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Contents

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Limitations of Two-Dimensional Indicators and unconstrained radial DEA models in Evaluating Judicial Efficiency: Insights from Poland's Appellate Court System

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Abstract

Motivation: Two-dimensional efficiency indicators provide only a narrow perspective on a system's functional efficiency, a limitation that is addressed by multidimensional methods such as the widely used Data Envelopment Analysis. However, the uncritical application of this class of methods—which appears to be a common practice in judicial efficiency research—can result in misleading conclusions regarding efficiencies of Decision-Making Units (DMUs).

Aim: The aim of this study is to evaluate the technical efficiency of Poland's appellate court system in the first two decades of the 21st century (years 2002-2021) using a constrained version of Data Envelopment Analysis (DEA) applied to time-series data. Unlike two-dimensional judicial performance indicators, such an approach facilitates a comprehensive assessment of the aggregated efficiency of the legal, administrative, procedural, organizational, and economic macro-frameworks—consistently implemented across all appellate courts—which collectively shape the system's performance during each year under review.

Results: The outcomes of this research show the fundamental shortcomings of classical applications of DEA, raising valid concerns about the reliability and interpretability of the outcomes derived from this approach. To mitigate these challenges, it presents a novel procedure specifically aimed at addressing these limitations in evaluating judicial efficiency, which is next successfully implemented.

Keywords: judicial efficiency, appellate court system, (un)constrained radial DEA models, disposition time

JEL: C44; C80; K19

1. Introduction

Ensuring careful management of public funds, reflected in the commitment to rational economic principles across all areas of the public sector, should be a genuine — not merely declarative — objective of every modern state. The well-being of contemporary societies increasingly depends on the quality and efficiency of public institutions. Although much of the impact of public initiatives cannot be directly monetized, this does not relieve governments from the responsibility to pursue objective valuation and assessment of public sector inputs and outcomes. Numerous methods are available to facilitate the objectivity of such efforts.

An efficient and independent general judiciary, as a critical component of the judicial system, significantly influences the quality of social, public, and economic life. It forms the backbone of democracy and a free-market economy, generating numerous positive externalities. Given the judiciary's pivotal role in the functioning of society and the state, it should operate as a particularly effective sector within the public sphere. Achieving high judicial efficiency, as well as the reforms needed to accomplish this, requires an accurate assessment of the prevailing trends and current state through objective quantitative analysis tools. However, in Poland, public, academic, and media discussions surrounding the state of the judiciary, evaluations of its past performance, and suggested directions for reform are often dominated by legalistic debates. These discussions frequently overlook or selectively reference basic, two-dimensional efficiency indicators published on the Ministry of Justice's website, particularly the widely referenced metric of average case processing time (Ostaszewski, ed., 2020).

The study in this paper is fundamentally quantitative, engaging with legal debates around judicial system reforms only insofar as these reforms have measurable effects on the efficiency of the appellate court system. The focus remains on how changes in the judiciary manifest in quantitative performance metrics, rather than on the qualitative discussions or policy argu-

ments driving possible reforms. This approach ensures that the analysis remains grounded in empirical data, directly assessing the impact of reforms on the operational effectiveness of the appellate courts.

The aim of this study is to estimate the technical efficiency of Poland's appellate court system over the 21st century, specifically from 2002 to 2021, by employing an adequate variant of Data Envelopment Analysis (DEA), the primary analytical tool for evaluating the efficiency of public sector entities (e.g., Banker et al., 2014; Data Envelopment Analysis in the Public Sector, 2014; Avkiran, 2015), including the judiciary (e.g., Voigt, 2016). This study's macro-level perspective enables a holistic evaluation of the effectiveness of systemic legal, administrative, procedural, organizational, and economic frameworks—uniformly applied across all appellate courts—that synergistically influence the operations of judicial entities and thereby shape overall systemic efficiency. Only through the use of time series data aggregated at the macro level is it feasible to assess the impact of these systemic determinants on efficiency. Such an approach allows for an examination of the years in which these solutions were relatively more or less effective, ultimately helping to identify possible underlying causes for these variations.

The research presented in this article builds on international studies in this field by spanning a 20-year period focused on a single object: the last-instance court system. This approach facilitates a deeper understanding of systemic efficiency. Furthermore, by treating system load as a non-discretionary input and employing a DEA variant that maximizes outputs, the study addresses concerns related to discretionary influences. Analysing the weight values obtained from the classic DEA model and applying constructive adjustments enhances the substantive interpretation of the results, ultimately providing valuable insights into the efficiency of Poland's appellate court system over time. These features contribute to the study's originality and practical significance.

The structure of this paper is organized as follows. The next section contains a review of the literature on DEA applications for assessing efficiency within the judiciary, addressing various perspectives and stakeholders. Subsequently, a concise overview of the DEA methodology is provided, along with a detailed description of the database and some initial descriptive observations. The main empirical findings are then presented, and the paper concludes with a summary of key insights.

2. Literature review

Efficiency is a fundamental concept and one of the most significant topics of research in economics. This is underscored by the assertion of some scholars that the pursuit of effective utilization of scarce resources is at the core of this discipline. E.g., according to Krajewski and Milewski (2018, p. 11),

economics: *...shows how people use scarce resources, how they use them to conduct economic activities, how they allocate them between different uses that compete with each other, and what guides them in making such choices. It also shows whether the use of scarce resources is efficient or not and analyses the factors on which this depends.*

Strategies aimed at enhancing the organizational efficiency of individual decision-making units can lead to low-cost or even cost-free improvements in the productivity of various public sector institutions, including the judiciary, once the extent of their inefficiency has been identified and comparable efficient models have been recognized. However, a critical prerequisite for the successful implementation of such measures is a thorough diagnosis of the current situation, which must take into account prevailing quantitative trends over the historical period.

Measuring efficiency in the public sector, particularly within the judiciary, presents a range of complex challenges that stem from the complexity of judicial functions, the diverse perspectives of stakeholders, and the qualitative dimensions of justice. To enhance effectiveness measurement, there is a need for a multifaceted approach that integrates both qualitative and quantitative indicators, respects judicial independence, and accounts for the diverse nature of judicial work. Developing such comprehensive frameworks is crucial for fostering a fair, efficient, and effective judicial system that meets the needs of society.

In the quest to measure effectiveness in the public sector, particularly within the judiciary, quantitative methods provide essential insights. Among these, traditional metrics such as case clearance rates, average processing times, and judicial workload analyses offer straightforward, yet very limited, perspectives on performance. However, advanced methodologies like Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) offer more sophisticated frameworks for assessing efficiency, presenting both advantages and limitations compared to conventional metrics.

Of the two afore-mentioned it is indisputably – as judged by literature review – DEA and it's modifications prevail in investigations into efficiency of public sector institutions. This is so due to its key features, such as the capacity to account for multiple inputs and outputs common to all decision-making units (DMUs) without requiring arbitrary assumptions about the production function. Furthermore, the optimization techniques employed in DEA favour each of the DMUs being analysed, which makes the methodology particularly advantageous from their standpoint. These characteristics have led to DEA's widespread use in evaluating the efficiency of various entities in the public sector (Banker et al., 2014; Data Envelopment Analysis in Public Sector, 2014; Avikran, 2015), including the judicial system.

Two-dimensional productivity and efficiency indicators, such as those available on the Ministry of Justice's website offer only a limited view of a sys-

tem's functional efficiency since they provide only a partial representation of its performance. Even among these two-dimensional metrics, those that focus on the 'final effects' of a system's activity (for instance, the commonly discussed indicators on the average duration of court proceedings) fall short of delivering an accurate measure of systemic efficiency because they fail to incorporate the relationship between outputs and inputs. Consequently, fluctuations in these indicators could signal either a shift in efficiency levels or simply reflect changes in the system's workload or burden.

Unlike all two-dimensional efficiency measures DEA enables estimation of overall, technical efficiency of homogeneous public sector institutions because it (i) takes into account the diversity of functions/tasks performed by the institutions, whereby it is not possible to objectively (monetarily) assess the importance/value of the performance of individual functions/tasks, (ii) takes into account the main factor inputs that serve to fulfil the functions/tasks entrusted to such institutions, (iii) needs no knowledge regarding the analytical form of the production function according to which factor inputs are transformed into the realisation of individual functions/tasks by the institutions analysed, i.e. into outputs, (d) offers the possibility of objectively assessing the degree of empirical efficiency achieved by individual institutions in comparison with other homogeneous institutions included in the sample.

When investigating judicial efficiency through DEA, several fundamental issues dictate its application and the interpretation of results. These issues encompass the subject of research (DMU), the scope of the investigation, and the data utilized. The research subject, the extent of the analysis, and the data can vary significantly, from micro-survey data relating to factors affecting judicial efficiency (e.g., Ostrom, Hanson, 2003; Schneider, 2005) to evaluations of selected first-instance courts in specific countries (e.g., Garcia-Riubio, Rosales-Lopez 2010; El Bialy, Garcia-Rubio 2011; Falavigna et al., 2015), as well as assessments of selected higher courts (e.g., Yeung, Azevedo 2011; Yeung, 2018). Some studies even attempt to analyse all first-instance courts over a selected period (e.g., Buonanno Galizzi 2014; Peyrache, Zago 2016; Mattsson, Tidana 2019) or higher courts (Gupta, Bolia 2020), and others explore international cross-sectional environments (e.g., Deynelli, 2012; Malcarne, Ramello 2015; Voigt S, El Bialy, 2016).

The selection of variables defining inputs varies widely in empirical studies. While the number of judges is almost always included as a "duty variable" (exceptions include Lewin et al., 1982 and Tulkens, 1993), other variables are often selected based on data availability. Along with the number of judges, DEA studies frequently consider variables such as the number of pending cases (caseload), which is often paired with the number of judges (e.g., Pedraja, Salinas 1996; Schneider 2005; Peyrache, Zago 2016; Mattsson, Tidana 2019), as well as the size of non-judicial staff (e.g., Kittelsen, Forsund 1992; Pedraja, Salinas 1996; Agrell et al., 2019), office and IT equipment, work-

space (e.g., El Bialy, Garcia-Rubio 2011; Yeung, Azevedo 2011; Agrell et al., 2019), and expenditures on court operations (e.g., Deynelli 2012). Notably, in the majority of DEA applications concerning the judiciary, the number of inputs considered simultaneously rarely exceeds three, with Peyrache and Zago (2016) serving as an exception.

When it comes to selecting outcome-defining variables, most empirical applications reviewed include an aggregate of cases resolved in a given year as their sole output factor. This presents a significant simplification, as it does not adequately account for the variation in litigation durations and labour inputs across different legal subjects. Such a homogenized approach raises concerns about the reliability of the efficiency scores derived from these broad aggregate results. Some exceptions to this generalization are found in studies like Kittelsen and Forsund (1992), which categorize cases by subject of law into seven categories, Tulkens (1993) with four categories, and Mattsson and Tidana (2019) and Agrell et al. (2019), which each utilize three categories, as well as Santos and Amado (2014), who provide a comprehensive breakdown into 43 categories.

The issue of non-discretionary variables in judicial efficiency analyses is often overlooked in DEA. While some researchers address the influence of such factors and external conditions in later stages of their analysis using two-stage DEA (2SDEA) (e.g., Schneider 2005; Falavigna et al., 2015), it is critical to recognize that the caseload variable—which aggregates backlog cases from previous periods with newly received cases—is inherently a non-discretionary variable. Consequently, DEA analyses should adopt either analytical variants that directly account for the presence of non-discretionary factors (Ruggiero, 1997; Muniz et al., 2006; Cordero-Ferrera et al., 2010) or use the output maximization version of DEA.

Regarding the choice of DEA version, the empirical literature predominantly employs the outcome-maximizing version of DEA, which aligns with the judiciary's operational specifics, particularly given the increasing demands placed on court systems in recent years. The only noted exception is Schneider (2005). In instances where a non-discretionary variable appears among the inputs (e.g., caseload), it can only be treated the same way as discretionary inputs if the chosen version of DEA is output-oriented (Dyson et al,. 2001; Cook et al., 2014).

In terms of scale returns, studies utilizing constant returns to scale (CRS) dominate the literature, while variable returns to scale (VRS) are employed when analysing the effect of court size on efficiency, as seen in the works of Garcia-Rubio, Rosales-Lopez (2010), El Bialy and Garcia-Rubio (2011), and Peyrache and Zago (2016). However, the selection between CRS and VRS tends to be somewhat arbitrary, resulting in ambiguous conclusions regarding scale effects within the judiciary.

The limited degree of discrimination in the performance indicators obtained—especially with a small number of DMUs and numerous inputs and outputs—often leads to a high percentage of efficient DMUs. To address this,

authors frequently resort to techniques aimed at enhancing the differentiation of efficiency indicators. One common method is the super-efficiency concept, introduced by Andersen and Petersen in (1993), to amplify the variation in efficiency among DMUs already deemed efficient through classic DEA. Classical super-efficiency (SE-DEA) models are constructed as radial extensions of the CCR or BCC models. This means that their objective function maximizes or minimizes the radial efficiency measure (input- or output-oriented), while slack variables do not appear in the objective function and are not active decision variables in the construction of rankings above one.

Furthermore, the reflection—or lack thereof—on the assessment of weights assigned to inputs and outputs, particularly the zero and unit weights, is a significant issue. To the author's knowledge, with the exception of a single study by Santos and Amado (2014), no other research has thoroughly investigated the substantive acceptability of the weights attributed to individual inputs and outputs. This lack of scrutiny raises doubts about the substantive validity of the obtained results.

Finally, all of the studies referenced above employed cross-sectional data to examine variations in the efficiency of individual courts within a single year of analysis. However, as noted by researchers such as Maital and Vaninsky (1999) and Avkiran (2015), DEA can also be used for longitudinal or time series data, applying it to a single entity—such as the entire court system at a particular judicial level—to track changes in efficiency over time. The prevalent use of DEA in the judiciary with cross-sectional data is likely due to limited access to time-series data at the necessary level of detail. Nonetheless, DEA still lacks a universally accepted framework for clearly separating temporal and cross-sectional effects in panel-data settings.

Empirical research on the efficiency of the Polish judiciary using Data Envelopment Analysis (DEA) remains relatively limited but has developed along a clear trajectory. The first systematic applications concerned entities within the justice sector rather than courts sensu stricto: Guzowska and Strąk (2010) analysed 45 public prosecutor regions, estimating technical and cost efficiency under CRS and VRS assumptions and identifying sizeable potential savings, thereby demonstrating the suitability of DEA for Polish justice-sector units. A subsequent milestone was Major (2015), who applied CCR-DEA to 26 district civil courts in the Kraków region, treating human resources as inputs and resolved cases as outputs, and showing scope for backlog reduction without additional resources, thus setting a reference framework for later court-level studies.

More recent work has both deepened and diversified the approach. Kapelko (2024) investigates Polish district courts nationwide for 2017–2021 using input- and output-specific DEA-based models, decomposing inefficiency by factors (judges, other staff) and types of cases, and showing strong heterogeneity across courts and a marked deterioration in 2020 linked to the COVID-19 shock. At the regional-court level, Świtłyk, Sompolska-Rzechuła

and Oesterreich (2025) estimate technical and scale efficiency of 43 regional courts (2015–2022) in separate civil, criminal and labour divisions, documenting generally high CCR scores but also persistent scale inefficiencies and size effects in civil divisions.

3. Methods and data

In economic terms, efficiency measurement typically involves assessing the relationship between multifarious inputs and outputs. When both all inputs and all outputs can be quantified in monetary terms, efficiency can be expressed using the following formula:

$$Efficiency = \frac{\sum_{o=1}^{O} p_o Y_o}{\sum_{i=1}^{I} p_i X_i} \tag{1}$$

Where:
Y_0 – volume of the *o-th* output,
X_i – volume of the *i-th* input,
p_0 – unit price of the *o-th* output,
p_i – unit price of the *i-th* input.

One such measure that is based directly on formula (1) and extensively used in economic and managerial analyses is the Benefit–Cost Ratio, which evaluates whether the aggregated monetary value of outputs exceeds the aggregated monetary value of inputs. Closely related is the well-known Return on Investment (ROI), which expresses the excess of benefits over costs relative to the total value of inputs and is routinely applied in corporate finance and performance evaluation. Both BCR and ROI have been widely employed in empirical research, for example in project appraisal in public infrastructure (Boardman et al. 2018) or in evaluating firm-level investment efficiency (Damodaran 2012).

This approach, however, is practically limited to economic agents operating within markets, where nearly all inputs and outputs are measurable in monetary terms. In public service provision, such as within the judiciary, this framework falls short, as most public sector activities cannot be valued monetarily. Nonetheless, the general formula holds if unit price parameters are appropriately replaced by weights that reflect the relative importance of each output produced by a public institution. The primary and most challenging issue lies in determining these weights accurately, leading directly to the relevance of Data Envelopment Analysis (Allen et al. 1997, Podinovski 2016).

The starting point of the classical DEA method (e.g., Panwar et al., 2022) is the following quotient of the weighted sum of outputs to the weighted sum of inputs, defining the technical efficiency of a given decision-making unit

(for ease of reading, the equivalents of general terms used in this study are provided in parentheses):

$$E_z = \frac{\sum_{t=1}^{T} w_{tz} Y_{tz}}{\sum_{s=1}^{S} v_{sz} X_{sz}} \tag{2}$$

E_z – technical efficiency of the *z-th* decision-making unit (efficiency of the appellate court system in each year of the 2002–2021 period);

$z = 1, 2 \ldots Z$ – index of the *z-th* decision-making unit (total Z =20, i.e. number of years);

X_{sz} – the *s-th* type of input in the *z-th* decision-making unit (the amount of the *s-th* input - out of the three considered in the study: the number of judges, outlays on the appellate court and the system load – in a given year of analysis);

$s = 1, 2 \ldots S$ – index of the *s-th* input (total of S=3 types of inputs, listed above, common to all decision-making units);

Y_{tz} – *t-th* type of output in the *z-th* decision-making unit (amount of the *t-th* type of output – out of the six included in the study: number of resolved civil, criminal, family, labour law, social security and commerce cases – in the given year of analysis);

$t = 1, 2 \ldots T$ – index of the *t-th* output (total of T=6 output types, listed above, common to all decision-making units;

W_{tz}, V_{sz} – weights assigned to the *t-th* outcome and *s-th* input in the *z-th* DMU, respectively.

A key property of the DEA method is that the weights appearing in formula (2) are determined through a linear programming procedure, rather than by arbitrarily assigning specific values to them. Thus, the most important—and at the same time, most 'inflammatory'—issue of determining the values of these weights, which implicitly conveys the gradation/importance/significance of individual inputs and outputs, is objectivized in a way that ensures the most favourable set from the perspective of individual decision-making units. This is achieved by maximizing outputs and minimizing inputs for all the DMU-s in the sample, represented by the following mathematical problem (e.g., Panwar et al., 2022):

$$max\ E_z = \frac{\sum_{t=1}^{T} w_{tz} Y_{tz}}{\sum_{s=1}^{S} v_{sz} X_{sz}} \tag{3}$$

with respect to the following constraints:

$$0 \leq \frac{\sum_{t=1}^{T} w_{tz} Y_{ti}}{\sum_{s=1}^{S} v_{sz} X_{si}} \leq 1 \tag{4}$$

where „*i*" denotes all DMU-s in the sample $0 \leq W_{tz;} 0 \leq V_{sz}$ (5)

The above problem can be reduced to an equivalent linear programming problem, which determines the optimal weights. The optimization is conducted separately for each DMU included in the sample:

$$max\ E_z = \sum_{t=1}^{T} w_{tz} Y_{tz} \tag{6}$$

with respect to the following constraints:

$$\sum_{t=1}^{T} w_{tz} Y_{ti} - \sum_{s=1}^{S} v_{sz} X_{si} \leq 0 \tag{7}$$

$$\sum_{s=1}^{S} v_{sz} X_{sz} = 1 \tag{8}$$

$$W_{tz}, V_{sz} \geq 0 \tag{9}$$

The classic version of Data Envelopment Analysis (DEA) is hampered by several significant assumptions and undesirable properties that can obscure the clarity of its results. This is especially true when these issues are overlooked, as is common in studies concerning the judicial sector. One notable concern is the low discrimination power of the results, which becomes problematic in analyses involving a limited number of Decision-Making Units (DMUs). To enhance result discrimination, researchers have begun to favour a super-efficiency variant of DEA known as the SE-DEA model (Andersen, Petersen 1993). A concise representation of this extension of the DEA-CRS model is shown below:

$$max\ E_z = \sum_{t=1}^{T} w_{tz} Y_{tz} \tag{10}$$

with respect to the following constraints:

$$\sum_{t=1}^{T} w_{tz} Y_{ti} - \sum_{s=1}^{S} v_{sz} X_{si} \leq 0, \forall i \neq z \tag{11}$$

$$\sum_{s=1}^{S} v_{sz} X_{sz} = 1 \tag{12}$$

$$W_{tz}, V_{sz} \geq 0 \tag{13}$$

The difference between the classical DEA-CRS and its super-efficiency extension consists in excluding the *z-th* DMU from constraint (7) and using constraint (11) instead (see formulae (7) and (11)). As a result, the efficiency scores of DMUs that were previously considered efficient in the classical DEA-CRS model (with scores of 1) are no longer capped at 1, allowing for a more meaningful discrimination among these DMUs.

Additionally, traditional DEA produces efficiency ratios that range from 0 to 1, potentially leading to situations where certain efficient Decision-Making Units —those achieving a score of 1—attribute their efficiency solely to a single input or output. This aspect raises significant concerns regarding the interpretation of findings obtained from conventional DEA analyses. Although the DEA algorithm's ability to optimally choose weights to enhance each DMU's interests is a key feature, the choice of inputs and outputs remains vital for evaluating efficiency and cannot be overlooked. Granting full credit for efficiency to one factor implies that all other factors receive zero weights, complicating the interpretation. Moreover, it is important to acknowledge that DEA measures relative or empirical efficiency, not potential efficiency, which raises questions about the appropriateness of presenting this efficiency in what may be perceived as the "most favourable light" — one that has never been observed.

An effective approach to addressing the above issues is the use of the constrained SE-DEA model, which ensures that all inputs and outputs meaningfully contribute to the analysis—a feature intrinsic to the structure of any DEA model. Although this version of DEA has not yet been applied to judicial efficiency contexts, it compels optimal weights to align with specific, logically based assumptions, ensuring that no weights are zero and thereby addressing previously raised concerns.

Generally, three types of weights are distinguished in constrained SE-DEA analysis (Allen et al. 1997): absolute, price, and virtual weights. In this research, the latter two were used, resulting in the following presentation of the constrained SE-DEA model:

$$max\ E_z = \sum_{t=1}^{T} w_{tz} Y_{tz} \tag{14}$$

with respect to the following constraints:

$$\sum_{t=1, z\neq a}^{T} w_{ti} Y_{ti} - \sum_{s=1}^{S} v_{si} X_{si} \leq 0, \forall i \tag{15}$$

$$\sum_{s=1}^{S} v_{sz} X_{sz} = 1 \tag{16}$$

$$W_{tz},\ V_{sz} \geq 0 \tag{17}$$

$$W_{sd} \leq V_{sz} \leq V_{se} \tag{18}$$

$$W_{tb} \leq V_{tz} \geq W_{tc} \tag{19}$$

$$f \leq W_{wz} y_{tz} g_t \tag{20}$$

The additional constraints (18)-(20) introduce the following modifications to the unconstrained weights in the classical SE-DEA:

(i) Subscripts *b* and *c* denote DMU-s whose input weights cannot be greater or smaller than those of the referenced *z-th* DMU, respectively (these are referred to as input *price weights*).

(ii) Subscripts *d* and *e* denote DMU-s whose input weights cannot be greater or smaller than those of the referenced *z-th* DMU, respectively (also referred to as output *price weights*).

(iii) Constants *f* and *g* put the lower and the upper limits upon the contribution/share of the *t-th* output in the production of total outputs (referred to as *virtual weights*).

To complete the outlined analysis, data collection at the macroeconomic level was essential, requiring a combination of multiple sources and the subsequent processing of gathered information. Data concerning the activities of the appellate court system, categorized by type of case (including criminal, civil, family, labour law, social security, and commercial cases) for the years 2011–2021, were obtained from publicly accessible databases provided by the Ministry of Justice. The primary resource was the .xls-format dataset titled *Register of Cases in Common Courts in Poland* (available at https://isws.ms.gov.pl/pl/baza-statystyczna/opracowania-wieloletnie). To extend the scope of the analysis to cover 2002–2010, the document *Statistical Analysis of the Activity of the Judiciary in the Years 2002–2011* (https://isws.ms.gov.pl/pl/baza-statystyczna/opracowania-jednoroczne-w-tym-pliki-dostepne-cyfrowo/rok-2011/) was also utilized.

In preparing the data for application to DEA efficiency analyses, several identity-based adjustments were necessary. These adjustments entailed defining fundamental relationships within the statistical court records to ensure the accuracy and consistency required for proper DEA computation. Specifically, the following relationships were essential:

$$Caseload_t = Pending\ cases_{t-1} + Incoming\ cases_t \tag{21}$$

$$Pending\ cases_t = Caseload_t - Resolved\ cases_t \tag{22}$$

$$Case\ processing\ time_t = \frac{Pending\ cases_t}{Resolved\ cases_t} \tag{23}$$

where the subscript t stands for *t-th* year.

For analysing the performance of appellate courts, the number of cases processed by area of law was selected as a central measure. This choice of variables ensures both homogeneity and completeness for the decision-making units under review—here, each year of appellate court activity—meeting a critical requirement for the DEA method's validity.

Data for input variables were gathered from various sources. The non-discretionary caseload variable, representing system load, was calculated based on equation (21). Information on the average number of judges in appellate courts from 2006 to 2021 was obtained through public information access requests to the Ministry of Justice. While corresponding data for 2002-2005 were not available, the number of judges could be accurately estimated for these earlier years. This estimation relied on judicial appointment statistics for the full 2002-2021 period, drawn from the statistical yearbooks published by the Central Statistical Office (CSO), and applied the perpetual inventory method to bridge the data gap.

The starting point was the following identity linking stocks and streams of relevant variables:

$$K_t = K_{t-1} + I_t - D_t \tag{24}$$

K_t – stock/capital in period t (in our case – the number of judges in a given year),
K_{t-1} – stock/capital in the preceding period (the number of judges in the preceding year),
I_t – stream of gross investment in stock K in period t (number of newly appointed judges in a given year),
D_t – the stream of depreciated stock/capital in period t (the number of judges who stopped – for whatever reason – working in the courts in year t).

Formula (24) is the same as the following relation:

$$K_t = (1 - \sigma_t)K_t - I_t \tag{25}$$

σ – is the stock/capital depreciation rate (the fraction of judges employed in year *t-1*, but ceasing – for whatever reason – to work in year *t*).

Assuming a constant depreciation rate from 2002 to 2005, equivalent to the average rate observed from 2006 to 2021, the number of judges in the appellate courts during 2002–2005 was estimated using a recursive form of formula (25):

$$K_{t-1} = (K_t - I_t)/(1 - \sigma) \tag{26}$$

σ – the average depreciation rate for 2006-2021, which is 0.04 (the average depreciation rate proved relatively stable, remaining close to 0.04 for variously selected time ranges, not necessarily based on the full sample for 2006–2021).

Data on state budget expenditures for the appellate judiciary, adjusted to constant prices, required several recalculations and sources. First, a time series of current expenditures on the broader judiciary (encompassing the appellate judiciary) was compiled from Ministry of Finance data sources (https://www.gov.pl/web/finanse/sprawozdania-roczne and https://mf-arch2.mf.gov.pl/web/bip/ministerstwo-finansow/dzialalnosc/finanse-publiczne/budzet-panstwa / wykonanie-budzetu-panstwa/sprawozdanie-z-wykonania-budzetu-panstwa-roczne). This approach was necessary because the Central Statistical Office's (CSO) statistical yearbooks do not provide budget expenditure data at the required level of disaggregation.

Second, in calculating the share of total judicial budget directed to the appellate judiciary, the fraction determined by Siemaszko and Ostaszewski (2013) was applied. Third, the budget allocation for the appellate judiciary in current prices was obtained by multiplying the total judiciary budget by the appellate judiciary fraction. Finally, this time series was adjusted to real terms by dividing it by the 2015 Consumer Price Index (CPI) deflator, yielding a constant-price series. The processed data used in this research is presented in Table 1.

Both the graphical analyses of the analysed categories and the linear correlation coefficients[1] for the first three variables suggest a low degree of collinearity among the input variables. This finding implicitly indicates that each variable can independently influence output levels, a conclusion supported by both theo-

[1] For want of space, all figures elaborated on the basis of the data reported in Table 1 —and supporting the descriptive conclusions in the following sections—as well as the Pearson correlation coefficients, have been omitted.

retical and empirical evidence (as detailed in the literature review). It should be noted that there is no need to examine the dataset for potential outliers, as such information is not relevant in the present study. This is because the dataset employed here contains macro-aggregated and complete information on the functioning of the Polish appellate court system over a twenty-year period and therefore represents a full population rather than a statistically defined sample. In contrast, detecting potential outliers is highly advisable—although not always undertaken—when efficiency analyses rely on data for individual courts, as is the case in all empirical studies cited in the "Literature Review" section.

Throughout the analysed period, the number of judges increased moderately, with an average annual growth rate of 1.17%. In contrast, real expenditures on the appellate judiciary experienced substantial growth, exceeding 4% per year over the same timeframe, resulting in total budget allocations for the appellate judiciary more than doubling by the final year of the analysis compared to the initial year. Consequently, the per-judge budget outlay also saw a significant increase.

Conversely, the number of cases pending resolution remained relatively stable. This stability led to consistently variable yet overall stable volumes of cases per judge, alongside a regular rise in unit costs associated with case resolution. As a result, judges are faced with a fairly constant caseload while their salaries have been progressively increasing. Notably, the average growth rates of pending cases outpaced those of resolved cases—1.4% compared to 1%, respectively—resulting in a continually rising number of unresolved cases, particularly evident since 2014.

Significant disparities in the dynamics of the output variables are evident. The most pronounced increase is observed in criminal cases, which nearly doubled during the analysis period. Additionally, civil cases represent another category that exhibited a growth trend, with levels at the conclusion of the sample period surpassing those at its commencement. In contrast, commercial and insurance cases displayed high variability, yet maintained relatively stable expected values. Meanwhile, volumes of labour cases have been in a consistent decline.

It is essential to note that the fluctuations in the number of resolved cases correspond to parallel changes in the volume of incoming cases for each category of law. Furthermore, the Pearson linear correlation coefficients among the various output variables are relatively low. This indicates that none of the aforementioned variables replicate the informational content of the others, as the dynamics of all variables differ significantly.

Consequently, beyond the substantive rationale—characterized by a set of mutually exclusive and collectively exhaustive elements, namely the number of cases resolved by category as outcome variables—the statistical rationale further underscores the importance of examining all these variables simultaneously. This approach stands in contrast to the predominant tendency in

most studies on judicial efficiency utilizing the Data Envelopment Analysis (DEA) method, which often relies on a singular aggregate figure.

A similar conclusion applies to the input variables incorporated into the analysis. While the role of judges in adjudicating cases within appellate courts is undeniably critical and irreplaceable, other input variables—specifically, real budgetary expenditures allocated to the judiciary and the total number of unresolved cases—also significantly influence the volume of cases processed by the courts, largely independent of the number of judges. Therefore, when such data is available, incorporating these additional input variables alongside the number of judges in DEA analyses enhances the credibility of the conclusions drawn from such assessments. This inclusion not only enriches the analysis but also affirms its legitimacy.

Table 2 illustrate the fluctuations in the average duration of case processing across various areas of law, derived using formula (23). Notably, there is a consistent annual increase in processing times, despite the relatively stable number of cases. A significant observation pertinent to the analyses presented in this article is the systematic gradation in average case resolution times across different legal categories. Regardless of the year analysed, criminal cases consistently exhibited the shortest processing times, whereas insurance cases demonstrated the longest. In relation to the other legal categories, no discernible pattern emerges, characterized by a regular minority/majority gradation. This means that the actual average processing times for these categories fall between the disposition times recorded for criminal and insurance cases.

If the estimates of disposition times by legal category presented above are accepted as definitive, it becomes feasible to ascertain the proportion of the total time dedicated to resolving all cases within a specific area of law throughout the analysed period as shown in formula (27):

$$s_i = \frac{d_i \cdot n_i}{\sum_{j=1}^{6} d_i \cdot n_i} \tag{27}$$

S_i – fraction of the courts' time devoted to resolving the cases of the i-th subject of law (i=1, 2, ...6). By definition we have: ,

d_i – average processing time of cases for *i-th* subject of law, determined according to formula (23),

n_i – number of cases per *i-th* subject of law.

The significant variability in the proportions of total time allocated to resolving cases by legal category underscores temporal fluctuations in both the disposition times and the volume of cases. Table 3 displays the values of all quantities, alongside their respective minimum and maximum values.

Before proceeding to the primary focus of this article, it is essential to highlight that both the estimates of average case processing durations by area

of law and the corresponding proportions of these durations in relation to the total time dedicated to court operations represent the actual, historical, and empirical ranges of variation for these metrics over the analysed period, as opposed to hypothetical ranges. This observation is pivotal and will be further developed and empirically operationalized to provide a clear interpretation of the results obtained through DEA in assessing the efficiency of the Polish appellate court system.

Let us conclude this section of the discussion with a brief comparative analysis of several two-dimensional judicial performance indicators that are frequently utilized in studies concerning the efficiency of judicial systems (e.g., CEPEJ 2018). These indicators are listed in Table 4:

a) Judges' work productivity: ratio of the total number of cases resolved to the total number of judges in a given year (i.e. average number of cases resolved by one judge, in thousands).
b) Unit cost of resolving an average judicial case: ratio of total expenditure to total number of cases resolved in a given year (thousands of PLN, real prices of 2015).
c) Average case handling time (calculated according to formula (23) for the total number of cases (in months)).
d) Clearance rate: ratio of the total number of resolved cases to the total number of incoming cases in a given year; in percentage.

Percentage normalization (relative to *Labour productivity* and *Clearance rate*) and reverse percentage normalization (relative to *Overall disposition time* and *Unit Costs*) enable direct comparisons among these measures. First, it is noteworthy that all indicators exhibit high variability, and consequently, a significant degree of unpredictability concerning projections of their future values. Second, the best (and thus, after normalization, the highest) values concerning systemic efficiency for these measures are observed in different years: specifically, for *Labour productivity*, *Unit costs*, *Overall disposition time*, and *Clearance rate*, these years are 2019, 2002, 2009, and 2007, respectively. Third, from the perspective of the entire two-decade period, a concerning trend of deterioration in all indicators can be observed.

Fourth, depending on which indicator is considered, various sub-periods of relatively high and relatively low "efficiency" can be distinguished. If conclusions are based on the indications of the *Clearance rate* and *Disposition time*, a relatively high "efficiency" is noted in the years following Poland's accession to the European Union (2006-2012). In contrast, using *Labour productivity* as a reference leads to entirely opposing conclusions. Similarly, drawing inferences about the degree of "efficiency" based on *Unit costs* favours the beginning of the sample period. However, regardless of the specific indicator chosen, all of them clearly deteriorate in the last years of the analysed period.

Fifth, the most stringent evaluation of the effects of the appellate judiciary's activities is reflected in the *Disposition time*, which has more than tripled in duration in the last years of analysis compared to 2009. In contrast, the least severe evaluation is indicated by the *Clearance rate*, with the lowest recorded value at 90% in 2013 and the highest nearly 111% in 2007. This situation regarding the Clearance Rate is entirely natural, as a sustained ratio of resolved to incoming cases — that is, the definition of the Clearance Rate — remaining below 100% (referring to the non-normalized value) would indicate a steadily worsening crisis in the judiciary, akin to a "slippery slope".

Unfortunately, the situation appears quite alarming in light of the indications from the second measure mentioned above. Although one should refrain from hastily making an overall assessment of the functioning of the judicial system using two-dimensional indicators it is nonetheless evident that from the perspective of the "court client/petitioner", *Disposition time* is undoubtedly a key factor influencing the public perception of the judiciary and, more importantly, directly affecting the functioning of society and the economy.

The variability of conclusions that can be drawn based on two-dimensional indicators highlights the complexity and multifaceted nature of measuring the effectiveness of the judiciary's functioning. There is a risk that the selective choice of one such indicator may be motivated by a desire to prove pre-established theses. Therefore, any attempts to evaluate the functioning of judicial systems should consider a range of metrics. Even then, inferring the effectiveness of the judiciary—whether in its current state or from a historical perspective—will be methodologically burdened, as such metrics do not account for the simultaneous occurrence of numerous factors that undoubtedly influence the system's functioning and its efficiency, whether on the input side (e.g., the number of judges, budget allocations for the judiciary, or system overload due to the volume of incoming cases) or on the output side (aggregating all judicial cases into a single category instead of disaggregating them).

In summary, methodologically sound research on the effectiveness of public institutions, including the judiciary, must employ analytical tools that take these conditions into account. This observation leads us directly to the next section of the article.

4. Results

In the analyses presented in this section, variants of DEA that employ constant returns to scale and maximized outputs were selected. Firstly, investigations that explore the potential influence of the size of court units on their observed efficiency typically focus on cross-sectional data, where different-

sized court units are treated as DMUs. Conversely, this study, as highlighted in previous sections, examines the appellate court system as a whole across an extensive 20-year period, rather than individual courts. Secondly, it is important to note that the total number of operating appellate court units exhibit very low variability, with 10 units present from 2002 to 2004 and increasing to 11 thereafter. Finally, the incorporation of a non-discretionary systemic burden variable, specifically caseload, serves to mitigate any potential 'economies of scale' that might arise due to the changes in the volume of cases processed by the appellate courts, should the individual years of analysis be treated as standard DMUs.

The same theoretical and empirical rationale that underpinned the previous analyses employing DEA methods on judicial efficiency, as already discussed in this paper, was also applied to the chosen variant focused on performance maximization. The primary argument for selecting this DEA variant stems from the significant rigidity observed in both the supply of judges and the budgetary provisions governing the financing of the judiciary. Additionally, in light of the rising average duration of court case processing noted in many EU countries, including Poland (e.g., Study on the Functioning of Judicial Systems in EU Member States, 2022), it is imperative that any potential improvement strategies emphasize the maximization of outcomes rather than simply maintaining existing outputs while minimizing incurred expenditures. Moreover, as already noted, the output-oriented DEA framework makes it possible to treat non-discretionary inputs in the same manner as discretionary ones. Furthermore, given that the vast majority of empirical studies on judicial efficiency employ an output-oriented approach, the present analysis may be regarded as a methodological continuation of the current mainstream research.

This paper presents the findings of a study examining the efficiency of appellate courts through the classic CCR method of performance-maximizing DEA, alongside its modification that incorporates the super-efficiency concept and variants that impose restrictions on model parameters and weights. The sequential analysis aims to highlight the inherent limitations of the classic DEA method, which remain unaddressed by the super-efficiency variant. Instead, a viable and substantively sound approach to resolving these issues is to employ constrained DEA. These features, combined with the utilization of time-series data encompassing the entire judicial system and the treatment of this system as a DMU, underscore the scientific originality of this study.

The second column of Table 6 presents the efficiency scores derived from the classic DEA approach. As anticipated, the scores produced by this method demonstrate limited discriminatory capability, a shortcoming primarily attributable to technical rather than substantive factors[2]. To enhance the dis-

[2] In practice, the minimum number of effective DMUs obtained using the classic DEA

criminative power of the DEA model, one can employ the concept of super-efficiency. In essence, this approach involves calculating a "new" efficiency score for a specific DMU deemed efficient in the classic DEA model by excluding that DMU from the analysis. Consequently, the efficiency scores may surpass the value of 1 to varying extents, thereby allowing for differentiation among DMUs that are classified as "classically" efficient but are capped at the upper end of the scale. By rescaling these scores to a maximum of "1" for the highest score, a "traditional" interpretation of the results can be achieved.

Table 5 presents the efficiency scores derived from the DEA super-efficiency procedure, including both the original and rescaled values (refer to columns 3 and 4 of Table 5, respectively). At first glance, the results appear quite satisfactory. Despite the limited number of Decision-Making Units, it seems that a commendable level of discrimination among their efficiency scores has been achieved, resulting in a notably diverse empirical set of scores that may misleadingly suggest a more realistic representation of efficiency. In fact, this represents the pinnacle of what many researchers examining judicial efficiency through DEA aspire to attain, with the majority stopping at the classic DEA stage. Why then not interpret the results right now, what would be wrong about it or what is wrong about such interpretation, especially if that's what everyone does?

The adage, "The less people know about how sausages and laws are made, the better they'll sleep at night," attributed to Otto von Bismarck, can be rephrased to reflect the concerns of DEA practitioners: "The less DEA practitioners—and even more so, DEA stakeholders—understand about the parameters and weights derived from their DEA analyses, the more comfortably they rest at night." This observation reveals a troubling reality: it appears that very few individuals regard the actual parameter estimates obtained in DEA models as significant. However, these are not trivial matters; they are essential to establishing trust in the resulting efficiency scores. The stark fact that only one publication referenced in this paper[3] provides explicit, albeit not exhaustive, consideration of parameter estimates underscores the extent

model is equal to the product of the inputs and outputs included in the analysis, as noted by Dyson et al. (2001). Thus, if one were to limit the study to the classical DEA model, given the number of DMUs (20), inputs (3), and outputs (6), it would be devoid of any deeper meaning.

3 Santos S.P., Amado C.A.F. (2014), *On the need for reform of the Portugese Judicial System – Does Data Envelopment Analysis assessment support it?*, Omega – The International Journal of Management Science, vol. 47, pp. 1–16. However, even this publication refrains from disclosing the actual weights generated in its DEA analysis, suggesting that reliance on relative weights alone may be inadequate to fully address the problem of 0–1 weights highlighted in this paper. This omission indicates that a more rigorous approach may be necessary to ensure the robustness and interpretability of DEA results, particularly regarding the consistency and significance of the derived weights.

of both intentional and unintentional ignorance surrounding this critical issue.

Examining the weights assigned to outputs in the super-efficiency DEA model (Table 6), both in absolute and virtual terms (for want of space the latter not reported), reveals a concerning trend: many weights take on a value of zero and, at times, all but one weight are zero, indicating that only one factor, whether output or input, appears to contribute to the efficiency score of a DMU. Economically interpreting these weights suggests an improbable scenario where factors with zero weights contribute nothing to efficiency, or that a single factor exclusively drives overall efficiency—a conclusion that, though internally consistent within the model, is practically unrealistic. Such outcomes challenge the foundational assumptions of DEA as a reliable tool for assessing efficiency.

DEA requires that every input and output included in the model exert a measurable influence on efficiency—outputs should reflect a comprehensive representation of the DMU's activities. Otherwise, their inclusion is methodologically unjustifiable. This issue becomes even more pronounced when the DMUs are successive years within a given time frame (2002–2021). It defies logic to suggest that in one year, an output fully absorbs the inputs, while in another year, it has no impact at all (as shown in the weights for *LABOUR* in 2002-2004 in Table 6). Similarly, it is implausible to assume that in one period an input accounts for all outputs, yet in another, it contributes nothing (e.g., see weights for *OUTLAYS* in DMU04 and DMU05 in Table 6). These inconsistencies underscore the need for a robust and balanced approach to parameter weighting within DEA models.

This prompts the question of whether such outcomes have any explanatory value. The logical answer appears to be negative, leading to the subsequent question: what can be done to improve interpretability? The primary goal should be to ensure that the estimated weights are meaningful. This objective can be achieved through constrained DEA, wherein the optimization of efficiency scores includes logical and empirically justified constraints on weights, established on substantive grounds, as part of the optimization process.

A straightforward approach might involve assigning a meaningful value to each resolved case based on the time required for its resolution, aligning with the maxim "time is money"—especially pertinent when the precise costs associated with resolving an average case are difficult to ascertain. Additionally, by employing the super-efficiency model alongside constraints on both absolute and virtual weights (on the inputs and outputs side), one can derive consistent and robust efficiency scores for individual decision-making units without the anomalous zero or unitary weight values that undermine interpretability. This structured methodology is explained and implemented step by step in the following sections.

We begin with the approach proposed by Santos and Amado (2014), who utilized empirical data to establish appropriate minority-to-majority ratios for output weights assigned to different case types, according to their average time requirements derived using formula (23) and summarized in Table 2. Following this approach results in a set of relations regarding the value weights assigned to cases, differentiated by subject matter in accordance with their time absorption rates (refer to Table 2)[4]:

ACIVIL / *ACRIME* >= 1
ALABOUR / *ACRIME* >= 1
ACOMMERCE / *ACRIME* >= 1
AINSURANCE / *ACRIME* >= 1
AINSURANCE / *ACIVIL* >= 1
AINSURANCE / *ALABOUR* >= 1
AINSURANCE / *ACOMMERCE* >= 1

While innovative compared to prior studies in this area, this approach fails to address the significant issue of unacceptable output weights, as many weights still default to values of 0 or 1[5]. Notably, Santos and Amado, like most others in the field, omit discussion on this critical matter in their analyses of judicial efficiency. Only by introducing additional constraints—this time on what are known as virtual weights, which clearly indicate the share of total time allocated to cases of specific types relative to the total time spent on all cases—do the resulting output weights begin to hold meaningful interpretive value. These constraints are precisely specified with a help of formula (27) and are shown in Table 7.

Similarly to the minority/majority relationships established for absolute weights, realistic variability ranges for virtual weights assigned to respective case types by legal subject area must also be defined in accordance with logical criteria. These empirically derived values, which provide the most practical and realistic representation of each category, were derived on the basis of Table 3 and are presented in Table 7.

Applying a DEA variant with simultaneous restrictions on both price and virtual weights does, ultimately, lead to appropriate and substantively accurate weights on the output side (though the specifics are not presented here). However, the previously highlighted issues regarding input weights persist. This prompts a reconsideration of the admissibility of these results. To frame the discussion, consider two rhetorical yet insightful questions that underscore the essential role of judges in case resolution:

4 This notation aligns with the conventions established in the *pyDEA* software, where the weight names are intuitively labelled, with the prefix "A(?)" indicating absolute weights. This notation allows for the direct application of the previously discussed constraints on the respective terms in formula (2).

5 Due to space limitations, the relevant outcome tables have not been included.

1) Would judges, tasked with adjudicating all pending cases, undertake their responsibilities without compensation?
2) Would the judicial institution exist at all if there were no cases to be adjudicated?

The answer, self-evidently negative, reinforces that any challenges to the relevance of unconstrained DEA—especially regarding the appropriateness of output weights and the practicality of rankings it produces—are equally pertinent for input weights. Thus, empirical realism in input weights is essential, as this is a prerequisite for the reliability and validity of efficiency scores generated by DEA analyses.

In contrast to outputs, for which both price weights and virtual weights could feasibly be estimated based on actual time absorption, such an approach proves impractical for inputs. Instead, a viable alternative centres on the evidently indispensable role of judges in the case disposition process. As underscored by the earlier questions, judicial functions are contingent on the presence of two other key inputs: caseload and financial outlays. This insight leads to a heuristic approach that leverages the foundational role of judges as the critical input. By integrating this observation, a method can be devised to establish realistic, empirically grounded price weights among the inputs used, thereby positioning judges as the central input in the efficiency analysis (Allen et al., 1997).

The initial step involves establishing the empirical variability range of the ratios of outlays to judges and caseloads to judges. The respective extreme values observed during the analysed period from 2002 to 2021 are as follows:

min (*CASELOAD/JUDGES*) = 0.205
max (*CASELOAD/JUDGES*) = 0.377
min (*OUTLAYS/JUDGES*) = 0.660
max (*OUTLAYS/JUDGES*) = 1.213

Consequently, based on the assumption regarding the primary role of judges in the overall case disposition process, it follows that the price weights attributed to the other two inputs must fall within the intervals defined by the aforementioned extreme points. The absolute weights assigned to the "judges" input will serve as the reference category. An excessively high weight would be detrimental, indicating that the relative price (or significance) of the other inputs exceeds that of judges. Conversely, an excessively low weight would undervalue the empirical significance of these inputs. Thus, the constraints imposed on the price weights for all inputs are as follows:

ACASELOAD / AJUDGES > = 0.205
ACASELOAD / AJUDGE < = 0.377
AOUTLAYS / AJUDGES > = 0.660
AOUTLAYS / AJUDGES < = 1.213

It is only after imposing all the necessary constraints on both price and virtual weights for outputs and inputs that we arrive at the final results,

which are devoid of the critical adverse properties that typically remain unacknowledged yet significantly undermine the credibility and interpretability of efficiency scores derived from classic DEA. At this stage, no weight—whether associated with outputs or inputs—assumes a value of "0" or "1" (refer to Table 8). Furthermore, due to the manner in which these constraints were applied, the estimated range of weight variability aligns with the historically observed minimum and maximum intervals throughout the analysed period. Consequently, we assert that the final outcomes of this empirical study are fully reliable and interpretable, facilitating a robust assessment of the actual performance of the Polish regional court system over a 20-year timeframe.

The portrayal of the Polish appellate court system that emerges from the analysis conducted over the past 20 years is rather pessimistic (see the last column of Table 5). The peak of performance has long since passed, and there are no signs of a return to relatively high efficiency levels (above 90%) that were recorded just before Poland's accession to the European Union and shortly thereafter. The technical maximum was precisely in 2004, and only the efficiency levels noted between 2002 and 2005 can be considered satisfactory. In subsequent years, the efficiency of the appellate courts began to deteriorate noticeably, reaching a local minimum in 2010 (with a 35 percentage points decline in efficiency compared to the most efficient year, 2004).

In the years following 2010 and up to 2019, there was a certain strengthening of the system, manifesting as an increase in efficiency by 5 to 15 percentage points compared to 2010. Consequently, the efficiency during these years fluctuated around 80%, still significantly lower than the levels that characterized the early years of the 21st century. Finally, towards the end of the sample period, a significant decline in the functional efficiency of the system occurred once again, with 2020 recording the lowest efficiency throughout the entire analysed period, at a mere 60%.

The year 2004, when Poland became a formal member of the European Union on May 1st, not only marks the most efficient period in the functioning of the Polish appellate court system but also reveals that *DMU04* serves as the sole peer DMU for all years included in the study. In other words, according to the measures used in this research to evaluate the efficiency of the Polish appellate court system, the standards and legislative-organizational-administrative frameworks that were in place in 2004 most effectively promoted the efficiency of this system. Therefore, in seeking answers to potential questions regarding the possibilities for reforming the current system, it would be advisable to conduct comprehensive, multidimensional comparisons between the current state and the operational status of the Polish appellate judiciary at the time of Poland's accession to the European Union. Clearly, not all changes—whether discretionary or external (though this suggestion primarily concerns the former)—that occurred in the Polish

judiciary over the years following Poland's accession to the European Union have been effective from the standpoint of systemic efficiency.

Accurate estimation of the efficiencies of a set of decision-making units (DMUs) is one aspect, while the effective identification—and, ideally, quantification—of the factors influencing those efficiencies at various levels is quite another. However, if the first step is executed poorly, it inevitably leads to erroneous conclusions regarding the second stage of analysis. To illustrate the potential pitfalls in this regard, let us consider the outcomes of the simple, unconstrained super-efficiency DEA (SE-DEA) as reference estimates for the efficiencies of the Polish appellate court system presented in this research.

Figure 1 addresses this issue through the use of bar charts and simple linear trend regressions applied to the rescaled efficiency scores. A cursory visual examination of the two charts and their respective trend lines clearly reveals markedly different overall patterns in the dynamics of efficiency scores derived from unconstrained versus constrained SE-DEA models. There is little to no numerical or logical correlation between these outcomes, with the unconstrained SE-DEA exhibiting a more lenient assessment of the historical performance of the Polish appellate court system.

Notably, the scores for individual years not only vary in an erratic manner, but the overarching conclusions drawn about the long-term dynamics of the system also differ significantly. This discrepancy can lead to a fundamentally altered evaluation of the performance of the Polish appellate court in the 21st century. Thus, relying on the unconstrained SE-DEA results may obscure critical insights and misrepresent the actual state of judicial efficiency over time.

The results from the unconstrained super-efficiency DEA (SE-DEA) indicate that, although the system is not consistently efficient, it maintains relatively high efficiency scores exceeding 80% across individual years. This finding is further reinforced by the absence of a discernible trend line suggesting any significant decline in performance. In contrast, the outcomes from the constrained variant of SE-DEA, which serves as our methodologically rigorous reference, present a markedly less favourable assessment of the Polish appellate court system.

Specifically, the efficiency levels recorded in the constrained model are 10-20 percentage points lower than those derived from the unconstrained approach. Moreover, unlike the unconstrained variant, the constrained SE-DEA demonstrates a consistent downward trend in the system's functional performance over time.

In summary, the methodological framework adopted significantly influences the interpretation of judicial efficiency. Investigators who limit their analysis to a few decision-making units using classical SE-DEA—a prevalent practice—may overlook critical insights. Conversely, extending the analysis to incorporate constrained SE-DEA can yield qualitatively different conclu-

sions and, consequently, inform distinct political recommendations. Such differences underscore the importance of rigorous methodological choices in evaluating the efficiency of judicial systems.

To conclude, we will conduct a concise descriptive statistical analysis, supplemented by graphical representation, to explore potential relationships between simple, two-dimensional judicial performance indicators and the efficiency scores derived from the constrained super-efficiency DEA (SE-DEA). For this analysis, all measures will be expressed in normalized percentage terms, utilizing data from the last column of Table 5 (constrained SE-DEA scores) and the last four columns of Table 4, which include labour productivity, unit costs, disposition time, and clearance rate.

Figure 2 illustrates the normalized efficiency scores from the constrained SE-DEA alongside the two-dimensional judicial performance indicators for the years 2002 to 2021. Additionally, Table 9 presents the results of the correlation analysis, including both Pearson and Spearman correlation coefficients. This analysis aims to provide insights into the interrelations between the performance indicators and the derived efficiency scores, contributing to a deeper understanding of judicial efficiency dynamics over the specified period.

Both the bare-eye "analysis" and the formal correlation analysis, utilizing both Pearson's linear correlation coefficient and Spearman's rank correlation coefficient, indicate a lack of any relationship between the efficiency indicators obtained through constrained SE-DEA and the clearance rate and disposition time. Regarding labour productivity and unit costs, the conclusions are less straightforward. Although, from a formal-statistical perspective, the null hypothesis of no correlation between these performance indicators and the efficiency coefficients should be rejected at the 5% significance level, an examination of the trajectories of these three categories (see Figure 2) allows for the conclusion that a rather loose relationship existed between the examined measures only in the first half of the analysed sample period—an observation that can explain the significance of the correlation analysis. In contrast, in the second half of the period, there is a complete divergence of these trajectories. Thus, asserting that there is no need to conduct complex, systemic DEA analyses to determine the scale of efficiency/inefficiency in judicial systems—since this objective could equally well be achieved using two-dimensional judicial performance indicators—would not be fully justified.

In summary, it can be definitively stated that two-dimensional judicial performance indicators, whether considered in isolation or in any configuration, cannot replace well-conducted DEA analyses. However, they can facilitate such analyses and significantly complement/enrich them, particularly concerning the category of disposition time.

First, this specific measure has allowed for the imposition of substantively correct constraints on the parameters/weights associated with the outcome

variables, thereby addressing a key issue that effectively undermines the credibility and interpretability of results obtained through classical DEA: the presence of zero or unit values in the input variables.

Second, from the perspective of the "court user/client," disposition time is undoubtedly a key factor influencing the social perception of the judiciary and, more importantly, directly affecting the functioning of society and the economy. Thus, even in those years when the system's efficiency is relatively high—when measured by appropriate, multidimensional methods that take into account various inputs and outputs—if there is an accompanying increase in the average duration of court proceedings, it is difficult to assess the functional state of such a system in a unambiguously positive and uncritical manner. This situation is not hypothetical; the issue highlighted emerges from the current analysis (see Figure 2).

5. Conclusion

Disregarding the inherent limitations of classical or super-efficiency unconstrained radial DEA models can result in substantial inaccuracies in the efficiency ratings attributed to individual DMUs. As a consequence, policy recommendations based on these methods, aimed at improving the actual performance of specific DMUs, may prove to be unreliable and potentially misleading. The outcomes of this research show the fundamental shortcomings of classical applications of DEA, raising valid concerns about the reliability and interpretability of the outcomes derived from this approach. To mitigate these challenges, it presents a novel procedure specifically aimed at addressing these limitations in evaluating judicial efficiency, which is next successfully implemented.

Identifying the most historically efficient benchmark years through empirical analysis is merely an initial step toward a more qualitatively oriented investigation aimed at uncovering the factors that contributed to the superior efficiency of certain decision-making units (DMUs) during those years. This endeavour necessitates interdisciplinary expertise and the involvement of various stakeholders, as Data Envelopment Analysis (DEA) is primarily a descriptive method used to estimate relative efficiencies among homogeneous DMUs. While DEA effectively reveals variations in the effectiveness of the individual DMUs analysed over a specified period, it does not provide insights into the underlying reasons for such discrepancies.

A promising starting point for this exploration could be the application of two-stage DEA (2SDEA), as seen in studies by Schneider (2005), Deynelli (2011), Malcarne and Ramello (2015), and Nissi et al. (2019), utilizing the efficiency scores obtained from the current research. However, a more robust research agenda would require panel data analyses that encompass in-

dividual courts across different years, integrating both spatial (across various locations) and temporal dimensions. This approach would necessitate the incorporation of micro-level formal and administrative data, as well as survey-based data. Once the results of such comprehensive research are available, it would be possible to differentiate between inefficiency factors stemming from unique characteristics inherent to specific courthouses and those related to systemic or procedural issues that are prevalent across all operational courthouses.

Another potentially valuable extension of the analyses presented in this article would involve applying window analysis or the Malmquist index to assess the dynamics of productivity within the judicial system under consideration. Moreover, by employing panel data and applying the same classification of court cases by domain of law as in the present study, it would be possible—at the level of individual courts of appeal—to attempt to identify and disentangle three distinct classes of determinants of efficiency. First, this would concern system-wide macro-effects that uniformly affect all judicial units and arise from, inter alia, legislative changes, binding procedural rules, guidelines issued by central authorities, and other institutional conditions. Second, one could isolate meso-level effects reflecting the socio-economic heterogeneity of the regions under the jurisdiction of the respective courts of appeal, which may have implications for their caseload and operational performance. Third, further analyses could focus on micro-level factors associated with idiosyncrasies in the internal organisation and operational practices of individual courts. Such analyses would, however, require access to survey-based data, which in turn would necessitate the cooperation and approval of the competent judicial authorities for their collection.

In light of the above, a wide range of potential avenues exists for further developing the research initiated in this article. These may include an in-depth, quantitative assessment of the state of the Polish judiciary from the perspective of its efficiency, as well as the identification and empirical evaluation of factors influencing that efficiency at the macro, meso, and micro levels. The purpose of such research would be not only to estimate the strength and statistical significance of the effects of particular determinants, but also to indicate areas in which institutional intervention could yield the greatest benefits. Given the fundamental importance of an effective judiciary—for the functioning of a modern state, economy, and society—as well as its well-documented performance shortcomings, further empirical studies in this field should be regarded as both justified and socially desirable.

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Appendix

Table 1. Input and output values used in DEA of appellate court efficiency

DMU/YEAR	INDICATORS				NORMALIZED INDICATORS			
	Labour productivity	Unit costs	Overall disposition time	Clearance rate	Labour productivity	Unit costs	Overall disposition time	Clearance rate
DMU02	0.244	2.709	4.294	93.438	88.478	100.000	39.963	84.379
DMU03	0.246	2.804	4.185	97.638	89.351	96.634	41.003	88.172
DMU04	0.247	2.834	4.109	98.330	89.689	95.612	41.761	88.798
DMU05	0.235	2.996	4.120	99.534	85.282	90.422	41.657	89.885
DMU06	0.221	3.436	3.339	108.117	80.227	78.841	51.392	97.636
DMU07	0.210	3.809	2.352	110.735	76.380	71.122	72.967	100.000
DMU08	0.186	4.109	2.144	103.129	67.585	65.940	80.051	93.131
DMU09	0.185	3.981	1.716	103.269	67.035	68.049	100.000	93.258
DMU10	0.177	4.378	1.915	99.090	64.260	61.886	89.615	89.484
DMU11	0.188	4.076	2.013	98.231	68.394	66.463	85.266	88.708
DMU12	0.201	3.713	2.464	95.202	72.849	72.963	69.653	85.973
DMU13	0.217	3.512	3.588	90.210	78.854	77.138	47.835	81.465
DMU14	0.233	3.396	3.469	99.052	84.524	79.782	49.477	89.449
DMU15	0.228	3.576	3.803	97.825	82.736	75.750	45.128	88.341
DMU16	0.238	3.711	3.761	100.348	86.396	72.997	45.627	90.620
DMU17	0.255	3.615	3.419	101.838	92.490	74.945	50.188	91.965
DMU18	0.265	3.893	4.055	95.840	96.222	69.584	42.326	86.549
DMU19	0.275	3.872	4.407	94.825	100.000	69.962	38.944	85.632
DMU20	0.228	5.319	6.302	94.879	82.787	50.933	27.230	85.681
DMU21	0.238	4.765	5.546	99.506	86.389	56.851	30.945	89.860

Inputs: *Jugdes* – number of judges in a given year; *Outlays* – expenditure on appellate courts, million PLN, constant 2015 prices; *Caseload* – number of cases to be handled in appellate courts in a given year, in thousands. **Outputs:** *Crime*: number of criminal law cases handled, in thousands; *Civil*: number of civil law cases handled, in thousands; *Family*: number of family law cases handled, in thousands; *Labour* - number of labour law cases handled, in thousands; *Insurance* - number of insurance law cases handled, in thousands; *Commerce* - number of business law cases handled, in thousands; **Aggregate measures**: *Resolved* – number of all cases handled in appellate courts, in thousands; *Incoming* – number of all new cases incoming to the court in a given year, in thousands; *Pending* – number of all unsolved cases in a given year, in thousands

Source: Own elaboration based on the data described in section *Methods and data*

Table 2. Average disposition time in Polish appellate courts system by subject of law in the years 2002-2021

Subject of law	YEAR/DMU																					MIN	MAX
	DMU02	*DMU03*	*DMU04*	*DMU05*	*DMU06*	*DMU07*	*DMU08*	*DMU09*	*DMU10*	*DMU11*	*DMU12*	*DMU13*	*DMU14*	*DMU15*	*DMU16*	*DMU17*	*DMU18*	*DMU19*	*DMU20*	*DMU21*			
CRIME	1.079	1.059	0.927	0.952	0.785	0.777	0.833	0.787	0.973	0.915	0.853	0.892	0.980	0.942	0.903	0.947	1.176	1.296	1.825	1.648		0.777	1.825
CIVIL	2.373	2.276	2.063	2.135	1.643	1.389	1.338	1.396	1.474	1.444	1.812	2.264	2.893	3.426	3.915	4.179	4.049	4.528	5.843	6.742		1.338	6.742
LABOUR	1.714	1.800	1.800	2.182	2.824	2.571	1.000	2.182	2.400	1.795	2.513	2.582	3.532	3.611	4.572	4.608	3.050	3.618	5.502	5.702		1.000	5.702
INSURANCE	10.737	9.993	9.337	9.095	7.758	4.895	4.489	3.160	3.904	4.729	6.056	9.549	6.277	7.903	7.258	8.051	8.529	7.714	15.643	10.204		3.160	15.643
COMMERCE	2.545	2.051	2.146	2.164	1.404	1.412	1.600	1.524	1.714	1.592	2.127	3.515	5.776	4.800	3.592	4.321	5.051	6.293	8.493	7.123		1.404	8.493

Source: Own elaboration based on the data in table 1 and formula (23)

Table 3. Shares of total time spent on resolving appellate courts cases by subject of law

Subject of law	YEAR/DMU																					MIN	MAX
	DMU02	*DMU03*	*DMU04*	*DMU05*	*DMU06*	*DMU07*	*DMU08*	*DMU09*	*DMU10*	*DMU11*	*DMU12*	*DMU13*	*DMU14*	*DMU15*	*DMU16*	*DMU17*	*DMU18*	*DMU19*	*DMU20*	*DMU21*			
CRIME	0.075	0.069	0.055	0.054	0.061	0.097	0.126	0.153	0.173	0.155	0.118	0.079	0.085	0.075	0.069	0.070	0.094	0.093	0.119	0.120		0.054	0.173
CIVIL	0.162	0.159	0.152	0.158	0.155	0.177	0.182	0.244	0.259	0.250	0.258	0.223	0.283	0.330	0.389	0.400	0.388	0.366	0.288	0.330		0.152	0.400
LABOUR	0.009	0.009	0.008	0.011	0.014	0.016	0.006	0.015	0.014	0.010	0.010	0.007	0.009	0.008	0.010	0.009	0.008	0.007	0.006	0.007		0.006	0.016
INSURANCE	0.688	0.705	0.725	0.717	0.730	0.667	0.635	0.527	0.489	0.525	0.550	0.600	0.457	0.457	0.427	0.379	0.408	0.428	0.486	0.446		0.379	0.730
COMMERCE	0.065	0.058	0.061	0.060	0.040	0.043	0.050	0.061	0.065	0.060	0.064	0.090	0.167	0.130	0.105	0.141	0.103	0.105	0.100	0.097		0.040	0.167

Source: Own elaboration based on the data in table 1 and formula (27)

Table 4. Two-dimensional "efficiency" measures for Polish appellate court system in the years 2002-2021 along with their percentage (reversed percentage) normalization regarding the "most effective" values

DMU/YEAR	INDICATORS				NORMALIZED INDICATORS			
	Labour productivity	Unit costs	Overall disposition time	Clearance rate	Labour productivity	Unit costs	Overall disposition time	Clearance rate
DMU02	0.244	2.709	4.294	93.438	88.478	100.000	39.963	84.379
DMU03	0.246	2.804	4.185	97.638	89.351	96.634	41.003	88.172
DMU04	0.247	2.834	4.109	98.330	89.689	95.612	41.761	88.798
DMU05	0.235	2.996	4.120	99.534	85.282	90.422	41.657	89.885
DMU06	0.221	3.436	3.339	108.117	80.227	78.841	51.392	97.636
DMU07	0.210	3.809	2.352	110.735	76.380	71.122	72.967	100.000
DMU08	0.186	4.109	2.144	103.129	67.585	65.940	80.051	93.131
DMU09	0.185	3.981	1.716	103.269	67.035	68.049	100.000	93.258
DMU10	0.177	4.378	1.915	99.090	64.260	61.886	89.615	89.484
DMU11	0.188	4.076	2.013	98.231	68.394	66.463	85.266	88.708
DMU12	0.201	3.713	2.464	95.202	72.849	72.963	69.653	85.973
DMU13	0.217	3.512	3.588	90.210	78.854	77.138	47.835	81.465
DMU14	0.233	3.396	3.469	99.052	84.524	79.782	49.477	89.449
DMU15	0.228	3.576	3.803	97.825	82.736	75.750	45.128	88.341
DMU16	0.238	3.711	3.761	100.348	86.396	72.997	45.627	90.620
DMU17	0.255	3.615	3.419	101.838	92.490	74.945	50.188	91.965
DMU18	0.265	3.893	4.055	95.840	96.222	69.584	42.326	86.549
DMU19	0.275	3.872	4.407	94.825	100.000	69.962	38.944	85.632
DMU20	0.228	5.319	6.302	94.879	82.787	50.933	27.230	85.681
DMU21	0.238	4.765	5.546	99.506	86.389	56.851	30.945	89.860

Source: Own elaboration on the basis of data reported in table 1

Table 5. Efficiency scores obtained by classical DEA, super-efficiency DEA, and by constrained super-efficiency DEA

DMU/YEAR	Classical DEA	Super-efficiency DEA	Super-efficiency DEA (rescaled)	Constrained super-efficiency DEA	Constrained super-efficiency DEA (rescaled)
DMU02	1.0000	1.2017	1.0000	0.9732	0.9335
DMU03	1.0000	1.0332	0.8598	0.9858	0.9457
DMU04	1.0000	1.0463	0.8707	1.0425	1.0000
DMU05	1.0000	1.0415	0.8667	0.9657	0.9264
DMU06	1.0000	1.0009	0.8329	0.8878	0.8516
DMU07	1.0000	1.0683	0.8890	0.8341	0.8001
DMU08	1.0000	1.0071	0.8381	0.7368	0.7068
DMU09	1.0000	1.0445	0.8692	0.7354	0.7054
DMU10	1.0000	1.0042	0.8357	0.6729	0.6455
DMU11	1.0000	1.0394	0.8650	0.7012	0.6726
DMU12	1.0000	1.0467	0.8711	0.7503	0.7197
DMU13	0.9950	0.9950	0.8280	0.8047	0.7719
DMU14	1.0000	1.0035	0.8351	0.8785	0.8427
DMU15	0.9902	0.9902	0.8240	0.8183	0.7850
DMU16	0.9981	0.9981	0.8306	0.8336	0.7996
DMU17	1.0000	1.1963	0.9956	0.8147	0.7815
DMU18	1.0000	1.0758	0.8952	0.8261	0.7924
DMU19	1.0000	1.1036	0.9184	0.9171	0.8797
DMU20	0.9976	0.9976	0.8302	0.6376	0.6116
DMU21	1.0000	1.0789	0.8978	0.7201	0.6908

Source: Own computations using data from table 1 and *pydea* software

Table 6. Efficiency scores and absolute weights obtained in the super-efficiency DEA

DMU	INPUTS			OUTPUTS					
	Efficiency	*JUDGES*	*OUTLAYS*	*CASELOAD*	*CRIME*	*CIVIL*	*LABOUR*	*INSURANCE*	*COMMERCE*
DMU02	1.20165445	0	0.00342443	0	0	0	0.47619048	0	0
DMU03	1.03317391	0.0011711	0.00178322	0	0.0049284	0	0	0	0.07401261
DMU04	1.04631632	0	0.00318202	0	0	0	0	0.0232382	0.01744301
DMU05	1.04151627	0	0	0.00668155	0	0	0.17660635	0.01539828	0.00632342
DMU06	1.0008754	0.00013026	0.00067279	0.00549412	0	0.02106154	0.01056189	0.01021377	0
DMU07	1.06831453	0.00037647	0	0.00675124	0	0	0	0.03289474	0
DMU08	1.00710013	0	0	0.00946568	0.01360623	0	0.2327803	0.01217793	0
DMU09	1.04451548	0	0.00049195	0.00743765	0.02676973	0	0	0.0070047	0
DMU10	1.00422348	0	0	0.00985935	0.03365019	0	0	0.0001892	0
DMU11	1.03938282	0	0.00044616	0.00737758	0.00040259	0.02556763	0.15420645	0	0
DMU12	1.04674801	0	0.00147585	0.00339972	0.01964336	0.00943961	0	0	0
DMU13	0.99495884	0	0.00147215	0.00321508	0.00490988	0.01834992	0	0.00549203	0
DMU14	1.00349273	0.00050405	0.00050358	0.00371466	0.00952239	0.00956086	0	0.00884951	0.00363945
DMU15	0.99022274	0	0.00138715	0.00302945	0.0046264	0.01729044	0	0.00517493	0
DMU16	0.99805907	0.0001132	0.00060831	0.00468057	0	0.01817272	0	0.00935118	0
DMU17	1.19631575	0.00182511	0	0	0	0.00747862	0	0	0.04419966
DMU18	1.07576812	0.00177397	0	0.00115073	0	0.01929521	0.13596099	0	0
DMU19	1.1035576	0.00204551	0	0	0.00962054	0.00479668	0	0.01404903	0
DMU20	0.99761241	0.00064286	0	0.00506232	0.02081856	0.00623842	0	0	0
DMU21	1.07887073	0.00081228	0	0.00346868	0.01699333	0	0	0.00944341	0

Source: Own computations using data from table 1 and *pydea* software

Table 7. Constraints imposed on virtual weights

Virtual weights (minima)	Virtual weights (maxima)
VCRIME >= 0.054	*VCRIME* <= 0.173
VCIVIL >= 0.152	*VCRIME* <= 0.400
VLABOUR >= 0.006	*VLABOUR* <= 0.016
VINSURANCE >= 0.379	*VSOCIVIL* <= 0.730
VCOMMERCE >= 0.040	*VCOMMERCE* <= 0.167

Source: Own computations using data from table 3

Table 8. Efficiency scores and virtual weights obtained in the super-efficiency DEA variant with minority/majority relationships imposed on output and input weights as well as with constraints put on virtual output weights

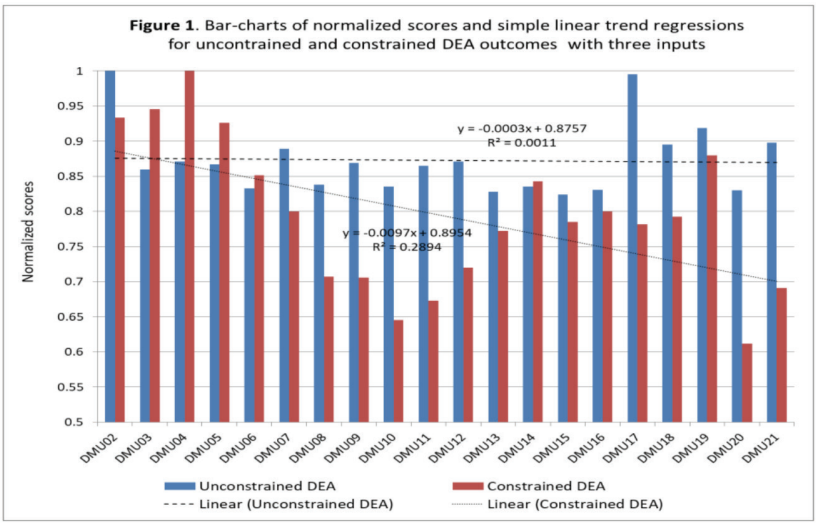
DMU	INPUTS			OUTPUTS					
	Efficiency	*OUTLAYS*	*JUDGES*	*CASELOAD*	*INSURANCE*	*LABOUR*	*CRIME*	*CIVIL*	*COMMERCE*
DMU02	0.97315407	0.44043645	0.54984293	0.03730714	0.37900001	0.016	0.173	0.36785394	0.06414607
DMU03	0.98582205	0.44571647	0.53245267	0.03621273	0.37900001	0.016	0.173	0.2806587	0.1513413
DMU04	1.0424726	0.42489613	0.50031683	0.03404487	0.64760519	0.006	0.054	0.152	0.14039481
DMU05	0.96574548	0.30377426	0.65384474	0.07785049	0.73	0.016	0.054	0.16	0.04
DMU06	0.88780861	0.3509147	0.70007152	0.07538268	0.44212767	0.00723404	0.1106383	0.40000002	0.04
DMU07	0.83406952	0.39057988	0.73831217	0.0700488	0.62058824	0.00823529	0.16352941	0.16764706	0.04
DMU08	0.73684436	0.43158952	0.85482523	0.07072391	0.39725235	0.00720833	0.173	0.3825393	0.04
DMU09	0.73538037	0.42170927	0.86903882	0.06909244	0.38092979	0.00623934	0.173	0.39983089	0.04
DMU10	0.6728777	0.4784261	0.93533997	0.07238809	0.381	0.006	0.173	0.4	0.04
DMU11	0.70117447	0.45470195	0.89699867	0.07447798	0.381	0.006	0.173	0.40000001	0.04
DMU12	0.75030632	0.41408532	0.84192237	0.07678129	0.38099999	0.006	0.173	0.40000001	0.04
DMU13	0.80467773	0.38869952	0.77191458	0.08211941	0.379	0.006	0.16682664	0.4	0.04817336
DMU14	0.87849223	0.36333064	0.69620008	0.07878327	0.37900001	0.006	0.16119038	0.39999998	0.05380962
DMU15	0.81832028	0.39818342	0.74008094	0.08375107	0.37900001	0.006	0.16030042	0.4	0.05469958
DMU16	0.83355978	0.41121896	0.70532627	0.08312879	0.37900001	0.006	0.15525322	0.4	0.05974678
DMU17	0.81467076	0.43099709	0.70898002	0.08751265	0.379	0.006	0.14942641	0.4	0.06557359
DMU18	0.82606523	0.45435504	0.66701989	0.08918324	0.37899999	0.006	0.17158721	0.4	0.04341279
DMU19	0.91705654	0.41589083	0.59067795	0.08387656	0.38070466	0.006	0.173	0.4	0.04029534
DMU20	0.63761167	0.65003158	0.8118533	0.10646787	0.379	0.006	0.173	0.39999999	0.042
DMU21	0.72012572	0.55298118	0.73874485	0.09692037	0.381	0.006	0.173	0.40000001	0.04

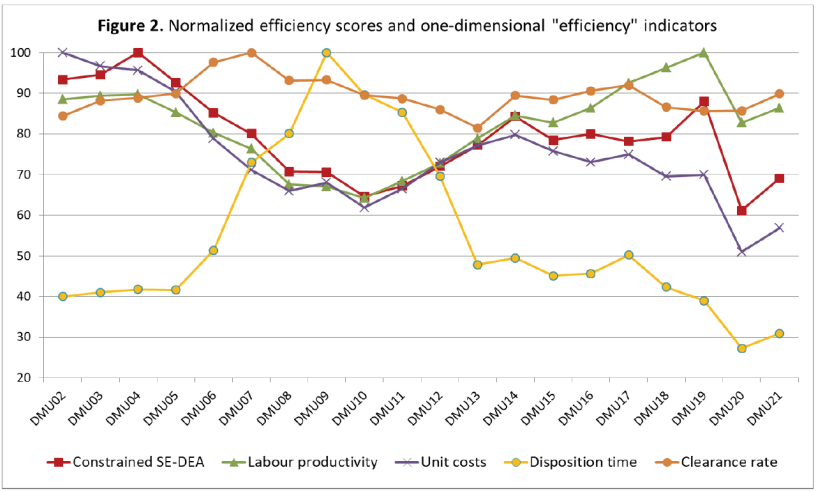
Source: Own computations using data from table 1 and *pydea* software

Table 9. Pearson's and Spearman's rank correlation coefficients between normalized constrained SE-DEA efficiency scores and normalized two-dimensional judicial performance indicators

Correlation test	Productivity	Unit costs	Disposition time	Clearance rate
Pearson's correlation coefficient (5% critical value = 0.4438)	0.6106	0.9070	-0.4442	-0.0309
Spearman's rank correlation (in parentheses *p*-values are given)	0.6150 (0.0073)	0.8615 (0.0002)	0.3774 (0.0999)	-0.0586 (0.7982)

Source: own elaboration based on research outcomes





Source: own elaboration based on research outcomes

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Agricultural Land Lease in Slovakia – selected issues and economic aspects

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Abstract

Motivation: Agricultural land is an important natural resource and a fundamental factor of production that Slovak farmers typically use based on numerous land lease contracts concluded with landowners, due to the high fragmentation of land ownership in Slovakia. Therefore, the legal regulation of agricultural land lease is crucial for the development of the agricultural land market, and it is essential to properly establish the legal rules that market participants should follow.

Aim: The main objective of our article is to determine whether the selected legal norms regulating land lease (the minimum rent and the administrative rent, and its modifications.), are appropriately adapted to the conditions of the land lease market in Slovakia.

Results: The results of the study indicate a need for legislative amendments if these legal rules are to fulfil the purpose intended by the legislator, rather than merely representing an unnecessary element within the already complex framework of land-related legal regulations

in Slovakia. Moreover, we formulated de lege ferenda recommendations based on an analysis of land rents in selected agricultural regions of Slovakia.

Keywords: agricultural land, land lease, land use, legal regulations, usual rent

JEL: K11, Q15, Q24, R14

1. Introduction

Agricultural land is a valuable, very limited, and slowly renewable natural resource that fulfils numerous ecological (e.g., providing living space for organisms, supporting biodiversity) and environmental functions in a country (e.g., water purification, climate regulation through carbon sequestration in the soil). As such, it directly affects quality of human life. Land also serves as a fundamental production factor for agriculture, which is essential for food security and the sustainable development of agriculture and rural areas. Therefore, appropriate attention must be paid to the legal regulation of land ownership, land use and land protection.

The fundamental problem regarding land ownership and use in Slovakia is the enormous fragmentation of land ownership (Lazíková et al., 2017). As a result, agricultural land is predominantly used by tenants (e.g., agricultural cooperatives and commercial companies), who manage hundreds to thousands of hectares of land through numerous lease contracts concluded with individual landowners or other authorized entities (such as the Slovak Land Fund)[1]. Consequently, the legal regulation of agricultural land lease is highly important, and special attention should be given to the proper structuring of its legal instruments, which directly affect the land lease market.

In some of our previous studies (e.g., Lazíková, Takáč, 2010; Lazíková et al., 2012; Bandlerová, Lazíková, 2016), we have already addressed certain aspects of the legal regulation of land lease. However, our efforts to apply the economic analysis of law were limited using a small and randomly selected sample of respondents of agricultural enterprises. The current legal regulation of land lease imposed an obligation on district offices to publish information on the usual rent annually from individual cadastral areas of Slovakia. This development facilitates a more accurate comparison between the actual conditions of the land lease market and the legal framework.

Legal instruments regulating land lease, such as the minimum rent and the administratively determined rent, should be based on analyses of current market conditions and regularly reviewed. We agree that farmland markets

[1] Slovak Land Fund is a legal entity established by law which administers state land and land with unknown owners, i.e., land whose ownership is not properly documented.

need to be closely monitored with up-to-date official statistics informing potential market participants and public policy (Loughrey, Geoghegan, 2024). However, the minimum rent established in Slovak legislation has remained unchanged since the adoption of the relevant law in 2004. The main objective of our article is to determine whether the selected legal norms regulating land lease (the minimum rent and the administrative rent, and its modifications.), are appropriately adapted to the conditions of the land lease market in Slovakia. Based on an analysis of the usual rent within the context of the current legislation, we have proposed several *de lege ferenda* solutions.

The paper is organized as follows: The second chapter discusses the legal and political conditions of the land lease market in Slovakia, based on national and foreign academic sources. The third chapter describes material and methods of the paper. The fourth chapter is divided into three subchapters. The first one examines the development and current state of the usual rent in selected agricultural regions of Slovakia. The second and third subchapters analyse selected legal instruments—particularly the minimum rent and the administratively determined rent—considering the current land lease market and formulates *de lege ferenda* recommendations. The fifth chapter presents the conclusions, including the *de lege ferenda* proposals, and outlines possibilities for further research on the land lease market.

2. Literature review

Agricultural land is not ordinary goods or capital but our heritage that need to be protected. Land is also one of the main factors generating various economic, environmental and social benefits in rural areas (Vranken et al., 2021). According to the UN Declaration on the Rights of Peasants and Other People Working in Rural Areas, peasants and other people living in rural areas have the right to land, individually and/or collectively including the right to have access to, sustainably use and manage land and the water bodies, coastal seas, fisheries, pastures and forests therein, to achieve an adequate standard of living, to have a place to live in security, peace and dignity and to develop their cultures (Article 17 of UN Declaration). However, agricultural land is an essential asset for societal development in general, for food production and ensuring food security for the general population (Vranken et al., 2021). There are many scenarios of experts how the land will be used in future. All scenarios show an increase in built-up areas and forest areas, some land is expected to become protected for nature or recreation, which could limit other land use changes and bioenergy crops will increase in all scenarios (Rounsevell et al., 2006)

Land regulations need a holistic approach but there is no specific EU law of land market transactions. Land market policies are predominantly formu-

lated at the national level and vary significantly among EU Member States (Loughrey, Geoghegan, 2024). While some countries have heavily regulated markets (e.g. Croatia, Hungary, Poland and Romania), other countries have a very liberal approach to land markets (e.g. Czechia, Denmark, Ireland and Finland) (Vranken et al., 2021). There is heterogeneity between MS in the type of agricultural land market regulations in place (Vranken et al., 2021). However, the land market, including the land rental market, is part of the EU internal market and must comply with the provisions on the free movement of capital (C-213/04). It means there are forbidden any restrictions that can limit the free movement of capital. Since land is not an ordinary commodity, the Court of Justice allowed certain exceptions in the public interest, such as restrictions on the establishment of residence by foreigners in a specific geographical area in order to preserve a permanent population and autonomous activities in that region (C-213/04) or restrictions on the acquisition of real estate for the purpose of maintaining agricultural communities, promoting the rational use of available land, and preventing natural disasters (C-452/01). Finally, the Commission's interpretative guidelines allow Member States a certain degree of flexibility in regulating agricultural land markets when serving various objectives, such as keeping land in agricultural use, maintaining a rural population, addressing land fragmentation, or monitoring and possibly reducing land concentration (2017/C 350/05). Boinon (2003) concludes that land market regulation (including price regulation) appears as a tool to support the allocation of land to the relatively more productive farmers. The certain level of land market regulation is necessary due to the risk of several undesirable outcomes that can emerge from market failures including excessive speculation, the accumulation of land ownership, market power and the inequitable distribution of rents among farmers and landowners (Odening, Hüttel, 2021).

The lease of agricultural land is an important form of land use in most of the European Union states (Marks-Bielska, 2021). Leasing is a widespread and highly successful economic institution because of: (1) Leasing is an attractive method of financing the acquisition of assets; (2) Leasing is a device for minimizing the; and (3) By dividing the rights to an asset between lessor and lessee, leasing permits the parties to specialize in different functions and to solve various impediments to contracting that would be difficult to overcome among separate owners (Merrill, 2020). Land rental activity varies across Europe with relatively high rental shares (over 50 per cent) in Germany, the Czech Republic and Slovakia and relatively low rental shares (less than 35 per cent) in Poland, Portugal and Greece (Loughrey et al., 2020). Freedom of land management (the scope of decisions concerning activities carried out on own land) is the greatest when the land is owned, but land lease brings about certain limitations imposed on both the lessor and the lesser (Marks-Bielska, 2021). However, formal written land leasing contracts

offer an alternative to land purchase for those farmers wishing to expand their land area and provide greater security relative to informal short-term rental contracts and are particularly important for beginning farmers with resources insufficient to purchase land (Onofri et al., 2023). Formal land leasing contracts are more prevalent in other Western European countries including France and Belgium where long-term land leases are the dominant form of land tenure (Adenuga et al 2021). The long-term land lease contracts are often perceived as secure, resulting in equal soil conservation behaviour on rented and owned plots and personal relationships between renter and landowner support soil conservation (Leonhardt et al., 2019). On the other hand, the deregulation of the land rental market is associated with a clear decreasing trend in the length of the contracts in Italy (Guastella et al., 2018). It confirms the research of Vranken et al. (2021) in Netherlands when declining in contract duration where short-term or liberal leases are increasingly adopted. Landowners prefer lease contracts with as little regulation as possible but reducing regulation requires a shift in co-ordination mechanisms from that of the handbook to that of the 'invisible hand' (prices) and 'handshake' (e.g., mutual adjustment) where the importance of trust and reputation will increase for both tenant and landowner (Slangen et al., 2008).

Slovakia is among the EU countries with the highest share of rented agricultural land. While the average share of rented land in the EU-27 is 58%, in Slovakia it reaches as much as 90% (European Commission, 2022). The explanation for such variation lies in the differences in historical context between countries (Bradfield et al., 2023). According to Swinnen et al. (2016), the reason for this high percentage in Slovakia is the fact that most of the agricultural land is used by large corporate farms. Nevertheless, this is not the main reason for the high share of rented land, but rather a consequence of it. Landowners want to change the current status quo, but the problem lies in the extreme fragmentation of land ownership, which prevents them from using and managing their own land in a rational way. Therefore, most landowners ultimately decide to continue leasing their land to large agricultural enterprises. However, we can agree with Swinnen et al. (2008) that the quantity of rented land is typically higher in countries with strict market regulations. It can be confirmed that Slovakia has relatively strict regulation of lease relations, particularly in favour of the tenant, although the legal framework is gradually becoming more liberal, e.g., through the abolition of the tenant's pre-emptive right to conclude a new lease contract in relation to the private persons as landowners (Lazíková, Bandlerová, 2017).

Slovak legislation on land lease regulates the duration of the lease, the minimum amount of rent, rent modifications, methods of lease termination and notice periods, the tenant's pre-emptive right to lease land from the Slovak Land Fund, protection of the tenant's investments, the creation of a lease relationship in the event of the landlord's inactivity, sublease arrangements,

and the tenant's obligations towards the district office. Despite the relatively strict regulation of land leases, it fails to adjust the minimum rent amount to reflect current market conditions and establishes different procedures for determining the minimum rent for various types of land. The latest amendment has improved market participants' access to information on rent levels in individual cadastral territories. District offices are now obliged to calculate the average rent in each cadastral area based on information provided by tenants and to publish this data annually. In the absence of necessary data, the law provides a procedure to determine this usual rent based on existing price regulations. However, the issue lies in the fact that these price regulations reflect land prices at the time of their adoption—approximately 20 years ago. Loughrey and Geoghegan (2024) argue that there is a need for this information on the distribution of both land rental and land sale prices and possibly on a quarterly rather than annual basis in the case of land sales. Finally, due to the lack of transparency regarding land prices—including rent — it is difficult to verify whether the property rights of landowners are fully respected in accordance with the case law of the European Court of Human Rights. This court has recognized and effectively protected the landlord's property rights against rent controls that were disproportionate and could not ensure a reasonable return on investment, and has contributed to reshaping the distribution of power between tenants and landlords (Sardo et al., 2024; cases of ECHR such as Bittó and others v. Slovakia, Hutten-Czapska v. Poland; Statileo v. Croatia; Vassallo v. Malta).

3. Methods

The main objective of our article is to determine whether the selected legal norms regulating land lease (the minimum rent and the administrative rent, and its modifications.), are appropriately adapted to the conditions of the land lease market in Slovakia. To achieve the main objective, the following partial goals were established: (1) Market rent is represented by the usual rent, which is published annually as of June 30 for the previous year by the district offices for each cadastral area on the website of Ministry of Agriculture and Rural Development of Slovak Republic. This data is based on records of agreed and paid rent between the contracting parties, therefore, it represents the average market value of rent in the cadastral territory of the municipality (smaller municipalities generally have one cadastral territory, while larger municipalities usually consist of several cadastral territories). The usual rents have been published since 2018, so we only have data for a six-year period up to 2023. We presume that if the rent amount did not change significantly over the six-year period, it suggests that lease contracts—typically concluded for a ten-year term—include a flat-rate rent that remains unchanged throughout the duration of the lease, and that the rent modification option provided by Act No. 504/2003

Coll. on the Lease of Agricultural Land, Agricultural Enterprise and Forest Land and on the Amendment of Certain Acts (hereinafter referred to as Act No. 504/2003 Coll. or the Lease Act) is not being utilized. If the rent were determined solely by market conditions, we would expect the usual rent to increase more rapidly during the observed period in areas with more fertile soil. (2) The minimum rent is intended to ensure adequate compensation for the landowner (lessor) for the willingness to make the land available for use by another person (lessee), a principle also affirmed by the case law of the European Court of Human Rights. We assume that if no statistically significant differences are found between the usual rent and the minimum rent, which is set at 1% of the land's value as determined under a specific regulation, the legal provision on the minimum rent amount is justified. Otherwise, it should be considered for amendment or repeal. According to the economic analysis of law, legal rules should be shaped by market principles, supporting the free forces of the market rather than hindering them (Posner, 2014). (3) When the usual rent cannot be determined due to a lack of data from tenants in the relevant cadastral area, it is replaced by administrative rent. The administrative rent is established pursuant to Decree No. 172/2018 Coll. of the Ministry of Agriculture and Rural Development of the Slovak Republic, which sets out the details on the method and scope of maintaining and providing records and determining the usual rent. This administrative rent is set at 2% of the value of arable land in the given cadastral area, as defined by a specific regulation. If statistically significant differences are not found between the usual rent and the administrative rent, it can be concluded that the administrative rent is appropriately set and can substitute the usual rent. Otherwise, its setting should be reconsidered and appropriately amended.

The subject of the study is the usual rent in two regions of Slovakia (NUTS 3), namely the Trenčín and Nitra regions. Both regions are in western Slovakia. The Nitra Region is particularly known as the agricultural heartland of Slovakia, with the most fertile soils in the country. Its southern border forms the boundary with Hungary. To the north, it borders the Trenčín region. The southern areas of the Trenčín region represent a continuous extension of agricultural production, gradually changing from plains and hills with agricultural land to a mountainous and forested area as one moves north. The northern border of the Trenčín region also marks the state border of Slovakia with Poland. Therefore, the studied area represents a continuous territory across the country from south to north. Both regions represent a representative sample of areas in Slovakia. They include all soil types (from the highest to the lowest quality) and a diverse range of landscape structures, from lowlands to hills and mountains. At the same time, the results are sufficient to enable the legislator to decide whether it is more appropriate to set legal rent limits at the national level or whether separate limits should be established for each region. Both regions are divided into 16 districts (LAU

2) and 829 cadastral areas. The Trenčín Region is divided into 9 districts with a total of 378 cadastral territories, and the Nitra Region into 7 districts with 451 cadastral territories.

The Nitra Region covers an area of 6,343.8 km² and lies within the Danubian Lowland. Of it, there are 464 thousand hectares (73% of the total area) of agricultural land, which is the largest area among all Slovak regions. Because of the soil quality, the land is primarily used for agricultural purposes. Arable land represents 87.23% of agricultural land; permanent grasslands account for 6.2%, vineyards make up 2.45% and gardens account for 3.02% of agricultural land. The remaining agricultural land consists of orchards. Hop fields are found only in the Trenčín Region. The Trenčín Region is one of the smallest regions of Slovakia (4,501.8 km²). Of it, the agricultural land covers 181,435 ha (40% of the total area), with arable land making up the largest portion at 53.13%. Permanent grassland occupies 40.88% of the agricultural land. Vineyards and hop fields together make up less than 1%.

We applied a legal analysis to the selected legal norms with the aim of identifying their application issues in relation to the current state of land lease relations and with the goal of proposing possible amendments.

For the data analysis, we use descriptive statistics indicators and statistical inference tests, such as the parametric paired t-test, non-parametric Kruskal – Wallis test and contrast tests performed using StatgraphicsPlus.

Descriptive analysis is used to compare the development of land rent among the districts in the selected regions.

To find out the statistically significant differences among the districts of both regions the Kruskal-Wallis test and contrast tests are used. While the Kruskal-Wallis test confirms or refutes differences between the evaluated districts, contrast tests identify the pairs between which these differences occur.

Moreover, to compare the development of the usual rent between the districts (LAU 1) of both regions, we applied sigma and beta convergence. We measured sigma convergence by taking the logarithms of the values of the average usual rent in the districts for the years 2018-2023. The standard deviation from the logarithmic values of the usual rent for the districts in the relevant years was plotted graphically to identify whether the trend indicates a convergent or divergent development of the usual rent. Beta convergence was calculated as the regression coefficient of the linear function of the logarithm of the average growth rate of UR and the logarithm of the UR values in the base period (more detailed in Minařík et al., 2013).

4. Results

The legal regulation of land lease is contained in several legal acts, the most important of which is Act No. 504/2003 Coll. It represents a special legal regulation in relation to the provisions on lease contracts in the Civil Code.

Over 20 years existence, the Act no. 504/2003 Coll. was amended many times, but there are still provisions that have not been amended during this entire period, such as the minimum rent. From a holistic approach and the theory of law and economics, it is essential that legal norms fulfill their roles in the land market and strive to create a balanced relationship between lessors and lessees. If the legal norms fail to fulfill this function, they should be amended or repealed so as not to unnecessarily burden market participants.

4.1. Development of the usual rent in selected NUTS III regions

Since typical rent data has only been published since 2018, we have six years of data up to 2023. If rent remained relatively stable during this period, it suggests that lease contracts include fixed rents with no adjustments, and the rent adjustment option under Act No. 504/2003 Coll. is likely not being exercised.

4.1.1. Usual rent among the districts of the selected regions

Charts 1 and 2 show that during the observed six-year period, the usual rent (UR) increased on average in every monitored district, though with varying intensity. In the districts of the Trenčín Region, the increase in UR was generally no more than €10 per hectare per observed period, except for the Bánovce nad Bebravou district, which borders the Nitra Region, and the situation here better corresponds to the conditions of the Nitra Region. Moreover, usual rent in the Ilava district in 2023 is distorted due to the use of administratively calculated UR instead of market-based values in six cadastral territories. While the measured UR ranged from €20 to €30 per hectare per year, the administratively calculated UR ranged from €90 to €100, which explains the extreme rise in average UR in the final observed year in the Ilava district. In the Nitra Region, the average UR per district increased over the observed period by approximately €19 per hectare. The overall increase in average UR across both regions over the period (3.97%) does not even correspond to the average inflation rate for the period 2019–2023 (6.20%). From this, we cannot conclude without further analysis that there are statistically significant differences among the monitored districts of both regions. Therefore, we conducted Kruskal – Wallis test for the districts of both regions in the first and last years of the observed period to confirm or refuse statistically significant differences between the districts of the two regions. There were not enough observations in each group (minimum 30) to use the parametric test.

The results of the Kruskal-Wallis test (p-value = 0.0 < 0.05) confirmed the existence of statistically significant differences among the districts. Subsequently, we used contrast tests available in StatgraphicsPlus to determine

which specific districts showed statistically significant differences. The districts of the Nitra and Trenčín regions were divided into six groups from the highest to the lowest average usual rent (Chart 3): Group I: Komárno (KN), Nové Zámky (NZ); Group II: Levice (LV), Šaľa (SA), Nitra (NR); Group III: Topoľčany (TO), Zlaté Moravce (ZM); Group IV: Partizánske (PE), Bánovce nad Bebravou (BN); Group V: Nové Mesto nad Váhom (NM), Púchov (PU), Trenčín (TN); Group VI: Ilava (IL), Myjava (MY), Prievidza (PD), Považská Bystrica (PB).

We then examined whether there was a change in the grouping of districts in 2023. The existence of statistically significant differences in the average usual rents across districts was confirmed (p-value = 0.0 < 0.05). Using contrast tests, we divided the districts into six groups again in 2023 as follows (Chart 3): Group I: Komárno, Nové Zámky, and Šaľa; Group II: Levice and Nitra; Group III: Topoľčany and Zlaté Moravce; Group IV: Bánovce nad Bebravou and Partizánske; Group V: Nové Mesto nad Váhom; and Group VI: Púchov, Trenčín, Ilava, Myjava, Prievidza, and Považská Bystrica. Changes in group assignments occurred in the district of Šaľa (shift from the second group to the first) and in the districts of Trenčín and Púchov (shift from the fifth group to the sixth). It can be concluded that the districts have formed groups in which the average usual rent gradually decreases from south to north, as the southern part of the observed area contains the most fertile soils and still the most favorable conditions for agricultural production. However, this fact may be significantly affected soon by climate change, particularly due to decreasing precipitation and an increasing number of tropical days.

4.1.2. Usual rent development in the districts of the selected regions

The results of the analysis show that during the observed period, there were no significant changes either in the high of usual rents or in the ranking of the districts. We were interested in whether UR increased more rapidly in districts with more fertile soil. If so, we would expect a divergent trend in the development of UR among the districts. If no, or only negligible, changes are observed, it can be concluded that this is due to long-term lease contracts that fix a flat rent throughout the lease duration, and therefore UR increases only slightly when some lease contracts expire, and new ones are signed at higher rents. We used sigma and beta convergence to prove it. According to Chart 4, a very weak divergent trend can be observed. A similar trend was recorded also among the districts of the Trenčín Region. In the Nitra Region, we observed a weak convergent trend, but the development in the final years of the observed period rather suggests stagnation. We try to confirm the results also by the beta convergence. In the calculation of beta convergence, we rely on the logarithmic growth coefficient and the logarithmic values of UR in the initial period (2018). However, the regression function shows that the

regression coefficient representing beta convergence is nearly zero (0.0075), and the model is not statistically significant. This implies that the calculations of both beta and sigma convergence indicate stagnation in the development of usual rents across regions. Rent is not increasing more rapidly in regions with fertile soil. This suggests that the flat rents agreed upon in lease contracts, which are typically concluded for a 10-year period, do not reflect the rate of inflation during that time or any other changes on the agricultural markets in the world or at least in the EU, nor does it make use of the options for rent modification allowed by law (e.g. natural events, economic events, land use restrictions, or prices changes of agricultural products).

4.2. The Minimum Rent

4.2.1. Short legal analysis of the minimum rent

The legal regulation of agricultural land lease was first codified in 2004. Even then, the provision of § 10 para. 1 stipulated that *for the conclusion of a lease contract for land used for agricultural purposes, a contract on the rent or on the method of its determination was required, whereby the rent was set at a minimum of 1% of the value of the agricultural land determined according to the evaluated soil-ecological unit*. However, the very first amendment modified the wording to *1% of the value of agricultural land determined according to a special regulation*. A footnote referred to this special regulation, specifically to § 43 para. 2 of the Act of the Slovak National Council No. 330/1991 Coll., according to which *the details regarding the determination of the value of land (...) shall be laid down in a generally binding legal regulation issued by the Ministry*. It is the Decree of the Ministry of Agriculture of the Slovak Republic No. 38/2005 Coll. on the determination of the value of land and vegetation on it for the purposes of land consolidation. It sets the value of land based on evaluated soil-ecological units, with the relevant rates listed in Annex No. 1 in Slovak crowns (SKK). It is one of the few regulations that has never been amended, meaning the rates established in 2005 have been applied unchanged for 20 years. The value of land ranges from 5,000 SKK to 120,000 SKK per hectare, which is app. €166 - €3,983 per hectare. The minimum rent is set at 1% of these values, meaning the minimum annual rent ranges from €1.66 to €39.83 per hectare. It is evident that the current market rent is significantly higher than the required minimum rent. The purpose of minimum prices is to ensure an adequate reward or compensation for a market participant. If the market price is several times higher than the minimum price, the given provision fails to fulfill its function. Before proceeding with statistical evidence, it is also necessary for completeness to mention that the stated minimum rent applies to land classified as agricultural land or other land used for agricultural purposes (e.g., land registered as a water surface

may in fact be arable land). Land registered as a built-up area, farmyard used for agricultural purposes, or land occupied by a building for agricultural purposes has a minimum rent determined based on the usual rent. According to § 10 para. 2 of Act No. 504/2003 Coll., *if the contracting parties do not agree otherwise, this value is determined as at least twice the usual rent in the given cadastral area*. There is missing the reason why the legislator did not similarly amend the minimum rent for agricultural land. According to the explanatory report to Act No. 291/2017 Coll., which amended the Lease Act, the amendment aimed to address the absence of rent calculation mechanisms for land not registered in the cadaster as agricultural or other land.

4.2.2. Statistical analysis of the minimum rent

To compare the usual and minimum rent and test for significant differences, we used a paired t-test. Usual rent data per cadastral area came from the Ministry's database. To avoid yearly outliers, we used the average value from 2018–2023. Minimum rent was set at 1% of land value, calculated per Decree No. 38/2005 Coll.

The paired t-test (Table 1) revealed a statistically significant difference between the usual and minimum rent in the Trenčín Region (p-value = 9.96×10^{-84} <0.05). The average usual rent in the Trenčín Region is €38.20 per 1ha per year. The average minimum rent in the region is €9.84 per 1ha per year. This clearly shows that the usual rent is several times higher than the minimum value prescribed by law. Thus, the legal provision no longer fulfills its intended function in the Trenčín Region, as it fails to protect landowners' right to fair rent given the significantly higher usual rent. To reflect market conditions, the 1% rate should be raised to at least 3.7%. The same test was then applied to each district in the Trenčín Region. The results indicate that the legal minimum rent should range from 2.4% to 6.1%, with average and median rates around 3.5%. The lower the land quality, the higher the minimum rent rate needs to be to match the usual rent. Setting a uniform rate for the entire region would cause the minimum rent in districts like Ilava, Nové Mesto nad Váhom, and Partizánske to exceed the usual rent by €10 to €15 per 1ha.

The average rent in the Nitra Region is €95.50/ha/year, while the legal minimum is €22.98. To better align with market values, the minimum should be raised to at least 4% of the land's regulated value. In the Nitra Region, the minimum rent should range from 3.1% to 4.5%, with an average and median of 4%, to meet its purpose. Lower rent variability suggests more uniform natural conditions than in the Trenčín Region. A 4% rate in the Nitra Region would negatively impact the Topoľčany district, raising the minimum rent by €14/ha/year above the usual rent.

The above indicates that there are several possible approaches to adjusting the minimum rent. Firstly, the minimum rent could be abolished alto-

gether, as it has been shown that the market can ensure the protection of landlords' rights more effectively than the current legal regulation. If minimum rent is deemed necessary, it could be based on: (1) usual rents by cadastral areas; (2) regional rates (e. g. 4% in Nitra, 3.7% in Trenčín); (3) district rates (2.4% - 6.1% in Trenčín, 3.1% - 4.5% in Nitra); (4) an updated and regularly revised pricing regulation from 2005. Setting rates by region or district could be enabled by a provision in Act No. 504/2003 Coll., authorizing the Ministry to set rates via regulation. This would avoid amending the Act for each change, with reviews needed only every 5–10 years.

The above proposals require more frequent updating of the legislation based on the monitoring of market rents. However, given the obligation to send annually data on the rent paid by individual tenants, this should not cause major problems or lead to additional costs on the part of the state or the tenants. The change in the legislation could have a potential impact on some tenants who offer lower rents than the minimum rent would have been set. Such lease agreements would have to be revised from the date of entry into force of the new legislation, i.e. in accordance with the transitional provisions, which could increase administrative costs for the contracting parties. It is therefore questionable whether the minimum rent is necessary at all and whether the land lease market is not sufficient to protect the rights of the contracting parties. The introduction of an information obligation of tenants towards landlords regarding data for determining the amount of rent and exercising the rights to modify it in accordance with the law, and a publicly available register of the average amount of rent in individual cadastral areas would be sufficient to achieve an adequate remuneration for land rent for landlords.

4.3. The Administrative Rents

4.3.1. Short overview of legal regulation

According to Decree No. 172/2018 Coll., *if in a cadastral area the sum of the provided land areas is less than one third of the agricultural land in the cadastral area, or if no data is provided, the usual amount of rent in euros per hectare is determined as 2% of the value of arable land in the given cadastral area according to a specific regulation. If the value of arable land is not determined in the cadastral area, the highest value from all neighboring cadastral areas is used.* The specific regulation refers to Act No. 582/2004 Coll. on Local Taxes and Local Fee for Municipal Waste and Small Construction Waste. This Act sets land values by cadastral area in euros per square meter. These values are used to calculate property taxes paid to local self-government based on real estate ownership. Although the stated values were originally derived from the land values calculated under Decree No. 38/2005 Coll., the legislator

increased the land values using various coefficients, up to threefold, to avoid low property taxes. As a result, these land values are higher than the land values determined under Decree No. 38/2005 Coll. This raises the question of whether the administratively set usual rent, at 2% of land value, reflects market conditions. The Ilava district example demonstrates that this setting is unlikely to align with market conditions in 2023.

4.3.2. Statistical analysis of the Administrative Rents

We used a two-sample paired t-test to compare the usual rent with the administratively set rent (2% of land value) in the Trenčín and Nitra regions. If differences are identified, we will simulate the corresponding rate reflecting the market rent rate. The results (Table 2) of the t-test indicate that 2% of arable land value is too high in both regions for the administrative rent to reflect market conditions. To align with market rent, the rate would need to be reduced to 1.1% in the Trenčín Region and 1.5% in the Nitra Region. In the districts of the Trenčín Region, a rate of 0.6% to 1.5%, with a median of 1%, would better reflect market conditions. In the districts of the Nitra Region, the appropriate rate would range from 1.2% to 1.5%, with a median value of 1.4%. To align with the market, the Trenčín rate should be reduced to 1% or 1.1%, and the Nitra rate to 1.4% or 1.5%.

The legal regulation of the administrative determined rent in the ministry's implementing regulation can be agreed with in principle, but a uniform rate for all of Slovakia is unsuitable. This rate does not correspond to the conditions in districts of the Trenčín or Nitra Regions. A region specific or district specific rate would better reflect the actual land lease market. Regular reassessment every 5 to 10 years could be made through an amendment to the decree.

Unlike the minimum rent, the institute of administratively determined rent cannot be abolished. There must be an alternative in the event of the absence of data from tenants. On the other hand, however, the rent determined in this way must correspond at least approximately to the rent determined by the market, whether for the previous period or from surrounding cadastral areas with comparable land quality and potential yields from it. The rent determined in this way would not have any negative impacts on the contracting parties and would at the same time provide transparent information about the rent in the given cadastral area. This would not distort the market situation and would equalize the information asymmetry between the contracting parties when concluding lease agreements regarding the determination of rent.

5. Conclusion

Agricultural land is a limited and practically non-renewable natural resource and part of our natural heritage. It is sought after not only by farmers but also by other sectors such as construction or energy. To ensure farmers remain competitive and can acquire land for producing healthy and high-quality food, it is important for land policy to protect their access to land. The fragmentation of land ownership and the issue of unknown landowners in Slovakia complicate the land market, giving farmers a competitive advantage in leasing land for agricultural production. Act No. 504/2003 Coll. aims to protect farmers' interests and investments while also respecting landowners' fundamental ownership rights. The European Court of Human Rights ensures legal protection of tenants by recognizing appropriate rent as compensation for allowing others to use their property. The land lease law should protect both tenants and lessors to establish a balanced tenant-lessor relationship.

From the perspective of Agency Theory, the agricultural land lease relationship reveals a typical principal–agent problem. Landowners (principals) are primarily motivated to preserve the long-term quality of their land and receive fair rental income, while tenants (agents) may focus on maximizing short-term profits. This divergence can lead to overexploitation of land or neglect of sustainable farming practices. The legal minimum lease term of five years and minimum rent payment, as prescribed by the legislator, aims to partially mitigate this conflict by incentivizing tenants to care for the land. However, asymmetric information—where landlords often lack insight into tenants' farming practices—intensifies agency costs related to monitoring and incentivizing responsible behavior. To address this, legislation should not only define minimum lease durations but also introduce information obligations for tenants. Similar to consumer protection laws where the entrepreneur is required to inform the consumer—who is typically the weaker party—in the land lease context, the landlord similarly suffers from limited access to relevant information. Imposing information obligations on tenants would promote transparency, accountability, and better decision-making by landowners, thereby enhancing the long-term sustainability of land use. As always, rights belong to the vigilant; it is then up to the landowner to use the provided information effectively.

From the viewpoint of Market Failure Theory, the agricultural land lease market does not function fully efficiently. Besides the information asymmetry, there are externalities such as land degradation, reduced biodiversity, and environmental damage—harms that are not reflected in market prices and that the market cannot correct on its own. Additionally, the concentration of land ownership may limit access for small-scale landowners and negatively affect rental pricing. These market failures suggest that legislative or

contractual mechanisms are necessary to reduce principal–agent conflicts and compensate for inefficient market outcomes. Therefore, effective lease agreements should include clear rules for land management, monitoring mechanisms, and incentives for sustainable land use. Legislation also plays a critical role in addressing externalities and ensuring fair access to land, which reduces the risk of market failure and supports long-term economic efficiency. In this context, the setting of minimum or administrative rents must reflect market conditions—those determined by supply and demand—or at least be grounded in them. Otherwise, such regulations risk distorting the land lease market or imposing unnecessary legal burdens. For example, minimum rent values set decades ago based on outdated price regulations, such as those from 2005, no longer serve their intended function. In the regions we studied, market-based lease pricing provided fairer outcomes for both parties than the legally fixed minimum rent established in 2004.

A positive development in this regard is the publication of usual rents on the Ministry's website, which supports greater transparency and can help both parties make more informed decisions. Nevertheless, the current land lease law fails to meet its intended objectives, and we therefore recommend repeal the legal norms on the land rent or its amendment to better align with modern economic realities and theoretical foundations.

There are some limitations of the study in relation to the dataset. Although tenants are required to report rental data to the district office annually, there are no penalties for failing to comply with this obligation. It is sufficient if data are submitted by tenants who farm at least one-third of the cadastral area for the usual rent to be calculated. If this area is smaller, the usual rent is determined by a special administrative procedure. It may happen that data from key tenants in the given cadastral area are missing, which can distort the results. The second limitation is that although tenants provide data to the relevant office, the result is an average rent for the entire cadastral area. This may include rents from expiring contracts that have not changed for 5–10 years, as well as rents from newly concluded leases, where at least a small rent increase is typically expected compared to the expiring ones. This can distort the resulting figure, the average rent, downward and create the impression that the market rent in each cadastral area is lower than it would be if based solely on newly concluded leases (yet it is higher than the minimum set by current law). However, the dataset on the ministry´s website is currently the only publicly available source of information on rental prices.

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Appendix

Table 1. Paired t-test of usual rent in the districts of Trenčín and Nitra regions

The Trenčín region			The Nitra region	
Usual rent		Minimum rent	Usual rent	Minimum rent
Mean	38,20	9,84	95,50	22,98
Observance	340	340	414	414
P (T<=1) two-tail	$9{,}96*10^{-84}$		$1{,}70*10^{-205}$	

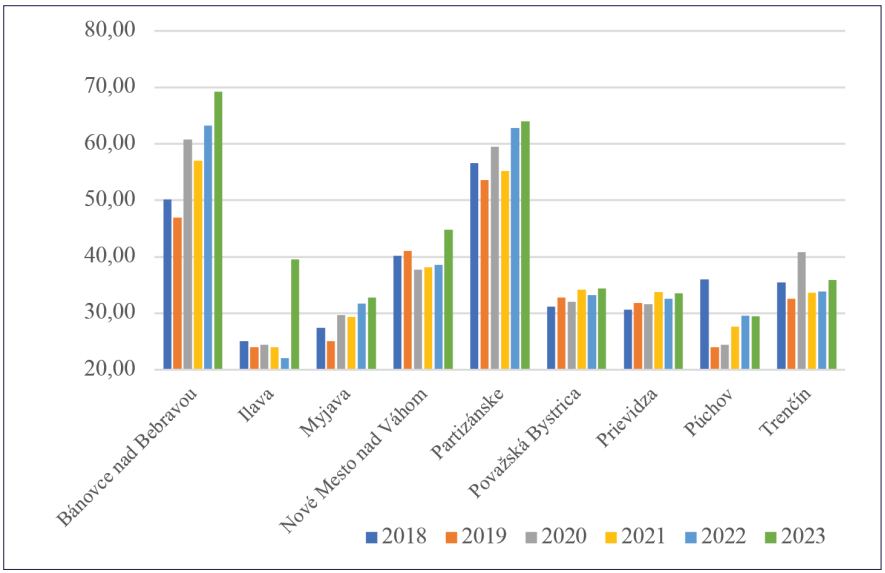
Source: Own preparation based on data available in the ministry website and in the legal regulations

Table 2. Paired t-test of usual rent in the districts of Trenčín and Nitra regions

The Trenčín region			The Nitra region	
Usual rent		Administrative rent	Usual rent	Administrative rent
Mean	38,20	69,62	95,50	131,34
Observance	340	340	414	414
P (T<=1) two-tail	$6{,}68*10^{-62}$		$2{,}95*10^{-85}$	

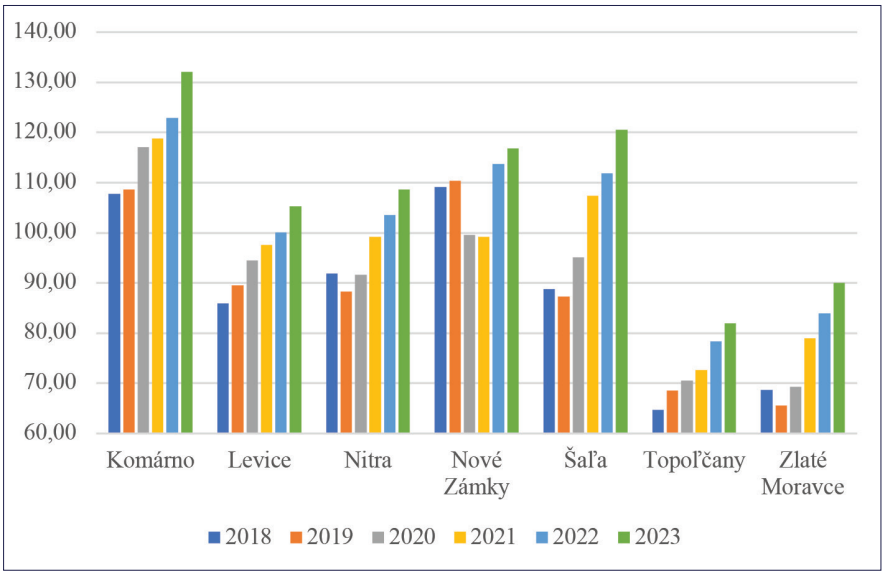
Source: Own preparation based on data available in the ministry website and in the legal regulations

Chart 1. Average usual rent in the districts of Trenčín region in euro per 1 ha



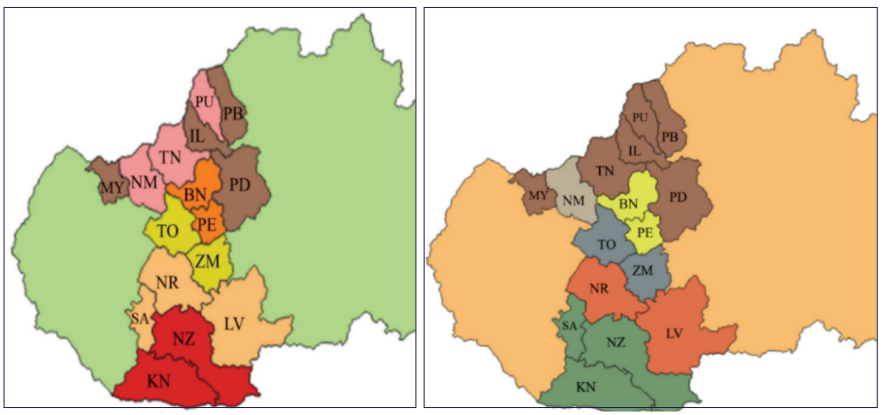
Source: Own preparation based on data available in the ministry website

Chart 2. Average usual rent in the districts of Nitra region in euro per 1 ha



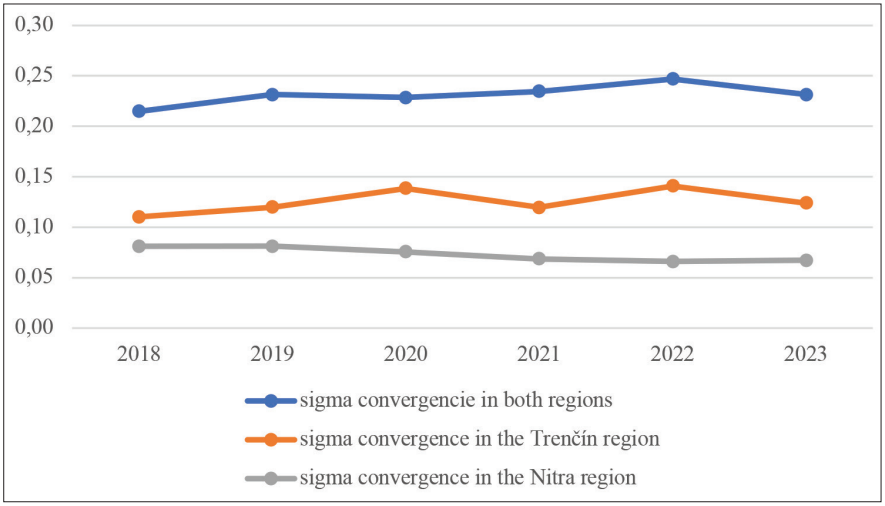
Source: Own preparation based on data available in the ministry website

Chart 3. The groups of districts according to the difference in the usual rent in both regions in 2018 2023



Source: Own preparation based on data available in the ministry website

Chart 4. The development of usual rent in the Trenčín and Nitra regions



Source: Own preparation based on data available on the ministry website

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The Resource Curse: The Situation of Women in Resource-Rich Countries

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Abstract

Motivation: The occurrence of the resource curse phenomenon presents a significant challenge to the long-term, stable, and sustainable economic development of resource-rich countries. The paradox is a multidimensional phenomenon, encompassing economic, political, and social dimensions. An important issue that has been receiving increasing attention from researchers in recent years is determining the impact of natural resource abundance on women's economic and political participation.

Aim: This study aims to assess the situation of women in the professional sphere in countries rich in natural resources.

Results: The study conducted a detailed analysis of the situation of women in the professional sphere of 46 resource-rich countries over the period 1990–2020. It employed a critical literature review and quantitative methods, including data mining techniques such as cluster analysis and descriptive statistics. Based on the results of the study, it was found that in countries rich in natural resources where Islam is practiced, the situation of women in the professional sphere, considering all analysed indicators, is worse. The significant impact of Islam on the situation of women in resource-rich countries is additionally confirmed by the results obtained for the United Arab Emirates, which were classified among highly developed countries that achieve positive development outcomes in the context of the resource curse. However, the situation of women in this country is just as unfavourable as in the group of predominantly Islamic states. Thus, Islam significantly affects the situation of women in the professional sphere in resource-rich countries. Moreover, economies that are more heavily dependent on natural resource revenues tend to exhibit deeper gender disparities across key dimensions of labour market participation. The best results regarding the situation of women are achieved by developed countries that have managed to avoid the effects of the resource curse.

Keywords: resource curse; resource-rich countries; gender inequality; labour market; comparative analysis

JEL: Q00; J16; J24

1. Introduction

The resource curse refers to the tendency of resource-rich countries to experience weaker economic development compared to those relying on non-resource sectors. Though not a rule, this paradox poses a major challenge to the sustainable growth of nations exporting strategic resources like fuel and minerals. Due to their global and socio-economic significance, the resource curse remains a key topic of research.

The resource curse is a multidimensional phenomenon with economic, political, and social implications. One increasingly studied aspect is its impact on women in resource-rich countries. This issue was first addressed in a landmark and highly influential article by Michael L. Ross (2008), titled "Oil, Islam, and Women". In it, Ross argued that oil production – not Islam – reduces female labour force participation, thereby limiting women's political and social influence. His findings sparked broad scholarly debate, with some supporting his conclusions (e.g. Grecu & Bataille, 2024; Simmons, 2016, 2019) and others expressing scepticism (e.g. Groh & Rothschild, 2012; Kang, 2009).

Existing research on women in resource-rich countries has explored diverse dimensions, including the Dutch disease (Groh & Rothschild, 2012; Mavisakalyan & Tarverdi, 2019a, 2019b; Ross, 2008, 2012), institutional factors (Kang, 2009), the role of democracy (Liou & Musgrave, 2016), and

geographic, cultural, and social contexts (Rorbæk, 2016; Ross, 2008). Findings remain inconclusive. However, both the resource curse and women's economic and political participation are increasingly seen as critical global issues. Moreover, gender dynamics within the extractive sector remain among the least understood in resource economics, underscoring the need for further research.

This study aims to assess the situation of women in the professional sphere in countries rich in natural resources.

This study focuses on one specific aspect of women's status in resource-rich countries: the professional sphere, defined as their position in the labour market in terms of economic activity, employment, and unemployment. In recent research, this issue has received rather indirect attention. At the same time, the significance of this dimension is highlighted by the fact that the first study conducted on this topic by Ross (2008, 2012) was dedicated to analysing the impact of natural resource abundance on the number of women in the labour force, which in turn affects their political influence.

The study put forward two research hypotheses. Based on a detailed analysis of the relevant literature, it was found that there is no consensus among researchers regarding the impact of natural resource abundance on women's economic participation. Therefore, the first hypothesis was formulated as follows:

H1: In resource-rich countries where economies are more dependent on natural resources, the situation of women in the professional sphere is less favourable.

A broad discussion among researchers on this issue also concerns the significance of Islam for the socio-economic situation of women in resource-rich countries (Kang, 2009; Rorbæk, 2016; Ross, 2008, 2012). There is no consensus among researchers on this matter either. Therefore, the second hypothesis was formulated as follows:

H2: Islamic countries rich in natural resources are characterized by the least favourable situation for women in the professional sphere within the studied group of countries.

The study analysed women's professional status in 46 resource-rich countries from 1990 to 2020, using clearly defined selection criteria and data obtained from the World Bank's World Development Indicators and Gender Statistics Database, as well as the International Labour Organization's database. Covering a 30-year span allowed for identifying long-term trends, with 2020 chosen as the endpoint due to its relative stability before the COVID-19 pandemic. To test the research hypothesis, the study combined a critical literature review with quantitative methods, including data mining techniques like cluster analysis and descriptive statistics.

The paper is organized as follows: Section 2 provides a detailed review of the theoretical and empirical literature. Section 3 outlines the research meth-

ods used, along with the data and statistics specifications. Section 4 presents the results and discussion, while Section 5 concludes the paper.

2. Literature review

The phenomenon of the resource curse (also known as the paradox of plenty (Cooper & Karl, 1998), the paradox of economic development in resource-rich countries, is a subject of extensive research by specialists in economics (Auty, 2004; Dymitrowska, 2015, 2023; Stevens, 2005), political science (Ross, 1999; Humphreys, 2005) and sociology (Papyrakis & Parcero, 2022). While in initial studies the resource curse was analysed in economic terms, focusing primarily on the significance of Dutch disease (Corden & Neary, 1982), over time the scope of the paradox of plenty has expanded to include new dimensions – political, social, institutional, environmental, and cultural (e.g. Humphreys, 2005; Ross, 2004; Rosser, 2006). Thus, the literature on the natural resource curse is extensive and multidimensional.

A relatively new topic in research on the resource curse is the assessment of the impact of resource abundance on the situation of women in the economic, political, and social spheres. Although this dimension of the resource curse has not yet been thoroughly studied, certain areas of research can be identified based on the literature review (Scheme 1). These include: the Dutch disease argument, social and cultural determinants, political conditions (democracy, autocracy), institutional quality and governance, industry specifics, and demographic trends.

One of the most influential studies on this topic is Michael Ross's (2008) analysis, based on the Dutch disease model by Corden and Neary (1982). Dutch disease describes how a resource boom harms the competitiveness of non-resource sectors, often causing their decline and increasing reliance on natural resource exports (Corden & Neary, 1982; Dymitrowska, 2015). Ross argued that, in developing countries, women are typically employed in tradable sectors – especially low-wage export industries and agriculture. When these sectors contract, women's labour market position worsens. Meanwhile, rising male incomes in the resource-extraction sector increase total household earnings without requiring women's labour market participation, which reduces their motivation to seek employment. This decline in economic participation also diminishes women's political influence (Ross, 2008).

Ross also highlights the role of socio-cultural factors, particularly the influence of Islam, in the context of the resource curse and women's status. Analysing data from 169 countries (1993–2002), he concludes that it is oil – not Islam – that reduces female labour force participation, thereby limiting women's political influence. He further argues that oil-producing states often maintain patriarchal norms, laws, and institutions that reinforce gender inequality.

Ross's study sparked a heated debate among researchers. His findings have faced considerable criticism and have been empirically re-examined. Some researchers agreed with Ross's approach and, by expanding his study to include new issues, reached similar conclusions (Awoa Awoa et. al., 2022; Grecu & Bataille, 2024; Mavisakalyan & Tarverdi, 2019a, 2019b). However, others remained sceptical, particularly regarding the argument related to the significance of Islam for the situation of women in resource-rich countries (Groh & Rothschild, 2012; Kang, 2009; Rorbæk, 2016).

For example, Simmons (2016, 2019), in his study of US states over the period 1997–2012, presented evidence of a "gendered resource curse". He argued that resource abundance, combined with patriarchal attitudes, leads to a reduction in the significance of women in the economic and political spheres.

Liou and Musgrave (2016) support Ross's view, linking autocratic survival in resource-rich countries to state-imposed gender bias. They highlight the role of political regimes in shaping the resource curse's gendered effects. Their analysis shows that in autocratic, resource-rich states, resource wealth fosters anti-social policies that restrict women's political rights and freedoms.

Mavisakalyan and Tarverdi (2019a, 2019b), building on Ross (2008), confirmed a negative link between resource abundance and women's employment, political participation, and social engagement. They also identified two additional effects: economically, oil production shifts women's employment from the traded to the non-traded sector; socially, it leads to earlier marriage and higher fertility rates among women.

Awoa Awoa et al. (2022), expanding on Ross's work, analysed 130 developing countries (2002–2017) and found that higher resource rent *per capita* strongly undermines women's political empowerment. Resource abundance was shown to reduce female employment in manufacturing and tradable services, widen gender gaps in education, and increase fertility rates. The study also emphasized the critical role of institutional quality and governance.

The most recent study confirming the negative impact of resource abundance on women's economic and political participation is by Grecu and Bataille (2024). Analysing giant oil discoveries, they found these events correlate with poorer outcomes for women – higher male-to-female ratios, more teen births, and lower female tertiary education rates. However, during oil price increases, this negative effect is not significant, and impacts on health outcomes tend to fade after eight years.

Among the scholars critical of Ross's conclusions is Kang (2009), who reanalysed his study by incorporating the institutional dimension. She found that gender quotas mitigate the negative impact of oil rents on women's political representation in resource-rich countries. Both her findings and those of Awoa Awoa et al. (2022) highlight the importance of institutions in shaping gendered outcomes of the resource curse. Recent research increasingly

emphasizes that institutional quality and governance are key to counteracting the resource curse (e.g., Entele, 2021; Mehlum et al., 2006; Narh, 2023).

The institutional dimension also includes the role of democracy in the resource curse. In principle, democracy ensures civil liberties, the rule of law, and equal political rights – including for women. Thus, its erosion limits women's freedoms and participation in economic and political life (Awoa Awoa et al., 2022). Yet, many resource-rich countries lack democratic governance and are ruled by autocratic regimes.

Among other sceptics of Ross's study are Groh and Rothschild (2012), re-evaluating his (2008) study, found no causal link between oil rents and female labour force participation via the gendered Dutch disease. Instead, they emphasized the role of Islam in explaining low female labour force rates. Similarly, Rorbæk (2016) argued that the negative impact of oil on women's rights is mainly driven by the 11 Arab OAPEC countries. He noted that Muslim countries underperform regardless of oil wealth, income, or democracy, attributing this to enduring orthodox elements of Islamic culture that limit women's empowerment.

Beyond institutional and cultural factors, scholars also examine demographics and sector-specific dynamics. Rising natural resource values are linked to higher fertility rates (Black et al., 2013; Grecu & Bataille, 2024), which significantly reduce women's labour force participation – each birth lowering work availability by nearly two years. Thus, shifts in resource value can directly affect female employment (Grecu & Bataille, 2024). The extractive sector is traditionally male-dominated, with limited female employment – even in developed countries. When this industry dominates the economy, women's labour market prospects tend to worsen, especially in resource-dependent nations.

The main conclusions drawn from the literature review are summarized in Scheme 1 and Table 1.

The reviewed literature consistently indicates that resource abundance tends to depress women's participation in the labour market and, consequently, their political and social influence. These effects appear to operate through several mechanisms, including rising male incomes in the extractive sector, the reinforcement of patriarchal norms, and institutional weaknesses typical of rentier economies. Studies further suggest that these dynamics are particularly pronounced in Muslim-majority countries, where cultural and religious norms intersect with the economic structure of resource dependence to constrain women's autonomy. Accordingly, the empirical analysis tests two hypotheses: first, that women's professional position is less favourable in more resource-dependent economies; and second, that this disadvantage is most evident in resource-rich Islamic countries.

3. Methods

3.1. Research group (selection criteria and procedure)

The study focuses on resource-rich countries typically analysed within the context of the resource curse. According to the authors, this phenomenon applies to countries whose economies rely heavily on the extraction and export of natural resources – not merely those with large reserves that are neither extracted nor exported.

After conducting a detailed analysis of the literature to define the research group, the following criteria were adopted: the average annual revenues of the mining industry (as a % of GDP) exceed 25%, or 25% of the average annual exports consist of natural resources. The choice of these percentage thresholds was based on findings presented in previous research studies dedicated to the resource curse (Auty, 2004; Dymitrowska, 2015; Gelb, 1988; Stevens, 2005; van der Ploeg, 2011).

The study focuses on strategic resources commonly linked to the resource curse: fuel resources (oil, natural gas, coal) and mineral resources, as defined by the World Bank: tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate.

Data were sourced from the World Bank's World Development Indicators for 1990–2020, with 1990 chosen for data availability and 2020 marking the pre-COVID-19 cutoff. Indicators included rents from minerals, oil, gas, and coal (% of GDP), as well as fuel and metal exports (% of merchandise exports). From these, two indices were calculated: total natural resource rents (TNRR) and total natural resource exports (TNRE). The final sample comprised 46 countries that exceeded set thresholds in at least 16 of the 31 years.

Some countries were excluded from the study for various reasons, such as a lack of natural resources, a focus on the export of services or agricultural products, and significant gaps in available statistical data. The final research group comprised 41 countries, as presented in Table 2.

3.2. Country classification

The classification of the examined group of resource-rich countries was conducted using cluster analysis, which is a technique that enables the detection of interdependencies among objects. The choice of this method (Kaufman and Rousseeuw, 2009, pp. 1–3) was motivated not only by its effectiveness in detecting structures based on a set of specific variables (varying both temporally and spatially) but also to ensure the clarity of the comparative analysis of the situation of women in the labour market across the examined group of countries.

The purpose of the cluster analysis conducted in this study is to categorize the group of countries under investigation in terms of the professional situation of women and men over the period 1990–2020. Based on the conducted literature review and examination of international organizations' databases, variables characterizing the economic situation of the studied countries were selected for cluster analysis, with particular emphasis on manifestations of the resource curse phenomenon[1].

In the course of the analysis, the selected variables were collected for 41 countries over the period 1990–2020. Missing data points were replaced with country-specific averages. The data used in the cluster analysis were standardized. The Ward method, an agglomerative clustering technique, was employed as the classification method. This approach assumes that initially each object represents a separate cluster. Distances between all objects are calculated, and the two most similar are merged into a pair. The algorithm then iterates this process until all objects are merged into one cluster. Euclidean distances were applied as the similarity measure (Andenberg, 2014, pp. 141–148).

3.3. Indicators of gender inequality in the professional sphere

The presented indicators are intended to capture the differentiated status of women and men with regard to the level and structure of their economic activity, employment, and unemployment. Variations in the values of the analysed variables reflect the extent of gender-based disparities within the professional sphere. The literature highlights several fundamental metrics used to quantify gender inequality in the labour market (Bettio et. al., 2009; Domagała, 2019, pp. 31–35).

The first of these measures is the Economic Activity Disparity Index (hereinafter referred to as EADI), which is defined by the following formula:

$$EADI = Lf_m - Lf_f,$$

where:
Lf_m – Labour force participation rate, female,
Lf_f – Labour force participation rate, male.

Subsequently, attention should be directed to the Employment Disparity Index (hereinafter: EDI), which is defined by the following formula:

$$EDI = E_m - E_f,$$

[1] Variables used for cluster analysis (World Bank 2025a;2025b): Fuel exports (% of merchandise exports); GDP per capita (constant 2015 US$); Labour force, female (% of total labour force 15+); Ores and metals exports (% of merchandise exports); Total natural resources rents (% of GDP).

where:
E_m – Employment to population ratio, male,
E_f – Employment to population ratio, female.

Another indicator under analysis addresses gender inequality in the context of unemployment — Unemployment Disparity Index (hereinafter: UDI) – and is defined by the following formula:

$$UDI = U_f - U_m,$$

where:
U_f – Unemployment, female (% of female labour force)
U_m – Unemployment, male (% of male labour force)

These indices can take values ranging from –100 to 100. A positive value of the index is interpreted as indicating a higher level of economic activity (EADI) or employment (EDI) among men than among women during the analysed period, while a negative value reflects the opposite relationship. In the case of the Unemployment Disparity Index (UDI), a positive value indicates a higher unemployment rate among women compared to men, whereas a negative value signifies a higher unemployment rate among men. The closer the values of these indices are to zero, the greater the level of gender equality observed in the respective dimension of the labour market.

The observation of changes in employment structure by gender within the economy is conducted through the analysis of the employed population according to, among other factors, economic sectors and ownership, economic sections, occupational groups, positions, and employment status (Kwiatkowska, 2013, pp. 179–180). This approach aims to reveal the extent of gender inequality within various labour market structures by analysing feminization and masculinization indicators across different segments (Strawiński et al., 2016). The article presents a comparative analysis of the identified country clusters using the following structural indicators (hereinafter referred to as RATIO).

- Ratio of female to male employment in three economic sectors:

$$RATIO_{ststus} = FE_{group\ 1,\ 2,\ 3} \Big/ ME_{group\ 1,\ 2,\ 3}$$

where:
FE sector 1,2,3: Female Employment in: [1]agriculture/ [2]industry/ [3]service,
ME sector 1,2,3: Male Employment in: [1]agriculture/ [2]industry/ [3]service.

- Ratio of female to male employment by status on the labour market:

$$RATIO_{ststus} = {}^{FE_{group\ 1,\ 2,\ 3}}\Big/ ME_{group\ 1,\ 2,\ 3}$$

where:
FE status 1,2,3: Female Employment in a group of: [1]employers/ [2]self-employed/ [3]employees,
ME status 1,2,3: Male Employment in a group of: [1]employers/ [2]self-employed/ [3]employees.

A value of the indicator equal to 1 (RATIO = 1) is interpreted as gender equality. An indicator value greater than 1 (RATIO > 1) signifies feminization of the given structure, whereas values below 1 (RATIO < 1) indicate masculinization[2].

In the context of employment analysis by labour market status, it is equally important to examine employment distribution by required skill levels (ILO, 2023). Such an approach facilitates the identification of occupational segregation and its associated phenomena, notably the glass ceiling and the sticky floor effects (Totleben&Domagała, 2024, pp. 82-84).

4. Results and discussion

4.1. Cluster analysis

The cluster analysis was conducted in three stages:
Stage 1: The criterion of the largest relative increase in distance (>10) between consecutively formed clusters was adopted, indicating the removal of four dendrogram edges (see Scheme 2):

- Between groups [A, B] – [C, D, E]: 26.39
- Between groups [C] – [D, E]: 14.93
- Between groups [D] – [E]: 11.86
- Between groups [A] – [B]: 10.06

Stage 2: The countries were divided into five groups and given labels[3]:

- Group A: Islamic countries (IC): Algeria, Bahrain, Egypt, Iran, Iraq, Oman, Saudi Arab, Yemen[4];

2 For ease of interpretation, the raw ratio value is multiplied by 100, allowing the result to be expressed as the number of women per 100 male workers.

3 These labels and their abbreviations will be used throughout the article.

4 The classification of Islamic countries adopted in this study serves as an analytical simplification aimed at capturing the interaction between resource dependence and socio-cultural norms in predominantly Muslim societies, rather than implying homogeneity within this group.

- Group B: Highly resource-dependent countries (HRDC): Angola, Azerbaijan, Brunei Darussalam, Congo, Rep., Gabon, Kuwait, Libya, Qatar, Turkmenistan;
- Group C: Countries rich in mineral resources (CRMR): Armenia, Bolivia, Chile, Guinea, Jamaica, Mauritania, Mongolia, Mozambique, Niger, South Africa, Zambia;
- Group D: Countries that avoided the resource curse (CARC): Australia, Canada, Norway, Peru, United Arab Emirates;
- Group E: Countries rich in fuel resources (CRFR): Cameroon, Colombia, Ecuador, Indonesia, Kazakhstan, Nigeria, Russian Federation, Trinidad and Tobago.

Stage 3: To validate the cluster analysis performed using the agglomerative method, a k-means clustering approach was applied as a control, employing Euclidean distances and defining five groups. The results were largely consistent with the agglomerative clustering, except for five countries: Nigeria (assigned to group B instead of E), Kuwait (group A instead of B), Egypt (group E instead of A), Bolivia (group E instead of C), and South Africa (group E instead of C)[5].

The examined countries were thus grouped based on the highest possible similarity, with particular emphasis on the dependence of their economies on natural resource wealth. A preliminary comparative analysis of the cluster analysis results and the classification of resource-rich countries according to key labour market indicators (World Bank, 2025a) suggests that countries within each cluster may also share similarities regarding the economic status of women in the professional sphere.

Countries in cluster IC exhibited, on average during the study period, the lowest levels of women's economic activity (19.4%), the lowest average employment rate (16.92%), and the highest average unemployment rate (14.47%). Conversely, countries in group D (CARC) showed the highest average female employment rate (52.74%) and the lowest unemployment rate (5.4%) among the studied clusters between 1990 and 2020. Moreover, countries rich in mineral resources (cluster C) and fuel resources (cluster E) both demonstrated female employment rates exceeding 50% of the total economically active female population—50.83% for cluster C and 52.23% for cluster E—and unemployment rates below 10%—8.6% for cluster C and 7.78% for

5 In the case of Bolivia and South Africa, the change in cluster assignment may stem from their specialization in exporting mineral as well as fuel resources. For Egypt, both its specialization in the export of oil and natural gas and the presence of Islam as the state religion play a key role. The significant influence of each of these factors may have affected the clustering outcome. A similar situation can be observed in Kuwait, where Islam is also the state religion. High resource dependence is one of the key drivers of the resource curse. Nigeria is a country highly dependent on the extraction and export of natural resources. When applying various analytical methods, this factor may outweigh the influence of export specialization in fuel commodities.

cluster E. Countries classified in the HRDC group had an average female employment rate of 46.85% and an average unemployment rate of 12.56%.

4.2. Gender inequalities in the labour market

The level of inequality in the labour market can be assessed through an analysis of key indicators such as economic activity, employment, and unemployment. When this analysis is complemented by a gender perspective, it provides a clearer picture of the disparities between women and men in the labour market. In the context of highly developed countries and European economies, considerable academic attention has been devoted to the gender pay gap (Blau & Kahn, 2017) as well as the phenomenon of the gender gap on corporate boards (Tyrowicz et al., 2020). In contrast, for resource-rich countries, a more accurate assessment of women's position in the labour market may be achieved by examining basic labour market activity measures through a gender lens, such as the Economic Activity Disparity Index (EADI), the Economic Disparity Index (EDI), and the Unemployment Disparity Index (UDI)[6].

An analysis of the average values of the EADI (see Chart 1) across the identified clusters reveals that, in all country groups, women were less economically active than men. The respective average EADI values were: [A] – 55.54; [B] – 18.61; [C] – 17.21; [D] – 21.42; [E] – 19.68. Notably, the largest gender disparities were observed in the group of Islamic countries. A similar pattern emerges when examining gender inequalities in employment as measured by the EDI (see Chart 2), where the average values for each country cluster during the study period were as follows: [A] – 52.31; [B] – 18.71; [C] – 16.37; [D] – 20.65; [E] – 19.30. In both cases, the smallest gender gaps in economic activity and employment were recorded in group [D] – the countries that avoided the resource curse – when the United Arab Emirates was excluded from the analysis (EADI: 14.17; EDI: 13.17). This finding may indicate the significant influence of Islamic religious norms, cultural patterns, and related gender stereotypes on labour market gender disparities.

This trend is also evident in the context of unemployment, which disproportionately affects women. According to the average values of the UDI (see Chart 3): [A] – 6.8; [B] – 2.9; [C] – 1.2; [D] – 0.3; [E] – 1.7, women consistently exhibited higher unemployment rates than men across all country clusters. Once again, the most pronounced disparities were found in the group of Islamic countries, while the smallest gender gap was observed in the group of countries that avoided the resource curse.

6 The closer the values of these indices are to zero, the greater the level of gender equality observed in the respective dimension of the labour market.

Another important dimension in the analysis of gender inequality in the labour market is occupational segregation, which manifests in the masculinization or feminization of specific economic sectors or occupational groups – often characterized by distinct skill levels or labour market status, such as employer roles. An examination of the $RATIO_{sector}$ across economic sectors (see Chart 4)[7] reveals that the services sector is feminized in all examined country groups ([A] – 117; [B] – 122; [C] – 115; [D] – 138; [E] – 134). Agriculture shows relative gender parity in clusters [C] – 96 and [A] – 90. In contrast, a male employment predominance is observed in the remaining clusters: [B] – 84; [E] – 71; [D] – 47. Industry, on the other hand, is marked by masculinization across all country groups, with the most pronounced imbalance in group [D] – 32, followed by [B] – 42; [A] – 48; [C] – 58; and [E] – 61.

When examining gender disparities in labour market status ($RATIO_{status}$ – see Chart 5), particular attention should be paid to the masculinization of the employer group across all analysed country clusters: [A] – 33; [D] – 37; [E] – 44; [C] – 45; [B] – 47. Among the self-employed, relative gender parity was observed across most groups: [A] – 97; [B] – 92; [C] – 109; [E] – 104, with the exception of group [D] – 65. Interestingly, group [D] also showed full gender parity among employees ([D] – 100). In contrast, for the remaining clusters, $RATIO_{employees}$ values indicate a male-dominated structure in the employee segment: [A] – 92; [B] – 81; [C] – 72; [E] – 82. This underlines the importance of further analysing the employee category in terms of the skill levels associated with male and female occupations.

The adopted analytical approach enabled the identification of the glass ceiling effect in resource-rich countries. In all analysed clusters, women were, on average, underrepresented in high-skill occupations compared to men: [A] – 24%; [B] – 39%; [C] – 41%; [D] – 40%[8]; [E] – 49% (see Chart 6). The gender gap was most pronounced in the Islamic Countries group, where less than one-quarter of individuals in high-skill positions were women.

Moreover, the analysis revealed the presence of the sticky floor phenomenon (see Chart 7) during the study period. In clusters [B] and [C], over half of all employed women were concentrated in low-skill occupations ([B] – 51%; [C] – 54%), typically associated with low wages and limited social protection. In cluster [A] – 32% and [E] – 34%, more than one-third of all working women held low-skill jobs. The lowest average share was observed in cluster [D] – 29%, with some countries—such as Canada, Australia, and Norway—recording values below 10% (see Chart 7). Although vulnerable employment affects both genders, women are disproportionately represented

7 The RATIO indicator reflects the number of women employed per 100 men in a given economic sector.

8 When the United Arab Emirates are excluded, the indicator stands at 46%.

in certain forms of such work. Men are more likely to engage in own-account employment, whereas women more often occupy unpaid contributing roles within households or family businesses.

5. Conclusion

Globally, women face greater challenges in accessing employment compared to men. When employed, they are disproportionately concentrated in low-quality and precarious jobs, with limited prospects for significant improvement. Across countries at all stages of economic development, women's participation in paid employment is primarily shaped by individual preferences. However, these preferences are significantly influenced by socio-economic constraints associated with traditional gender roles. Gender roles vary significantly across regions, cultures, religions, and individual households. Despite that, women who seek employment encounter greater barriers to labour market entry than men, with this disparity being particularly pronounced in Africa and the Arab States.

The results of the conducted analysis offer empirical support for both research hypotheses. In line with H1, countries whose economies are more heavily dependent on natural resource revenues tend to exhibit deeper gender disparities across key dimensions of labour market participation. The best results regarding the situation of women are achieved by developed countries that have managed to avoid the effects of the resource curse. These findings align with theoretical perspectives on the resource curse, which emphasize not only institutional stagnation but also the persistence of traditional social structures that constrain women's economic agency. Furthermore, H2 is confirmed by the evidence that Islamic resource-rich countries show the most pronounced gender inequalities within the examined sample. These countries consistently score lowest in indicators measuring women's participation in employment, entrepreneurship, and high-skill occupations, while showing the highest levels of occupational segregation and the strong effects of both the glass ceiling and the sticky floor. The intersection of resource dependence and cultural-religious norms rooted in patriarchal interpretations of Islam appears to exacerbate structural barriers to gender equality in the labour market. Taken together, these findings highlight the complex interplay between economic structure, institutional quality, and socio-cultural factors in shaping the professional status of women.

Future research on resource-rich countries should explore the impact of the COVID-19 shock and assess post-pandemic labour market dynamics, while also more deeply examining cultural determinants—such as religious affiliation and prevailing family models—that shape gender roles and labour market outcomes.

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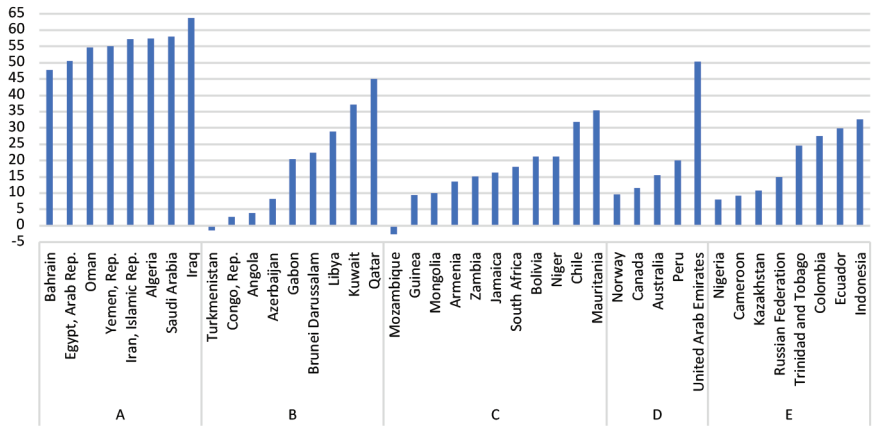
Appendix

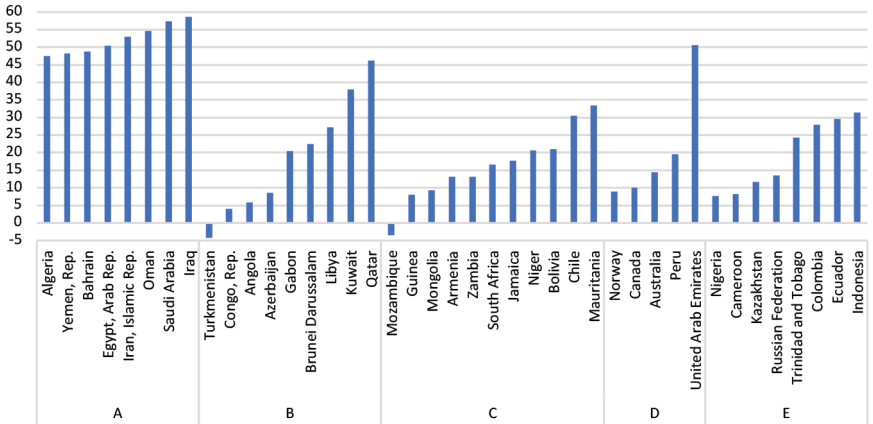
Chart 1. Economic Activity Disparity Index by Gender



Additional information: The countries were ranked by the increasing value of the variable in each group. Average values for each country from 1990 to 2020 were used in the analysis.

Source: Own elaboration based on World Bank 2025a.

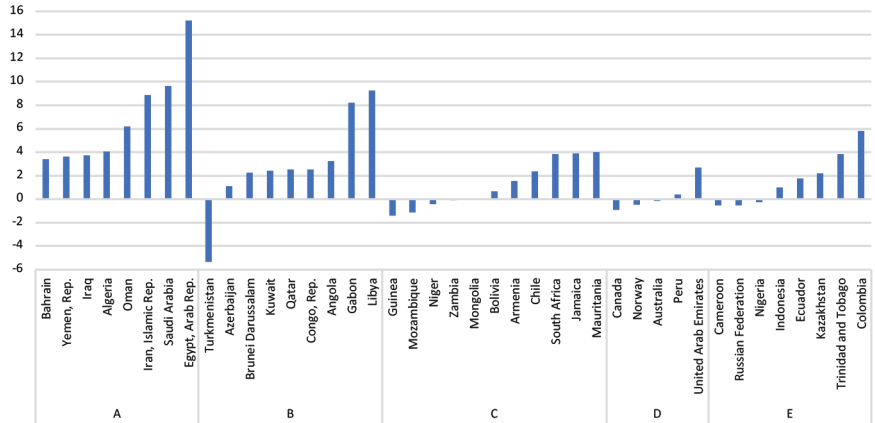
Chart 2. Employment Disparity Index by Gender



Additional information: The countries were ranked by the increasing value of the variable in each group. Average values for each country from 1990 to 2020 were used in the analysis.

Source: Own elaboration based on World Bank 2025a.

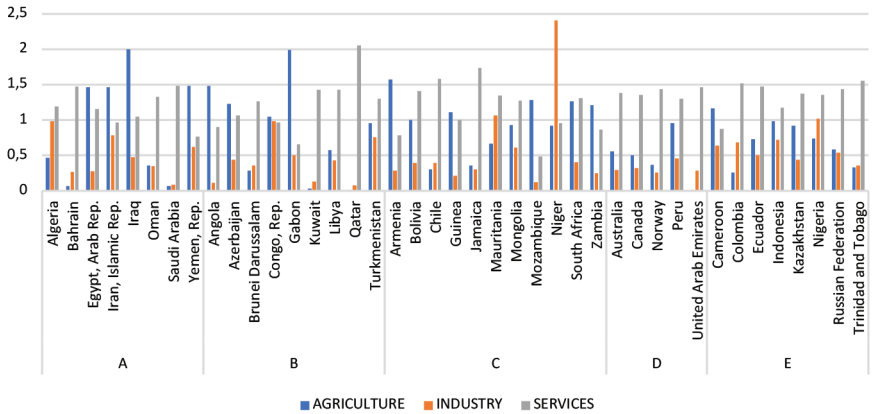
Chart 3. Unemployment Disparity Index by Gender



Additional information: The countries were ranked by the increasing value of the variable in each group. Average values for each country from 1990 to 2020 were used in the analysis.

Source: Own elaboration based on World Bank 2025a.

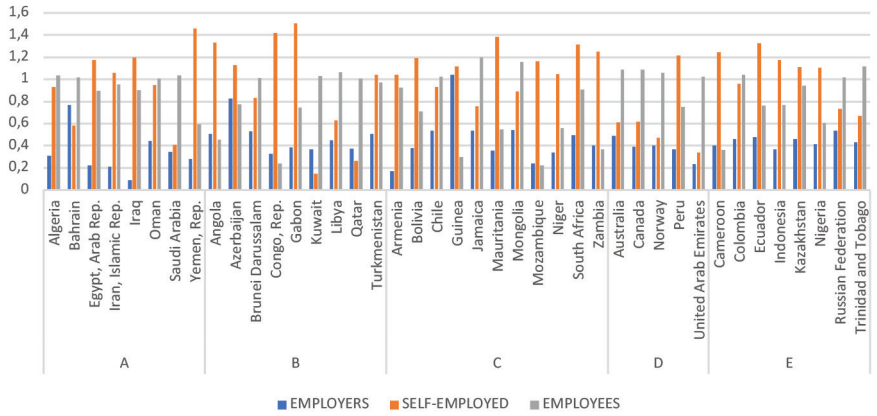
Chart 4. Ratio of female to male employment in three economic sectors ($RATIO_{sector}$)



Additional information: Countries in each cluster are listed alphabetically. Average values for each country from 1990 to 2020 were used in the analysis.

Source: Own elaboration based on World Bank 2025a.

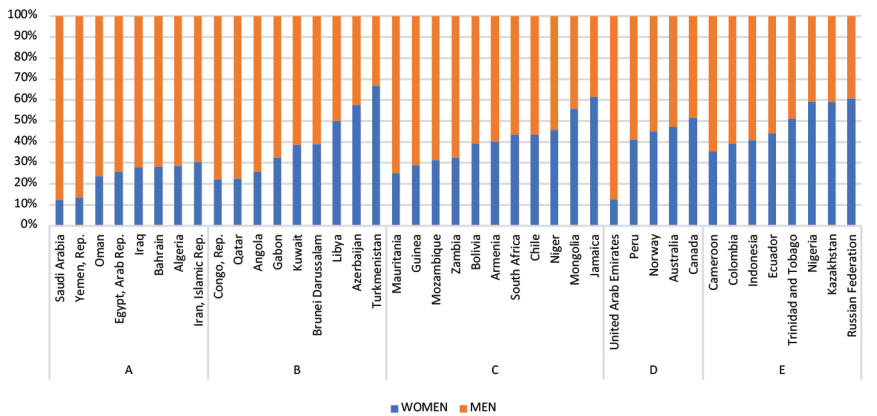
Chart 5. Ratio of female to male employment by status in the labour market ($RATIO_{status}$)



Additional information: Countries in each cluster are listed alphabetically. Average values for each country from 1990 to 2020 were used in the analysis.

Source: Own elaboration based on: World Bank 2025a.

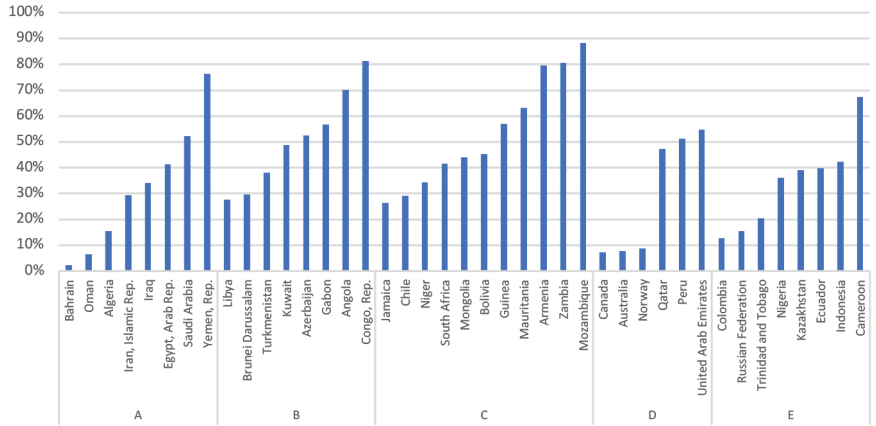
Chart 6. Proportion of women and men among total employment in occupations requiring a high level of skills



Additional information: The countries were ranked by the increasing value of the variable in each group. Average values for each country from 1990 to 2020 were used in the analysis. Skill level 3/4: Managers, professionals, and technicians.

Source: Own elaboration based on: ILO 2023; ILO 2025.

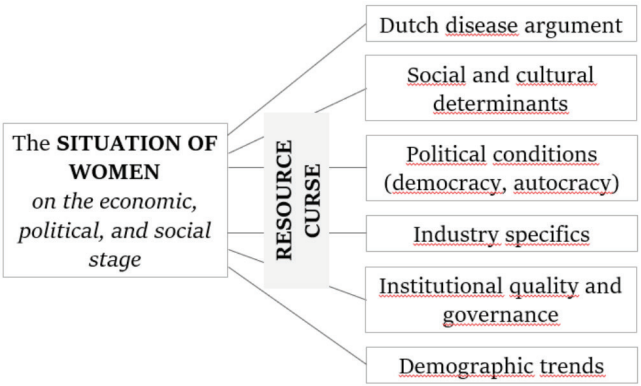
Chart 7. Proportion of women (in%) in occupations requiring a low level of skills among total female employment



Additional information: The countries were ranked by the increasing value of the variable in each group. Average values for each country from 1990 to 2020 were used in the analysis. Skill level 1: elementary occupations.

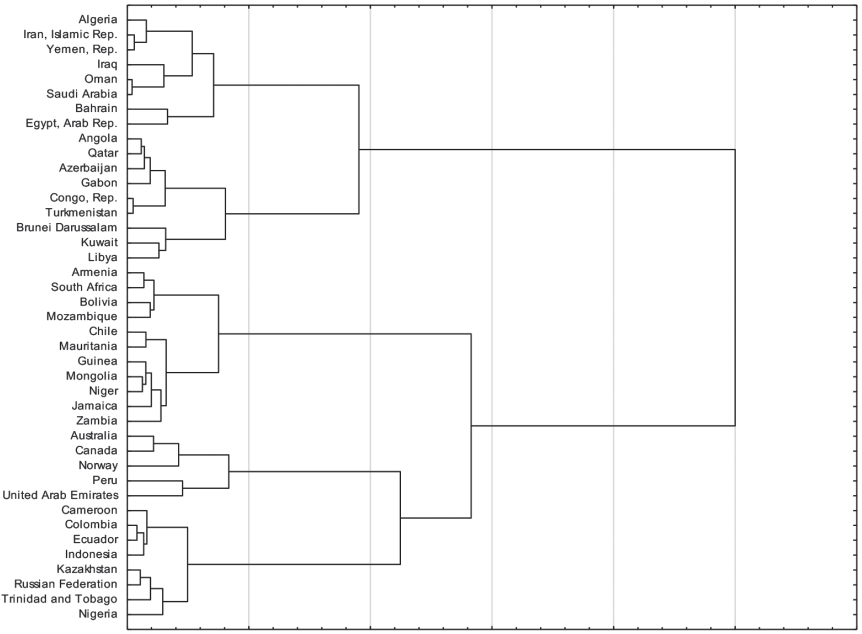
Source: Own elaboration based on: ILO 2023; ILO 2025.

Scheme 1. Areas of research



Source: Own elaboration.

Scheme 2. Dendrogram of Similarity Among the Examined Countries



Additional information: Variables used in the cluster analysis were averaged (country-level means for the years 1990–2020) and standardized.

Source: Own elaboration.

Table 1. Literature review

Year	Authors	Research issue	Main conclusions	
2008, 2012	Ross	RA & women's participation	oil reduces female labor force → lower political influence	RA ↓ women's econ/pol participation
			oil, not Islam, lowers female labor → less political/social influence	
2016, 2019	Simmons	resource wealth & women's status in U.S. states	gendered resource curse	
			RA ↑ non-labor income → ↓ female workforce participation	
			resources + patriarchy → weaker women's econ/pol influence	
2016	Liou & Musgrave	gendered repression & autocratic survival	women's autonomy varies with oil income per capita (cross-country)	
			RA → anti-social policies in autocracies → limits on women's rights	
2019a, 2019b	Mavisakalyan & Tarverdi	RA & women's participation	oil production ↓ women's labor & political representation	
			oil ↓ women's jobs in traded sector, ↑ in non-traded sector	
		RER	oil → earlier marriage & more children for women	
2022	Awoa Awoa et al.	RA & women's political empowerment	resource rent per capita ↓ women's political empowerment	
			outcomes mainly depend on institutional quality	
			RA ↓ female jobs in manufacturing/tradable services, ↑ education gap & fertility rate	
2024	Grecu & Bataille	oil discoveries & female outcomes	giant oil finds → worse outcomes for women: ↑ male/female ratio, teen births, ↓ female tertiary education, health impact fades after 8 years	
			rising oil prices → no clear link between oil finds & female outcomes	
2009	Kang	RER + institutional dimension	gender quotas offset oil rent effects on women's political representation	*RA ≠ women's econ/pol participation*
2012	Groh & Rothschild	RER	no evidence that oil rents affect female labor via gendered Dutch Disease	
			Islam significantly linked to lower female labor force participation	
2016	Rorbæk	oil abundance & poor women's rights in Muslim societies	oil's negative effect driven by 11 OAPEC members	
			Muslim countries underperform despite oil, income & democracy controls	
			Orthodox Islamic norms best explain limited Muslim women's empowerment	

Additional information: RA - resource abundance, RER - re-examination Ross's (2008).
Source: Own elaboration.

Table 2. Research group

	COUNTRY	RESOURCE			COUNTRY	RESOURCE	
1	Algeria	O, NG		22	Kazakhstan	O, NG	C, M, ME
2	Angola	O, NG	M, ME	23	Kuwait	O, NG	
3	Armenia		M, ME	24	Libya	O, NG	
4	Australia	CL, NG	M, ME	25	Mauritania	O, NG	C, ME
5	Azerbaijan	O, NG	M, ME	26	Mongolia	CL	C, ME
6	Bahrain	O, NG	A	27	Mozambique	NG, CL	M
7	Bolivia	NG	M, ME	28	Niger	U, O	M, ME
8	Brunei Darussalam	O, NG		29	Nigeria	O, NG	C
9	Cameroon	O, NG	A, M	30	Norway	O, NG	
10	Canada	O, NG	M, ME	31	Oman	O, NG	C
11	Chile		C, M, ME	32	Peru	O, NG	C, ME
12	Colombia	O, CL		33	Qatar	O, NG	
13	Congo, Rep.	O	C	34	Russian Federation	O, NG, CL	M, ME
14	Ecuador	O		35	Saudi Arabia	O, NG	ME
15	Egypt, Arab Rep.	O, NG	A	36	South Africa	CL	ME
16	Gabon	O	M, ME	37	Trinidad and Tobago	O, NG	
16	Guinea	O	M, ME	38	Turkmenistan	O, NG	M
18	Indonesia	O, NG, CL	C	39	United Arab Emirates	O, NG	ME
19	Iran, Islamic Rep.	O, NG	M, ME	40	Yemen, Rep.	O, NG	ME
20	Iraq	O, NG		41	Zambia		C, CO
21	Jamaica		B, (A)				

Additional information: Both TNRR and TNRE > limit. Only TNRR > limit. Only TNRE > limit.

TNRR – total natural resource rent, TNRE - total natural resource export.

O – oil, NG – natural gas, M – minerals, ME – metals, C – copper, A – aluminium, CO – cobalt, B – bauxite, CL – coal, U – uranium.

Source: Own elaboration.

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Domain-specific Expertise in Economics, Business and Finance of Research Institutions in Poland

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Abstract

Motivation: The efficacy of research institutions, including those active in the areas of economics, business and finance, is often measured by published high-quality scientific articles. Whether the scientific output depends on thematic specialization is an open question. Scientific profiles can be estimated based on the publications affiliated with the research entities using the topic modelling techniques. The results can be used to compare the research mixes of different institutions and to measure the degree of their specialization.

Aim: We apply the latent Dirichlet allocation model (LDA) to evaluate research diversity in the fields of economics, business and finance of major scientific institutions in Poland. The importance of various research areas is evaluated using two metrics.

Results: The obtained rankings of topics provide information on the distribution of expert knowledge and specialization of various research entities in Poland.

Keywords: topic models; text analysis; latent Dirichlet allocation; research topics; research expertise

JEL: C49; O3; O43

1. Introduction

The main aim of this paper is to evaluate research diversity in the areas of economics, business and finance of major research institutions in Poland. The analysis is based on the latent Dirichlet Allocation (LDA) model of Blei et al. (2003), which allows revealing topics discussed in journal articles authored by researchers with Polish affiliations and analysing the prevalence of these topics among research institutions. The results provide insights into the domain-specific competence and interests of researchers from different organizations.

We focus on papers published in journals indexed in the Web of Science Core Collection in the years 2000-2024. The analysis is performed using abstracts and bibliographic information for these articles. Since research topics are not pre-defined but are treated as latent in the LDA approach, in the first step, we estimate the topics discussed in the collected corpus. The estimation results include information on the weights of each topic in every paper, providing a deeper insight into contents and focus of the publications than, e.g., typical keywords or classification codes. In the second step, we use these weights to assess the importance of the uncovered research topics for each institution.

It can be expected that institutions under study differ with respect to their research mixes, as regards the types of dominant topics as well as their weights. Such research diversity is likely to stem from various missions and objectives of some of these institutions, which include universities, business and economic schools of higher education, the academy of sciences, a university of technology and the central bank. Some other factors which might also have an impact on narrower or wider research areas are the size of an institution, its location, and past activities and interests of researchers employed there.

Our analysis is related to the literature on topic modelling in the following ways. Firstly, we provide a novel application of the LDA model to textual data from the fields of economics, business and finance. Some previous analyses of abstracts, articles and other sources include, for example, the papers by Mishra et al. (2024) who studied evolution of topics within computational economics or Bystrov et al. (2024a) who considered topics of economics articles from Poland and Germany to investigate the links between topics' importance and economic developments. Using abstracts from finance articles, Aziz et al. (2022) investigated the main topics of research using machine

learning methods and Liu and Wang (2024) studied thematic evolution of this strand of literature. Applications to business data include e.g. the paper by Bastani et al. (2019) who used LDA to analyse consumer complaints.

Secondly, we evaluate whether research topics can be properly inferred from scientific abstracts. This question was also studied e.g. by Syed and Spruit (2017) who compared coherence of LDA topics obtained on the basis of full-text data to those derived from abstracts. The authors concluded that analyses based on abstracts may capture broader topics and can include more noise terms. However, these effects become insignificant for larger samples of documents (see also Cao et al., 2023). Since our corpus includes more than 7000 documents and we obtain topics that are fully interpretable, we conclude that abstract data are, in our case, informative to a satisfactory degree about the latent research topics.

The structure of the paper is as follows. Section 2 presents research institutions included in our study. In section 3 we describe the source, structure and preparation of textual data used in the analysis. Section 4 provides a description of the methods for modelling latent research topics and computing their prevalence among different affiliations. The main results are presented in section 5. Section 6 contains the conclusions and perspectives for future research.

2. Research institutions and publishing policy

In this subsection we provide an overview of research institutions in Poland and the factors that influence their publication policy and output. In the description we focus on 16 research organizations analyzed in the paper. The selection criteria which led to obtaining the particular set of entities are described in detail in section 3.

Most of research organizations from our sample (14 out of 16) are institutions of higher education and science that can be characterized using disciplines in which scientific activities are conducted. There are seven universities (University of Warsaw, University of Lodz, Nicolaus Copernicus University, University of Szczecin, Jagiellonian University, University of Warmia and Mazury and University of Gdansk), six higher schools of business and economics (Warsaw School of Economics, Cracow University of Economics, Poznan University of Economics and Business, Wroclaw University of Economics and Business, Kozminski University and University of Economics in Katowice) and one university of technology (Gdansk University of Technology). All these entities apart from Kozminski University are public. The sample also contains Narodowy Bank Polski and Polish Academy of Sciences. To briefly describe research conducted by these institutions, for which disciplines are not available, we use the information from their webpages.

Table 1 provides information from the POL-on integrated system of information on science and higher education on scientific disciplines from

the area of social sciences of the institutions from our sample. We consider disciplines that are closely related to research fields from the Web of Science analyzed in this paper. The table also presents scientific categories assigned to the institutions by the Minister of Science and Higher Education within individual scientific disciplines for the evaluation period 2017-2021. Evaluation provides an assessment of the quality of scientific activity which includes: publications, grants and the impact on the functioning of society and the economy. The highest scientific category that can be awarded in each discipline is A+ and the lowest is C. The category has bearing on the rights to conduct studies, doctoral schools, award degrees and titles and the amount of funds received from the state budget. For the evaluation purposes, publication activities are assessed based on the list of scientific journals and peer-reviewed proceedings of international conferences published by the Ministry of Science and Higher Education which takes into account international rankings of journals as well as evaluation by the national experts. In our study, we consider publications from Web of Science which provides an external source of information on the quality of academic journals.

As follows from Table 1 there is a distinction between universities and most of the remaining science and higher education institutions (schools of business and economics and the university of technology), which consists in scientific activities in a broader scope of disciplines including economics and finance, socio-economic geography and spatial management, political and administrative sciences and management and quality studies. Only one higher school of economics, namely Cracow University of Economics, is also active and evaluated in all these fields. Warsaw School of Economics is not involved in research of the socio-economic geography and spatial management, while Poznan University of Economics and Business, Wroclaw University of Economics and Business, Kozminski University, University of Economics in Katowice and Gdansk University of Technology are active in two disciplines: economics and finance and management and quality studies. All categories for every discipline and institution are A or B+ confirming high scientific standing in Poland of organizations selected for this study.

Table 1. Scientific activities and evaluation of research institutions

Name of institution	Discipline (awarded category)
University of Warsaw	economics and finance (A), socio-economic geography and spatial management (A), political and administrative sciences (B+), management and quality studies (A)
Warsaw School of Economics	economics and finance (B+), political and administrative sciences (B+), management and quality studies (B+)
University of Lodz	economics and finance (B+), socio-economic geography and spatial management (B+), political and administrative sciences (B+), management and quality studies (B+)

Name of institution	Discipline (awarded category)
Poznan University of Economics and Business	economics and finance (B+), management and quality studies (B+)
Cracow University of Economics	economics and finance (B+), socio-economic geography and spatial management (B+), political and administrative sciences (A), management and quality studies (B+)
Wroclaw University of Economics and Business	economics and finance (B+), management and quality studies (B+)
Kozminski University	economics and finance (B+), management and quality studies (A)
Nicolaus Copernicus University	economics and finance (A), socio-economic geography and spatial management (B+), political and administrative sciences (A), management and quality studies (A)
University of Szczecin	economics and finance (B+), socio-economic geography and spatial management (B+), political and administrative sciences (A), management and quality studies (A)
University of Economics in Katowice	economics and finance (B+), management and quality studies (B+)
Jagiellonian University	economics and finance (B+), socio-economic geography and spatial management (A), political and administrative sciences (A), management and quality studies (A)
Gdansk University of Technology	economics and finance (A), management and quality studies (A)
University of Warmia and Mazury	economics and finance (B+), socio-economic geography and spatial management (A), political and administrative sciences (B+), management and quality studies (B+)
University of Gdansk	economics and finance (B+), socio-economic geography and spatial management (B+), political and administrative sciences (B+), management and quality studies (B+)

Source: Own preparation

The research undertaken by employees of Narodowy Bank Polski supports the accomplishment of the main goal of this institution that is ensuring macroeconomic and financial stability. To this end, the primary focus of research activities is on application of various methodological approaches and tools to analyse monetary and financial stability.

The Polish Academy of Sciences conducts research in almost all fields. The main research topics of the Committees on Economic Sciences and on Financial Sciences of the Polish Academy of Sciences are quite broad and inlude: economic theory, socio-economic systems, market economy, public finance, the evolution of economic sciences, economic development, global economy and finance.

3. Data

3.1. Data source and structure

The data were collected from the Web of Science Core Collection platform. We selected publications by specifying the publication type as article, the

publication date as the window 2000-2024 and the country as Poland. The research area of interest was indicated by setting the Web of Science Categories to one of the following: Economics, Business & Economics, Economics & Finance or Business. Then, to consider institutions with relatively high publication output, we narrowed the search by selecting affiliations with at least 200 articles. Their list with the corresponding number of publications is provided in the Appendix in Table 2.

In the next step, we downloaded full records for the selected publications[1]. This dataset included information on journal articles and papers published in books. In the latter case, no abstracts were often available and so we disregarded the records on book chapters from further analysis. The final dataset consisted of: the main textual data in the form of abstracts of articles and the corresponding metadata with bibliographic information including e.g. the names and affiliations of the authors, title of the paper, journal title, publication year etc. The size of this database was 7079. Figure 1 presents the number of papers associated with different affiliations and Figure 2 shows the total number of articles published in each year.

3.2. Preprocessing

The data were prepared for LDA modelling by applying several typical preprocessing operations (see e.g. Chai, 2023). The purpose of preprocessing is to reduce dimensionality of the analysis by excluding those words from the corpus that can be treated as relatively irrelevant and reducing different forms of a word to one single form, e.g. by means of lemmatization or stemming. Some common approaches to dimensionality reduction is to filter out language-specific stop words (commonly used words which appear in any collection of documents), corpus-specific stop words and infrequent words.

In this paper, we pre-processed the textual data by: lemmatization of words, removal of language-specific stop words, lowercasing, removal of punctuation and numbers. Additionally, we disregarded lemmas shorter than 3 characters. Preprocessing also involved removing the following corpus-specific stop words: aim, analyse, analysis, article, author, discuss, evidence, examine, find, impact, main, paper, present, purpose, report, research, result, show, study and suggest. These terms can be expected to appear in any abstract, but are not helpful in identifying latent research topics. We also removed rare terms defined as those used in fewer than 0.5% of all documents. As discussed by Bystrov et al. (2025) such vocabulary pruning is, on the one hand, not likely to lead to information loss and on the other hand, increases computational efficiency.

[1] Data were retrieved on February 4, 2025

The resulting dataset was then used to compute a matrix showing how often each of the terms appeared in each document (document-term (DTM) matrix). The matrix had dimensions 7079×1822.

4. Methods

In the first step, to identify research topics, we analysed the abstracts using the latent Dirichlet allocation model introduced by Blei et al. (2003). The model describes a mechanism of generating documents from a set of latent topics and provides a statistical framework for inferring these topics from a corpus of documents.

The first assumption in the LDA approach, is that each document in a text corpus is a distribution over some latent topics. According to the second assumption, each topic is a mixture of corpus vocabulary. Denoting the number of topics by K, the number of unique terms in a corpus by V and the number of documents by N, these assumptions can be presented using the following probability vectors:

1) $\theta_n = (\theta_{n,1}, ..., \theta_{n,K})$, where $\theta_{n,k}$ is a weight of topic k in document n, $\sum_{k=1}^{K} \theta_{n,k} = 1$ and $\theta_{n,k} > 0$ for each document, indicating that each document contains all topics with positive probabilities. In the LDA method, the document-topic probabilities follow the Dirichlet distribution with a single concentration parameter α,
2) $\beta_k = (\beta_{k,1}, ..., \beta_{k,v})$, where $\beta_{k,v}$ is a weight of term v in topic k, $\sum_{v=1}^{V} \beta_{k,v} = 1$ and $\beta_{k,v} = 0$ for each topic $k \in \{1, ..., K\}$, presenting each topic as a mixture of corpus vocabulary. Topic-term probabilities are also assumed to have the Dirichlet distribution with a parameter η.

Given the vectors θ_n and β_k, the generation of each document from a corpus can be described in two steps: 1) for each word slot in a document, a topic $k \in \{1, ..., K\}$ is drawn according to probabilities θ_n and 2) a word from the selected topic is chosen based on the distribution β_k.

The model can be estimated using the variational EM algorithm of Blei et al. (2003) or Gibbs sampling described by Griffiths and Steyvers (2004). In this application we use the latter estimation method as implemented in the R environment in *topicmodels* package (Grün and Hornik, 2011). We select the Dirichlet prior similarly to Griffiths and Steyvers (2004), who considered $50/K$ and 0.1 in the case of α and η, respectively. We consider the values of $5/K$ and 0.1 since our dataset is much smaller and driven by considerably fewer topics.

The LDA estimation requires the user to specify the number of topics to be modelled (K). Since this number is typically unknown, several methods were proposed to estimate it (see e.g. Cao et al., 2009; Arun et al., 2010; Mimno et al., 2011, Deveaud et al., 2014; Lewis and Grossetti, 2022; Bystrov

et al., 2022). Some of these approaches were compared in a Monte Carlo study by Bystrov et al. (2024b) who demonstrated good performance of the singular Bayesian information criterion (sBIC) of Bystrov et al. (2022). Thus, in this paper we apply sBIC in the model selection process.

The results of the estimation are then used to assess the importance of topics for various research institutions. This analysis is based on vectors of the estimated document-topic probabilities, $\hat{\theta}_n$. The weights of the topics for all preselected research institutions are calculated as follows. First, we search the metadata for each document (abstract) to identify all affiliations that belong to the list from Appendix A and select vectors of estimated topic probabilities for documents affiliated with each institution. Then, for each affiliation and each topic, we compute the mean weights of the topic.

An alternative indicator of institution-specific topic weights proposed in this paper is based on the dominant topic, i.e. topic with the highest weight for each abstract. It is calculated as the share of documents from a given institution dominated by specific topics.

To provide a measure of dispersion of the prevalence of topics, which can be treated as a specialization indicator, we calculate standard deviations for the estimated topic probabilities for both metrics (mean topic weights and the dominant topic).

5. Results

The first step of the analysis is the selection of the model. The sBIC criterion indicated that the LDA with 11 topics would have the minimal generalization error in predicting probabilities of new documents (when searching in the interval from 5 to 30 topics). However, for the purpose of evaluating topic prevalence across institutions/affiliations in the corpus of published research articles, we decided to consider a slightly larger number of topics. Starting from 11, we augmented the number of topics by one as long as every topic belonged to the set made up of the top three most important topics for every institution. This criterion made it possible to focus on relevant topics only and not to stretch the number of topics too much as compared to the number of topics selected by sBIC. The final number of topics chosen in this way was 16.

The estimated topics are presented in Figure 3 in a typical form of word clouds. The font size in these graphs corresponds to the weight of the respective word for a specific topic. For example, "model", "method" and "forecast" are the most important terms for topic three. Their respective probabilities were estimated at 0.0837, 0.0168 and 0.0150. The word clouds presented include 50 most important words for each topic. This means that the remaining 1772 terms whose weights were also estimated are not shown. The order in which the word clouds are presented in Figure 3 is random.

The uncovered topics are quite coherent. Thus, in the next step, they were labelled based on the top words, but also titles and abstracts of the documents with the highest weight of the respective topics. These concise titles are also provided in Figure 3. The extracted topics included: 1) entrepreneurship, 2) financial markets, 3) econometric modelling and forecasting, 4) innovations, 5) regional studies, 6) economic growth, 7) foreign trade, 8) labour market, 9) banking and finance, 10) income and inequality, 11) consumer behaviour, 12) monetary and fiscal policy, 13) European Union studies, 14) management, 15) public policy and sustainability and 16) institutional economics.

Table 3 presents three most important topics for each institution. The prevalence is measured using mean topic weights. The complete topic-importance distributions computed using this metric are depicted in Figure 4.

In general, according to mean weights, research mixes and top three research topics of the investigated institutions differ from each other. Nevertheless, there are also some similarities, e.g. for specific types of research organizations.

Table 3. Top topics for research institutions: mean weights

Research Institution	Top topics	Topic weights
University of Warsaw	3 – Econometric modelling & forecasting	0.1019
	10 – Income & inequality	0.0914
	8 – Labour market	0.0806
Warsaw School of Economics	3 – Econometric modelling & forecasting	0.1092
	12 – Monetary & fiscal policy	0.0971
	9 – Banking & finance	0.0750
University of Lodz	13 – European Union studies	0.0845
	12 – Monetary & fiscal policy	0.0765
	6 – Economic growth	0.0755
Poznan University of Economics and Business	2 – Financial markets	0.1700
	14 – Management	0.0754
	1 – Entrepreneurship	0.0714
Cracow University of Economics	3 – Econometric modelling & forecasting	0.0993
	14 – Management	0.0925
	1 – Entrepreneurship	0.0730
Wroclaw University of Economics and Business	14 – Management	0.1284
	16 – Institutional economics	0.0770
	1 – Entrepreneurship	0.0739

Research Institution	Top topics	Topic weights
Kozminski University	1 – Entrepreneurship	0.1510
	7 – Foreign trade	0.1072
	9 – Banking & finance	0.0885
Polish Academy of Sciences	15 – Public policy & sustainability	0.1008
	3 – Econometric modelling & forecasting	0.1003
	16 – Institutional economics	0.0943
Nicolaus Copernicus University	16 – Institutional economics	0.1015
	3 – Econometric modelling & forecasting	0.0888
	2 – Financial markets	0.0802
University of Szczecin	14 – Management	0.1005
	16 – Institutional economics	0.0855
	4 – Innovations	0.0847
Narodowy Bank Polski	12 – Monetary & fiscal policy	0.2087
	3 – Econometric modelling & forecasting	0.1213
	6 – Economic growth	0.0872
University of Economics in Katowice	1 – Entrepreneurship	0.1553
	4 – Innovations	0.0956
	14 – Management	0.0899
Jagiellonian University	14 – Management	0.1212
	1 – Entrepreneurship	0.1085
	16 – Institutional economics	0.0957
Gdansk University of Technology	1 – Entrepreneurship	0.0882
	6 – Economic growth	0.0865
	7 – Foreign trade	0.0860
University of Warmia and Mazury	5 – Regional studies	0.1604
	2 – Financial markets	0.0807
	14 – Management	0.0713
University of Gdansk	14 – Management	0.0954
	11 – Consumer behaviour	0.0871
	4 – Innovations	0.0759

Source: Own preparation

There seems to be more research diversity in the group of universities. The most important research areas for University of Warsaw, described by topics 3, 10 and 8, are econometric modelling and forecasting, income and

inequality and the labour market. Articles published by researchers affiliated with University of Lodz mainly focus on European Union studies (topic 13), monetary and fiscal policy (topic 12) and economic growth (topic 6), however the weights distribution is relatively flat for this institution. Researchers from Nicolaus Copernicus University are interested to the largest extent in institutional economics (topic 16), econometric modelling and forecasting (topic 3) and financial markets (topic 2), while the main research areas at the University of Szczecin are represented by topics on management (topic 14), institutional economics (topic 16) and innovations (topic 4). The profile of the Jagiellonian University resembles that of several business and economics schools described above, as the most important topics for this institution are: management, entrepreneurship and institutional economics. Researchers from University of Warmia and Mazury focus on regional studies, financial markets and management (topics 5, 2 and 14, correspondingly). The weight of regional studies is quite considerable, as it amounts to 0.1604. Finally, the top three research areas for the University of Gdansk are represented by management (topic 14), consumer behaviour (topic 11), and innovations (topic 4).

The remaining three institutions: Polish Academy of Sciences, Narodowy Bank Polski and Gdansk University of Technology are neither higher schools of business and economics nor universities. According to our results, Polish Academy of Sciences has the largest specialist knowledge in the areas of public policy and sustainability (topic 15), econometric modelling and forecasting (topic 3) and institutional economics (topic 16). As could be expected, the most important research areas for Narodowy Bank Polski (NBP) include monetary and fiscal policy (topic 12, most important) and economic growth (topic 6, third most important). The weight estimated for monetary and fiscal policy topic (0.2087) is the largest among all research areas and all institutions indicating a very strong focus on this topic by researchers from NBP. The second most prevalent research topic (econometric modelling and forecasting – topic 3) shows a strong quantitative component of papers affiliated with Narodowy Bank Polski. The main topics of articles affiliated with Gdansk University of Technology are entrepreneurship (topic 1), economic growth (topic 6) and foreign trade (topic 7).

Table 4 from the Appendix and Figure 5 present topic prevalence values for each institution measured using our second metric - the share of documents for which a specific topic had the highest weight (dominant topic). While Table 4 includes the top three indicator values, Figure 5 presents the complete distributions. By focusing on the top probabilities when constructing these indicators only, we do not take full advantage of the LDA estimation results. However, it might still be of interest to investigate the main areas of competence of researchers from various organizations. It can be seen that the two approaches do not order the topics' importance in exactly the same

way. For example, the top three research areas have the same ranking only for Cracow University of Economics. In the case of five further institutions (University of Warsaw, Warsaw School of Economics, Kozminski University, Polish Academy of Sciences and Nicolaus Copernicus University) the most important three topics are the same, however their ordering according to weights is different. For the remaining research organizations, apart from University of Lodz and Wroclaw University of Economics and Business, there is an overlap of two top research areas as measured by mean weights and the dominant weight. For University of Lodz and Wroclaw University of Economics and Business only one topic makes it to the top three in both rankings. According to the measure based on the dominant topic, articles affiliated with University of Lodz focus mainly on the monetary and fiscal policy (topic 12, ranked 2 by the mean weights metric), banking and finance (topic 9) and financial markets (topic 2). While the most important research area for Wroclaw University of Economics is still management (topic 14), institutional economics and entrepreneurship are replaced by innovations (topic 4) and public policy and sustainability (topic 15).

Table 5. Dispersion of topic prevalence

Research Institution	Dispersion (mean weights)	Dispersion (dominant topic)
University of Warsaw	0.0187	0.0313
Warsaw School of Economics	0.0190	0.0331
University of Lodz	0.0131	0.0209
Poznan University of Economics and Business	0.0308	0.0505
Cracow University of Economics	0.0171	0.0243
Wroclaw University of Economics and Business	0.0213	0.0283
Kozminski University	0.0318	0.0600
Polish Academy of Sciences	0.0198	0.0338
Nicolaus Copernicus University	0.0173	0.0276
University of Szczecin	0.0192	0.0277
Narodowy Bank Polski	0.0485	0.0798
University of Economics in Katowice	0.0326	0.0476
Jagiellonian University	0.0267	0.0401
Gdansk University of Technology	0.0185	0.0256
University of Warmia and Mazury	0.0295	0.0609
University of Gdansk	0.0166	0.0308

Source: Own preparation

In general, despite some differences, the shapes of the full distributions obtained using the two metrics remain similar, however as could be expected, the approach based on the dominant topic assigns even more weight to the topics which were identified as very important using mean probabilities.

Table 5 reports information on the dispersion of the topic prevalence for each research entity and both indicators of topic relevance. Higher values indicate focus on selected topics, while smaller values (meaning that probabilities for the topics were more similar) larger research diversity. No matter which metric is used, Narodowy Bank Polski is identified as most specialized and University of Lodz as most diversified.

Our results on scientific diversification are broadly in line with observations from section 2 which indicated differences among the institutions with respect to the number of disciplines in which scientific activities are conducted. In general, universities tend to be more diversified than higher schools of business and economics. However, some additional comments can be made. Firstly, Cracow University of Economics, which supports more disciplines than the remaining schools of business and economics, turned out to be more diversified also in view of our results. Secondly, researchers from Gdansk University of Technology (quite diversified according to our results) work on more subjects than could be expected based on the declared number of disciplines. Thirdly, Jagiellonian University and University of Warmia and Mazury are the least diversified universities in our sample.

As for the remaining institutions, the diversification of the Polish Academy of Sciences, which declares broad scope of research activities, is similar to that of universities from our sample. The largest specialization of Narodowy Bank Polski is in line with the declared, quite narrow, scope of research which aims to support the main aim of this institution.

6. Conclusions

The latent Dirichlet allocation model has become a standard tool for identifying unknown topics in publications from many areas. In this paper, we estimated the LDA model using abstracts of papers from the fields of economics, business and finance, affiliated with selected research institutions from Poland. The sixteen uncovered topics were coherent and interpretable, making it easy to label them.

The aim of the paper was to use the estimated document-topic probabilities provided by the LDA approach to evaluate research diversity of scientific institutions. We considered two alternative measures of topical research output that aggregate topic weights of research articles published by the analyzed institutions. The two measures can be used together as they provide slightly different ranking of research topics.

Our results inform about research mixes of the major Polish institutions carrying out research in the areas of economics, business and finance. In particular, we evaluated the importance of each of the research topics for every institution. By computing standard deviations of the estimated topic prevalence values, we also provided a measure of specialization/diversification for the research entities.

The main conclusions from our study are as follows. Firstly, there is a substantial diversity in the prevalence of research topics among major Polish institutions where studies in the areas of economics, business, and finance are conducted. Although there is a greater convergence of research interests for business schools than for universities and other types of institutions, even most similar entities have some distinctive features of their research profiles. Secondly, the analysed research institutions differ in terms of their degree of specialization. For some of the entities, there is no dominant topic (e.g. Polish Academy of Sciences and University of Lodz), while researchers from other institutions (e.g. Narodowy Bank Polski and Poznan University of Economics and Business) focus on a single topic to a much larger degree. When the whole distribution of topic probabilities is considered, the institutions can be ranked according to their specialization/diversification starting from Narodowy Bank Polski (most specialized) to the University of Lodz (most diversified).

Our results on diversification can be further explained by exploring the institutional settings for scientific activities in Poland. Most entities from our sample are institutions of higher education and science which are evaluated by the respective ministry within specific scientific disciplines. The awarded category depends to a large degree on the publications from these disciplines. The higher the category the more funds is channelled to the institution. Our results on larger diversification of universities than higher schools of business and economics partly reflect the general rule that universities conduct research in a larger number of scientific disciplines.

This work could be extended in several ways. One direction of future research is to use topic models with word embedding (see e.g. Grootendorst, 2022, Mu et al., 2024) which, in general, might provide topics which are more distinct from each other. At this point, it is not clear whether such an analysis could add to our results. Another interesting extension is to repeat our calculations using the full texts of the articles instead of abstracts. This could make it possible to extract more fine-grained topics and look into areas of specialization in more detail. However, collecting such a dataset would be more difficult and time-consuming. Further analyses could also take into account a different or extended set of publications than the Web of Science records used in this work. Finally, our results could be, perhaps, used to analyse whether research diversity or specialization are better drivers of scientific output.

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Appendix

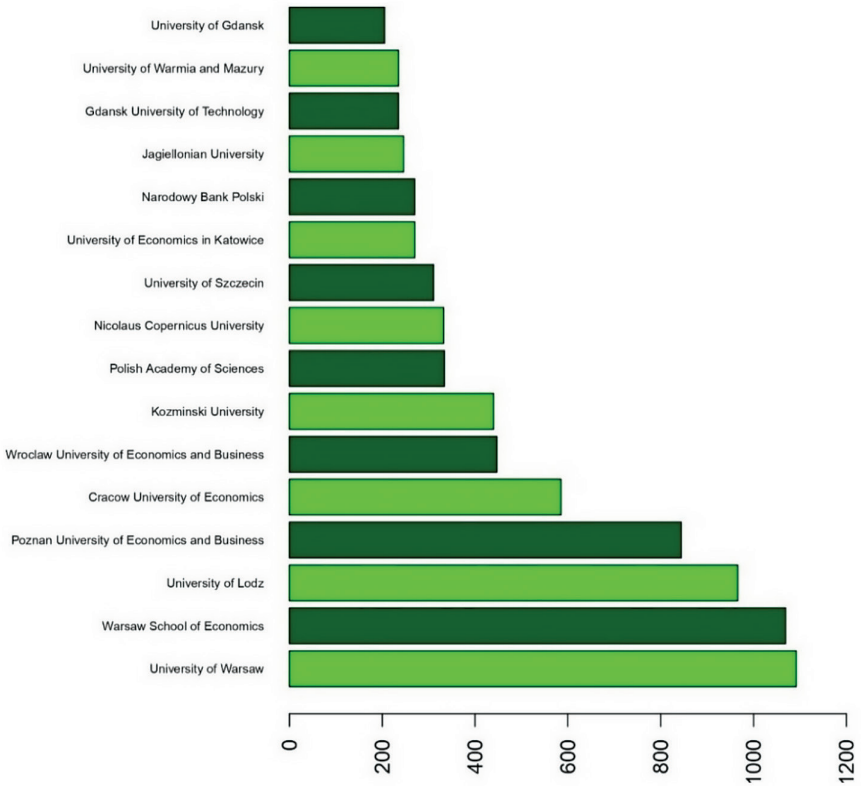
Table 2. Articles by research institutions in the period 2000–2024

Research Institution	No. of articles
University of Warsaw	1092
Warsaw School of Economics	1069
University of Lodz	966
Poznan University of Economics and Business	844
Cracow University of Economics	585
Wroclaw University of Economics and Business	447

Research Institution	No. of articles
Kozminski University	440
Polish Academy of Sciences	334
Nicolaus Copernicus University	332
University of Szczecin	311
Narodowy Bank Polski	270
University of Economics in Katowice	270
Jagiellonian University	246
Gdansk University of Technology	235
University of Warmia and Mazury	235
University of Gdansk	205

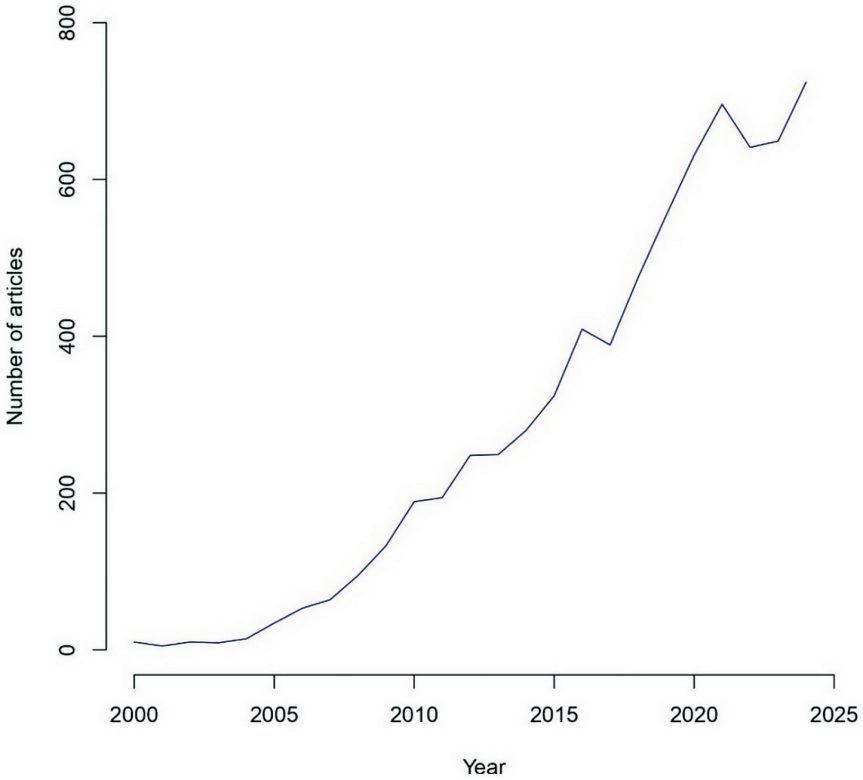
Source: Own preparation.

Figure 1. Number of articles per affiliation



Source: Own preparation.

Figure 2. Number of articles per year



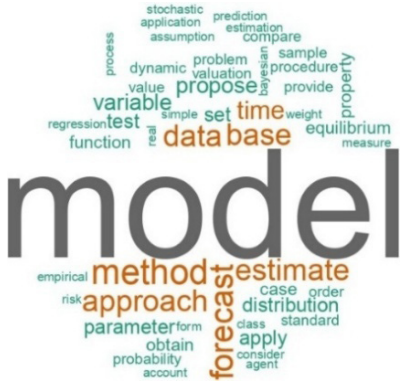
Source: Own preparation.

Figure 3. Word clouds

(1) Entrepreneurship

(2)Financial markets

Figure 3 cont. Word clouds



(3) Econometric modelling and forecasting

(4) Innovations

(5) Regional studies

(6) Economic growth

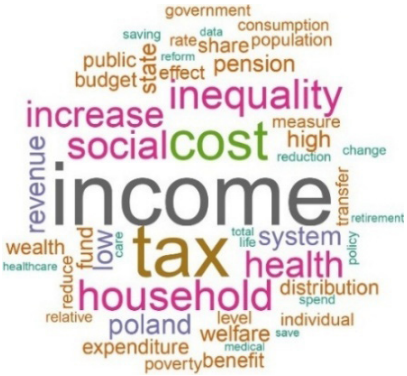
(7) Foreign trade

(8) Labour market

Source: Own preparation.

Figure 3 cont. Word clouds

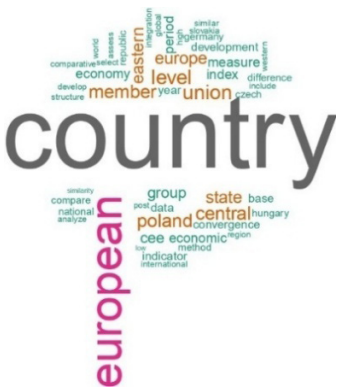
(9) Banking and finance



(10) Income and inequality

(11) Consumer behaviour

(12) Monetary and fiscal policy



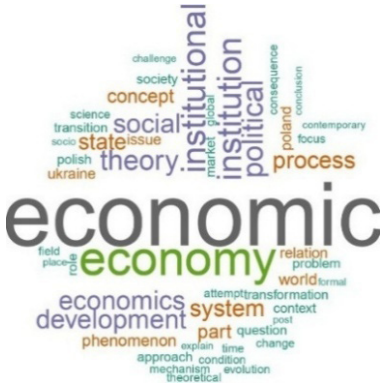
(13) European Union studies

(14) Management

Source: Own preparation.

Figure 3 cont. Word clouds

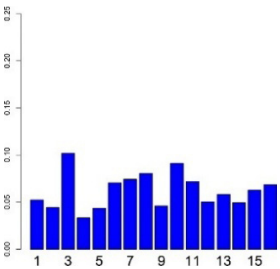
(15) Public policy and sustainability



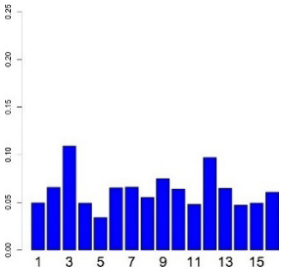
(16) Institutional economics

Source: Own preparation.

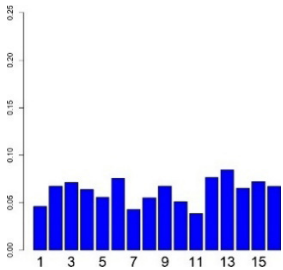
Figure 4. Topic prevalence: mean weights



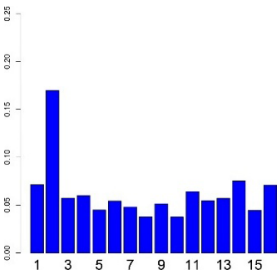
(1) University of Warsaw



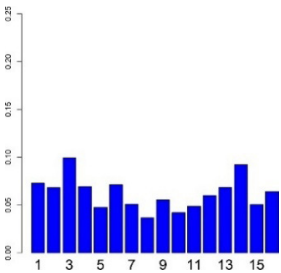
(2) Warsaw School of Economics



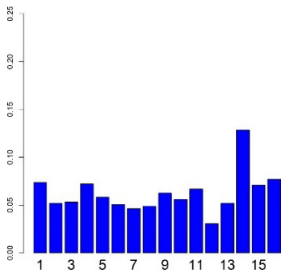
(3) University of Lodz



(4) Poznan University of Economics and Business



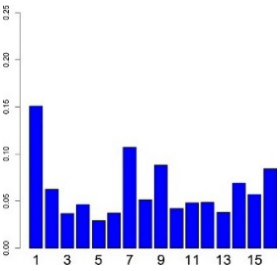
(5) Cracow University of Economics



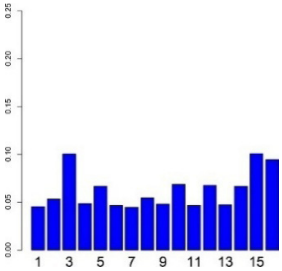
(6) Wroclaw University of Economics

Source: Own preparation.

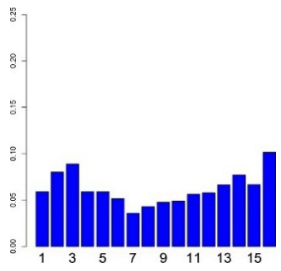
Figure 4 cont. Topic prevalence: mean weights



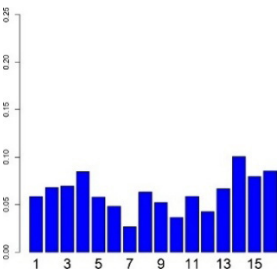
(7) Kozminski University



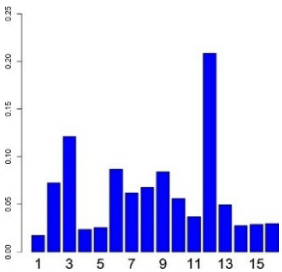
(8) Polish Academy of Sciences



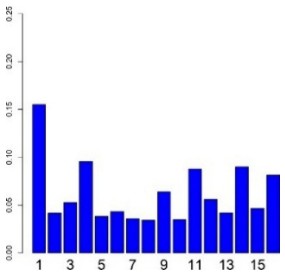
(9) Nicolaus Copernicus University



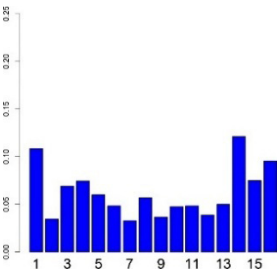
(10) University of Szczecin



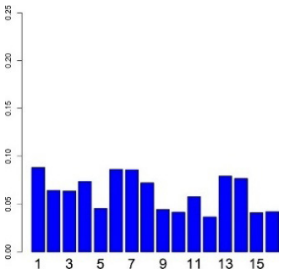
(11) Narodowy Bank Polski



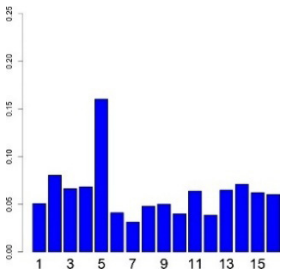
(12 University of Economics in Katowice



(13) Jagiellonian University



(14) Gdansk University of Technology



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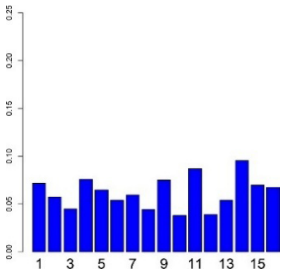


(16) University of Gdansk

Source: Own preparation.

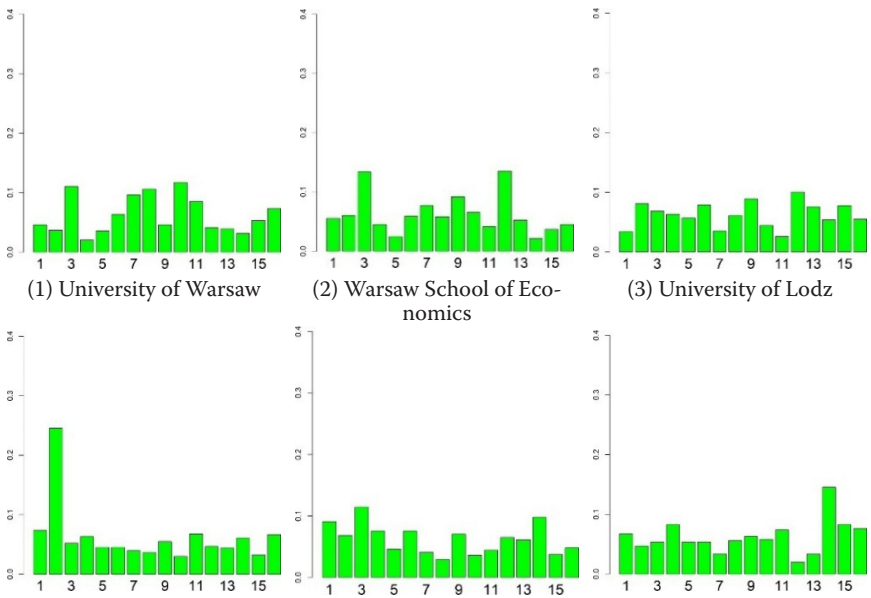
Table 4. Top topics for research institutions: dominant topic

Research Institution	Top topics	Topic weights
University of Warsaw	10 – Income & inequality	0.1172
	3 – Econometric modelling & forecasting	0.1099
	8 – Labour market	0.1062
Warsaw School of Economics	12 – Monetary & fiscal policy	0.1347
	3 – Econometric modelling & forecasting	0.1338
	9 – Banking & finance	0.0917
University of Lodz	12 – Monetary & fiscal policy	0.1004
	9 – Banking & finance	0.0890
	2 – Financial markets	0.0807
Poznan University of Economics and Business	2 – Financial markets	0.2453
	1 – Entrepreneurship	0.0735
	11 – Consumer behaviour	0.0675
Cracow University of Economics	3 – Econometric modelling & forecasting	0.1145
	14 – Management	0.0974
	1 – Entrepreneurship	0.0906
Wroclaw University of Economics and Business	14 – Management	0.1454
	4 – Innovations	0.0828
	15 – Public policy & sustainability	0.0828
Kozminski University	1 – Entrepreneurship	0.2182
	9 – Banking & finance	0.1432
	7 – Foreign trade	0.1386
Polish Academy of Sciences	15 – Public policy & sustainability	0.1198
	16 – Institutional economics	0.1198
	3 – Econometric modelling & forecasting	0.1048
Nicolaus Copernicus University	16 – Institutional economics	0.1084
	2 – Financial markets	0.1024
	3 – Econometric modelling & forecasting	0.0934
University of Szczecin	14 – Management	0.1029
	4 – Innovations	0.0997
	8 – Labour market	0.0900
Narodowy Bank Polski	12 – Monetary & fiscal policy	0.3111
	3 – Econometric modelling & forecasting	0.1556
	9 – Banking & finance	0.1074
University of Economics in Katowice	1 – Entrepreneurship	0.2000

Research Institution	Top topics	Topic weights
	11 – Consumer behaviour	0.1185
	4 – Innovations	0.0963
Jagiellonian University	1 – Entrepreneurship	0.1504
	14 – Management	0.1463
	15 – Public policy & sustainability	0.0894
Gdansk University of Technology	7 – Foreign trade	0.1106
	1 – Entrepreneurship	0.0979
	8 – Labour market	0.0894
University of Warmia and Mazury	5 – Regional studies	0.2723
	2 – Financial markets	0.1149
	4 – Innovations	0.0681
University of Gdansk	14 – Management	0.1171
	9 – Banking & finance	0.1024
	11 – Consumer behaviour	0.0976

Source: Own preparation

Figure 5. Topic prevalence: dominant topic

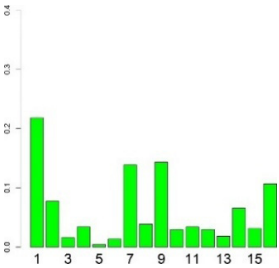


(1) University of Warsaw (2) Warsaw School of Economics (3) University of Lodz

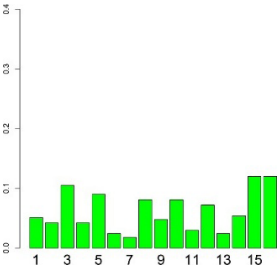
(4) Poznan University of Economics and Business (5) Cracow University of Economics (6) Wroclaw University of Economics

Source: Own preparation

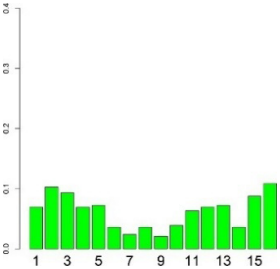
Figure 5 cont. Topic prevalence: dominant topic



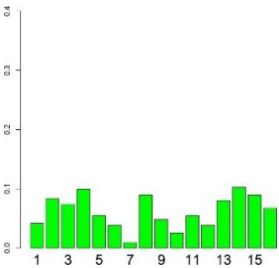
(7) Kozminski University



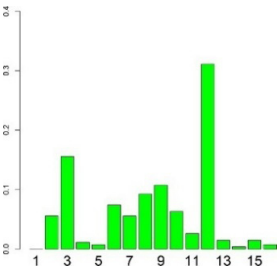
(8) Polish Academy of Sciences



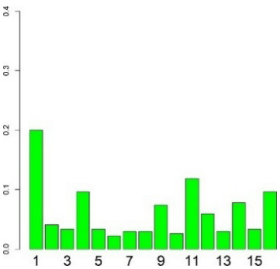
(9) Nicolaus Copernicus University



(10) University of Szczecin



(11) Narodowy Bank Polski



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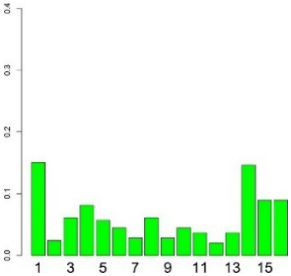

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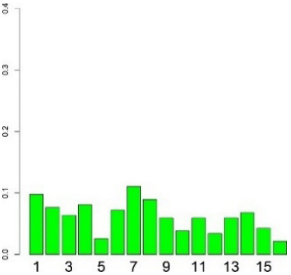

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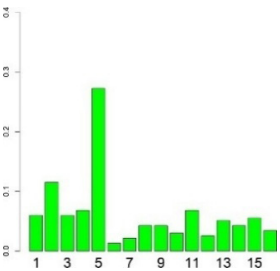

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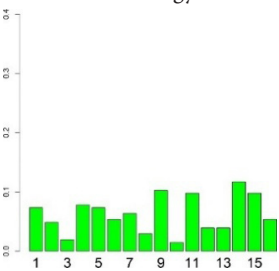

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The adaptability of informal institutions

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Abstract

Motivation: The study is guided by a set of research questions. How do informal institutions change? Does their deep historical and cultural embeddedness imply that such a change necessarily occurs at a slow pace? And to what extent can informal institutions be considered adaptive in responding to external pressures?

Aim: The author's primary intention was to investigate the specific character of informal institutions, with particular emphasis on their adaptive capacity. The analysis focuses on the factors that may trigger adaptation processes, and whether these changes can occur under certain conditions over a relatively short period of time.

Results: The study finds that informal institutions, though typically slow to evolve, exhibit uneven persistence across different clusters of norms. Some categories respond more quickly to external pressures, such as the introduction of new formal rules, shifts in socio-economic conditions, or political upheavals. These responses may generate new practices that, once routinised, crystallise into new social norms. Such adaptive dynamics foster complementarities among institutional components, reinforcing systemic coherence and enhancing the stability of the broader institutional order.

Keywords: informal institutions; adaptability; institutional change

JEL: B52; O17; D02

1. Introduction

This article presents the author's research on informal institutions, with a particular focus on the processes that drive their transformation. The analysis of the nature and evolution of informal institutions highlights a set of interdependencies that emerge within the institutional system of the economy. Effective economic performance requires the achievement of institutional equilibrium, understood as a state in which different groups of institutions are mutually compatible and oriented toward the pursuit of common objectives. Against this background, the paper addresses the question of the specific character of informal institutions, with particular attention to their adaptive capacity. While the literature on institutional economics generally emphasises the slow pace of change in informal institutions and the difficulty of identifying its drivers, this study considers the factors that may induce institutional adjustments and explores whether such changes can, under certain conditions, occur within relatively short time frames.

2. Informal institutions

For each society to ensure its long-term sustainability and resilience in the face of a period of disruption, it is essential to establish a robust institutional framework. Among the various institutions, informal institutions hold a position of particular significance due to their deep-rooted nature. These institutions serve a stabilising function within the social system, forming the core of the institutional structure of society and acting as a fundamental source of its long-term evolution. Due to their intrinsic nature, informal institutions are deeply embedded within the cognitive schemas of individuals, which confers upon them a considerable capacity for persistence across extended temporal horizons.

The institutional system is not a homogeneous structure. On the one hand, it is composed of institutions of various types; on the other hand, these institutions are interconnected in such a way that it becomes difficult to precisely examine their impact on the activities of individuals and groups. Most commonly, formal institutions are the subject of analysis – those that are established and legally binding within a specific territory (such as a country, region, or administrative unit). These are complemented by informal institutions and enforcement mechanisms. Together, they constitute a network of rules or norms that become embedded in a given society and influence the actions undertaken by individuals and groups. Identifying a clear criterion that distinguishes formal institutions from informal ones is not straightforward. Although this distinction is usually framed in terms of how rules are

written down or established, a more appropriate criterion appears to be the mode of their enforcement. Formal institutions are enforced by courts and the judicial system. In contrast, informal institutions lack a specific body responsible for overseeing their implementation. Instead, enforcement is carried out by other members of society (Hodgson, 2025, p. 3) Such an approach is employed by Voigt, who distinguishes between external institutions – sanctioned by the state – and internal institutions – sanctioned by society (Voigt, 2019, p. 17).

Explaining the nature of informal institutions requires reference to unwritten social rules that govern behaviour within society. Given this, it can be stated that „informal institutions are behavioural regularities based on socially-shared rules, usually unwritten, that are created, communicated, and enforced outside of officially-sanctioned channels" (Helmke & Levitsky, 2004). This is the most well-established research definition of informal institutions. Expanding on this definition, it can be pointed out that they are (OECD Development Centre, 2007, p. 3; North, 1990, p. 40):

- extensions, elaborations, and modifications of formal rules outside the official framework;
- socially sanctioned norms of behaviour (attitudes, customs, taboos, conventions, and traditions);
- enforcement characteristics are self-enforcement mechanisms of obligation, expectations of reciprocity, internalised norm adherence (standard operating procedures), gossip, social isolation, ostracism, boycotting, shaming, threats and the use of violence.

Defining informal institutions poses a significant conceptual challenge. It is somewhat easier to provide examples of such institutions, including rules of social coexistence, conventions, taboos, customs, and societal attitudes toward work, money, and similar issues. The institutional framework is shaped by the dominant ideology or by a set of values broadly shared within society. Voigt (2019, pp. 120–121) points out that informal institutions are often regarded as a part of culture. According to this author, however, only some of these institutions can be classified as cultural, for example, rules derived from religion. Alternative norms may emerge within smaller groups whose behaviour is guided by a shared set of interests. In such cases, members of these groups may act in ways that contravene formal legal regulations if doing so enhances their individual or collective benefits. The sanctions imposed by the broader society may be insufficient – either due to an ineffective judicial system or social tolerance expressed through a "blind eye" turned by other members of the community. Nonetheless, the extent to which specific behaviours deviate from accepted norms must be assessed on a case-by-case basis (Ostrom, 2008, p. 24).

It is beyond dispute that formal institutions can act effectively only when they are embedded within shared patterns of thought and behaviour. Habits

must be regarded as constituting the foundations of institutions, providing them with persistence and reinforcing their capacity to exert influence over social processes. „Many institutions, including property rights systems, work by creating certain expectations in the minds of agents about the meanings and implications of specific acts and symbols. Thus the success of an institution depends on and can be measured by how tenaciously people hold onto the expectations that the institution engenders" (Onoma, 2009, p. 69).

3. Methods

The analysis presented in this article is anchored in a review of the literature in institutional economics. By synthesising strands of institutional theory and applying logical inference to the selected field of inquiry, the author constructs a coherent conceptualisation of informal institutions. The article is, by design, of a theoretical and descriptive character.

4. Results

4.1. Changes of informal institutions

Informal institutions possess a relatively enduring nature. Their transformation occurs over significantly longer periods compared to other components of the institutional system (O.E. Williamson, 2000). A lengthy duration is essential for changes in value systems to become apparent. These changes constitute the foundation for the transformation of social norms, customs, rules, conventions, and so forth. According to the widely accepted classification of institutions proposed by O E. Williamson (2000), which is based on the criterion of the time of change, one should not expect rapid modifications of informal rules. Informal institutions are the most entrenched institutions. These institutions form the core of the institutional framework and serve as a source of change over the long term. „The idea of persistence of some kind is virtually built into the very definition of an institution. (…) The connection between institutions and persistence makes it natural for all of these approaches to focus on explaining continuity rather than change" (Mahoney & Thelen, 2009, p. 4). The persistence of certain institutions, measured in centuries, need not pose an obstacle to the adaptation of individuals and societies to changing conditions. This coexistence and systemic interconnection of various components of culture, with differing degrees of plasticity and susceptibility to change, underpins the durability of cultures and their dynamic equilibrium (Wilkin, 2016, p. 89). In general, they change rather slowly (referred to as slow-moving institutions). This is partly because many social norms are rooted in religions,

whose fundamental principles have remained largely unchanged over the centuries, and even millennia. The major world religions have shaped and continue to shape the core values and preferences of individuals. From religion arise fundamental issues for humanity, as well as expectations regarding others (Roland, 2004, p. 116). Due to their nature, they can be classified as primary institutions. This is the type of institution O.E. Williamson had in mind when referring to Level 1 (L1) institutions, which evolve only slowly over time – on the order of 10^2 to 10^3 years (O.E. Williamson, 2000, p. 597).

However, there are elements within the subsystem of informal institutions that change more rapidly than might be expected. This is particularly evident during periods of transformative change in economies and societies. Radical changes in formal institutions occurring over a relatively short time do not immediately result in modifications of informal institutions. Accelerated changes in the environment where economic or social activities are undertaken, such as crises, economic shocks political upheavals, technological advancements, or other factors, can lead to a corresponding acceleration in informal institutions as well. A shift in the distribution of power within a society, often triggered by economic or political shocks, can lead to significant institutional change, influencing both formal and informal rules. These changes can reshape value systems and, in a relatively short period, alter collective behaviours and cognitive frameworks. Such transformations may result in a departure from established norms and values, replacing them with new ones that reflect shifts in the distribution of resources and income. It is plausible that the underlying cause of these shifts lies in the changing incentives and constraints faced by different social groups, which in turn affect their bargaining power and access to economic opportunities. Chavance (2008, p. 65) has written that "Post-socialist transformation has not taken place in a uniform way in informal institutions: enduring legacies have co-existed with the rapid collapse of unwritten rules and with the swift emergence of new non-codified rules. For instance, a culture and informal behavioural traits linked to shortage have declined rapidly in all countries where a shift from a resource-constrained to a demand constrained economy has been realized in a few months or even a few weeks". It appears that certain types of informal institutions can be reprogrammed and modified in ways that differ from their original forms. Adaptive informal rules may emerge as a result of the dissonance between the formal and informal components of the institutional system. If they are sufficiently robust, they can also influence the transformation of formal rules (Tsai, 2006, pp. 126––127).

The introduction of a formal incentive may alter the conditions under which individuals operate and lead to adjustments in behavioural rules. Such a change can trigger a gradual process of adaptation of informal institutions

to the new context. However, this process tends to be slow and evolutionary. Institutional asymmetry - a misalignment between formal and informal institutions – can become a source of institutional change, affecting both types of institutions. In particular, conflict between formal rules and informal norms may result in pressure for informal components to evolve.

The evolution of institutions involves the gradual modification of informal norms, rules, and constraints embedded within society. Over time, certain behaviours may become more widespread and solidify into established social norms. On the other hand, formal institutions are introduced by the state to induce more rapid behavioural change. From the perspective of institutional system efficiency, the relationship between formal and informal institutions plays a crucial role.

4.2. The adaptive pattern of informal institutions' change

There is little doubt that adaptive change is an inherent feature of every society. This applies equally to institutional frameworks, which co-evolve with the real sector of the economy. As Friedrich von Hayek (1998, p. 25) observed "all evolution, cultural as well as biological, is a process of continuous adaptation to unforeseeable events, to contingent circumstances which could not have been forecast".

The interaction between formal and informal institutions constitutes a key source of institutional dynamism, as informal institutions shape the development and functioning of formal institutions, while simultaneously being transformed through their influence (Hodgson, 2025) Roland (2004, p. 118) proposes "to view institutional change as the interaction between slow-moving institutions, culture into particular, and fast-moving institutions such as political and legal institutions. It is this interaction that drives institutional change, and it is the interaction between institutional change and technology that drives economic growth".

Horak and Restel (2016, p. 532) have written that „informal institutions are dynamic constructs that change in nature and influence over time". For instance, the works of Inglehart and Welzel present cultural maps of various countries and trace their evolution over time (Inglehart & Welzel, 2010). These maps serve as a foundation for analysing the trajectories of change in informal institutions. Their research reveals cross-national similarities in both the direction and the pattern of such change, most notably the increasing salience of self-expression values and secular–rational orientations across the majority of countries (Yeganeh, 2024).

The question arises as to the causes of institutional change and the very nature of such change. Informal institutions evolve in ways that are often difficult to observe directly. Nevertheless, it can be noted that the following conditions typically characterise such a change (Farrell, 2009, pp. 166–167):

1. A departure from existing informal norms yields net benefits to the actors (individuals or groups) initiating the change;
2. The actors initiating the change can sustain their deviation from established norms despite resistance from others who may prefer the status quo;
3. The norm-deviating behaviour is replicated by all or the majority of remaining actors, to the extent that it becomes an expected pattern of behaviour within the community in specific situations.

This framework applies to any change in informal institutions, as – unlike formal institutions – they cannot be imposed upon a community by an external actor. However, it appears that within the broader category of informal institutions, some may be more prone to rapid change than others. „With repetition and diffusion, these informal coping strategies may take on an institutional reality of their own. In contrast to deep-rooted, "primordial" informal institutions, which tend to resist change, the resulting norms and practices can be called adaptive informal institutions because they represent creative responses to formal institutional environments that actors find too constraining. (…) Examining the life cycle of adaptive informal institutions can thus demonstrate how some formal institutions manage to undergo significant transformations in the absence of external intervention, crisis conditions, or societal demands" (Tsai, 2006, p. 118). Changes in informal institutions (e.g., religious norms) occur not only as a result of changes in values and beliefs, but also under the influence of power pressures and the play of interests. Tracing the history reveals their adaptations to changing social and economic conditions (Seror, 2018). Brousseau and Raynaud describe the evolution of informal institutions as a dynamic process in which these institutions gradually gain strength through practice and ascend the "hierarchical ladder of rules." Over time, they may become more formalised and eventually institutionalised as commonly accepted norms within the broader framework of society (Brousseau & Raynaud, 2011).

In institutional literature, four dimensions of institutional change are presented (Mahoney & Thelen, 2009, pp. 15–16):

1. Displacement: the removal of existing rules and the introduction of new ones,
2. Layering: the introduction of new rules on top of or alongside existing ones,
3. Drift: the changed impact of existing rules due to shifts in the environment,
4. Conversion: the changed enactment of existing rules due to their strategic redeployment.

It is essential to recognise that institutional change is generally examined in relation to an already existing institutional framework. Contemporary institutions are profoundly embedded in their historical antecedents, and

institutional transformation seldom entails a wholesale replacement of the prevailing order. Newly created formal institutions typically arise within the context shaped by existing informal institutions. Institutions, once established, are neither universally accepted nor seamlessly adapted to; rather, they remain arenas of dispute in which actors continually struggle over their appropriate design and the roles they ought to fulfil (Thelen, 2004, p. 32). The capacity of the institutional system to influence economic performance is contingent upon the degree of institutional coherence - that is, the extent to which various types and layers of institutions are mutually compatible and aligned.

In the case of informal institutions, the mechanism of change may involve their gradual evolution toward supporting goals that are identical or closely aligned with those of formal institutions. For example, the increasing introduction of smoking bans in a wide range of public spaces – combined with other state-led anti-smoking measures such as higher excise taxes, public health campaigns, and restrictions on tobacco advertising – has contributed to the gradual formation of social attitudes that are increasingly negative toward smoking and smokers. Surveys conducted by the Public Opinion Research Centre (CBOS) in Poland show that between 2008 and 2019, there was a significant increase in the percentage of Poles who supported the introduction of public smoking bans: from 47% in 2008 to 75% in 2019 (Palenie Papierosów, 2019, p. 5). One can therefore observe the emergence of a growing societal consensus regarding the harmful effects of smoking and its adverse effects, including those affecting non-smokers. This social norm or behavioural pattern is becoming increasingly widespread, rooted in the negative societal perception of smoking -particularly in relation to its health consequences. In this case, the evolution of informal institutions aligns with changes in formal institutions, leading to increased effectiveness of the institutional system in reducing smoking prevalence. As a result, the share of smokers in Poland has declined steadily - from 37% in 1997 to 26% in 2019 (Palenie Papierosów, 2019, p. 2).

Informal institutions may emerge or evolve in situations where formal institutions prove ineffective and fail to achieve their intended objectives. There may be circumstances in which formal institutions are highly restrictive, yet societal evaluation of the extent of these restrictions is negative. In such cases, formal institutions do not adequately respond to social needs. Under these conditions, informal behavioural patterns and norms assume the role of regulating actions. Members of society develop informal strategies to cope with prevailing problems. Over time, as such practices become widespread, informal rules of conduct may be established, which more efficiently address social issues (Gërxhani & Cichocki, 2023)and especially their interaction, affect participation in the shadow economy in transition countries; and (2. However, the ineffectiveness of formal solutions should not

be regarded as the primary cause of the emergence of informal institutions. They cannot be treated as residual (Helmke & Levitsky, 2004). Nevertheless, informal practices that arise in response to the ineffectiveness of formal rules often become institutionalised over time through a process of gradual formalisation of behavioural norms. A notable example is China, where local informal practices eventually led to subsequent legal reforms legalising private entrepreneurship and market mechanisms, transforming China's economy (Barbalet, 2023; Tsai, 2006). This, in turn, gives rise to further transformations within the institutional framework of the economy. G. Hodgson (2025, p. 13) presents examples of informal institutions (cultural norms) that have emerged as a result of the functioning – or lack thereof – or formal institutions.

When formal institutions are introduced exogenously – through transplantation from a different socio-political context – they frequently stand in dissonance with entrenched informal norms and practices. A substantial divergence between these institutional domains generates ambiguous incentive structures, producing what may be described as institutional asymmetry. Such asymmetry undermines generalised trust, including confidence in the state and its agencies, thereby constraining the propensity of economic actors to engage in productive activity.

Relations among different categories of institutions may be shaped by substitutability or complementarity. In the initial stages, when new formal institutions are transplanted or deliberately designed, efforts to construct a coherent institutional order give rise to frictions stemming from institutional misalignment. Competing arrangements seek to establish dominance in addressing specific coordination or enforcement problems: stronger institutions tend to crowd out weaker ones, while more efficient structures gradually replace those that generate higher transaction costs. This process reflects an early phase of institutional competition and selection. The inefficiency of formal institutions creates a structural advantage for informal arrangements, which are deeply rooted in prevailing mental models, social norms, and belief systems.

In the contexts of enforcement deficits and institutional voids, informal institutions offer alternative governance mechanisms that resonate more closely with societal expectations. Under such conditions, opportunistic behaviour proliferates, and actors increasingly resort to rent-seeking strategies rather than engaging in productive economic activity.

Over time, however, institutional evolution follows a path-dependent trajectory, marked by the gradual elimination of dysfunctional arrangements, mutual adjustment among surviving institutions, and the endogenous emergence of new rules. At more advanced stages of development, complementarities increasingly prevail, as institutions become mutually reinforcing, generating more coherent incentive structures and reducing systemic ambiguity. The consolidation of such complementarities is often a precondition for sustained economic performance and the stabilisation of generalised trust (Staniek, 2017, p. 89). The existence of

complementarity between culture and institutions enhances the effectiveness of the latter in shaping societal behaviour (Payen & Rondé, 2025). „The interdependence between institutions and culture is a fundamental factor, along with technology, driving socio-economic change and long-term institutional development" (Bisin et al., 2024, p. 35).

The analysis of the emergence or manifestation of informal institutions in response to the low effectiveness of formal rules indicates that this process depends significantly on the degree to which such behaviours are tolerated by the authorities and their agencies. The higher the level of tacit acceptance – when state actors quietly allow legal rules to be circumvented – the greater the likelihood that adaptive informal institutions will emerge and develop. Moreover, members of the ruling elite may also derive benefits from the existence of such informal arrangements (Tsai, 2006, p. 126). As a result, emerging adaptive informal institutions become increasingly entrenched and may begin to influence income distribution based on the interests of informal groups – including political elites, party networks, or circles within the ruling apparatus. Informal institutions may erode or subvert the functioning of formal rules, particularly when the operative logics of these two institutional domains are mutually incompatible. Manifestations of such institutional incompatibility include corruption, clientelism, and informal networks of influence, all of which diminish the effectiveness of formal governance structures and undermine the capacity of democratic institutions. The widespread diffusion of such informal arrangements tends to undermine the application of formal statutory law. Numerous examples of this phenomenon can be observed, particularly within the functioning of the public sector during the period of systemic transformation (Grzymala-Busse, 2010). For example, in the late 1980s and 1990s, it was common practice in Poland to 'arrange' access to public services through personal connections or bribes. As transparency in the provision of public services increased and legal regulations were strengthened, this type of behaviour became far less prevalent. According to CBOS (Korupcyjne doświadczenia Polaków, 2017), the share of Poles who had given a bribe or knew someone who had received one decreased threefold compared with the 1990s, and this indicator continued to decline in subsequent years (Różne barwy korupcji w Polsce, 2021).

Informal rules may become a barrier to the effectiveness of formal institutions. The consequences of such institutional conflict are often difficult to fully predict (Fiori, 2002, p. 1027). When the operative logics of formal and informal institutions are in conflict, the efficient functioning of the institutional system becomes exceedingly difficult to achieve. Unclear incentives within the institutional system lead actors to behave in ways that diverge from expectations, ultimately undermining trust in the environment and increasing the risk of business failure. Opportunistic behaviour becomes more frequent, and in response to the new circumstances, new informal behavioural patterns begin to emerge.

Continuous processes of adjustment among social norms demonstrate that the institutional system is characterized by permanent disequilibrium (Borkowski, 2023, p. 62). But the ongoing process of mutual adjustment among institutions gradually gives rise to a more comprehensive and internally consistent system, one that generates more effective incentives for enhancing human welfare. Contradictions among elements of the institutional system constrain the scope of societal benefits. It becomes a barrier to economic progress, decreases entrepreneurship and investment activities. Empirical studies have revealed that societies may, in fact, derive greater benefits under conditions of strong informal institutions coupled with weak formal ones than in situations characterised by weak informal institutions and strong formal structures (C.R. Williamson, 2009).

The adaptive trajectory of informal institutions, and their subsequent consolidation, ought to be understood as emerging from the routinized and patterned practices of individual actors in recurrent situational contexts. Their institutionalization further presupposes a collectively shared conviction regarding the indispensability and normative validity of the given social rule.

Institutional adaptability should not be reduced merely to alterations in the institutions themselves induced by exogenous economic, social, or political forces. Rather, it must be conceptualized as an inherent systemic property that facilitates the adjustment of individual and collective actors to shifting contextual conditions. This adaptive capacity enables the reconfiguration of cognitive frames, behavioural repertoires, and normative orientations (Lascaux, 2023, p. 194). It is typically not a single norm but an ensemble of informal institutions that underwrites the resilience and developmental potential of communities facing environmental change. The synergistic and mutually reinforcing impact of such institutions upon adaptive processes becomes most visible at the macro level, where dense interlinkages among distinct informal norms and practices are manifested (Curry et al., 2021, p. 1080).

5. Conclusion

The main aim of this article has been to investigate a key property of informal institutions, namely their capacity to adapt to other components of the institutional system. While research on institutional change generally suggests that the subsystem of informal institutions evolves at the slowest pace, this does not imply that all of its components are characterized by equally low dynamics. Distinct clusters of norms exhibit different degrees of durability, and within them, certain categories respond more rapidly than others. Institutions that are more enduring and deeply embedded in societal norms and collective mentality – often arising from long-standing cultural

or religious foundations – are classified as primary institutions. In contrast, those that adjust more rapidly in response to changing environmental or economic conditions are referred to in the article as adaptive institutions. Such responses may be triggered by the introduction of new formal institutions as well as by shifts in the conditions of economic activity and broader social functioning. Economic or political shocks, by altering the distribution of power and the configuration of interest groups, may transform patterns of societal interrelations. As a consequence of these processes, novel informal practices may emerge whose routinization ultimately consolidates new social norms. This relatively lower persistence of certain types of informal institutions facilitates the adaptive capacity of individuals, communities, and societies in the face of changing conditions of operation. Research suggests that, through path-dependent adjustment processes, the adaptation of informal institutions over time contributes to the emergence of institutional complementarities among system components, thereby reinforcing systemic coherence and enhancing the stability of the broader institutional order. As a result, a system of institutions is emerging that more effectively shapes individuals' behaviour and, in turn, increases social welfare.

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The role of stablecoins in the European payments market under MiCA regulation

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Abstract

Motivation: MiCA marks a pivotal regulatory shift for the fast-evolving digital asset and payments landscape, warranting a rigorous assessment of its consequences for both stablecoin issuers and users. The existing literature primarily concentrates on the investment attributes of cryptoassets, leaving the payment functionality of cryptocurrencies under-examined. This study addresses these gaps by highlighting the payment role of stablecoins and examining the regulatory impacts on their issuance and use.

Aim: The goal of the work is to determine the role of stablecoins in the European payment services market under the MiCA regulatory regime, considering their economic functions and legal classification.

Results: The study found that the issuance of EMT does not result in the creation of a payment system under EU law. Instead, electronic money tokens under MiCA are classified as funds. There is a substantial similarity between EMT and electronic money under EMD2. At the same time, EMT differs from classical electronic money in that it utilizes a decentralized blockchain infrastructure; therefore, EMTs are both e-money and crypto-assets. A comparison of the regulations governing stablecoins in five jurisdictions – the EU, the US, Japan, Switzerland, and the UK – revealed that, generally, new regulations do not replace earlier ones, but rather extend their logic to a new type of funds and decentralized blockchain technology. Nevertheless, detailed regulations differ significantly in particular aspects. Due to the short duration of the MiCA regulation, the general effects on the innovativeness of the European digital payment services market have not yet been revealed.

Keywords: stablecoin, MiCA, cryptocurrency, digital payment, FinTech

JEL: E42; G23; G28; K22

1. Introduction

Stablecoins constitute one of the key categories of digital assets, aiming to ensure relative price stability compared to traditional cryptocurrencies. The first stablecoin was introduced in 2014, and as for 2025 the market capitalization of stablecoins stands at 310 billion USD (*CoinMarketCap*, 2025). Over the course of one decade, there has been a rapid adoption of stablecoins, primarily due to their lower volatility compared to other cryptocurrencies.

In 2023, the European Parliament and the Council of the European Union formally adopted the introduction of the Markets in Crypto-Assets Regulation (MiCA, 2023), a comprehensive framework designed to provide legal clarity, protect investors, and ensure market integrity in the crypto space (Carata, 2024). On March 3oth, 2024, MiCA rules started to apply to the stablecoins. MiCA categorizes stablecoins as either E-money Tokens (EMTs) or Asset-Referenced Tokens (ARTs) (Alcorta, 2025). EMTs are stablecoins that are backed by a single official fiat currency, such as the euro or the US dollar. MiCA ensures that there is a 1:1 reserve of assets in a segregated ac-

count at a credit institution. ART issuers must maintain a reserve of assets that is sufficient to back the value of the tokens. MICA is a game-changing legal regulation in the rapidly growing digital asset and digital payments markets; therefore, its impact on both issuers and holders of stablecoins must be assessed (Alcorta, 2025).

Literature studies allowed the authors to identify several research gaps. Primarily, most academic articles and research reports have focused on capital issues and the investment role of cryptocurrencies. The payment role of cryptocurrencies, particularly stablecoins, has been insufficiently explored. Furthermore, the rapid pace of the abovementioned legal changes and new broad regulations, such as MiCA in Europe and the GENIUS Act in the US, creates an urgent need for new, up-to-date research on their impact on the stablecoins market.

The goal of the work is to determine the role of stablecoins in the European payment services market under the MiCA regulatory regime, considering their economic functions and legal classification. To achieve this goal, the authors formulated four research questions.

Q1. Does a stablecoin-based system meet the definition of a "payment system"?

The primary function of a payment system is to facilitate the transfer of value between the payer and the payee in accordance with established rules and regulations. Although stablecoins offer less volatility to facilitate the transfer of value, the underlying risk of the pegged assets in stablecoins creates a certain level of volatility for the stablecoins. In such a scenario, it is essential to investigate whether we should consider stablecoins as a payment system within the EU legal framework, which constitutes the first research question.

Q2. Should EMTs be classified as a specific form of electronic money consistent with the EMD2 framework, or rather as a *sui generis* category of digital assets embedded in distributed ledger technology?

Secondly, it is important to understand the relationship between the "electronic money" and "e-money token" from a legal perspective (MiCA). Electronic Money is the digital representation of physical money that can be used for online transactions and payments. While E-Money Tokens are a new classification of stablecoins under the MiCA regulation, representing stablecoins pegged to a single fiat currency. The second research question will help to understand the relationship between these two forms of value from a legal perspective.

Q3 How does the EU regulatory model for EMTs under MiCA compare with stablecoin frameworks in the United States, Japan, Switzerland, and the United Kingdom in terms of scope, stringency, and consumer protection?

Thirdly, the comparative dimension is crucial for contextualizing the EU's approach (Polasik et al., 2021). Stablecoin regulation is not uniform world-

wide, and jurisdictions such as the United States, Japan, Switzerland, and the United Kingdom have already developed or are in the process of developing distinct frameworks. Analyzing the similarities and divergences between MiCA and these international models will highlight the relative strictness, comprehensiveness, and consumer-protection orientation of the EU regime. This constitutes the third research question.

Q4. What general effects could MiCA regulation have on the innovativeness of the European digital payment services market?

While the MiCA Framework promises legal clarity, financial stability, and protection for users, it remains unclear whether the MiCA Framework will improve or hinder the innovativeness of the European payment services market. As the research question no. 4, the authors will explore the effects of MiCA regulation on the European digital payment services market.

2. Literature review

2.1. Stablecoins as a Key Category of Digital Assets

Stablecoins are cryptocurrencies that are backed by fiat currencies, other cryptocurrencies, or commodities, creating stability in their value and making them suitable for payments and transfers. Stablecoins backed by a national currency are used to trade in non-stable cryptoassets more efficiently than using national currencies (Lyons & Viswanath-Natraj, 2023). The core idea of stablecoins is to trade at par with the underlying asset (Fiedler & Ante, 2023).

The concept of a stablecoin refers to digital tokens designed to maintain a stable value through mechanisms linked to external reference assets, such as fiat currencies, commodities, other cryptocurrencies, or algorithmic formulas. As emphasized by Kołodziejczyk and Jarno (2020), stablecoins serve as a "conceptual umbrella" encompassing various forms of value-stable cryptocurrencies, unified by their objective of preserving value over time.

Within the academic literature, several fundamental types of stablecoins can be distinguished. Arner et al. (2020), Castrén et al. (2022), B. Cheng (2024) discuss types of stablecoins that the authors used to develop their own proposal, classifying them according to their method of value stabilization into four main categories:

1. **Asset-backed stablecoins** – These are secured by physical reserves of financial assets tied to a single fiat currency, such as the US dollar (USD), government bonds, treasury bills, certificates of deposit, or commercial paper (Fiedler & Ante, 2023). Examples include USDT (Tether), USDC (USD Coin), and BUSD (Binance USD). The primary advantage of this model lies in its simplicity and the intuitive nature of the stabilization mechanism. However, its effectiveness depends heav-

ily on the transparency and credibility of reserve audits (B. Cheng, 2024). MiCA further classifies these asset-backed stablecoins into two categories (see section 4.1).

2. **Commodity-backed stablecoins** – These tokens are backed by tangible commodities, such as precious metals (e.g., gold) or other physical assets. PAX Gold, Tether Gold, and Kinesis Gold are examples of commodity-backed stablecoins (J. Cheng & Torregrossa, 2022).
3. **Crypto-collateralized stablecoins** – The value of these stablecoins is underpinned by reserves held in other cryptocurrencies (e.g., ETH or BTC), which are stored in smart contracts. A notable example is DAI, issued by MakerDAO. Due to the volatility of the underlying collateral, such stablecoins require overcollateralization and incorporate automated liquidation mechanisms to respond to declines in collateral value (Caudevilla et al., 2022).
4. **Algorithmic stablecoins** – These tokens do not rely on reserves of any kind. Instead, they maintain price stability through algorithmic supply-and-demand management, which automatically adjusts the token supply to sustain parity with the reference value (Clements, 2021). The most well-known example is the failed TerraUSD (UST) project, which lost its peg to the USD in May 2022, leading to the collapse of multiple affiliated institutions (B. Cheng, 2024). According to the (Caudevilla et al., 2022), algorithmic stablecoins are particularly vulnerable to what is known as the "run risk" due to their lack of real, tangible backing. However, the algorithmic sUSD stablecoin based on the Synthetix platform, despite its high volatility for a stablecoin, has been successfully operating since mid-2018, recovering value even in cases of short-term depegs (*Coingecko*, 2025).

A different classification approach is proposed by Hafner et al. (2024), which divides stablecoins into two dimensions: the origin of the collateral (exogenous or endogenous) and the method of collateral management (centralized or decentralized), as presented in Table 1. Stablecoins with exogenous collateral are backed by assets external to the blockchain system, such as fiat currencies (e.g., USD), while endogenous collateral relies on native tokens within the issuer's ecosystem. Centralized collateral management refers to control exercised by a single entity (e.g., a company issuing the token). In contrast, decentralized management is conducted via autonomous protocols or decentralized autonomous organizations (e.g., DAOs). In this comparison, an example of a fully independent and decentralized stablecoin is sUSD. This classification (Table 1), based on the origin and governance of collateral, provides a valuable framework for evaluating risk mechanisms, transparency, and degrees of control across different stablecoin models.

2.2. Historical Perspective on the Development of Stablecoins

The development of stablecoins—one of the most dynamic segments of the digital asset market—has unfolded in parallel with the evolution of blockchain technological infrastructure and the maturation of institutional and regulatory responses to new forms of digital money.

The first stablecoin, BitUSD, was issued in 2014 on the BitShares blockchain (Dionysopoulos & Urquhart, 2024). BitUSD was a pioneering stablecoin designed to maintain a stable exchange rate relative to the US dollar (Scheme 1), thereby making it more suitable for everyday transactions compared to highly volatile cryptocurrencies (Bergsli et al., 2022; Polasik et al., 2016).

The era of large-scale adoption of stablecoins began in October 2014 (Scheme 1) with the launch of Tether (USDT). As an off-chain stablecoin, USDT was theoretically backed 1:1 by US dollar reserves. Its primary objective was to combine the stability of fiat currency with the speed and accessibility of blockchain technology. Despite persistent controversies regarding reserve transparency and ownership structure, USDT dominated the market for many years as the primary store of value and medium of exchange within the cryptocurrency ecosystem (Dionysopoulos & Urquhart, 2024).

A qualitative shift occurred in 2017 with the creation of MakerDAO and the issuance of DAI, the first fully decentralized stablecoin (Scheme 1). Unlike Tether, DAI is crypto-collateralized and issued through smart contracts on the Ethereum network. In 2018, USD Coin (USDC) was launched by the Center Consortium, founded by Circle and Coinbase (Rana, 2022). USDC represented a new wave of regulated stablecoins (fiat-backed and fully audited), meeting compliance standards and subject to regular reserve audits, which started the era of professionalization of the stablecoin market.

A key milestone in Europe's stablecoin history was the European Union's adoption of the Markets in Crypto-Assets Regulation (MiCA) in 2023 (Scheme 1). This regulation introduced a unified legal framework for stablecoins, distinguishing between asset-referenced tokens and e-money tokens (Alcorta, 2025). MiCA mandates compliance with capital requirements, reserve management obligations, and operational transparency, while enabling the legal entry of stablecoins into the EU financial market. In turn, the MakerDAO project underwent a significant transformation in 2024. Its decentralized governance system was simplified and rebranded as "Sky", and the DAI stablecoin was renamed "USDS" (Genc & Acikgoz, 2025). This restructuring aimed to enhance operational efficiency and align the protocol with emerging regulatory oversight, while preserving the core elements of decentralization and on-chain governance.

In 2025 (Scheme 1), the US introduced the GENIUS Act (Guiding and Establishing National Innovation for US Stablecoins Act), which requires

stablecoin issuers to back their coins with US dollars or short-term US Treasury securities (Krause, 2025). It also mandates a public disclosure of the composition of backed reserves, licensing of issuers by banking authorities, and standardized audit procedures. While the EU and the US follow different approaches to control stablecoins, it is essential to understand the impacts on the adoption of stablecoins and identify the strengths and weaknesses of each approach.

2.3. Use Cases and the Development of the Stablecoin Market

The specific nature of stablecoins—namely, their linkage to a stable value or reference asset—directly influences their range of potential applications. A key feature of a stablecoin is its price stability, a characteristic that has also been confirmed by empirical studies (Ahmed & Aldasoro, 2025). This feature generally implies lower risk when compared to other crypto-assets due to reduced volatility (Arner et al., 2020, p. 7). However, research findings indicate that stablecoins do not serve effectively as strong hedges or safe havens; instead, they perform well in their stabilizing function (Kołodziejczyk, 2023).

Stablecoins can serve as a useful payment instrument (Martínez Nadal, 2025). Their adoption offers the potential to reduce costs associated with traditional payment methods, while also accelerating settlement times, as the use of distributed ledger technology (DLT)/blockchain enables real-time transaction processing. These features are particularly significant in business environments, especially in the context of cross-border transactions, and are also valuable in the e-commerce sector (BIS, 2023)

Stablecoins are also widely used (Chart 1) as settlement instruments within the decentralized finance (DeFi) ecosystem, supporting the execution of smart contracts (Arner et al., 2020, p. 6). In this domain, speed and low transaction costs are critical, alongside the ease of conversion between stablecoins and other crypto-assets.

Furthermore, stablecoins may serve as an investment vehicle. Research suggests that stablecoins can serve as an alternative to money market funds, given their asset backing and similar market infrastructure. However, important differences remain. For example, secondary market trading is generally possible for stablecoins, which may reduce their price stability. In contrast, money market funds may offer dividend payouts or other forms of fixed income, which are typically not associated with stablecoins (Oefele et al., 2024, p. 19). At the same time, research on the interaction between monetary policy and crypto-assets, particularly stablecoins, is intensifying. A study conducted under the auspices of the Bank for International Settlements (BIS) suggests that monetary policy shocks lead to capital inflows into prime money market funds and significant outflows from stablecoins (Aldasoro et al., 2024, p. 9).

Beltrametti and Pittaluga (2023, p. 466) identify two possible pathways for achieving widespread adoption of digital currencies on par with fiat money: (1) granting stablecoins the legal status of money, or (2) introducing Central Bank Digital Currencies (CBDCs). This raises a crucial question: should these solutions be viewed as mutually exclusive competitors, or can they coexist and complement each other within a hybrid financial system?

Central banks have also begun to recognize the growing significance of stablecoins. The U.S. Federal Reserve (FED) appears to perceive stablecoins as a potential instrument for reinforcing the global role of the U.S. dollar, notably since the majority of stablecoins (97,4% of market cap) are pegged to this currency (Chart 1). This perspective was articulated by Christopher J. Waller, Member of the Board of Governors of the Federal Reserve, during his address at A Very Stable Conference in San Francisco (Waller, 2025).

The Chinese Central Bank Digital Currency (CBDC), known as Digital RMB, is issued by the People's Bank of China (PBOC) to establish the infrastructure for the long-term development of the digital economy, and it has a significant impact on businesses. Digital RMB is expected to promote China's competitive edge in the fourth Industrial Revolution (Yeung et al., 2020). The program is still in the test phase and yet to be rolled out.

India has taken a critical stance toward stablecoins. In a report by the Reserve Bank of India, stablecoins and other crypto-assets were identified as a threat to the effectiveness of monetary policy and as a factor limiting the financing of the real economy (Kasana & Singh, 2024). From India's perspective, the erosion of sovereign control over national currency and the diminished capacity to conduct autonomous monetary policy are seen as the most concerning implications of stablecoin proliferation (Malhotra, 2025, p. 145). Concurrently, India is conducting extensive testing of its own CBDC named e-Rupee or Digital Rupee (Kasana & Singh, 2024, p. 99), which in some respects serves as an alternative to stablecoins—particularly in terms of allowing the state to retain influence over monetary policy. The Indian government aims to utilize the e-Rupee for both public transactions and interbank payments.

The European Central Bank (ECB) is planning to roll out the digital Euro (CBDC) in 2025. The goal of the project is to ensure that people in the digital world retain the option to make or receive payments in central bank money. ECB also aims to provide an alternative to the usage of stablecoins through the Digital Euro in the European Union (Lane, 2025). At the same time, Europe is also planning to improve its market share of the stablecoin business by forming a European banking consortium consisting of banks such as Banca Sella, KBC, Danske Bank, DekaBank, UniCredit, ING, SEB, CaixaBank, and Raiffeisen Bank, to create a Euro-backed stablecoin under the MiCA regulations framework for cryptocurrencies by 2026 (Sims et al., 2025). Currently, Euro-pegged stablecoins have a market capitalization of

just 0.2% of all stablecoins (Chart 1), which is more than 500 times smaller than that of U.S. dollar stablecoins. Additionally, the American company Circle, based in Boston, is the most significant issuer of 43% of the eurozone's stablecoin value, issuing both EURC and USDC, the second most important stablecoin pegged to the dollar (Chart 1).

These varying national perspectives illustrate that political factors are the key determinants in shaping countries' attitudes toward stablecoins. In particular, the macroeconomic and monetary policy implications of stablecoin adoption are crucial. Given that the U.S. dollar is the dominant reference currency for most stablecoins, their global expansion reinforces the dollar's position as the primary reserve currency. Consequently, the United States has a strategic interest in supporting the development of this asset class. In contrast, geopolitical competitors of the U.S., such as Russia and India, are seeking to counterbalance or limit the influence of dollar-based stablecoins. Russia is leveraging them for sanction evasion, while India is reinforcing its monetary sovereignty.

3. Methods

A systematic literature review approach has been employed. A wide set of databases was explored on the subject of stablecoins, including ScienceDirect, JSTOR, and SpringerLink. We started by identifying research papers from reputable scientific journals by searching Web of Science, Scopus, and Google Scholar with keywords like "Stablecoins", "blockchain", "MiCA", "GENIUS Act", "CBDC", and the leading stablecoin brands – USDT, USDC, DAI, etc. Given that the subject of stablecoins also encompasses the practical aspects of the financial sector's operation, as well as monetary policy and payment infrastructure, we have utilized numerous statistical sources from public and financial institutions. These include, in particular, analyses, statistics, and policy statements published by the European Central Bank (ECB) and other central banks, the Bank of International Settlements (BIS), the International Monetary Fund (IMF), as well as national and European financial supervisory authorities, and the Eur-Lex database of legal acts. We also employed the current statistical data from portals that aggregate data from cryptocurrency exchanges.

The primary research was based on legal analysis. Several research methods were applied for this purpose. First, the dogmatic analysis of law method was used, which involves examining the content of the law as well as its interpretation found in the literature and case law (Szafrański, 2023, p. 61). The provisions of MiCA were analyzed in the context of legal acts relating to payment services and payment systems. This study aimed to place the MiCA regulation within the legal system and to interpret selected provisions in or-

der to assess their implications. This required a detailed analysis of the legal text, including the identification of legal norms, their systemic placement, and the interpretation of provisions using principles of legal interpretation (linguistic, systemic, and purposive). The study was based on legal sources, academic literature, as well as reports and analyses prepared by specialized industry entities.

Second, the economic analysis of law approach was applied, which allows for the assessment of legal regulations from the perspective of economic efficiency and the impact of legal norms on the behavior of individuals and businesses (Famulski, 2017). This method was employed to investigate the impact of MiCA on the market. Both direct regulatory effects—such as the obligations of entities to comply with the new framework and the exclusion of certain types of stablecoins from regulation—and indirect effects, including potential changes in market behavior, were taken into consideration. Elements of regulatory risk assessment, typical for interdisciplinary studies at the intersection of law and economics, were also incorporated.

Finally, the comparative-legal method was used to analyze selected provisions of the MiCA regulation by comparing them with corresponding solutions in other legal systems (the United States, the United Kingdom, Switzerland, and Japan). This enabled the identification of similarities and differences in the normative structure of the provisions and their potential consequences, allowing for the formulation of more comprehensive conclusions from the perspective of the law and economics approach.

4. Results

4.1. The legal nature of EMTs: e-money or sui generis digital assets

The MiCA Regulation defines electronic money tokens (EMTs) as crypto-assets that "purport to maintain a stable value by referencing the value of the official currency of a Member State" (MiCA, 2023, art. 3(6)). This definition highlights two essential features: (1) the reference to fiat currency, and (2) the intended stability of value. Crucially, MiCA explicitly states (MiCA, 2023, art. 43) that EMTs are deemed electronic money for Directive 2009/110/EC (EMD2).

This dual recognition has two implications. First, EMTs are not merely a new crypto-asset class, but are directly anchored in existing electronic money law. Second, EMT issuers must comply simultaneously with the requirements of MiCA (whitepaper, disclosure, prudential standards) and EMD2 (licensing and redemption rights), as well as with PSD2 (2015) when providing payment services based on EMT, thereby creating a complex, layered regulatory framework.

In the opinion of many legal experts, EMTs are a direct extension of the e-money concept under EMD2 (Martínez Nadal, 2025). The core rationale lies in their functional similarity: EMTs represent a claim against the issuer, must be issued at par value in exchange for fiat funds, and must be redeemable at par on demand (MiCA, 2023, art. 44). These features replicate the essence of electronic money under the EMD2 directive, which defined it as a monetary value stored electronically, representing a claim on the issuer and issued upon receipt of funds.

Accordingly, EMTs are best understood as technologically updated e-money, circulating not through centralized systems but via distributed ledger technology (DLT). From this perspective, the main novelty lies not in the legal nature of the instrument but in the infrastructural environment in which it operates (Alcorta, 2025).

By contrast, other legal experts argue that EMTs should be recognized as a *sui generis* category of digital assets, rather than assimilated into the EMD2 framework (Włoczka, 2025). Their reasoning emphasizes the distinct technological characteristics of EMTs:

a. They are issued and transferred on blockchain networks, often public and permissionless, which radically alters the mechanics of storage, transfer, and settlement.
b. EMTs are embedded in decentralized ecosystems, where intermediaries may no longer play the same role as in traditional electronic money.
c. Their potential integration into decentralized finance (DeFi) raises novel risks (e.g., smart contract vulnerabilities, governance failures) that were not envisaged by the EMD2 regime .

On this basis, proponents of the *sui generis* approach suggest that classical e-money concepts cannot fully capture EMTs. They constitute hybrid assets that combine contractual claims with technological self-execution, requiring tailored rules beyond those of EMD2.

The EU legislator appears to have adopted a compromise position, recognizing EMTs as both e-money and a distinct subcategory of crypto-assets. This dual classification has important regulatory consequences. EMTs fall under:

1. EMD2 obligations – licensing of issuers as electronic money institutions, safeguarding of funds, and redemption at par value.
2. MiCA obligations – mandatory whitepaper disclosure, prohibition of remuneration (no interest), full reserve requirements, and EBA oversight for significant issuances.

The overlap creates both strengths and challenges. On the one hand, it ensures legal continuity and consumer protection by integrating EMTs into existing monetary law. On the other hand, it generates complexity and possible regulatory redundancies, requiring close coordination between national competent authorities and the EU supervisor (EBA, 2024).

A related issue concerns whether EMTs qualify as "funds" under PSD2 (Polasik et al., 2020). The directive defines funds as "banknotes and coins, scriptural money and electronic money" (PSD2, 2015, art. 4(25)). Since MiCA recognizes EMTs as electronic money, they logically fall within the scope of PSD2 as a form of funds. As a result, payment services involving EMTs must comply with PSD2 rules, particularly those related to strong customer authentication, fraud prevention, and user rights (Alcorta, 2025).

This creates regulatory interoperability: EMTs serve as the bridge between traditional payment services and DLT-based ecosystems. In practice, it enables hybrid models where EMTs are used within conventional payment frameworks while still benefiting from the transparency and programmability of blockchain (see Opinion on the interplay between PSD2 and MiCA (EBA, 2025)).

The legal nature of EMTs remains a subject of contention between two interpretations. Functionally, EMTs strongly resemble e-money as defined in EMD2, and EU law explicitly adopts this classification. Doctrinally, however, their operation on DLT supports an argument for a *sui generis* category. The EU has resolved this debate pragmatically by applying a dual regulatory framework: EMTs are both e-money and crypto-assets. This layered approach enables regulators to maintain continuity with existing monetary law while addressing the novel risks associated with blockchain-based finance (Zetzsche & Woxholth, 2025).

Another issue is whether EMT can be considered a legal tender. The literature suggests that although MiCA does not confer upon them the formal status of "legal tender," their practical use as a substitute for fiat currency may lead to a quasi-monetary character (IMF, 2025). A constitutive feature of EMT is also the right to redemption at face value at any time (MiCA, art. 44). The issuer's obligation is thus unconditional and lies at the very core of the legal relationship between issuer and holder.

The EBA notes (2025) that in the event of large-scale adoption of EMT in payment ecosystems, the traditional role of money issued by central banks could be eroded. The debate over the legal nature of EMT is also embedded in the broader discussion on the distinction between private and public forms of digital money. While central banks focus on CBDC projects, the private sector is developing EMT as an instrument for faster and cheaper cross-border payments.

4.1.2. EMT in relation to Payment Services Directive 2

The Payment Services Directive 2 (PSD2) regulates the provision of payment services, including the initiation of transactions and access to payment accounts. Although PSD2 does not directly address crypto-assets, its logic applies in the case of EMT, which are treated as electronic money, and

electronic money constitutes a type of fund. Moreover, pursuant to MiCA, transactions involving EMT must be executed in accordance with PSD2 principles concerning security, fraud prevention, and user protection in payment services (MiCA, 2023).

For example, payment service providers (PSPs) may offer payment initiation services using EMT, while remaining subject to PSD2 requirements on strong customer authentication (SCA). In practice, this may lead to the emergence of hybrid models in which classical payment regulations under PSD2 are applied to operations conducted in DLT environments. Such a solution poses the challenge for regulators of ensuring interoperability between the world of "traditional" payment services and the world of crypto-assets.

Both EMD2 and PSD2 form the foundation upon which EMT regulation rests. It can be argued that MiCA does not so much "replace" earlier regulations as extend their logic to a new category of instruments with a different technological nature.

A similar process can be observed in other jurisdictions (see section 4.3). In Japan, stablecoins have been subject to the Payment Services Act, i.e., the payment services regime, whereas in the United States, the GENIUS Act explicitly references the principles of banking law and deposit liability (JFSA, 2022). This demonstrates that worldwide EMTs and their equivalents are treated as instruments closely related to traditional payment services.

The relationships between EMT, EMD2, and PSD2 point to clear regulatory continuity. EMT did not emerge in a vacuum, but constitutes the next stage in the evolution of concepts related to electronic money and payment services. At the same time, their reliance on DLT required the creation of a new regulatory layer supplementing the earlier directives. In practice, this means that EMTs operate simultaneously within three layers of legal acts, which increases system complexity but also provides greater coherence and consumer protection.

4.2. Stablecoin arrangements and the definition of a payment system under EU law

The rapid development of stablecoins has raised fundamental questions about their legal and systemic classification in the European Union. While stablecoins are primarily designed to function as a means of payment or store of value, their qualification under existing EU legal frameworks remains contested. A central issue is whether a stablecoin arrangement, particularly when organized through blockchain-based infrastructures, can be regarded as a "payment system" within the meaning of European Union law.

The answer to this question has direct implications for regulatory oversight. Payment systems in the EU are subject to stringent prudential and operational requirements under the Settlement Finality Directive (SFD) and

the Payment Services Directive (PSD2). Classifying stablecoin arrangements as such systems would therefore impose licensing obligations, systemic oversight by central banks, and mandatory participation rules, potentially transforming their regulatory treatment from a private contractual mechanism to a systemically significant market infrastructure.

The Settlement Finality Directive (Directive 98/26/EC or SFD) defines a payment system as a formal arrangement between at least three participants, governed by common rules and standardized arrangements for the execution of transfer orders, and recognized as such by a Member State authority (SFD, art. 2(a)). This definition presupposes the existence of multiple participants, mutual arrangements, and a degree of formalization comparable to that of clearinghouses or central counterparties.

By contrast, stablecoin issuance typically involves a single issuer and a decentralized technological infrastructure for token transfer. The transfer of stablecoins on a blockchain, although facilitating payments, does not constitute an "arrangement" between independent participants in the sense envisaged by the SFD. Instead, it is a technical protocol that enables peer-to-peer value exchange, without a central operator or a designated set of participants bound by common contractual rules (Zetzsche & Sinnig, 2025).

Stablecoins should be treated as a means of payment, but not as a payment system *per se*. The distinction is significant: whereas a payment system constitutes an organized market infrastructure that requires authorization, an EMT is a digital representation of value circulating within such infrastructures and is deemed electronic money, which, according to PSD2, is considered a type of "funds".

Stablecoin issuers are not themselves operators of payment systems merely by issuing tokens. Their activity is closer to that of electronic money institutions under EMD2, where the emphasis lies on the legal claim of redemption rather than on operating multilateral settlement frameworks. Only if a stablecoin arrangement were to develop institutionalized rules among multiple participants could it potentially qualify as a payment system.

This interpretation has two consequences. First, it avoids overextending systemic regulation to every blockchain-based stablecoin, which would be impractical and disproportionate given the decentralized architecture of many arrangements. Second, it ensures that stablecoins remain regulated under MiCA as electronic money tokens (EMTs), with a focus on issuer obligations, prudential safeguards, and consumer protection, rather than under SFD as infrastructures.

Nonetheless, the boundary is not absolute. Hybrid models may arise where stablecoins are embedded in payment arrangements that could function as systems, for example, if EMTs are used for settlement among financial institutions. EBA's evolving supervisory regime (e.g., its technical standards and oversight of significant EMTs) suggests that individual assessment will

be required where systemic risk is possible (EBA, 2024; Zetzsche & Woxholth, 2025).

In conclusion, a stablecoin-based arrangement does not qualify as a "payment system" under EU law in its ordinary form, since it lacks the organizational and contractual structure required by the SFD. Instead, electronic money tokens under MiCA are classified as funds, subject to prudential and consumer protection obligations, but not to systemic payment system regulation. This approach preserves regulatory coherence, ensuring that stablecoins are supervised as financial products rather than as infrastructures, while leaving open the possibility that more institutionalized arrangements could be brought within the SFD framework in the future.

4.3. Comparative perspectives: the EU model and other jurisdictions

4.3.1. The European Union model under MiCA

The European Union's approach under MiCA regulation is widely recognized as one of the most comprehensive and restrictive stablecoin regimes globally. EMT issuers are subject to exclusive licensing requirements (only credit institutions and electronic money institutions may issue), full reserve backing in low-risk liquid assets, and strict redemption rights at par value (MiCA, 2023, arts. 44–47). MiCA also prohibits the payment of interest on EMT holdings to prevent their misuse as investment instruments and imposes liability on issuers for misleading information disclosed in whitepapers (Alcorta, 2025).

In addition, MiCA introduces a special category of "significant EMTs", defined by thresholds such as more than 10 million users or circulation above EUR 5 billion (MiCA, 2023, art. 51). Such issuers fall under the direct supervision of the European Banking Authority (EBA), which may impose higher capital requirements, enhanced liquidity measures, and transaction limits (EBA, 2025). This reflects concerns that large-scale stablecoins could attain systemic importance comparable to that of global systemically important banks (Hafner et al., 2024).

The regulatory philosophy of MiCA can be summarized in three pillars: (1) strong consumer protection through redemption rights and transparency obligations; (2) financial stability safeguards via prudential and reserve requirements; and (3) fostering innovation under supervision, by creating a harmonized EU-wide regime to avoid regulatory fragmentation.

4.3.2. United States: the GENIUS Act

The United States adopted the GENIUS Act in 2025, which establishes a federal framework for the issuance of stablecoins. The Act restricts issuance to insured depository institutions and licensed non-bank entities that federal

regulators have approved. It requires 1:1 reserve backing US dollars or short-term Treasury securities, mandates monthly disclosure of reserve composition, and prohibits misleading claims of federal backing.

A distinctive feature of the US model is the priority status of stablecoin holders in insolvency proceedings, ensuring that they are repaid ahead of other creditors (FSB, 2023). While the reserve and disclosure obligations broadly mirror MiCA, the US regime places more emphasis on consumer recourse in bankruptcy and on aligning stablecoins with banking law concepts of deposit protection. At the same time, enforcement authority is fragmented between federal and state regulators, which may result in regulatory heterogeneity compared to the EU's harmonized approach.

4.3.3. Japan: the Payment Services Act

Japan was one of the first jurisdictions to comprehensively regulate stablecoins. The 2022 amendment to the Payment Services Act (PSA) classified stablecoins as "means of payment" and required them to be fully backed by bank deposits (JFSA, 2022). This effectively limited issuance to banks and trust companies, ensuring extremely high levels of stability but significantly narrowing the space for private sector innovation.

In 2025, Japan introduced further reforms allowing up to 50% of reserves to be invested in highly secure government bonds, thereby expanding issuers' flexibility while maintaining prudential safeguards (JFSA, 2022). Compared to the EU, the Japanese regime is more conservative in restricting issuers to traditional financial institutions, but it imposes fewer disclosure and white-paper obligations. The focus lies squarely on prudential safety rather than on transparency and consumer liability mechanisms (Bains, 2025).

4.3.4. Switzerland: FINMA's flexible approach

Switzerland has not enacted dedicated stablecoin legislation; instead, it relies on supervisory practice by the Swiss Financial Market Supervisory Authority (FINMA). FINMA assesses projects on a case-by-case basis, applying existing laws in the financial market. Stablecoins backed by fiat currency are typically treated as deposit-taking activities, requiring either a banking license or equivalent safeguards such as a complete bank guarantee (FINMA, 2024; FINMA Guidance 06/2024, 2024).

This approach offers greater regulatory flexibility than MiCA, enabling diverse tokenization models to emerge, including stablecoins utilized in wholesale financial markets. However, it also relies heavily on supervisory discretion rather than codified obligations. Consumer protection focuses primarily on ensuring the segregation and safekeeping of reserves, with less emphasis on disclosure and harmonized redemption rights.

4.3.5. United Kingdom: evolving regulation

The United Kingdom is in the process of finalizing its stablecoin regime, with reforms announced in 2025. The Financial Conduct Authority (FCA) has proposed the introduction of "qualifying stablecoins", defined as tokens maintaining stable value relative to fiat currency (FCA, 2025). These tokens will be subject to reserve backing, redemption rights, and transparency requirements, closely aligning with the EU model.

Additionally, the Bank of England has outlined that systemic stablecoin arrangements will be subject to prudential oversight, ensuring they meet standards equivalent to those of traditional payment systems (FCA, 2025). Notably, UK regulation intends to apply PSD2-style safeguards, including strong customer authentication, to stablecoin-based payments. This reflects a convergence with EU law, though the UK regime remains more principles-based and flexible in implementation (FSB, 2023).

4.3.6. The Comparison of Stablecoin Regulations

The EU's MiCA framework represents the most codified and harmonized approach, combining consumer protection, systemic safeguards, and prudential requirements in a single legal act. The US and Japan adopt similarly stringent reserve obligations but differ in institutional design: the US emphasizes insolvency protection, while Japan restricts issuance to banks. Switzerland and the UK pursue more flexible approaches, with Switzerland relying on supervisory discretion and the UK developing a hybrid regime aligned with PSD2 principles. Given that all these regulations are still relatively new, dating back to 2022-2025, it is still too early to assess their effects on the development and innovation of individual markets, as well as on the stability of the financial system and consumer protection.

5. Conclusions

One of the most important conclusions of our study is that a stablecoin-based arrangement does not qualify as a "payment system" under EU law in its ordinary form, due to a lack of organizational and contractual structure (research question Q1). Under MiCA, electronic money tokens (EMTs) are categorized as funds and are subject to prudential and consumer protection requirements. The act of issuing tokens does not, by itself, make stablecoin issuers operators of payment systems. Such an arrangement would only be considered a payment system if it evolved to include formalized rules among several participating entities.

Our studies, aimed at answering research question Q2, allowed us to determine that there is a strong similarity between EMT and electronic money under EMD2, as both involve a digital representation of value linked to fiat currency and used as a means of payment. At the same time, EMT differs from classical electronic money in infrastructural terms, as EMT operates in a decentralized system. For this reason, their regulation required a separate legal act in the form of MiCA. EMTs serve as the bridge between traditional payment services and DLT-based ecosystems. In practice, it enables hybrid models where EMTs are used within conventional payment frameworks while still benefiting from the transparency and programmability of blockchain. EMTs are both e-money and crypto-assets.

Referring to the comparison of regulatory models in different jurisdictions (research question 3), one can generally conclude that stablecoin regulations in the countries compared reflect a similar main approach applied in MiCA. It consists in the fact that the new regulations do not so much "replace" earlier regulations as extend their logic to a new category of funds that use decentralized blockchain technology. However, the accents are distributed differently. In Japan, stablecoins fall under the scope of the Payment Services Act, which governs the provision of payment services. In the United States, the GENIUS Act directly references banking law principles and deposit obligations. This suggests that, globally, EMTs and similar instruments are viewed as closely aligned with conventional payment services.

It may be assumed that the regulation of stablecoins will affect their market significance. The first natural consequence of the restrictions imposed on issuers by MiCA is the withdrawal of certain stablecoins from the European market. A notable example is the withdrawal of USDT from cryptocurrency exchanges, such as Binance. The issuer of USDT has not applied for authorization to conduct a public offering within the European Union's territory, which may be due to the fact that it essentially maintains its reserves in assets other than fiat currency (B. Cheng, 2024).

On the other hand, significant development may await those stablecoins whose issuers are the first to obtain, or have already obtained, the relevant authorization. An example of a stablecoin recognized as a potential market leader and successor to USDT is USDC. Its issuer, Circle, has already obtained authorization from the French supervisory authority. Less than all, however, the visible result of being a pioneer of new technology is the absolute dominance of stablecoins based on the US dollar.

The introduction of regulation may contribute to increased confidence in stablecoins (Kapica & Goławska, 2023, p. 52). Elements such as the obligation to maintain reserves (including in specified assets), ongoing supervision by a state authority, and a range of measures ensuring client protection may encourage investment in stablecoins by individuals who have so far been reluctant to engage in the crypto-asset market due to the high risks associated

with it. On the other hand, it should be assumed that some individuals, for whom the absence of state supervision was an advantage of crypto-assets, may be inclined to seek other forms of investment that will remain outside the regulatory sphere.

Nevertheless, the mere structuring of the market should have a positive effect on its development. MiCA defines the market structure by specifying its participants and their respective obligations (MiCA, 2023). This will improve market transparency and organization. The structuring of the crypto-asset market (including stablecoins), together with its regulation and state supervision, should encourage institutional investors to enter this market. The risks (other than those related to changes in the value of a crypto-asset) associated with such investments will be reduced. Furthermore, this may provide an impetus for stablecoins to be incorporated into the product offerings of entities from the traditional financial sector. In addition, regulation is of major importance from the perspective of financial system security and the prevention of fraud and abuse. Particularly important is the extension of AML/CFT obligations to a broader group of entities. This will reduce the risk of crypto-assets being used for illegal activities, and in particular for circumventing international sanctions.

Nevertheless, due to the short duration of the MiCA regulation, the answer to research question Q4, concerning its general effects on the innovativeness of the European digital payment services market, will require a longer observation horizon. In particular, some treats to stablecoins market developments can be identified, e.g. possible quantum computing negative impact on blockchain or competition with digital euro and other Central Bank Digital Currencies. Therefore, the impact of MiCA regulation on the stablecoins and the whole digital assets market should become an important subject of future studies.

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Appendix

Table 1. Classification of Stablecoins by Collateral Origin and Management Structure

Collateral Origin	Collateral Management	
	Centralized	Decentralized
Exogenous	USDT, USDC	Dai
Endogenous	TerraUSD	sUSD

Notes: Exogenous collateral refers to assets external to the native blockchain ecosystem (e.g., fiat currencies); Endogenous collateral is based on native tokens of the issuer's protocol; Centralized management implies control by a single entity, while smart contracts or DAOs govern decentralized management.

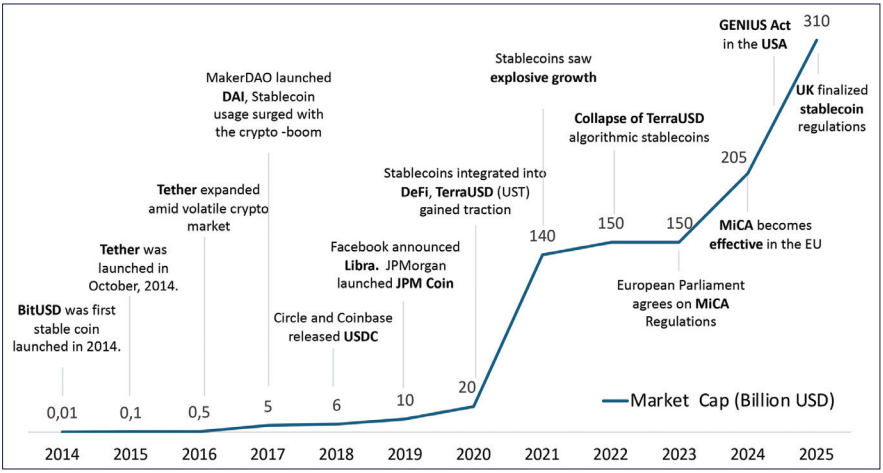
Source: Own preparation based on Hafner *et al.* (2024).

Table 2. The Comparison of Stablecoin Regulation Across Jurisdictions

Category	**EU (MiCA)**	**US**	**Japan**	**Switzerland**	**UK**
Scope of issuers	Only credit institutions and e-money institutions	Banks and licensed entities under federal approval	Only banks and trust institutions	On a case-by-case basis, often a banking license or guarantee	Open to non-bank entities, subject to prudential oversight
Reserve requirements	100% in low-risk liquid assets	100% in US dollars/ treasuries	100% bank deposits (later 50% bonds allowed)	Flexible, subject to FINMA review	Expected robust reserve assets, details pending
Consumer protection	Redemption rights; liability for misleading disclosures; prohibition of interest	Redemption rights plus priority in insolvency	Strong prudential guarantees, limited transparency obligations	Deposit protection focus, limited harmonized disclosure	PSD2-style safeguards; disclosure under FCA oversight
Supervisory architecture	Centralized under EBA for significant EMTs	Fragmented federal/state oversight	Centralized under JFSA	Case-by-case FINMA supervision	Joint FCA and BoE oversight, systemic focus
Interest-bearing possibility	Prohibited (no interest in EMTs)	Generally prohibited under stablecoin guidance	Prohibited from avoiding a bank-like deposit function	Case-by-case; typically not allowed without a banking license	Pending – expected prohibition for systemic tokens

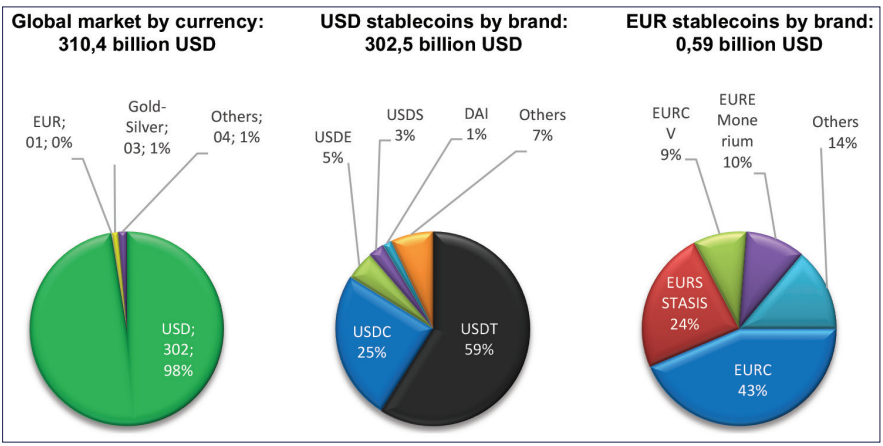
Source: Own elaboration.

Scheme 1. The evolution of stablecoins and the capitalization of the stablecoins' market



Source: Own preparation based on Dionysopoulos and Urquhart (2024), J. Czarnecki (2025), and CoinMarketCap (2025).

Chart 1. Stablecoins market caps in billions of USD



Source: Own preparation based on Coingecko data for 12 October 2025 (*Coingecko*, 2025).