

TAX WEDGE AND ITS IMPACT ON EMPLOYMENT IN OECD COUNTRIES

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Abstract: Our study explores the relationship between the tax wedge, unemployment rate and employment rate on the labor market in a comparative framework, highlighting existing approaches in the OECD countries. There are considerable differences in the level of the tax wedge between the OECD countries. The relationship between the tax wedge, employment rate and unemployment rate is a complex one, involving a broad approach, but appropriate to the particularities of each country. Such a comparative analysis at the level of the OECD countries offers us interesting perspectives, in order to adjust the policies that aim, on the one hand, to ensure budget revenues and, on the other hand, to stimulate economic growth and support employment. In order to identify the link between them, we used hierarchical cluster analysis, for a sample of 37 OECD countries. After analyzing the data from the OECD countries, we concluded that there is a positive correlation between the level of the tax wedge and the unemployment rate. Thus, in countries where the tax wedge is higher, the unemployment rate tends to be higher and vice versa. But this is verified especially for cluster 2, which includes Romania and most of the countries in Central-Eastern Europe. Therefore, it is particularly important to adopt those fiscal measures that stimulate employment and have beneficial effects on the results of the labor market. The associated new data modeling

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contributes to filling a gap in the statistical analysis of tax wedge implications by using a combination of quantile regression and clustering, finding robust country subgroups that enable refined, context-sensitive policy recommendations.

Keywords: tax wedge; employment rate; unemployment rate; labor; cluster analysis.

JEL Codes: E62, J32, J62, J64.

1. Introduction

The tax wedge represents the difference between the total labor cost for the employer and the net salary of the employee. Therefore, it is of interest to highlight the impact of taxes and social contributions on labor costs, and this will give us an image of the real level of remuneration for an employee. The level of the tax wedge can be expressed as a percentage and is often used to analyze the impact of taxation on the workforce, as well as to make comparisons regarding the level of taxation between different countries or comparisons over different periods of time. The impact of the tax wedge is a complex one, manifesting itself upon employers, employees, but also on the labor market as a whole.

Thus, an increase in the level of the tax wedge will negatively affect employment and investments in the workforce, because we are talking about higher costs for companies with employees. Employers may become more reluctant to increase the workforce and give salary increases. However, in order to maintain their competitiveness and attract well-trained workers, companies should know the impact of the tax wedge on the salary structure.

The increase in the tax wedge has a negative effect on the labor force participation rate in the OECD countries (Zimčík, 2017). In the case of employees, a high level of the tax wedge can discourage them from looking for new opportunities, reducing their mobility and motivation to look for jobs. The higher the tax wedge, the more they will see their net wage reduced and the taxes paid to the government higher. These will have negative consequences on the living standard of employees, affecting their spending decisions and saving capacity.

The flexibility of the labor market can be negatively affected by the tax wedge, because employers will have less ability to quickly adjust the number of employees according to changes in demand. In this case, we can talk about the rigidity of the labor market, as a result of a high wedge tax, and therefore an intensification of unemployment in periods of recession. The mobility of employees is affected, as well as the willingness to keep their jobs, as a result of unattractive salaries.

Also, entrepreneurship and innovation can be negatively affected by a high level of the tax wedge, because it may reduce the incentive to start new businesses or the expansion of innovations, with negative consequences on the labor market. In

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countries with a high level of the tax wedge, it is necessary to adopt some tax reforms aimed mainly at reducing it. The motivation for this has the objective of boosting economic growth, competitiveness and improving the living standard of individuals. For this reason, the tax wedge is the subject of numerous debates related to fiscal and salary policy, and its maintenance within certain appropriate limits can lay the foundations for a more prosperous and sustainable economic environment.

Sustainable development, an objective for any economy, involves ensuring a high level of employment, but also reducing unemployment to an acceptable level. Hence, it is necessary to promote the public-private partnership in order to stimulate the creation of jobs in domains of high productivity. Income redistribution should not be used for people who are able, but unwilling to work (Simionescu & Naroş, 2019).

In this paper, we aim to highlight the implications of tax wedge on the unemployment and employment rate, in the OECD countries. At the same time, we will mention the countries in which the tax wedge has the highest and respectively the lowest level. We start from the premise that the tax wedge is an important factor with negative effects on both unemployment and employment. For this purpose, we will use descriptive statistics, panel linear regression, quantile linear regression and hierarchical cluster analysis. Such an analysis is useful to identify groups of countries that are similar in terms of tax wedge, employment rate and unemployment rate. We will then investigate the characteristics of these more homogeneous groups of countries.

The reduction of tax wedge is beneficial for the economy, because it stimulates investments, consumption and productivity growth. A study on this topic is useful for creating sustainable economic strategies. Thus, a comparative analysis regarding labor tax wedge can be the basis for improving existing tax policies. In order to support economic growth and create new jobs, governments can adjust their tax rates, making economies more competitive.

The topic of the paper is of actuality in the post-pandemic context, because in many OECD countries it is necessary to adjust fiscal policies to the new economic realities of today. Therefore, it is useful to highlight the impact produced by the labor tax wedge on work demand and supply and to find ways to improve performance in the labor market. Many economies are still recovering from the COVID-19 pandemic, which caused great distortions in the labor market. Therefore, it is very important to adopt those fiscal policies that support employment and allow economic recovery.

The pandemic has revealed that individual adaptability is an important characteristic of work. Frequent technological innovation dramatically transforms workplaces and the role of humans in them. Therefore, people must continuously adapt to new working requirements (Botezat et al., 2023).

Population aging also puts high pressure on the social security systems and in many

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countries, there is a need for structural reforms regarding the healthcare and pension systems. Such a comparative analysis of the labor tax wedge is useful from the perspective of the reforms that should be adopted, contributing to a better understanding of these economic aspects.

On the other hand, countries with a high tax wedge may face labor migration to countries where taxation is more relaxed and where employment is supported. For this reason, it is important to know the essential aspects related to the tax wedge and to find strategies to increase the labor force participation rate. Therefore, the analysis related to the labor tax wedge can provide important information for political decision-makers and researchers in the economic field, helping to improve tax systems and increase the employment rate.

There are a number of studies that analyze the correlation between the tax wedge, the unemployment rate, or the employment rate, for OECD or EU countries. Our study enriches the existing literature on the tax burden on labor. The main contribution of this study to the literature lies in the refined methodology which reveals the tax wedge's impact on unemployment and employment. We investigated the impact of the tax wedge on the unemployment and employment rate in recent years, in OECD countries, using cluster analysis, panel linear regression, and quantile linear regression.

Our study also concentrates on the tax wedge in Romania, which is part of the model-derived cluster consisting mainly of Central and Eastern European countries, for which a positive correlation between the tax wedge and the unemployment rate is established, in that high tax wedge tends to imply unemployment rate.

The article is structured as follows: Introduction, Literature review, then the third section shows the methodology used and the data source. The fourth and fifth section presents descriptive statistics and cluster analysis to confirm or deny the hypothesis of the relationship between the tax wedge, the unemployment and employment rate, discussing the results obtained. The last section highlights the conclusions of the paper.

2. Literature review

Income tax and social contributions have a significant role in the fiscal systems of many countries but with some implications for companies and employees. The tax burden on labor is called a tax wedge and actually represents the difference between the employer's total labor cost and the employee's net salary (Enache, 2021; Krtalić & Peruško, 2022). In many studies regarding the EU and OECD countries, the tax wedge is calculated as the sum between the income tax plus the social contributions of employers and employees, expressed as a percentage of total labor cost. It is seen as a very important tool of fiscal policy since an increase in the tax wedge will lead

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to an increase in the labor cost for employers and implicitly in unemployment (Durovic-Todorovic et al., 2018).

In a number of studies, the impact of labor taxation on the employment or unemployment rate has been investigated using cluster analysis or regression, for the EU or OECD countries (Daveri & Tabellini, 2000; Dolenc & Vodopivec, 2005; Šeparović, 2009; Grdović Gnip, & Tomić, 2010; Dolenc & Laporsek, 2010; Cristescu et al., 2016; Zimčik, 2017; Đurović-Todorović et al., 2018; Bakirtas, 2018; Kalaš et al., 2022).

Dolenc & Laporsek (2010) highlighted a negative relationship between the tax wedge and employment, but it is suggested that the impact on employment depends on the institutional characteristics of the individual labor markets. Thus, the results of the panel for the EU countries revealed that increasing the tax wedge by one percentage point leads to a decrease in employment growth by 0.05 percentage points. Zimčik (2017) investigated the negative effect of high taxation on the labor market, highlighting the unfavorable impact on both labor demand and labor supply. He found from the econometric study for 26 OECD countries, that a ten percentage points decrease in the tax wedge would stimulate employment by 0.34 to 0.56 percentage points.

Then, according to Đurović-Todorović et al. (2018), the tax wedge negatively affects economic growth, making markets uncompetitive. Their empirical analysis also confirmed the positive correlation between the tax wedge and the unemployment rate. In order to increase the motivation of individuals to work, a fiscal environment that is favorable to economic growth is necessary, which can be ensured by lowering tax rates. Bakirtas (2018) argues that the tax wedge is an important factor in the increase of unemployment, especially among young people. On the one hand, the high cost of labor reduces the number of jobs and on the other hand, the high tax rates reduce the net wage. He showed that the tax wedge can explain 12% of youth unemployment, while inflation explains it around 8% and the economic growth rate around 4%.

Daveri & Tabellini (2000) drew attention to the dangers of high labor taxes. Thus, they suggested that an increase of 14 percentage points in the effective rate of labor taxation can lead to an increase of 4 percentage points in European unemployment. In addition, this is also associated with the decrease in the EU growth rate by around 0.4 percentage points per year.

Kalaš et al. (2022) carried out a study on a sample of 36 OECD countries, and after the panel analysis, they concluded that a 1% increase in the average tax wedge will lead to a lower employment rate of 0.33%. Therefore, in order to improve the employment rate, it is important to continue the process of reducing the tax wedge in OECD countries. This will support relaxation and stimulation of the labor market, but will also stimulate consumption.

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Cristescu et al. (2016) argued that the decrease in tax rates for personal income tax and social contributions led to more efficient use of labor and an increase in employment. At the same time, they emphasized the disruptive effect of labor taxation on the balance of demand and supply, with negative implications on growth and employment. Therefore, in order to stimulate economic performance and competitiveness, it is imperative to decrease the labor tax wedge in many EU countries.

Next, we present the results obtained by different authors who performed cluster analyses, identifying the presence of two or three clusters among the EU or OECD countries. These studies established the negative effect of the tax wedge on employment, in the analyzed countries.

Following the cluster analysis conducted for OECD countries, Dolenc & Vodopivec (2005) suggested that they can be grouped into two categories: the first cluster presents a high tax wedge, low employment rate and high unemployment rate, and the second group a low tax wedge, high employment rate and low unemployment. The authors highlighted that the EU countries had a higher labor tax wedge and higher unemployment rates than the other OECD countries.

Šeparović (2009) explored the correlation between the tax wedge and the unemployment rate, confirming the negative impact of the tax wedge on employment. The dendrogram of the cluster analysis highlights two clusters for the OECD countries: the first group is the one with a lower tax wedge and a lower unemployment rate, and the second group is the one with a higher tax wedge and a negative effect on unemployment. Also, Dolenc & Laporsek (2010), divided the EU countries into two groups: the first group characterized by higher unemployment, lower employment rate and higher tax wedge and the 2nd group with lower unemployment, higher employment rate and lower tax wedge. Grdović Gnip, & Tomić (2010) identified the presence of three clusters among EU countries. The first cluster includes the countries with an average tax wedge (18 countries, many are new EU member states), the second cluster has the countries with the highest tax wedge (7 countries), and the 3rd cluster consists of the countries with the lowest tax wedge (Ireland, Cyprus, Malta).

Đurović-Todorović et al. (2018) argued the presence of three clusters within the OECD countries, confirming the positive correlation between the tax wedge and the unemployment rate. Regarding the clusters found, the first and third clusters have similar characteristics and a more favorable economic environment than the second. The second cluster consists mainly of the EU countries (with a high tax wedge and high unemployment rates), the first cluster includes the countries with average performances, and the third cluster has the countries with the best performances.

Tax wedge and social contributions are seen as significant causes of unemployment and therefore they can be used as ways to combat unemployment (Öztürk & Üyesi,

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2021). At the same time, the tax wedge is a frequently analyzed indicator, due to its impact on investments, especially in the short term (Özker, 2020).

On average, a lower tax wedge tends to be associated with higher employment. Therefore, in countries characterized by a large gap between labor costs and net salary and a high level of unemployment, there is a need to adopt fiscal measures to reduce labor costs (Radu et al., 2018).

If the question of an optimal tax structure arises, it is important to identify from where and who will pay for that (Zimčík, 2017). The tax wedge is at the center of attention in the context of strategies to attract investments and increase competitiveness (Urban, 2016). A number of authors have identified that high labor costs are mainly responsible for the high rates of unemployment in many countries. In countries with a high tax burden, public services provided to individuals are more extensive. However, the cost of these services is considerable, representing over 50% of the average salary, and for many employees at least a third of their wage (Enache, 2021). The "fiscal bite" always hurts, but for EU countries the deepest bite occurs in old members, where the average gross wage is higher, while employees from the new member states are "bitten" less (Grdović Gnip, & Tomić, 2010).

Based on hierarchical clustering, Simková (2015) found that the new EU member states are mainly in the group with the lower tax burden, in order to encourage investors through more favorable taxation. Instead, in the second group there are mainly the old EU states, which offer extended social benefits to their citizens, financed by higher taxes. Stryzhak (2023) talks about a relationship between digitalization (linked to the level of economic development) and labor market indicators such as employment, labor force participation rate and unemployment.

According to Celikay (2020), there could be several reasons for increasing the tax burden, such as socioeconomic development, financial and organizational structure and the globalization process. However, reducing the labor tax wedge is recommended in many European countries where tax rates are high and productivity is low. Festa (2015) argues that the more elastic the labor supply curve, the more negative the impact of the tax wedge on the labor market and productivity.

Also, Sabău-Popa et al. (2011) pointed out that the high level of tax wedge in the EU is one of the main causes of the poor employment performance in these countries. At the same time, the increase of the tax wedge will have a stronger negative impact in the case of individuals with a low level of qualification or young people. Behar (2009) identified countries with poor results on the labor market, classifying them as generous (e.g. Bulgaria) and austere (Romania), from the point of view of the benefit systems granted.

As expected, it is appreciated that the reduction of the tax wedge is beneficial, leading to a decrease in unemployment, an increase in employment and competitiveness. Thus, employers will be motivated to create new jobs, and also

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people's willingness to work will increase (Dolenc & Laporsek, 2010). Due to high unemployment rates in the EU countries, it is recommended to continue moving taxation from labor to other sources of taxation, which would boost the creation of new jobs. Thus, the reduction of the tax wedge can be compensated, for instance, by increasing the consumption tax on immovable property, the pollution tax or by decreasing public spending (Cristescu et al., 2016).

Other authors also discuss the need to reduce the tax wedge, as a way to improve the performance of the labor market. Thus, Sabău-Popa et al. (2011) talked about a relaxation of labor taxation by transferring the fiscal burden from labor to property or energy taxation. Then Kalaš et al. (2022) argued that lowering the tax wedge can be compensated by increasing indirect taxes and property taxes. According to Attinasi et al. (2016), the decrease of tax wedge obtained by increasing consumption taxes has the most favorable effects on production, while the measure of reducing government spending contributes more to the increase of welfare. Krtalić & Peruško (2022) suggested that lowering labor taxes would require the introduction of new forms of taxes or significant structural reforms within the pension and health systems. These points of view are also supported by Stähler (2019), who argues the need to transfer the fiscal burden from direct taxation to consumption taxation, which is less distortive. Another way would consist of the transfer to higher wealth taxes. Deskar-Škrbić et al. (2018) concluded that the elements of the tax system that produce the highest distortions must be identified and minimized. As a recommendation, they insist on reducing the overall fiscal burden, but especially the fiscal burden on labor, by transferring it to other forms of taxes with a wider taxable base (e.g. consumption taxes). Social contributions are primarily targeted, their reduction leading to increased flexibility in the labor market. But such a measure should be supported by structural reforms in the pension, health and social security systems.

3. Methodology and data

Having the purpose of analyzing the interdependence between the tax wedge, unemployment rate and employment rate, we use the following methods: descriptive analysis, cluster analysis, panel linear regression, and quantile linear regression. Based on the descriptive analysis, we make a comparison between the tax wedge levels in the OECD countries. Next, we focus on the relationship between the tax wedge and the unemployment rate, respectively the employment rate in the OECD countries, using hierarchical cluster analysis. The goal is to find similarities between different countries regarding the tax wedge, unemployment rate and employment rate. After performing this analysis, we will obtain a dendrogram, meaning a graph that highlights the hierarchical cluster tree.

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The data used for the analysis of the tax wedge in the OECD countries are the annual data from OECD statistics (stats.oecd.org). We also used data from the OECD (2024) Employment rate (indicator) and OECD (2024) Unemployment rate (indicator). Then the data for Romania are from the EU database (European Commission, <http://europa.eu>). We specify that the data used for the tax wedge correspond to a single employee with an average wage (a single person with 100% of the income of an AW-average worker). Also, to perform the hierarchical cluster analysis, we used the data for 37 OECD countries, for the period 2020-2022.

4. Results

4.1. Descriptive analysis

In the beginning, we highlight the level of the tax wedge, the unemployment rate and the employment rate in OECD countries, using simple descriptive statistics.

Figure 1 shows the level of the tax wedge, the unemployment and employment rate in the OECD countries (for 2022). As we can see, the level of the tax wedge varies a lot between the OECD countries, because there are big differences between them. This graph also includes the data for Romania, but only for comparison, as they are not included in the analysis for now (Romania is not an OECD country). The data for the tax wedge refer to a single employee with an average wage.

Thus, analyzing the data regarding the tax wedge, we found that the OECD countries with the highest level of tax wedge in 2022 are: Belgium (53%), Germany (47.9%), France (47%), Austria (46.8%), Italy (45.9%), and the OECD average of 34.6%. Then the countries with the lowest level of tax wedge are Chile (7%), New Zealand (20.1%), Mexico (20.4%), Switzerland (23.4%), Israel (23.6%) and Korea (24.2%). We noticed that in 2022 only Belgium had a tax wedge above 50%, then 12 OECD countries had a tax wedge above 40%, 16 countries had between 30-40% and 8 countries below 30%. We see that the level of the tax wedge is high, especially in the European countries. Among them, those with the lowest tax wedge are Switzerland, the UK, Iceland and Ireland.

The unemployment rate varies widely in OECD countries, from 2.4% in the Czech Republic to 12.9% in Spain. The OECD average was 5% in 2022. The employment rate varies from 52.8% in Türkiye to 83.3% in Iceland, the OECD average being 69.4%.

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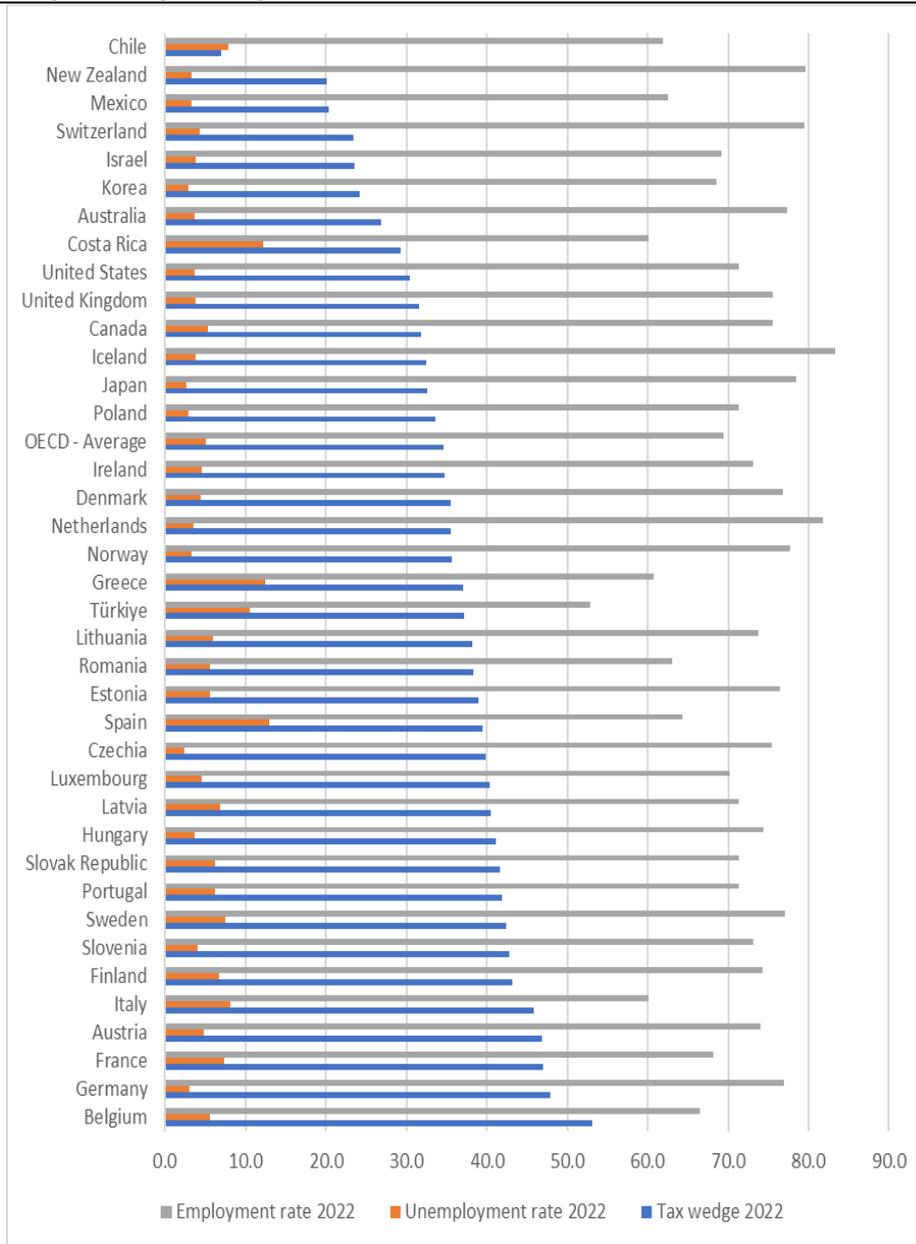


Figure 1 Total tax wedge on labor, unemployment rate and employment rate in OECD countries and Romania (in %), 2022 (for a single worker with average wage)
 Source: Own compilation.

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Figure 2 shows only the level of the tax wedge in OECD countries in 2022.

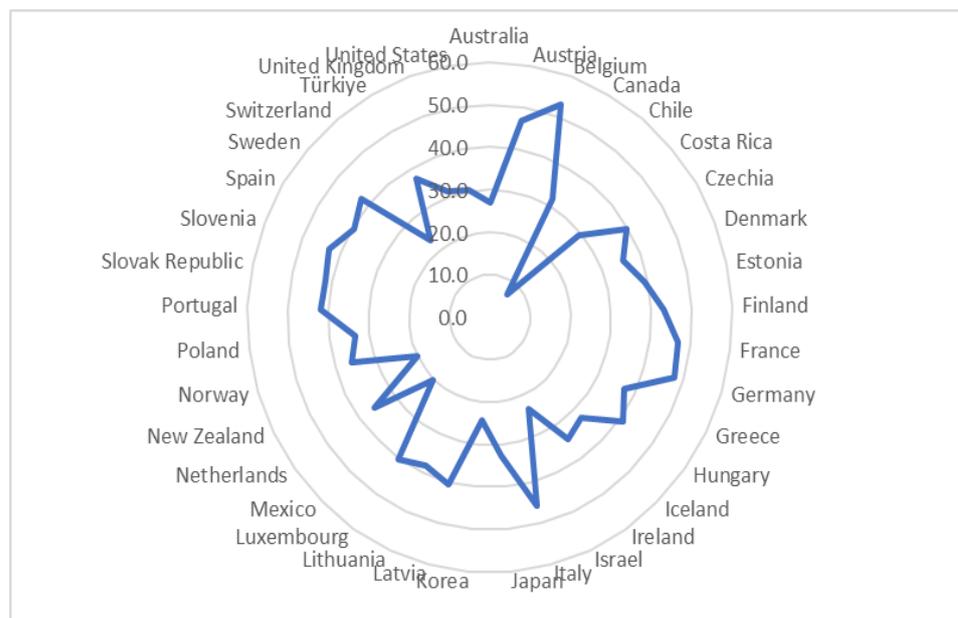


Figure 2 Tax wedge in OECD countries, 2022, (% of labor costs)

Source: Own compilation.

Figure 3 highlights the evolution of the tax wedge for the OECD countries with the highest level, over the period 2002-2022.

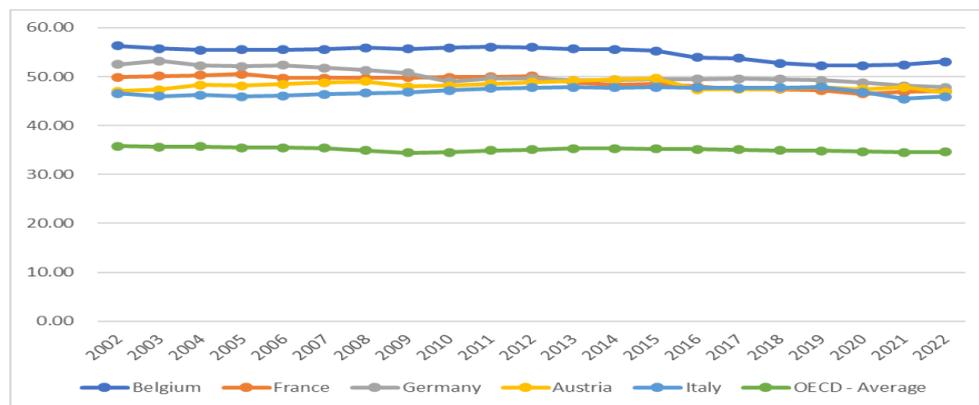


Figure 3 Evolution of tax wedge in OECD countries with the highest level, 2002-2022

Source: Own compilation.

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Then, Figure 4 highlights the evolution of the tax wedge for the OECD countries with the lowest level, over the period 2002-2022. We also specify that we have taken into account the data of the tax wedge for a single employee, having the average wage.

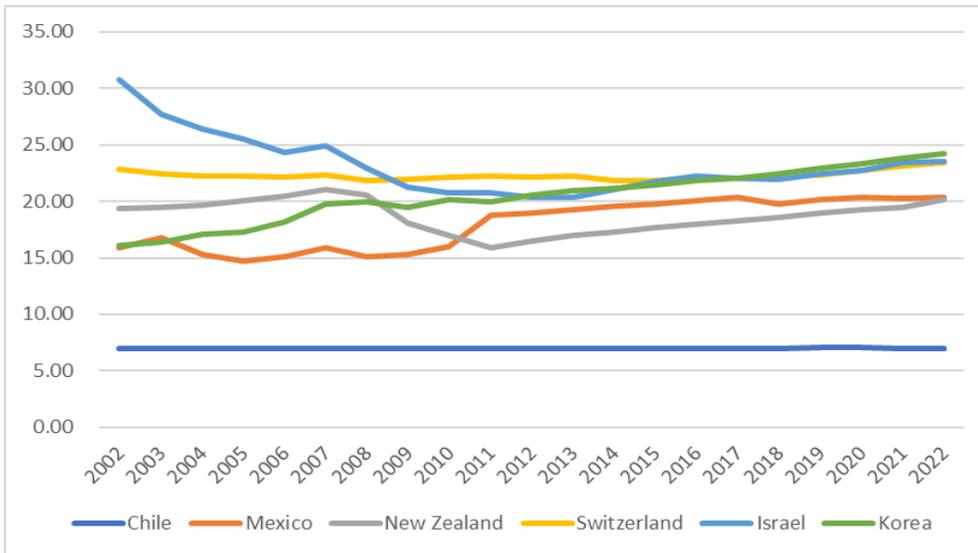


Figure 4 Evolution of tax wedge in OECD countries with the lowest level, 2002-2022
 Source: Own compilation.

We can see that in the countries with the highest level of tax wedge, it decreased slightly during the analyzed period, but the OECD average remained relatively constant, around 35%. Then in the countries with the lowest level, the tax wedge increased (except Israel) during the analyzed period. Only in Chile, the tax wedge has remained constant at 7%. As we said above, Belgium has the highest level of tax wedge, at 53%. This means that over 50% of labor cost represents the taxes paid to the state, for a single employee with an average income.

Next, we divide the OECD countries into three groups: the first includes countries with a low tax wedge: Chile, Korea, Mexico, New Zealand, Israel, Switzerland, Australia. In the second class are the countries with an average tax wedge: Canada, Costa Rica, Denmark, Estonia, Greece, Iceland, Ireland, Japan, Lithuania, Netherlands, Norway, Poland, Türkiye, the UK, USA. The third class has the countries with a high tax wedge: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Latvia, Luxembourg, Portugal, Slovakia, Slovenia, Sweden, Spain. We took the data for the year 2022.

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We then calculate the average tax wedge for each class, which is: 20.8; 34.3; 43.6. Also, the average unemployment rate for each class is: 4.3; 5.6; 6, and the average employment rate for each class is: 73; 72.6; and 71.2.

We calculated these average values for each class, both for the tax wedge and the unemployment and employment rates to see whether a lower tax wedge corresponds to a lower unemployment rate and a higher employment rate and vice versa. This will give us clues about the correlation between the tax wedge, unemployment rate and employment rate.

According to the calculations, we found that for the group of countries with a lower tax wedge, the unemployment rate is also lower (and the employment rate is higher), and for the group with a higher tax wedge, the unemployment rate is higher (and employment rate is lower). Therefore, we can conclude that the tax wedge, unemployment rate and employment rate are correlated. However, these results will have to be further confirmed by statistical analysis. The results are in accordance with the analysis made by Šeparović (2009) and Dolenc & Vodopivec (2005).

Figure 5 shows the average values of tax wedge, unemployment rate and employment rate, across the three groups of OECD countries for 2022.



Figure 5 Median values of the country classes, 2022

Source: Own compilation.

4.2 Data analysis and result interpretation

The goal of this work is to find relations between tax wedges (TW) and two records of employment, namely employment rate proper (Emp) and unemployment rate

(UnE), respectively. All three variables were observed country-wise and have three-time stamps each, namely 2020-2022. Accordingly, the data can be analyzed for $N=37$ countries\{fn: a country was deleted due to NA entries\} with nine variables each (representation A) which reads for one line j

Country j || TW20 TW21 TW22 | UnE2020 UnE21 UnE22 | Emp20 Emp21 Emp22

or by using a panel-like representation (representation B) as is for three consecutive lines $i, i+1, i+2$

i || Country j Year :2020 | TW20 UnE21 Emp20
 $i+1$ || Country j Year :2021 | TW21 UnE21 Emp21
 $i+2$ || Country j Year :2022 | TW22 UnE22 Emp22

resulting in $3N$ line entries, hence many more cases. While the panel-like representation B of the data seems more natural at first, a panel-based linear model (using R-package plm), regressing employment variables against tax-wedge, using index variables "Country" and "Year", does not show any significant results (down to any usual significance levels, hence we omit to show results). Furthermore, just a negligible change occurs when switching from fixed effects (the within case) to random effects (useful for, e.g., detecting inter-country dependencies). We also note that here, the more sophisticated, panel-based approach does not yield any more information than a simple linear regression. This indicates that no reliable relation is present for the entire data over all countries and all years.

As both theory and domain knowledge suggest that the relation between our variables should not be exactly random, specific reasons for the observed indeterminacy may be sought. Apart from the sparsity of the data, which does overshadow any such statistical analysis, two directions may be pursued, namely:

(1) The data may hide some multi-dependence or non-linearity in the relations between variables. Such situations may reveal themselves by applying quantile (linear) regression.

(2) Determining country clusters found by grouping countries according to similarities present in the entire data. This would then result in cluster-wise (linear) regressions.

Owing to further data subdivisions, namely (1) less data producing a given quantile output, and (2) less data contained in each cluster, these approaches should be treated with extreme care. In addition, anything above linear models is certainly not justified on this still more reduced data sets.

Quantile regression

It is straightforward to use data representation B in order to conduct quantile regression. Here, the cumulative probability distribution of observing outputs in a certain range reversely implies considering the inputs that produce these results. One may subdivide the probability range itself into two or more consecutive non-overlapping intervals or quantiles within (0,1) resulting in models which may differ in a more or less significant way. The influence of outliers is hence decoupled from most models, especially if using many quantiles. However, for sparse data like ours one must sharply constrain the number of quantiles. We use the R-package *quantreg* in order to fit four linear regression models on the data implied respectively by prespecified quantiles.

Figure 6 depicts the results of multiple linear quantile regressions as indicated above. Here we use the 0.2, 0.4, 0.6, and 0.8 quantiles (shown on the horizontal axes of the insets) in order to fit models on the data implied by these quantiles. The values on the vertical axes indicate the numerical value of the intercepts, and, respectively, the coefficients of the tax wedge. Hence, four linear models are fitted with coefficient values at the inflection points of the curves. The (rather fat) shaded corridors indicate zones of uncertainty. One observes four different linear models for the different input data implied by the quantiles which indicate a multi-relationship between tax-wedge and (un-)employment rates. Owing to data sparseness (and the resulting fat corridors) this does not translate into statistically significant results. Hence, here we also refrain from reporting the summary statistics. From these results, one may retain that different levels or regimes of (un-)employment depend differently on the tax wedge. This in turn motivates a country-based grouping of data which may reflect these differences in a more amenable way.

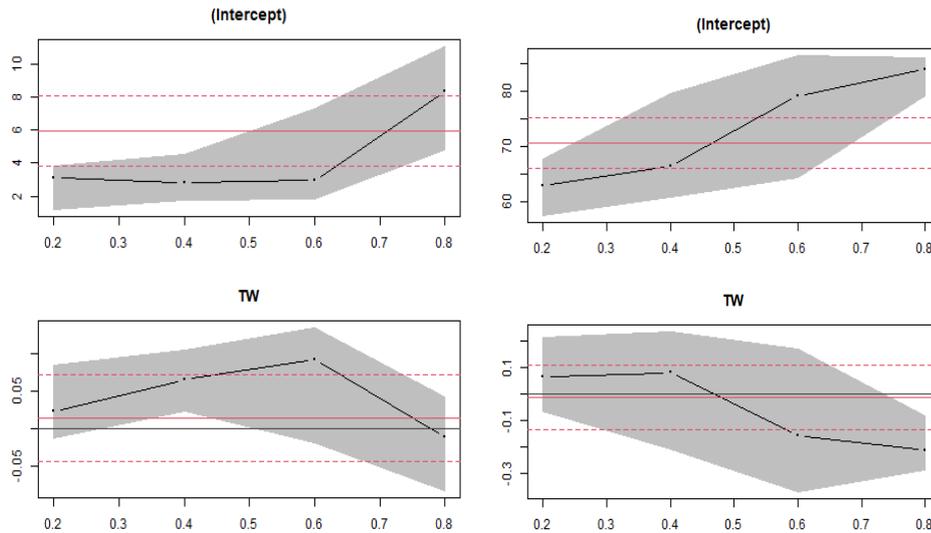


Figure 6 Quantile linear regressions. Left column: models for tax wedge explaining unemployment. Right column: models for tax wedge explaining employment. Source: own computation using R software.

Clustering the data

We now consider the information packaged in representation A in order to hard-cluster countries, thus hopefully obtaining some meaningful exclusive country groups, which may allow the detection of some statistically more significant relations as in the previous analyses. Again, data sparsity demands extended analyses in order to improve confidence in models. Clustering can be done in many meaningful ways, using alternative similarity measures between cases (observations) as well as alternative linkage methods best suited to applications (Jain (2010), von Luxburg et al. (2012)), especially so if data sets contain a large number of observations. Here we restrict ourselves to a few hierarchical and centroid models, and where each country always belongs to exactly one cluster. We probe five hierarchical clustering linkages, namely complete, single, average, centroid and ward.D2, using Euclidean distance as a similarity measure. In addition, we use k-means and k-medoid as representatives for centroid methods. We also restrict the number of clusters $k < N$ to $k = 3, 4$ as our data do not justify a larger cluster number, both (1) technically but also (2) based on reasonable country groupings based on our data. Before reporting on the comparative clusterings, looking at data representation

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A conveys information about why (global) linear regression and (global) panel linear regression cannot reveal any significant relations between the variables.

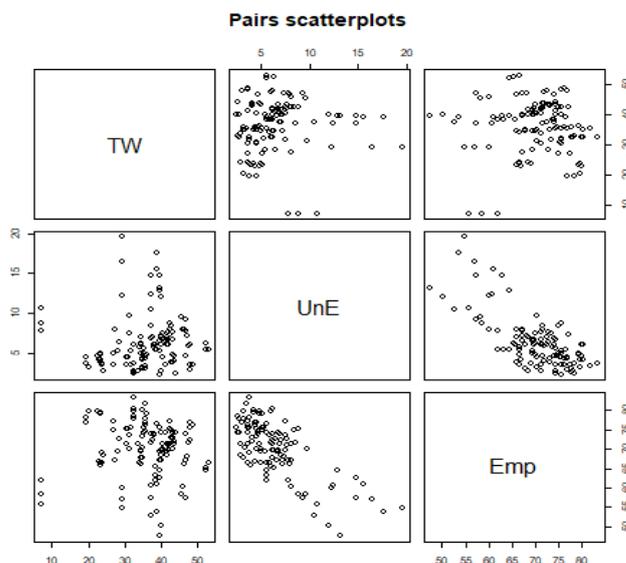


Figure 7 Scatterplots of pair-wise variable contra-positioning

Source: own computation using R software.

The scatterplots from Figure 7 do partially (rather qualitatively) explain some reasons for the indeterminacy in the relations of the variables from the entire data set: No functional dependence is visible which is also indicated by the inconclusive results of panel regressions reported above. The picture is also obscured by various "outliers" which seem to be responsible for the weak or low confidence structure of conventional regression (also supported by the above different quantile regression models).

The comparative grouping (clustering) of countries may lead to a way out of indeterminacy. Table 1 gives the country groups resulting from the imposed number of clusters, $k=3$. The number in front of the country names refers to cluster membership and the column to the linkage method.

Table 1 Country grouping according to seven alternative linkage procedures. The dashed lines "----" indicate the end of a respective cluster. Countries are named by the ISO 3166 international standard of three-letter codes from <https://www.iban.com/country-codes>

complete	single	average	centroid	ward.D2	3-means	3-medoids
1 AUS	1 AUS	1 AUS				
1 CND	1 AUT	1 AUT	1 AUT	1 CND	1 CND	1 CND
1 DNK	1 BEL	1 BEL	1 BEL	1 DNK	1 CHL	1 DNK
1 ISL	1 CND	1 CND	1 CND	1 EST	1 ISR	1 ISL
1 ISR	1 CZE	1 CZE	1 CZE	1 ISL	1 KOR	1 ISR
1 JPN	1 DNK	1 DNK	1 DNK	1 IRL	1 NZL	1 JPN
1 KOR	1 EST	1 EST	1 EST	1 ISR	1 CHE	1 KOR
1 NLD	1 FIN	1 FIN	1 FIN	1 JPN	1 GBR	1 NLD
1 NZL	1 FRA	1 FRA	1 FRA	1 KOR	1 USA----	1 NZL
1 NOR	1 DEU	1 DEU	1 DEU	1 LIT	2 AUT	1 NOR
1 CHE	1 HUN	1 HUN	1 HUN	1 NLD	2 BEL	1 POL
1 GBR	1 ISL	1 ISL	1 ISL	1 NZL	2 CZE	1 CHE
1 USA----	1 IRL	1 IRL	1 IRL	1 NOR	2 DNK	1 GBR
2 AUT	1 ISR	1 ISR	1 ISR	1 POL	2 EST	1 USA----
2 BEL	1 ITA	1 ITA	1 ITA	1 CHE	2 FIN	2 AUT
2 CRI	1 JPN	1 JPN	1 JPN	1 GBR	2 FRA	2 BEL
2 CZE	1 KOR	1 KOR	1 KOR	1 USA	2 DEU	2 CZE
2 EST	1 LTV	1 LTV	1 LTV	1 OECD.av--2	HUN	2 EST
2 FIN	1 LIT	1 LIT	1 LIT	2 AUT	2 ISL	2 FIN
2 FRA	1 LUX	1 LUX	1 LUX	2 BEL	2 IRL	2 FRA
2 DEU	1 NLD	1 NLD	1 NLD	2 CZE	2 JPN	2 DEU
2 GRC	1 NZL	1 NZL	1 NZL	2 FIN	2 LTV	2 HUN
2 HUN	1 NOR	1 NOR	1 NOR	2 FRA	2 LIT	2 IRL
2 IRL	1 POL	1 POL	1 POL	2 DEU	2 LUX	2 LTV
2 ITA	1 PRT	1 PRT	1 PRT	2 HUN	2 NLD	2 LIT
2 LTV	1 SVK	1 SVK	1 SVK	2 ITA	2 NOR	2 LUX
2 LIT	1 SVN	1 SVN	1 SVN	2 LTV	2 POL	2 PRT
2 LUX	1 SWE	1 SWE	1 SWE	2 LUX	2 PRT	2 SVK
2 POL	1 CHE	1 CHE	1 CHE	2 PRT	2 SVK	2 SVN
2 PRT	1 GBR	1 GBR	1 GBR	2 SVK	2 SVN	2 SWE
2 SVK	1 USA	1 USA	1 USA	2 SVN	2 SWE	2 EU-27
2 SVN	1 EU-27	1 EU-27	1 EU-27	2 SWE	2 EU-27	2 OECD.av
2 ESP	1 OECD.av	1 OECD.av	1 OECD.av	2 EU-27	2 OECD.av	2 ROU----
2 SWE	1 ROU----	1 ROU----	1 ROU----	2 ROU----	2 ROU----	3 CHL
2 TUR	2 CHL----	2 CHL----	2 CHL----	3 CHL----	3 CRI	3 CRI
2 EU-27	3 CRI	3 CRI	3 CRI	3 CRI	3 GRC	3 GRC
2 OECD.av	3 GRC	3 GRC	3 GRC	3 GRC	3 ITA	3 ITA
2 ROU----	3 ESP	3 ESP	3 ESP	3 ESP	3 ESP	3 ESP
3 CHL	3 TUR	3 TUR	3 TUR	3 TUR	3 TUR	3 TUR

Source: own computation using R software.

Table 1 shows quite substantial genuine variation in the country-cluster assignments, accounting for cases where clusters differ by naming and not by content (in the sense that cluster 2 of method j may correspond to cluster 3 of method k, hence they have the same content). Hierarchical clusterings single, average, and centroid do have unreasonably big clusters labeled "1". Hierarchical clusterings complete and ward.D2 as well as clusters resulting from k-means and k-medoid do lead to potentially more useful country groupings. Which one should then be effectively used for cluster-wise linear regression?

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An answer to this question can be given by (1) internal validation and (2) by validating stability. These procedures essentially test clustering methods by iteratively leaving out one of the variables and by simultaneously considering changes in clusterings for a range of cluster numbers $k=2,3,\dots$ with $k < N$. The R-package `clValid` provides the technical means for such a test.

In the sequel we depict the summary statistics for internal and stability validation of three cluster methods for our data called hierarchical, kmeans and pam (as to be used in the named software), which turns out to be precisely our linkage methods complete, k-means and k-medoid from table X.1.

Table 2 Internal validation of the three selected clustering methods

Clustering Methods:		hierarchical kmeans pam				
Cluster sizes:		2 3 4 5 6				
Validation Measures:						
		2	3	4	5	6
hierarchical	Connectivity	2.9290	9.3726	17.0746	22.4893	23.7254
	Dunn	0.5414	0.2599	0.2267	0.2752	0.2752
kmeans	Silhouette	0.5535	0.3909	0.3513	0.2940	0.2906
	Connectivity	14.9397	21.6194	18.4036	29.0579	33.9063
pam	Dunn	0.1039	0.1569	0.1736	0.1914	0.1736
	Silhouette	0.3518	0.3643	0.3707	0.2929	0.2977
pam	Connectivity	11.5123	17.8393	27.0139	30.4405	32.1905
	Dunn	0.0747	0.0747	0.1007	0.1347	0.1736
	Silhouette	0.3305	0.3542	0.3116	0.2890	0.2989
Optimal Scores:						
	Score	Method	Clusters			
Connectivity	2.9290	hierarchical	2			
Dunn	0.5414	hierarchical	2			
Silhouette	0.5535	hierarchical	2			

Source: own computation using R software.

We relegate the meaning of the validation measures from Table 2 to the Appendix. Important here is to note that the first measure is to be minimized while the following two are to be maximized.

Table 3 Stability validation of the three selected clustering methods

Clustering Methods:		hierarchical kmeans pam				
Cluster sizes:		2 3 4 5 6				
Validation Measures:						

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		2	3	4	5	6
hierarchical	APN	0.0000	0.0818	0.1538	0.1741	0.1955
	AD	22.2475	19.6130	16.6221	14.7658	14.3074
	ADM	0.0000	3.0001	4.2683	4.3163	4.9542
	FOM	5.8922	5.2199	4.2145	3.8770	3.8731
kmeans	APN	0.1026	0.0800	0.1130	0.1713	0.2185
	AD	20.7721	17.3923	14.4962	13.6359	12.8052
	ADM	4.1625	3.8652	3.2088	4.0497	5.7765
	FOM	6.0726	4.7317	3.8590	3.8321	3.7701
pam	APN	0.0933	0.1545	0.0947	0.2055	0.2208
	AD	20.8532	17.3004	14.0536	13.9275	12.5528
	ADM	5.3666	5.0721	2.5331	4.8144	4.4389
	FOM	6.1696	4.9706	4.1264	3.6821	3.5579

Optimal Scores:		
Score	Method	Clusters
APN 0.0000	hierarchical	2
AD 12.5528	pam	6
ADM 0.0000	hierarchical	2
FOM 3.5579	pam	6

Source: own computation using R software.

Here again, we relegate the meaning of the stability measures from Table 3 to the Appendix. Important here is to note that all three are to be minimized. Tables 2 and 3 indicate that for our acceptable cluster number range (<4) hierarchical clustering with complete linkage is to be preferred. Figure 8 depicts the hierarchical cluster tree for our data representation A. Using a cutoff at 50 two essential clusters (except Chile) are obtained. The data points from these two clusters are then used for two linear regression models. To this end we choose the formulas ($t = 2022$; here we suppress writing the intercepts and coefficients)

$$UnE(t) \leftarrow TW(t) + TW(t-1) + TW(t-2) \quad \text{and} \quad UnE(t) \leftarrow TW(t) + TW(t-1) + TW(t-2)$$

Thus, allowing to potentially capture time-lagged influences as well.

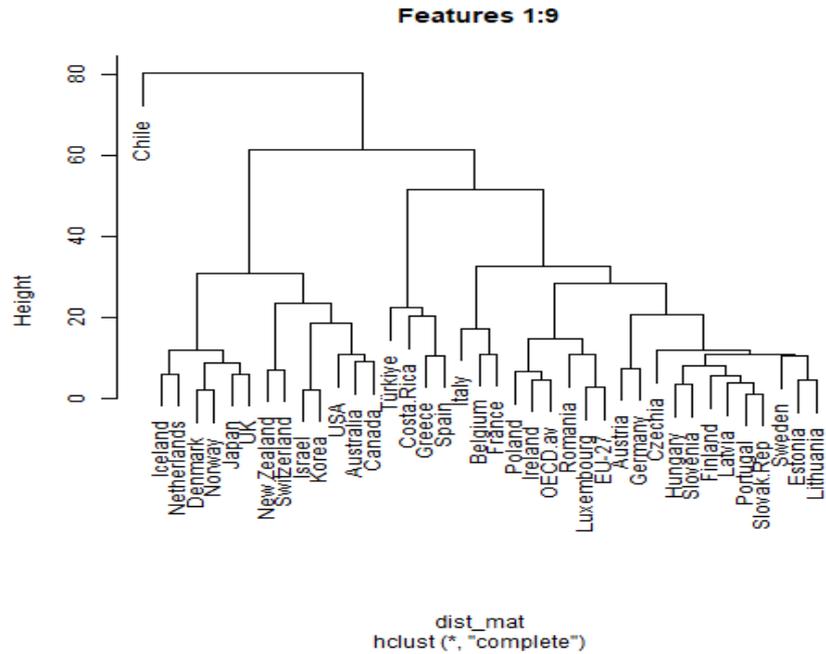


Figure 8 Dendrogram for clustering representation A of the data.

Source: own computation using R software.

Finally, the two cluster-wise linear regression statistical summary results are depicted in Tables 4 and 5. Table 4 reveals a barely significant intercept with the remaining coefficients unreliable.

Table 4 Summary statistics for model on country cluster 1 for unemployment

Call: <code>lm(formula = UnE22 ~ TW20 + TW21 + TW22, data = XD_C1)</code>				
Residuals:				
Min	1Q	Median	3Q	Max
-1.23345	-0.17817	0.01337	0.30318	1.43733
Coefficients:				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.9769	1.3473	2.210	0.0545.
TW20	-0.2541	0.4173	-0.609	0.5577

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TW21	0.3952	0.7538	0.524	0.6128
TW22	-0.1146	0.4407	-0.260	0.8006

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 0.7835 on 9 degrees of freedom				
Multiple R-squared: 0.0563, Adjusted R-squared: -0.2583				
F-statistic: 0.179 on 3 and 9 DF, p-value: 0.908				

Source: own computation using R software.

Table 5 Summary statistics for model on country cluster 2 for unemployment

Call: lm(formula = UnE22 ~ TW20 + TW21 + TW22, data = XD_C2)				
Residuals:				
Min	1Q	Median	3Q	Max
-2.36014	-0.87380	0.00426	0.71814	2.21193
Coefficients:				
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	2.4891	2.7169	0.916	0.3724
TW20	-0.2984	0.2707	-1.102	0.2857
TW21	-0.7646	0.5490	-1.393	0.1817
TW22	1.1352	0.4483	2.532	0.0215 *

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Residual standard error: 1.366 on 17 degrees of freedom				
Multiple R-squared: 0.352, Adjusted R-squared: 0.2377				
F-statistic: 3.078 on 3 and 17 DF, p-value: 0.05554				

Source: own computation using R software.

Table 5 shows an acceptably significant positive effect of the actual tax wedge on actual unemployment for country group 2 which contains most of the Central and Eastern European countries. Overall, the model is also a much better fit than the model for country group 1.

Interestingly enough, not the same situation occurs in the case of tax-wedge influencing employment. In Tables 6 and 7 we find that the intercept is highly significant, while the influence of tax-wedge changes tends to cancel out over the

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considered period, albeit in different ways regarding the contribution of time-indexed tax wedges.

Table 6 Summary statistics for model on country cluster 1 for employment

```

Call: lm(formula = Emp22 ~ TW20 + TW21 + TW22, data = XD_C1)

Residuals:
    Min     1Q   Median     3Q      Max
-5.7316 -1.6222 -0.3384  1.2493  5.4716

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 72.48750   7.04152  10.294 2.81e-06 ***
TW20         3.69530   2.18087   1.694  0.124
TW21        -3.64802   3.93981  -0.926  0.379
TW22         0.09768   2.30303   0.042  0.967
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.095 on 9 degrees of freedom
Multiple R-squared:  0.3838,    Adjusted R-squared:  0.1784
F-statistic: 1.869 on 3 and 9 DF, p-value: 0.2053
    
```

Source: own computation using R software.

Table 7 Summary statistics for model on country cluster 2 for employment

```

Call: lm(formula = Emp22 ~ TW20 + TW21 + TW22, data = XD_C2)

Residuals:
    Min     1Q   Median     3Q      Max
-9.6217 -2.5497  0.1679  2.7341  5.9823

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 75.8321   8.9396   8.483 1.63e-07 ***
TW20        -0.2552   0.8907  -0.286  0.778
TW21         1.9561   1.8065   1.083  0.294
TW22        -1.8075   1.4752  -1.225  0.237
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
    
```

Residual standard error: 4.495 on 17 degrees of freedom
 Multiple R-squared: 0.09197, Adjusted R-squared: -0.06827
 F-statistic: 0.574 on 3 and 17 DF, p-value: 0.6398

Source: own computation using R software.

The statistically most reliable model is reported in Table 5 followed by that of Table 6 and ending with those depicted in Table 7 and finally in Table 4. Overall, one may recall from this cluster-wise linear regression that (a) there is a positive relationship between tax-wedge and unemployment in countries from cluster 2 and (b) that there is marked asymmetry between and within country groups and (un-)employment types. Hence this is still another feature of the data different from that potentially uncovered by quantile regression. So, for the data on which the statistical analysis is based, the result is more differentiated.

5. Discussion

Our paper aimed to study the relationship between the tax wedge, unemployment rate and employment rate in the OECD countries.

A clear effect in the initial sense that we proposed to identify is shown only for the influence of the tax wedge on unemployment and significant only for cluster 2 of countries (which includes Romania and most of the countries in Central-Eastern Europe). For countries in cluster 1 (which contains countries such as Australia, USA, etc.) there are no clear (statistically significant) effects for this direction of influence between variables. For the influence of the tax wedge on employment, we do not find significant effects for both clusters of countries.

We specify that following the hierarchical cluster analysis, we divided the countries into two large groups. The first cluster is characterized by a lower tax wedge, lower unemployment and a higher employment rate, including the countries: Iceland, Netherlands, Denmark, Norway, Japan, UK, New Zealand, Switzerland, Israel, Korea, USA, Australia and Canada. The second cluster is characterized by a higher tax wedge, higher unemployment and a lower employment rate and is formed by the countries: Turkey, Costa Rica, Greece, Spain, Italy, Belgium, France, Poland, Ireland, Romania, Luxembourg, Austria, Germany, Czech Republic, Hungary, Slovenia, Finland, Latvia, Portugal, Slovakia, Sweden, Estonia and Lithuania. We see that the second cluster mainly includes EU countries (with higher taxation), while in the first cluster we have mainly non-EU countries.

We mention that the research of Dolenc & Laporsek (2010) revealed a negative correlation between the tax wedge and employment growth, but this is stronger for the cluster of countries with a low tax wedge.

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The results that we obtained generally correspond to other studies that analyzed the EU or OECD countries. So, our findings are somewhat consistent with the results of Šeparović (2009). Our results are also in line to some extent with the research of Dolenc & Vodopivec (2005), Dolenc & Laporsek (2010) and Đurović-Todorović et al. (2018). These studies established the negative effect of the tax wedge both on employment and unemployment, in the analyzed countries. Therefore, they found the clusters corresponding to a high tax wedge and high unemployment rate (and low employment rate), respectively a low tax wedge and low unemployment rate (and also high employment rate).

6. Conclusions

Our study explores the relationship between the tax wedge, unemployment rate and employment rate on the labor market in a comparative framework, highlighting existing approaches in the OECD countries. There are considerable differences in the level of the tax wedge between OECD countries. Some countries practice stricter labor taxation, while other countries pursue strategies to reduce these taxes, precisely from the consideration of stimulating the employment rate in the labor market. Various previous studies have highlighted that the level of the tax wedge has an impact on employment decisions and the mobility of employees.

In this study, we aimed to investigate the link between the tax wedge, the unemployment and employment rate in the OECD countries. With this in mind, we used descriptive statistics, panel linear regression, quantile linear regression and hierarchical cluster analysis.

After analyzing the data related to the OECD countries, we observed that there is a positive correlation between the level of the tax wedge and the unemployment rate. Thus, in countries where the tax wedge is higher, the unemployment rate tends to be higher and vice versa. But this is verified especially for cluster 2, which includes Romania and most of the countries in Central-Eastern Europe.

Therefore, it is particularly important to adopt those fiscal measures that stimulate employment and have beneficial effects on the results of the labor market. Retraining programs are also necessary to reduce unemployment. These will support the mobility of employees, to facilitate the reinsertion of individuals into the labor market.

However, we should not overlook that besides the labor tax wedge, there are other factors responsible for the poor performance of the labor market. Here we can mention: the flexibility of labor markets, demographic pressures, some political and institutional factors, international developments, etc. (Radu et al., 2018).

To counteract the negative effects of unemployment and to increase employment in the labor market, it is necessary to adopt fiscal policies aimed at reducing the level of the tax wedge. For this purpose, lowering income tax and social contributions,

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together with boosting youth employment could be useful. Therefore, decreasing the tax wedge has beneficial effects on unemployment reduction, but at the same time, the impact of these measures on public finances should not be neglected. A balanced approach to fiscal policies is required, creating the premises for a beneficial economic environment for the labor market. However, these cannot be obtained without undertaking some structural reforms related to the health and pension systems.

Therefore, in order to solve the problem of unemployment in Romania and other countries where it has high levels, efforts should be made to reduce the tax wedge. This will allow lower labor costs for companies, which will positively boost both labor demand and supply. Thus, employees will be stimulated to find jobs, as a result of the increase in net wages, and employers will be willing to create new jobs because they will bear lower labor costs. Positive effects on productivity growth can also be achieved by establishing an appropriate salary level, that will boost employment.

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Author Contributions

Conceptualization and methodology: C.F.R. and K.B.S. Then C.F.R. and K.B.S. created the empirical database and managed the analysis and interpretations of the empirical results. K.B.S. performed the econometric analysis and software computation. C.F.R. and C.F. are responsible for the literature review section. Discussion and recommendations were made by C.F.R. and K.B.S. The conclusions section is constructed and agreed upon by all authors. C.F. managed the English supervision of the manuscript. All authors have read and agreed to the published version of the manuscript.

Disclosure Statement

The authors do not have any competing financial, professional, or personal interests from other parties.

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Appendix

This appendix provides information for cluster method validation from Datta and Datta (2003).

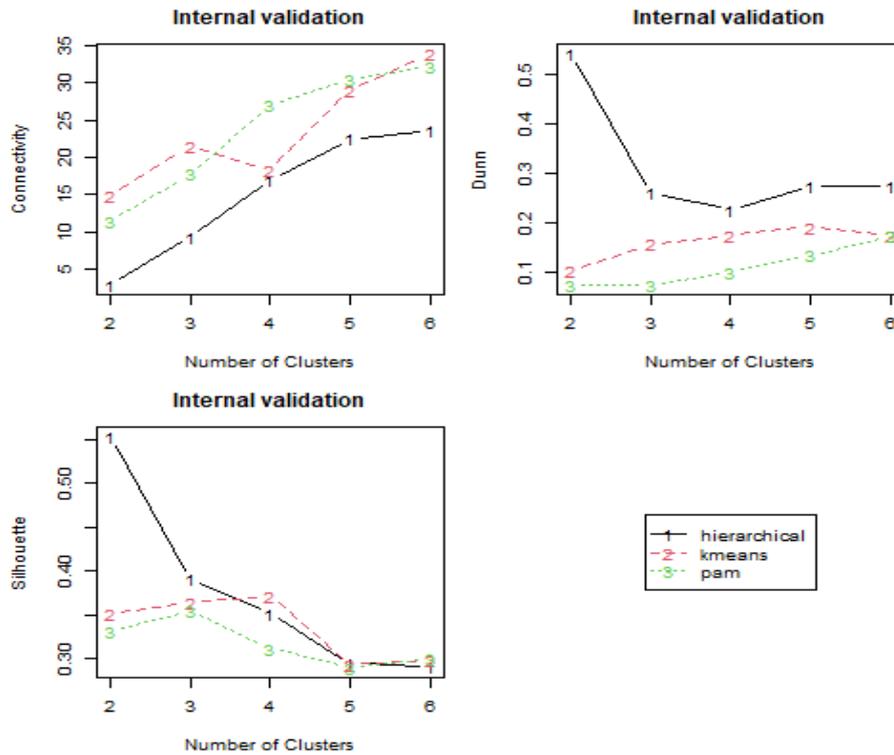
A1 On Internal Validation of Cluster Methods

To judge the merits of competing clustering methods for a given data set, one may start with internal cluster validation. The internal validation measures depicted in Table 2 are:

- (1) the **Connectivity**: to what extent observations are placed in the same cluster as their nearest neighbors in the data space,
- (2) the **Silhouette Width**: a non-linear combination of the compactness and separation within/between clusters, and
- (3) the **Dunn Index**: another non-linear combination of the compactness and separation within/between clusters.

In order to find out the best scores for the clustering methods, measure (1) should be minimized.

Measures (2) and (3) should be maximized.



Source: own computation using R software.

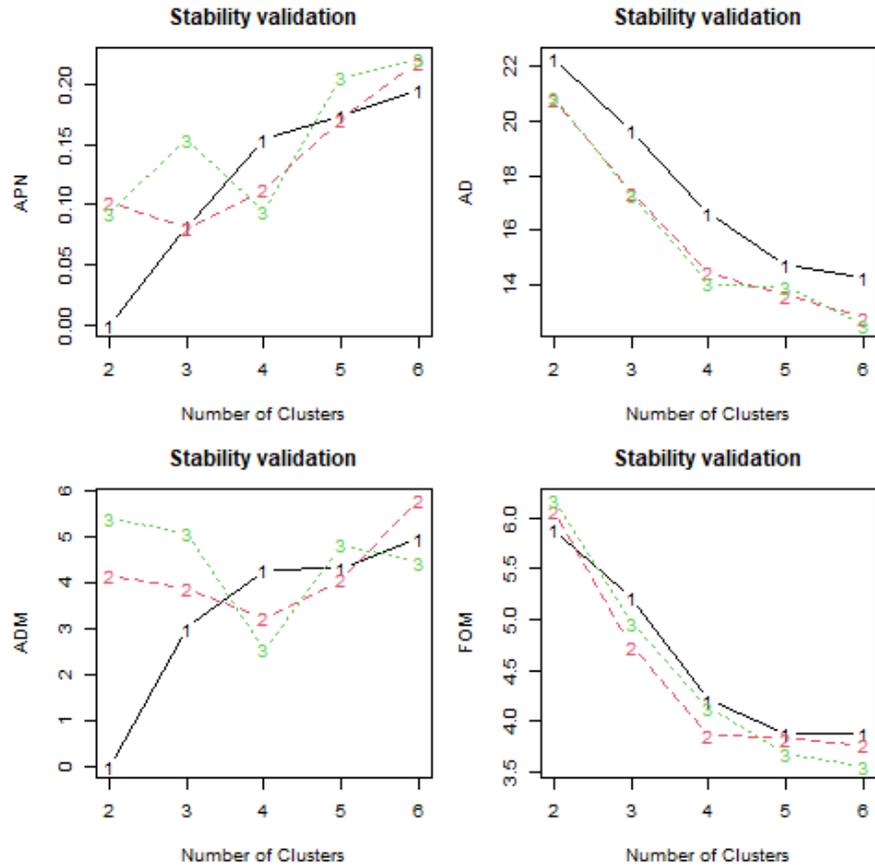
Appendix A.1: Stability validation for our data as summarized in table T3.

A2 On Stability Validation of Cluster Methods

Alternatively, or in addition to A.1, one may proceed with stability measures on clustering methods. These compare the results from clustering based on the full data (all variables) to clustering after removing columns, one at a time. The included measures from Table 3 are

- (1) the **average proportion of non-overlap (APN)**,
- (2) the **average distance (AD)**,
- (3) the **average distance between cluster centers (ADM)**, and
- (4) a **figure of merit (FOM)**

In all cases, the measures should be minimized.



Source: own computation using R software.

Appendix A.2: Stability validation for our data as summarized in Table 3.

Appendix A.1 and A.2 exemplify the evolution of the measures over the number of clusters evaluated.