EKONOMICKÁ UNIVERZITA V BRATISLAVE
FAKULTA HOSPODÁRSKEJ INFORMATIKY

UNIVERSITY OF ECONOMICS IN BRATISLAVA
FACULTY OF ECONOMIC INFORMATICS

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„Participácia doktorandov a mladých vedeckých pracovníkov na budovaní spoločnosti založenej na vedomostiach"

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O B S A H

Modeling customer decisions: balancing revenue and customer goals

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Abstract
Understanding how customers make decisions is central to revenue management, where pricing and assortment design shape both business outcomes and customer experience. This study explores ways to capture these decisions while extending the perspective beyond profit maximization to include environmental and sustainability goals. By using simulated data, it becomes possible to test and compare alternative models of customer choice, revealing not only their strengths but also their limits. The contribution provides a framework for linking economic objectives with principles of social responsibility and opens ways for future research grounded in real-world data and empirical validation.

Key words
Revenue management, customer preferences

JEL Classification:
D12, Q01, C53

1 Introduction

The challenge of realistically modelling customer preferences lies at the heart of assortment optimization, a problem where firms must decide which subset of products to offer in order to maximize expected revenue. Standard demand models, while analytically convenient, often impose behavioural assumptions that reduce their accuracy in practical settings. In response, research in revenue management has increasingly turned toward probabilistic choice models that integrate customer heterogeneity and sequential decision-making.

Among these, two approaches have received particular attention: the Multinomial Logit (MNL) model, valued for its tractability but constrained by the Independence of Irrelevant Alternatives (IIA) property, and the Markov Chain Choice Model (MCCM), which overcomes these limitations by explicitly modelling substitution as a stochastic process. Each offers distinct insights into how customers make purchasing decisions, and comparing their outcomes can help practitioners and researchers better understand both their strengths and limitations.

This article contributes to this discussion by examining the formulation and application of both MNL and MCCM in the context of assortment optimization. Using simulated hotel data, we illustrate how each model computes purchase probabilities and expected revenues, and we highlight the implications of model choice for decision-making. Beyond profit maximization, the study also acknowledges the growing importance of integrating sustainability considerations into RM, pointing toward an interdisciplinary research agenda that balances economic efficiency with social and environmental responsibility.

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2 Literature review

Revenue Management (RM) originated as a strategic response to deregulation in the airline industry during the late 1970s. Early approaches were largely heuristic and rule-based, focusing on seat allocation and fare class protection. With the advent of more advanced data-driven methods, firms began dynamically adjusting availability across multiple fare products, leading to substantial revenue improvements across the sector (Talluri & van Ryzin, 2004; McGill & van Ryzin, 1999). Soon thereafter, RM practices diffused to other industries like most notably hospitality, car rentals, and passenger transport, where the interplay of fixed capacities, uncertain demand, and perishable inventory provided ground for such optimization tools (Belobaba, 1987).

The first generation of RM models treated demand as exogenous and independent across products. Methods such as Littlewood's rule (1972) and early protection-level formulations (Brumelle & McGill, 1993) assumed that customer demand for a product was unaffected by availability constraints or by the presence of other alternatives. Although analytically convenient, these assumptions overlooked the reality of substitution behaviour and adaptive decision-making (Talluri & van Ryzin, 2004).

To address this, **discrete choice models** were progressively integrated into RM research. The most prominent of these is the **Multinomial Logit (MNL) model** (McFadden, 1974), which conceptualizes customer choice as a utility-maximization process with random disturbances. Owing to its closed-form choice probabilities and ease of estimation, the MNL became a cornerstone of choice-based RM (Train, 2009). However, the MNL is limited by the *Independence of Irrelevant Alternatives (IIA)* property, which assumes that the relative odds of choosing between any two products remain unaffected by the introduction or removal of other alternatives. This property, while ensuring tractability, is often violated in practice, especially in contexts with asymmetric substitution or hierarchical preferences (Blanchet, Gallego, & Goyal, 2016).

The shortcomings of the MNL model motivated the development of more flexible frameworks. Among them, the **Markov Chain Choice Model (MCCM)** has attracted particular attention (Blanchet, Gallego, & Goyal, 2016). In MCCM, customer decision-making is represented as a stochastic process: customers arrive with an initial preference and, if that option is unavailable, transition to other products or exit through a sequence of probabilistic steps. Unlike the MNL, which imposes the IIA property, the MCCM naturally accommodates complex substitution patterns, and it can approximate a wide class of random utility models, including MNL and nested logit, while remaining computationally tractable (Feldman & Topaloglu, 2017).

Applications of MCCM to RM have expanded rapidly. Feldman and Topaloglu (2017) showed that assortment optimization under MCCM can be formulated using linear programming, while Kleywegt and Shao (2022) demonstrated its adaptability under inventory and pricing constraints. More recent studies incorporated robust optimization techniques (Desir et al., 2020) and behavioural extensions such as choice overload (Goutam, Goyal, & Soret, 2019). In parallel, MNL remains widely used as a benchmark model, valued for its interpretability and established estimation procedures, with MCCM positioned as a more behaviourally realistic alternative when substitution dynamics play a central role.

In addition to methodological contributions, there is a growing recognition of the role RM can play in advancing sustainability and environmental objectives. Choice models such as MNL and MCCM provide a natural platform for integrating ecological attributes into decision-making. For example, assortment optimization frameworks may penalize carbon-intensive offerings, reward eco-certified products, or explicitly model customer segments with pro-environmental preferences (Liu & Chen, 2020; Strauss, Klein, & Steinhardt, 2018). Embedding such objectives allows RM not only to maximize revenue but also to align with corporate social responsibility and sustainable development goals, thereby bridging economic performance and societal impact.

Taken together, the literature highlights both the strengths and limitations of existing models. The MNL remains a foundational framework, offering interpretability and tractability, but its restrictive assumptions necessitate more advanced approaches. The MCCM provides one such extension, enabling richer substitution structures without sacrificing computational feasibility. Both models are increasingly relevant for tackling emerging challenges in RM, particularly where revenue optimization must be balanced with long-term environmental and social considerations.

3 Formulating the assortment optimization problem: from MNL to MCCM

Modelling customer decisions in assortment optimization has long relied on discrete choice frameworks. The most widely applied approach is the **Multinomial Logit (MNL) model**, introduced by McFadden (1974), which assumes that each product j in an offered assortment S provides a certain systematic utility to the customer. The utility is commonly expressed as a linear function of observed attributes:

$$U_{ij} = \alpha_j + \beta \cdot x_{ij} + \varepsilon_{ij} \tag{3.1}$$

Where α_j denotes the intrinsic preference (intercept) for product j, β is a parameter vector reflecting sensitivities to product attributes x_{ij}, such as price or quality. The variable ε_{ij} is an error term assumed to follow a Gumbel distribution (McFadden, 1974). Based on this specification, the probability that customer i selects product j from assortment S is given by the logit formula:

$$P_{ij}(S) = \frac{\exp(\alpha_j + \beta \cdot x_{ij})}{\sum_{k \in S} \exp(\alpha_k + \beta \cdot x_{ik})} \tag{3.2}$$

This functional form ensures that probabilities are positive and sum to one across all alternatives in S. To estimate the parameters α_j and β, the MNL model is typically calibrated by maximizing the **log-likelihood function**:

$$\ell(\alpha, \beta) = \sum_{i=1}^{N} \sum_{j \in S_i} y_{ij} \cdot \ln P_{ij}(S_i) \tag{3.3}$$

where y_{ij} =1 if customer i chose product j and 0 otherwise, and N denotes the number of observed customers (Train, 2009).

For revenue management purposes, the principal object of interest is the expected revenue associated with an assortment *S*, defined as

$$R(S) = \sum_{j \in S} p_j \cdot P_j(S). \tag{3.4}$$

This functional form directly links product prices, estimated purchase probabilities, and assortment decisions. It has been used extensively to derive assortment optimization policies under the MNL model, particularly in settings where closed-form properties of the choice probabilities enable tractable optimization (Talluri & van Ryzin, 2004).

Notwithstanding these advantages, the MNL model is limited by the well-known ***Independence of Irrelevant Alternatives (IIA)*** property, which implies that the odds ratio between any two products is unaffected by the presence or absence of other alternatives. While this assumption simplifies analytical treatment, it constrains the model's behavioural realism in contexts where substitution patterns are asymmetric or hierarchical (Blanchet, Gallego, & Goyal, 2016). To overcome this limitation, Blanchet, Gallego, and Goyal (2016) introduced the **Markov Chain Choice Model** (MCCM), which relaxes the IIA property by explicitly modelling sequential substitution. In this framework, each product *i* has an arrival probability λ_i:

$$\lambda_i = \pi(i, \mathcal{N}) \tag{3.5}$$

If the preferred product is unavailable, the consumer may transition to another alternative *j* with a probability:

$$\rho_{i,j} = \begin{cases} 1, & if\ i = 0, j = 0 \\ \frac{\pi(j, \mathcal{N}\{i\}) - \pi(j, \mathcal{N})}{\pi(i, \mathcal{N})}, & if\ i \epsilon \mathcal{N}, j \epsilon \mathcal{N}_+, i \neq j \\ 0, & otherwise \end{cases} \tag{3.6}$$

This formulation captures how the removal of product *i* affects the probability of product *j* being selected, normalized by the original preference for *i*. However, not all products are always available. When an assortment $S \subseteq N$ is offered, the set of products in *S* becomes absorbing states, while excluded products are treated as transient (Winston & Goldberg, 2004). In that case, Blanchet et al. (2016) defines the **modified transition probabilities** $\rho_{i,j}$ as:

$$\rho_{i,j}(S) = \begin{cases} 0, & if\ i \epsilon\ S. j \neq i \\ 1, & if\ i \epsilon\ S. j = i \\ \rho_{i,j}, & otherwise \end{cases} \tag{3.7}$$

This ensures that offered products terminate the process, while transient products capture substitution dynamics until absorption occurs. The overall transition matrix can be written in canonical form:

$$P = \begin{bmatrix} I & 0 \\ R & Q \end{bmatrix} \tag{3.8}$$

where *I* correspond to absorbing states, *0* is the zero matrix, *Q* to transitions among transient states, and *R* to transitions from transient to absorbing states.

Given the arrival distribution λ and the modified transition matrix **P**(*S*), the probability that a customer purchases product $j \in S$ is defined by Blanchet et al. (2016) as:

$$\hat{\pi}(j \mid S) = \lambda_j + \left(\boldsymbol{\lambda}(\bar{S})\right)^T (\boldsymbol{I} - \boldsymbol{C})^{-1} \boldsymbol{B} \boldsymbol{e_j} \tag{3.9}$$

where λ_j denotes the direct arrival probability for product *j*, $\lambda(S)$ is the vector of arrival probabilities for products not included in the assortment *S*, *C* is the transition submatrix between unavailable (transient) products, *B* represents the transition matrix from transient to absorbing states, and e_j is a unit vector selecting the absorbing state corresponding to product.

The ultimate objective of the assortment optimization problem under MCCM is to determine the subset of products $S \subseteq N$ that maximizes expected revenue while accounting for both direct preferences and sequential substitution dynamics. Once the purchase probabilities $\hat{\pi}(j \mid S)$ have been obtained, the expected revenue function is written as (Feldman & Topaloglu, 2017):

$$\max_{S \subseteq \mathcal{N}} R(S) = \max_{S \subseteq \mathcal{N}} \sum_{j \in S} (r_j * \hat{\pi}(j, S)) \tag{3.10}$$

Where r_j denotes the revenue generated by product *j* and $\hat{\pi}(j \mid S)$is the probability that product *j* is ultimately chosen given the offered assortment *S*.

This revenue formulation reflects both direct preferences and substitution dynamics in a compact, interpretable form. It allows the analyst to evaluate any proposed assortment S using estimated transition probabilities and known product prices.

Feldman and Topaloglu (2017) further develop this framework and show that despite the non-nested structure of optimal assortments under MCCM, the expected revenue function remains tractable. They demonstrate that even though standard monotonicity results from Multinomial Logit models no longer hold, the optimal assortment can be computed effectively by evaluating revenue over a feasible set of assortments or by applying approximation methods in larger-scale problems. Importantly, both models can be extended to incorporate sustainability-related objectives. For instance, assortment optimization may penalize environmentally costly options or reward offerings certified as eco-friendly. Embedding such considerations into MNL or MCCM formulations allows decision-makers to align revenue goals with broader sustainability objectives, thereby enhancing the societal relevance of revenue management strategies.

The simplicity and clarity of the revenue function R(S) make it well-suited for practical use. In the following section, this model will be applied to a numerical example based on simulated data, illustrating each computational step of the theoretical framework described above.

4 Practical implementation and extensions

To illustrate the practical implementation of the MNL a MCCM models in the context of assortment optimization, we present a step-by-step application using simulated customer choice data. The use of simulated data enables full control over customer preferences and assortment visibility, ensuring consistency with theoretical assumptions and supporting clear interpretation. This approach is aligned with the methodology outlined in Blanchet et al. (2016) and Feldman and Topaloglu (2017).

The problem under consideration concerns assortment optimization in the hospitality industry, where a hotel offers three types of rooms that differ solely in the inclusion and type of breakfast service:

1. **Standard Room** (Product 1) – €80
2. **Room with Breakfast in Restaurant** (Product 2) – €110
3. **Room with Breakfast Served in Room** (Product 3) – €150

All room types are structurally identical, differing only in the additional breakfast service included in the offer. Therefore, no capacity constraints are assumed in the analysis. In addition to these three purchase options, customers may also choose the **outside option (no purchase)**. The central managerial question is how to design the offered assortment in order to maximize expected revenue, taking into account both differences in willingness-to-pay and substitution behaviour between room types.

The dataset consists of 1 000 simulated customer records. Each record includes information about the customer's initial preference (i.e., the product they would choose if available), the assortment they were exposed to at the moment of decision-making, and their final choice.

Multinomial Logit (MNL) Model

To begin, we estimated a **Multinomial Logit (MNL)** model (McFadden, 1974) using **Python.** The model was specified with room without breakfast (Product 1) as the baseline alternative, so its alternative-specific constant (ASC) was normalized to zero. The estimation was performed on a simulated dataset of 3,264 offered customer choices. The Python estimation produced the following output at the Fig. 1:

Fig. 1: *MNLogit Regression Results*

chosen=1	coef	std err	z	P>|z|	[0.025	0.975]
price	-0.0023	0.001	-2.511	0.012	-0.004	-0.001
alt_0	-2.7694	0.134	-20.635	0.000	-3.032	-2.506
alt_2	0.3434	0.124	2.761	0.006	0.100	0.587
alt_3	-0.6399	0.160	-4.009	0.000	-0.953	-0.327

Source: Python output

The results confirm the expected negative effect of price, while revealing preference heterogeneity across alternatives. Relative to the baseline, the no-purchase option is strongly disfavoured, breakfast in the restaurant is positively valued, while in-room breakfast has a lower intrinsic utility.

Using these parameters, we computed the expected revenue across assortments shown in Fig.2:

Fig. 2: Expected Revenue by MNL

```
=== Expected Revenue by Assortment (MNL, baseline = izba bez raňajok) ===
  Assortment    R(S)  P(no-purchase)   P(1)   P(2)   P(3)
0          ∅    0.00           1.000  0.000  0.000  0.000
1        [1]   74.39           0.070  0.930  0.000  0.000
2        [2]  104.04           0.054  0.000  0.946  0.000
3        [3]  128.45           0.144  0.000  0.000  0.856
4     [1, 2]   93.99           0.032  0.418  0.550  0.000
5     [1, 3]   96.67           0.049  0.656  0.000  0.295
6     [2, 3]  115.26           0.041  0.000  0.715  0.244
7  [1, 2, 3]  102.84           0.027  0.352  0.463  0.158
```

Source: Python output

According to the MNL model, the highest revenue is obtained by offering only the in-room breakfast option (128.45). However, when all three alternatives are offered simultaneously, revenue paradoxically declines to €102.84. This counterintuitive result is a direct consequence of the **Independence of Irrelevant Alternatives (IIA)** property of the MNL, which mechanically redistributes probabilities when new options are introduced.

Markov Chain Choice Model (MCCM)

To address this limitation, we next estimated the **Markov Chain Choice Model (MCCM)** (Blanchet, Gallego, & Goyal, 2016) using the same dataset and Python implementation. The MCCM explicitly captures sequential substitution when preferred products are unavailable.

Arrival preferences are summarized through arrival probabilities λ_j , computed from simulated data assuming the full assortment N={1,2,3} is available. These values reflect the probability that a customer initially prefers product *j:*

Fig. 3: *Arrival Probabilities*

```
Arrival Probabilities λ: {1: 0.3652694610778443, 2: 0.4530938123752495, 3: 0.18163672654690619}
```

Source: Python output

These values reflect empirical arrival frequencies under full information. In the MCCM framework, products in the offered set, alongside the no-purchase option, are modelled as absorbing states. Any product not in the assortment is treated as a transient state, from which customers probabilistically transition until they either purchase an available product or exit. In this case, the absorbing states are 0, 1, and 2, while the transient state is 3. We construct the transition probability matrix from customer behaviour when their preferred product was **not** available in the offered assortment. The resulting empirical transition matrix is as follows in the Fig. 4:

Fig. 4: *Transition matrix*

```
=== Transition Probability Matrix ===
         End=1  End=2  End=3  End=0
Start=1  0.000  0.370  0.333  0.296
Start=2  0.370  0.000  0.412  0.218
Start=3  0.321  0.509  0.000  0.170
```

Source: Python output

The computed expected revenues are as follows in the picture n. 5:

Fig. 4: Expected Revenue by MCCM

	Assortment	Expected Revenue
0	()	0.00
1	(1,)	61.60
2	(2,)	88.20
3	(3,)	100.22
4	(1, 2)	93.90
5	(1, 3)	97.85
6	(2, 3)	110.23
7	(1, 2, 3)	106.31

Source: Python output

Unlike the MNL model, the MCCM predicts that the **combination of Products 2 and 3** yields the highest revenue (€110.23), followed by the full assortment (€106.31). The single premium product (Product 3) generates high revenue but is surpassed by multi-product assortments that capture a broader range of preferences.

5 Conclusion

This study compared two discrete choice models for assortment optimization in the hotel industry: the Multinomial Logit (MNL) and the Markov Chain Choice Model (MCCM). Using Python and simulated customer data, we demonstrated that the MNL remains a tractable benchmark, offering interpretable parameters and closed-form probabilities. However, its reliance on the Independence of Irrelevant Alternatives (IIA) assumption can lead to implausible managerial insights, such as predicting higher revenue from offering only a single premium product.

The MCCM, while more computationally demanding, provides a behaviourally richer representation of substitution dynamics. In our application, it produced more realistic results, showing that broader assortments outperform single product offers. This highlights the importance of capturing substitution when making assortment decisions in revenue management.

Beyond its economic relevance, the MCCM framework may also support environmentally informed assortment decisions. By incorporating sustainability-related metrics—such as energy consumption, packaging intensity, or supply chain emissions—into the product evaluation process, the model can serve as a decision-support tool for assortment planning that is not only revenue-maximizing but also environmentally responsible and resource-efficient.

In sum, while MNL remains useful as a baseline model, the MCCM emerges as a superior tool in contexts where substitution patterns and sustainability considerations are central to strategic decision-making.

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Determinanty samostatného bývania mladých ľudí na Slovensku
Determinants of Independent Living Among Slovak Youth

Lívia Krajčíková[1]

Abstrakt
Na Slovensku mladí dospelí odchádzajú z rodičovského domu podstatne neskôr ako vo väčšine krajín EÚ. Tento článok skúma determinant bývania mladých dospelých na Slovensku pomocou mikroúdajov EU-SILC 2023. Použité sú dve metodológie: binárna logistická regresia, ktorá rozlišuje medzi bývaním s rodičmi a samostatným bývaním, a multinomická logistická regresia, ktorá rozlišuje medzi bývaním s rodičmi, prenájmom a bývaním vo vlastnom. Výsledky potvrdzujú významný vplyv rodinného stavu, ekonomickej aktivity a pohlavia na dosiahnutie bytovej autonómie, zatiaľ čo vzdelanie má slabší vplyv pri analýze binárnym modelom. Porovnanie oboch prístupov poskytuje komplexný pohľad na faktory, ktoré ovplyvňujú samostatné bývanie a voľbu formy vlastníctva mladých ľudí na Slovensku.

Kľúčové slová
mladí dospelí, bývanie, vlastníctvo domu, logistická regresia

Abstract
In Slovakia, young adults leave the parental home significantly later compared to most EU countries. This paper examines the determinants of young adults' housing patterns in Slovakia using EU-SILC 2023 microdata. Two approaches are applied: a binary logistic regression distinguishing between co-residing with parents and independent living, and a multinomial logistic regression differentiating among co-residence with parents, renting, and homeownership. The results confirm the strong role of marital status, economic activity and gender in facilitating housing autonomy, while education shows a weaker effect when analysed in a binary framework. By comparing both modelling strategies, the paper provides a comprehensive view of the drivers of residential independence and tenure choice among young adults in Slovakia.

Key words
young adults, housing, homeownership, logistic regression

JEL classification
C12, C21, R20

1 Introduction

Housing represents one of the fundamental human needs as well as an important socio-economic indicator, reflecting living standards, economic capacities, and the preferences of the population. The housing situation of young adults has become a pressing issue in recent years, since access to the housing market is shaped not only by the financial position of households, but also by institutional and cultural factors.

In the European context, Slovakia has been characterized by one specific feature, an exceptionally high share of residents living in owner-occupied dwellings. According to Eurostat (2025b), Slovakia ranks among the EU countries with the highest homeownership rate, a trend

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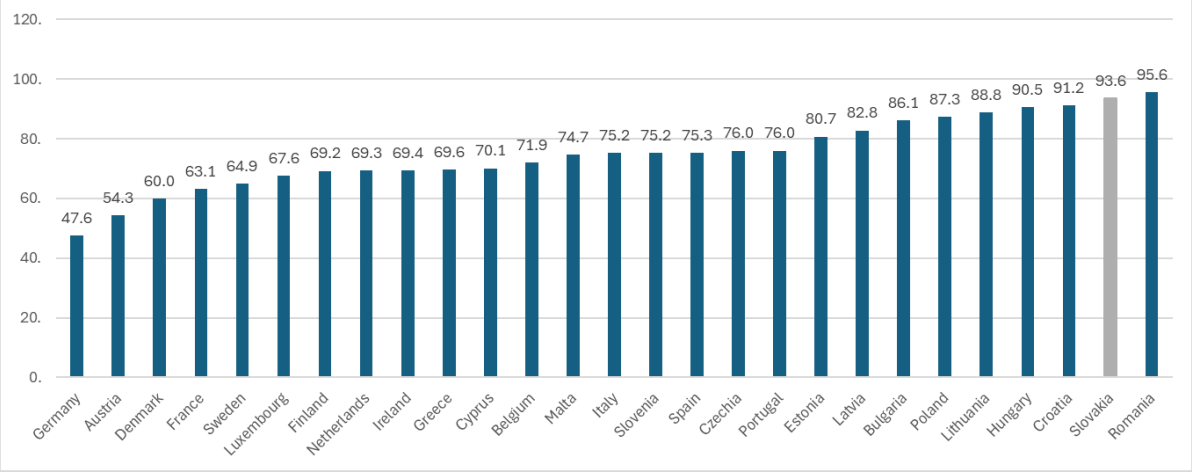
that has persisted for several decades. In 2023, with 93.6% of households owning their homes, Slovakia occupied the second place after Romania (see Fig. 1). Compared to Western and Northern European countries, where homeownership rates are typically below 70%, the housing structure in Slovakia clearly reflects a dominance of ownership over rental tenure. The lowest shares of homeownership were recorded in Germany (47.6%) and Austria (54.3%), which illustrates a strong contrast between post-socialist and Western European housing markets.

In Slovakia, by contrast, rental housing is still often associated with uncertainty and temporariness. Moreover, the phenomenon of young adults remaining in the parental household for an extended period is widespread, influenced by a combination of economic barriers, limited availability of affordable rental options, and deeply rooted cultural norms. This divergence highlights the importance of both structural conditions and societal attitudes in shaping housing choices across Europe.

Sompolska-Rzechuła and Kurdyś-Kujawska (2022) highlight the growing phenomenon of young adults remaining in the parental household, often referred to as "nesting". This trend is particularly widespread in Central, Eastern, and Southern European countries, where it is associated with limited availability of rental housing, labour market uncertainty, and strong family ties. In contrast, in Northern European countries, young adults tend to leave the parental home much earlier, which is linked to well-developed social systems and a cultural preference for independence. According to Eurostat (2025a), Slovakia is among the countries where young people leave the parental household at the latest age. In 2023, Slovak women left home at an average age of 29.6 years, while men did so at 32.4 years (see Fig. 2), which represents the second-highest average in the EU, right after Croatia. A strong Nort-South and East-West divide can be observed across Europe. The earliest home-leaving occurs in Nordic countries such as Finland (20.7 years for women and 22.0 for men) and Denmark (21.3 and 22.2), where early independence is supported by well-developed welfare systems and rental housing markets. In contrast, Southern and Eastern European countries show significantly higher average ages. For instance, in Italy (29.2 and 30.9), Spain (29.4 and 31.3), and Bulgaria (28.2 and 31.8), young adults tend to stay longer in the parental household. This pattern is driven by economic constraints, cultural norms and limited housing affordability.

Fig. 1: Homeownership rate in EU countries in 2023



Source: Eurostat (2025b)

At the same time, the literature consistently points to a worsening of young Europeans' access to homeownership. Based on EU-SILC data (2007, 2012) for 15 European countries, Lennartz et al. (2015) showed that the global financial crisis led to a significant decline in the homeownership rate among people aged 18-34, particularly in countries with highly developed

mortgage markets, where tightened lending conditions sharply restricted access to ownership. Lersch and Dewilde (2015) similarly emphasized that precarious employment substantially hinders in Northern and Western Europe. In the same vein, Gousia et al. (2020) demonstrated that labour market instability, such as unemployment, part-time employment or temporary contracts, reduce young people's chances of leaving the parental home. Moreover, housing decisions are shaped not only by current labour market status bit also by career trajectories and future expectations, underscoring the importance of employment stability for housing autonomy.

Arundel and Doling (2017) argue that the era of mass homeownership in Europe is in decline, as younger generations face increasing barriers to ownership due to labour market transformations, growing inequality and more restrictive access to credit. Dewilde (2020) further stresses that these processes deepen social inequalities and result in young people more frequently securing lower-quality housing in less desirable locations.

Fig. 2: Average age of leaving the parental home by gender in EU countries in 2023 (women on the left, men on the right)

Source: Eurostat (2025a)

In summary, the housing trajectories of young Europeans are shaped by both structural and cultural factors. While in Northern and Western Europe early departure from the parental home and stronger rental markets are common, in Central, Eastern and Southern Europe young adults tend to stay longer with their parents and strongly aspire to homeownership. Across Europe, however, access to ownership has become increasingly constrained by labour market insecurity, inequality, and stricter credit conditions, with education, income and family status playing a key tole. Slovakia, with one of the highest average age of leaving the parental

household in the EU, stands out as a representative case in the European context. The study addresses two main research questions:

1. Which socio-economic factors most strongly influence the decision of young adults to leave the parental household?
2. What drives the choice between rental housing and homeownership among young people living independently?

2 Data and methodology

For the empirical analysis, we use the microdata from the EU-SILC survey (European Union Statistics on Income and Living Conditions), provided by the Statistical Office of the Slovak Republic. The models are based on data from 2023, which is the most recent year available at the time of writing. The analysis focuses exclusively on young adults aged 25 – 34. It is a life stage in which crucial decisions about leaving the parental household and establishing independent housing typically occur. The dataset includes 1245 individuals within this age group. Table 1 provides a detailed summary of the sample composition across key factors and housing types, while also specifying the categories of variables used in the models.

Table 1: Structure of young adults by type of housing and selected characteristics

Factor	Category	2023			
		Type of housing			Total
		Owners	Tenants	With parents	
Economic activity status	Employed	379 (40,8)	98 (10,6)	451 (48,6)	928
	Unemployed	24 (28,2)	8 (9,4)	53 (62,4)	85
	Disabled	1 (2,4)	2 (4,8)	39 (92,8)	42
	Student or other inactive person	101 (53,2)	26 (13,7)	63 (33,1)	190
Education	ISCED 0 – 2	21 (25,6)	14 (17,1)	47 (57,3)	82
	ISCED 3 – 4	286 (41,6)	66 (9,6)	335 (48,8)	687
	ISCED 5 – 8	198 (41,6)	54 (11,3)	224 (47,1)	476
Gender	Male	225 (33,9)	66 (9,9)	373 (56,2)	664
	Female	280 (48,2)	68 (11,7)	233 (40,1)	581
Marital status	Unmarried	163 (21,0)	84 (10,8)	529 (67,2)	776
	Married	335 (74,1)	46 (10,2)	71 (15,7)	452
	Widowed	2 (66,7)	0 (0,0)	1 (33,3)	3
	Divorced	5 (35,7)	4 (28,6)	5 (35,7)	14

Note: The values in parentheses represent the percentage distribution of housing types among young adults within each category.
Source: own processing in SAS EG based on EU-SILC 2023 database

Table 1 highlights differences in housing arrangements of young adults across socio-economic characteristics. Among the employed, nearly half (48.6%) continue to live with their parents, while 40.8% reside in owner-occupied housing and only a minority in rental housing. The reliance on the parental home is even stronger among the unemployed (62.4%) and particularly pronounced among young people with disabilities, where as many as 92.8% remain in their parents' household. By contrast, students and other economically inactive individuals display a different pattern: more than half (53.2%) live in owner-occupied housing, a smaller share stays with parents (33.1%), and only 13.7% rent their dwelling.

Education also plays an important role. Most young adults with low educational attainment (ISCED 0-2) remain in their parents' household (57.3%). For both secondary (49.0%) and tertiary educated young adults (47.1%), a similar share continues to reside with parents, yet a notable part of each group has transitioned into ownership, with rental tenure representing only a minor option.

Gender differences are evident as well. Men most often reside with their parents (56.2%), whereas women are more likely to live in owner-occupied housing (48.2%), and 40.1% of women are staying in the parental home. Rental housing represents the least common option for both genders, with comparable proportions.

Finally, marital status appears to be a key determinant. The majority of single adults continue to live with their parents (67.2%). In contrast, among married individuals, owner-occupied housing strongly prevails (74.1%), while only 15.7% remain in the parental household.

To analyse the factors influencing the housing situation of young adults in Slovakia, logistic regression models were employed, specifically, binary and multinomial logistic regression. These models allow examining the relationship between a categorical dependent variable and several explanatory variables (Hosmer and Lemeshow, 2010, Terek et al., 2010).

The binary logistic regression model is used when the dependent variable has two categories. The model estimates the probability that an observation belongs to one of the two categories as a function of the independent variables. Formally, the model can be expressed as:

$$g(x) = ln\left(\frac{P(Y=1|X=x)}{P(Y=0|X=x)}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p \quad (1)$$

where $X_1, \ldots, X_p$ are independent variables and β_p are model coefficients. These coefficients describe how a one-unit increase in X_p affects the log-odds of belonging to category $Y = 1$ versus $Y = 0$, assuming all other variables remain constant.

When the dependent variable has more than two categories, the multinomial logistic regression model extends the binary case. For K categories, the model constructs $K - 1$ logit equations relative to a chosen reference category. Let the reference category be 0 and the remaining categories $j = 1,2, \ldots, K - 1$. The model is defined as:

$$g_j(x) = ln\left(\frac{P(Y=j|X=x)}{P(Y=0|X=x)}\right) = \beta_{j0} + \beta_{j1} X_1 + \beta_{j2} X_2 + \cdots + \beta_{jp} X_p \quad (2)$$

where β_{jp} represents the change in the log-odds of being in category j versus the reference category 0 associated with a one-unit increase in X_p, assuming all other variables remain constant. For interpretation, the estimated coefficients are transformed into odds ratios (OR) by exponentiation:

$$OR = e^{\beta_p} \quad (3)$$

The odds ratio expresses how the odds of a particular outcome category change when the explanatory variable X_p increases by one unit, assuming all other variables remain constant. An $OR > 1$ indicates higher odds of belonging to a given category relative to the reference category, an $OR < 1$ indicates lower odds, and an $OR = 1$ suggests no effect of the variable.

3 Selection of regressors

Based on previous studies, the key factors influencing young people's housing include:

- age and marital status – these affect life decisions such as partnership or parenthood, which are closely linked to leaving the parental home (Matel (2022)),
- gender – the literature highlights differences between men and women (Matel (2022)),
- education – higher education is associated with better chances of stable employment, and with the ability to secure independent housing (Garcia and Figueira (2020)),
- economic activity – unemployment and temporary forms of work significantly delay young people's departure from the parental household (Gousia et al. (2020), Matel (2022)).

For the selection of variables in the models, the stepwise selection method was applied, which means, that it includes only statistically significant regressors. In the binary logistic regression model, the variables selected at the 0.05 significance level were marital status, age, economic activity, and gender (Table 2). In the multinomial logistic regression model, the variables selected at the 0.05 significance level were marital status, age, economic activity, gender, and education. The selection of variables indicates that these factors had the greatest impact on the type of housing among young Slovaks, namely whether they live in their own dwelling, in rental housing or with their parents. Variables such as type of employment contract and individual health status were not included in the model, as they did not prove to be statistically significant during the selection process.

Table 2: Statistical significance and entry order of factors affecting young adults' housing

Summary of Stepwise Selection						
Step	Effect Entered	Effect Removed	DF	Number In	Score Chi-Square	Pr > ChiSq
Binary logistic regression model						
1	Marital status		3	1	315.9134	<.0001
2	Age		1	2	25.1536	<.0001
3	Economic activity		3	3	23.8094	<.0001
4	Gender		1	4	10.6959	0.0011
Multinomial logistic regression model						
1	Marital status		6	1	365.9472	<.0001
2	Age		2	2	34.0125	<.0001
3	Economic activity		6	3	25.6864	0.0003
4	Gender		2	4	11.7655	0.0028
5	Education		4	5	11.2170	0.0242

Source: own processing in SAS EG based on EU-SILC 2023 database

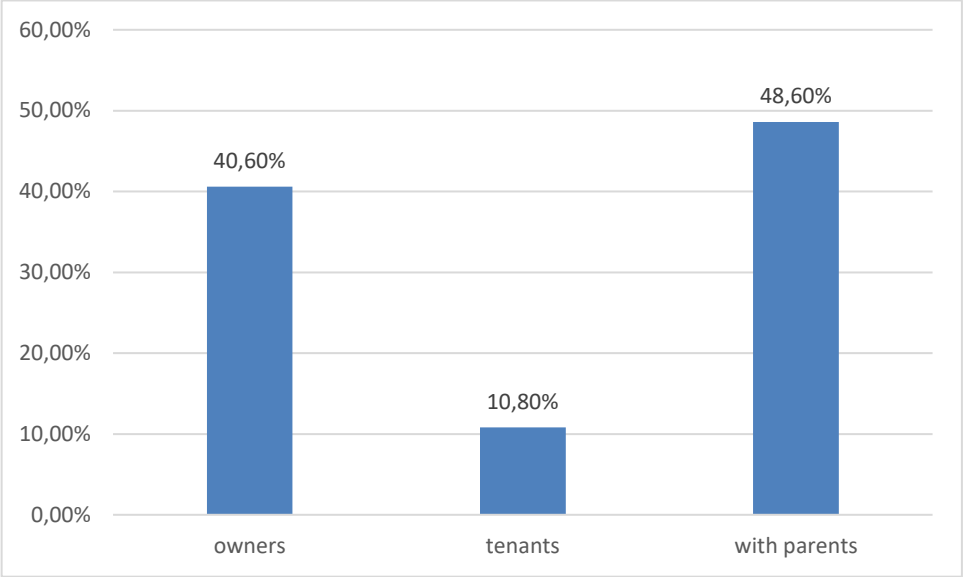
4 Odds Ratios for key determinants

At the beginning of this section, we present the distribution of young adults aged 25-34 by the type of housing (Fig. 3). In 2023, 40.6% of young adults lived in their own dwelling. The share of those living in rental housing reached 10.8%. However, almost half of young people remained in the parental household (48.6%).

The results of the binary and multinomial logistic regression models are interpreted based on the estimated odds rations (OR) for the year 2023. For easier interpretation, odds ratios lower than 1 were expressed as their reciprocal values (1/OR). The reported values express the relative

odds of each category compared to the reference category (independent living and homeownership, respectively). The interpretation of the results is made under the ceteris paribus assumption, meaning that all other variables in the model remain constant.

Fig. 3: Housing structure of young adults in Slovakia in 2023



Source: own processing in SAS EG based on EU-SILC 2023 database

The results of the binary logistic regression model (Table 3) show that age, gender, marital status, and economic activity have a statistically significant effect on the likelihood of independent living among young adults.

With each additional year of age, the odds of living with parents rather than independently are 0.88 times lower, indicating that older young adults are more likely to live independently.

The odds of living with parents rather than independently are 1.59 times higher for men compared to women, suggesting that women tend to leave the parental home earlier.

In terms of marital status, the odds of living with parents rather than independently are 9.09 times higher for unmarried than for married young adults, confirming that partnership formation is a key factor in housing independence.

In terms of economic activity, young adults who are disabled are 12.18 times more likely to live with their parents rather than independently compared to those who are employed.

The results of the multinomial logistic regression model (Table 4) indicate that age, gender, marital status, education, and economic activity have a statistically significant effect on the type of housing among young adults.

With each additional year of age, the odds of living with parents rather than in the own dwelling are 0.86 times lower, and the odds of living in rent rather than in own dwelling are 0.90 times lower. This confirms that older young adults are more likely to transition towards homeownership.

Regarding gender, the odds of living with parents rather than in the own dwelling are 1.72 times higher for men compared to women, while the difference between men and women is not statistically significant when comparing living with parents versus living in rental housing.

In terms of marital status, the odds of living with parents rather than in the own dwelling are 12.50 times higher, and the odds of living in rent rather than in the own dwelling are 3.75 times higher for unmarried than for married people. Statistically significant differences were not found between widowed and unmarried, or divorced and unmarried people when comparing the likelihood of living with parents or in rental housing rather than in the own dwelling.

Table 3: Results of the binary logistic regression showing factors affecting the likelihood of co-residence with parents vs homeownership

Odds Ratio Estimates and Wald Confidence Intervals					Analysis of Maximum Likelihood Estimates
Effect	Housing	Point Estimate	95% Wald Confidence Limits		Pr > ChiSq
Age	With parents	**0.881**	0.847	0.917	<.0001
Gender | female vs male	With parents	**0.628**	0.496	0.794	0.0011
Marital status | married vs unmarried	With parents	**0.110**	0.085	0.143	<.0001
Marital status | widowed vs unmarried	With parents	**0.379**	0.049	2.951	0.4370
Marital status | divorced vs unmarried	With parents	**0.367**	0.142	0.949	0.0825
Economic activity | unemployed vs employed	With parents	**1.581**	1.013	2.467	0.0902
Economic activity | disabled vs employed	With parents	**12.175**	4.235	35.000	<.0001
Economic activity | student or other inactive person vs employed	With parents	**1.005**	0.703	1.437	0.9823

Source: own processing in SAS EG based on EU-SILC 2023 database

Table 4: Results of the multinomial logistic regression showing factors affecting the likelihood of co-residence with parents or renting vs homeownership

Odds Ratio Estimates and Wald Confidence Intervals					Analysis of Maximum Likelihood Estimates
Effect	Housing	Point Estimate	95% Wald Confidence Limits		Pr > ChiSq
Age	With parents	**0.855**	0.811	0.901	<.0001
Age	Rent	**0.903**	0.841	0.970	0.0054
Gender | female vs male	With parents	**0.581**	0.423	0.796	0.0007
Gender | female vs male	Rent	**0.815**	0.527	1.259	0.3566
Marital status | married vs unmarried	With parents	**0.080**	0.058	0.112	<.0001
Marital status | married vs unmarried	Rent	**0.267**	0.173	0.412	<.0001
Marital status | widowed vs unmarried	With parents	**0.244**	0.021	2.901	0.2643
Marital status | widowed vs unmarried	Rent	**<0.001**	<0.001	>999.999	0.9791
Marital status | divorced vs unmarried	With parents	**0.476**	0.131	1.730	0.2595
Marital status | divorced vs unmarried	Rent	**1.843**	0.464	7.319	0.3847
Education | medium vs low	With parents	**0.449**	0.226	0.894	0.0226
Education | medium vs low	Rent	**0.286**	0.130	0.630	0.0019
Education | high vs low	With parents	**0.536**	0.264	1.085	0.0830
Education | high vs low	Rent	**0.363**	0.162	0.816	0.0142
Economic activity | unemployed vs employed	With parents	**1.462**	0.790	2.705	0.2261
Economic activity | unemployed vs employed	Rent	**0.916**	0.373	2.249	0.8486
Economic activity | disabled vs employed	With parents	**28.933**	3.555	235.462	0.0017
Economic activity | disabled vs employed	Rent	**6.241**	0.522	74.628	0.1481
Economic activity | student or other inactive person vs employed	With parents	**1.064**	0.670	1.690	0.7933
Economic activity | student or other inactive person vs employed	Rent	**1.297**	0.732	2.298	0.3726

Source: own processing in SAS EG based on EU-SILC 2023 database

Regarding education, the odds of living with parents rather than in the own dwelling are 2.23 times higher, and the odds of living in rental housing rather than in the own dwelling are 3.50 times higher for young adults with low education than young adults with medium education. The odds of living in rental housing rather than in the own dwelling are 2.75 times higher for those with low education compared to those with high education.

Finally, economic activity also plays a key role. Young adults who are disabled are 28.93 times more likely to live with their parents rather than in their own dwelling compared to those who are employed. Differences in other categories of economic activity were not statistically significant.

While the binary logistic regression model focused on distinguishing between independent and dependent living, the multinomial logistic regression model provided a more detailed perspective by differentiating between various forms of independent housing (homeownership and rental housing) in comparison to living with parents. The results highlight the strong influence of age, marital status, and economic activity on housing outcomes, confirming that life-cycle factors and financial stability remain key determinants of residential independence. Education proved to be significant only in the multinomial model, indicating that education does not directly determine whether young people leave the parental home, it influences the type of housing they choose once they live independently.

Previous studies indicate that strong family ties persist in Central and Eastern Europe (Sompolska-Rzechuła and Kurdyś-Kujawska, 2022), and young people tend to leave the parental home more slowly. This pattern is confirmed by our findings for Slovakia, where a substantial share of young adults continued to live with their parents in 2023.

The studies by Garcia and Figueira (2020) and Matel (2022) highlight the importance of education, employment stability and marital status in the transition to homeownership. Our results similarly show that higher education and being married increase the likelihood of living in one's own dwelling compared to living with parents or in rental housing.

Gender differences are also evident. Matel (2022) reports that in Poland, women tend to leave the parental home earlier than men, and our findings confirm a similar trend in Slovakia.

Overall, the findings reveal a multidimensional pattern of housing transitions among young Slovaks, shaped by demographic and economic characteristics. These results provide an important empirical basis for understanding the housing challenges faced by young adults.

5 Conclusion

This paper examined the housing situation of young adults in Slovakia using EU-SILC 2023 data, focusing on the socio-economic determinants of their living arrangements. The analysis employed binary and multinomial logistic regression models to estimate the probability of living with parents, in rental housing, or in owner-occupied dwellings.

Regarding the first research question, the results confirmed that age, gender, marital status, and economic activity are the most significant predictors. With increasing age and marriage, the likelihood of independent living rises, while men and economically inactive individuals, particularly those with disabilities, are significantly more likely to remain in parental home.

As for the second research question, the findings indicate that education plays a key role in the choice between rental housing and homeownership among young people living independently. Higher education significantly increases the likelihood of homeownership compared to rental housing.

A considerable share of young Slovaks still resides with their parents, reflecting persistent economic constraints, housing affordability issues, and strong family ties, which are features typical for Central and Eastern European societies. The study highlights the complex interaction

of demographic, social and economic factors shaping the housing trajectories of young adults in Slovakia.

Overall, the results contribute to a better understanding of youth transitions in post-transition economies and provide a valuable basis for further comparative research across EU countries. They may also serve as an empirical input for housing and social policies aimed at supporting earlier and more stable independent living among young people.

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Experience in Teaching Artificial Intelligence and Neural Networks in Higher Education

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Abstract
This paper explores the experience of teaching artificial intelligence and neural networks in higher education. It highlights how modern tools such as Python, Google Colab, and TensorFlow can enhance students' professional competencies. A quasi-experimental design, involving both control and experimental groups, was used to assess the impact on students' theoretical knowledge and practical skills. The results show improvements in students' understanding of neural network concepts, their ability to apply algorithms, and their motivation to learn. These findings contribute to the development of teaching methodologies for artificial intelligence in higher education and underscore the importance of adapting international best practices to fit the local educational context.

Key words
Artificial Intelligence, Neural Networks, Machine Learning, Higher Education

JEL classification
JEL C45

1 Introduction

Artificial Intelligence (AI) has become a transformative force that shapes the digital landscape of modern society, impacting education, science, and industry. As nations evolve alongside technological advancements, developing human capital in AI has become a strategic priority. In Kazakhstan, this focus was emphasized in the Presidential Address titled “The Economic Course of a Fair Kazakhstan”. President Kassym-Jomart Tokayev underscored the importance of enhancing research and training in AI to bolster national competitiveness (Tokayev, 2023). The Concept for the Development of Higher Education and Science of the Republic of Kazakhstan (2023–2029) emphasizes the integration of fundamental technologies such as artificial intelligence, machine learning, robotics, blockchain, and the Internet of Things into the educational process. This integration is essential for promoting future-oriented learning (MES RK, 2023).

The incorporation of artificial intelligence in higher education is transforming traditional teaching and learning methods. According to Salgaraeva and Zhumabaeva (2020), the methodological preparation of future informatics teachers should combine theoretical foundations with practical implementation through programming tools and problem-based learning. Similarly, Kerimberdina and Sadvakassova (2022) argue that neural networks and

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machine learning should not only be taught as abstract concepts but also demonstrated through applied projects that stimulate students' analytical and creative thinking. Spirina et al. (2024) highlight that AI-driven learning environments provide adaptive feedback, personalized learning pathways, and facilitate digital transformation across all levels of education.

AI technologies can now perform cognitive functions previously exclusive to humans, such as data processing, pattern recognition, and decision-making. This makes them invaluable for developing 21st-century skills. The integration of AI in education presents exciting opportunities for automating assessments, analyzing learning behaviors, and delivering personalized feedback to students (Kazimova et al., 2025). However, it also poses challenges, including limited readiness among teachers, inadequate infrastructure, and a shortage of pedagogical models that effectively combine technology with educational goals.

In the context of Kazakhstan's universities, teaching AI and neural networks holds particular importance for programs in Informatics and Information and Communication Technologies (ICT). Future teachers in these fields must not only understand the theoretical structure of neural networks but also acquire hands-on experience with programming frameworks such as Python, TensorFlow, and Keras. Such experience helps develop essential digital competencies—algorithmic thinking, problem-solving, and creative use of data-that are crucial for both educators and students in a knowledge-based economy.

In comparison with other countries, such as Finland and South Korea, where AI literacy has already been systematically integrated into teacher education programs (UNESCO, 2023), Kazakhstan is currently in the process of developing similar pedagogical foundations. Building on the works of Salgaraeva and Zhumabaeva (2020), Kerimberdina and Sadvakassova (2022), and Spirina et al. (2024), the present study aims to examine the methods of teaching artificial intelligence and neural networks and to evaluate the implementation of AI tools in the learning process at L.N. Gumilyov Eurasian National University.

The study employs both control and experimental groups: the control group uses traditional teaching methods (lectures and offline coding), while the experimental group learns through interactive, cloud-based environments such as Google Colab and TensorFlow. This dual approach enables comparison between conventional and AI-assisted learning. The study also seeks to identify the challenges of integrating AI tools into higher education and to propose evidence-based recommendations for improving AI pedagogy within the Kazakhstani context.

2 Materials and Methods

This research was conducted within the framework of the grant project funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan under the program IRN AP23489632 "Theoretical and practical foundations for comprehensive improvement of computer science teacher training based on STEM education and machine learning". The project aims to modernize the preparation of future informatics teachers by integrating artificial intelligence and neural network technologies into the teaching and learning process.

The study employed a mixed-method approach, combining theoretical analysis and empirical investigation. The theoretical part involved an in-depth review of academic literature on AI-based education, analysis of national strategies for digital transformation, and comparative evaluation of global practices in teaching neural networks and machine learning within STEM education.

The empirical part included both a survey and an experimental study conducted among university instructors and students specializing in Informatics and ICT.

The survey was aimed at identifying teachers' attitudes, readiness, and preferences in applying AI technologies in higher education. The study design followed a mixed-method sequence: an initial survey was conducted to identify general readiness and attitudes, followed by an experimental phase to test the effectiveness of AI-integrated instruction.

The empirical study involved 111 students and pre-service informatics teachers from prominent universities in Kazakhstan, including L.N. Gumilyov Eurasian National University and Karaganda Buketov University. These participants took part in a survey designed to evaluate their readiness and attitudes regarding the use of artificial intelligence in education. The online questionnaire contained both closed and open-ended questions focused on three aspects:

- Awareness of artificial intelligence and machine learning tools;
- Practical experience in using AI applications in teaching;
- Readiness to implement adaptive and personalized learning methods in higher education.

To assess the educational effectiveness of AI-based teaching methods, a quasi-experimental design was implemented at L.N. Gumilyov Eurasian National University. Students were divided into control and experimental groups: the control group studied neural network concepts through traditional lectures and standard laboratory work, while the experimental group used Python, Google Colab, and TensorFlow to perform interactive tasks such as developing and testing neural network models for image recognition and data classification. The control group used standard programming tools (offline Python and Jupyter Notebook) without access to AI-based platforms. This ensured that both groups engaged in programming activities, but only the experimental group used cloud-based interactive tools such as Google Colab and TensorFlow.

Data were collected using pre- and post-tests, classroom observations, and student reflections. The analysis covered three components of learning outcomes:

- Motivational component - measuring students' interest and engagement;
- Cognitive component - evaluating their understanding of AI and NN concepts;
- Technical component - assessing programming and model development skills.

Statistical and qualitative analysis methods were used to process the data. The results were compared to evaluate the effectiveness of the AI-integrated teaching approach and to formulate methodological recommendations for enhancing computer science teacher training within the STEM and machine learning framework.

3 Results and Discussion

The results of the quasi-experimental study revealed significant differences in learning outcomes between the control and experimental groups. The introduction of AI-based tools such as Python, Google Colab, and TensorFlow into the teaching process showed measurable benefits in students' motivation, conceptual understanding, and technical proficiency.

As shown in Table 1, the experimental group achieved higher performance across all components compared to the control group. The data in Table 1 were collected from 111 students and pre-service informatics teachers who participated in a quasi-experimental study conducted at L.N. Gumilyov Eurasian National University and Karaganda Buketov University

Table 1: Comparison of Learning Outcomes between Control and Experimental Groups

Learning Component	Control Group (%)	Experimental Group (%)	Improvement (%)
Motivational (student engagement)	58	78	+20
Cognitive (theoretical understanding)	62	79	+17
Technical (practical skills)	55	82	+27

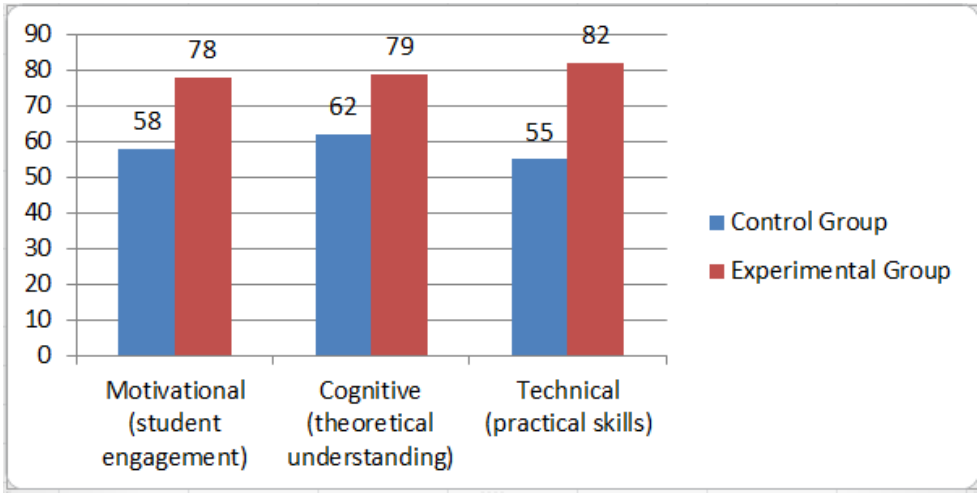
Source: Authors' experimental data (2025)

3.1 Improvement in Theoretical Understanding

The cognitive component of learning showed notable growth. Students in the experimental group achieved an average of 27% higher post-test scores compared to the control group. They demonstrated a clearer understanding of fundamental neural network structures, including activation functions, backpropagation, and classification algorithms. This confirms that the integration of hands-on programming and visualization enhances comprehension of abstract AI concepts. Similar results were reported by Salgaraeva and Zhumabaeva (2020), who emphasized the importance of combining theoretical study with applied activities to reinforce students' understanding.

As illustrated in Figure 1, the experimental group demonstrated consistent improvement across all learning components.

Fig. 1: Improvement of Students' Learning Outcomes after AI Integration



Source: Authors' experimental data (2025)

3.2 Increased Motivation and Engagement

The motivational component showed the most pronounced improvement. Students expressed higher interest in AI-related topics and greater confidence in using technological tools for solving real-world problems. Interactive assignments conducted in Google Colab encouraged collaboration, experimentation, and self-directed learning. Compared to the control group, the experimental group showed a 35% increase in student engagement, as evidenced by attendance rates, task completion, and participation in discussions. These findings are consistent with those of Spirina et al. (2024), who noted that AI-supported learning environments foster active student involvement and curiosity.

3.3 Development of Technical Skills

The technical component demonstrated significant enhancement as well. Students in the experimental group successfully implemented and tested neural network models for image recognition and data classification tasks using TensorFlow. The use of real datasets allowed them to connect theory with practice and understand the workflow of machine learning projects. This practical experience contributed to the development of essential digital competencies—problem-solving, data processing, and analytical reasoning— as highlighted by Kerimberdina and Sadvakassova (2022) as critical for future informatics teachers.

3.4 Pedagogical and Methodological Insights

Beyond student outcomes, the research also provided insights for educators. The study showed that effective teaching of AI requires a flexible methodological framework that combines classical instruction with interactive digital tools. Teachers involved in the experiment reported that AI-based platforms simplified classroom management, automated assessment, and provided immediate feedback to students. However, they also noted challenges such as limited access to high-performance hardware (GPU) and the need for additional training in neural network development.

These observations are consistent with international findings Kazimova et al. (2025), indicating that the sustainable integration of AI relies on institutional support, robust digital infrastructure, and ongoing professional development for faculty. The study confirms that when appropriately implemented, AI not only enhances the quality of education but also transforms the learning environment into an adaptive, student-centered ecosystem.

4 Conclusion

The conducted research confirms that the integration of artificial intelligence and neural networks into higher education significantly improves students' learning outcomes and teaching efficiency. The application of interactive digital tools such as Python, Google Colab, and TensorFlow transforms traditional learning into dynamic, practice-oriented, and research-based activities.

Students participating in AI-enhanced classes demonstrated measurable improvements across three main dimensions—motivation, theoretical understanding, and technical proficiency. The experimental findings revealed that interactive, hands-on learning fosters not only better comprehension of complex neural network algorithms but also higher engagement and creativity in solving applied problems.

From a pedagogical perspective, the research highlights the importance of adopting AI-supported teaching methodologies within STEM education. The results show that the combination of theoretical foundations and practical experimentation strengthens the professional readiness of future computer science teachers. Moreover, implementing AI tools in university courses contributes to the development of critical thinking, data literacy, and independent learning skills—competencies essential for the digital era.

Despite these achievements, several challenges remain. Successful integration of AI technologies in higher education requires adequate digital infrastructure, access to computational resources (such as GPU-based environments), and continuous professional development for academic staff. Future research should focus on designing scalable AI integration models and on developing adaptive learning systems tailored to individual student needs.

Overall, this study contributes to the advancement of AI pedagogy within Kazakhstan's higher education system and demonstrates that incorporating neural networks and machine

learning into teaching practices enhances both the quality and relevance of teacher training in informatics.

Acknowledgements
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Integrating Technological Risk into Audit Reporting: Evidence from Key Audit Matters in IBEX 35 Companies

Natália Macová[1]

Abstract
In the era of escalating cybersecurity threats and heightened demands for data protection, companies are increasingly exposed to technological risks. Auditors, in turn, have begun reflecting these emerging risks within their disclosure of Key Audit Matters (KAM). This study examines the audit reports of the 35 companies listed on Spain's IBEX 35 index to investigate the extent to which technological risks are represented in KAM. The analysis employs an automated content analysis approach supported by Retrieval-Augmented Generation (RAG) systems, ensuring a systematic and replicable identification of technology-related KAM across firms and sectors. The findings contribute to the understanding of how auditors incorporate new forms of risk into their communication with stakeholders and highlight the evolving role of KAM as a mechanism to address the growing relevance of technology in corporate governance.

Key words
Key Audit Matters, Technological risks, Cybersecurity, Financial reporting.

JEL classification
M42, G32, O33

1 Introduction and background

Nowadays, when we are starting to use technology almost everywhere, it is important that we also take an interest in it when it comes to the reporting of financial information. Cybersecurity risks and incidents represent a global challenge and are consistently ranked among the most pressing issues confronting organizations today (Kappelman et al., 2020). Also, Liu and Barbar (2024) said that cybersecurity represents a critical concern for contemporary corporations. Cyberattacks targeting corporations may stem from a variety of strategic or financial motives. Although many incidents are financially driven — for instance, through ransomware extortion or the sale of stolen data to third parties (Vrhovec & Markelj, 2024). Cybersecurity breaches can trigger significant and lasting consequences, such as stock price declines, reputational damage, operational and policy disruptions, transformations in IT practices, managerial challenges, and spillover effects across industry peers (Liu & Babar, 2024). Among the most prevalent forms of cyberattacks are malware, phishing schemes, and spoofing techniques (Haruna et al., 2022). A major challenge continues to be the limited availability of comprehensive resources that would allow corporate managers to fully understand cybersecurity risks and evaluate the potential consequences of security breaches (Liu & Babar, 2024). Regulatory interventions, including the introduction of the Sarbanes–Oxley Act, have been shown to stimulate greater levels of cybersecurity disclosure (Gordon et al., 2006). The audit report is one of the main tools of communication between the auditor and users of financial statements (Gold & Heilmann, 2019). Enhancing the rigor of auditing practices contributes significantly to reducing cybersecurity risks, both through regular audit

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procedures and targeted, specialized engagements (Schoenfeld, 2022). The effects of cyberattacks extend beyond the directly targeted firms, influencing their industry peers as well (Liu & Babar, 2024). Robust auditing practices and well-designed internal controls are essential for reducing cybersecurity risks, since deficiencies within corporate IT control environments can create pathways for such threats to emerge (Gordon et al., 2008). In our preliminary research, we therefore focused on whether and to what extent these new challenges in the form of cyber-threats appeared in key audit matters. We therefore focused on companies that were part of the Spanish IBEX35 index in fiscal year 2024. Using a combination of content analysis and statistical testing, the research examines whether firms operating in sectors with high technological exposure are more likely to disclose cybersecurity-related KAMs than those in low-exposure sectors. Specifically, the analysis applies Fisher's exact test, Pearson's chi-square test, and Cramér's V to assess the presence, significance, and strength of this relationship. The findings contribute to the growing body of literature on audit reporting and emerging risks.

2 Literature review

To this date, there have been various studies focusing on KAM. Hosseinniakani et al. (2024) investigates the alignment between IAS 1 disclosures and auditor KAMs after ISA 701's adoption and explores the audit committee's moderating effect, using data from Swedish listed firms in years 2016 to 2018. There is another study. Study of UK non-financial FTSE 100 companies, Gambetta et al. (2023) contended that the communicative effectiveness of the KAM section is shaped by the characteristics of the audit firm as well as by the specific nature of the KAMs disclosed. Smith (2023) conducted another study. Their findings support the view that KAMs serve an important informative function, as their disclosure improves the transparency and comprehensibility of audit reports and offers users valuable insights into the risk-focused nature of the audit. In line with the above evidence, Gutierrez et al. (2018) investigated the influence of KAM disclosure in a UK setting and reported no observable effect on investors' responses. Based on a large sample of EU non-financial firms, this study explores how KAMs affect auditors' professional judgments. Results reveal that more KAMs are linked to higher audit fees, longer reporting lags, and a greater probability of non-standard opinions (Cameran & Campa, 2025). Klevak et al. (2023) reported significant market reactions to KAMs in the US, indicating their value relevance. Nonetheless, they noted that investors often misinterpret longer KAM disclosures as signals of greater client risk. However, we have not yet found any studies that examine whether concerns related to new technologies are also reflected in KAM. We therefore decided to fill this gap and analyse this impact on IBEX35, 2024.

3 Methodology

In our research, we focused on Spain's largest companies – IBEX 35 for 2024. We divided the companies into two groups based on how likely we expect cyber threats to be real and significant in each company. This resulted in two groups. The first group is where the probability of a cyber threat is high, and the second is where this risk does not represent a significant part. The auditor's published reports were collected manually for the period under review from these companies. Some of the audit reports were only available as scanned PDF documents, which required optical character recognition (OCR) to extract the textual content for analysis. We further analysed these auditor's reports, focusing exclusively on key audit matters. The study tries to determine to what extent, in which group, and whether auditors mention cyber-related issues in this section. We used Retrieval-Augmented Generation (RAG) systems to analyse the auditor's reports (Google, 2024). We had to enter a suitable prompt into this software for the analysis to run correctly. The prompt for this analysis was: "Analyse the Key Audit Matters (KAM) texts in this company's audit report. Check if any of these keywords or their synonyms are found in the text: cyber, security, penetration, ransomware, malware,

hacking, phishing, intrusion. For each KAM, provide the answer in the following format: KAM name: [text of the name or first sentence], Contains keywords: YES/NO, Words found: [list specific words, if any]." We then performed statistics in R (R Core Team, 2024) with standard statistical packages using the data obtained. After that there were two variables from the data collected from publicly available auditor's reports. A binary variable where we marked companies operating in a high-risk sector in terms of cybersecurity with 1 and companies whose sector we did not consider high-risk with 0. Companies which are in the group with 1 are generally more vulnerable to cyber threats due to the nature of their operations and the critical importance of information security to their business continuity. In contrast, firms operating in sectors where technology plays a less critical role — such as real estate, consumer goods, or traditional manufacturing — were assigned a value of 0 - low cybersecurity exposure.

Table 1: IBEX35 divided into categories

Company	Cybersecurity_category	Sector
ACS	0	EnergyIndustry
Acciona	0	EnergyIndustry
Acciona Energía	0	EnergyIndustry
Acerinox	0	EnergyIndustry
ArcelorMittal	0	Other
Enagás	0	EnergyIndustry
Endesa	0	EnergyIndustry
Ferrovial	0	EnergyIndustry
Fluidra	0	EnergyIndustry
Grifols	0	Other
Iberdrola	0	EnergyIndustry
Inditex	0	Other
Inmobiliaria Colonial	0	Other
Laboratorios Rovi	0	Other
Logista	0	EnergyIndustry
Merlin Properties	0	EnergyIndustry
Naturgy	0	Other
Puig	0	EnergyIndustry
Redeia Corporación	0	EnergyIndustry
Repsol	0	EnergyIndustry
Sacyr	0	EnergyIndustry
Solaria	0	EnergyIndustry
AENA	1	TechnologyFinance
Amadeus IT Group	1	TechnologyFinance
Banco Sabadell	1	TechnologyFinance
Banco Santander	1	TechnologyFinance
Bankinter	1	TechnologyFinance
BBVA	1	TechnologyFinance
CaixaBank	1	TechnologyFinance
Cellnex Telecom	1	TechnologyFinance
Indra	1	TechnologyFinance
International Airlines Group	1	TechnologyFinance
Mapfre	1	TechnologyFinance
Telefónica	1	TechnologyFinance
Unicaja	1	TechnologyFinance

Source: Author's elaboration (IBEX35, 2024)

The second variable was also a binary variable. It indicated whether the auditor's report contained a mention related to cybersecurity in the section on key audit matters - 1, or whether there was no such mention - 0. Because both variables were categorical and binary, non-

parametric and association-based statistical tests were applied to assess the relationship between them. First, we used Pearson's Chi-Square Test to assess the independence of individual variables. This test determines whether there is a statistically significant relationship between variables (Moore et al., 2009). Since our sample was relatively small, we also used Fisher's Exact Test, which confirmed the results of the Chi-Square Test. Fisher's Exact Test is better in our study than Chi-Square because it is more suitable for analysing smaller samples and small contingency tables (Moore et al., 2009). We continued with the statistical analysis because we also wanted to find out how strong the relationships between the individual variables are, and for this we used Cramér's V. Significance was assessed at the conventional 5% level (alpha=0,05).

4 Results and Discussion

The research examined whether companies in the IBEX 35 classified as having a higher cyber risk also had more frequently mentioned Key Audit Matters related to cybersecurity in their auditor's report. It was found that auditors more frequently reported key audit matters related to cybersecurity in companies classified as being at higher risk of cyber threats. The contingency table revealed a contrast between the categories. While none of the companies classified as low-cybersecurity risk disclosed a KAM related to cybersecurity or data protection, approximately one-third of companies in the high-risk category did so. This descriptive difference was confirmed by statistical testing. Fisher's exact test indicated a significant association ($p = 0{,}004$), and the result was consistent with the Pearson chi-square test ($\chi^2 = 9{,}87$, $df = 1$, $p = 0{,}0017$). To evaluate the substantive importance of the relationship, Cramér's V was calculated, with a value of 0,447, which corresponds to a moderate effect size. Taken together, these results suggest that auditors are considerably more likely to disclose technology-related KAMs when the audited company operates in a cybersecurity-intensive sector. The research found that auditors are also interested in technological aspects that may affect the audited companies, but mainly in sectors that are directly affected by these technologies – the technology, financial, and telecommunications sectors. Overall, the evidence from this preliminary study suggests that cybersecurity is beginning to enter the language of auditor reporting, but its treatment remains selective.

5 Conclusion

The research confirmed the assumption that auditors more frequently identified key audit matters related to technology in the reports of IBEX35 companies, which are among those most significantly affected by new technologies. Companies operating in high-risk industries, such as financial services and telecommunications, were considerably more likely to disclose cybersecurity-related audit issues, while none of the firms in low-risk industries included such disclosures. The statistical analysis — combining Fisher's exact test, Pearson's chi-square test, and Cramér's V — confirms both the significance and moderate strength of this association. This suggests that auditors currently perceive new technologies as threats only in companies where new technologies are directly embedded. This study adds to the literature on audit reporting and risk communication by providing empirical evidence on how cybersecurity risks are reflected in Key Audit Matters (KAMs). It highlights that auditors are more likely to disclose technology-related KAMs in sectors with high cybersecurity exposure, revealing how industry context shapes materiality judgments. During the data collection process, it was observed that several of the auditor's reports were available only as scanned PDF documents rather than as machine-readable text files. Since scanned reports are stored as image-based files, their textual content cannot be directly processed or analysed by automated tools. To address this challenge, the study applied Optical Character Recognition (OCR) technology to convert

the scanned documents into searchable and machine-readable text. This step was necessary to enable subsequent keyword-based content analysis and ensure that technology and environment-related Key Audit Matters (KAMs) could be systematically identified. Despite these efforts, the use of OCR introduces a potential source of error and represents an inherent limitation of this research. OCR technology, while generally accurate, is not flawless — particularly in cases where the original scan quality was poor, the formatting was inconsistent, or the language contained technical terms. As a result, there remains a possibility that some relevant KAM references were not correctly recognized or were partially misinterpreted during the text extraction process. This limitation should be considered when interpreting the findings, as it may have led to a slight underestimation of the frequency of certain disclosures. Future research could address this limitation by using higher-quality source documents or more advanced text-recognition methods to further improve data reliability. For future research, we also recommend including more large companies in the analysis and thus expanding the observed sample.

Acknowledgements

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Digitálna ekonomika a potreba reformy DPH: Analýza návrhov Európskej komisie
Digital Economy and the Need for VAT Reform: Analysis of European Commission Proposals

Maroš Píro[1]

Abstrakt
Obchodné vzťahy a praktiky sa neustále vyvíjajú, posledná harmonizácia pravidiel dane z pridanej hodnoty v rámci Európskej únie prebehla ešte počas minulého tisícročia. Technologický vývoj transformoval oblasť obchodu do takej miery, že pravidla dane z pridanej hodnoty z poslednej harmonizácie sa nestíhajú prispôsobovať. Európska komisia navrhla nové pravidlá a predstavila iniciatívu s názvom „DPH v digitálnom veku (ViDA)“. Cieľom tejto iniciatívy bola harmonizácia pravidiel pre daň z pridanej hodnoty, aby reflektovala potreby aktuálneho trhu. Práca sa zameriava na posúdenie dôvodov zavedenia a zároveň návrhov pre nové pravidlá v legislatívnom kontexte Slovenskej republiky.

Kľúčové slová
DPH v digitálnom veku, Elektronická fakturácia, Medzištátny predaj, Zdaňovanie platforiem

Abstract
Business relations and practices are constantly evolving, with the last harmonization of value-added tax rules within the European Union taking place in the last millennium. Technological developments have transformed the field of trade to such an extent that the value-added tax rules from the last harmonization are unable to keep up. The European Commission has proposed new rules and presented an initiative called "VAT in the Digital Age (ViDA)". The aim of this initiative was to harmonize value-added tax rules to reflect the needs of the current market. This paper focuses on assessing the reasons for the introduction and proposals for new rules in the legislative context of the Slovak Republic.

Key words
VAT in the digital age, Electronic invoicing, Cross-border sales, Platform taxation

JEL classification
M48, K34

1 Úvod

Globalizácia má podstatný vplyv na fungovanie krajín a ich hospodárstva. Rastúcou digitalizáciou sa transformovala aj oblasť obchodu prostredníctvom digitálneho obchodovania a nárastom cezhraničných transakcií. Takáto transformácia trhu spôsobila, že nastolené pravidlá pre daň z pridanej hodnoty boli už prikrátke. Posledná harmonizácia týchto pravidiel nastala ešte počas minulého tisícročia.

Iniciatíva DPH v digitálnom veku vznikla v roku 2022. Zameriava sa na tri oblasti a to zavedenie elektronických faktúr, špeciálne schémy pre dodávanie tovaru a služieb do viacerých krajín a zdaňovanie digitálnych platforiem. Iniciatíva DPH v digitálnom

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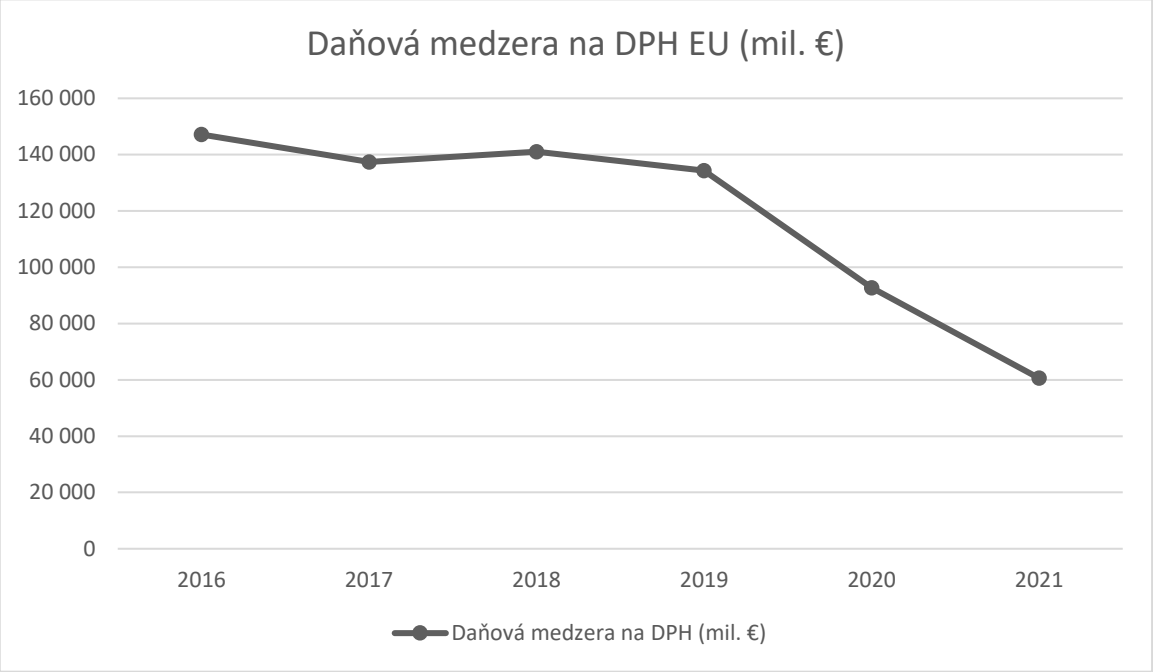
má ako hlavnú úlohu vytvoriť novú harmonizáciu pravidiel pre DPH, ktoré by vedeli reagovať na trendy a nové trhové podmienky. Cieľom iniciatívy bolo znížiť daňovú medzeru, ktorá sa v posledných rokoch prehlbovala a spôsobovala veľké straty pre štátne rozpočty jednotlivých krajín. Daňová medzera v posledných rokoch dosahovala vysoké úrovne, čo predstavovalo veľké straty pre štátne rozpočty.

Cieľom príspevku je posúdenie iniciatívy DPH v digitálnom veku, analyzovať jej prínosy a úroveň implementovania jednotlivých oblasti iniciatívy do legislatívy platnej v Slovenskej republike.

2 Dôvody zavedenia iniciatívy DPH v digitálnom veku

Samotné dôvody zavedenia iniciatívy DPH v digitálnom veku, na ktoré sa odkazuje dôvodová správa je zvyšujúca sa daňová medzera výberu dane z pridanej hodnoty. Daňová medzera predstavuje rozdiel medzi predpokladaným a reálnym výberom dane. Na obrázku 1 je znázornená daňová medzera pri dani z pridanej hodnoty v rámci členských krajín Európskej únie.

Obr. 1: Medzera výberu dane z pridanej hodnoty na území Európskej únie (mil. €)



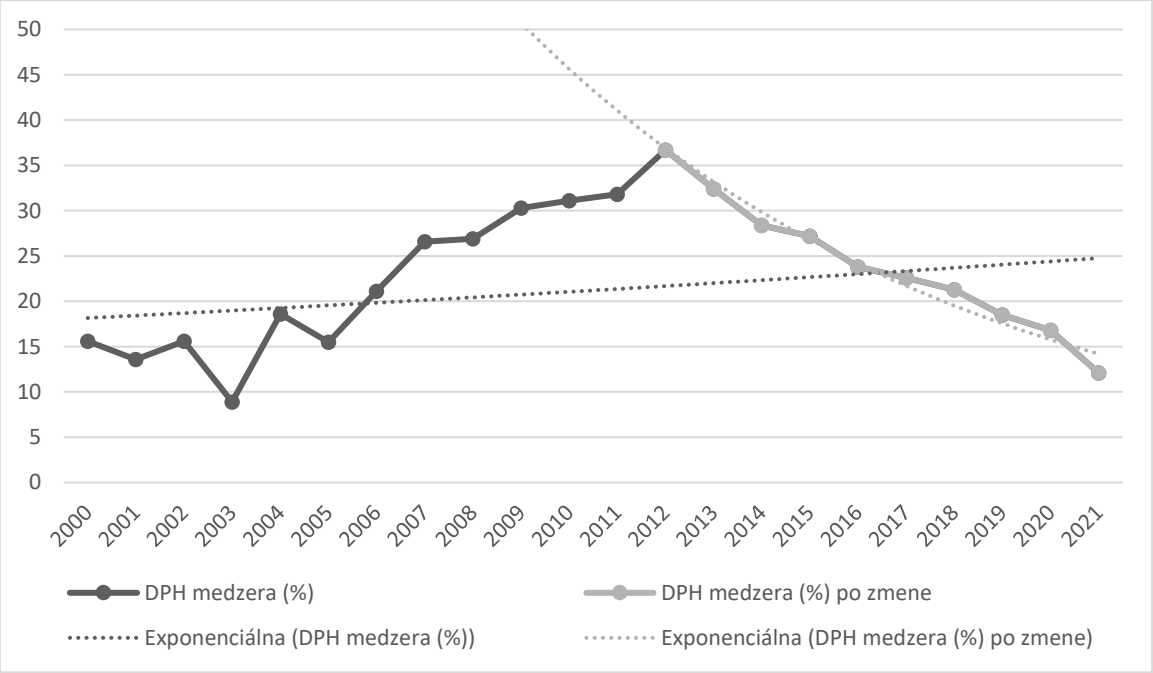
Zdroj: Centrum pre sociálny a ekonomický výskum (vlastné spracovanie)

Ako môžeme vidieť daňová medzera dlhodobo dosahovala hodnoty okolo 140 – 150 miliárd eur. V rokoch 2020 a 2021 nastal prudký pokles daňovej medzery. Na základe reportu daňovej medzery z roku 2023 sa autori sa dištancujú od posledných dvoch meraných rokov. Údaje za roky 2020 a 2021 vykazujú nižšie hodnoty z dôvodu ochromenia národných a medzinárodných obchodov spôsobených pandémiou. Preto nie je možné poskytnúť relevantný a spoľahlivý obraz na vývoj daňovej medzery krajín Európskej únie (CASE Center for Social and Economic Research, 2023).

Lepší pohľad na graf nám môže ukázať porovnanie výšky daňovej medzery napríklad do rozsahu hrubého domáceho produktu Slovenskej republiky. Hodnota okolo 140 – 150 miliárd eur predstavuje v časoch od 2016 – 2019 približne 1,4 – 1,5 násobok slovenského hrubého domáceho produktu. Všetky krajiny Európskej únie teda prišli pri výbere daní sumárne o viac ako o hodnotu produkcie všetkých tovarov a služieb na území Slovenskej republiky (Štatistický úrad SR, 2025).

Report daňovej medzery za rok 2023 poukazuje na pozitívny prípad vývoja daňovej medzery na území Slovenskej republiky, kde v priebehu niekoľkých rokov sa dokázala daňová medzera výrazne znížiť. Vývoj daňovej medzery pri dani z pridanej hodnoty na území Slovenskej republiky môžeme pozorovať v obrázku 2.

Obr. 2: medzera výberu dane z pridanej hodnoty na území Slovenskej republiky (%)



Zdroj: opendata.financnasprava.sk (vlastné spracovanie)

Daňová medzera na území Slovenskej republiky po vstupe do Európskej únie začala výrazne rásť. Od vstupu do Európskej únie v roku 2004 až po vrchol v roku 2012 vzrástla daňová medzera dvojnásobne a dosiahla najvyššiu hodnotu na úrovni 36,7%. V roku 2012 dosiahla hodnotu približne 1,8 miliardy eur. Rok 2012 bol zároveň aj rok od ktorého sa začala daňová medzera postupne znižovať. Dochádzalo k postupnému a kontinuálnemu znižovaniu daňovej medzery. Možno usudzovať, že znižovanie daňovej medzery bolo dôsledkom reforiem a projektov zavádzaných Finančnou správou SR. Významným posunom bolo zavedenie elektronických pokladníc, ktoré mali pozitívny vplyv na zníženie daňovej medzery.

V roku 2022 Európska komisia predpokladala, že zavedením iniciatívy DPH v digitálnom veku sa budú daňové medzery znižovať, čo bude priamo vplývať na zvýšenie daňových príjmov jednotlivých členských krajín. Na základe tohto uviedla predpoklad, že dodatočné príjmy do štátnych rozpočtov sa odhadujú na úrovni 172 – 214 miliárd eur. Zároveň predpokladajú, že zmeny by dokázali odbremeniť časť kontrolných orgánov. Táto zmena by mohla spôsobiť zníženie výdavkov štátu o približne 51 miliárd eur. Okrem finančných benefitov pre členské štáty Európskej únie by tieto zmeny mali mať dopad v podobe ochrany životného prostredia, automatizácie a fungovania vnútorného trhu (Európska Komisia, 2022).

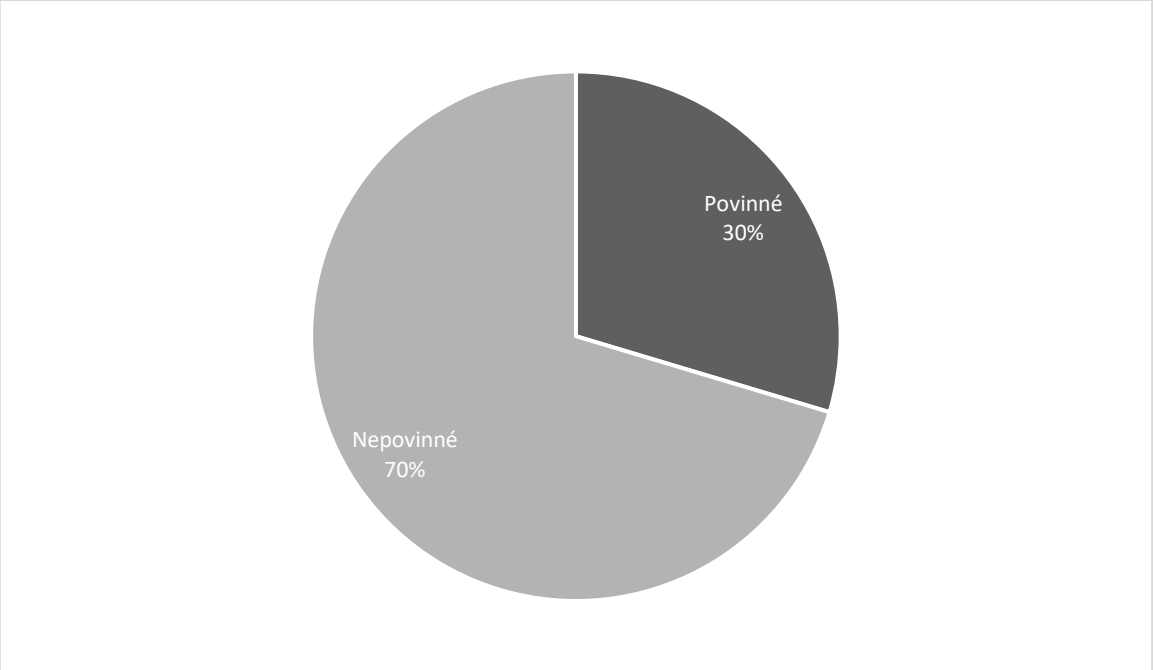
3 Elektronická fakturácia

Zavedenie elektronických faktúr dokáže priniesť mnoho výhod pre verejný sektor a rovnako aj pre súkromný sektor. Verejnému sektoru môže elektronická fakturácia priniesť zefektívnenie výberu daní, čo bude vplývať na minimalizáciu daňových únikov v dôsledku daňovej kontroly vystavovania faktúr v reálnom čase. Na druhej strane z pohľadu súkromného sektoru môže priniesť zníženie administratívnych nákladov (Koch, 2019).

Podľa Kocha (2019) sa daňová medzera pri výbere dane z pridanej hodnoty po prijatí elektronickej fakturácie znížila až o 50% v krajinách ako Čile a Mexiko.

Ak chceme aplikovať danú problematiku na Európsku únie, tak je dôležité uviesť, aký je podiel povinného využívania elektronických faktúr v rámci Európskej únie, čo ilustruje obr. 3.

Obr. 3: Povinné využívanie elektronických faktúr podnikateľmi v Európskej únií



Zdroj: ec.europa.eu (vlastné spracovanie)

Na základe obrázka 3 môžeme pozorovať, že povinné používanie elektronickej fakturácie v rámci krajín Európskej únie je iba na úrovni 30%, čo reprezentuje 8 krajín únie (niektoré zdroje uvádzajú 6 krajín). Prognózy Európskej únie hovoria o tom, že zavedenie elektronickej fakturácie by malo znížiť daňovú medzeru približne o 24%. V krajinách Európskej únie, ktoré využívajú povinnú elektronickú fakturáciu možno pozorovať nižšie hodnoty daňovej medzery ako v krajinách, kde elektronická fakturácie ešte nie je zavedená (Európska Komisia, 2022).

V Slovenskej republike ešte nie je zavedená elektronická fakturácia, avšak aktuálne je táto problematika predmetom schvaľovania a zavedenie sa predpokladá od roku 2027.

Na základe predloženej novely zákona, ktorá nie je ešte schválená a neobsahuje finálne znenie úpravy zákona sa zavádza pojem elektronická faktúra. Pridáva tým povinnosť vystavovania elektronických faktúr pre tuzemské a zahraničné obchody. Účtovné jednotky registrované ako platitelia dane budú musieť vystavovať elektronické faktúry pre všetky dodávky v tuzemsku. Pre dodanie tovaru a služieb do iných krajín budú mať túto povinnosť od roku 2030 (Vládny návrh 1023, 2025).

Dôvodová správa pre novelizáciu zákona, ktorý zavádza elektronickú fakturáciu rieši problematiku daňových podvodov s takzvaným zmiznutým obchodníkom (inak známe aj ako karuselové podvody). V dôvodovej správe sú vyjadrené negatívne a pozitívne dopady zavedenia elektronických faktúr pre rozpočet verejnej správy aj podnikateľský sektor.

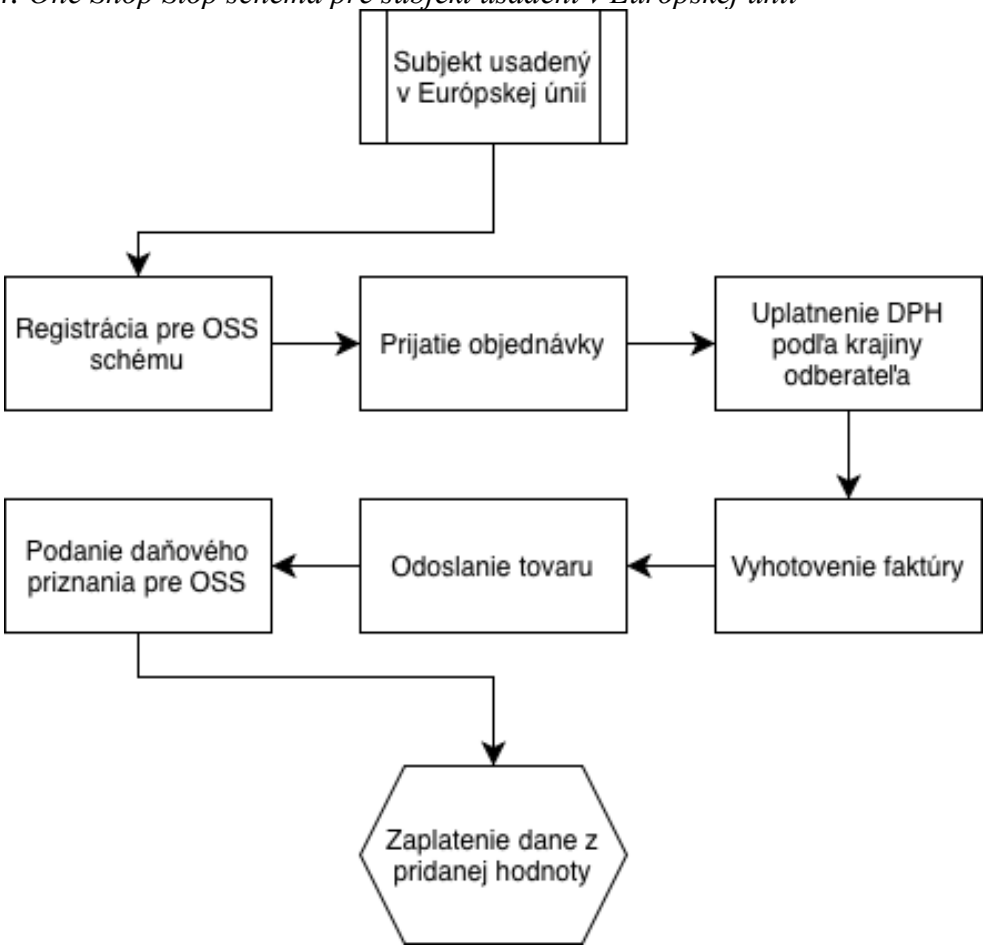
Z pohľadu verejnej správy sa predpokladajú náklady na zavedenie informačných systémov v hodnote takmer 16 miliónov eur. Na druhej strane predpokladané výnosy strednodobého horizontu zavedenia elektronických faktúr sa nachádzajú na hodnote niekoľkých stoviek miliónov eur, pričom presné číslo a kalkulácia tejto hodnoty nebola v dôvodovej správe vysvetlená. (Vládny návrh 1023, 2025).

4 Špeciálne schémy

Schémy One Stop Shop (OSS) boli zavedené s cieľom zníženia administratívnych nákladov pre spoločnosti v oblasti vykazovania a platenia dane z pridanej hodnoty. Jedná sa o zjednodušenie vykazovania pre účtovné jednotky, ktoré dodávajú tovar alebo služby v rôznych členských štátoch. Medzi hlavné princípy OSS schémy sa radí jednoduchšia daňová registrácia, ľahšie zdanenie v mieste spotreby, jednoduchšia administratíva, úspora času a nákladov (Matesanz & Services, 2021).

Na obrázku 4 je znázornená One Shop Stop schéma pre subjekty usadené v Európskej únii, ktoré dodávajú tovar do viacerých krajín v rámci krajín Európskej únie.

Obr. 4: One Shop Stop schéma pre subjekt usadení v Európskej únií



Zdroj: vlastné spracovanie

V situácií, že by sa podnik chcel zaregistrovať pre One Stop Shop schému, je potrebné začať registráciou prostredníctvom Finančného riaditeľstva SR, poprípade v inej krajine prostredníctvom príslušného orgánu. Následne pri predaji do iných členských krajín Európskej únie je potrebné zistiť príslušnú sadzbu dane v krajine dodania. Na základe toho je potrebné s príslušnou sadzbou dane vyhotoviť daňový doklad. Pri podaní daňového priznania k One Stop Shop schéme je potrebné vykázať predaje za každú krajinu, v ktorej bol dodaný tovar alebo služba za príslušné obdobie aj s vyčíslenou daňou. Táto činnosť je vykazovaná slovenskému správcovi dane a zároveň mu je aj daň poukázaná. Slovenský správca dane následne vysporiada

daň s príslušnými správcami dane v iných členských štátov, bez nutnosti subjektu sa registrovať ako platiteľ dane vo viacerých členských štátoch.

5 Platformy uľahčujúce dodanie

Technologický pokrok priniesol aj rozvoj poskytovania digitálnych služieb. Tieto digitálne služby častokrát prepájajú konečného spotrebiteľa s reálnym dodávateľom. Digitálne služby teda vystupujú v postavení sprostredkovateľa pri predaji tovaru alebo služby. Spomínané sprostredkovanie služieb so sebou prinieslo problémy ohľadne daňových povinností, čo spôsobuje daňové úniky a znižuje efektivitu výberu dane z pridanej hodnoty. Podľa iniciatívy DPH v digitálnom veku by mali byť digitálne platformy, ktoré vystupujú ako sprostredkovatelia dodania tovaru alebo služieb zodpovedné za výber a platenie dane z pridanej hodnoty. Zaviedol sa pojem „domnelý dodávateľ“, ktorý hovorí o tom, že konečný spotrebiteľ si nemusí uvedomiť, že platforma cez ktorú vykonal nákup služby alebo tovaru nie je reálny dodávateľ. Iniciatíva DPH v digitálnom veku mala za úlohu postaviť tieto platformy ako primárneho platiteľa pri dani z pridanej hodnoty, čím by museli platformy vykazovať a platiť daň z pridanej hodnoty ako reálny dodávatelia (Matesanz & Services, 2021).

Ako je problém ohľadne digitálnych platforiem zakotvený v slovenskej legislatíve? Slovenská legislatíva nereagovala zmenou zákona, ale vydaním metodického pokynu k určeniu miesta dodania tovaru pri predaji na diaľku vydaný Finančným riaditeľstvom SR. Súčasťou metodického pokynu bolo aj dodávanie tovaru alebo služby prostredníctvom digitálnej platformy. Prípady boli rozdelené na základe toho, či subjekt, ktorý je reálnym dodávateľom je usadený na území Európskej únie alebo nie. Finančné riaditeľstvo sa pri takomto obchodnom vzťahu pozerá na dodanie ako na dve odlišné transakcie. Prvú transakciu ako B2B (business-to-business) medzi reálnym dodávateľom a digitálnou platformou. Druhú transakciu ako B2C (business-to-customer) medzi digitálnou platformou a konečným spotrebiteľom (Metodický pokyn k určeniu miesta dodania tovaru pri predaji tovaru na diaľku z pohľadu dane z pridanej hodnoty, 2021)

Subjekty, ktoré nie sú usadené v rámci krajín Európskej únie postupujú podľa §8 ods. 7 zákona o dani z pridanej hodnoty. Tento paragraf nám ustanovuje, že digitálna platforma v takomto prípade tovar prijala a dodala. Na transakciu sa nazerá ako keby pochádzala z dvoch dodaní. Prvé dodanie od reálneho dodávateľa k digitálnej platforme a druhé dodanie od digitálnej platformy ku konečnému spotrebiteľovi

Ak je subjekt usadený na území členských krajín Európskej únie, nie je možné využiť §8 ods. 7 zákona o dani z príjmov a na základe metodického pokynu vydaného Finančným riaditeľstvom SR si reálny dodávateľ musí splniť vo vlastnom mene všetky povinnosti ohľadom vykázania a zaplatenia dane z pridanej hodnoty.

6 SWOT analýza

Pri vypracovaní SWOT analýzy sme sa zamerali na posúdenie iniciatívy „DPH v digitálnom veku“ z viacerých aspektov. Cieľom nebolo len identifikovať pozitívne a negatívne dopady, ktoré sú predmetom dôvodovej správy, ale aj rozšíriť hodnotenie o potenciálne príležitosti a hrozby, ktoré môžu z implementácie tejto iniciatívy vyplynúť. Výsledky SWOT analýzy sú zhrnuté v Tabuľke 1.

Tab. 1: SWOT analýza

Silné stránky (Strengths)	Slabé stránky (Weaknesses)
• Zvýšenie transparentnosti • Efektívnejší výber DPH	• Zložitosť adaptácie na nové pravidlá • Rezistencia podnikateľskej komunity

Príležitosti (Opportunities)	Hrozby (Threats)
• Podpora cezhraničného obchodu • Potenciál pre nové podnikateľské príležitosti	• Zvýšenie administratívne zaťaženie • Kybernetické riziká • Strata konkurencieschopnosti MSP

Zdroj: vlastné spracovanie

Medzi silné stránky predmetnej iniciatívy patrí najmä zvýšenie efektívnosti výberu dane z pridanej hodnoty, ako aj zníženie miery daňových únikov a daňových podvodov. Zavedenie elektronickej fakturácie zároveň prispieva k vyššej transparentnosti podnikateľského prostredia, čím sa zjednodušuje aj riešenie sporných pohľadávok a záväzkov v rámci súdnych konaní.

Za slabé stránky iniciatívy možno považovať odpor zo strany podnikateľského prostredia, ktorý môže vzniknúť v dôsledku potreby adaptácie na nové pravidlá a technologické systémy.

Iniciatíva poskytuje príležitosti v oblasti zjednodušenia cezhraničného obchodu, a to najmä prostredníctvom eliminácie povinnosti registrácie pre DPH vo viacerých členských štátoch. Okrem toho vytvára priestor pre rozvoj nových podnikateľských aktivít v oblasti kybernetickej bezpečnosti, ktoré budú reagovať na zvýšené nároky na ochranu elektronických údajov.

Z pohľadu príležitostí iniciatíva otvára možnosti na zjednodušenie cezhraničného obchodu, a to najmä prostredníctvom eliminácie povinnosti registrácie pre DPH vo viacerých členských štátoch. Okrem toho vytvára priestor pre rozvoj nových podnikateľských aktivít v oblasti kybernetickej bezpečnosti, ktoré budú reagovať na zvýšené nároky na ochranu elektronických údajov.

Medzi hrozby patrí predovšetkým zvýšenie administratívneho zaťaženia v počiatočnej fáze implementácie, súvisiace s potrebou prispôsobenia sa novým systémom. Významné riziko predstavujú aj potenciálne kybernetické hrozby, ktoré by mohli viesť k úniku dôverných informácií, vrátane údajov o kľúčových obchodných partneroch a ďalších citlivých informácií. V neposlednom rade existuje riziko zníženia konkurencieschopnosti malých a stredných podnikov, a to v dôsledku vyššej miery integrácie trhu a zjednodušeného prístupu zahraničných subjektov na jednotný trh Európskej únie.

7 Záver

Digitalizácia vo veľkej miere ovplyvnila podobu hospodárstva nie len Slovenska, ale aj iných členských krajín Európskej únie a aj mimo nej. Dôsledkom digitalizácie a prepojenia hospodárstiev viacerých krajín dochádza k narušeniu vykazovania a platenia daní z dôvodu disharmónie legislatívy členských krajín Európskej únie. Daňová medzera výberu dane z pridanej hodnoty dosiahla veľkých rozmerov. Iniciatíva DPH v digitálnom veku sa postupne snaží priniesť harmonizáciu pravidiel k dani z pridanej hodnoty, aby odpovedali aktuálnej situácii na trhu.

Slovenská republika sa do veľkej miery dokázala adaptovať na zmeny, ktoré je potrebné implementovať. Poslednou zmenou je novelizácia zákona o dani z pridanej hodnoty, ku ktorej je podaný legislatívny návrh zákona, ktorý by mal priniesť elektronické faktúry na územie Slovenskej republiky od roku 2027. Možno tým predpokladať (aj na základe skúseností z iných krajín), že by sa týmto krokom zabezpečilo predchádzaniu daňovým únikom a daňovým podvodom.

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Key Audit Matters as a Means of Communicating Environmental and Social Risks

Zuzana Užíková[1]

Abstract
The growing importance of environmental and social issues in corporate governance increases firms' exposure to sustainability risks beyond traditional financial measures. Auditors reflect these developments through Key Audit Matters (KAM), emphasizing the relevance of such factors for financial assurance. This study examines the audit reports of 35 companies listed on Spain's IBEX 35 index to assess the presence of environmental and social topics in KAM. It further analyzes whether firms in higher-risk sectors are more likely to disclose such issues. The analysis applies automated content processing supported by Retrieval-Augmented Generation (RAG), ensuring systematic and replicable identification. The findings enhance understanding of how auditors incorporate environmental and social dimensions into stakeholder communication and illustrate the expanding role of KAM in addressing sustainability challenges within the audit process

Key words
Audit report, Key audit matters, Environmental, Social and governance

JEL classification
M42, Q56, G34

1 Introduction

In recent years, the growing importance of environmental and social sustainability has fundamentally reshaped the way companies are evaluated by investors, regulators, and the public. Traditional financial reporting, while essential for assessing corporate performance, no longer provides a complete picture of a firm's risk exposure. Issues such as climate change, resource scarcity, labor conditions, and community impact have become material factors for business continuity and stakeholder trust. Consequently, both financial and non-financial auditors are increasingly expected to integrate sustainability-related risks into their assurance processes.The introduction of *International Standard on Auditing (ISA) 701*, which requires auditors to communicate *Key Audit Matters (KAMs)*, has transformed the auditor's report into a more informative instrument. The purpose of KAMs is to highlight areas where the auditor identified a higher risk of material misstatement or required significant professional judgment. Although this concept was initially designed to enhance transparency regarding complex financial issues, its scope has gradually expanded. Auditors today face the challenge of incorporating environmental and social factors into their professional judgments, particularly because such risks can indirectly affect the financial statements through asset impairment, contingent liabilities, or going-concern assumptions. Despite growing awareness of sustainability reporting and the expansion of ESG (Environmental, Social, and Governance) frameworks, only a limited number of studies have examined how environmental and social risks are actually reflected in auditors' communication with stakeholders. Previous research has

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largely focused on financial KAMs—such as goodwill impairment, revenue recognition, or taxation—while the presence of environmental or social KAMs remains underexplored. Understanding how and when auditors include sustainability-related issues in their reports can reveal how audit practices adapt to the broader sustainability agenda. Environmental risks relevant to audit reporting may include issues related to greenhouse gas emissions, energy consumption, waste management, water and soil pollution, or a company's dependency on fossil fuels. These factors can have direct financial implications through increased compliance costs, regulatory penalties, or asset devaluation in environmentally intensive industries. Social risks, on the other hand, may arise from labor conditions, employee safety, respect for human rights in supply chains, equality of opportunity, or relationships with local communities. When such risks are not adequately managed, they may result in reputational damage, legal disputes, or operational disruptions. Incorporating these dimensions into KAMs thus represents an important step toward a more holistic audit approach that reflects the complex risk landscape of modern business environments. This study therefore investigates the extent to which environmental and social risks are incorporated into KAMs within the audit reports of companies listed on Spain's IBEX 35 index. The analysis aims to determine whether firms operating in industries with higher exposure to environmental risks are more likely to disclose such issues as KAMs. By combining automated content analysis with manual verification, the study seeks to provide empirical evidence on how environmental factors are communicated through the audit process and to what extent auditors use KAMs as a medium for sustainability-related transparency.

2 Literature review

Key Audit Matters (KAMs) are defined as those matters that, in the auditor's professional judgment, were of most significance in the audit of the current period's financial statements (IAASB, 2016; Alshdaifat et al., 2024). They are selected from issues communicated with those charged with governance and were introduced through International Standard on Auditing (ISA) 701 to enhance transparency and restore trust in the audit profession following a series of corporate accounting scandals (Knechel, 2007; Flodström & Gavelin, 2025). In practice, the most frequently reported KAMs relate to asset impairment, revenue recognition, and investment valuation (Svanström et al., 2020). The process of determining KAMs typically involves three steps: identifying all issues communicated to management, determining which required the most auditor attention, and selecting those ultimately deemed most significant for disclosure (Flodström & Gavelin, 2025; Alshdaifat et al., 2024). Audit firms use standardized methodologies to ensure consistency with ISA 701 requirements (Narváez-Castillo et al., 2024).

Disclosure of KAMs is considered to enhance financial reporting transparency and reduce information asymmetry between management and investors (Wang et al., 2022; Alshdaifat et al., 2024). Previous research indicates that KAMs improve users' confidence in financial statements, support informed decision-making, and can serve as early warning signals of potential misstatements (Bédard et al., 2016; Zeng et al., 2021). In this way, KAMs contribute not only to the accountability of auditors but also to the overall quality of financial reporting. In recent years, environmental, social, and governance (ESG) factors have become increasingly relevant for auditors due to the growing focus on sustainability risks (Dabbous et al., 2024; Narváez-Castillo et al., 2024). The EU Directive 2022/2464 replaced the concept of non-financial information with sustainability information and introduced the principle of double materiality, which requires companies to disclose both their impact on the environment and society and the way sustainability risks affect their financial position (EU, 2022). The Corporate Sustainability Reporting Directive (CSRD) further strengthens this requirement, while the IFRS

Foundation has established the International Sustainability Standards Board (ISSB) to align sustainability and financial reporting (IFRS Foundation, 2022). These developments increase pressure on auditors to recognize ESG-related risks in their assessments. Environmental risks such as greenhouse gas emissions, waste management, energy consumption, or regulatory compliance can have direct financial implications through impairment, fines, or contingent liabilities. Social risks, including working conditions, supply chain ethics, or human rights, may lead to reputational damage or operational disruptions. Yet, research consistently shows that ESG risks are still rarely reflected in audit reporting, particularly within KAM disclosures (Narváez-Castillo et al., 2024; Flodström & Gavelin, 2025). Several theoretical perspectives help explain the connection between ESG considerations and KAMs. According to Stakeholder Theory (Freeman, 1984), companies should create value for all stakeholders rather than solely for shareholders. Providing information through sustainability disclosures and KAMs helps meet diverse stakeholder expectations and supports their decision-making (Freeman & Phillips, 2002; Gambetta et al., 2024). Legitimacy Theory (Deegan, 2002) suggests that organizations disclose ESG and audit information to maintain social legitimacy, signaling responsible and ethical behavior (Boonlert-U-Thai & Suttipun, 2023; Flodström & Gavelin, 2025). Agency Theory (Ross, 1973) highlights the audit's role in reducing information asymmetry between managers and owners, where KAMs serve as a mechanism for mitigating agency conflicts and enhancing accountability (Issa & Velte, 2019; Özkan, 2021). Empirical studies confirm that the integration of ESG factors into KAMs remains limited. A study of Colombian companies between 2019 and 2021 found that auditors focused primarily on governance-related issues, while social and environmental topics were almost entirely excluded from KAM disclosures (Narváez-Castillo et al., 2024). Similar findings were reported across Europe, where auditors tend to emphasize quantifiable financial risks over qualitative sustainability concerns (Flodström & Gavelin, 2025). Nonetheless, emerging evidence suggests that firms' ESG performance influences the way auditors communicate KAMs. Higher ESG scores are associated with fewer but clearer KAM disclosures, particularly in governance and social dimensions (Zhu et al., 2024). In China, Wang and Wu (2024) found that strong carbon emission management is linked to a greater number and higher readability of KAMs, reflecting auditors' sensitivity to environmental scrutiny. These results imply that ESG performance indirectly shapes audit reporting practices. Despite this growing attention, auditors still face challenges when attempting to include ESG issues in KAMs. One major obstacle is the difficulty of quantifying sustainability risks in financial terms and linking them to material misstatement risk (Flodström & Gavelin, 2025). Many ESG-related matters involve qualitative judgments or non-financial indicators that do not easily translate into monetary measures. Another challenge lies in the lack of expertise and standardized guidance for assessing ESG risks in audits, as sustainability assurance is still developing within the profession (Narváez-Castillo et al., 2024). These limitations highlight the need for enhanced auditor training, clearer methodologies, and closer cooperation between financial and sustainability assurance specialists. Research has shown that KAM disclosure generally improves audit quality, though the marginal effect varies depending on firm characteristics and information redundancy (Lin, 2023; Wang & Wu, 2024). By highlighting key risks and auditor judgments, KAMs enhance transparency, reduce stock price crash risk, and promote more conservative accounting practices. Moreover, the presence of ESG-related KAMs may encourage companies to adopt greener innovations and more robust risk management strategies (Wang & Wu, 2024). European auditors, particularly in Sweden, view the gradual implementation of CSRD positively, as it provides time to develop the necessary competencies before full integration of sustainability assurance (Flodström & Gavelin, 2025). In the long term, both scholars and practitioners suggest extending KAM requirements to sustainability reporting, aligning audit transparency with the broader objectives of corporate accountability. Although recent studies

have advanced understanding of KAM disclosures, environmental and social aspects remain underrepresented compared to financial and governance topics. Most existing research concentrates on the traditional audit context, leaving limited insight into how sustainability risks are communicated in practice. This study aims to address this gap by analyzing the presence of environmental and social issues within KAMs of IBEX 35 companies and by exploring whether industry-level exposure influences the likelihood of their disclosure.

3 Methodology

To examine how environmental risks are reflected in audit reporting, the study constructed two binary variables based on the IBEX 35 sample. The first, enviro_category, classified firms as operating in a sector with high (1) or low (0) exposure to environmental risks. Classification was based on industry characteristics, with companies in energy, utilities, and extractive sectors coded as high exposure, while firms in services or consumer industries were coded as low exposure. The second variable, KAM_enviro, captured the presence (1) or absence (0) of environment-related Key Audit Matters (KAMs) in the auditor's report. Environment-related KAMs were identified through a content analysis procedure using keyword searches (e.g., "environmental," "sustainability," "emissions," "climate," "decarbonization," "ESG") and subsequent manual verification. Because both variables are categorical, the same set of non-parametric statistical tests was applied as in the cybersecurity analysis. Fisher's exact test was used to determine whether a statistically significant association exists between sectoral environmental exposure and the reporting of environment-related KAMs. The Pearson chi-square test served as a complementary measure of independence, and Cramér's V was calculated to evaluate the strength of the association. All statistical analyses were performed in R, with significance assessed at the 5% level ($\alpha = 0.05$).

4 Findings

Descriptive statistics show that environment-related KAMs were disclosed by a minority of firms, and unexpectedly, these disclosures occurred more frequently among companies classified as low environmental risk than among those in the high-risk group. The statistical analysis supports this observation. Fisher's exact test indicates a statistically significant association between sectoral environmental exposure and the disclosure of environment-related KAMs ($p = 0.027$). These results highlight a paradox: while environmental issues are expected to be most material for high-exposure industries such as energy and utilities, they are underrepresented in their KAM disclosures. By contrast, companies with lower direct exposure occasionally disclose environmental KAMs, possibly reflecting reputational considerations, broader ESG reporting trends, or auditor discretion. This discrepancy suggests that environmental risks are not yet consistently integrated into audit reporting, even in industries where they are most salient.

5 Discussion

The study investigated the extent to which environmental and social risks are incorporated into Key Audit Matters (KAMs) within the audit reports of 35 companies listed on Spain's IBEX 35 index, specifically analyzing whether firms in sectors with higher exposure to environmental risks are more likely to disclose such issues. The findings indicate that environment-related KAMs were disclosed by only a minority of firms, which aligns with research consistently showing that Environmental, Social, and Governance (ESG) risks are still

rarely reflected in audit reporting, particularly within KAM disclosures. Crucially, descriptive statistics revealed an unexpected paradox: these disclosures occurred more frequently among companies classified as having low environmental risk compared to those in the high-risk group, an observation supported by Fisher's exact test, which found a statistically significant association between sectoral environmental exposure and the disclosure of environment-related KAMs ($p = 0.027$). This paradox is significant because environmental issues, such as greenhouse gas emissions or regulatory compliance, are expected to be most material for high-exposure industries like energy and utilities, yet they are underrepresented in the KAM disclosures of those high-risk sectors. The presence of environmental KAMs in companies with lower direct exposure may instead reflect other motivational drivers, such as reputational considerations, broader ESG reporting trends, or the exercise of auditor discretion. This suggests that environmental risks are not yet consistently integrated into audit reporting, even in industries where their saliency is highest. The persistent challenge auditors face in incorporating these issues stems largely from the difficulty of quantifying sustainability risks in financial terms and linking them to the risk of material misstatement, given that many ESG matters involve qualitative judgments that do not easily translate into monetary measures. Furthermore, the lack of expertise and standardized guidance for assessing ESG risks within the audit profession contributes to this limitation. Ultimately, while KAMs enhance the transparency and accountability of financial reporting, scholars and practitioners suggest that extending KAM requirements to sustainability reporting is needed to align audit transparency with broader corporate accountability objectives.

6 Conclusion

This study examined the extent to which environmental and social risks are incorporated into Key Audit Matters (KAMs) within the audit reports of 35 companies listed on Spain's IBEX 35 index, aiming to enhance the understanding of how auditors address sustainability challenges and communicate these risks to stakeholders. The findings confirm established trends, indicating that environment-related KAMs were disclosed by only a minority of firms, suggesting that Environmental, Social, and Governance (ESG) risks are still rarely reflected in audit reporting. The most critical finding revealed an unexpected paradox: environment-related KAMs were found to occur more frequently among companies classified as low environmental risk compared to those in the high-risk group, an observation confirmed by a statistically significant association derived from Fisher's exact test ($p = 0.027$). This discrepancy highlights those environmental risks - which should be most material for high-exposure industries such as energy and utilities - are not yet consistently integrated into audit reporting. Instead, their disclosure in low-risk sectors may be driven by factors such as reputational considerations or the exercise of auditor discretion. This limited integration stems from fundamental challenges, including the difficulty of quantifying sustainability risks in financial terms and linking them to the risk of material misstatement, as many ESG matters involve qualitative judgments. Furthermore, the audit profession still faces a lack of expertise and standardized guidance for assessing ESG risks. Although KAMs contribute to enhancing financial reporting transparency and reducing information asymmetry, the study concludes that their potential as a medium for sustainability-related transparency is not yet fully utilized. Consequently, scholars and practitioners suggest the long-term necessity of extending KAM requirements to sustainability reporting to align audit transparency with broader corporate accountability objectives, particularly in the context of emerging regulations like the Corporate Sustainability Reporting Directive (CSRD).

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Financovanie športových organizácií: porovnanie verejných a súkromných zdrojov na základe analýzy účtovných závierok
Financing of Sports Organizations: Comparison of Public and Private Sources Based on the Analysis of Financial Statements

Diana Žinčáková[1]

Abstrakt
Príspevok sa zaoberá problematikou financovania športových organizácií, pričom osobitnú pozornosť venujeme porovnaniu financovania v oblasti športu zo súkromných zdrojov a verejných zdrojov. Analýza je založená na pomerne rozsiahlej databáze, ktorá zahŕňa 1 085 účtovných závierok mikro účtovných jednotiek pôsobiacich v oblasti športu za obdobie rokov 2014 až 2023. Na overenie teoretických predpokladov sme vytvorili modelovú mikro účtovnú jednotku. Cieľom príspevku je analyzovať financovanie športových organizácií a posúdiť, nakoľko sa teoretické predpoklady zhodujú s výsledkami získanými z vytvorenej modelovej mikro účtovnej jednotky. Analýza výsledkov odhaľuje odchýlky od teoretických predpokladov. Príspevok tak poskytuje pohľad na reálny podiel verejných a súkromných zdrojov v oblasti športu.

Kľúčové slová
financovanie športových organizácií, ekonomika športu, verejné zdroje, súkromné zdroje, modelová mikro účtovná jednotka

Abstract
The paper deals with the issue of financing sports organizations, with particular attention given to the comparison of financing in sports from private sources and public sources. The analysis is based on a relatively extensive database, which includes 1085 financial statements of micro accounting entities operating in the field of sports for the period 2014 to 2023. To verify the theoretical assumptions, we created a model micro accounting entity. The aim of the paper is to analyse the financing of sports organizations and to assess the extent to which theoretical assumptions correspond with the results obtained from the created model micro accounting entity. The analysis of results reveals deviations from the theoretical assumptions. Thus, the paper provides an insight into the real share of public and private sources in the field of sports.

Key words
financing of sports organizations, sports economics, public sources, private sources, model micro accounting entity

JEL classification
Z230, Z200

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1 Úvod

Žijeme v dobe, kedy je šport viac než len hra. Je to silný nástroj na formovanie charakteru, budovanie komunít a na podporu zdravého životného štýlu. No za každým úspechom športovca, či športového tímu stojí aj neviditeľná, zároveň dôležitá časť a tou je stabilné a udržateľné financovanie.

Práve tu zohráva kľúčovú rolu účtovníctvo. Účtovníctvo chápeme ako základný nástroj evidencie hospodárskych javov a finančných tokov v každej účtovnej jednotke. Každá účtovná jednotka má zo zákona č. 431/2002 o účtovníctve v znení neskorších predpisov (ďalej „zákon o účtovníctve“) povinnosť viesť účtovníctvo. Výnimkou nie sú ani športové organizácie, ktoré môžu mať rôzne právne formy. V praxi sa môžeme stretnúť najmä s neziskovými organizáciami, občianskymi združeniami či nadáciami, ale aj s akciovými spoločnosťami alebo spoločnosťami s ručením obmedzeným.

Financovanie športových organizácií je kľúčové z viacerých dôvodov, ktoré sa dotýkajú nielen samotných športovcov, ale celej spoločnosti. Bez stabilných finančných zdrojov by šport nemohol efektívne fungovať a rozvíjať sa. Práve preto sa v tomto príspevku zameriame na rôzne možnosti financovania, ktoré dominujú vo svete. Taktiež sa podrobne pozrieme na význam súkromných a verejných zdrojov financovania v oblasti športu. Základom tohto príspevku sú zistenia z diplomovej práce, v ktorej sme okrem iného aj vykonali analýzu zdrojov financovania športu prostredníctvom modelovej mikro účtovnej jednotky v oblasti športu.

2 Základné modely financovania športu

Financovanie športu sa neustále vyvíja a prechádza zmenami po celom svete. Neexistuje len jeden univerzálny model, ktorý by sa dal použiť na každú krajinu či typ športu. Podľa odborníkov existuje niekoľko prístupov k financovaniu športu, pričom najčastejšie sa uvádza týchto päť modelov:

a) európsky,
b) americký,
c) čínsky,
d) austrálsky a
e) brazílsky. (Bogačev et al., 2021)

Európsky model financovania športu sa vyznačuje silnejším zapojením štátu, pričom riadenie jednotlivých športov v Európe je zverené najmä národným športovým federáciám. Napríklad, čo sa týka Slovenska, od 1. januára 2016 je hlavným právnym predpisom v oblasti športu na Slovensku zákon č. 440/2015 Z. z. o športe. Práve ten zásadne upravil fungovanie národných športových zväzov, ktoré sú subjektmi súkromného neziskového sektora, no ich financovanie sa posunulo najmä na verejné zdroje. Zväzy sa tak stali nositeľmi verejnej športovej politiky a sú podporované prostredníctvom transferov a ďalších foriem štátneho financovania. (Kučera & Nemec, 2022) Vo väčšine krajín EÚ je teda prítomná aktívna úloha štátu pri rozvoji športu – od masového cez vrcholový až po profesionálny. Na tento účel sa využíva príslušné normatívno-právne zabezpečenie a systém štátneho financovania. (Bogačev et al., 2021) Tento európsky model tak kladie dôraz na význam verejnej podpory, ktorá má zabezpečiť istú stabilitu, dostupnosť športových aktivít a zároveň vytvára podmienky pre rozvoj talentov.

Americký model financovania športu je zasa viac decentralizovaný, kde štát zohráva iba okrajovú úlohu pri organizovaní športových činností. (Bogačev et al., 2021) Je to najmä tým, že tento model financovania športu je podmienený najmä silnou tradíciou univerzitného športu,

ktorý vytvára širokú základňu talentov a zároveň je významným zdrojom financovania. Univerzity a vysoké školy v USA prevádzkujú rozsiahle športové programy, ktoré sú financované zo školských rozpočtov, sponzorských príspevkov a výnosov z predaja vstupeniek či vysielacích práv. Výsledkom je teda taký model, kde šport funguje prevažne na báze súkromného kapitálu a konkurencie, pričom verejné inštitúcie vystupujú skôr ako podporný prvok než ako hlavný garant financovania.

Ak by sme mali porovnať iba európsky a americký model financovania športu, európske profesionálne ligy sa od amerických líšia v dvoch kľúčových oblastiach: v spôsobe riadenia a v riziku zostupu. Taktiež politická a verejná mienka majú na šport v Európe oveľa väčší vplyv. Európsky futbal má oproti USA tzv. pyramídový systém s postupom a zostupom. (MetLife Investment Management, 2024) Práve to môže odradiť súkromných investorov investovať do futbalových klubov v Európe. Najhoršie kluby totiž na konci sezóny zostupujú do nižšej ligy. Zostup má však aj značný vplyv na príjmy klubu, čo robí vnímanú pravdepodobnosť scenára zostupu kľúčovým rizikovým faktorom pre veriteľov. (MetLife Investment Management, 2024)

Ďalším modelom financovania je model, ktorý sa uplatňuje v Číne – popri verejnom financovaní sa do rozvoja športu efektívne zapájajú aj ďalšie zdroje, ako sú napríklad príjmy z predaja vysielacích práv, sponzorské príspevky či národné lotérie. (Bogačev et al., 2021)

V Austrálii je financovanie športových subjektov realizované prostredníctvom Austrálskeho športového fondu, ktorý zároveň aj podporuje rozvoj športu prostredníctvom rôznych daňových zvýhodnení pre športové subjekty. Výhodné daňové podmienky sa vzťahujú na predaj športových produktov školským a univerzitným organizáciám, na príjmy športovcov, ako aj na registrované neziskové organizácie, ktoré sa zaoberajú zbieraním prostriedkov na rozvoj športu. (Bogačev et al., 2021) Okrem toho, má športový sektor v Austrálii aj silné zázemie zo strany štátu, ktorý zabezpečuje financovanie a rozvoj v oblasti športu.

V Brazílii sa výstavba a prevádzka športovej infraštruktúry financuje zo štátnych zdrojov, zatiaľ čo organizovanie podujatí a podpora športových klubov sú prevažne v rukách sponzorov. Tí sú motivovaní rozličnými daňovými úľavami, ktoré im umožňujú odpočítať pevne stanovené percento zo sumy dane určenej na úhradu.(Bogačev et al., 2021) Brazílsky model tak kombinuje verejné financovanie s podporou zo strany súkromného sektora, čím vytvára prostredie, kde je možné efektívnejšie rozvíjať športové aktivity a zároveň motivovať podnikateľov k podpore športu.

Rôzne modely financovania športu tak jasne odrážajú špecifiká politického, ekonomického a sociálneho prostredia jednotlivých krajín. Každý prístup, či už ide o silnú štátnu podporu, kombináciu verejných a súkromných zdrojov alebo decentralizovaný systém, má za cieľ zabezpečiť udržateľný rozvoj športu a dostupnosť športových aktivít pre širokú verejnosť. Zároveň tieto modely umožňujú rozvoj športových talentov a podporujú organizovanie podujatí na lokálnej aj medzinárodnej úrovni. Rozdiely v daňových stimuloch a sponzorstve odrážajú odlišné stratégie krajín pri motivovaní súkromného sektora k podpore športu. V konečnom dôsledku každý model prispieva k vytvoreniu stabilnej športovej infraštruktúry a podporuje kultúru športu medzi obyvateľmi.

3 Hlavné zdroje financovania športu

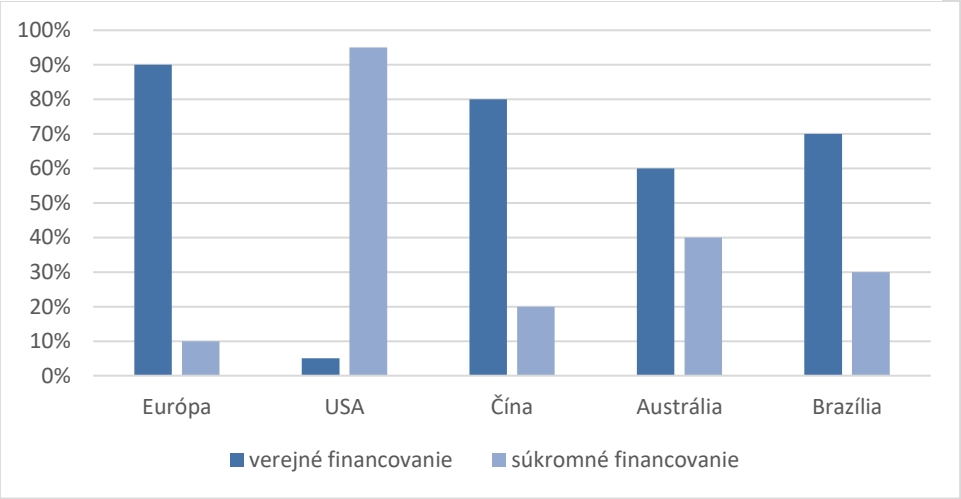
Financovanie športu je dôležitá súčasť jeho rozvoja a trvalej udržateľnosti. Zdroje pre financovanie konkrétnych športových organizácií sa líšia podľa krajiny, legislatívneho prostredia, typu športových organizácií a ekonomického modelu. Efektívne zabezpečenie

financovania umožňuje subjektom v športe pokrývať bežné náklady, ale aj napríklad investovať do rozvoja infraštruktúry, talentov či marketingu.

V tejto časti sa venujeme analýze hlavných zdrojov financovania športu. Zameriavame sa najmä na rozdiely medzi verejnými a súkromnými zdrojmi. Cieľom je identifikácia a porovnanie ich významu, výhod a obmedzení s dôrazom na odlišné ekonomické a právne podmienky.

Nasledujúci graf nám predstavuje hlavné zdroje financovania športu v rôznych krajinách. Konkrétne nám porovnáva podiel verejného a súkromného financovania a zároveň nám pomôže vizuálne podložiť tvrdenia o rozdielnych modeloch financovania športu.

Graf č. 1 Hlavné zdroje financovania športu



Zdroj: vlastné spracovanie, uvedené v diplomovej práci

Percentuálne rozdelenie v grafoch sme vytvorili na základe kvalitatívneho opisu jednotlivých modelov financovania športu. Z údajov je teda zrejmé, že v Európe a Číne dominuje verejné financovanie, ktoré pokrýva väčšinu výdavkov na šport. Avšak, aj v Európe sa nájdu krajiny, ktoré v porovnaní s priemerom EÚ majú vysoký podiel súkromného financovania športu, tými sú napríklad Cyprus, Fínsko, Nemecko, Holandsko, Švédsko. Práve to nám vo všeobecnosti potvrdzuje trend smerom k „privatizácii“ financovania športu v západnej Európe, ktorý sa zaznamenal už v roku 1990. (Andreff, 2009) V USA je účasť štátu minimálna, čo spôsobuje, že financovanie športu je založené najmä na súkromných zdrojoch, pričom kluby a organizácie sú odkázané hlavne na sponzorov a komerčných partnerov. Z grafu č. 1 vyplýva, že v Austrálii a Brazílii sa na financovaní športu podieľajú významným spôsobom ako verejný, tak aj súkromný sektor.

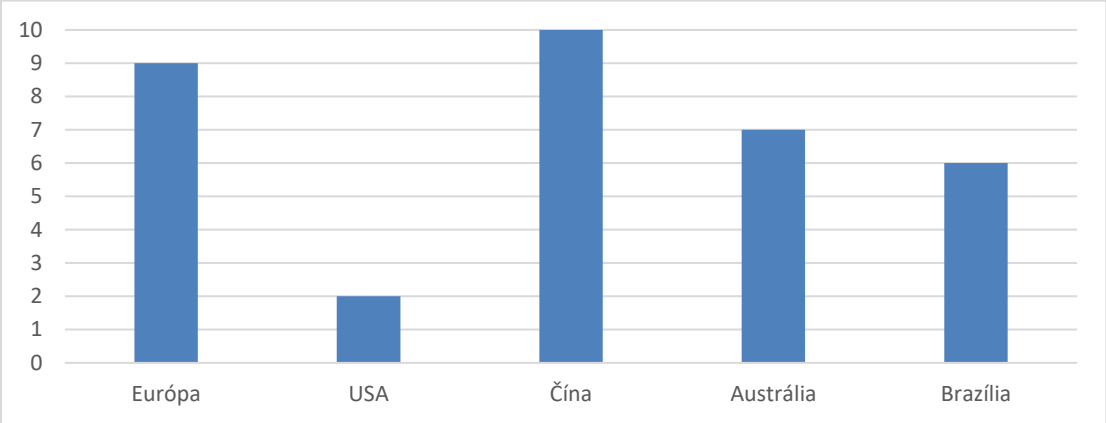
4 Stupeň zapojenia štátu do financovania športu

Jedným z hlavných faktorov financovania športu je miera zapojenia štátu do podpory športu. V niektorých krajinách, najmä v Európe a Číne, štát výrazne zasahuje do financovania a organizácie športových aktivít, zatiaľ čo napríklad USA uprednostňujú súkromné zdroje a decentralizovaný prístupy, kde štát hrá len obmedzenú úlohu. Tento rozdiel ovplyvňuje

spôsob rozvoja športovej infraštruktúry, organizovania podujatí a dostupnosť športu pre širokú verejnosť.

Graf č. 2 nám ilustruje mieru zapojenia štátu do financovania športu v rôznych krajinách, pričom úroveň štátneho zásahu je vyjadrená na stupnici od 0 do 10, pričom hodnota 10 predstavuje maximálny stupeň zapojenia štátu do financovania športu a hodnota 0 predstavuje úplnú absenciu štátnej účasti na financovaní športu. Hodnotenie vychádza z podrobnej analýzy dostupnej odbornej literatúry a zo syntézy opisu jednotlivých modelov financovania športu, ktoré sú uvedené v predchádzajúcej časti práce. Graf nám umožňuje jednoduché vizuálne porovnanie, ako sa rozsah štátnej podpory líši medzi piatimi vybranými regiónmi.

Graf č. 2 Stupeň zapojenia štátu do financovania športu



Zdroj: vlastné spracovanie, uvedené v diplomovej práci

Graf ukazuje, že v štátnom financovaní športu je na čele Čína, kde vláda masívne podporuje šport cez rôzne dotácie a programy. Rovnako aj Európa má silné zapojenie štátu, čo je dané hlavne financovaním cez spomínané národné športové federácie. V strede sa nachádza Austrália a Brazília, ktoré spájajú štátne dotácie so súkromnými investíciami a daňovými úľavami. Naopak, Spojené štáty americké sa spoliehajú na súkromné zdroje, sponzoring a množstvo univerzitných programov, s minimálnou podporou zo strany štátu.

Zasahovanie štátu pomáha stabilite a systematickému rozvoju športu. Naopak, systémy s malým vplyvom štátu sú flexibilnejšie a dávajú viac priestoru súkromným firmám. Zatiaľ čo štátne financovanie môže zaručiť rovnomerný prístup k športu pre všetkých, súkromné investície často cielia na komerčne úspešné odvetvia. Je veľmi dôležité nájsť rovnováhu, ktorá podporí masový aj vrcholový šport. Preto je nevyhnutné, aby každá krajina zvážila svoje jedinečné potreby a vyvinula si vlastný systém financovania.

5 Modelová mikro účtovná jednotka v oblasti športu

V tomto príspevku sme sa zamerali na problematiku financovania športových organizácií, pričom osobitnú pozornosť sme venovali najmä porovnaniu súkromného a verejného

financovania športových organizácií. V rámci spracovania diplomovej práce sme z dostupnej databázy vybraných účtovných závierok mikro účtovných jednotiek vyfiltrovali 1 085 účtovných závierok za roky 2014 až 2023 pre účtovné jednotky s jednotlivými SK NACE, ktoré prislúchajú športovým činnostiam, alebo činnostiam spojeným so športom. Nakoniec sme si z dostupných údajov vymodelovali vlastnú mikro účtovnú jednotku, ktorou sme porovnávali získanú teóriu. Spomínané SK NACE predstavovali tieto činnosti:

- 85510 – športová a rekreačná výroba,
- 93110 – prevádzka športových zariadení,
- 93120 – činnosti športových klubov,
- 93190 – ostatné športové činnosti. (NACE, n. d., online)

Tabuľka č. 1 obsahuje výnosy našej modelovej mikro účtovnej jednotky, pretože tieto údaje sú kľúčové pre účely analýzy podielu súkromných a verejných zdrojov financovania. Poskytuje prehľad o výnosoch z predaja tovaru, výrobkov, služieb a o ostatných výnosoch z hospodárskej činnosti medzi rokmi 2014 – 2023. Ostatné účtovné údaje a položky účtovnej závierky modelovej mikro účtovnej jednotky sú zahrnuté v diplomovej práci, z ktorej príspevok vychádza.

Tabuľka č. 1 Vybrané účtovné údaje z ÚZ modelovej účtovnej jednotky v športe

Rok	Výnosy z predaja tovaru	Výnosy z predaja výrobkov a služieb	Ostatné výnosy z hospodárskej činnosti
2014	13 802	96 173	18 180
2015	17 872	102 699	14 263
2016	31 725	84 378	18 542
2017	30 123	92 884	27 183
2018	31 808	93 498	33 232
2019	34 357	92 441	30 843
2020	33 985	81 962	27 209
2021	72 458	99 162	21 191
2022	106 480	136 898	40 608
2023	74 908	132 194	50 014

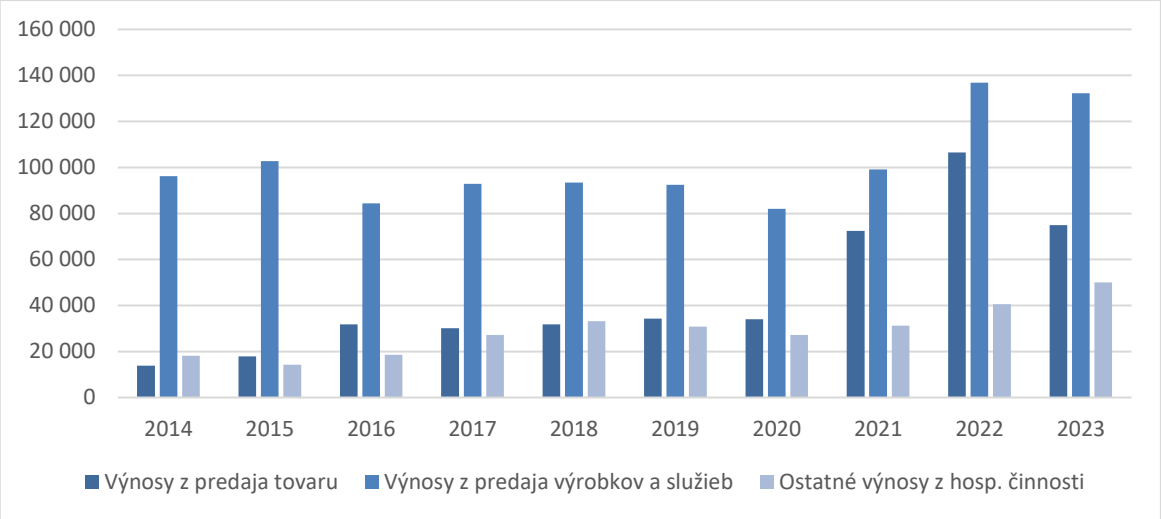
Zdroj: vlastné spracovanie, uvedené v diplomovej práci

Výnosy z predaja tovaru, výrobkov a služieb považujeme za formu osobného financovania, keďže vznikajú na báze priamej protihodnoty medzi športovou organizáciou a súkromným sektorom – či už ide o fanúšikov kupujúcich vstupenky, členov platiacich poplatky alebo zákazníkov využívajúcich služby. Ide vlastne o príjmy, ktoré si organizácia zabezpečuje vlastnou činnosťou na trhu, a teda odrážajú jej schopnosť samostatne generovať zdroje bez závislosti na verejných dotáciách. Tento tok zdrojov je teda podmienený individuálnym dopytom a nepredstavuje záťaž pre verejné financie. Naopak, ostatné výnosy z hospodárskej činnosti sú vo väčšine prípadov odvodené od podpory zo strany štátu,

samosprávy alebo verejných inštitúcií, majú teda pôvod vo verejných rozpočtoch. Mohli by sme medzi ne zaradiť rôzne príspevky, dotácie atď. Ich cieľom je podpora činností vo verejnom záujme, a preto ich logicky zaraďujeme medzi verejné financovanie.

Graf č. 3 nám znázorňuje vývoj výnosov modelovej mikro účtovnej jednotky v rokoch 2014 – 2023, pričom sú rozdelené na spomínané tri hlavné kategórie: výnosy z predaja tovaru, výnosy z predaja výrobkov a služieb a ostatné výnosy z hospodárskej činnosti.

Graf č. 3 Výnosy modelovej mikro účtovnej jednotky v športe



Zdroj: vlastné spracovanie

Z grafu je zrejmé, že dominantnú časť výnosov počas celého sledovaného obdobia tvorili tržby z predaja výrobkov a služieb, ktoré predstavujú najstabilnejší zdroj financovania. Ich hodnota sa v rokoch 2014 – 2020 pohybovala približne medzi 80 000 až 100 000 eur, výraznejší rast nastal až po roku 2021, kedy prekročili hranicu 130 000 eur. Výnosy z predaja tovaru mali do roku 2020 pomerne vyrovnaný charakter (približne 30 000 eur), avšak v období 2021 – 2022 zaznamenali prudký nárast, pričom v roku 2022 dosiahli až vyše 100 000 eur. Tento skok naznačuje zvýšenú aktivitu v oblasti predaja alebo rozšírenie ponuky. Hoci ostatné výnosy z hospodárskej činnosti, predovšetkým spomínané verejné financovanie, vykazujú postupný rast z približne 18 000 eur v roku 2014 na viac ako 50 000 eur v roku 2023, ich absolútna hodnota je stále nižšia než výnosy zo súkromných zdrojov. To naznačuje, že dominantným zdrojom financovania v našej modelovej mikro účtovnej jednotke je súkromné financovanie, ktoré tvoria hlavné príjmy organizácie.

V ďalšom kroku analýzy vychádzame už zo spomínaného predpokladu, že tržby z predaja tovaru, výrobkov a služieb predstavujú príjmy zo súkromného sektora, zatiaľ čo ostatné výnosy hospodárskej činnosti možno považovať za financovanie z verejných zdrojov. Je potrebné však zdôrazniť, že takéto rozdelenie nemusí v každom jednotlivom prípade zodpovedať realite, no umožňuje získať základný prehľad o pomere medzi súkromným a verejným financovaním. Detailný prehľad za roky 2014 – 2023 uvádza tabuľka č. 2.

Tabuľka č. 2 Vývoj financovania modelovej účtovnej jednotky v športe

Rok	Podiel súkromného financovania	Podiel financovania z verejných zdrojov
2014	85,81 %	14,19 %
2015	89,42 %	10,58 %
2016	86,23 %	13,77 %
2017	81,90 %	18,10 %
2018	79,04 %	20,96 %
2019	80,43 %	19,57 %
2020	80,99 %	19,01 %
2021	84,62 %	15,38 %
2022	85,70 %	14,30 %
2023	80,55 %	19,45 %

Zdroj: vlastné spracovanie, uvedené v diplomovej práci

V úvodnej časti príspevku sme sa zamerali na analýzu a porovnanie modelov financovania športu na základe verejného a súkromného financovania a zároveň aj na porovnanie jednotlivých modelov financovania z hľadiska zapojenia štátu do športu v rôznych krajinách. Na základe týchto poznatkov bol vytvorený graf č. 1, ktorý znázorňuje rozdelenie medzi verejným a súkromným financovaním vo vybraných štátoch. Zo spomínaného grafu je zrejmé, že v Európe prevláda verejné financovanie, zatiaľ čo v USA majú dominantné postavenie súkromné zdroje. Údaje z tabuľky č. 2, ktorá zachytáva výsledky našej modelovej mikro účtovnej jednotky v športe, však tieto všeobecné závery spochybňujú. Ako môžeme vidieť, v rokoch 2014 – 2023 tvoril podiel súkromného financovania približne viac než 80 %, pričom verejné zdroje sa podieľali iba na úrovni približne 10 – 20 %. V priemere tak súkromné zdroje v našej modelovej mikro účtovnej jednotke tvorili približne 83 % výnosov a verejné zdroje okolo 17 %. Tento pomer sa počas sledovaného obdobia udržiaval relatívne stabilne, pričom aj v rokoch s vyšším podielom verejných financií zostávali tržby zo súkromného sektora dominantným zdrojom príjmov.

Z toho vyplýva, že výrazná dominancia súkromného financovania nemusí byť charakteristická výlučne pre USA, ale môže sa prejavovať aj v európskom kontexte, a to aj napriek všeobecným porovnaniam, ktoré poukazujú na opak.

6 Záver

Na základe uskutočnenej analýzy môžeme konštatovať, že štruktúra financovania športu sa v jednotlivých krajinách výrazne líši. Každý z uvedených spôsobov financovania má svoje výhody i nevýhody, ani jeden zo spomínaných modelov financovania športu nemôžeme charakterizovať ako ideálny. Každá krajina má svoje špecifické historické, ekonomické a spoločenské podmienky, ktoré ovplyvňujú, či sa viac uplatňuje verejné alebo súkromné financovanie. Kým v niektorých štátoch je efektívnejší model založený na podpore zo strany štátu, inde zohráva rozhodujúcu úlohu súkromný sektor. Vytvorením našej modelovej mikro účtovnej jednotky sme sa snažili poukázať na to, že všeobecné tvrdenia o dominancii súkromného financovania výlučne v USA nemusia vždy platiť. Naše zistenia ukázali, že aj v európskom prostredí môže mať súkromný sektor pri financovaní športu výrazne silnejšie postavenie, než naznačujú bežné porovnania. Tento prístup tak spochybňuje zaužívaný názor

a potvrdzuje potrebu analyzovať financovanie športu na úrovni konkrétnych subjektov, nie iba prostredníctvom všeobecných medzinárodných štatistík.

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