discussion

In conclusion, examining eye-tracking technology for monitoring consumer perspectives presents a comprehensive understanding of its applications across various domains. An extensive review shows that eye-tracking technology offers invaluable insights into consumer behavior, preferences, and decision-making processes. The diverse range of studies showcased in this overview underscores the versatility and effectiveness of eye-tracking technology in capturing nuanced aspects of consumer engagement. As technology continues to evolve, it is foreseeable that eye-tracking will play an increasingly integral role in understanding consumer behavior and shaping decision-making processes in the marketplace.

In essence, this overview underscores the significance of eye-tracking technology as a powerful tool for monitoring consumer views, offering researchers and businesses alike the opportunity to gain deeper insights into the intricacies of consumer perception and behavior.

Exploring its potential applications and refining methodologies, eye-tracking stands poised to remain at the forefront of consumer research, driving innovation and informing strategic decision-making in the dynamic landscape of consumer markets.

Like any research method, eye tracking has limitations that researchers must know. One of the primary limitations of eye-tracking technology is its potential for inaccuracy. Eye-tracking technology assumes that the gaze point corresponds to the visual stimulus being looked at, but this is not always the case. Several factors can affect the accuracy of eye tracking, such as head movements, blinks, and pupil size, which can result in erroneous information (Holmqvist et al., 2011). In addition, the calibration procedure used to determine the relationship between gaze position and screen position can also introduce inaccuracies if not performed correctly (Duchowski, 2002).

Another limitation of the eye-tracking method is the spatial resolution of the equipment. Although modern eye trackers are capable of very high sampling rates and spatial resolutions, there are still limitations to their accuracy. For example, some eye trackers may have difficulty resolving small saccades or fixations, especially when the user moves quickly or in low-light conditions (Bulling et al., 2011).

Eye tracking is sensitive to artefacts that can affect the quality of the collected data. Artefacts can arise from various sources, such as reflections from glasses, contact lenses, or corneal irregularities, which can distort the eye's image and introduce inaccuracies in the collected data (Duchowski, 2002). In addition, lighting conditions can affect data quality, as changes in ambient light can affect pupil size and iris-pupil contrast, which can affect tracking accuracy (Bulling et al., 2011). Furthermore, eye-tracking technology cannot reveal precisely why subjects position their eyes on a particular element. Therefore, this technology is often supplemented with additional methods, such as the interview method (Rajapake, 2018). Another disadvantage of eye tracking is bias. When users are aware that researchers are interested in certain product elements, they may be more cautious than they would be if that element were just one of many they encountered during their search. In their research, Krajina and Mladenović (2018) supplemented the quantitative value of eye-tracking data with the qualitative value of retrospective interviews. Also, it is necessary to pay great attention to the correct coding and analysis of the obtained data to avoid reaching incorrect conclusions. Another precaution concerns concluding cognitive

processes. For example, visual attention is not perfectly correlated with awareness, so the focus of the gaze is not always a direct mirror of what is being processed. Furthermore, the gaze is influenced by various factors such as memory, colour, and saliency. This could confirm the influence in experimental eye movement research and, therefore, must be properly controlled.

**Table 1**  
Eye-tracking technology – main findings, limitations and solutions

Technology	Main findings	Limitations	Solutions
Eye-tracking	Give invaluable insight into consumer behaviour preferences  Decision-making process in different areas	Rather expensive technology  Technology still in progress (e.g., fast moves of the eye cannot be tracked)  Potential for inaccuracy (head movement, blinks etc.)  Quality of the collected data  Private protection issue	SW price will fall in the next few years  Technology is constantly improved  Conducting additional tools, such as interviews with consumers, focus groups, filling out questionnaires, etc.  Education of eye-tracker professionals and/or AI  Consumer legal privacy issues should be solved before the experiments

Source: Authors' compilation.

Although this is a valuable literature review, it also acknowledges certain limitations. Namely, by reviewing only a certain number of databases, we omitted research available from other sources. Furthermore, by including only articles from the English-speaking area, we skipped valuable research written in other languages. To avoid these limitations in future studies, conducting a more extensive study on this topic would include a larger number of databases, and using tools to translate the article into other languages is recommended.

Before conducting any experiment with eye-tracking technology, it is necessary to ensure the ethicality of the procedure in the direction of privacy and data protection. Future research should also address some of the limitations of eye-tracking technology and investigate other factors influencing consumer behavior, such as tracking devices connected to the customer's skin. All these technological innovations for monitoring consumer behavior need to be supplemented with traditional techniques used in marketing, such as conducting

interviews with consumers, focus groups, filling out questionnaires, etc. to scientifically and in practice support the usefulness and effectiveness of the used techniques for monitoring decision-making during consumption, voting and all other activities of human behavior. It also remains to be investigated how AI techniques can be used for better and faster processing of data obtained by applying eye-tracking in different areas of human activity.

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# Pregled uporabe tehnologije sledenja očem za spremljanje pogledov potrošnikov

## Izvleček

Tehnologija sledenja očem postaja vse bolj priljubljena pri preučevanju vedenja in odločanja potrošnikov v okviru področja trženjskih raziskav. V prispevku je poudarjen pomen sledenja očem pri preučevanju vedenja potrošnikov, vključno z uporabo sledenja očem v okoljih virtualne resničnosti, povezovanjem sledenja očem z drugimi fiziološkimi meritvami in razvojem bolj izpopolnjenih analitičnih tehnik. Z opazovanjem gibanja oči in fiksacij lahko raziskovalci dobijo vpogled v vizualne in kognitivne procese, na katerih temeljijo odločitve potrošnikov. Zato pregled literature o ustreznih študijah zagotavlja podrobno sintezo razvoja eksperimentov s sledenjem očem. Ta članek prispeva k najnovejšim ugotovitvam o vedenju potrošnikov na področju tehnologije sledenja očem.

**Ključne besede:** vizualna pozornost, sprejemanje odločitev, tehnologija sledenja očem, vedenje potrošnikov, izbira potrošnika

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Primer 2a: Engle and Granger (1987) present critical values also for other cointegration tests.

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