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Key Pillars of Media Freedom: The Strength of Institutions and Thresholds in European Democracies

ABSTRACT

Media freedom is widely recognized as a cornerstone of democratic governance, yet its determinants remain complex and multifaceted. This study examines the institutional and structural factors that shape press freedom across European democracies, with particular attention to nonlinear relationships and threshold effects. Using data from internationally recognized indices – including the World Press Freedom Index (WPFI), Corruption Perceptions Index (CPI), Rule of Law Index, and Freedom of Expression indicators, we apply a Random Forest regression model combined with SHAP (SHapley Additive exPlanations) analysis to identify key predictors and their interactions. The authors findings reveal that media freedom is not influenced by a single factor but emerges from the synergistic interplay of multiple democratic pillars. The most significant predictors are the Corruption Perceptions Index (CPI), Rule of Law (RuleLaw), and Freedom of Expression (ExpInfor), which together account for approximately 75% of the variance in WPFI scores. Critically, authors identify specific threshold values, such as CPI > 55, RuleLaw > 0.65, and ExpInfor > 8.0, beyond which the impact of these factors accelerates sharply. This suggests that incremental reforms may yield limited results until certain institutional maturity levels are achieved. Contrary to expectations, economic indicators such as GDP per capita and political stability play only a supporting role, while media market pluralism exhibits a negative correlation with press freedom, indicating that quantitative diversity does not guarantee editorial independence without robust legal and institutional safeguards. SHAP interaction analysis further demonstrates that the influence of each variable is highly conditional on the presence of other democratic factors, underscoring the systemic nature of media freedom. These results have important implications for policymakers: sustainable improvements in press freedom require comprehensive, coordinated reforms that strengthen the rule of law, reduce corruption, and protect freedom of expression simultaneously. Isolated interventions are unlikely to produce lasting change. The study contributes to the growing literature on media systems by offering an empirically grounded, data-driven framework for understanding the institutional architecture that underpins free and independent journalism in democratic societies.

KEY WORDS

Corruption Perception. Democratic Institutions. Freedom of Expression. Media Freedom. Rule of Law.

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1 Introduction

In the current global context, media freedom faces unprecedented challenges. Digital transformation, economic instability, societal polarization, and the rise of authoritarian tendencies create pressure on journalistic independence, even in traditional democratic systems. Although formal legal guarantees of freedom of expression and press exist almost universally, their actual implementation varies significantly among countries. This discrepancy between norm and practice represents one of the central problems in contemporary political science and media studies.

European democracies, which have long served as a reference framework for protecting media freedoms, are not immune to these trends. On the contrary, several of them have experienced a decline in international press freedom rankings over the past decade, raising questions about the sustainability of democratic institutions and the factors that either strengthen or weaken them. Understanding the causes and mechanisms behind changes in the level of media freedom is therefore crucial not only for academic debate but also for the development of effective public policies.

This article starts with the idea that media freedom is not something that exists on its own. It is, rather, the outcome of many different dimensions of democratic life working together, or sometimes against each other. Most existing research tends to look at how individual variables relate to media freedom in a straightforward, linear way. We suspect, however, that reality is somewhat more complicated than that. The relationships involved are probably nonlinear, shaped by threshold effects and by the way different factors interact with one another. Put simply, some conditions may matter very little until they reach a certain level, and then their influence can shift quite dramatically. At the same time, the presence or absence of one institutional factor may change how much another one matters.

With this in mind, the study tries to identify which institutional and structural factors most strongly shape media freedom across European democracies, how important each of them is relative to the others, and whether there are specific points at which their influence changes in meaningful ways. To explore these questions, we use Random Forest regression combined with SHAP analysis. These are methods that are reasonably well suited to capturing the kind of complex, nonlinear patterns we are interested in. We would not claim this approach is without limitations, but it does offer something that more conventional linear models tend to miss.

We hope the findings will be useful on more than one level, not just as a contribution to academic debates about democratic institutions and media systems, but also as something that might guide the thinking of policymakers, civil society actors, and international organizations working to protect press freedom in practice. Whether or not we fully succeed in that ambition is, of course, for the reader to judge. At a time when democracy is under pressure, understanding what sustains or weakens it is an essential condition for its defence.

2 Literature Review

Freedom of the media is one of the fundamental pillars of a democratic society and creates conditions for transparency, informed citizens, and effective control of the exercise of power. The media are not only tools for guiding, but also play an important role in maintaining democratic processes (Voltmer, 2006). According to Article 19 of the Universal Declaration of Human Rights (1948), everyone has the right to freedom of opinion and expression, and according to Article 10 of the European Convention for the Protection of Human Rights and Fundamental Freedoms (1950), everyone also has the right to freedom of expression, which includes the freedom to receive and impart information without interference by public authority.

Despite these norms, the level of media freedom in the world is uneven. According to the latest World Press Freedom Index 2025 by Reporters Without Borders, 138 countries out of 180 operate in a journalistic environment described as “problematic”, “difficult”, or “very serious”. This represents more than 76% of the assessed countries. The 2025 report also specifically states that the main threat to press freedom is economic instability, which weakens editorial autonomy and leads to media dependence on private investors or greater dependence on political entities (Reporters Without Borders, 2025).

Media freedom is the result of the interaction of several factors, the impacts of which are often measured through internationally recognized indices and quantitative indicators. These factors, as well as institutions related to media freedom, will be the subject of the theoretical section.

2.1 Media Freedom as a Fundamental Pillar of Democracy

The fundamental pillar of a democratic society is freedom of the media, which is related to the right to freedom of expression, free expression through the media without censorship or institutional pressure. This right is guaranteed by several international agreements with the aim of transparency, ensuring public awareness, and controlling political entities (Maniou & Papadopoulou, 2024; Walters, 2022). As Maniou and Papadopoulou (2024) state, media freedom cannot be characterized merely by the absence of censorship; it is a complex phenomenon that combines political, legal, economic, and social dimensions, and it is necessary to create conditions that help journalists perform their work independently without external interference. Free media then have the ability to contribute to the exposure of institutional failures, corruption, or abuse of power, especially in countries where control mechanisms do not function sufficiently (Hamada & Abdel-Salam, 2024).

Walters (2022) makes a point that is easy to agree with: media freedom is not just a professional concern for journalists, it is something that affects everyone in a democratic society. When media can operate freely and independently, people are better placed to form their own views, ask difficult questions, and hold power to account. Without that, the space for manipulation grows and democracy quietly loses some of its substance. Part of what makes this work, Walters argues, is not simply having a lot of media outlets. A crowded media landscape does not automatically mean a healthy one. What actually matters is whether different voices, values, cultural perspectives, and ownership structures are genuinely represented, because that kind of diversity is what gives plurality its real meaning. However, Maniou (2023) points out that the degree of media freedom is influenced by a broader context and should be understood in relation to the media system, social and political conditions, or historical development. It can be said that media freedom is a dynamic phenomenon that depends on legal, political, cultural, and economic factors.

2.2 Normative and Legislative Frameworks of Media Freedom

Media Freedom is closely linked to freedom of speech and the right to information. It is not a political or philosophical ideal, but an established right that is internationally recognized and protected. Freedom of speech as a fundamental human right is enshrined in several international legal instruments. In the Universal Declaration of Human Rights (1948), Article 19 states the right of every individual: “Everyone has the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers”. A similar provision is contained in the International Covenant on Civil and Political Rights (1966) (Art. 19), which further develops this norm and recognizes certain restrictions in the interest of public safety and the protection of the

rights of others. In the European context, this stems from the European Convention on Human Rights (1950). Article 10 guarantees freedom of expression, including "the freedom to receive and impart information without interference by public authority and regardless of frontiers". The article states that freedom of expression may be restricted only if it is necessary to preserve a democratic society, protect the rights of others, national security and public order (*European Convention for the Protection of Human Rights and Fundamental Freedoms*, 1950).

Beyond international documents, the protection of media freedom is also necessary at the national level. The Constitution of the Slovak Republic in Article 26 guarantees freedom of speech and the right to information: "Freedom of speech and the right to information are guaranteed. Everyone has the right to express their opinions by word, in writing, in print, in images or in any other manner"[1]. The Constitution of the Slovak Republic also prohibits censorship and guarantees the freedom of the press and other mass media (Ústava Slovenskej republiky, 1992). However, Rubio (2023) points out that there can be a significant gap between formal constitutional protection and its actual implementation, particularly in authoritarian or hybrid regimes. Maslen and Solík (2025) warn that despite the privileged status of media freedom, it is not unlimited. Its boundaries are determined by courts through constitutional and legal norms. Privacy protection laws, hate speech laws, and criminal laws concerning defamation and spreading false alarms may restrict media freedom, which in some cases can be abused to silence them (Walters, 2022). Media freedom should not only be free from state interference, but also about ensuring appropriate conditions for media independence and plurality. The legal framework should create conditions for their free functioning and protect them from political and economic pressure (Charney, 2021).

2.3 Institutions Ensuring Media Freedom

An integral part of media freedom are institutions that protect it from external pressures. These include non-governmental, international and civic (watchdog) institutions, the functions of which are particularly important when media must face challenges such as populism, disinformation, economic dependence or authoritarian tendencies (Maniou & Papadopoulou, 2024).

State institutions participate in creating and maintaining the legal framework in which media operate. These include legislative bodies that adopt media laws, courts that decide on freedom of speech and protection of journalists, and regulatory bodies that ensure compliance with laws. Research by Hamada and Vallesi shows that out of 67 analyzed countries, journalists working in public service media and in democratic systems more often represent watchdog bodies. It was also found that journalists who perceive their control function and autonomy have less trust for public institutions (Hamada & Vallesi, 2025).

Among international organizations that care for media freedom are Reporters Without Borders (RSF), Freedom House and UNESCO. These organizations monitor the situation, collect data and exert pressure on governments in cases of press freedom violations. The organization Reporters Without Borders has been publishing the World Press Freedom Index annually since 2002, which evaluates the media situation in more than 180 countries. Indicators such as media independence, plurality, transparency, legal framework and journalist safety are taken into account (Reporters Without Borders, 2025). Another important organization is Freedom House, which provides detailed analyses of both press and internet freedom. It publishes the Freedom in the World report annually, in which it designates countries as free, partly free and not free. The analysis also reflects political interference, legal framework and violence against media. Freedom House points to a decline in media freedom in recent years due to factors such as populism, increasing

[1] Authors' note: The quotation is translated from Slovak to English by the authors of the article: "(1) Sloboda prejavu a právo na informácie sú zaručené. (2) Každý má právo vyjadrovať svoje názory slovom, písmom, tlačou, obrazom alebo iným spôsobom..." (Ústava Slovenskej republiky, 1992, Art. 26).

economic pressure and political polarization (Gorokhovskaia & Grothe, 2025). UNESCO is a specialized UN agency dedicated to promoting freedom and free media, particularly in developing countries. Its key activities include protecting journalists from violence, promoting a legislative framework for press freedom and increasing media literacy (Media Freedom Coalition, n.d.).

Where state organizations fail, non-governmental and watchdog organizations play a key role. Their task is to ensure international solidarity, monitor violations of journalists' rights, provide legal assistance, document cases of censorship and point out the discrepancy between law and its enforcement (Ngangum, 2019). In a comparative study by Hasfi et al. (2024) on the digital system in Indonesia and the Philippines, it is shown that cooperation between journalists and such civil society organizations significantly increases the ability to resist state repression. Journalists can thus mobilize the public and also gain international support.

2.4 Key Factors Affecting Media Freedom

Level of Legal Protection for Journalists and Media

One of the key factors affecting media freedom is legal protection. Laws should guarantee the right to disseminate information and protection against censorship. An important part is also the protection of editorial independence and confidential sources (Hamada & Abdel-Salam, 2024). According to a study by Hamada and Abdel-Salam (2024), which is based on a sample of 27,567 journalists, legal conditions play a significant role, but are not always decisive in how journalists perceive their watchdog function. Their study shows that even when laws exist, their enforcement is often insufficient (particularly in authoritarian and hybrid regimes). Laws can sometimes play the opposite role and serve as a tool to suppress freedom of speech. According to Majeed (2022), journalists in Indian Kashmir face censorship, legal repression, or internet outages daily as a form of state control over the media. Another example is Turkey, where according to Davis (2022), foreign journalists practice self-censorship in response to repressive state reactions. This emphasizes that even in free countries, journalists are not completely protected from political interference.

Level of Political Freedom and Democracy

The quality of democracy and political freedom affects the state of media freedom. In democratic regimes, media are generally freer, while in authoritarian and hybrid regimes they face media manipulation or censorship (Bjørnskov et al., 2022). According to research by Bjørnskov et al. (2022), violent regime changes lead to a significant decline in media freedom in various countries. They examined the impact of regime changes and state coups and found that they have a lasting negative effect on journalist autonomy and media independence. According to Hamada & Vallesi (2025), journalists in more democratic states have more freedom, but also a more critical attitude toward power. They have lower trust in public institutions and play the role of watchdogs.

Level of Corruption in Media and State Institutions

Media are often influenced by financial pressure not to report on certain cases, which leads to self-censorship and loss of media credibility (Breen & Gillanders, 2020). According to Flavin & Montgomery (2020), the relationship between press freedom and the perception of corruption is closely linked. They argue that the higher the level of media freedom, the more sensitive the public is to corrupt behaviour by politicians. Research by Breen & Gillanders (2020) showed that in countries where media freedom is more pronounced, journalists have the opportunity to perform a control function and to expose corruption.

Media Pluralism and Diversity of Media Ownership

A functioning democracy needs more than just many media outlets – it needs genuine diversity in how those outlets are owned, how they approach editorial decisions, and whose voices they represent. In practice, this is often harder to achieve than it sounds. Charney (2021) points out that in many contexts, media ownership ends up concentrated in relatively few hands, and that tends to squeeze the space for independent journalism. Maniou & Ketteni (2023) looked at Western media systems specifically and found that the more concentrated ownership becomes, the harder it is for journalists to do their work without outside pressure. Smaller publishers feel this most acutely – when a handful of large players dominate the market economically, the rest struggle to stay afloat without compromising their independence. The digital environment adds another layer of complexity. Platforms like Meta and Google have reshaped the advertising market in ways that have opened doors for some new voices, while quietly pulling the financial ground from under traditional media (Maniou & Papadopoulou, 2024). It is a tension that does not have an easy resolution.

Level of Censorship and Persecution of Journalists

If ownership concentration is a slow and often invisible threat to media freedom, censorship and the persecution of journalists are its most visible and brutal face. Pressure on editorial offices, blocked access to information, state interference in news content, physical threats, arrests: these are not abstract risks in many parts of the world. Reporters Without Borders (2025) documents these cases systematically, and the numbers are not reassuring. Strovsky & Schleifer (2021) trace how this plays out in Russia, where the media has been gradually turned into an instrument of state messaging, leaving independent journalists with little choice but to face arrest, harassment, or exile.

Media Independence and Commercial Pressures

Independence is easy to claim and hard to maintain, especially when the bills need to be paid. Many editorial offices, particularly smaller and regional ones, find themselves in a position where economic dependence on large advertisers or state funding quietly shapes what they can and cannot report. Nguyen et al. (2021) describe how this dynamic works in practice: outlets that rely on sponsors for survival tend to soften their coverage in ways that gradually erode both their credibility and their usefulness to the public. State financing of public service media has the potential to create stability in the media market. In some cases, however, it serves as a tool of political propaganda, particularly in countries lacking a strong legal framework that would ensure editorial independence (Maniou & Ketteni, 2023).

Online Freedoms and Internet Censorship

Increasingly, information is disseminated over the internet, which is why internet freedom is a key component of media freedom. However, threats arise from increasing state interference in the digital space, particularly regarding website blocking, content censorship, and user surveillance. According to Freedom House, internet freedom is declining annually, and this is increasingly occurring not only in authoritarian but also in democratic regimes (Gorokhovskaia & Grothe, 2025). Lu & Luqiu (2020) in their research found that internet censorship significantly affects citizens' participation in public discourse. In countries where internet censorship is higher, civic participation is lower. They also suggest that people in countries with higher trust in media use online news as a source of information.

Economic Factors Affecting Media Financing

Media independence and their ability to monitor democracy are significantly influenced by their financial model. Media can be dependent on state subsidies or oligarchic owners, which may threaten editorial autonomy (Nguyen et al., 2021). Several studies show that state financing can support media in the public interest, but can also be misused for control (Vujanic, 2021).

Social Tolerance and Support for Freedom of Speech

Freedom of the media also depends on the public's attitude toward various opinions. Social tolerance creates an environment in which journalists can perform their role without fear of aggression from society (Guo & Lei, 2025). Many studies show that societies in which trust in media and journalists is higher also have stronger support for freedom of speech. However, as a result of political polarization, public trust in the media is also polarized (VonDoepp & Young, 2024).

Security of Journalists and Protection from Violence

The fundamental prerequisite for media freedom is the safety of journalists. They can be endangered by threats, legal harassment, physical attacks, or even murder. Perpetrators often remain unpunished, which leads to self-censorship among journalists (Hasfi et al., 2024). The organization Reporters Without Borders (2025) regularly documents dozens of murdered and hundreds of imprisoned journalists annually in countries such as Iran, Russia, China, and Belarus.

3 Methods

This study examines the institutional and structural determinants of media freedom in European democracies, through quantitative research based on internationally recognized indices. The examined dataset includes 32 European countries and integrates multiple dimensions of democratic governance, institutional quality, and media environment characteristics. The dependent variable is the Press Freedom Index (WPFI) published by Reporters Without Borders (2025), which measures the level of freedom available to journalists and media organizations on a scale where higher values indicate greater freedom.

Independent variables include the Corruption Perceptions Index (CPI) from Transparency International, the Rule of Law Index (RuleLaw) from the World Justice Project, Freedom of Expression and Information (ExpInfor) from the V-Dem dataset, overall civil and political freedoms (FreWorld) from Freedom House, GDP per capita in purchasing power parity (GDPcapPPP), Political Stability (PolStab) from the World Bank's governance indicators, Media Market Plurality (MMarkPlur) from the Media Pluralism Monitor, and Education adjusted for learning quality (EducaLPI) from the World Bank. Descriptive statistics and correlation analysis were used to process data in the study to assess data distribution, symmetry, and preliminary relationships between variables.

Given the complexity of the examined phenomenon and the likelihood of nonlinear relationships and interaction effects, a Random Forest regression model was employed (Breiman, 2001). Random Forest is an ensemble learning method that constructs multiple decision trees during training and produces an averaged prediction across trees, which is suitable for capturing complex nonlinear patterns and threshold effects without requiring parametric assumptions (Muchlinski et al., 2017; Montgomery & Olivella, 2018). The model was optimized using grid search to identify the optimal number of trees (ntree = 100) and the number of variables randomly selected at each split (mtry = 5), achieving an out-of-bag mean squared error (OOB RMSE) of 4.754 and explaining 72.28% of the variance in WPFI.

To improve model interpretability and identify threshold effects, Partial Dependence Plots (PDPs) were used, which visualize the marginal effect of individual predictors on the output while averaging other variables (Friedman, 2001). PDPs enable detection of critical breaking points where the predictor's influence changes sharply, a technique increasingly utilized in political science to reveal critical mass thresholds (Funk et al., 2022).

The study subsequently implemented SHAP (SHapley Additive exPlanations) analysis to quantify each variable's contribution to individual predictions and to assess interaction effects between predictors (Lundberg & Lee, 2017). SHAP values are based on cooperative game theory and provide a unified measure of feature importance by calculating the average marginal

contribution of each variable across all possible combinations of features (Molnar, 2025; Lundberg et al., 2020). For tree-based models such as Random Forest, SHAP values can be calculated exactly and efficiently using the TreeExplainer algorithm (Lundberg et al., 2020), enabling both global interpretability (through average absolute SHAP values) and local explanations (through waterfall plots and dependence plots). This approach has been increasingly adopted in quantitative social science research for its robustness in revealing synergistic and conditional effects (Zhao & Hastie, 2021).

All analyses were performed in R version 4.3.2 using the RandomForest (Liaw & Wiener, 2002), pdp (Greenwell, 2017), and shap packages (adapted from the Python implementation). Model validation was performed using out-of-bag error estimation and sensitivity analysis, which confirmed the stability of identified thresholds across different model specifications.

4 Results

4.1 Descriptive Statistic

By comparing the mean and median, it is possible to determine the symmetry or asymmetry of the distribution of values. If the mean and median are almost equal, it is a symmetric distribution. Most variables in this analysis exhibit an almost symmetric distribution, which suggests that values are evenly distributed around the centre. For example, variables such as FreWorld, PolStab, MMarkPlur, RuleLaw, and ExpInfor have only a minimal difference between the mean and median. EducaLPI and WPFI exhibit slight asymmetry, where the median is somewhat higher than the mean, indicating a slightly left-skewed distribution. The variables GDPcapPPP and CPI exhibit pronounced right-skewed asymmetry, where the mean is substantially higher than the median. This points to the presence of extremely high values that increase the average value – typically wealthy countries in terms of GDP per capita or countries with high corruption perception index scores.

From the perspective of variability of values between countries, the coefficient of variation was used, which expresses the standard deviation as a percentage of the mean. This indicator makes it possible to compare the relative dispersion of different variables regardless of their scale. Variables such as FreWorld and EducaLPI exhibit low variability (CV below 10%), which means that values are very similar between individual observations. Most other variables – for example, PolStab, MMarkPlur, RuleLaw, ExpInfor, and WPFI – have moderate variability (CV between 10–15%), which indicates a certain degree of difference between countries, but not extreme. The variable CPI has moderately high variability, which points to greater differences in corruption perception across countries.

The variable GDPcapPPP has by far the highest variability, with a coefficient of variation exceeding 42%, corresponding to large differences in the economic level of individual states.

Overall, it can be said that most of the analyzed variables have a uniform distribution with slight variability. The exceptions are indicators related to economy and corruption, which show higher variability and asymmetry, reflecting the real differences between individual countries in these areas.

	Minimum	Maximum	Average	Median	Standard deviation	Coefficient of variation (%)
FreWorld	65.00	100.00	90.37	91.00	7.70	8.52
PolStab	54.03	87.68	68.02	68.72	8.71	12.80
GDPcapPPP	31536.17	134507.67	55853.92	48346.97	23559.43	42.18
MMarkPlur	47.00	84.00	67.48	68.00	8.21	12.17
RuleLaw	0.51	0.90	0.73	0.72	0.10	13.66
ExpInfor	5.47	9.92	8.53	8.53	1.16	13.58
EducaLPI	66.92	88.12	80.40	81.79	4.94	6.15
CPI	42.00	90.00	63.59	60.00	13.53	21.27
WPFI	57.15	89.60	76.58	78.65	9.37	12.23

Table 1: *Descriptive statistics*

Source: own processing, 2026

4.2 Dependencies

The displayed matrix of Pearson correlation coefficients (Figure 1) provides an overview of the mutual relationships between the monitored variables, with particular attention paid to correlations with the target variable WPFI (media freedom index). This variable exhibits strong and statistically significant relationships with several key indicators of institutional quality and social openness.

The strongest positive correlation was found between WPFI and RuleLaw (rule of law), with a value of r = 0.85***. This relationship suggests that in countries where the rule of law is firmly established, there is simultaneously a significantly higher level of media freedom. A similarly strong correlation was identified between WPFI and CPI (Corruption Perceptions Index), also r = 0.85***. Higher CPI values, which represent lower levels of corruption, are significantly associated with greater media freedom. These two variables – rule of law and public administration transparency – thus emerge as fundamental pillars of media freedom.

The variable ExpInfor (freedom of expression) exhibits a significant correlation, with a value of r = 0.82***. This result confirms that countries protecting freedom of speech simultaneously create favourable conditions for independent media. Another factor is overall civil and political freedom (FreWorld), which correlates with WPFI at the level of r = 0.75***. Although this variable represents a broader concept, its connection to WPFI indicates that media freedom is inseparably linked to democratic rights as a whole.

Slightly weaker, yet still significant correlations were recorded for EducaLPI (education index, r = 0.65***) and GDPcapPPP (GDP per capita, r = 0.44*). This suggests that higher levels of education and economic development may contribute to media freedom, but their effect is weaker compared to institutional factors. Political stability (PolStab) has a correlation of r = 0.42*, indicating that a stable environment can support media freedom.

The negative relationship between WPFI and MMarkPlur (media market plurality) is interesting, where a correlation of r = –0.50** was identified. This negative relationship does not mean that media plurality harms media freedom, but rather points to the complex and conditional nature of this variable. There may be several explanations. One is that quantitative plurality (e.g., number of media outlets or owners) does not automatically mean quality or independent journalism. In some countries, the media market may be fragmented, but simultaneously under the political or economic influence of certain groups, thereby reducing the actual freedom and independence of media.

Another possible explanation is that high plurality can also occur in politically unstable or transitioning countries, where a sufficient legal framework for protecting media independence does not yet exist. In such a context, plurality may exist, but institutional conditions for its free functioning are lacking.

In conclusion, it can be said that the negative correlation does not mean that plurality is harmful, but rather that its positive impact on media freedom manifests itself only when supplemented by quality institutional foundations, such as rule of law, low corruption levels, and protection of freedom of expression. This relationship confirms the need for interpretive caution when dealing with non-linear and systemically interconnected phenomena, such as media freedom.

Overall, the results confirm that media freedom is most influenced by the quality of institutions, the level of rule of law, the degree of corruption, and the protection of freedom of expression. Economic indicators and political stability play a supporting, but not decisive role. Media freedom is thus not an isolated phenomenon, but part of a broader framework of democratic values and functional institutions.

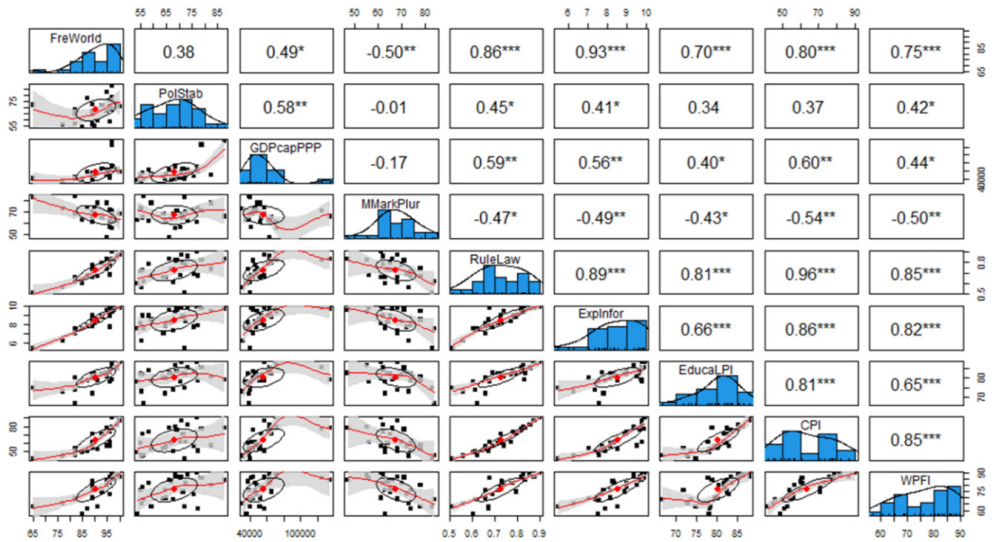

Figure 1: *Pearson's correlation coefficients, histograms and scatter plots*

Source: own processing

4.3 Random Forest

A Random forest model type, which was used to predict the WPFI variable, is suitable in relation to the nonlinearities of relationships and existing dependencies between explanatory variables.

The model was optimized in the first step in order to achieve the most accurate result possible. Based on the selection of the most suitable parameters, the number 5 was determined as the optimal number of variables used at each tree split (mtry), and the number 100 was chosen as the optimal number of trees (ntree) in the forest. These values were selected because the model achieved the lowest out-of-bag error value at these parameters, specifically OOB RMSE = 4.754. This metric represents an estimate of the model's prediction error, and its low value indicates good generalization ability of the model to new data.

The model was constructed as a regression random forest, thus designed to predict a continuous target variable. In this case, it was the WPFI variable, with the model utilizing all other available variables as inputs. To construct it, 100 decision trees were created, with 5 variables randomly selected at each node split in each of them.

Overall, the model exhibits very good performance. The mean squared error of residuals was 24.33, which means that the differences between actual and predicted values are not large. At the same time, the model achieved an explained variability value of 72.28%, which means it can explain more than two-thirds of the variance in the target variable. This indicates that the model has sufficient predictive power and is capable of capturing most of the important relationships between variables in the data.

Based on these results, it can be concluded that the random forest model was successfully optimized and provides reliable prediction of the WPFI variable. Its use can be helpful in identifying key factors that influence the values of this index.

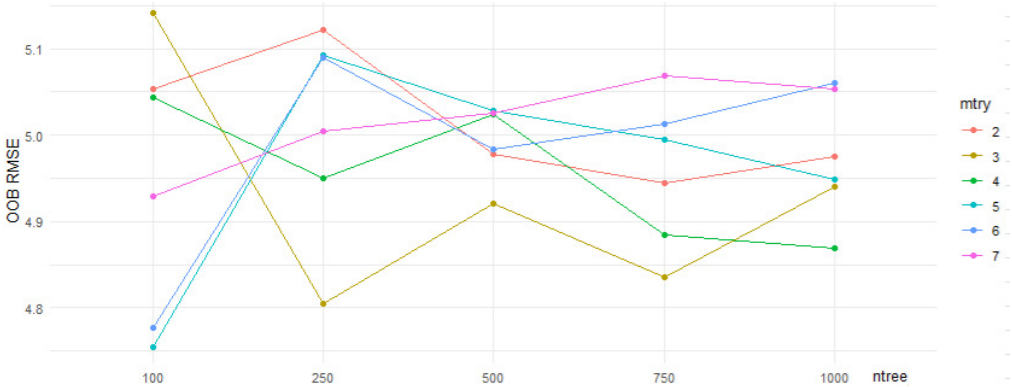

Figure 2: *Optimization of Random Forest: RMSE for different values of mtry and ntree*

Source: own processing, 2026

Visualization (Figure 3) displays the importance of variables in the final random forest model that was used to predict the WPFI variable. The graphs are divided into two parts: the left graph shows the contribution of individual variables to reducing model error (%Increase in Mean Squared Error – %IncMSE) and the right graph displays the increase in node purity (Increase in Node Purity – IncNodePurity), which are standard metrics for measuring importance within random forest models.

From the graph, it is evident that the most significant variable for the model is CPI (Corruption Perception Index). This variable has the highest value in both metrics: it increases model error the most when removed and simultaneously contributes most to node purity when splitting trees. This suggests that CPI has a key impact on predicting the target variable WPFI.

Other important variables are RuleLaw (rule of law) and ExpInfor (freedom of expression and information), which also have high contribution to the model, although less pronounced than CPI. These factors point to a strong relationship between the level of institutional quality and media freedom.

Moderately significant are variables such as FreWorld and EducaLPI, which contribute to model accuracy, but their effect is less dominant. Other variables such as GDPcapPPP, PolStab, and MMarkPlur have relatively low contribution compared to those mentioned above. Their removal would affect the model only minimally, which means that in the context of WPFI prediction, they play a subordinate role.

In conclusion, it can be stated that the model identified corruption, rule of law, and freedom of information as the most significant factors affecting the media freedom index (WPFI). This indicates that institutional quality and the level of transparency in society are decisive factors

for the level of media freedom. Economic indicators such as GDP per capita, meanwhile, play only secondary roles.

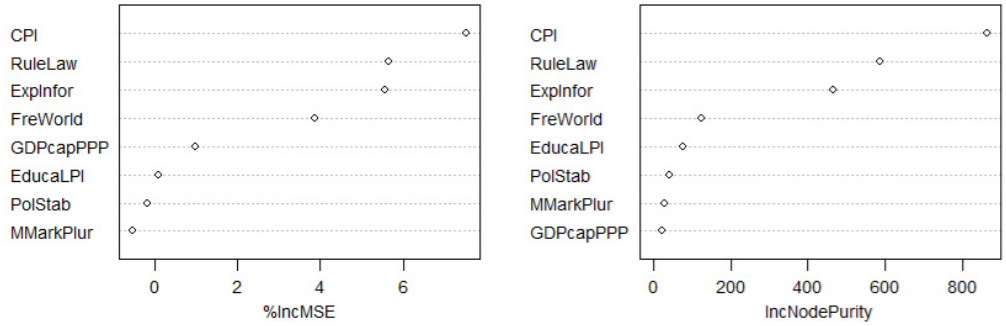

Figure 3: *Importance of variables*

Source: own processing, 2026

Based on the results of comparing the performance of models with different numbers of the most important variables, it can be concluded that the optimal choice is to use the 4 top variables (Table 2 and Figure 4). This model variant achieved the best results in terms of key evaluation metrics. Specifically, the value of the coefficient of determination R2 reached 0.748, which means that the model explains almost 75% of the variability of the target variable WPFI. At the same time, this model had the lowest value of average prediction error with RMSE = 4.708. Compared to other configurations, this is therefore the best compromise between prediction accuracy and reliability.

Furthermore, the selection of four variables contributes to maintaining a simple and clear model structure. Adding a larger number of input variables (for example, 6, 7, or 8) did not lead to further model improvement – on the contrary, there was a slight deterioration in both the R2 value and RMSE. This suggests that these additional variables no longer contribute to better prediction and only increase model complexity, which may be undesirable in terms of interpretability and computational efficiency.

At the same time, it is necessary to emphasize that for the model with 4 variables, the parameter value mtry = 1 was chosen as optimal, which indicates that the selection of one variable when splitting nodes in individual trees within the Random forest is most efficient in this case.

Overall, it can therefore be concluded that the selection of the four most important variables represents the best balance between model simplicity and performance, and therefore this configuration is the optimal choice for predicting the WPFI index.

The number Top variables	mtry	R^2	RMSE
2	1	0.738	4.797
3	1	0.729	4.875
4	1	0.748	4.708
5	4	0.744	4.745
6	1	0.732	4.852
7	3	0.742	4.761
8	3	0.736	4.817

Table 2: *Performance of models according to the number of Top variables*

Source: own processing, 2026

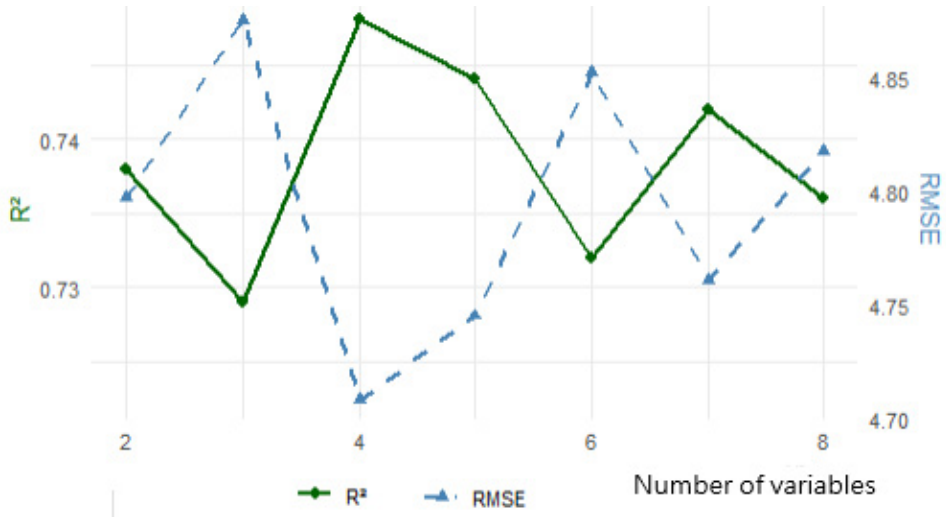

Figure 4: *Performance of models according to the number of Top variables*

Source: own processing, 2026

The model shows (Figure 5) that media freedom (WPFI) depends on several social and institutional factors, with these relationships being markedly nonlinear – that is, their effect is not evenly distributed across the entire range of values, but concentrated around certain "breaking points".

CPI (Corruption Perceptions Index) has a nonlinear effect that manifests itself particularly around the value of 50. Up to this level, the predicted WPFI changes almost imperceptibly, but after exceeding it, a sharp jump occurs. This means that only after crossing a certain threshold of public trust in institutions (i.e., lower corruption) does a rapid improvement in media freedom take place. The model thus does not assume a smooth linear relationship, but rather a breaking point after which the effect fundamentally changes.

Similarly, RuleLaw (Rule of Law Index) exhibits nonlinear growth in WPFI, particularly between values of 0.6 to 0.8. In this interval, the steepest growth in media freedom is manifested, while outside it the effect is more moderate. This points to the fact that improvements in the legal framework have the greatest effect only after crossing a certain level of legal system functionality.

ExpInfor (Freedom of Expression and Information Dissemination) does have an overall positive effect, but again a nonlinear one. In the lower value range, the effect is weak, but around the value of 8 and higher, the curve rises significantly, which means that only a high level of freedom of speech can substantially influence media freedom. It is therefore not a matter of gradual improvement, but of acceleration of effect at higher values.

In the case of FreWorld (Index of Overall Civil and Political Freedom), nonlinear dynamics are also evident. While in the range below the value of 85 the effect is moderate, above this threshold a sharp increase in WPFI occurs. This effect suggests that only the highest level of overall societal freedom creates favourable conditions for independent and free media.

These patterns confirm that the relationships between social factors and media freedom are neither simple nor linear. The Random Forest model is able to capture these nonlinearities – particularly breaking points, effect thresholds, and acceleration zones that a linear model might overlook.

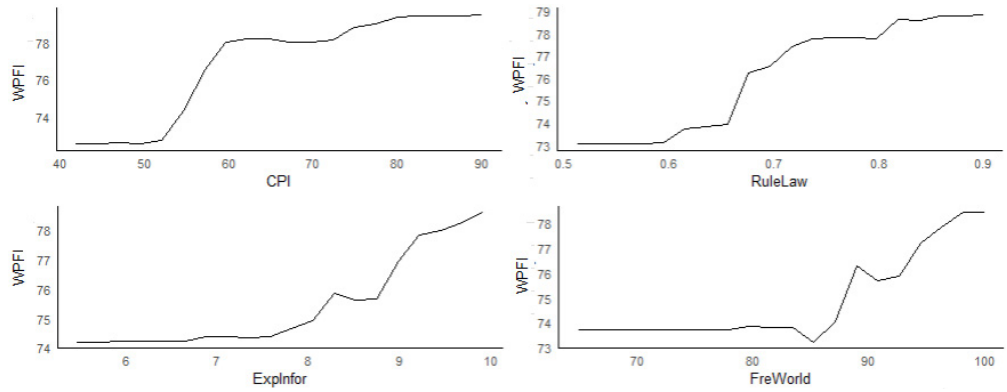

Figure 5: *Partial dependence plots for top 4 variables*

Source: own processing, 2026

CPI – Corruption Perception Index shows a marked change in influence around the value of 53–55, where the previously stable level of WPFI begins to increase sharply. This turning point indicates that after reaching a certain level of anti-corruption efforts, media freedom will grow much more rapidly. However, after exceeding the value of 70–75, saturation occurs, when the effect of corruption on improving WPFI decreases significantly and the curve flattens.

In the case of the RuleLaw variable – Rule of Law, the positive effect on WPFI begins to manifest itself at a value of 0.65, which represents a turning point after which the effect becomes noticeable. Subsequently, after exceeding the value of 0.80, the effect further decreases – saturation occurs, when further improvements in the rule of law no longer bring significant increases in WPFI.

ExpInfor – Freedom of Expression shows a turning point around 8.0, after which there is a clear growth in media freedom. This effect continues approximately until the level of 9.3–9.5, where it does not stop, but growth slows down, that is, a classic saturation pattern occurs, when further improvements result in only modest increases in WPFI.

Finally, with the FreWorld indicator – Overall Freedom, the effect does not begin to manifest itself until the value of 87–89. Before that, the influence is practically zero, but after this turning point there is a sharp jump in WPFI. However, this trend again does not increase indefinitely – after exceeding the value of 97, the effect stabilizes and the increase in WPFI practically stops.

Overall, our findings confirm that the influence of individual variables on media freedom is not linear, but exhibits clear turning points after which rapid change occurs, followed by saturation periods where the effect weakens. It is necessary to exceed specific thresholds where the effect begins to work, to target reforms where acceleration of influence occurs, to perceive relationships systemically – not as a sum of linear effects.

Turning points can serve as political or analytical thresholds for reforms: for example, achieving CPI > 55, RuleLaw > 0.65, ExpInfor > 8, FreWorld > 88. They can be key to political strategy or reform measures aimed at improving conditions for media freedom.

From the previous analysis, it emerged that the relationship between explanatory variables and the target variable WPFI is nonlinear and is often characterized by the existence of turning points and saturation periods. This approach provided us with valuable insights into at what values variables begin to more significantly influence WPFI, and when their effect gradually weakens. Although such analysis makes it possible to reveal the basic dynamics of the influence of individual factors, it does not capture complex interactions between variables or detailed contributions of individual observations to prediction.

For a deeper understanding of how individual variables influence the model output at the level of each observation, and simultaneously for identifying interactions between variables, it is appropriate to use the SHAP method (SHapley Additive exPlanations). This approach is

based on the principles of cooperative game theory and makes it possible to quantify how each variable contributes to the model's prediction – not only independently, but also in combination with other variables.

Using SHAP values, we can precisely determine the direct effects of individual variables – that is, whether a given value of a variable pulls the prediction upward or downward – and simultaneously capture interaction relationships, where the influence of one variable depends on the value of another.

Therefore, the following part of the analysis will focus precisely on SHAP interpretation, which will supplement the view of the model with individual and synergistic effects of input variables.

Figure 6: *Heatmap of SHAP interaction values between variables*

Source: own processing, 2026

The analysis of SHAP values, which are divided into main effects and interaction contributions, provides a deeper insight into how individual variables influence the prediction of the World Press Freedom Index (WPFI). Unlike traditional methods of assessing importance, SHAP makes it possible to distinguish to what extent a variable acts independently and to what extent it acts in combination with other factors.

From the results (Figure 6), it is clear that all four analyzed variables play an important role in the model, but their impact is often conditioned by interaction with other variables (Figure 7). The strongest effect is exerted by CPI (Corruption Perceptions Index), which has a high main effect (1.130), but its interaction contribution is even more pronounced (2.515). This means that while CPI itself contributes to a higher WPFI score, its impact is significantly amplified when combined with other favourable factors, such as freedom of speech or a well-functioning rule of law.

Similarly, ExpInfor (freedom of expression and access to information) has a strong individual effect (0.970) and an even more pronounced interaction effect (2.290). Its impact thus increases significantly especially in a more democratic environment with a lower level of corruption, which points to the synergistic nature of this variable – the better the rest of the system functions, the more freedom of speech can contribute to the overall level of press freedom.

RuleLaw (rule of law) has the lowest main effect among the three main variables (0.580), but at the same time a significant interaction contribution (2.020). This suggests that the rule of law alone does not yet guarantee press freedom, but is a necessary support that strengthens the impact of other variables. The presence of a strong legal framework thus enables better implementation of other freedoms.

FreWorld (overall level of civil and political freedoms) has the weakest main effect (only 0.160), but nevertheless has a pronounced interaction effect (1.605). This result indicates that "overall freedom" in itself may not be a decisive factor for WPFI, but creates a favourable environment in which other factors can act more effectively.

Overall, the SHAP value analysis confirms that press freedom does not arise in isolation, but is the result of the interaction of multiple democratic institutions and factors. Although some variables, such as CPI and ExpInfor, have significant direct impact, their true importance is revealed only in synergy with other pillars of democratic society. This finding has practical significance – it shows that to promote press freedom, it is not enough to focus on a single indicator, but it is necessary to systematically build a comprehensive and mutually reinforcing democratic environment.

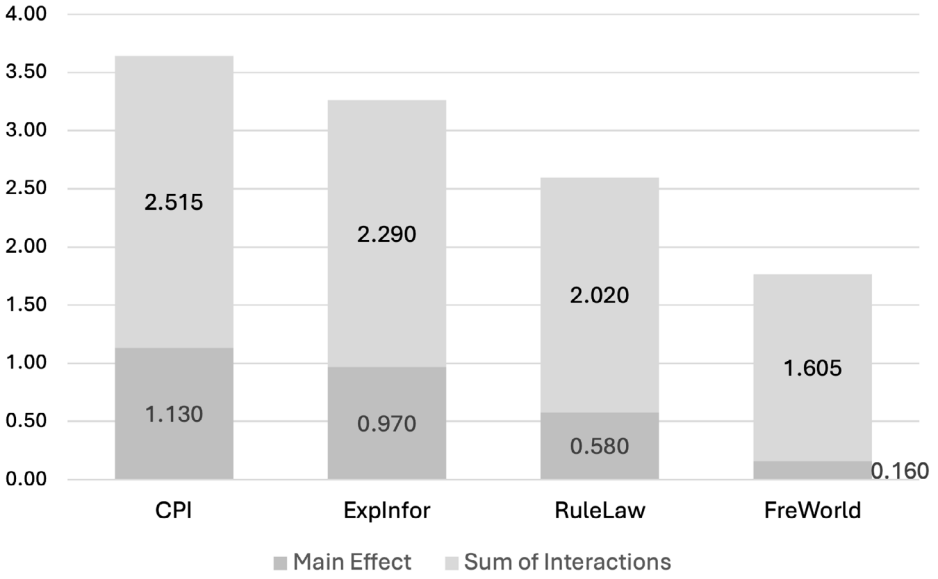

Figure 7: *Main and interaction contributions of the most important factors influencing media freedom (WPFI) according to SHAP evaluation*

Source: own processing, 2026

5 Discussion and Conclusion

The analysis results show that media freedom (WPFI) is not influenced by a single variable, but is the result of a complex interplay of multiple democratic, legal, and social factors. The strongest relationships were identified with variables such as rule of law (RuleLaw), low corruption (CPI), and freedom of expression (ExpInfor), which form the core of conditions enabling independent and free media. These variables exhibit not only strong direct effects, but as SHAP analysis shows. also significant interaction contributions, confirming that media freedom is the result of synergistic action of multiple components of the democratic environment.

On the other hand, variables such as economic level (GDPcapPPP) or political stability (PolStab) play only supporting roles. Particularly interesting is the negative relationship between media market plurality (MMarkPlur) and WPFI, which suggests that quantitative media plurality does not automatically mean their independence – without a quality legal framework and journalist protection, even a pluralistic market can be susceptible to manipulation. From the perspective of public policy-making and reform measures, it is crucial to recognize that media freedom cannot be built in isolation, but it is necessary to strengthen the entire ecosystem of democratic values – from rule of law through transparency to support for education and civil liberties. These components reinforce each other, and only their joint occurrence creates a stable environment in which media freedom can function effectively.

The authors' findings are consistent with recent empirical studies confirming the central role of institutional factors in shaping media freedom. In their analysis, Breen and Gillanders (2020) demonstrated a strong relationship between press freedom and the perception of corruption, emphasizing that higher levels of media freedom enable more effective journalistic oversight functions. This finding corresponds with our results regarding the key role of CPI (Corruption Perceptions Index), which we identified as the most significant predictor of WPFI. Similarly, Flavin and Montgomery (2020) found a positive interaction between press freedom and rule of law in influencing corruption perception, which confirms our SHAP results on synergistic effects between RuleLaw and CPI.

The identification of threshold values in the study is consistent with research published in the OSCE (2023) report, which documents nonlinear relationships between media freedom and political outcomes, including an inverted U-shape in relation to domestic armed conflicts. This study similarly emphasizes that the effects of media freedom change significantly after crossing certain critical points. In our case, we identified specific thresholds for CPI (>55), RuleLaw (>0.65), ExpInfor (>8.0), and FreWorld (>87-89), beyond which there is an acceleration of positive effects on media freedom. However, interesting divergences emerge regarding media plurality. While proponents of the traditional view (e.g., Charney, 2021) consider plurality a necessary condition for media freedom, our results show a negative correlation between MMarkPlur and WPFI. This finding is supported by the latest reports from the European context. The Liberties Media Freedom Report 2024 (Brooks, 2024) and European Federation of Journalists (Council of Europe, 2024) documented that high media ownership concentration in countries such as Croatia, France, Hungary, the Netherlands, Poland, Slovakia, and Slovenia leads to weakened media freedom, despite the formal existence of plurality. Similarly, in their analysis of Western media systems, Maniou and Ketteni (2023) confirmed a strong correlation between ownership concentration and reduced capacity to conduct independent journalism. These findings suggest that quantitative plurality without institutional protection can be counterproductive, which is consistent with our results.

Regarding economic factors, our finding about the relatively weak role of GDP per capita contrasts with some earlier work (e.g., Nguyen et al., 2021), which emphasized economic stability as a key factor. However, the latest Reporters Without Borders (2025) report confirmed that economic instability has become a major threat to press freedom globally, with this threat operating through indirect mechanisms (media dependence on sponsors, political pressure) rather than through direct economic development. This supports our interpretation that economic factors play supporting, but not decisive, roles.

Our results also resonate with research by Bjørnskov et al. (2022), who documented the negative and persistent impact of violent regime changes on media freedom, confirming the importance of political stability as a contextual factor. Similarly, Hamada and Vallesi (2025) confirmed that journalists in democratic systems with higher media and press freedom show lower trust in public institutions, but simultaneously perform oversight functions more effectively, which corresponds with our findings on the importance of ExpInfor.

From the perspective of public policy-making and reform measures, it is crucial to recognize that media freedom cannot be built in isolation, but rather it is necessary to strengthen the entire ecosystem of democratic values – from rule of law through transparency to support for education and civil liberties. These components reinforce each other, and only their joint occurrence creates a stable environment in which media freedom can function effectively.

This analysis provides several specific recommendations for policy-makers. Political reforms should primarily focus on achieving the identified threshold values. Specifically, this involves a Corruption Perceptions Index above 55 points, a Rule of Law Index above 0.65, and a Freedom of Expression Index above 8.0. Only after crossing these thresholds does significant improvement in media freedom occur. Simply increasing the number of media platforms is insufficient. It is necessary to simultaneously strengthen the legal framework for protecting journalists. Equally

important are media ownership transparency and the independence of regulatory bodies. Without these measures, even a pluralistic media market can be susceptible to manipulation.

Fighting corruption should be a central part of any strategy to promote media freedom. Our results point to the dominant influence of the Corruption Perceptions Index and its strong interactive effects with other factors. Reducing corruption is therefore not just a standalone goal, but a catalyst for the entire democratic ecosystem. Protecting freedom of expression acts as an amplifier of other democratic factors. Its protection should therefore be a priority. Freedom of expression enables more effective functioning of the rule of law and more efficient anti-corruption efforts. It can be stated that narrowly focused reforms will have only limited impact. Purely economic support for media or only legislative changes are insufficient to improve media freedom in a country. Real improvement occurs only when all pillars of the democratic system are strengthened simultaneously. Reforms must be coordinated and systemic, because media freedom is the result of the mutual interaction of multiple factors.

This study makes a fundamental contribution to growing knowledge about media systems by providing an empirically grounded, data-driven analysis of the institutional architecture that supports free and independent media in democratic societies. The use of advanced statistical methods (Random Forest and SHAP) made it possible to capture complex nonlinear relationships and interactions that traditional linear models cannot reveal. The study's results indicate that media freedom is an emergent property of a democratic system – it does not arise merely from the sum of individual factors, but from their mutual synergistic interaction.

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