Wage Function Estimation of Estonia and Latvia

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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.

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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 (Staehr, 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 (Staehr, 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 & Staehr, 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 & Staehr, 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$_{t-1}$)	0.279729	5.523755***	5.842294***	6.127251***
		(0.050641)	(0.048284)	(0.046039)
Log (Unemployment$_t$)	-0.060309	-6.367342***	-6.772216***	-6.869152***
		(0.009472)	(0.009038)	(0.008910)
Log (Real Wages$_{t-1}$)	0.755573	20.13846***	22.69889***	22.82328***
		(0.037519)	(0.033186)	(0.033005)
Total observations	65	F statistic		1410.955***
R^2	0.985794	Durbin-Watson statistic		1.996348
Adjusted R^2	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$_{t-1}$)	0.076492	2.476749**	2.027854**	1.765307*
		(0.030884)	(0.037721)	(0.043331)
Log (Unemployment$_t$)	-0.125207	-8.529752***	-6-823410***	-6.101224***
		(0.014679)	(0.018350)	(0.020522)
Log (Real Wages$_{t-1}$)	0.751447	22.42820***	16.94912***	16.23272***
		(0.033505)	(0.044335)	(0.046292)
Total observations	74	F statistic		1191.554***
R^2	0.980794	Durbin-Watson statistic		1.855311
Adjusted R^2	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

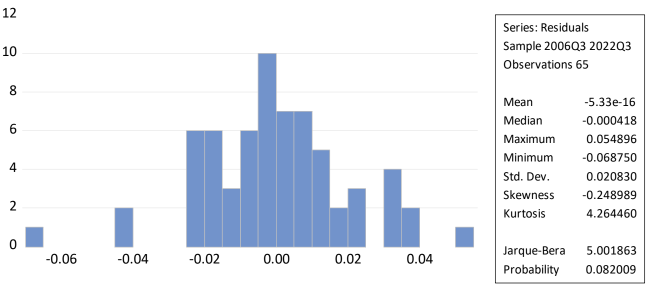
Ramsey RESET test for Estonia			
	Value	df	p-value
t-statistic	0.172364	60	0.8637
F-statistic	0.029709	(1,60)	0.8637
Likelihood ratio	0.032177	1	0.8576
Ramsey RESET test for Latvia			
	Value	df	p-value
t-statistic	1.714311	69	0.0910
F-statistic	2.938861	(1,69)	0.0910
Likelihood ratio	3.086548	1	0.0789

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.

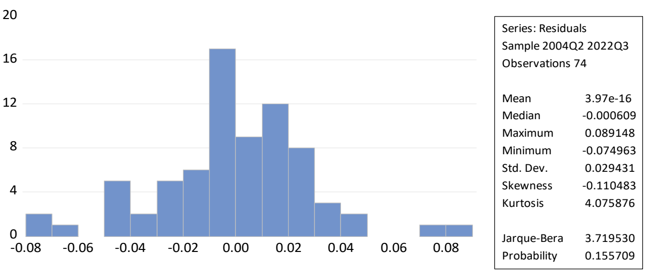
The second assumption of the OLS method that we examined is the absence of multicollinearity among the explanatory variables in the model. The critical value above which Variance Inflation Factor (VIF) values would indicate the presence of multicollinearity is 10. Table 6 shows that the values of centered VIF for all explanatory variables for Estonia and Latvia are less than 10. This implies that there is no multicollinearity or that the 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$_{t-1}$)	4.177831	2.332252
Log (Unemployment)	2.013629	2.431224
Log (Real Wages$_{t-1}$)	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

Breusch-Godfrey test – Serial correlation of the first order			
F-statistic	0.004503	Prob. F (1,60)	0.9467
Obs*R-squared	0.004878	Prob. Chi-Square (1)	0.9443
Breusch-Godfrey test - Serial correlation of the fourth order			
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

Breusch-Godfrey test - Serial correlation of the first order			
F-statistic	0.153674	Prob. F (1,69)	0.6963
Obs*R-squared	0.164444	Prob. Chi-Square (1)	0.6851
Breusch-Godfrey test - Serial correlation of the fourth order			
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 relanih 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