

# Unpacking Board Model Choice in Europe: A Multi-Methods Approach

Law Working Paper N° 950/2026

August 2026

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The authors thank the participants of the EUI faculty seminar and the the EU Sustainable Corporate Governance Workshop at WU Vienna, and the annual conferences of the European Society for Empirical Legal Studies (EELS) at Toulouse Capitole University, the International Corporate Governance Society (ICGS) at Manchester University, and the Economic Data Science Society at the Banque de France for helpful comments. We also thank the editor and three anonymous referees whose excellent comments resulted in improvements of the article.

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## Abstract

The design of corporate governance structures is a major topic in the legal and management literature; yet there is little research on what accounts for the choices that companies make. This paper aims to contribute to this under-researched topic by examining the fundamental choice between corporate board models, notably, between one-tier and two-tier models (i.e. companies with or without a supervisory board). Based on data from 147,000 firms across fourteen European countries, it finds that the choice of board model is associated with the composition of the company's shareholders, personal characteristics of the company's directors and different types of firms. In addition, the paper exemplifies the benefits of applying a multi-method approach, being based on a combination of regression and random forest analysis, as well as qualitative interpretation. The random forest analysis, which had not yet been applied to this question, was found to be particularly helpful in understanding, by means of exploratory research, a large number of possible reasons, forms of non-linearity and other complexities.

Keywords: Board of directors, supervisory board, management board, comparative corporate governance, logit regression, random forests

JEL Classifications: G34, K22, L22

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## Abstract

The design of corporate governance structures is a major topic in the legal and management literature; yet there is little research on what accounts for the choices that companies make. This paper aims to contribute to this under-researched topic by examining the fundamental choice between corporate board models, notably, between one-tier and two-tier models (i.e. companies with or without a supervisory board). Based on data from 147,000 firms across fourteen European countries, it finds that the choice of board model is associated with the composition of the company's shareholders, personal characteristics of the company's directors and different types of firms. In addition, the paper exemplifies the benefits of applying a multi-method approach, being based on a combination of regression and random forest analysis, as well as qualitative interpretation. The random forest analysis, which had not yet been applied to this question, was found to be particularly helpful in understanding, by means of exploratory research, a large number of possible reasons, forms of non-linearity and other complexities.

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## 1. Introduction

Many countries offer public companies a choice between multiple board models, notably a one-tier model with a single board of directors and a two-tier model with both a management board and a supervisory board. Why companies choose a particular model, however, is largely underexplored. Based on data from 147,000 firms across fourteen European countries, this paper aims to unpack the reasons for the choice of board models. This research contributes to a key question of corporate governance, as the board structure of companies is fundamental to many further questions of corporate governance, such as the use of independent directors, board committees, board size, frequency of board meetings, relationship to shareholders, etc.

Beyond this particular topic, recent research has explored other cases where lawmakers leave it to individuals (be it citizens or firms) to choose between multiple regulatory options. Some of it discusses other questions of corporate law (Listokin 2009; Lin and Chang 2018), but elements of choice have, for example, also been observed for the selection among different bankruptcy proceedings (Bernardo et al. 2016), the provision of different default contract laws (Ringe 2013), the choice between different matrimonial property regimes (Nutz et al. 2022) and the introduction of domestic partnerships and civil unions in addition to marriage (Eskridge 2011). These rules come in many shapes and forms: some contain tools such as defaults to nudge individuals in certain directions. By contrast, in the present case, companies simply need to select one of the board models, which thus raises the open question of why firms decide on a particular model.

As possible reasons, this paper examines sets of variables associated with the composition of the company's shareholders, personal characteristics of the company's directors and different types of firms. Understanding the prevalence of these types of reasons can have wider analytical and normative implications. For example, if companies with dispersed shareholder ownership choose the two-tier board, this may be seen as a positive finding as these companies have a heightened need for managerial control. By contrast, in the category of directors, the greater presence of certain groups of persons as directors in the two-tier model may be a negative sign as it may mean that companies want to reduce their influence (e.g., the role of employee representatives). With respect to different types of firms, findings can also be interesting from a policy perspective as they may indicate that lawmakers could provide distinct rules for companies that fall under certain categories (e.g. firms of certain industries) (for the theoretical framing see further section 2.2).

Beyond its substantive contribution, this paper provides a methodological innovation in this field of research as it combines a multiple-method research strategy. The conventional cross-sectional logit regression analysis uses the respective board model as the dependent variable to examine the possible role of a small number of key variables. This is complemented by the use of the "random forest" machine learning method. This non-parametric approach can make use of a larger set of variables to uncover, for example, further reasons not captured by regression analysis, forms of non-linearity and other complexities. The use of random forests is chiefly exploratory because it does not operate with thresholds of statistical significance like regression analysis and thus does not lend itself to statistical inference. However, this can also be seen as advantageous, as it does not invite forms of "p-hacking"; rather, the findings can simply be interpreted on their own terms. While the goal of machine learning is prediction, we employ SHAP (SHapley

Additive exPlanation) analysis, a method that allows us to compare the contribution of each variable to the respective outcome (explained further in Section 5.2).

Given the cross-sectional nature of the data, this paper cannot claim causal proof of the determinants of board choice; yet, it provides qualitative interpretations of the plausibility and relevance of its findings. Thus, it aims to understand the firm as an endogenous organisation akin to the finding by Adams et al. (2010) that corporate governance structures of firms are largely endogenous, as well as the classical more general insight by Selznick (1949: 10) that “the important point about organizations is that, though they are tools, each nevertheless has a life of its own”.

The structure of this paper is as follows. Section 2 outlines the state of the art of board choices and related questions, as well as its distinction between groups of variables that address the composition of the company’s shareholders, personal characteristics of the company’s directors and different types of firms. Section 3 explains the data and methods used in this paper and presents descriptive statistics on the use of board choice in the fourteen countries. Sections 4 and 5 present and discuss the findings of the logit regression and random forest analysis. Section 6 concludes on this paper’s substantive and methodological contributions.

## **2. State of the art and theoretical framing**

### *2.1. Choice between board models and their treatment in the literature*

In some countries, notably the UK and the US, companies simply have a single board of directors, notwithstanding possible variations, such as the prevalence of non-executive directors and board committees. In other countries, a frequent distinction is between the legal form of the company: companies incorporated in the form of a private company (such as the SARL in France or the GmbH in Germany) typically only have one group of manager-directors (which may function as a board, or it can simply be one person). By contrast, for companies incorporated in the form of a public company, which may be listed, otherwise publicly traded or privately held (see Section 3.1), many variations exist. For instance, German public companies (AGs) necessarily have two boards, a management and supervisory board (two-tier model), whereas Spanish public companies (SAs) always have a single board of directors (one-tier model). In many other countries, the law of public companies leaves it to the companies to choose their board model. This can be observed in most parts of the world; for example, a choice of board models for which the law provides two or three sets of templates is possible in countries as diverse as Algeria, Brazil, Japan, Russia and Vietnam (Gelter and Siems 2021: 140).

In 2004, an EU regulation introduced the special legal form of the European Company (SE), which allows for a choice between the one-tier and two-tier models. While some countries (notably France) already had a choice of board models for a long time, many of the EU Member States took the SE law as an occasion to also introduce choice to their national public-company forms. Thus, as shown in Figure 1, more than half of the EU Member States currently allow board choice in their laws of public companies (for references to the precise laws, see Gelter and Siems 2021: 148–152). For most of them, this is a choice between the one-tier and two-tier models. Italy and Portugal, in addition, provide

the option of their traditional “audit model”, which involves a board of auditors entrusted only to verify the legality of management, but not its business judgement. Thus, in this paper, we classify the “audit model” as a third model, while some other authors sometimes treat it as an untypical form of either the one-tier (Gerner-Beuerle et al. 2013: 5 fn 17) or the two-tier model (Bonini and Lagasio 2022: 101).

|                    | <b>Original model</b> | change (if any) | <b>Current Model</b> |                 |
|--------------------|-----------------------|-----------------|----------------------|-----------------|
| <b>One Tier</b>    | Cyprus                |                 | Cyprus               | <b>One Tier</b> |
|                    | Greece                |                 | Greece               |                 |
|                    | Ireland               |                 | Ireland              |                 |
|                    | Malta                 |                 | Malta                |                 |
|                    | Spain                 |                 | Spain                |                 |
|                    | Sweden                |                 | Sweden               |                 |
|                    | Belgium               | → 1/5/2019 →    | Belgium              |                 |
|                    | Denmark               | → 1/3/2010 →    | Denmark              |                 |
|                    | Finland               | → 1/9/1997 →    | Finland              |                 |
|                    | France                | → 1/2/1967 →    | France               |                 |
| <b>Choice</b>      | Luxembourg            | → 31/8/2006 →   | Luxembourg           | <b>Choice</b>   |
|                    | Romania               | → 1/12/2006 →   | Romania              |                 |
|                    | Bulgaria              |                 | Bulgaria             |                 |
| <b>Audit model</b> | Lithuania             |                 | Lithuania            | <b>Choice</b>   |
|                    | Netherlands           | → 1/1/2013 →    | Netherlands          |                 |
|                    | Italy                 | → 1/1/2004 →    | Italy                |                 |
| <b>Two Tier</b>    | Portugal              | → 30/6/2006 →   | Portugal             | <b>Two Tier</b> |
|                    | Croatia               | → 1/4/2008 →    | Croatia              |                 |
|                    | Czech Rep.            | → 1/1/2014 →    | Czech Rep.           |                 |
|                    | Hungary               | → 1/7/2006 →    | Hungary              |                 |
|                    | Slovenia              | → 4/5/2006 →    | Slovenia             |                 |
|                    | Austria               |                 | Austria              |                 |
|                    | Estonia               |                 | Estonia              |                 |
|                    | Germany               |                 | Germany              |                 |
|                    | Latvia                |                 | Latvia               |                 |
|                    | Poland                |                 | Poland               |                 |
|                    | Slovakia              |                 | Slovakia             |                 |

*Figure 1: Overview of board structures of public companies in Europe*

In the literature on differences between corporate board models, the focus is typically on the respective advantages and disadvantages of the two (or three) models (e.g. Hopt and Leyens 2021; Davies et al. 2013). In a nutshell, the main rationale of the two-tier model is that the presence of a supervisory board can provide better control of management in the interests of shareholders and the company as a whole. While one-tier boards may have both executive and non-executive directors, it is seen as less likely that non-executive directors can be as effective as those on a separate board. Supporters of the one-tier model present the reverse line of reasoning. Such a board may be more effective as executive and non-executive directors can work together with a faster flow of information and avoid the risk of fractional disputes between two separate boards.

Empirical research on choice of board models is rare. As far as it exists, its usual focus is on the effect of having one or the other board model. Jungmann (2006) did not find a significant difference in financial performance between companies with the German two-tier and the UK one-tier model, nor did Hornuf et al. (2019) for the impact of establishing European Companies (SEs) by choosing either a one-tier or two-tier model. Other studies observe some differences. Using data from multiple European countries, Sayari and Marcum (2022) found that companies with one-tier boards usually have a higher Tobin's Q, while Fard and Chung (2024) found that one-tier boards are more likely to align with the CEO and increase their pay. A number of studies from France and Italy have examined the effect of choosing a particular model on a variety of financial variables, with mixed results (for France: Boubaker et al. 2015; Belot et al. 2014; Millet-Reyes and Zhao 2010; Jeanjean and Stolowy 2008; Roosenboom and Schramade 2006; for Italy: Pellegrini et al. 2010; Pellegrini et al. 2017).

This paper forms part of a broader research project which aims to fill this gap through an empirical exploration of the situation in fourteen European countries that allow such board choice. This paper is the third in a trilogy of papers. Gelter and Siems (2021) analysed variations in the popularity of these models at the country level. It coded details on the way each country implemented the choice between board models (Gelter and Siems 2021: 164); yet, it ultimately found a strong path dependence to be the main determinant of the preference for a particular board model at the country level. Gelter and Siems (2024) used the method of propensity score matching (PSM) to examine whether, at the firm level, the choice of a particular board model can explain financial measures such as operating revenue, cash ratio and leverage, ultimately finding few significant differences between the two models. This paper also briefly considered the other side of the causal relationship; yet, due to the use of data suitable for PSM, it did so only for companies in nine countries which were established before board choice was introduced and where finance data were available. Thus, the rudimentary regression analysis with board choice as a dependent variable of this second paper was based on less than 8% of the observations included in the analysis of the present paper (Gelter and Siems 2024: 7 report results for 10,665 firms while Tables 3 and 4 of the present paper report results for 147,008 firms).

## *2.2. Literature and theoretical framing to explain the choice of board structures*

A large body of empirical literature deals with specific data points related to corporate boards, such as the identity of board members (e.g., their independence, gender, nationality, employee representatives), the size of the board and the frequency and length of board meetings. Typically, this research asks whether any of these factors have an effect on financial or other variables (for literature reviews see James 2020; Farrell et al. 2026). To provide three concrete examples, Pucheta-Martínez and Gallego-Álvarez (2020) examined the effect of board size, board independence, CEO duality, female directors and board compensation on firm performance, García-Ramos and Díaz (2021) did so for “complex configuration of several board features (board size, board independence, leadership structure and board activity) and several corporate characteristics (firm size, firm leverage and firm age),” while Liao et al. (2021) examined how far board reforms can have significant effects on CSR performance.

There are fewer empirical studies on the determinants of board structures. As noted in the systematic literature review by Lu et al. (2022), such studies “are scarce”, also lamenting

an “absence of cross-country, mixed-methods, and qualitative investigations.” The present paper has the aim of contributing to this under-researched topic. The following text distinguishes between three possible sets of reasons to explain companies’ choices regarding questions of corporate governance: the composition of the company’s shareholders, personal characteristics of the company’s directors and different types of firms.

First, variations in the company’s shareholders may be the main determinants for a firm’s corporate governance structure. A prominent position in this line of research draws on the divide between companies with dispersed and concentrated shareholder ownership, given that, in the former case, the main principal-agent problem is between management and shareholders, whereas in the latter it is between minority and majority shareholders (e.g. Kraakman et al. 2017). In the empirical literature, Voordeckers et al. (2007) examine the specific case of firms with or without full family ownership on board structures, while Roosenboom and Schramade (2006) examine the choice of board models at the moment of an IPO when there is owner-manager control of a firm. In further research on shareholders, Chizema and Shinozawa (2012) relate the proportion of foreign ownership to the choice of adopting a committee-based governance system, and Pellegrini et al. (2010) relate the proportion of non-corporate shareholders to the three board models in Italy.

Regarding the choice between different board models, shareholders matter as they decide on this it through setting or changing the company’s articles of association.<sup>1</sup> Applying the aforementioned distinction on agency costs, a heightened need for managerial control, and thus potentially the more structured two-tier board model, may be needed if shareholder ownership is dispersed (for descriptive statistics from other studies, see Gelter and Siems 2021: 153); however, it has also been suggested that the two-tier model may be particularly suitable for companies with concentrated ownership in order to limit an economically harmful interference from the large shareholder (Graziano and Luporini 2012; on the role of directors representing specific large shareholders see Gelter and Helleringer 2015: 1079–1080). Relevant variables to test this (see Section 3.2) are data on shareholder concentration, but also the number of shareholders and shareholders also being directors of the company. Other considerations may also matter, for example, foreign shareholders may prefer a board model similar to their home jurisdiction.

Second, personal characteristics of the company’s directors may play a role. Prior studies have, for example, examined the determinants of foreign executive and non-executive directors (van Veen and Elbertsen 2008) and the relationship between the proportion of female directors and other board characteristics such as age, education and experience (De Acutis et al. 2024). As far as countries have a system of employee co-determination in corporate boards, it has been shown that, if companies fall under these requirements, this requirement can shape decisions of corporate governance and the place of incorporation (e.g., Hornuf et al. 2019; Njoya 2011; Eidenmüller et al. 2009).

Applied to board choice, the presence of foreign directors may speak in favour of choosing the two-tier model, as these directors may preferably be made members of a supervisory board, given the fact that they may often lack the local knowledge to be involved in

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<sup>1</sup> See e.g. Code de commerce, art. L.225-57 (France); Legea privind societățile comerciale, art. 153 (Romania); Civil Code, art. 2380 (Italy); Código das Sociedades Comerciais, art. 278(6) (Portugal).

management decisions. As with shareholders, it may matter whether foreign directors of a company come from a one-tier or two-tier system as these preferences may be reflected in the choice of a board model. Vis-à-vis female directors and employee representatives, some studies point in the direction that the two-tier model is used strategically in order to reduce their influence, given that influence on a supervisory board is typically smaller than membership on a one-tier board that sometimes exercises management functions directly (for female board membership: Draskowski et al. 2024; for employee co-determination: Sayari and Marcum 2022).

Third, it may be the case that firms in different industries and with different business models use different corporate governance structures. For example, Coles et al. (2008) and Linck et al. (2008) find that R&D-intensive firms differ from other firms in having smaller boards with a higher proportion of inside directors. For the choice of the one-tier model in France, Belot et al. (2014) observe positive coefficients for R&D and high-tech industries, but negative ones for firms in the media and entertainment industries, which they explain by informational advantages in the former and the extraction of private benefits in the latter case. For Italy, Brogi (2009) finds that some large banks have adopted the two-tier board governance structure, hypothesising about the ability to appoint financial intermediaries to the supervisory board and linking it to their heightened need for accountability; yet, Mucciarelli and Pomelli (2024: 10, 119) indicate that Italian banks subsequently abandoned the two-tier model, while also mentioning the growing use of the one-tier model by some start-up companies. Beyond the hypothesis that substantive reasons push certain industries into the use of a particular board model (Section 2.2), industry clustering of board models may also be attributed to network effects (e.g., lawyers and other consultants advising similar firms to adopt the same structure).

The age of firms is another factor that may matter. On the one hand, this can be due to switching costs. For example, such costs can play a role for the decision not to reincorporate a company in another jurisdiction (Eldar and Magnolfi 2020; Sanga 2020). For board choice, switching costs include the costs to change the company's articles of association, as noted above. While this is a straightforward procedure if there is sufficient shareholder support, further frictions may arise if the current directors fear a change of their status and power (e.g., a change from being a director in a one-tier board to that of a management or supervisory board only). Such switching costs may thus point towards a divide between companies established before and after the introduction of such a choice. On the other hand, Gelter and Siems (2021) found that countries with board choice have often seen a general decline in the use of the two-tier model. Thus, preference for board models seems to have varied over time, similar to the observation that topics of corporate law scholarship are driven by certain "fads and fashions" (Cheffins 2004: 472).

Another set of firm-type explanations relates to the size and listing of companies. In the general empirical literature, according to Coles et al. (2008), the size of a company is correlated with larger board size, Linck et al. (2008) relate company size to factors such as the prevalence of outside directors, and Federo and Parente (2023) find that large firms are more likely to comply with global standards for "good" corporate governance. In the present case, a possible hypothesis is that larger companies and listed companies are more likely to choose the two-tier model as they are in greater need to have a more structured supervision of their management. But it can also be noted that, for such companies, there are sometimes structural requirements that also apply to the one-tier board (notably, this

is the case in the Netherlands, further discussed in Section 5.2). Moreover, as Corporate Governance Codes often recommend that listed companies appoint a certain number of independent directors, the attraction of flexibility of the one-tier model loses some of its appeal compared to the two-tier model.

Overall, the three categories thus include several explanations based on arguments and studies of the prior literature, but not yet empirically explored for the fundamental choice between different board models. Some of these explanations also have normative implications, notably as far as they may show that board choice benefits certain groups or interests to the possible detriment of others. These implications are not the focus here; yet, they also motivate this paper (see Section 1). As the analysis of this paper is based on data from fourteen countries, another question is whether these explanations are likely to play a similar role in all of them. Considering the general rationales for these explanations, we expect that, generally, this may be the case; yet the following also identifies and explains some heterogeneity in the findings.

### **3. Data, variables and methods**

#### *3.1. Firm-level data and descriptive statistics of board structures*

The data of this paper, as well as the previous ones of this project (Gelter and Siems 2021; Gelter and Siems 2024), are based on information on the choice between the one-tier and the two-tier board models in Bulgaria, Croatia, the Czech Republic, Denmark, Finland, France, Hungary, Lithuania, Luxembourg, the Netherlands, Romania and Slovenia (Belgium only introduced board choice after the data collection had been completed). We also analyse the situation in Italy and Portugal, where companies can also choose a third model, the “board of auditors” model (Section 2.1). We used the database Orbis (Bureau van Dijk; now part of Moody’s) for data on all public companies of these countries. Orbis does not mention their board structure explicitly; yet, as explained in Gelter and Siems (2024), we developed an algorithm coded in R to determine the board structure based on the positions of active “directors and managers” in the terminology of Orbis. It was therefore possible to identify the board structure for 147,270 of the active 154,056 public companies of these countries included in Orbis.<sup>2</sup>

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<sup>2</sup> Unfortunately, the standard Orbis database does not generally provide data over time, which makes it impossible to generate panel data for shareholders, directors and managers, and hence the development of our board structure variable. Only certain financial information is available for a limited number of financial statements from prior years.

Table 1: General data about public companies in this study

| Country        | Number of firms by board structure |          |                   | Further information              |                                |                                                    |
|----------------|------------------------------------|----------|-------------------|----------------------------------|--------------------------------|----------------------------------------------------|
|                | One-Tier                           | Two-Tier | Board of Auditors | Total number of public companies | Percentage of listed companies | Percentage of firms with data on all key variables |
| Bulgaria       | 8,539                              | 57       | n/a               | 8,596                            | 2.58%                          | 98.72%                                             |
| Croatia        | 20                                 | 635      | n/a               | 655                              | 22.75%                         | 99.85%                                             |
| Czech Republic | 4,115                              | 13,070   | n/a               | 17,185                           | 0.08%                          | 99.98%                                             |
| Denmark        | 35,316                             | 31       | n/a               | 35,347                           | 0.43%                          | 99.95%                                             |
| Finland        | 239                                | 7        | n/a               | 246                              | 58.94%                         | 97.56%                                             |
| France         | 14,962                             | 93       | n/a               | 15,055                           | 3.93%                          | 99.80%                                             |
| Hungary        | 4,191                              | 1,576    | n/a               | 5,767                            | 0.66%                          | 99.81%                                             |
| Italy          | 101                                | 71       | 24,007            | 24,179                           | 1.17%                          | 99.92%                                             |
| Lithuania      | 265                                | 15       | n/a               | 280                              | 10.71%                         | 100.00%                                            |
| Luxembourg     | 7,025                              | 28       | n/a               | 7,053                            | 0.95%                          | 99.46%                                             |
| Netherlands    | 2,726                              | 550      | n/a               | 3,276                            | 4.79%                          | 99.97%                                             |
| Portugal       | 24                                 | 4        | 22,367            | 22,395                           | 0.23%                          | 99.92%                                             |
| Romania        | 3,161                              | 3,583    | n/a               | 6,744                            | 5.10%                          | 99.97%                                             |
| Slovenia       | 110                                | 380      | n/a               | 490                              | 7.14%                          | 99.18%                                             |

Table 1 displays the data for the choice of board models. It can be observed that there is considerable variation among countries in terms of preferences for a particular board model. These country differences were explored in Gelter and Siems (2021), notably finding a strong path dependence in some of the countries (namely, that even new companies tend to choose the board model that existed before choice was introduced). Beyond differences in the chosen board model, Table 1 indicates variations in the total number of public companies and the proportion of those which are listed. In particular, it is noteworthy that, while more than 50% of the Finnish public companies are listed, in the other countries the vast majority of public companies is privately held. As regards all privately held companies, countries differ in the use of the legal form of a public or private company (e.g. Wymeersch 2009, as well as Section 2.1 for the relevance of the legal form for rules of board choice), which thus explains the large variations of the number of public companies for countries of similar population sizes (e.g., Denmark and Finland).

For the purpose of this paper, we also collected a large volume of further company information from Orbis. However, with respect to these data, many of the firms lack complete information. Thus, as explained in the next section, parts of the analysis focus on a set of key variables that are available for almost all companies (see the last column of Table 1). Some of the descriptive data of these variables also show interesting variations between countries: for example, there is a large proportion of foreign shareholders in Luxembourg (almost 50% of the companies with known shareholders), whereas in most other countries the proportion of foreign shareholders is below 1%. Differences may also relate to variations for which data are not easily available: for example, it is said that, in France, family members are frequently appointed as members of the supervisory board (Barrédy 2021);

yet, while it is known that many European companies are family businesses,<sup>3</sup> data on the identity of family members are not available for the companies in our dataset.

### 3.2. Main explanatory variables and broader set of variables

Table A.1 of the Appendix contains the list of all variables downloaded from Orbis and used in the random forest analysis. By contrast, the main regression analysis is based on twelve key variables that are available for most firms. Table 2 displays these variables, and Tables A.2 through A.4 of the Appendix show the descriptive statistics and table of correlations of these variables (with correlations being less than 0.5, thus indicating that multicollinearity is unlikely to be a major problem).

Table 2: Main explanatory variables

| Group          | Variable                                     | Explanation                                                                                                                                                   |
|----------------|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Shareholders   | <i>log (no. shareholders)</i>                | number of shareholders plus 1 (log scale)                                                                                                                     |
|                | <i>Majority shareholder</i>                  | shareholder holding more than fifty per cent (dummy variable) (see footnote 4 and text for details)                                                           |
|                | <i>Shareholder-directors</i>                 | share of all current directors and managers who are also shareholders                                                                                         |
|                | <i>Shareholders with two-tier background</i> | weighted index of shareholders coming from countries favouring a particular board structure (see footnote 6 and text for details)                             |
| Directors      | <i>Foreign directors</i>                     | share of all current directors and managers who do not hold the citizenship of the firm's country of registration                                             |
|                | <i>Directors with two-tier background</i>    | weighted index of directors and managers coming from countries favouring a particular board structure (see footnote 6 and text for details)                   |
|                | <i>Female directors</i>                      | share of all current directors and managers who are female                                                                                                    |
|                | <i>Employee board representation</i>         | number of employees exceeds the legal threshold for employee representation on the (supervisory) board (dummy variable) (see footnote 7 and text for details) |
| Types of firms | <i>Industry</i>                              | Reduced industry classification based on NACE (see footnote 8 and text for details)                                                                           |
|                | <i>Post-choice establishment</i>             | dummy variable indicating whether company was formed after choice of board structure became available                                                         |
|                | <i>log (age)</i>                             | log of the age of the company in years (in 2018) plus 1                                                                                                       |
|                | <i>Listed</i>                                | public trading status (dummy variable)                                                                                                                        |

Table 2 distinguishes between explanations for the choice of the board model based on the theoretical framing presented in Section 2.2. Thus, only a few additional remarks are

<sup>3</sup> See e.g. the European Commission at [https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/family-business\\_en](https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/family-business_en) ("Family businesses make up more than 60% of all companies in Europe"). For aggregate data see also <https://europeanfamilybusinesses.eu/about-european-family-businesses/#facts>.

needed on the way certain variables have been constructed. The variable for majority shareholder ownership is based on all firms in the Orbis “company independence” categories C, D, and U (and not A and B).<sup>4</sup> Data on directors is not directly provided by Orbis on the firm-level, but on the individual director level.<sup>5</sup> We therefore had to compute them for each firm first. The variables “shareholders with two-tier background” and “directors with two-tier background” are indices of whether directors/managers or shareholders are nationals of jurisdictions favouring a particular board structure.<sup>6</sup> For the variable “employee board representation”, we coded whether the number of employees exceeds the threshold for employee participation in this country.<sup>7</sup> For both the age of the company and post-choice establishment, we used the Orbis data for “date of incorporation”, despite some concerns that this data may sometimes refer to the prior establishment in another legal form (discussed in Gelter and Siems 2024: 4–6). Specifically, as we use the choice of the two-tier model as the dependent variable, we expect the coefficient of “post-choice establishment” to be positive in countries that initially only allowed a one-tier structure, and negative in countries with a traditional two-tier structure. The industry categories have been consolidated into larger categories due to the relatively low number of observations in some specific industry categories.<sup>8</sup>

The wider set of all further variables (Table A.1 of the Appendix) is only used for the random forest analysis. Applying this method (see further Section 3.3) has the advantage that the machine learning approach automatically accounts for the relationship between variables. However, it invariably drops observations if a single variable included in the model is missing. Consequently, the more variables we include, the more dramatically the number of observations will shrink. This obviously defeats the purpose of machine learning methods to make use of the variation found in “big data”. We therefore imputed missing data for each country using the MissForest method.<sup>9</sup> MissForest is a non-para-

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<sup>4</sup> The definitions are: “A: Company with known recorded shareholders none of which having more than 25% of direct or total ownership. B: Company with a known recorded shareholder none of which with an ownership percentage (direct, total or calculated total). over 50% but having one or more shareholders with an ownership percentage above 25%. C: Company with a recorded shareholder with a total or a calculated total ownership over 50%. D: Company with a recorded shareholder with a direct ownership of over 50%. U: Unknown).” Thus, this assumes that firms within the category “U” are typically very small and therefore in the hand of a majority shareholder.

<sup>5</sup> All variables representing a share or percentage are scaled between 0 and 1.

<sup>6</sup> For this purpose, we coded the available board structures of the 100 most frequent countries as regards both foreign directors and foreign shareholders in our dataset. The indices range between -1 and +1. Directors and managers are weighted equally in the construction of the respective index, whereas shareholders are weighted by their ownership stake. Individuals from one-tier jurisdiction contribute to the index negatively, individuals from a two-tier jurisdiction positively, and if information on the nationality of a director was unknown (or if it was a choice jurisdiction, including domestic directors/shareholders), this was coded as “0”. For example, if all directors/managers are from Germany, the variable would be +1.

<sup>7</sup> Reported in Gelter and Siems 2021: 164. If no information on the number of employees was available, we assumed it to be a very small company that did not reach this threshold for purposes of this variable.

<sup>8</sup> NACE category A refers to agriculture (reference category), B to E to heavy industry. F to construction, G to J to low-skilled services sector, K to financial and insurance categories, L to N to high-skilled services sector, “other” to non-classified categories, see <https://classification.codes/classifications/industry/nace>. In the random forest analysis, we also use the two-digit NACE classification on which these letter codes map.

<sup>9</sup> Implemented using the missforest package in R.

metric method that combines imputation of different types of data (categorical and continuous), using an algorithm based on random forest (Stekhoven and Bühlmann 2012). We ran the algorithm for each country separately, using the default settings in R. Given the large number of missing financial data for small firms in some countries, we decided to use only imputations for variables where the original dataset had a value for more than 50%. Other variables were dropped from the model on a country basis. For the vast majority of variables, the actual level of imputed variables was very low (often below 1% and rarely more than 10%, see Table A.10 in the Appendix). To further check whether the imputation led to possible distortions, we compared the distribution of the original and imputed data for each variable. Finally, for the selection of variables which are discussed in the results of the random forest analysis (section 5.2), we focus on those with low levels of imputation.

### 3.3. *Methods: logit regression analysis and random forest*

For each country with a choice between a one-tier and two-tier board, we ran logistic regressions with the board structure as the dependent variable. As the data underlying this paper are cross-sectional, this provides evidence of a relationship between variables, not causal proof of the determinants of board choice. For Italy and Portugal, which also have the option of the traditional board-of-auditors model, the use of a multinomial logit model faced the challenge that we were not able to confirm that the “independence of irrelevant alternatives (IIA) assumption” holds (i.e. that the addition of a third alternative does not affect the relative odds of selecting either of the two original options; see e.g. Wooldridge 2002: 502; Greene 2018: 834–835). Moreover, given the low number of companies that choose the one-tier or two-tier models in Italy and Portugal (Table 1), we decided to simply run the logistic regressions with the choice between the board-of-auditors model and the other two models, with other approaches reported in the Appendix (see Section 4.1 with fn 16).

A further challenge has been that the absolute number of observations using a particular board structure is extremely small in some jurisdictions (Table 1, again). To account for countries where one board structure is so rare that regular logistic regression would produce biased results, we use Firth’s bias-reduced logistic regression, also known as “penalised maximum likelihood estimation” or PMLE, which employs a penalty function to correct for the bias against such rare events in the maximum likelihood estimate (Firth 1993). Thus, we used PMLE in countries where one board structure was so rare that most regular logistic models produced fitted values of 0 or 1. When using analogous regular logit models, coefficients tended to be very close to the PMLE estimates, and statistical significance was apparently not affected except on the margins.

Traditional regression models often have limits when “the relationship between features is nonlinear or where features interact with each other” (Molnar 2025: 83). Classification trees and regression trees seek to address this issue. Moreover, as more generally noted by Ludwig and Mullainathan (2024), it can help that “machine learning algorithms (...) notice patterns people might not”.

The conceptual starting point is the possibility of creating “classification trees” which “[segment] the predictor space into a number of simple regions” (James et al. 2021: 327) based on variable values. At each node, the observed units are split into two branches

depending on a cutoff for a single variable value. A classification tree algorithm iteratively builds a tree to split the dataset into regions that minimise a measure of variance across classes.<sup>10</sup> A user of such a tree could follow the tree from top to bottom and manually assign a firm to one of the terminal node, each of which provides particularly probabilities of belonging to a specific class (here: using a specific board structure). For illustration, Figures A.1 of the Appendix shows a classification tree based on some of our data for the Czech Republic and Italy. The decision-making process of such a tree differs from a regression, among other things, in that it does not assume a linear (or transformed linear) relationship between the dependent and independent variables. Instead, firms are assigned to specific branches of the tree by sequential classifications at each node. Thus, the effect of one variable can depend on the value of another variable at an earlier node. Regressions pick up such interactions only if they are specified in the model.

The random forest model extends the idea of classification (or regression) trees by avoiding some of their disadvantages. While classification trees are quite intuitive, they tend toward overfitting if only a single tree is used (James et al. 2021: 340). Because they are based on a highly specific dataset, they may change significantly if applied to slightly different data, or even because of a different randomisation seed, thus reducing generalisability.<sup>11</sup> A random forest model randomly creates many trees based on the same data (in our case: 500) and aggregates results across those trees. Each tree uses only a randomly chosen set of predictors from the full set of variables for the first split. If there is a single (or there a few) strong predictors, this allows the predictive power of other variables to come to the fore; this is particularly helpful when there are many correlated predictors (James et al. 2021: 345), which is true for our dataset (considering, for example, financial information from multiple years or different indicators of firm size). Thus, each of the trees looks different. For the classification of each firm, our model averages the estimated probability of belonging to each class produced by each tree. We ran random forest models for each country, dropping variables where we did not impute missing values due to the overall small number of available observations (see Section 3.2).<sup>12</sup> We randomly divided each country's firms into a training dataset (80%) and a testing dataset (20%). Dividing the dataset into training and testing data is a common approach to determine whether the model trained on one set of data predicts well outside of it (on splitting the data in machine learning, see generally Gholamy et al., 2018).<sup>13</sup>

Machine learning models such as random forest often can be varied across different tuning parameters that can be varied to find the model that provides the best predictions in the training data. For each country, we used the caret package in R (version 7.0-1) to select the tuning-parameter combination that produced the best cross-validated performance in the training data, measured by the area under the receiver operating character-

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<sup>10</sup> One commonly used measure is the Gini index. See James et al. 2021:336.

<sup>11</sup> There are several ways to address this issue, one of which is the random forest method; see generally Breiman 2001.

<sup>12</sup> The reason here is that we considered the imputation less trustworthy when they were based only on few non-missing data points.

<sup>13</sup> Specifically, we used the caret package in R (version 7.0-1) to train a random forest model of the ranger package (version 0.17.0) on the training data. The ranger package was chosen over the randomforest package because it better supports parallelisation and thus permits faster computation of random forest models.

istic curve (AUC).<sup>14</sup> In our implementation of random forest, the tuning parameters were *mtry*, *split rule*, and *minimum node size*. *mtry* is the number of variables randomly chosen to split the training data at in each node, the *split rule* determines the criterion used to select the best split among those candidate variables, and *minimum node size* specifies the minimum number of observations required in a terminal node (see, e.g., Probst et al. 2019). Because the outcome classes were often imbalanced, we also used *smote* within the training process where feasible. *smote* creates synthetic examples of the minority class in the training data in order to improve the model’s ability to learn patterns associated with that class (Chawla et al. 2002). Finally, we divided the dataset into training and testing data to see whether there are any considerable differences in the predictive qualities (which would indicate overfitting).

## 4. Logistic regression analysis: results and discussion

### 4.1. Regressions results (individual countries and pooled)

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<sup>14</sup> AUC, the area under the receiver operating characteristic (ROC) curve, summarises the model’s ability to distinguish between the two outcome classes across possible probability thresholds.

Table 3: Logistic regression with dependent variable ‘two-tier model’

|                                       | Bulgaria <sup>#</sup> | Croatia <sup>#</sup> | Czech Rep.           | Denmark <sup>#</sup>  | Finland <sup>#</sup> | France               | Hungary              | Lithuania <sup>#</sup> | Luxembourg <sup>#</sup> | Netherlands          | Romania              | Slovenia           |
|---------------------------------------|-----------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|----------------------|------------------------|-------------------------|----------------------|----------------------|--------------------|
| (Intercept)                           | -10.923***<br>(1.301) | 3.923<br>(1.983)     | 1.548***<br>(0.348)  | -10.039***<br>(1.740) | -0.148<br>(2.476)    | -19.594<br>(459.393) | -1.721***<br>(0.418) | -4.565<br>(2.142)      | -10.177***<br>(2.244)   | -3.313**<br>(0.970)  | -0.278<br>(0.322)    | -0.310<br>(1.449)  |
| log (no. shareholders)                | 0.946*<br>(0.299)     | 0.028<br>(0.418)     | 0.402***<br>(0.066)  | -0.061<br>(0.316)     | -1.333<br>(0.668)    | 0.625**<br>(0.174)   | 0.721***<br>(0.076)  | 0.386<br>(0.639)       | 0.443<br>(0.290)        | 0.407*<br>(0.123)    | 0.490***<br>(0.059)  | 0.090<br>(0.204)   |
| Shareholder-directors                 | -3.050**<br>(0.882)   | -1.334<br>(1.128)    | -1.057***<br>(0.063) | -2.553<br>(1.167)     | -10.586<br>(5.045)   | -2.619<br>(0.925)    | -3.565***<br>(0.248) | -2.781<br>(2.588)      | -1.517<br>(0.895)       | -0.992<br>(0.964)    | -1.271***<br>(0.110) | -1.639*<br>(0.479) |
| Female directors                      | 0.021<br>(0.604)      | 2.820<br>(1.167)     | -0.324***<br>(0.059) | 1.721<br>(0.771)      | 1.806<br>(2.267)     | 0.327<br>(0.802)     | 0.395**<br>(0.116)   | 0.430<br>(1.323)       | -1.294<br>(1.182)       | 0.423<br>(0.225)     | 2.018***<br>(0.108)  | 0.469<br>(0.497)   |
| Foreign directors                     | 2.346<br>(0.754)      | 7.197<br>(3.502)     | -0.231<br>(0.106)    | 2.443*<br>(0.563)     | -7.400<br>(5.375)    | 1.920<br>(0.924)     | -0.838*<br>(0.311)   | 1.341<br>(1.349)       | 2.581**<br>(0.613)      | 0.417<br>(0.268)     | -2.460***<br>(0.193) | 2.030<br>(1.528)   |
| Directors with two-tier background    | 1.015<br>(0.932)      | 1.962<br>(1.525)     | 0.403*<br>(0.138)    | 1.325<br>(0.605)      | 16.405<br>(6.073)    | 0.682<br>(0.732)     | 0.320<br>(0.268)     | 1.117<br>(1.202)       | 1.037<br>(0.413)        | 0.516<br>(0.226)     | 0.104<br>(0.254)     | -0.641<br>(0.840)  |
| Shareholders with two-tier background | -0.171<br>(0.483)     | -3.473<br>(1.461)    | 0.134<br>(0.096)     | -0.287<br>(0.441)     | -1.191<br>(1.654)    | 0.121<br>(0.615)     | 0.558***<br>(0.139)  | 0.981<br>(0.781)       | 0.730<br>(0.416)        | 0.435<br>(0.228)     | 0.416**<br>(0.119)   | -0.065<br>(0.771)  |
| Listed                                | 3.012***<br>(0.384)   | 0.395<br>(0.617)     | 10.713<br>(133.528)  | 3.229*<br>(0.780)     | 2.841<br>(1.549)     | 3.740***<br>(0.394)  | 0.635<br>(0.477)     | 4.022***<br>(0.752)    | 3.390**<br>(0.711)      | -0.002<br>(0.352)    | -2.433***<br>(0.167) | 0.601<br>(0.671)   |
| Majority shareholder                  | 1.504**<br>(0.404)    | -1.197<br>(0.606)    | -0.479<br>(0.296)    | 1.509<br>(0.772)      | -1.526<br>(0.981)    | 0.078<br>(0.280)     | -0.071<br>(0.285)    | -0.623<br>(0.864)      | 0.765<br>(0.607)        | -1.112***<br>(0.241) | -0.252***<br>(0.062) | -0.217<br>(0.299)  |
| Industry categories B to E            | -1.411<br>(0.934)     | 0.077<br>(1.422)     | -0.285<br>(0.121)    | -0.416<br>(1.400)     |                      | 12.940<br>(459.393)  | -0.760***<br>(0.156) | 0.996<br>(1.104)       | 0.188<br>(1.563)        | 0.850<br>(0.925)     | -1.142***<br>(0.121) | 0.460<br>(0.754)   |
| Industry category F                   | -0.652<br>(1.080)     | -0.285<br>(1.557)    | -0.329<br>(0.132)    | -1.690<br>(1.889)     | -1.092<br>(1.673)    | 13.114<br>(459.393)  | -1.200***<br>(0.215) | -0.487<br>(1.927)      | -0.046<br>(2.015)       | 1.570<br>(0.970)     | -0.738***<br>(0.134) | 0.129<br>(0.820)   |
| Industry categories G to J            | -1.774<br>(1.021)     | -0.510<br>(1.394)    | -0.375*<br>(0.114)   | -0.184<br>(1.370)     | -1.570<br>(1.291)    | 12.988<br>(459.393)  | -0.808***<br>(0.147) | 0.846<br>(1.295)       | -0.026<br>(1.558)       | 0.566<br>(0.925)     | -0.769***<br>(0.123) | 0.405<br>(0.756)   |
| Industry category K                   | 1.647<br>(0.886)      | -3.625<br>(1.585)    | 0.097<br>(0.165)     | -0.172<br>(1.396)     | 1.501<br>(1.166)     | 12.767<br>(459.393)  | 0.681***<br>(0.151)  | 2.388<br>(1.429)       | 2.578<br>(1.546)        | 0.207<br>(0.915)     | -1.238***<br>(0.247) | 0.391<br>(0.789)   |

|                            |                     |                   |                      |                   |                   |                     |                      |                   |                  |                     |                      |                   |
|----------------------------|---------------------|-------------------|----------------------|-------------------|-------------------|---------------------|----------------------|-------------------|------------------|---------------------|----------------------|-------------------|
| Industry categories L to N | -2.562<br>(1.177)   | -0.645<br>(1.431) | -0.394**<br>(0.112)  | 0.079<br>(1.373)  | 0.902<br>(1.026)  | 13.571<br>(459.393) | -1.108***<br>(0.142) | 0.140<br>(1.415)  | 0.307<br>(1.570) | 0.127<br>(0.919)    | -0.838***<br>(0.126) | 0.234<br>(0.759)  |
| Industry categories O to U | -0.749<br>(1.174)   | -1.235<br>(1.661) | -0.096<br>(0.162)    | -0.927<br>(1.912) | -0.142<br>(1.629) | 14.071<br>(459.393) | -0.140<br>(0.234)    | -0.314<br>(1.918) | 1.789<br>(1.659) | 2.039<br>(0.945)    | -0.791**<br>(0.220)  | -0.229<br>(0.903) |
| Industry categories other  | 2.000<br>(1.692)    |                   | -1.474*<br>(0.527)   | -0.472<br>(1.883) |                   |                     | -11.499<br>(226.688) |                   | 1.136<br>(2.076) |                     | 0.010<br>(0.420)     |                   |
| log (age)                  | 1.228***<br>(0.256) | -0.157<br>(0.401) | 0.299***<br>(0.048)  | 0.392<br>(0.256)  | -0.567<br>(0.580) | -0.278<br>(0.169)   | 0.530***<br>(0.083)  | -0.079<br>(0.350) | 0.515<br>(0.414) | 0.624***<br>(0.079) | 0.244*<br>(0.089)    | 0.376<br>(0.356)  |
| Post-choice                |                     | -0.496<br>(0.863) | -0.947***<br>(0.083) | 1.963<br>(0.672)  | -0.898<br>(1.115) |                     | -0.569***<br>(0.134) |                   | 0.623<br>(0.590) | -0.286<br>(0.230)   | -0.358*<br>(0.130)   | -0.459<br>(0.545) |
| Co-determination required  |                     | 0.691<br>(0.533)  | 0.582***<br>(0.082)  | 1.333*<br>(0.364) | 2.993<br>(1.079)  | 0.270<br>(0.345)    | 1.733***<br>(0.150)  |                   | 0.426<br>(0.821) | 1.817***<br>(0.157) |                      | 0.560<br>(0.295)  |
| AIC                        | 356.349             | 175.273           | 17104.408            | 432.944           | 80.049            | 692.753             | 4898.570             | 86.020            | 245.655          | 2118.858            | 7724.720             | 504.401           |
| Pseudo R2                  | 0.502               | 0.174             | 0.098                | 0.183             | 0.244             | 0.407               | 0.279                | 0.510             | 0.408            | 0.297               | 0.175                | 0.099             |
| Num. obs.                  | 8486                | 654               | 17182                | 35328             | 240               | 15025               | 5756                 | 280               | 7015             | 3275                | 6742                 | 486               |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. Significance levels are based on the Holm-Bonferroni correction to account for the multiple comparisons problem. In countries marked with #, we used Firth's Bias-Reduced Logistic Regression, which uses a penalty function to account for the small number of observations in one group (PMLE). Otherwise, we use conventional logistic regressions.

Table 4: Pooled logistic regressions with dependent variable “two-tier model” (twelve countries) and regressions with dependent variable “new structure” (Italy and Portugal)

|                                       | Twelve Countries    | Italy                | Portugal              |
|---------------------------------------|---------------------|----------------------|-----------------------|
| (Intercept)                           | -5.187<br>(2.634)   | -5.156***<br>(0.643) | -11.501***<br>(1.466) |
| log (no. shareholders)                | 0.719***<br>(0.130) | 0.298**<br>(0.077)   | 1.315***<br>(0.277)   |
| Majority shareholder                  | -0.326<br>(0.171)   | 0.036<br>(0.184)     | 0.495<br>(0.544)      |
| Shareholder-directors                 | -1.378<br>(0.567)   | -1.070**<br>(0.291)  | -2.766<br>(1.642)     |
| Shareholders with two-tier background | 0.298<br>(0.096)    | 0.477<br>(0.390)     | 0.336<br>(0.689)      |
| Foreign directors                     | -0.643<br>(0.643)   | 1.253<br>(0.841)     | 2.520<br>(1.608)      |
| Directors with two-tier background    | 0.510**<br>(0.142)  | 1.747<br>(0.910)     | -2.390<br>(0.984)     |
| Female directors                      | 0.344<br>(0.566)    | 0.219<br>(0.415)     | -1.030<br>(1.332)     |
| Employee board representation         | 1.297<br>(0.476)    |                      |                       |
| Industry categories B to E            | -0.769<br>(0.357)   |                      |                       |
| Industry category F                   | -0.605<br>(0.277)   |                      |                       |
| Industry categories G to J            | -0.605<br>(0.233)   |                      |                       |
| Industry category K                   | -0.047<br>(0.444)   |                      |                       |
| Industry categories L to N            | -0.678<br>(0.273)   |                      |                       |
| Industry categories O to U            | -0.204<br>(0.369)   |                      |                       |
| Industry categories other             | -0.725<br>(3.501)   |                      |                       |
| Post-choice                           | -0.643<br>(0.231)   | 0.340<br>(0.289)     | -0.580<br>(0.891)     |
| log (age)                             | 0.359<br>(0.120)    | -0.035<br>(0.171)    | 0.874<br>(0.360)      |
| Listed                                | -0.457<br>(1.575)   | 0.263<br>(0.525)     | 3.169***<br>(0.671)   |
| Country indicator                     | Yes                 | No                   | No                    |
| AIC                                   | 36648.398           | 2023.947             | 298.553               |
| BIC                                   | 36933.926           | 0.020                | 0.357                 |
| Num. obs.                             | 100469              | 24160                | 22379                 |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. For ‘twelve countries’ bootstrapped standard errors are clustered by country. Significance levels are based on the Holm-Bonferroni correction.

Table 3 reports the individual regression results for the twelve countries with a choice between two board models with positive coefficients indicating a preference for the two-tier structure. Table 4, first, reports regressions that pool the data for all of these twelve countries with a choice between two board models. We add country dummies given the divergent general preferences for the respective board models, as shown in Table 1 (Section 3.1). Second, for Italy and Portugal, Table 4 reports the results for the choice of one of any of the non-traditional models as it can be hypothesised that such cases are similar in that only large companies, perhaps with foreign directors or shareholders, or companies with special governance needs undertake the effort to adopt one of the here atypical models.<sup>15</sup> In the pooled regression, we cluster standard errors by country to account for heterogeneous patterns of variation between countries. Due to the small number of clusters, we use bootstrapping to generate the standard errors. To assess significance, we apply the Holm-Bonferroni correction (reported only in the p values) to account for the multiple comparisons problem.

As this paper aims to identify general patterns of board choice, the pooled regression of Table 4 could be most relevant to this paper. However, despite the country dummies, it is doubtful how meaningful it is to include all countries. Countries do not only differ in their general preference for the board models but also the possible explanations to explain a choice at the firm level. The theoretical framing of this paper (Section 2.2) already pointed towards some possible variations, for example, that there are arguments for or against firms with dispersed shareholder ownership choosing the two-tier model. In the previous paper that focussed on country differences (Gelter and Siems 2021), we found that the situation in Romania is rather atypical (see further Section 4.2). Other countries could also display distinct dynamics for various reasons, for example, France given its long tradition with board choice (Figure 1), the Netherlands given its special requirements for large companies which take away some of the flexibility of the one-tier model (see Section 5.2), Croatia given its very low usage of the one-tier model (Table 1), meaning that many small firms choose the potentially more costly two-tier model, and Denmark and Finland given that their initial one-tier model already had hybrid elements akin to a two-tier model (Gelter and Siems 2021: 148), but also a strong divide between these two countries in terms of using the legal form of the public company for privately held companies (see text following Table 1). For these reasons, we run further regressions where we always omitted one country at a time (see Table A.5 in the Appendix). The variant that excludes Romania, as its omission from the regressions has by far the most obvious effects, confirming that it is likely the most atypical country for board choice.

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<sup>15</sup> This approach was used since, given the low use of the two new models (Table 1), it is difficult to capture differences in the choice of any of the two non-traditional models (i.e. one-tier or two-tier). The Appendix includes further analysis for Italy and Portugal. Table A.6 is based on a logistic two-step regression using the method suggested by Fox and Weisberg (2011: 264), where the first step compares the traditional structure with the two new structures, and the second step looks only at the two different types of new structures. Table A.7 shows the results of multinomial probit regressions, which use a factor variable with three choices as the dependent variable and thus provide statistical inferences for the distinction between the traditional model on the one hand, and each of the one-tier and two-tier systems on the other hand, in a single regression. Results largely confirm those of Table 4.

Thus, as the pooled regression results risk being driven by idiosyncratic reasons for one or few outlier countries with strong results and/or many observations, the following mainly focusses on the results for individual countries as reported in Tables 3 and 4. The country variations in the significance of variables do not come as a surprise, given the large variation in the number of firms per country. This number is further reduced for additional regressions that include the three further variables (foreign shareholders, total assets and employees), reported in Tables A.8 and A.9 of the Appendix. The subsequent text also explains, however, that some of the diverging results are not simply due to differences in observations but related to the countries in question.

Logistic regression results cannot be interpreted effects independently from the current values of an observation. An intuitive interpretation is provided by interpreting coefficients as multiplicative changes in odds ratios, where an odds ratio of  $>1$  (corresponding to a coefficient of  $>0$ ) indicates an increase, and an odds ratio of  $<1$  (corresponding to a coefficient of  $<0$ ) a decrease.<sup>16</sup> Table 5 looks at the effects of variables that are frequently significant and have similar effects across countries.

*Table 5: Effect sizes of selected variables*

| Variable                             | Countries              | Coefficient ( $\beta$ ) | Approximate effect size                                                                                                                |
|--------------------------------------|------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Shareholder-directors                | BG, CZ, HU, RO, SI     | -3.050 to -1.057        | Firms with 0% shareholder-directors have 3-20 times higher odds of the two-tier model compared to firm with 100% shareholder-directors |
| Listed                               | BG, DK, FR, LT, LU     | 3.012 to 4.022          | Listed firms have 20-55 times higher odds to have the two-tier model (opposite effect in RO)                                           |
| Co-determination required            | CZ, DK, HU, NL         | 0.582 to 1.817          | Firms with mandatory codetermination have 1.8-6 times higher odds of the two-tier model                                                |
| Log (no. shareholders) <sup>17</sup> | BG, CZ, FR, HU, NL, RO | 0.402 to 0.946          | Doubling the number of shareholders is associated with the odds of the two-tier model being 32% and 93% higher                         |
| Log (age)                            | BG, CZ, HU, NL, RO     | 0.244 to 1.228          | Doubling the age of the firm is associated with odds that are between 18% and 134% higher                                              |

For the two countries with three options, these results translate into an about 22-23% (Italy) or 148%-158% (Portugal) increase in the odds of the new structure when the number of shareholders doubles. In Italy, a firm with only shareholder-directors is about 1/3 as likely as a firm with no shareholder directors to have chosen one of the “new” board models. In Portugal, listed firm has about 24 to 35 times higher odds of using a new structure than a non-listed company.

<sup>16</sup>  $OR = e^{\beta}$ . I.e., the odds ratio is computed by taking the coefficient as the exponent to the basis of the natural logarithm.

<sup>17</sup> With a log-transformed independent variable, the effect  $d$  of a multiplicative change  $k$  in the underlying variable can be computed as follows:  $d = k^{\beta}$ . E.g.  $2^{0.402} = 1.321$ , where a doubling of the underlying independent variable is associated with a 32.1% increase in the odds.

#### 4.2. Discussion of the main regression results

In the category “shareholders”, two of the variables show results for many countries. First, the higher total number of shareholders is associated with the two-tier system in six countries (and it is also significant for the choice of a non-traditional model in Italy and Portugal). This model may better help diverse groups of shareholders to monitor and make their voice heard without being granted management rights. It seems particularly likely when representatives of minority shareholders are appointed to the supervisory board, either through an informal arrangement, a shareholder agreement, or a legal requirement (TSG Baltic 2018: 85–88 provides an overview on appointment rights). Another argument could be that firms with more shareholders tend to be larger firms, which requires a more extensive supervision of management and, thus, the use of the two-tier model.<sup>18</sup>

The second variable is the one on “shareholder-directors” which is significant with a negative sign for six of the countries. Thus, firms with shareholders and directors being the same persons tend to prefer the one-tier model, or, for Italy, the traditional model. This is plausible, in particular as many of such firms are likely to be family-type businesses (as common in Europe, see Section 3.1) that may prefer to maintain close control over the management of the company. In other cases, too, it may be regarded as beneficial that the one-tier model puts non-executive directors into closer proximity to business decisions.

By contrast, for the presence of a majority shareholder, only the results for the Netherlands and Romania seem to confirm the intuition that firms with more dispersed shareholder ownership want to implement a structure with a supervisory board to monitor management. For other countries, the subsequent random forest analysis will, however, provide some further insights. The national background of the foreign shareholders only shows significantly with the expected positive signs for Hungary and Romania. Cautiously, this may be interpreted as being due to the influence of foreign investors in late transition economies; yet it does not show for other countries from Central and Eastern Europe, where this coefficient is insignificant and/or negative.

In the category “directors”, the variable indicating whether the number of employees exceeds the legal threshold for employee board representation is significant, with the expected positive sign, in three countries. Thus, this confirms the hypothesis that some companies use the two-tier model to reduce the powers of employee representatives by limiting them to the supervisory board (Section 2.2). Hungary is one of the three countries; yet the Hungarian law on this topic is more complex as it allows considerable flexibility, mainly for one-tier boards but also two-tier ones if the company’s work council approves the lack of employee participation (for details see Neumann 2018): thus, more data on the precise nature of worker participation in individual companies would be needed.

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<sup>18</sup> This finding seems to be confirmed by the additional regressions, which also include two size-related variables (assets and employees), as the variable on the total number of shareholders only remains significant in three out of these eight countries (Tables A.8 and A.9); however, this result may also be due to the lower number of observations in these additional regressions; the variables on assets and employees also have some inconsistent signs, as discussed at the end of this Section 4.2.

The results for the other director-related variables are rather idiosyncratic. The variables on foreign and female directors are sometimes significant but with inconsistent signs.<sup>19</sup> With respect to foreign nationality, only the data for the rare use of the two-tier model in Denmark and Luxembourg seems to confirm the hypothesis that such complexity tends to lead to the preferred use of two boards. The further analysis of the national background of the foreign directors only shows a significant positive sign for the Czech Republic. However, contrary to the corresponding data for shareholders, the signs of the other countries are also positive, and there is a significant positive sign for directors with two-tier background in one of the pooled regressions. Thus, with caution, it may be said that foreign directors are more likely to drive a particular model than foreign shareholders. With respect to female directors, the inconsistent findings will be revisited in the random forest analysis (which indeed show that some patterns can be observed).

Finally, for the category “types of firms”, company age is significant for many countries with a positive sign. Thus, older companies are more likely to be two-tier companies, and younger companies are more likely to be one-tier companies. This confirms prior research (Gelter and Siems 2021 and 2024) about a decline of the two-tier model in countries with board choice. This result is most plausible for countries which recently introduced the one-tier model (Czech Republic and Hungary); yet we also see it for three other countries (Bulgaria, the Netherlands and Romania). Here, a possible interpretation is that, as companies grow older and the founding generation retires, agency costs increase, and a greater need for a strict division between management and supervision arises. The variable on post-choice establishment shows a significant effect for three countries. This decline of the two-tier model is most plausible for the Czech Republic and Hungary, as they used to have only the two-tier model. By contrast, Romania was originally a one-tier country; however, there are special reasons to be considered here, as explained in the following.

The variable on “listed” shows that, in five countries (Bulgaria, Denmark, France, Lithuania and Luxembourg), *ceteris paribus*, listed companies are more likely to choose the two-tier model. This is likely to reflect a greater need of listed companies to have a more structured supervision of their management. As listed companies often have professional executives, there is also a lesser need to be able to combine the positions of being both an executive and a director of the company. It is also noteworthy that all of these countries initially either had the one-tier model or always some form of choice. In other words, listing is not significant for the traditional two-tier countries; thus, here, even non-listed public companies frequently decide to remain faithful to the established two-tier structure. Listing is also significant in Portugal for the choice of a non-traditional model. Thus, here, a plausible interpretation is that only listed companies tend to undertake the effort to scrutinise whether it is worth adopting the here unusual one-tier or two-tier model.

The one country that deviates from many of these findings is Romania, where two-tier companies tend to be non-listed, and they also tend to have smaller assets and a lower

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<sup>19</sup> Note that our data predate the effect of Directive (EU) 2022/2381 of the European Parliament and of the Council of 23 November 2022 on improving the gender balance among directors of listed companies and related measures, which was to be implemented by companies by July 2026.

number of employees (extended regression in Table A.9 of the Appendix). In this regard, is helpful to refer to the findings of one of the companion papers which provided a descriptive analysis of firms based on their time establishment (Gelter and Siems 2021: 182–184). Here, the Romanian data reveals that more than one-third of its public companies were established in the early 1990s. Among the firms with a founding date between 1991 and 2000, more than 60% use the two-tier system in all years except 1998. For companies founded in 2006 or later, the annual percentage ranges from 29.7% to 47.7%. All of the older firms must have switched to the two-tier model after its introduction in 2006. Very likely, these companies were former state enterprises which were directly transformed into public companies, initially often with significant state ownership. The subsequent use of the two-tier model was not due to legal requirements; rather, Romanian corporate law experts have suggested to us that politicians and state officials were keen on obtaining positions on these companies’ supervisory boards (Gelter and Siems 2021: 183). Thus, it is these small- to medium-sized non-listed companies that drive the results regarding preferences for the two-tier model in Romania.

For other countries, the variable on assets is positive and significant for Hungary, the Netherlands and Portugal, possibly as larger firms more often have a two-tier board to ensure more extensive supervision of management; however, the fact that the variable on the number of employees has some significant negative signs puts doubts on the hypothesis that the one-tier/two-tier use is simply a reflection of the size of companies.

The variables for industry are significant for some of the countries that have a relatively large number of companies with different board structures in our dataset. Thus, it seems plausible to say that some of these firm characteristics can determine the board structure; yet it is difficult to identify clear patterns, in the sense that companies from particular industries tend to choose a particular board model. Here too, however, the random forest analysis has been able to produce further insights which hold for many of the countries, as we will see in the following.

Overall, the main results of the regression analysis are in the first and third categories. The results on shareholders confirm the principal-agent theory (see Section 2.2) as far as having more shareholders is associated with the two-tier and more shareholder-directors with the one-tier model. The main results in the category “types of firms” are a confirmation of the decline of the two-tier model with the introduction of board choice as well as a continued preference of listed companies for the two-tier model. Most of the findings are consistent across countries; yet, we also noted the exception of Romania as well as some inconsistent signs (in particular, for the variables on foreign and female directors).

## **5. Random forest analysis: results and discussion**

### *5.1. Model training and performance metrics*

Table 6 presents summaries for the random forest models. For the choice between three board models in Italy and Portugal, random forest would in principle be capable of predicting three classes; yet this was not in practice workable given the small number of

firms that have the one-tier or two-tier structures. Thus, similar to the regression analysis, we used the distinction between the board-of-auditors model on the one hand and the two new structures on the other hand as our two classes to be predicted.

Table 6: Model summary for individual countries

| Country | smote | data  | N One-Tier* | N Two-Tier** | N Predictors | mtry | split rule  | min node size | positive class | AUC   | Sensitivity | Specificity | Accuracy |
|---------|-------|-------|-------------|--------------|--------------|------|-------------|---------------|----------------|-------|-------------|-------------|----------|
| BG      | Yes   | train | 5,973       | 45           | 167          | 43   | ex-tratrees | 1             | Two-Tier       | 0.993 | 0.556       | 0.995       | 0.992    |
|         |       | test  | 1,486       | 11           |              |      |             |               |                | 0.994 | 0.727       | 0.992       | 0.990    |
| CZ      | Yes   | train | 2,383       | 7,178        | 162          | 42   | gini        | 1             | One-Tier       | 0.716 | 0.258       | 0.947       | 0.775    |
|         |       | test  | 573         | 1,822        |              |      |             |               |                | 0.714 | 0.277       | 0.948       | 0.788    |
| DK      | Yes   | train | 27,699      | 26           | 152          | 2    | gini        | 1             | Two-Tier       | 0.794 | 0.077       | 0.997       | 0.996    |
|         |       | test  | 6,897       | 5            |              |      |             |               |                | 0.862 | 0.000       | 0.999       | 0.998    |
| FI      | No    | train | 188         | 4            | 144          | 144  | ex-tratrees | 1             | Two-Tier       | 0.676 | 0.000       | 0.989       | 0.969    |
|         |       | test  | 42          | 2            |              |      |             |               |                | 0.655 | 0.000       | 1.000       | 0.955    |
| FR      | Yes   | train | 11,194      | 67           | 177          | 2    | ex-tratrees | 1             | Two-Tier       | 0.912 | 0.731       | 0.976       | 0.975    |
|         |       | test  | 2,799       | 24           |              |      |             |               |                | 0.933 | 0.833       | 0.977       | 0.976    |
| HR      | No    | train | 15          | 463          | 156          | 40   | ex-tratrees | 1             | One-Tier       | 0.637 | 0.000       | 1.000       | 0.969    |
|         |       | test  | 5           | 115          |              |      |             |               |                | 0.675 | 0.000       | 1.000       | 0.958    |
| HU      | Yes   | train | 2,486       | 1,206        | 166          | 166  | ex-tratrees | 1             | Two-Tier       | 0.908 | 0.751       | 0.877       | 0.836    |
|         |       | test  | 639         | 304          |              |      |             |               |                | 0.898 | 0.704       | 0.890       | 0.830    |
| LT      | No    | train | 169         | 12           | 144          | 73   | ex-tratrees | 1             | Two-Tier       | 0.972 | 0.333       | 0.982       | 0.939    |
|         |       | test  | 40          | 2            |              |      |             |               |                | 0.925 | 0.500       | 0.975       | 0.952    |
| LU      | Yes   | train | 4,656       | 18           | 139          | 2    | gini        | 1             | Two-Tier       | 0.982 | 0.722       | 0.986       | 0.985    |
|         |       | test  | 1,170       | 4            |              |      |             |               |                | 0.967 | 0.500       | 0.979       | 0.977    |
| NL      | Yes   | train | 2,182       | 439          | 117          | 30   | gini        | 1             | Two-Tier       | 0.924 | 0.640       | 0.951       | 0.899    |
|         |       | test  | 544         | 110          |              |      |             |               |                | 0.947 | 0.700       | 0.961       | 0.917    |
| RO      | Yes   | train | 2,092       | 2,406        | 180          | 91   | ex-tratrees | 1             | One-Tier       | 0.914 | 0.858       | 0.843       | 0.850    |
|         |       | test  | 545         | 593          |              |      |             |               |                | 0.906 | 0.840       | 0.825       | 0.832    |
| SI      | Yes   | train | 83          | 283          | 159          | 119  | ex-tratrees | 1             | One-Tier       | 0.706 | 0.313       | 0.859       | 0.735    |
|         |       | test  | 19          | 67           |              |      |             |               |                | 0.642 | 0.421       | 0.761       | 0.686    |
| IT      | Yes   | train | 18,855      | 141          | 183          | 92   | gini        | 1             | New            | 0.682 | 0.000       | 1.000       | 0.993    |
|         |       | test  | 4,752       | 28           |              |      |             |               |                | 0.529 | 0.000       | 1.000       | 0.994    |
| PT      | Yes   | train | 14,533      | 19           | 176          | 2    | ex-tratrees | 1             | New            | 0.993 | 0.684       | 0.996       | 0.996    |
|         |       | test  | 3,651       | 9            |              |      |             |               |                | 0.872 | 0.556       | 0.998       | 0.997    |

For IT and PT the data for \* refer to the traditional model and \*\* to either of the two new models (one-tier or two-tier)

Table 6 shows that, in some countries, some of the classes are too small to populate both the training and testing datasets with reasonable numbers of observations in each class. The predictive success of the algorithm also varies considerably. While overall measures such as AUC (area under the curve) – which was used to select the final model – and predictive accuracy are very good, this is not true in some countries when we look at sensitivity, which is the percentage of correctly predicted observations in the smaller class. In some classes, the overall (unweighted) accuracy is very high because the algorithm always predicted the majority but never the minority class, thus leading to a very small (or zero) sensitivity.

The predictive power of the models varies considerably between countries. Generally, we would want to see high values (close to 1) on all four measures. By itself, a high (un-weighted) accuracy can be misleading, as by far most observations are in one category, and the model predicts the other (minority) category relatively badly. While all models have a high specificity (defined as the percentage of correctly predicted observations in the larger category), some have a relatively low sensitivity, i.e., they predict the minority category badly. It is important to note that, in principle, it would be possible to reach higher sensitivity for virtually all countries by not dividing our firms into training and testing data. However, this could create concerns about overfitting if the model nearly perfectly predicted the existing firms but were not generalisable to other firms that are not on our list. It is of course true that our dataset comprises all currently existing firms, but a nearly perfect fit could be a largely random snapshot not reflecting and deeper patterns, for example, where the model is largely determined by very specific industry variables. This appears not to be the case in our models, which are built with the training data but do not predict considerably worse in the testing data where measures such as sensitivity do not drop off to a considerable degree and, thus, overfitting is not a concern.

Looking at individual countries, we can identify three groups in terms of sensitivity: high (Bulgaria, France, Hungary, Luxembourg, Netherlands, Romania), medium (Czech Republic, Lithuania, Slovenia) and low (Croatia, Denmark, Finland). Among the three-structure countries, we would categorise Portugal as high and Italy as low. In the “medium” countries, the model predicts the smaller board category comparatively badly, in the “low” category hardly or not at all (in several countries not even in the training data). This may suggest that, in Croatia, Denmark, Finland and Italy, firms using different board models are not materially very different. This is itself an interesting result.

## 5.2. *Discussion of main SHAP results*

As the primary goal of machine learning models is prediction, data scientists are often not particularly interested in interpreting the model. However, to be useful for research questions such as ours, it helps to have interpretative tools available that make them more comparable to traditional statistical inference or econometrics. One way to make individual features of a machine learning model interpretable is the SHAP framework (Lundberg and Lee 2017). SHAP (SHapley Additive exPlanation) Values are the “Shapley values of a conditional expectation function of the original model”, whereby the “original model” refers to the random forest or other machine learning model for which SHAP values are calculated (Lundberg and Lee 2017). The concept of Shapley values was developed to find a fair distribution of an outcome over different inputs in the context of game theory (Molnar 2025: 165). For example, if several workers contribute to a particular project, it can show how much each worker should receive of the profit (Shapley 1951). Shapley values are “the average marginal contribution[s] to the feature value across all possible coalitions” (Molnar 2025: 166). An example in the context of corporate governance is provided by Zingales (1995), who uses the Shapley value to capture the probability that an individual shareholder’s vote is pivotal in a contest for corporate control, and thus to proxy the marginal value of voting rights.

For the computation of the SHAP value for a specific feature for a specific observation (note: “feature” is the preferred term for “independent variable” in machine learning), we compare versions of the model that include that feature with all other alternative models that omit the feature. Simply put, the SHAP value is the added contribution of the models including the feature, relative to those models without it.<sup>20</sup> For the purpose of calculating SHAP values within a reasonable time, we re-estimated each random forest model with only the top 30 variables (by permutation importance). We then estimate SHAP values for the observations in the testing data for the 30 top variables (as reported by the random forest model using the permutation measure) in each model.

SHAP values can be interpreted intuitively to represent the contribution to the model prediction, which in our case is a probability. Starting from the average predicted probability (based on the training data), the SHAP value of each variable for one observation is how much the variable increased or decreased the predicted probability of a two-tier prediction, or for Italy and Portugal, the probability of a non-traditional model (starting from the average value for the country).<sup>21</sup> In other words, the model’s baseline prediction plus the sum of the SHAP values across all variables for one observation add up to the predicted probability for that observation.

These SHAP values can be visualised by country through SHAP summary plots, explained and displayed in the Appendix of this paper (Figures A.2.1 to A.2.14). Another way of presenting these results is by displaying SHAP dependence plots for individual variables. For the purposes of this paper, these SHAP variable plots are particularly suitable as they also enable to comparison between variables across countries. They show the feature values on the x-axis and the corresponding SHAP value on the y-axis (meaning that SHAP values on top of each graph push the prediction for the firm toward the two-tier model). While the data are the same as in the SHAP summary plots, they highlight whether particular values (or ranges of values) frequently show a strong impact on the prediction (in either direction). These charts can also help to illustrate non-linear relationships, show break points in the effect of a particular feature, and identify possible interactions (for example, when SHAP values for a particular feature value differ strongly). To aid interpretation, the subsequent SHAP variable plots include a GAM smoother that visually summarises the association between feature values and their corresponding SHAP contributions. The smoother is not part of the random forest estimation and does not affect the calculation of SHAP values.

The Appendix of this paper (Figures A.3.1 to A.3.14) includes SHAP variable plots for each of the countries. The remainder of this section shows two combined figures, each containing nine charts. They show a selection of findings where the SHAP plots provide insights that go beyond the findings of the regression results. We show only selected re-

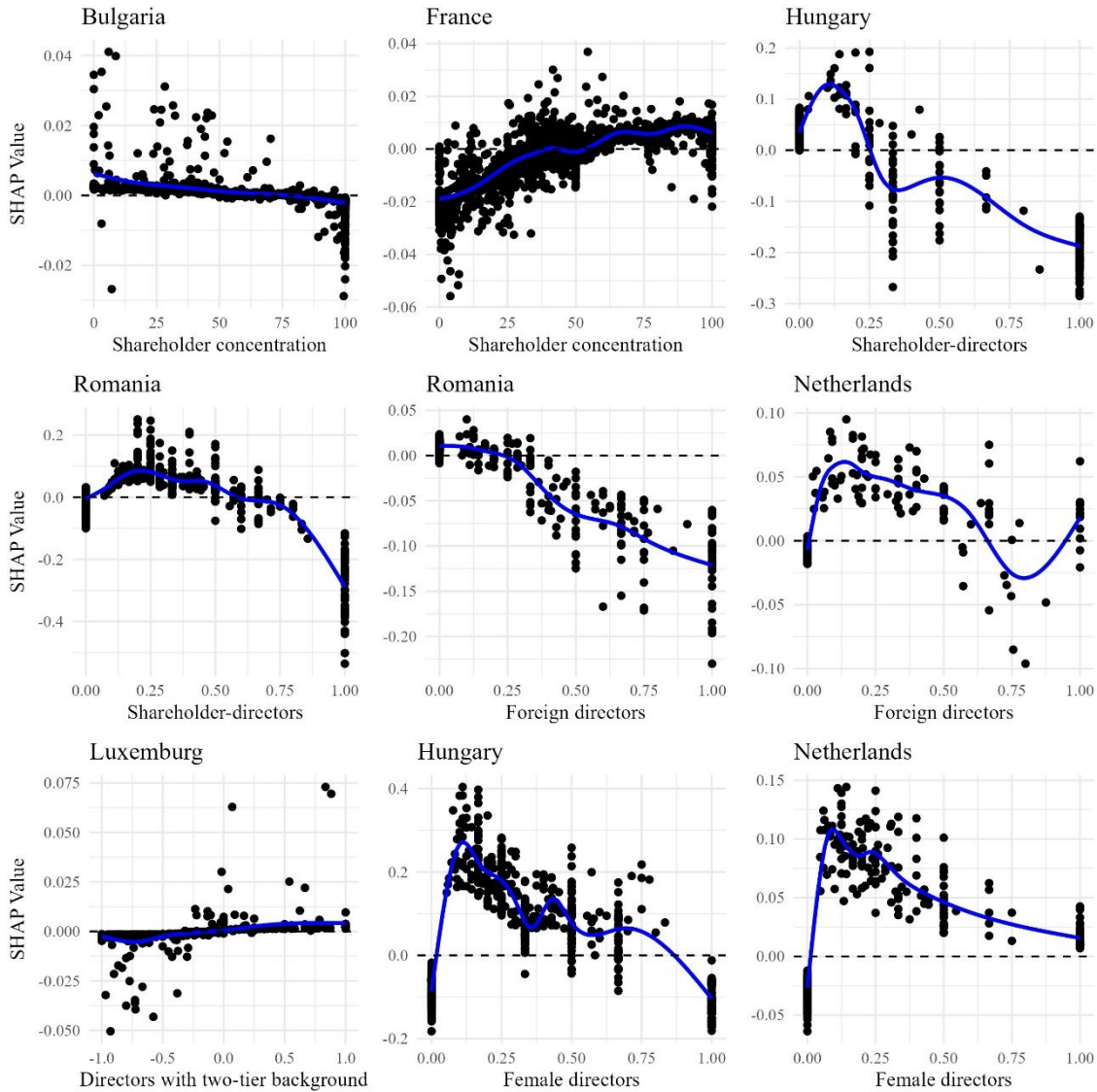
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<sup>20</sup> There are different sampling methods to calculate or estimate SHAP values; we use Kernel SHAP (Lundberg & Lee, 2017), again because it permits parallelisation and is compatible with ranger. In theory, treeshap, which computes SHAP values for tree-based models, might be preferable, but it does not natively permit parallelisation.

<sup>21</sup> <https://www.aidancooper.co.uk/a-non-technical-guide-to-interpreting-shap-analyses/>. In the legal context, see also Langenbucher 2026:196–197.

sults from countries with high sensitivity of the models (Section 5.1). The choice of the charts also considered whether they are in the top 1% ranks in terms of the mean absolute SHAP value (as indicated in Figure A.2) and whether they refer to variables that have, generally speaking, low levels of imputation (following on from Section 3.3).<sup>22</sup> Methodologically, we also need to restate that random forest analysis does not provide significance levels akin to inferential tests (see Sections 1 and 3.3). Thus, even showing a clear pattern from random forest finding provides a different type of information than a significant result of a regression analysis.

Figure 2: Selected SHAP variable plots for categories “shareholders” and “directors”



<sup>22</sup> For 16 of the 18 data shown in Figures 2 and 3, the extent of imputation is below 1%. The only higher ones are shareholder-concentration in France (22.62%) and cash ratio for Hungary (5.93%). For the precise data see Table A.10.

*Note:* positive values on the y-axis indicate that the value of a particular variable, *ceteris paribus*, increases the probability of the two-tier model in the prediction for a specific firm in the testing data, and, vice versa, that negative values increase the probability of the one-tier model, by the amount of the SHAP value.

Figure 2 combines information on selected results in the categories “shareholders” and “directors”. For shareholder concentration, the Bulgarian data show the expected result that high concentration is associated with a higher use of the one-tier model which enables the one or few shareholders to directly influence management (likewise for Lithuania and Slovenia, Figures A.3.8 and 3.12). However, it may be surprising that the French data go in a different direction, albeit with some variations. Similarly, Belot et al. (2014: 376) found a statistically significant higher likelihood that, in France, closely held firms utilise the two-tier model. They explained this finding by arguing that this board structure “encourages managerial initiative”, whereas the “members of the control group are represented on the supervisory board”. Yet, such a line of reasoning cannot explain the difference from other countries. A possible reason may be that, generally speaking, France has larger and older firms than countries in Central and Eastern Europe (see the descriptive statistics in Table A.3.1), and these firms may have often simply retained their initial board model over time, regardless of any changes to their shareholder structure.<sup>23</sup>

The next charts for Hungary and Romania confirm that the presence of shareholder-directors is generally associated with predicting the one-tier model (likewise for the Czech Republic and Slovenia, Figures A.3.3 and 3.12). However, it can also be seen that with no shareholder-directors the one-tier model is somewhat more common than with a low percentage of shareholder-directors. Thus, the model points towards predicting the two-tier model most strongly in firms with a small – but non-zero – percentage of shareholder directors. The likely reason is that two-tier companies are typically larger ones, and here some executive board members may hold a small number of shares as part of employee stock ownership plans (ESOPs).<sup>24</sup>

With respect to foreign directors, it would be most interesting if the decision for one of the board models could be tied to the nationality of the directors. However, in the data and the SHAP charts of Figure 2, the variable “directors with two-tier background” is only shown for one country (Luxembourg) and has a fairly weak effect here. Considering foreign directors in general, the finding that in Romania having a high proportion of foreign directors is related to the choice of the one-tier model is in line with the results of the regression analysis.

For foreign directors in the Netherlands, Figure 2 shows an inverse S-curve. Further analysis identified an interaction between the foreign directors and the listed variable. Among the firms in the range of 0.5 to 0.8 foreign directors, most firms where the SHAP value is negative are actually listed firms, while all those with a positive SHAP value are uniformly non-listed. By contrast, where foreign directors are below 0.5, both listed and non-

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<sup>23</sup> E.g., Peugeot S.A. had up to its merger with Fiat in 2020 a two-tier structure, chosen in 1972: see page 34 of [https://www.stellantis.com/content/dam/stellantis-corporate/sustainability/csr-disclosure/psa/groupe\\_psa\\_2020\\_csr\\_report.pdf](https://www.stellantis.com/content/dam/stellantis-corporate/sustainability/csr-disclosure/psa/groupe_psa_2020_csr_report.pdf).

<sup>24</sup> For data see the European Federation of Employee Share Ownership (EFES), [www.efesonline.org](http://www.efesonline.org).

listed firms have positive SHAP values.<sup>25</sup> With some caution, this can be interpreted as follows: if there are no foreign directors, these are small companies for which the use of the one-tier model is most plausible. If there is a moderate number of foreign directors, complexities may arise, pointing towards the benefit of using the two-tier model. However, some very large international Dutch firms use the one-tier model (see Nowak 2013, referring to Unilever and Heineken), tend to have a very international board and follow international corporate governance practices. Moreover, as Dutch law contains certain requirements for the one-tier model of large public companies (e.g., on non-executive directors),<sup>26</sup> the choice of this model can also fulfil the signal of a structured corporate governance, usually associated with the two-tier model. Finally, firms with only foreign directors are likely to be companies without a strong connection to the Netherlands, and it is therefore fairly open which board model they choose.

The findings of regression analysis for female directors were found to be “rather idiosyncratic”, in particular due to inconsistent signs (Sections 4.1 and 4.2). By contrast, the two SHAP charts for Hungary and the Netherlands have a broadly similar shape, namely an asymmetric peak with a long right-tail decline.<sup>27</sup> Thus, firms with only male or only female directors are more strongly associated with the one-tier model compared to other companies. Such a situation is obvious for situations where one-tier boards of public companies are permissible with just one director.<sup>28</sup> When there are more directors, it is plausible that more diverse boards point towards the use of the two-tier model as supervisory boards are often a means to bring in outsiders, ie that there is a downward slope (similar Drazkowski et al. 2024: 16: management boards more often without women than supervisory boards). There is also some evidence of gender homophily on corporate boards (Richardson 2017), meaning that at least some directors may prefer to work closely together in a single board of directors with individuals of the same gender.

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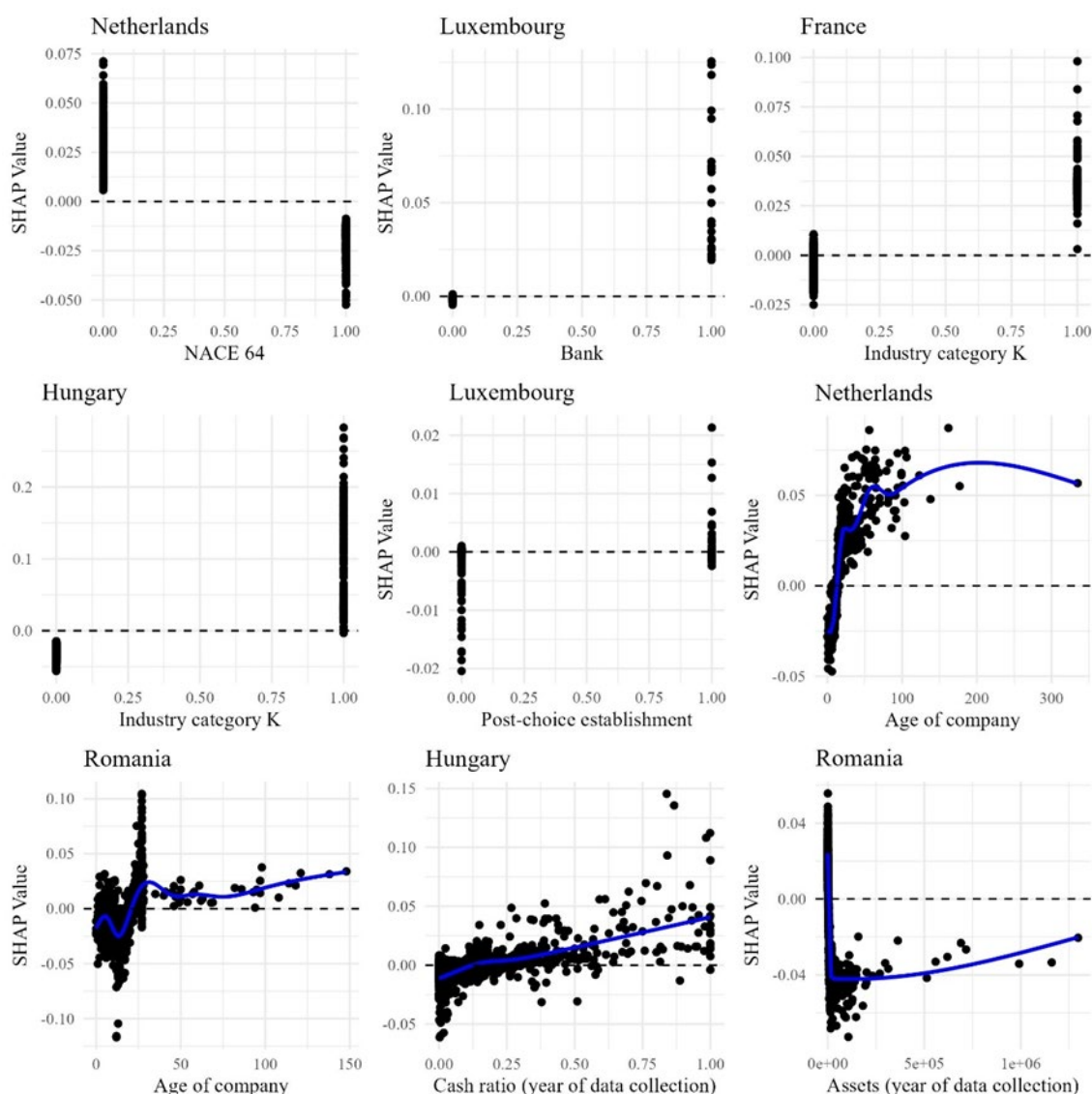
<sup>25</sup> We observed this by visually displaying interactions between variables in the SHAP plots (omitted for the purposes of this paper but available on request).

<sup>26</sup> Following the Royal Decree of 6 June 2011, amending the Civil Code, companies that fall under the so-called “structure regime” are (only) allowed choice of the one-tier model under certain restrictions (e.g., requiring non-executive directors).

<sup>27</sup> The latter can also be seen for Bulgaria, Romania and Slovenia, see Figures A.3.1, 3.5 and 3.12. By contrast, the Czech results of the variable on former female directors, Figure A.3.3, show the reverse shape, which is in line with its regression results, see Section 4.1.

<sup>28</sup> Out of the fourteen countries analysed here, this is the case for the Czech Republic, Finland, Hungary, the Netherlands and Romania (see the comparative table in Gelter and Siems 2021: 164).

Figure 3: Selected SHAP variable plots for category “types of firms”



*Note:* positive values on the y-axis indicate that the value of a particular variable, ceteris paribus, increases the probability of the two-tier model in the prediction for a specific firm in the testing data, and, vice versa, that negative values increase the probability of the one-tier model.

For “types of firms”, Figure 3 shows a selection of findings that go beyond the regression result. In addition, many of the findings of the Appendix show that “listed” is among the top variables, with the expected result that listed companies are more likely to be two-tier companies with the exception of Romania (see Figures A.3.1, 3.6, 3.8 and 3.11 for Bulgaria, France, Lithuania and Romania).

While the regression results for the industry variables, industry variables feature in many of the SHAP plots for the top variables (see Figures A.3). Some of them are specific in pointing towards certain NACE codes (e.g., NACE 46 on wholesale trade for the Czech Republic; NACE 82 for office administration for Luxembourg; various NACE codes for

Portugal). In several countries, the SHAPs also include the consolidated category for the high-skilled services sector (“L to N”). Here, the general preference for the one-tier model aligns with the expectation that R&D-intensive firms prefer this model (Section 2.2).<sup>29</sup>

Figure 3 reports the industry findings related to the financial industry. The Orbis variables included here have different nuances: NACE 64 specifically codes “financial service activities, except insurance and pension funding”, and there is also a special variable for banks. The NACE-based classification K is wider as it covers all “financial and insurance activities”. Generally, these variables contribute to predicting a higher probability of the two-tier model (likewise Figure A.3.1 for Bulgaria and, for one of the non-traditional models, Figure A.3.14 for Portugal). The intuitive explanation is that the two-tier model is appreciated by banks and other financial firms due to their need for stronger oversight. Yet, we have also seen that the previous trend towards the use of the two-tier model by Italian banks has subsequently been reversed (Section 2.2). There is also the exceptional case of the Netherlands where firms of the financial services industry prefer the one-tier model. This is unlikely to be due to the largest Dutch banks as those follow the two-tier model (e.g. ING, ABN AMRO, BNG). The Netherlands is, however, also a major jurisdiction for financial conduit companies established for tax reasons (see e.g. Garcia-Bernardo et al. 2017). For them, the desire to have an inexpensive board structure with full control indeed points towards the use of the one-tier board structure.<sup>30</sup>

For the variable “post-choice establishment”, Figure 3 shows for Luxembourg the expected positive impact for the two-model as it used to only allow the one-tier model (Figure 1). Some of the other SHAP plots, shown in the Appendix, are less clear as they show both of the variables “post-choice establishment” and “post-SE introduction establishment” among the most impactful variables. The latter date could have played a role for countries with a long tradition of board choice (e.g. France), where the Europe-wide introduction of choice through the European Company (SE) in 2004 (Section 2.1) may have stimulated the visibility of this option. However, in the SHAP plots, the post-SE variable mainly appears for countries where the introduction of choice happened in a similar period but just a few years later. Thus, the more likely explanation is that this is due to the fact that the Orbis date of incorporation sometimes refers to the prior establishment of the firm in another legal form (see Section 3.2). In other words, this variable shows a greater impact than would otherwise be expected because a public company was actually established a few years earlier as a private company and that it is this date which broadly coincides with the earlier date of SE choice in this country.<sup>31</sup>

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<sup>29</sup> For details see the Figures A.3.3, 3.9 and 3.12 for the Czech Republic, Luxembourg and Slovenia in the Appendix. The exception are French firms, Figure A.3.6, which prefer the two-tier model. This could be since these are older firms than in the other countries. As the “L to N” category includes many types of industries, there could also be variations within this category.

<sup>30</sup> Interestingly, two-tier firms in the Dutch NACE 64 category have about 17.06% foreign directors/managers (compared to 6% among one-tier firms); by contrast, we observe only 23.14% foreign share ownership (compared 29.12% among one-tier firms). But we also note that there are some difficulties with the comparison: we have far more one-tier Dutch financial firms in our dataset (1,677 compared to 134 two-tier firms), and, while we have no missing data for directors/managers, for a larger number of one-tier firms the share ownership figure is missing (likely because many of these firms are relatively small).

<sup>31</sup> For example, for Hungary the difference between 8 October 2004 (SE choice) and 1 July 2006 (general choice) may explain the opposite colourings of these variables in Figure A.3.7 of the Appendix.

Figure 3 also displays two SHAP charts on the “age of the company”. Notwithstanding the aforementioned proviso about the Orbis data, the following interpretations can be made. For the Netherlands, it makes sense that the two-tier model dominates for older companies, as Dutch law, while always having provided some flexibility of board models, only gradually allowed the one-tier model for larger companies (for details see Calkoen 2021). The Romanian data show the prevalence of the two-tier model for older companies (similarly, for “post-choice”, Figure A.3.11). At first sight, this may be puzzling as Romania traditionally only had the one-tier model; however, it aligns with our finding that, in Romania, it was large and older former state-owned enterprises that mainly made use of the two-tier model when it was introduced in 2006 (see Section 4.2).

Some of the SHAP plots include a variety of financial data beyond those used in the regression analysis (in its extended version see Tables A.8 and A.9). Some do not show clear patterns as they are driven by few values (e.g. Figure A.3.9 for Luxembourg). For financial variables, the causality may also go in the other direction (examined in Gelter and Siems 2024). Still, it is generally visible that financial variables that reflect the size of a company are positively related to the choice of the two-tier model: for example, see the variable on cash ratio in Hungary in Figure 3 and further examples in the Appendix.<sup>32</sup> For the Romanian data on assets, the regression analysis found a statistically negative relationship. In other words, in Romania, we have the special situation that the two-tier model is often preferred by smaller companies (historical explanation in Section 4.2). For the corresponding SHAP chart, the predictive contribution of very small firm size varies, given how the SHAP values are spread out across the scale. By contrast, it can be seen that all of the data points for firms with large values are below “0”, thus showing that all but the very smallest firm sizes contribute toward predicting the one-tier model (likewise EBRD 2017: 8: almost all large Romanian companies use the one-tier model).

### 5.3. *Contributions of the random forest analysis beyond the regression analysis*

The results of the random forests, as outlined in the previous section, have, to some extent, complicated the picture as they have shown the possible relevance of further variables, forms of non-linearity and other unexpected findings. They have also complemented the findings of the regression analysis. Thus, beyond the topic of this paper, it was the aim to show that random forest analysis, including its visualisation in SHAP charts, can be a tool to strengthen a nuanced exploratory data analysis where many variables are available and which may interact in a complex manner.

Table 7 aims to clarify the precise contributions that the random forest analysis has made to the empirical findings of this paper. On the one hand, it summarises the main findings of the regression analysis, also indicating where it has remained inconclusive. On the other hand, it presents the key findings of the random forest analysis in terms of modifying the results of the regression analysis as well as showing findings for further variables.

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<sup>32</sup> See the data on operating revenue and assets in Figure A.3.3 for the Czech Republic, on employees and cash holdings in Figure A.3.7 for Hungary, on tangible assets and EBIT for Lithuania in Figure A.3.8, and on cash holdings, equity capital, leverage and tangible assets for the Netherlands in Figure A.3.10.

Table 7: Juxtaposition of main results from regression and random forest analysis

| Catego-<br>ries   | Regression analysis                                                                                                                                                                                                                                                                                                                                                                                                                   | Random forest analysis                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Share-<br>holders | Main findings: <ul style="list-style-type: none"> <li>– <i>More shareholders</i>: two-tier (various countries)</li> <li>– <i>More shareholder-directors</i>: one-tier (various countries)</li> </ul> Less clear: <ul style="list-style-type: none"> <li>– <i>Majority shareholder</i>: two-tier (Netherlands, Romania)</li> </ul>                                                                                                     | Modified findings: <ul style="list-style-type: none"> <li>– <i>Shareholder-directors</i>: in general, positive relation to one-tier confirmed, but different if few shareholder-directors</li> </ul> Findings for further variables: <ul style="list-style-type: none"> <li>– <i>High shareholder concentration</i>: one-tier (various countries); exception: France</li> </ul>                                                        |
| Directors         | Main findings: <ul style="list-style-type: none"> <li>– <i>Employee board representation</i>: two-tier (various countries)</li> </ul> Less clear: <ul style="list-style-type: none"> <li>– <i>Female and foreign directors</i>: inconsistent</li> </ul>                                                                                                                                                                               | Modified findings: <ul style="list-style-type: none"> <li>– <i>Foreign directors</i>: inverse S-curve for the Netherlands</li> </ul> Findings for further variables: <ul style="list-style-type: none"> <li>– <i>Female directors</i>: asymmetric peak with a long right-tail decline for choice of two-tier</li> </ul>                                                                                                                |
| Types of<br>firms | Main findings: <ul style="list-style-type: none"> <li>– <i>Post-choice firms</i>: one tier; as well as <i>age</i> (ie older firms): two-tier</li> <li>– <i>Listed firms</i>: two-tier (various countries) or non-traditional model (Portugal); exception: Romania</li> </ul> Less clear: <ul style="list-style-type: none"> <li>– <i>Industry</i>: no clear patterns</li> <li>– <i>Size-related variables</i>: few results</li> </ul> | Modified findings: <ul style="list-style-type: none"> <li>– <i>Post-choice</i> and <i>age</i>: more complex than results of the regression analysis</li> <li>– <i>Size of firms</i>: two-tier for various size-related variables</li> </ul> Findings for further variables: <ul style="list-style-type: none"> <li>– <i>Financial industry</i>: two-tier; exception: Netherlands; some other <i>industry</i> effects likely</li> </ul> |

In the category “shareholders”, both regression and random forest analysis found that, generally speaking, companies with more shareholders, fewer majority shareholders and less shareholder concentration choose the two-tier model, confirming the principal-agent view of the use of the two-tier model (Section 2.2). In addition, however, the random forest analysis was helpful in extending this finding to further countries and measures but also in modifying the finding where there are no shareholder-directors.

In the category “directors”, the regression results found little beyond the fact that employee board representation is related to the use of the two-tier model (as also hypothesised in the literature, Section 2.2). Thus, the random forest analysis was particularly advantageous here in showing that data on female directors also matter; yet, not in a linear fashion, as explained. It also provided some nuances for data on foreign directors in the Netherlands.

Last but not least, in the category “types of firms”, the regression analysis already presented several findings for the variables on post-choice establishment, age of the firm and listed. Here, the random forest analysis, on the one hand, has shown that there are not only differences between countries but also between different industries: this is a key contribution of this paper, in particular as we found clear evidence for using the two-tier model in firms of the financial industry. On the other hand, the random forest analysis

helped to revisit the variables on post-choice establishment and age of the firm in showing forms of non-linearity not captured by the regression analysis.

## 6. Conclusion

The design of corporate governance structures is major topic in the legal and management literature; yet, there is the aforementioned neglect on what accounts for the choices that companies make (Lu et al. 2022, as cited in Section 2.2). This paper aimed to contribute to this under-researched topic, specifically examining the fundamental choice between the one-tier and two-tier models of corporate boards. Methodologically, it was based on a combination of regression and random forest analysis and qualitative interpretation. The machine-learning approach of the random forest analysis was a key contribution of this paper, as it has not been applied in this field of research. It was particularly helpful in understanding a large number of possible reasons, forms of non-linearity and other complexities underlying corporate governance choices. Notably, as the analysis of the cross-sectional data of this paper cannot claim to provide causal proof, the visualisation of the random forests in SHAP values and its interpretation provided an inductive way to unpack the reasons for firms' use of board choice.

As a theoretical framing, this paper followed the distinction between explanations related to the composition of the company's shareholders, personal characteristics of the company's directors and different types of firms. Based on firm-level data from fourteen European countries, it found that all three sets of reasons play some role. Normatively, some of the empirical findings may point towards a positive normative assessment of board choice. For example, as far as it has shown that different types of firms prefer different board models, it may be argued that choice of board models helps companies to select corporate governance arrangements suited to their needs. However, other findings point in a different direction: for example, some companies seem to choose the two-tier model to reduce the influence of female directors and employee representatives. Thus, ultimately, this paper cannot provide a general answer to the normative implications of the growing use of board choice, as well as similar rules in other fields of law (Section 1).

Beyond many empirical details, which were already summarised in Section 5.3, the following three findings stand out. First, in general, we confirmed hypotheses that firms that have more shareholders, fewer shareholder-directors, less ownership concentration, larger size and being listed choose the two-tier model as providing a more structured form of corporate governance, though there are also some exceptions to this finding (summarised in the next paragraph). Second, the random forest analysis further pointed towards profound differences between industries, notably with the finding that the financial services industry generally prefers the two-tier model; thus, this form of market segmentation is noteworthy as the legal literature has its conventional focus on the uniform nature of domestic company laws. Third, variables related to foreign and female directors as well age of the company showed only some significance in the regression analysis (notably age, i.e. newer firms prefer the one-tier model); yet, the random forest analysis was particularly valuable here as it illustrated complexities due to endogenous dynamics at the

firm level (notably, for the appointment of directors and board choice) as well as forms of non-linear relationships (as summarised in Table 7).

How uniform are these findings across the fourteen choice countries analysed in this paper? The fact that some countries had few significant results in the regression analysis and/or meaningful results in the random forest analysis is likely to be driven by the low number of companies in a particular jurisdiction and/or the dominance of one of the board models. In other words, the absence of evidence for these countries does not indicate the evidence of absence. Comparing the countries where we often did have results, it is noteworthy that, by and large, the explanations go in the same direction, despite country differences in the preference for a particular model (see Table 1 and the analysis in Gelter and Siems 2021). As far as there is heterogeneity, we do not find that there are different patterns of explanations for countries from different parts of Europe (such as a divide between Central and Eastern European countries and others), nor a divide between different models of the civil law family (French, German and Nordic). Rather, the cases where one or more variables diverge from the general picture are in need of specific explanations (see, e.g., the discussions on Romania for listed firms and assets; the Netherlands for foreign directors and financial industry; France for shareholder concentration).

## References

- Adams, Renée B., Hermalin, Benjamin E., Weisbach, Michael S., 2010. The role of boards of directors in corporate governance, *Journal of Economic Literature*, 48, 58–107.
- Barrédy, Céline, 2021. Succession and family business in between emotional and financial issues: The role of governance with a two-tier system, in Bérangère Deschamps et al. (eds.), *Business Transfers, Family Firms and Entrepreneurship*, London: Routledge, 84–98.
- Belot, François, Ginglinger, Edith, Slovin, Myron B., Sushka, Marie E., 2014. Freedom of choice between unitary and two-tier boards: An empirical analysis, *Journal of Financial Economics*, 112, 364–385.
- Bernardo, Antonio E., Schwartz, Alan, Welch, Ivo, 2016. Contracting externalities and mandatory menus in the U.S. Corporate Bankruptcy Code, *The Journal of Law, Economics, and Organization*, 32, 395–432.
- Bonini, Stefano, Lagasio, Valentina, 2022. Board meetings dynamics and information diffusion, *Corporate Governance: An International Review*, 30, 96–119.
- Boubaker, Sabri, Derouiche, Imen, Nguyen, Duc Khuong, 2015. Does the board of directors affect cash holdings? a study of French listed firms, *Journal of Management and Governance*, 15, 341–370.
- Breiman, Leo, 2001. Random Forests, *Machine Learning*, 45, 5–32.
- Brogi, Marina, 2009. Two-tier boards for the governance of banks, EFMA Annual Conference, <https://ssrn.com/abstract=1710082>.
- Calkoen, Willem J.L., 2011. *The One-Tier Board in the Changing and Converging World of Corporate Governance: A comparative study of boards in the UK, the US and the Netherlands* (PhD thesis Rotterdam), available at <https://repub.eur.nl/pub/26502/>.
- Chawla, Nitesh V., Bowyer, Kevin W., Hall, Lawrence O., Kegelmeyer, W. Philip, 2002. SMOTE: Synthetic Minority Over-sampling Technique, *Journal of Artificial Intelligence Research*, 16, 321–357.
- Cheffins, Brian C., 2004. The trajectory of (corporate law) scholarship, *Cambridge Law Journal*, 63, 456–506.
- Chizema, Amon, Shinozawa, Yoshikatsu, 2012. The “company with committees”: change or continuity in Japanese corporate governance, *Journal of Management Studies*, 49, 77–101.
- Coles, Jeffrey, et al., 2008. Boards: Does one size fit all?, *Journal of Financial Economics*, 87, 329–356.

- Davies, Paul, Hopt, Klaus, Nowak, Richard, van Solinge, Gerard (eds.), 2013. *Corporate Boards in Law and Practice: A Comparative Analysis in Europe*, Oxford: Oxford University Press.
- De Acutis, Costanza, Weber, Andrea, Wurma, Elisabeth, 2024. The effects of board gender quotas: A meta-analysis, *Labour Economics* 91, 102634.
- Drazkowski, Hubert, Tyrowicz, Joanna, Zalas, Sebastian, 2024. Gender board diversity across Europe throughout four decades, *Scientific Data*, 11, 567.
- EBRD 2017. *Corporate Governance in Transition Economies: Romania Country Report* (London: European Bank for Reconstruction and Development).
- Eidenmüller, Horst, Engert, Andreas, Hornuf, Lars, 2009. Incorporating under European law: the Societas Europaea as a vehicle for legal arbitrage, *European Business Organization Law Review* 10, 1–33.
- Eldar, Ofer, Magnolfi, Lorenzo, 2020. Regulatory competition and the market for corporate law, *American Economic Journal: Microeconomics*, 12, 60–98.
- Eskridge Jr. William N., 2012. Family law pluralism: The guided-choice regime of menus, default rules, and override rules, *Georgetown Law Journal* 100, 1881–1988.
- Fard, Amirhossein, Chung, Chune Young, 2024. Do board-level employee representatives increase pay equity in firms?, *Corporate Governance: An International Review*, 32, 1110–1132.
- Farrell, Matthew, et al., 2026. Board attributes, firm performance, and the moderating role of national culture: a meta-analysis, *Corporate Governance: An International Review*, 34, 310–337.
- Federo, Ryan, Coutinho Parente, Tobias, 2023. Understanding board designs in Latin American firms: Insights from Brazil, *Journal of Business Research* 166, 114102.
- Firth, David, 1993. Bias reduction in maximum likelihood estimates, *Biometrika* 80, 27–38.
- Fox, John, Weisberg, Sanford, 2011. *An R Companion to Applied Regression* (Los Angeles: SAGE Publications, 2nd ed.).
- Garcia-Bernardo, Javier, Fichtner, Jan, Takes, Frank W., Heemskerk, Eelke M., 2017. Uncovering Offshore Financial Centers: Conduits and Sinks in the Global Corporate Ownership Network, *Scientific Reports* 7, Article Number: 6246
- García-Ramos, Rebeca, Díaz Díaz, Belén, 2021. Board of directors structure and firm financial performance: A qualitative comparative analysis, *Long Range Planning* 54, 102017.

Gelter, Martin, Helleringer, Geneviève. 2015. Lift not the painted veil! To whom are directors' duties really owed? *University of Illinois Law Review*, 2015, 1069-1118.

Gelter, Martin, Siems, Mathias, 2021. Letting companies choose between board models: an empirical analysis of country variations, *University of Pennsylvania Journal of International Law*, 43, 137–186.

Gelter, Martin, Siems, Mathias, 2024. Elective corporate governance: does board choice matter?, *International Review of Law & Economics*, 78, 106190.

Gerner-Beuerle, Carsten, Paech, Philipp, Schuster, Edmund Philipp, 2013. *Study on Directors' Duties and Liability*, Report for the European Commission, available at [https://personal.lse.ac.uk/schustee/2013-study-analysis\\_en.pdf](https://personal.lse.ac.uk/schustee/2013-study-analysis_en.pdf).

Gholamy, Afshin, Kreinovich, Vladik, Kosheleva, Olga, 2018. Why 70/30 or 80/20 relation between training and testing sets: a pedagogical explanation, *International Journal of Intelligent Technologies and Applied Statistics* 11, 105–111.

Graziano, Clara and Annalisa Luporini, 2012. Ownership concentration, monitoring, and optimal board structure, *Economics Bulletin*, 32, 3333–3346.

Greene, William H. 2018. *Econometric Analysis*, New York: Pearson, 8<sup>th</sup> edn.

Hopt, Klaus J., Leyens, Patrick C., 2021. The structure of the board of directors, in Afra Afsharipour and Martin Gelter (Eds.) *Research Handbook on Comparative Corporate Governance*, Cheltenham: Edward Elgar, 115–143.

Hornuf, Lars, Mohamed, Abdulkadir, Schwienbacher, Armin, 2019. The economic impact of forming a European Company, *Journal of Common Market Studies*, 57, 659–674.

James, Gareth, Witten, Daniela, Hastie, Trevor, Tibshirani, Robert, 2021. *An Introduction to Statistical Learning with Applications in R*, Springer: New York, 2<sup>nd</sup> edn.

James, Phillip C., 2020. Understanding the impact of board structure on firm performance: a comprehensive literature review, *International Journal of Business and Social Research*, 10, 1–12.

Jeanjean, Thomas, Stolowy, Hervé, 2008. Determinants of board members' financial expertise – empirical evidence from France, *The International Journal of Accounting*, 44, 378–402.

Jungmann, Carsten, 2006. The effectiveness of corporate governance in one-tier and two-tier board systems – evidence from the UK and Germany, *European Company and Financial Law Review*, 3, 426–474.

Kraakman, Reinier, et al., 2017. *The Anatomy of Corporate Law: A Comparative and Functional Approach*, Oxford: Oxford University Press, 3<sup>rd</sup> end.

- Langenbucher, Katja. 2026. Explainable AI as a Component of Building Trust, in Sebastian Bucker, Marcus Düwell, Andreas Kaminski, Michael Leyer (eds.) *Trust, Responsibility, and Digital Governance* (Bielefeld: transcriptVerlag) 189–205.
- Liao, Chih-Hsien, et al. 2021. Board reforms around the world: The effect on corporate social responsibility, *Corporate Governance: An International Review* 29, 496–523.
- Lin, Yu-Hsin, Chang, Yun-chien, 2018. An empirical study of corporate default rules and menus in China, Hong Kong, and Taiwan, *Journal of Empirical Legal Studies*, 15, 875–915.
- Linck, James S., Netter, Jeffry M., Yang, Tina, 2008. The determinants of board structure, *Journal of Financial Economics* 87, 308–328.
- Listokin, Yair, 2009. What do corporate default rules and menus do? An empirical examination, *Journal of Empirical Legal Studies*, 6, 279–308.
- Lu, Yun, et al., 2022. Board of directors’ attributes and corporate outcomes: A systematic literature review and future research agenda, *International Review of Financial Analysis* 84, 102424.
- Ludwig, Jens, Mullainathan, Sendhil, 2024. Machine learning as a tool for hypothesis generation, *The Quarterly Journal of Economics*, 139, 751–827
- Lundberg, Scott M., Lee, Su-In, 2017. A unified approach to interpreting model predictions, in *Advances in Neural Information Processing Systems*, 4765–4774.
- Molnar, Christoph, 2025. *Interpretable Machine Learning. A Guide for Making Black Box Models Explainable*. 3<sup>rd</sup> ed. Munich.
- Millet-Reyes, Benedicte, Zhao, Ronald, 2010. A comparison between one-tier and two-tier board structures in France, *Journal of International Financial Management & Accounting*, 21, 279–310.
- Mucciarelli, Federico M., Pomelli, Alessandro, 2024. *Sistemi dualistico e monistico di amministrazione e controllo nelle società per azioni*, Turin: G. Giappichelli Editore.
- Neumann, László, 2018. Board-level employee representation in Hungary: a useful tool for company unions and works councils, in Jeremy Waddington (ed.) *European Board-Level Employee Representation: National Variations in Influence and Power* (The Hague: Kluwer Law International) 103–126.
- Njoya, Wanjiru, 2011. Employee ownership in the European company: reflexive law, reincorporation and escaping co-determination, *Journal of Corporate Law Studies*, 11, 267–298.
- Nowak, Richard G.J., 2013. Corporate Boards in the Netherlands, in Davies, Paul, Hopt, Klaus, Nowak, Richard, van Solinge, Gerard (eds.), *Corporate Boards in Law and*

*Practice: A Comparative Analysis in Europe*, Oxford: Oxford University Press, 429–510.

Nutz, Theresa, Nelles, Anika, Lersch, Philipp M., 2022. Who opts out? The customisation of marriage in the German matrimonial property regime, *European Journal of Population*, 38, 353–375.

Pellegrini, Carlo Bellavite, Pellegrini, Laura, Sironi, Emiliano, 2010. Alternative vs. traditional corporate governance systems in Italy: an empirical analysis, *Problems and Perspectives in Management*, 8, 4–15.

Pellegrini, Carlo Bellavite, Sironi, Emiliano, 2017. Does a one-tier board affect firms' performances? Evidences from Italian unlisted enterprises, *Small Business Economics*, 48, 213–224.

Probst, Philipp, Wright, Marvin N, Boulesteix, Anne Laure, 2019. Hyperparameters and tuning strategies for random forest, *WIREs Data Mining Knowledge Discovery*, 9, e1301.

Pucheta-Martínez, María Consuelo, Gallego-Álvarez, Isabel, 2020. Do board characteristics drive firm performance? An international perspective, *Review of Managerial Science* 14, 1251–1297.

Richardson, Wendyann, 2017. *Homophily: The Antithesis of Corporate Board Diversity in the United Kingdom* (PhD thesis, Loughborough University).

Ringe, Wolf-Georg, 2013. Menügesetzgebung im Privatrecht, *Archiv für die civilistische Praxis*, 213, 98–127.

Roosenboom, Peter G.J., Schramade, Willem L.J., 2006. The price of power: Valuing the controlling position of owner–managers in French IPO firms, *Journal of Corporate Finance*, 12, 270–295.

Sanga, Sarath, 2020. Network effects in corporate governance, *The Journal of Law and Economics*, 63, 1–41.

Sayari, Naz, Marcum, Bill, 2022. Board systems, employee representation, and neo-institutional theory: The moderating effect of economic freedom on corporate boards and financial performance, *Managerial and Decision Economics*, 43, 3931–3952.

Selznick, Philip, 1949. *TVA and the grass roots: A study of politics and organization*, Berkeley, CA: University of California Press.

Shapley, Lloyd S., 1951. Notes on the n-Person Game, II: The Value of an n-Person Game. Santa Monica, Calif.: RAND Corporation. Available at [https://www.rand.org/content/dam/rand/pubs/research\\_memoranda/2008/RM670.pdf](https://www.rand.org/content/dam/rand/pubs/research_memoranda/2008/RM670.pdf).

Stekhoven, Daniel J., Bühlmann, Peter, 2012. MissForest – non-parametric missing value imputation for mixed-type data, *Bioinformatics* 28(1), 112-118.

TSG Baltic, 2018. *Study on Minority Shareholders Protection*, European Commission Publications Office, available at <https://data.europa.eu/doi/10.2838/658269>.

van Veen, Kees, Elbertsen, Janine, 2008. Governance regimes and nationality diversity in corporate boards: a comparative study of Germany, the Netherlands and the United Kingdom, *Corporate Governance: An International Review*, 16, 386–399.

Voordeckers, Wim, Van Gils, Anita, Van den Heuvel, Jeroen, 2007. Board composition in small and medium-sized family firms, *Journal of Small Business Management* 45, 137–156.

Wooldridge, Jeffrey M., 2002. *Econometric Analysis of Cross-Sectional and Panel Data*, Cambridge, MA: MIT Press.

Wymeersch, Eddy, 2009. Comparative study of the company types in selected EU States, *European Company and Financial Law Review* 6, 71–124.

Zingales, Luigi, 1995. What determines the value of corporate votes?, *Quarterly Journal of Economics* 110, 1047–1073.

## Appendix

Table A.1: Explanatory variables (all data)

| Variable                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NACE 2-digit categories</b>                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Company type: Bank, Corporate, Financial company, Foundation or research institute, Insurance company, Funds, Private equity firm, Venture capital</b>                                                                                                                                                                                                                                                                  |
| <b>Legal form:</b> A.S. (Denmark), ab (Lithuania), d.d. (Croatia or Slovenia), SA (France, Luxembourg, Portugal or Romania), SPA (France), A.S. (Denmark), SA (France, Luxembourg, Portugal or Romania), A.S. (Faroe Island), One person SA (France), One person SPA (France), EAD (Bulgaria), ZRT (Hungary), AD (Bulgaria), NYRT (Hungary), OYJ (Finland), SA (France, Luxembourg, Portugal or Romania), NV (Netherlands) |
| <b>Status:</b> Status active, Status active (default payment), Status active (dormant), Status active (insolvency), Status active (reorganisation), Status active (rescue), Status unknown                                                                                                                                                                                                                                 |
| <b>Number of shareholders</b>                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Foreign shareholders (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Largest shareholder (ratio of ownership)</b>                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Shareholder concentration (calculated as sum of ownership ratio of each known shareholder, ranging from 0 to 100, analogous to the Herfindahl-Hirschman index [HHI]).</b>                                                                                                                                                                                                                                               |
| <b>ORBIS Company independence category:</b> A, B, C, D, U (unknown)                                                                                                                                                                                                                                                                                                                                                        |
| <b>Shareholder-directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Female directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Foreign directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Former shareholder-directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Former female directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Former foreign directors (ratio)</b>                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>ROE (Return on equity):</b> year of data collection, -1 year of data collection, -2 year of data collection, -3 year of data collection, -4 year of data collection, -5 year of data collection, -6 year of data collection, -7 year of data collection, -8 year of data collection, -9 year of data collection)                                                                                                        |
| ROE average                                                                                                                                                                                                                                                                                                                                                                                                                |
| ROE standard deviation                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>ROA (Return on assets):</b> year of data collection, -1 year of data collection, -2 year of data collection, -3 year of data collection, -4 year of data collection, -5 year of data collection, -6 year of data collection, -7 year of data collection, -8 year of data collection, -9 year of data collection)                                                                                                        |
| ROA average                                                                                                                                                                                                                                                                                                                                                                                                                |
| ROA standard deviation                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Operating revenue:</b> year of data collection, -1 year of data collection, -2 year of data collection, -3 year of data collection, -4 year of data collection                                                                                                                                                                                                                                                          |
| Operating revenue average                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>EBIT:</b> year of data collection, -1 year of data collection, -2 year of data collection, -3 year of data collection, -9 year of data collection                                                                                                                                                                                                                                                                       |
| <b>PP&amp;E turnover (operating revenue / PP&amp;E)</b>                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Sales growth average</b>                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>EBIT margin average</b>                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Age of company</b>                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Post-choice establishment</b>                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Post-SE introduction establishment</b>                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>weighted index of directors and managers coming from countries favouring a particular board structure</b>                                                                                                                                                                                                                                                                                                               |
| <b>weighted index of shareholders coming from countries favouring a particular board structure</b>                                                                                                                                                                                                                                                                                                                         |
| <b>Majority shareholder (based on BvD independence categories)</b>                                                                                                                                                                                                                                                                                                                                                         |
| <b>Co-determination required</b>                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Listing status:</b> Delisted company, Listed company Unlisted company (never listed)                                                                                                                                                                                                                                                                                                                                    |
| <b>Industry categories:</b> A, B-E, F, G-J, K, L-N, O-U, other                                                                                                                                                                                                                                                                                                                                                             |
| <b>Majority shareholder (based on independence categories)</b>                                                                                                                                                                                                                                                                                                                                                             |

*Table A.2: Descriptive statistics of key explanatory variables*

| <b>Variable</b>                       | <b>N</b> | <b>Mean</b> | <b>St. Dev.</b> | <b>Min</b> | <b>Max</b> |
|---------------------------------------|----------|-------------|-----------------|------------|------------|
| log (age)                             | 147,013  | 2.845       | 0.826           | 0.000      | 6.213      |
| log (no. shareholders)                | 147,268  | 0.926       | 0.706           | 0.000      | 7.522      |
| Shareholder-directors                 | 147,263  | 0.180       | 0.284           | 0.000      | 1.000      |
| Female directors                      | 147,263  | 0.205       | 0.241           | 0.000      | 1.000      |
| Foreign directors                     | 147,263  | 0.053       | 0.168           | 0.000      | 1.000      |
| Directors with two-tier background    | 147,268  | -0.039      | 0.195           | -1.000     | 1.000      |
| Shareholders with two-tier background | 147,268  | -0.042      | 0.249           | -1.000     | 1.000      |

| <b>Variable</b>           | <b>N</b> | <b>Percent</b> |
|---------------------------|----------|----------------|
| Listed                    | 147268   |                |
| ... No                    | 144988   | 98%            |
| ... Yes                   | 2280     | 2%             |
| Majority shareholder      | 147268   |                |
| ... No                    | 28019    | 19%            |
| ... Yes                   | 119249   | 81%            |
| Post-choice establishment | 147013   |                |
| ... No                    | 94286    | 64%            |
| ... Yes                   | 52727    | 36%            |
| Co-determination required | 147268   |                |
| ... No                    | 137853   | 94%            |
| ... Yes                   | 9415     | 6%             |
| Industry                  | 147268   |                |
| ... A                     | 3657     | 2%             |
| ... B-E                   | 27838    | 19%            |
| ... F                     | 11046    | 8%             |
| ... G-J                   | 38182    | 26%            |
| ... K                     | 17358    | 12%            |
| ... L-N                   | 43601    | 30%            |
| ... O-U                   | 4433     | 3%             |
| ... other                 | 1153     | 1%             |

Table A.3.1: Descriptive statistics of key variables by country

|                | log (age) |      |         | log (total assets) |       |         | log (employees) |      |         | log (no. shareholders) |      |         | Shareholder-directors |      |         |
|----------------|-----------|------|---------|--------------------|-------|---------|-----------------|------|---------|------------------------|------|---------|-----------------------|------|---------|
|                | N         | Mean | St.Dev. | N                  | Mean  | St.Dev. | N               | Mean | St.Dev. | N                      | Mean | St.Dev. | N                     | Mean | St.Dev. |
| Bulgaria       | 8,488     | 2.57 | 0.78    | 8,421              | 6.83  | 2.35    | 6,240           | 2.64 | 1.67    | 8,596                  | 1.18 | 0.45    | 8,594                 | 0.28 | 0.32    |
| Croatia        | 654       | 3.18 | 0.78    | 655                | 9.16  | 2.11    | 600             | 4.18 | 1.82    | 655                    | 1.45 | 0.71    | 655                   | 0.15 | 0.22    |
| Czech Republic | 17,182    | 2.43 | 0.74    | 13,784             | 7.10  | 2.24    | 8,067           | 3.01 | 1.59    | 17,185                 | 0.32 | 0.38    | 17,185                | 0.14 | 0.33    |
| Denmark        | 35,328    | 2.73 | 0.85    | 34,303             | 7.73  | 2.09    | 25,983          | 2.30 | 1.61    | 35,347                 | 0.92 | 0.40    | 35,347                | 0.20 | 0.25    |
| Finland        | 240       | 3.22 | 0.97    | 239                | 11.85 | 2.60    | 220             | 5.71 | 2.35    | 246                    | 2.55 | 1.36    | 246                   | 0.09 | 0.16    |
| France         | 15,025    | 3.42 | 0.61    | 15,055             | 8.62  | 2.26    | 7,759           | 3.52 | 1.75    | 15,055                 | 0.88 | 0.73    | 15,055                | 0.08 | 0.19    |
| Hungary        | 5,759     | 2.34 | 0.88    | 5,531              | 6.98  | 2.55    | 3,846           | 2.84 | 1.71    | 5,767                  | 0.61 | 0.51    | 5,764                 | 0.19 | 0.37    |
| Italy          | 24,160    | 3.26 | 0.70    | 24,179             | 9.89  | 1.65    | 20,720          | 3.83 | 1.61    | 24,179                 | 1.50 | 0.84    | 24,179                | 0.32 | 0.32    |
| Lithuania      | 280       | 3.09 | 0.63    | 185                | 9.93  | 2.06    | 275             | 4.08 | 2.00    | 280                    | 0.88 | 0.73    | 280                   | 0.11 | 0.26    |
| Luxembourg     | 7,015     | 2.77 | 0.66    | 6,392              | 7.93  | 2.68    | 2,000           | 2.91 | 1.87    | 7,053                  | 0.82 | 0.59    | 7,053                 | 0.20 | 0.33    |
| Netherlands    | 3,275     | 2.57 | 0.97    | 3,047              | 8.66  | 2.82    | 1,046           | 3.83 | 2.64    | 3,276                  | 0.46 | 0.75    | 3,276                 | 0.01 | 0.06    |
| Portugal       | 22,379    | 2.76 | 0.77    | 22,378             | 7.67  | 2.12    | 14,566          | 2.56 | 1.66    | 22,395                 | 0.71 | 0.67    | 22,395                | 0.08 | 0.19    |
| Romania        | 6,742     | 2.92 | 0.63    | 6,744              | 7.07  | 2.31    | 6,732           | 2.59 | 1.99    | 6,744                  | 1.39 | 0.54    | 6,744                 | 0.19 | 0.28    |
| Slovenia       | 486       | 3.28 | 0.58    | 490                | 9.26  | 2.35    | 382             | 4.11 | 1.82    | 490                    | 1.18 | 0.78    | 490                   | 0.13 | 0.25    |

Table A.3.2: Descriptive statistics of key variables by country

|                | Female directors |      |         | Foreign shareholders |      |         | Foreign directors |      |         | Directors with two-tier background |       |         | Shareholders with two-tier background |       |         |
|----------------|------------------|------|---------|----------------------|------|---------|-------------------|------|---------|------------------------------------|-------|---------|---------------------------------------|-------|---------|
|                | N                | Mean | St.Dev. | N                    | Mean | St.Dev. | N                 | Mean | St.Dev. | N                                  | Mean  | St.Dev. | N                                     | Mean  | St.Dev. |
| Bulgaria       | 8,594            | 0.30 | 0.28    | 8,543                | 0.13 | 0.31    | 8,594             | 0.05 | 0.18    | 8,596                              | -0.03 | 0.17    | 8,596                                 | -0.07 | 0.28    |
| Croatia        | 655              | 0.24 | 0.21    | 605                  | 0.09 | 0.26    | 655               | 0.04 | 0.12    | 655                                | 0.00  | 0.16    | 655                                   | -0.01 | 0.20    |
| Czech Republic | 17,185           | 0.18 | 0.31    | 7,494                | 0.17 | 0.37    | 17,185            | 0.04 | 0.18    | 17,185                             | 0.02  | 0.15    | 17,185                                | -0.01 | 0.22    |
| Denmark        | 35,347           | 0.16 | 0.19    | 34,610               | 0.09 | 0.27    | 35,347            | 0.05 | 0.16    | 35,347                             | -0.06 | 0.19    | 35,347                                | -0.04 | 0.25    |
| Finland        | 246              | 0.21 | 0.15    | 238                  | 0.09 | 0.23    | 246               | 0.08 | 0.15    | 246                                | -0.07 | 0.12    | 246                                   | -0.13 | 0.23    |
| France         | 15,055           | 0.26 | 0.21    | 11,649               | 0.08 | 0.24    | 15,055            | 0.03 | 0.12    | 15,055                             | -0.06 | 0.22    | 15,055                                | -0.03 | 0.19    |
| Hungary        | 5,764            | 0.22 | 0.32    | 4,083                | 0.15 | 0.34    | 5,764             | 0.03 | 0.13    | 5,767                              | 0.00  | 0.15    | 5,767                                 | -0.02 | 0.26    |
| Italy          | 24,179           | 0.17 | 0.19    | 24,118               | 0.08 | 0.26    | 24,179            | 0.02 | 0.08    | 24,179                             | -0.01 | 0.08    | 24,179                                | -0.02 | 0.20    |
| Lithuania      | 280              | 0.22 | 0.28    | 202                  | 0.23 | 0.39    | 280               | 0.03 | 0.14    | 280                                | 0.01  | 0.15    | 280                                   | 0.00  | 0.32    |
| Luxembourg     | 7,053            | 0.18 | 0.25    | 5,419                | 0.47 | 0.47    | 7,053             | 0.29 | 0.33    | 7,053                              | -0.16 | 0.45    | 7,053                                 | -0.18 | 0.47    |
| Netherlands    | 3,276            | 0.13 | 0.27    | 1,476                | 0.20 | 0.38    | 3,276             | 0.08 | 0.22    | 3,276                              | -0.06 | 0.26    | 3,276                                 | -0.05 | 0.25    |
| Portugal       | 22,395           | 0.24 | 0.23    | 14,397               | 0.13 | 0.32    | 22,395            | 0.03 | 0.10    | 22,395                             | -0.04 | 0.15    | 22,395                                | -0.04 | 0.22    |
| Romania        | 6,744            | 0.32 | 0.27    | 6,613                | 0.15 | 0.33    | 6,744             | 0.08 | 0.23    | 6,744                              | -0.03 | 0.17    | 6,744                                 | -0.06 | 0.27    |
| Slovenia       | 490              | 0.22 | 0.23    | 414                  | 0.12 | 0.29    | 490               | 0.04 | 0.12    | 490                                | 0.03  | 0.18    | 490                                   | 0.02  | 0.21    |

Table A.3.3: Descriptive statistics of key variables by country

|                | Board structure |        |                   | listed |        | Majority shareholder |       | Post-choice establishment |        |     |
|----------------|-----------------|--------|-------------------|--------|--------|----------------------|-------|---------------------------|--------|-----|
|                | 1-Tier          | 2-Tier | Board of Auditors | Yes    | No     | Yes                  | No    | Yes                       | No     | NAs |
| Bulgaria       | 8,539           | 57     | 0                 | 222    | 8,374  | 6,187                | 2,409 | 8,488                     | 0      | 108 |
| Croatia        | 20              | 635    | 0                 | 149    | 506    | 415                  | 240   | 60                        | 594    | 1   |
| Czech Republic | 4,115           | 13,070 | 0                 | 14     | 17,171 | 17,005               | 180   | 3,112                     | 14,070 | 3   |
| Denmark        | 35,316          | 31     | 0                 | 153    | 35,194 | 29,560               | 5,787 | 4,197                     | 31,131 | 19  |
| Finland        | 239             | 7      | 0                 | 145    | 101    | 93                   | 153   | 106                       | 134    | 6   |
| France         | 14,962          | 93     | 0                 | 591    | 14,464 | 12,337               | 2,718 | 15,025                    | 0      | 30  |
| Hungary        | 4,191           | 1,576  | 0                 | 38     | 5,729  | 5,674                | 93    | 3,349                     | 2,410  | 8   |
| Italy          | 101             | 71     | 24,007            | 284    | 23,895 | 15,585               | 8,594 | 4,864                     | 19,296 | 19  |
| Lithuania      | 265             | 15     | 0                 | 30     | 250    | 216                  | 64    | 280                       | 0      |     |
| Luxembourg     | 7,025           | 28     | 0                 | 67     | 6,986  | 5,742                | 1,311 | 2,425                     | 4,590  | 38  |
| Netherlands    | 2,726           | 550    | 0                 | 157    | 3,119  | 3,077                | 199   | 832                       | 2,443  | 1   |
| Portugal       | 24              | 4      | 22,367            | 51     | 22,344 | 18,197               | 4,198 | 8,576                     | 13,803 | 16  |
| Romania        | 3,161           | 3,583  | 0                 | 344    | 6,400  | 4,812                | 1,932 | 1,360                     | 5,382  | 2   |
| Slovenia       | 110             | 380    | 0                 | 35     | 455    | 349                  | 141   | 53                        | 433    | 4   |

Table A.3.4: Descriptive statistics of key variables by country

|                | Employee board representation |        |     | Industry |       |        |       |       |     |       |
|----------------|-------------------------------|--------|-----|----------|-------|--------|-------|-------|-----|-------|
|                | Yes                           | No     | A   | B-E      | F     | G-J    | K     | L-N   | O-U | other |
| Bulgaria       | 0                             | 8,596  | 221 | 1,633    | 560   | 2,013  | 597   | 2,985 | 325 | 262   |
| Croatia        | 572                           | 83     | 18  | 214      | 57    | 231    | 11    | 105   | 19  | 0     |
| Czech Republic | 2,249                         | 14,936 | 799 | 2,485    | 1,097 | 4,163  | 543   | 7,511 | 568 | 19    |
| Denmark        | 5,140                         | 30,207 | 694 | 4,835    | 3,161 | 10,685 | 6,223 | 8,474 | 574 | 701   |
| Finland        | 138                           | 108    | 0   | 85       | 6     | 58     | 52    | 36    | 9   | 0     |
| France         | 324                           | 14,731 | 146 | 2,584    | 1,086 | 4,635  | 2,148 | 3,646 | 810 | 0     |
| Hungary        | 356                           | 5,411  | 342 | 758      | 293   | 1,281  | 958   | 1,966 | 162 | 7     |
| Italy          | 0                             | 24,179 | 133 | 9,171    | 1,388 | 6,191  | 1,723 | 4,927 | 623 | 23    |
| Lithuania      | 0                             | 280    | 15  | 114      | 26    | 41     | 20    | 58    | 6   | 0     |
| Luxembourg     | 67                            | 6,986  | 10  | 325      | 506   | 1,873  | 643   | 3,301 | 291 | 104   |
| Netherlands    | 355                           | 2,921  | 15  | 235      | 57    | 303    | 1,987 | 599   | 80  | 0     |
| Portugal       | 0                             | 22,395 | 748 | 3,264    | 1,883 | 4,915  | 2,257 | 8,515 | 813 | 0     |
| Romania        | 0                             | 6,744  | 506 | 1,992    | 889   | 1,681  | 119   | 1,384 | 136 | 37    |
| Slovenia       | 214                           | 276    | 10  | 143      | 37    | 112    | 77    | 94    | 17  | 0     |

Table A.4: Table of correlations of key explanatory variables

|                                       | log (age) | log (no. shareholders) | Shareholder-directors | Female directors | Foreign directors | Directors with two-tier background | Shareholders with two-tier background | Listed    | Majority shareholder | Post-choice establishment | Employee board representation | Industry categories B-E | F         | G-J       | K         | L-N       | O-U       |
|---------------------------------------|-----------|------------------------|-----------------------|------------------|-------------------|------------------------------------|---------------------------------------|-----------|----------------------|---------------------------|-------------------------------|-------------------------|-----------|-----------|-----------|-----------|-----------|
| log (no. shareholders)                | 0.20 ***  |                        |                       |                  |                   |                                    |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Shareholder-directors                 | 0.05 ***  | 0.34 ***               |                       |                  |                   |                                    |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Female directors                      | 0.07 ***  | -0.02 ***              | 0.02 ***              |                  |                   |                                    |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Foreign directors                     | -0.04 *** | -0.01 ***              | -0.07 ***             | -0.07 ***        |                   |                                    |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Directors with two-tier background    | -0.02 *** | -0.02 ***              | 0.06 ***              | 0.03 ***         | -0.32 ***         |                                    |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Shareholders with two-tier background | 0.01 ***  | -0.04 ***              | 0.06 ***              | 0.01 ***         | -0.21 ***         | 0.45 ***                           |                                       |           |                      |                           |                               |                         |           |           |           |           |           |
| Listed                                | 0.09 ***  | 0.25 ***               | -0.03 ***             | 0.01 ***         | 0.02 ***          | -0.02 ***                          | -0.04 ***                             |           |                      |                           |                               |                         |           |           |           |           |           |
| Majority shareholder                  | -0.09 *** | -0.47 ***              | -0.21 ***             | 0.00             | 0.06 ***          | -0.02 ***                          | -0.02 ***                             | -0.10 *** |                      |                           |                               |                         |           |           |           |           |           |
| Post-choice establishment             | -0.44 *** | -0.05 ***              | -0.08 ***             | 0.05 ***         | 0.02 ***          | -0.01 ***                          | -0.01 ***                             | 0.03 ***  | 0.01 ***             |                           |                               |                         |           |           |           |           |           |
| Employee board representation         | 0.08 ***  | 0.03 ***               | -0.09 ***             | -0.06 ***        | 0.05 ***          | -0.03 ***                          | -0.02 ***                             | 0.13 ***  | 0.02 ***             | -0.15 ***                 |                               |                         |           |           |           |           |           |
| Industry categories B-E               | 0.18 ***  | 0.14 ***               | 0.03 ***              | -0.03 ***        | -0.01 ***         | 0.01 ***                           | 0.01 ***                              | 0.08 ***  | -0.05 ***            | -0.08 ***                 | 0.09 ***                      |                         |           |           |           |           |           |
| F                                     | 0.01 ***  | 0.00                   | 0.02 ***              | -0.02 ***        | -0.03 ***         | 0.02 ***                           | 0.02 ***                              | -0.02 *** | -0.01 ***            | -0.02 ***                 | 0.01 ***                      | -0.14 ***               |           |           |           |           |           |
| G-J                                   | 0.05 ***  | 0.02 ***               | 0.03 ***              | 0.00             | 0.04 ***          | -0.03 ***                          | -0.02 ***                             | 0.00      | 0.01 ***             | -0.03 ***                 | 0.02 ***                      | -0.29 ***               | -0.17 *** |           |           |           |           |
| K                                     | -0.07 *** | -0.04 ***              | -0.03 ***             | -0.02 ***        | -0.01 ***         | -0.01 ***                          | 0.00                                  | -0.01 *** | 0.01 ***             | 0.05 ***                  | -0.02 ***                     | -0.18 ***               | -0.10 *** | -0.22 *** |           |           |           |
| L-N                                   | -0.14 *** | -0.11 ***              | -0.03 ***             | 0.04 ***         | 0.00              | 0.01 ***                           | -0.01 *                               | -0.05 *** | 0.02 ***             | 0.07 ***                  | -0.09 ***                     | -0.31 ***               | -0.18 *** | -0.38 *** | -0.24 *** |           |           |
| O-U                                   | 0.01 ***  | 0.02 ***               | -0.03 ***             | 0.02 ***         | -0.01 **          | 0.00                               | 0.01 ***                              | 0.01 **   | 0.01 **              | 0.03 ***                  | 0.01 ***                      | -0.09 ***               | -0.05 *** | -0.10 *** | -0.06 *** | -0.11 *** |           |
| other                                 | -0.10 *** | 0.00                   | 0.00                  | 0.00             | 0.02 ***          | -0.02 ***                          | -0.01 ***                             | -0.01 *** | 0.00                 | 0.02 ***                  | -0.01 **                      | -0.04 ***               | -0.03 *** | -0.05 *** | -0.03 *** | -0.06 *** | -0.02 *** |

*Table A.5: Pooled logistic regressions with dependent variable “two-tier model” omitting always one country*

|                                       | <b>omits BG</b>     | <b>omits HR</b>     | <b>omits CZ</b>     | <b>omits DK</b>     | <b>omits FI</b>     | <b>omits FR</b>     | <b>omits HU</b>     | <b>omits LT</b>     | <b>omits LU</b>     | <b>omits NL</b>     | <b>omits RO</b>     | <b>omits SI</b>     |
|---------------------------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| (Intercept)                           | 1.365<br>(1.196)    | -5.203<br>(2.676)   | -5.685<br>(2.869)   | -5.160<br>(2.629)   | -5.191<br>(2.561)   | -5.301<br>(2.597)   | -5.138<br>(2.824)   | -5.192<br>(2.595)   | -5.161<br>(2.641)   | -4.871<br>(2.693)   | -5.730<br>(2.566)   | -5.195<br>(2.320)   |
| log (no. shareholders)                | 0.720***<br>(0.128) | 0.723***<br>(0.132) | 0.797***<br>(0.155) | 0.721***<br>(0.129) | 0.724***<br>(0.120) | 0.667***<br>(0.118) | 0.711***<br>(0.158) | 0.723***<br>(0.129) | 0.715***<br>(0.128) | 0.667***<br>(0.125) | 0.521***<br>(0.092) | 0.742***<br>(0.127) |
| Majority shareholder                  | -0.354<br>(0.150)   | -0.323<br>(0.188)   | -0.322<br>(0.203)   | -0.347<br>(0.184)   | -0.326<br>(0.161)   | -0.334<br>(0.206)   | -0.310<br>(0.175)   | -0.330<br>(0.180)   | -0.339<br>(0.171)   | -0.256<br>(0.211)   | -0.099<br>(0.241)   | -0.340<br>(0.196)   |
| Shareholder-directors                 | -1.371<br>(0.553)   | -1.380<br>(0.538)   | -1.942<br>(0.640)   | -1.379<br>(0.568)   | -1.381<br>(0.509)   | -1.355<br>(0.616)   | -1.213**<br>(0.322) | -1.380<br>(0.509)   | -1.375<br>(0.584)   | -1.371<br>(0.524)   | -1.320<br>(0.784)   | -1.381<br>(0.565)   |
| Shareholders with two-tier background | 0.293<br>(0.107)    | 0.303*<br>(0.095)   | 0.407***<br>(0.075) | 0.304<br>(0.102)    | 0.298*<br>(0.091)   | 0.288<br>(0.103)    | 0.234<br>(0.095)    | 0.299*<br>(0.096)   | 0.278<br>(0.096)    | 0.300<br>(0.103)    | 0.318<br>(0.131)    | 0.306<br>(0.101)    |
| Foreign directors                     | -0.652<br>(0.596)   | -0.649<br>(0.634)   | -1.052<br>(1.022)   | -0.666<br>(0.593)   | -0.641<br>(0.565)   | -0.647<br>(0.648)   | -0.637<br>(0.829)   | -0.642<br>(0.657)   | -0.693<br>(0.605)   | -0.780<br>(0.769)   | -0.107<br>(0.530)   | -0.655<br>(0.649)   |
| Directors with two-tier background    | 0.503**<br>(0.131)  | 0.506*<br>(0.145)   | 0.400<br>(0.199)    | 0.516*<br>(0.149)   | 0.507**<br>(0.134)  | 0.535**<br>(0.143)  | 0.541<br>(0.184)    | 0.504*<br>(0.153)   | 0.479**<br>(0.134)  | 0.601*<br>(0.181)   | 0.391<br>(0.166)    | 0.524**<br>(0.141)  |
| Female directors                      | 0.347<br>(0.561)    | 0.340<br>(0.535)    | 1.115<br>(0.515)    | 0.341<br>(0.552)    | 0.344<br>(0.565)    | 0.341<br>(0.570)    | 0.336<br>(0.702)    | 0.344<br>(0.557)    | 0.349<br>(0.550)    | 0.333<br>(0.604)    | -0.119<br>(0.292)   | 0.342<br>(0.583)    |
| Employee board representation         | 1.316<br>(0.467)    | 1.318<br>(0.482)    | 1.999***<br>(0.404) | 1.291<br>(0.484)    | 1.296<br>(0.445)    | 1.278<br>(0.486)    | 1.131<br>(0.514)    | 1.304<br>(0.461)    | 1.283<br>(0.440)    | 1.087<br>(0.457)    | 1.027<br>(0.353)    | 1.341<br>(0.526)    |
| Industry categories B to E            | -0.770<br>(0.361)   | -0.772<br>(0.382)   | -1.059<br>(0.586)   | -0.771<br>(0.354)   | -0.770<br>(0.332)   | -0.758<br>(0.341)   | -0.741<br>(0.523)   | -0.772<br>(0.355)   | -0.765<br>(0.352)   | -0.793<br>(0.322)   | -0.364<br>(0.400)   | -0.782<br>(0.408)   |
| Industry category F                   | -0.609<br>(0.294)   | -0.603<br>(0.300)   | -0.797<br>(0.526)   | -0.602<br>(0.294)   | -0.605<br>(0.261)   | -0.591<br>(0.278)   | -0.507<br>(0.396)   | -0.603<br>(0.288)   | -0.600<br>(0.283)   | -0.645<br>(0.235)   | -0.487<br>(0.495)   | -0.609<br>(0.346)   |
| Industry categories G to J            | -0.602<br>(0.227)   | -0.602<br>(0.260)   | -0.797<br>(0.435)   | -0.609<br>(0.219)   | -0.604<br>(0.200)   | -0.590<br>(0.205)   | -0.545<br>(0.355)   | -0.606<br>(0.234)   | -0.600<br>(0.228)   | -0.631*<br>(0.200)  | -0.448<br>(0.373)   | -0.615<br>(0.277)   |
| Industry category K                   | -0.128<br>(0.491)   | -0.035<br>(0.461)   | -0.177<br>(0.639)   | -0.042<br>(0.508)   | -0.051<br>(0.454)   | -0.019<br>(0.480)   | -0.558<br>(0.600)   | -0.051<br>(0.469)   | -0.077<br>(0.481)   | 0.317<br>(0.420)    | 0.303<br>(0.386)    | -0.047<br>(0.511)   |
| Industry categories L to N            | -0.678              | -0.675              | -0.965              | -0.682              | -0.679              | -0.668              | -0.594              | -0.679              | -0.675              | -0.701              | -0.503              | -0.688              |

|                            | <b>omits BG</b> | <b>omits HR</b> | <b>omits CZ</b> | <b>omits DK</b> | <b>omits FI</b> | <b>omits FR</b> | <b>omits HU</b> | <b>omits LT</b> | <b>omits LU</b> | <b>omits NL</b> | <b>omits RO</b> | <b>omits SI</b> |
|----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                            | (0.263)         | (0.292)         | (0.457)         | (0.261)         | (0.235)         | (0.251)         | (0.356)         | (0.266)         | (0.262)         | (0.253)         | (0.425)         | (0.314)         |
| Industry categories O to U | -0.196          | -0.199          | -0.268          | -0.201          | -0.205          | -0.218          | -0.203          | -0.204          | -0.210          | -0.373          | 0.129           | -0.201          |
|                            | (0.397)         | (0.415)         | (0.684)         | (0.379)         | (0.363)         | (0.352)         | (0.609)         | (0.381)         | (0.394)         | (0.263)         | (0.536)         | (0.461)         |
| Industry categories other  | -0.697          | -0.723          | -0.349          | -0.708          | -0.725          | -0.725          | -0.652          | -0.729          | -0.703          | -0.755          | -1.717          | -0.734          |
|                            | (3.286)         | (3.328)         | (5.473)         | (3.355)         | (2.942)         | (3.662)         | (3.251)         | (3.244)         | (3.477)         | (3.325)         | (4.642)         | (3.385)         |
| Post-choice                | -0.671*         | -0.642          | -0.343          | -0.651          | -0.645          | -0.588          | -0.649          | -0.641          | -0.651          | -0.758*         | -0.729          | -0.646          |
|                            | (0.208)         | (0.224)         | (0.215)         | (0.232)         | (0.212)         | (0.240)         | (0.304)         | (0.218)         | (0.210)         | (0.231)         | (0.273)         | (0.241)         |
| log (age)                  | 0.339*          | 0.362           | 0.406           | 0.358*          | 0.359*          | 0.407***        | 0.334           | 0.362*          | 0.358           | 0.293           | 0.415*          | 0.359*          |
|                            | (0.111)         | (0.119)         | (0.183)         | (0.108)         | (0.101)         | (0.093)         | (0.136)         | (0.115)         | (0.116)         | (0.102)         | (0.121)         | (0.110)         |
| Listed                     | -0.716          | -0.460          | -0.637          | -0.491          | -0.451          | -0.911          | -0.486          | -0.547          | -0.514          | -0.618          | 2.284*          | -0.494          |
|                            | (1.564)         | (1.631)         | (1.564)         | (1.663)         | (1.562)         | (1.566)         | (1.728)         | (1.595)         | (1.568)         | (1.941)         | (0.674)         | (1.600)         |
| AIC                        | 36048.159       | 36459.491       | 18955.897       | 36157.501       | 36586.599       | 35690.773       | 31374.725       | 36533.815       | 36313.186       | 34247.777       | 27544.911       | 36130.552       |
| BIC                        | 36321.611       | 36735.312       | 19226.468       | 36420.946       | 36862.540       | 35962.086       | 31649.024       | 36809.745       | 36587.098       | 34522.827       | 27818.907       | 36406.422       |
| Log Likelihood             | -17995.080      | -18200.746      | -9448.949       | -18049.750      | -18264.299      | -17816.387      | -15658.362      | -18237.908      | -18127.593      | -17094.889      | -13743.456      | -18036.276      |
| Deviance                   | 35990.159       | 36401.491       | 18897.897       | 36099.501       | 36528.599       | 35632.773       | 31316.725       | 36475.815       | 36255.186       | 34189.777       | 27486.911       | 36072.552       |
| Num. obs.                  | 91983           | 99815           | 83287           | 65141           | 100229          | 85444           | 94713           | 100189          | 93454           | 97194           | 93727           | 99983           |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. Bootstrapped standard errors clustered by country; pooled logistic regression with country dummies; p values are calculated using the Holm-Bonferroni correction.

Table A.6: Logistic two-step regression for Italy and Portugal

|                                        | Italy                |                       | Portugal              |                       |
|----------------------------------------|----------------------|-----------------------|-----------------------|-----------------------|
|                                        | new structure        | two-tier <sup>#</sup> | new structure         | two-Tier <sup>#</sup> |
| (Intercept)                            | -5.156***<br>(0.643) | 9.011<br>(4.275)      | -11.501***<br>(1.466) | -3.579<br>(2.555)     |
| log (no. shareholders)                 | 0.298**<br>(0.077)   | -0.504<br>(0.394)     | 1.315***<br>(0.277)   | -0.282<br>(1.000)     |
| Majority shareholder                   | 0.036<br>(0.184)     | -0.148<br>(1.240)     | 0.495<br>(0.544)      | 0.261<br>(1.200)      |
| Shareholder-directors                  | -1.070**<br>(0.291)  | -0.800<br>(1.908)     | -2.766<br>(1.642)     | 3.696<br>(6.320)      |
| Shareholders with two-tier back-ground | 0.477<br>(0.390)     | -1.194<br>(1.587)     | 0.336<br>(0.689)      | 0.139<br>(1.344)      |
| Foreign directors                      | 1.253<br>(0.841)     | -6.400<br>(3.119)     | 2.520<br>(1.608)      | 2.213<br>(7.266)      |
| Directors with two-tier background     | 1.747<br>(0.910)     | 0.758<br>(2.279)      | -2.390<br>(0.984)     | 1.499<br>(5.122)      |
| Female directors                       | 0.219<br>(0.415)     | -3.202<br>(2.472)     | -1.030<br>(1.332)     | -2.578<br>(5.601)     |
| Post-choice                            | 0.340<br>(0.289)     | -1.861<br>(1.809)     | -0.580<br>(0.891)     | 2.343<br>(2.382)      |
| log (age)                              | -0.035<br>(0.171)    | -0.716<br>(0.996)     | 0.874<br>(0.360)      | 0.633<br>(0.476)      |
| Listed                                 | 0.263<br>(0.525)     | -3.137<br>(1.521)     | 3.169***<br>(0.671)   | 0.884<br>(1.555)      |
| AIC                                    | 2023.947             | 37.078                | 298.553               | 51.739                |
| Pseudo R2                              | 0.020                | 0.420                 | 0.357                 | 0.150                 |
| Num. obs.                              | 24160                | 172                   | 22379                 | 28                    |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. p-values are calculated using the Holm-Bonferroni correction. In regressions marked with #, we used Firth's Bias-Reduced Logistic Regression, which uses a penalty function to account for the small number of observations in one group (PMLE). Note that industry dummies are omitted as they prevented the convergence of the algorithm.

Table A.7: Multinomial probit models for Italy and Portugal

|                                       | (1)<br>Italy         | (2)<br>Italy         | (3)<br>Portugal      |
|---------------------------------------|----------------------|----------------------|----------------------|
| <b>One-tier</b>                       |                      |                      |                      |
| Intercept                             | -3.526***<br>(0.399) | -3.045***<br>(0.560) | -6.746***<br>(0.801) |
| log (no. shareholders)                | 0.137<br>(0.0514)    | 0.154<br>(0.0596)    | 0.729***<br>(0.162)  |
| Majority shareholder                  | 0.0314<br>(0.115)    | 0.0145<br>(0.132)    | 0.250<br>(0.301)     |
| Shareholder-directors                 | -0.444<br>(0.178)    | -0.449<br>(0.207)    | -2.272<br>(1.136)    |
| Foreign shareholders                  |                      | 0.440<br>(0.208)     |                      |
| Shareholders with two-tier background | 0.0152<br>(0.240)    | 0.228<br>(0.234)     | 0.349<br>(0.365)     |
| Foreign directors                     | -0.189<br>(0.745)    | -0.950<br>(0.929)    | 1.335<br>(0.847)     |
| Directors with two-tier background    | -0.343<br>(0.706)    | -0.609<br>(0.755)    | -1.285<br>(0.520)    |
| Female directors                      | -0.0987<br>(0.267)   | -0.0248<br>(0.303)   | -0.293<br>(0.653)    |
| Post-choice                           | -0.0549<br>(0.185)   | -0.133<br>(0.210)    | -0.470<br>(0.489)    |
| log (age)                             | -0.0835<br>(0.106)   | -0.138<br>(0.123)    | 0.425<br>(0.196)     |
| Listed                                | 0.0559<br>(0.367)    | -0.0189<br>(0.509)   | 1.923***<br>(0.428)  |
| log (total assets)                    |                      | -0.0336<br>(0.0451)  |                      |
| log (employees)                       |                      | -0.0111<br>(0.0435)  |                      |
| <b>Two-tier</b>                       |                      |                      |                      |
| Intercept                             | -4.403***<br>(0.471) | -5.034***<br>(0.650) | -12.30***<br>(2.441) |
| log (no. shareholders)                | 0.175*<br>(0.0576)   | 0.184<br>(0.0642)    | 0.771<br>(0.408)     |
| Majority shareholder                  | 0.00246<br>(0.135)   | -0.0614<br>(0.150)   | 0.678<br>(0.814)     |
| Shareholder-directors                 | -0.627*<br>(0.214)   | -0.492<br>(0.244)    | 0.511<br>(1.540)     |
| Foreign shareholders                  |                      | 0.231<br>(0.246)     |                      |
| Shareholders with two-tier background | 0.381<br>(0.260)     | 0.416<br>(0.266)     | -0.0307<br>(1.414)   |
| Foreign directors                     | 0.955<br>(0.602)     | 0.849<br>(0.764)     | -1.210<br>(5.875)    |
| Directors with two-tier background    | 1.678<br>(0.639)     | 1.338<br>(0.681)     | -0.838<br>(2.652)    |
| Female directors                      | 0.379<br>(0.290)     | 0.342<br>(0.341)     | -1.668<br>(2.797)    |
| Post-choice                           | 0.437<br>(0.206)     | 0.486<br>(0.227)     | 2.265<br>(1.199)     |
| log (age)                             | 0.0679<br>(0.123)    | 0.0757<br>(0.138)    | 1.429*<br>(0.491)    |
| Listed                                | 0.224<br>(0.367)     | 0.158<br>(0.406)     | 1.946<br>(0.927)     |
| log (total assets)                    |                      | 0.0571<br>(0.0489)   |                      |
| log (employees)                       |                      | -0.00212<br>(0.0476) |                      |
| AIC                                   | 2261.2               | 1862.3               | 326.1                |
| BIC                                   | 2439.3               | 2084.5               | 502.4                |
| Ll                                    | -1108.6              | -903.2               | -141.0               |
| N                                     | 24160                | 20653                | 22379                |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. p-values are calculated using the Holm-Bonferroni correction

Table A.8: Extended Logistic regression with dependent variable “two-tier model”

|                                       | Bulgaria <sup>#</sup> | Croatia <sup>#</sup> | Czech Rep.           | Denmark <sup>#</sup>  | Finland <sup>#</sup> | France               | Hungary              | Lithuania <sup>#</sup> | Luxembourg <sup>#</sup> | Netherlands         | Romania              | Slovenia           |
|---------------------------------------|-----------------------|----------------------|----------------------|-----------------------|----------------------|----------------------|----------------------|------------------------|-------------------------|---------------------|----------------------|--------------------|
| (Intercept)                           | -12.835***<br>(2.143) | 1.962<br>(2.441)     | 1.023<br>(0.816)     | -10.777***<br>(1.864) | -1.664<br>(3.354)    | -20.157<br>(732.895) | -4.003***<br>(0.655) | -12.625<br>(4.501)     | -10.256<br>(3.039)      | -2.416<br>(1.653)   | 2.030***<br>(0.369)  | 0.065<br>(2.023)   |
| log (no. share-holders)               | -0.565<br>(0.490)     | -0.385<br>(0.524)    | 1.091<br>(0.519)     | -0.777<br>(0.376)     | -1.612<br>(0.725)    | 0.285<br>(0.248)     | 0.843***<br>(0.137)  | 0.773<br>(0.827)       | 0.016<br>(0.393)        | -0.119<br>(0.219)   | 0.564***<br>(0.066)  | 0.351<br>(0.295)   |
| Majority share-holder                 | 1.263<br>(0.613)      | -1.245<br>(0.621)    | -0.389<br>(0.401)    | 0.794<br>(0.778)      | -1.956<br>(1.107)    | -0.171<br>(0.335)    | 0.083<br>(0.339)     | -1.134<br>(0.996)      | 0.678<br>(0.874)        | -1.186**<br>(0.326) | -0.051<br>(0.067)    | -0.508<br>(0.343)  |
| Shareholder-directors                 | -2.876<br>(1.381)     | -0.194<br>(1.299)    | -0.959***<br>(0.127) | -1.937<br>(1.613)     | -10.173<br>(4.522)   | -0.802<br>(1.023)    | -3.817***<br>(0.329) | -1.513<br>(2.000)      | -1.952<br>(2.431)       | -0.613<br>(1.256)   | -1.846***<br>(0.120) | -1.762*<br>(0.568) |
| Foreign share-holders                 | 0.497<br>(0.751)      | 0.009<br>(1.252)     | -0.014<br>(0.177)    | -0.530<br>(0.589)     | 2.183<br>(1.701)     | 0.720<br>(0.590)     | -0.773***<br>(0.166) | -0.127<br>(0.944)      | 0.197<br>(0.686)        | 0.437<br>(0.323)    | 0.146<br>(0.135)     | -1.302<br>(0.654)  |
| Shareholders with two-tier background | 0.188<br>(0.700)      | -3.563<br>(1.761)    | 0.047<br>(0.177)     | -0.490<br>(0.482)     | -2.204<br>(1.652)    | 0.871<br>(0.706)     | 0.352<br>(0.181)     | 0.787<br>(0.859)       | -0.546<br>(0.550)       | 0.584<br>(0.321)    | 0.337<br>(0.151)     | 0.217<br>(0.836)   |
| Foreign directors                     | 0.564<br>(1.376)      | 7.906<br>(4.360)     | -0.213<br>(0.307)    | 3.418*<br>(0.788)     | -3.912<br>(3.974)    | 1.748<br>(1.175)     | 0.470<br>(0.441)     | 3.577<br>(2.113)       | 1.429<br>(0.940)        | -1.287<br>(0.496)   | -1.935***<br>(0.242) | 7.156<br>(3.017)   |
| Directors with two-tier background    | 0.458<br>(1.384)      | 1.410<br>(1.535)     | 0.697<br>(0.375)     | 2.072<br>(0.629)      | 19.925<br>(7.602)    | 0.263<br>(0.849)     | 0.445<br>(0.349)     | 5.326<br>(2.386)       | 2.274<br>(0.668)        | 0.008<br>(0.342)    | -0.021<br>(0.289)    | -0.407<br>(1.037)  |
| Female directors                      | 0.460<br>(0.909)      | 1.941<br>(1.249)     | -0.260<br>(0.169)    | 2.259<br>(0.929)      | -0.710<br>(2.791)    | 0.409<br>(1.100)     | 0.248<br>(0.187)     | 1.939<br>(1.606)       | -3.394<br>(2.556)       | 1.004<br>(0.531)    | 1.902***<br>(0.116)  | -0.384<br>(0.605)  |
| Employee board representation         |                       | 2.461<br>(0.939)     | 0.085<br>(0.212)     | 0.501<br>(0.597)      | 2.387<br>(1.446)     | 0.112<br>(0.535)     | 0.532<br>(0.203)     |                        | -0.301<br>(1.063)       | 0.729<br>(0.351)    |                      | 0.698<br>(0.484)   |
| Industry categories B to E            | -1.685<br>(1.498)     | 0.787<br>(1.441)     | -0.502<br>(0.320)    | -0.758<br>(1.343)     |                      | 13.307<br>(732.895)  | -0.234<br>(0.230)    | 0.191<br>(1.308)       | -0.234<br>(1.633)       | -0.817<br>(1.558)   | -0.679***<br>(0.136) | 1.065<br>(0.832)   |
| Industry category F                   | 0.172<br>(1.542)      | -0.009<br>(1.541)    | -0.401<br>(0.355)    | -1.626<br>(1.813)     | -0.449<br>(1.665)    | 13.180<br>(732.895)  | -0.160<br>(0.309)    | -0.499<br>(1.824)      | 2.092<br>(1.937)        | 0.079<br>(1.654)    | -0.419*<br>(0.148)   | 0.388<br>(0.893)   |
| Industry categories G to J            | -2.343<br>(1.575)     | -0.435<br>(1.362)    | -0.500<br>(0.316)    | -0.876<br>(1.331)     | -2.121<br>(1.365)    | 13.162<br>(732.895)  | -0.083<br>(0.227)    | 1.822<br>(1.611)       | 0.707<br>(1.583)        | -1.083<br>(1.560)   | -0.604***<br>(0.137) | 0.877<br>(0.843)   |
| Industry category K                   | -0.481<br>(1.571)     | -3.670<br>(1.626)    | 0.307<br>(0.487)     | -0.732<br>(1.368)     | 1.779<br>(1.467)     | 12.971<br>(732.895)  | 1.620***<br>(0.270)  | -1.587<br>(2.069)      | 1.696<br>(1.659)        | -0.955<br>(1.560)   | -1.322***<br>(0.269) | 0.742<br>(0.966)   |

|                            |                     |                   |                      |                   |                   |                     |                     |                     |                   |                    |                      |                   |
|----------------------------|---------------------|-------------------|----------------------|-------------------|-------------------|---------------------|---------------------|---------------------|-------------------|--------------------|----------------------|-------------------|
| Industry categories L to N | -1.546<br>(1.687)   | -0.405<br>(1.473) | -0.309<br>(0.317)    | -0.900<br>(1.362) | 0.901<br>(1.105)  | 13.666<br>(732.895) | 0.082<br>(0.228)    | -6.704<br>(2.754)   | -0.661<br>(1.741) | -1.629<br>(1.556)  | -0.869***<br>(0.140) | 0.805<br>(0.864)  |
| Industry categories O to U | -1.062<br>(1.643)   | -0.338<br>(1.906) | 0.199<br>(0.396)     | -1.290<br>(1.873) | -1.412<br>(1.824) | 14.168<br>(732.895) | 0.652<br>(0.314)    | -1.681<br>(2.049)   | 2.553<br>(1.914)  | 0.804<br>(1.596)   | -0.652*<br>(0.240)   | 0.019<br>(1.022)  |
| Industry categories other  | 3.098<br>(2.078)    |                   | 13.882<br>(1455.398) | -0.025<br>(1.825) |                   |                     | -9.814<br>(324.744) |                     | 10.536<br>(3.056) |                    | -1.407*<br>(0.450)   |                   |
| Post-choice                |                     | -0.227<br>(0.993) | -0.809<br>(0.278)    | 0.503<br>(0.912)  | 0.518<br>(1.184)  |                     | -0.060<br>(0.197)   |                     | 0.488<br>(0.871)  | 0.038<br>(0.432)   | -0.455*<br>(0.142)   | -0.972<br>(0.742) |
| log (age)                  | 0.441<br>(0.326)    | 0.135<br>(0.434)  | -0.043<br>(0.127)    | 0.117<br>(0.282)  | -0.385<br>(0.642) | -0.564<br>(0.216)   | 0.231<br>(0.127)    | 0.638<br>(0.456)    | -0.763<br>(0.612) | 0.427*<br>(0.139)  | 0.366**<br>(0.097)   | -0.075<br>(0.468) |
| Listed                     | 5.040***<br>(0.676) | 0.267<br>(0.628)  | 11.509<br>(364.913)  | 2.875<br>(0.894)  | 4.035<br>(1.853)  | 3.438***<br>(0.506) | 0.316<br>(0.679)    | 4.781***<br>(1.263) | 1.332<br>(1.123)  | 0.486<br>(0.521)   | -1.926***<br>(0.175) | 0.769<br>(0.752)  |
| log (total assets)         | 0.420<br>(0.161)    | 0.115<br>(0.160)  | 0.074<br>(0.033)     | 0.318<br>(0.116)  | 0.143<br>(0.258)  | 0.167<br>(0.112)    | 0.127**<br>(0.035)  | 1.344<br>(0.424)    | 0.484<br>(0.155)  | 0.183**<br>(0.048) | -0.371***<br>(0.021) | 0.088<br>(0.122)  |
| log (employees)            | 0.462<br>(0.165)    | -0.332<br>(0.209) | 0.143<br>(0.066)     | 0.214<br>(0.148)  | -0.063<br>(0.370) | 0.048<br>(0.124)    | 0.349***<br>(0.051) | -1.706**<br>(0.477) | 0.183<br>(0.202)  | 0.118<br>(0.076)   | -0.138***<br>(0.022) | -0.063<br>(0.162) |
| AIC                        | 159.308             | 140.190           | 2698.332             | 273.136           | 76.539            | 474.325             | 2345.253            | 69.840              | 98.037            | 682.296            | 6738.435             | 356.239           |
| Pseudo R2                  | 0.661               | 0.227             | 0.085                | 0.290             | 0.273             | 0.425               | 0.311               | 0.640               | 0.586             | 0.293              | 0.264                | 0.141             |
| Num. obs.                  | 5994                | 564               | 3251                 | 24668             | 204               | 6508                | 2664                | 163                 | 1215              | 661                | 6599                 | 349               |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. p-values are calculated using the Holm-Bonferroni correction. In countries marked with #, we used Firth's Bias-Reduced Logistic Regression, which uses a penalty function to account for the small number of observations in one group (PMLE).

Table A.9: Extended Logistic regressions for Italy and Portugal

|                                       | Italy                |                      |                       | Portugal                   |                       |                       |
|---------------------------------------|----------------------|----------------------|-----------------------|----------------------------|-----------------------|-----------------------|
|                                       | new structure        | new structure        | two-tier <sup>#</sup> | new structure <sup>#</sup> | new structure         | two-tier <sup>#</sup> |
| (Intercept)                           | -4.926**<br>(1.360)  | -5.229***<br>(0.904) | 7.017<br>(4.352)      | -14.964***<br>(2.523)      | -17.434***<br>(2.876) | -2.944<br>(4.414)     |
| log (no. shareholders)                | 0.316**<br>(0.089)   | 0.327**<br>(0.087)   | -0.407<br>(0.381)     | 1.238<br>(0.305)           | 1.025<br>(0.446)      | -0.344<br>(1.311)     |
| Majority shareholder                  | -0.061<br>(0.210)    | -0.070<br>(0.210)    | -0.080<br>(1.162)     | 1.072<br>(0.650)           | 0.917<br>(0.896)      | -1.198<br>(1.497)     |
| Shareholder-directors                 | -0.945<br>(0.337)    | -0.966<br>(0.337)    | -0.742<br>(1.837)     | 0.244<br>(1.407)           | -0.381<br>(2.137)     | 8.632<br>(9.070)      |
| Foreign shareholders                  | 0.724<br>(0.313)     | 0.718<br>(0.314)     | -1.589<br>(1.861)     | 0.036<br>(0.700)           | 0.132<br>(0.880)      | -0.010<br>(1.615)     |
| Shareholders with two-tier background | 0.632<br>(0.354)     | 0.614<br>(0.354)     | 0.193<br>(1.229)      | 0.634<br>(0.757)           | 0.800<br>(0.950)      | -1.376<br>(2.263)     |
| Foreign directors                     | 0.399<br>(1.088)     | 0.369<br>(1.091)     | -1.975<br>(4.314)     | 4.884<br>(1.822)           | 3.733<br>(2.512)      | 9.591<br>(18.320)     |
| Directors with two-tier background    | 1.187<br>(0.967)     | 1.211<br>(0.973)     | -0.900<br>(2.282)     | -1.497<br>(1.215)          | -1.387<br>(1.649)     | 1.832<br>(10.314)     |
| Female directors                      | 0.227<br>(0.481)     | 0.283<br>(0.480)     | -1.369<br>(2.790)     | 0.305<br>(1.534)           | -0.401<br>(2.206)     | 2.848<br>(5.944)      |
| Industry categories B to E            | -0.475<br>(1.018)    |                      |                       | -2.012<br>(1.440)          |                       |                       |
| Industry category F                   | -0.435<br>(1.087)    |                      |                       | -3.263<br>(2.139)          |                       |                       |
| Industry categories G to J            | -0.388<br>(1.020)    |                      |                       | -1.134<br>(1.329)          |                       |                       |
| Industry category K                   | -0.420<br>(1.070)    |                      |                       | 0.541<br>(1.366)           |                       |                       |
| Industry categories L to N            | -0.000<br>(1.023)    |                      |                       | 0.366<br>(1.296)           |                       |                       |
| Industry categories O to U            | -0.258<br>(1.106)    |                      |                       | -0.171<br>(1.743)          |                       |                       |
| Industry categories other             | -10.758<br>(425.265) |                      |                       |                            |                       |                       |
| Post-choice                           | 0.304<br>(0.324)     | 0.304<br>(0.324)     | -1.327<br>(1.630)     | -0.911<br>(0.929)          | -0.701<br>(1.294)     | 0.484<br>(3.645)      |
| log (age)                             | -0.082<br>(0.197)    | -0.108<br>(0.196)    | -0.483<br>(0.852)     | 0.388<br>(0.448)           | 0.506<br>(0.565)      | 0.063<br>(1.038)      |
| Listed                                | 0.218<br>(0.627)     | 0.177<br>(0.628)     | -2.512<br>(1.482)     | 2.305<br>(0.819)           | 2.171<br>(1.026)      | -1.361<br>(2.479)     |
| log (total assets)                    | 0.010<br>(0.072)     | 0.022<br>(0.071)     | -0.114<br>(0.337)     | 0.490*<br>(0.129)          | 0.688***<br>(0.158)   | -0.031<br>(0.249)     |
| log (employees)                       | 0.020<br>(0.069)     | -0.006<br>(0.068)    | 0.280<br>(0.392)      | 0.011<br>(0.125)           | -0.115<br>(0.170)     | 0.355<br>(0.461)      |
| AIC                                   | 1671.237             | 1661.530             | 40.462                | 138.319                    | 150.078               | 54.918                |
| Pseudo R2                             | 0.029                | 0.026                | 0.432                 | 0.562                      | 0.488                 | 0.130                 |
| Num. obs.                             | 20653                | 20653                | 140                   | 10106                      | 10106                 | 16                    |

\*\*\*p < 0.001; \*\*p < 0.01; \*p < 0.05. p-values are calculated using the Holm-Bonferroni correction. In regressions marked with #, we used Firth's Bias-Reduced Logistic Regression, which uses a penalty function to account for the small number of observations in one group (PMLE)



Table A.10: Percentage of imputations

|                                  | BG    | HR    | CZ     | DK     | FI    | FR     | HU    | IT     | LT    | LU    | NL    | PT     | RO    | SI    |
|----------------------------------|-------|-------|--------|--------|-------|--------|-------|--------|-------|-------|-------|--------|-------|-------|
| n                                | 8,596 | 655   | 17,185 | 35,347 | 246   | 15,055 | 5,767 | 24,179 | 280   | 7,053 | 3,276 | 22,395 | 6,744 | 490   |
| Foreign shareholders             | 0.62  | 7.63  | 56.39  | 2.09   | 3.25  | 22.62  | 29.20 | 0.25   | 27.86 | 23.17 | 54.95 | 35.71  | 1.94  | 15.51 |
| Largest shareholders             | 0.62  | 7.63  | 56.39  | 2.09   | 3.25  | 22.62  | 29.20 | 0.25   | 27.86 | 23.17 | 54.95 | 35.71  | 1.94  | 15.51 |
| Shareholder concentration        | 0.62  | 7.63  | 56.39  | 2.09   | 3.25  | 22.62  | 29.20 | 0.25   | 27.86 | 23.17 | 54.95 | 35.71  | 1.94  | 15.51 |
| Shareholder-directors            | 0.02  | 0     | 0      | 0      | 0     | 0      | 0.05  | 0      | 0     | 0     | 0     | 0      | 0     | 0     |
| Female directors                 | 0.02  | 0     | 0      | 0      | 0     | 0      | 0.05  | 0      | 0     | 0     | 0     | 0      | 0     | 0     |
| Foreign directors                | 0.02  | 0     | 0      | 0      | 0     | 0      | 0.05  | 0      | 0     | 0     | 0     | 0      | 0     | 0     |
| ROE (year of data collection)    | 20.30 | 11.76 | 28.54  | 10.91  | 6.10  | 9.40   | 12.14 | 3.07   | 35    | 70.74 | 81.01 | 13.92  | 16.55 | 17.14 |
| ROE (-1 year of data collection) | 23.59 | 10.23 | 31.25  | 13.97  | 9.76  | 10.82  | 22.39 | 5.07   | 36.07 | 65.06 | 79.30 | 17.24  | 16.95 | 12.24 |
| ROE (-2 year of data collection) | 26.42 | 9.16  | 33.84  | 16.78  | 15.04 | 11.63  | 25.75 | 7.06   | 37.50 | 64.02 | 79.33 | 21.11  | 17.29 | 13.47 |
| ROE (-3 year of data collection) | 29.19 | 11.76 | 36.64  | 19.55  | 21.14 | 12.65  | 32.17 | 8.74   | 33.93 | 65.80 | 78.94 | 24.48  | 18.05 | 13.47 |
| ROE (-4 year of data collection) | 32.28 | 13.13 | 39.62  | 21.90  | 26.83 | 13.69  | 37.04 | 10.19  | 37.86 | 68.65 | 79.79 | 27.21  | 19.78 | 15.10 |
| ROE (-5 year of data collection) | 37.28 | 15.88 | 43.07  | 99.60  | 32.52 | 15.11  | 42.15 | 11.65  | 38.57 | 70.78 | 80.98 | 29.73  | 22.58 | 16.94 |
| ROE (-6 year of data collection) | 41.43 | 17.71 | 46.58  | 99.61  | 34.15 | 16.75  | 50.84 | 13.08  | 40    | 73.67 | 82.05 | 32.72  | 24.56 | 21.63 |
| ROE (-7 year of data collection) | 63.10 | 19.54 | 50.54  | 99.69  | 39.84 | 18.43  | 55.89 | 14.89  | 50.36 | 78.55 | 83.61 | 35.98  | 25.87 | 42.65 |
| ROE (-8 year of data collection) | 63.82 | 23.97 | 55.78  | 99.72  | 42.28 | 19.79  | 57.10 | 16.92  | 50    | 82.14 | 87.12 | 39.79  | 26.25 | 44.49 |
| ROE (-9 year of data collection) | 63.08 | 27.48 | 62.87  | 99.72  | 45.53 | 21.99  | 61.85 | 19.46  | 47.14 | 85.17 | 90.69 | 43.80  | 28.07 | 43.67 |
| ROA (year of data collection)    | 8.67  | 1.22  | 21.37  | 5.59   | 4.07  | 1.56   | 7.89  | 0.21   | 34.29 | 64.43 | 80.28 | 3.30   | 2.22  | 12.86 |
| ROA (-1 year of data collection) | 12.60 | 1.22  | 24.32  | 8.43   | 7.32  | 3.20   | 18.17 | 2.15   | 35    | 57.85 | 78.02 | 7.25   | 3.44  | 6.73  |
| ROA (-2 year of data collection) | 15.83 | 2.14  | 27.26  | 11.25  | 13.01 | 3.99   | 21.97 | 4.03   | 36.43 | 56.83 | 78.24 | 11.19  | 4.51  | 8.16  |
| ROA (-3 year of data collection) | 18.90 | 3.51  | 30.39  | 13.80  | 17.48 | 5.54   | 28.77 | 5.68   | 33.21 | 59.38 | 77.87 | 15.26  | 6.60  | 10    |
| ROA (-4 year of data collection) | 22.43 | 4.89  | 33.91  | 16.26  | 24.39 | 6.84   | 34.30 | 7.26   | 36.79 | 62.70 | 78.85 | 18.89  | 9.76  | 12.65 |
| ROA (-5 year of data collection) | 28.68 | 7.94  | 37.78  | 99.59  | 28.46 | 8.63   | 39.95 | 9.02   | 37.50 | 65.08 | 80.10 | 22.67  | 13.76 | 15.10 |
| ROA (-6 year of data collection) | 33.93 | 11.76 | 41.87  | 99.60  | 31.30 | 10.35  | 48.73 | 11.90  | 39.64 | 68.91 | 81.50 | 26.56  | 16.62 | 19.80 |

|                                                |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
|------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| ROA (-7 year of data collection)               | 59.78 | 12.98 | 46.73 | 99.69 | 37.80 | 12.35 | 54.31 | 14.22 | 50    | 75.37 | 83.33 | 30.65 | 18.80 | 41.63 |
| ROA (-8 year of data collection)               | 60.71 | 19.54 | 52.60 | 99.72 | 40.65 | 14.16 | 55.94 | 16.27 | 50    | 79.77 | 86.87 | 34.95 | 20.26 | 43.47 |
| ROA (-9 year of data collection)               | 60.25 | 23.97 | 60.20 | 99.72 | 43.50 | 16.50 | 61.11 | 18.80 | 46.79 | 83.78 | 90.48 | 39.66 | 22.89 | 42.86 |
| Operating revenue (year of data collection)    | 4.65  | 0     | 9.32  | 81.01 | 0.81  | 0     | 17.36 | 0     | 22.14 | 62.73 | 84.10 | 11.14 | 0     | 9.59  |
| Operating revenue (-1 year of data collection) | 8.34  | 0.15  | 15.38 | 81.02 | 4.47  | 1.87  | 26.30 | 1.95  | 12.86 | 57.01 | 82.66 | 14.04 | 1.56  | 13.27 |
| Operating revenue (-2 year of data collection) | 12.06 | 1.07  | 20.05 | 80.11 | 10.16 | 2.78  | 29.27 | 3.83  | 10    | 56.12 | 83.18 | 18    | 2.95  | 14.29 |
| Operating revenue (-3 year of data collection) | 15.22 | 3.05  | 23.92 | 75.94 | 17.48 | 4.25  | 34.78 | 5.49  | 11.79 | 58.84 | 83.42 | 21.38 | 5     | 15.10 |
| Operating revenue (-4 year of data collection) | 46.25 | 23.82 | 59.74 | 99.73 | 43.09 | 15.70 | 62.42 | 18.72 | 26.43 | 83.55 | 88.71 | 49.88 | 22.81 | 43.47 |
| EBIT (year of data collection)                 | 4.91  | 0     | 19.97 | 3.46  | 8.54  | 0.50  | 6.12  | 0.20  | 38.21 | 63.65 | 80.01 | 1.81  | 0.03  | 6.73  |
| EBIT (-1 year of data collection)              | 9.74  | 0.15  | 23.01 | 6.51  | 10.98 | 2.29  | 16.66 | 2.14  | 37.50 | 56.95 | 77.72 | 5.92  | 1.56  | 11.22 |
| EBIT (-2 year of data collection)              | 13.54 | 1.07  | 26.03 | 9.50  | 15.85 | 3.16  | 20.63 | 4     | 37.86 | 55.89 | 77.59 | 10.19 | 2.97  | 12.45 |
| EBIT (-3 year of data collection)              | 16.82 | 3.05  | 29.35 | 12.17 | 21.95 | 4.64  | 27.59 | 5.65  | 34.64 | 58.78 | 77.59 | 14.25 | 4.98  | 14.08 |
| EBIT (-9 year of data collection)              | 59.88 | 23.82 | 59.74 | 99.75 | 43.50 | 15.78 | 60.52 | 18.73 | 47.14 | 83.65 | 86.36 | 39.41 | 22.08 | 44.08 |
| Assets (year of data collection)               | 2.04  | 0     | 19.79 | 2.95  | 2.85  | 0     | 4.09  | 0     | 33.93 | 9.37  | 6.99  | 0.08  | 0     | 0     |
| Assets (- 9 year of data collection)           | 58.97 | 23.82 | 59.74 | 99.72 | 43.09 | 15.66 | 60.08 | 18.72 | 46.79 | 69.94 | 66.54 | 38.65 | 22.08 | 42.45 |
| Employees (year of data collection)            | 27.41 | 8.40  | 53.06 | 26.49 | 10.57 | 48.46 | 33.31 | 14.31 | 1.79  | 71.64 | 68.07 | 34.96 | 0.18  | 22.04 |
| Employees (-9 year of data collection)         | 43.56 | 28.70 | 69.16 | 99.75 | 48.78 | 50.55 | 77.94 | 35.97 | 26.43 | 97.99 | 81.84 | 56.65 | 23.19 | 43.67 |
| Tangible assets (year of data collection)      | 2.19  | 0     | 26.38 | 12.12 | 10.16 | 0.52  | 16.66 | 0.20  | 36.07 | 16.33 | 31.01 | 20.33 | 0.03  | 8.37  |
| Tangible assets (-9 year of data collection)   | 49.63 | 23.82 | 59.85 | 99.75 | 43.90 | 15.78 | 62.49 | 18.73 | 47.14 | 71.96 | 70.02 | 42.50 | 22.08 | 44.08 |
| Cash holdings (year of data collection)        | 10.96 | 1.83  | 30.60 | 17.59 | 11.38 | 4.35  | 5.72  | 2.78  | 36.79 | 13.46 | 34.28 | 4.31  | 1.81  | 8.16  |
| Cash holdings (-9 year of data collection)     | 59.99 | 25.65 | 60.24 | 99.75 | 43.90 | 18.70 | 60.76 | 19.31 | 47.50 | 71.26 | 69.72 | 40.45 | 22.57 | 44.29 |
| Equity capital (year of data collection)       | 2.04  | 0     | 19.79 | 2.95  | 2.85  | 0     | 3.99  | 1.74  | 33.93 | 9.37  | 6.41  | 0.05  | 0     | 0.61  |
| Equity capital (-9 year of data collection)    | 58.97 | 23.82 | 59.74 | 99.72 | 43.09 | 15.66 | 60.29 | 18.72 | 46.79 | 69.94 | 66.51 | 38.65 | 22.08 | 42.65 |
| Leverage (year of data collection)             | 2.76  | 0     | 20.40 | 3.60  | 2.85  | 0.13  | 4.35  | 1.74  | 33.93 | 9.49  | 7.48  | 0.28  | 0.56  | 1.02  |
| Leverage (-9 year of data collection)          | 58.97 | 23.82 | 59.83 | 99.72 | 43.09 | 15.72 | 60.36 | 18.72 | 46.79 | 69.97 | 66.58 | 38.67 | 22.18 | 42.65 |
| Cash ratio (year of data collection)           | 10.96 | 1.83  | 30.83 | 17.75 | 11.38 | 4.44  | 5.93  | 2.78  | 36.79 | 13.55 | 34.40 | 4.39  | 2.21  | 8.57  |
| Cash ratio (-9 year of data collection)        | 59.99 | 25.65 | 60.26 | 99.75 | 43.90 | 18.73 | 60.86 | 19.31 | 47.50 | 71.27 | 69.75 | 40.46 | 22.67 | 44.29 |

|                           |       |      |       |       |       |      |       |      |       |       |       |       |       |       |
|---------------------------|-------|------|-------|-------|-------|------|-------|------|-------|-------|-------|-------|-------|-------|
| ROA average               | 4.57  | 0    | 20.26 | 3.92  | 3.66  | 0.50 | 5.39  | 0.05 | 29.64 | 48.76 | 75.27 | 1.34  | 0.64  | 1.43  |
| ROA standard deviation    | 7.58  | 0.46 | 23.08 | 7.22  | 5.69  | 1.58 | 12.50 | 2.01 | 22.86 | 39.47 | 74.66 | 5.43  | 1.97  | 3.47  |
| ROE average               | 15    | 7.33 | 26.03 | 8.46  | 5.28  | 6.66 | 8.13  | 2.08 | 30    | 56.33 | 76.25 | 9.34  | 12.44 | 5.51  |
| ROE standard deviation    | 15.15 | 3.97 | 26.88 | 11.96 | 7.32  | 5.25 | 14.67 | 3.92 | 23.21 | 48.28 | 75.37 | 9.44  | 7.41  | 5.31  |
| Operating revenue average | 2.06  | 0    | 9.19  | 74.90 | 0.41  | 0    | 13.27 | 0    | 7.86  | 47.28 | 79.73 | 7.12  | 0     | 7.55  |
| PPE turnover              | 23.15 | 4.89 | 43.66 | 83.26 | 10.98 | 8.20 | 26.93 | 3.74 | 37.14 | 74.86 | 85.35 | 27.65 | 12.65 | 16.33 |
| Sales growth average      | 23.98 | 4.89 | 30.90 | 82.06 | 5.69  | 8.40 | 26.65 | 5.52 | 8.21  | 61.68 | 82.42 | 18.82 | 11.42 | 12.24 |
| EBIT margin average       | 16.75 | 2.90 | 33.41 | 77.06 | 9.35  | 6.36 | 17.98 | 3    | 32.14 | 60.27 | 79.79 | 10.97 | 8.35  | 12.86 |
| Age of company            | 1.26  | 0.15 | 0.02  | 0.05  | 2.44  | 0.20 | 0.14  | 0.08 | 0     | 0.54  | 0.03  | 0.07  | 0.03  | 0.82  |

*Note: The table shows percentages of imputations created for purposes of the random forest model. For each country, variables with more than 50% of imputations (shown in italics) were dropped. Variables where no imputations were necessary are not shown*

Figure A.1.1: Example classification tree for the Czech Republic

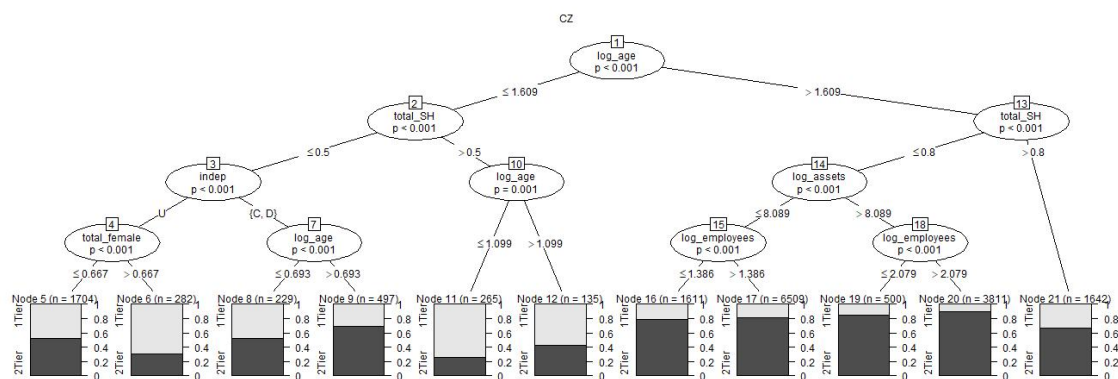
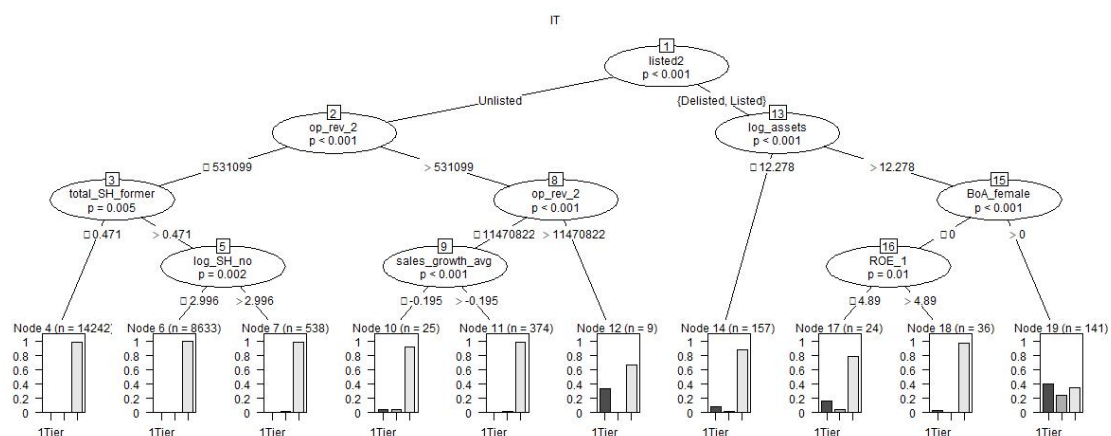


Figure A.1.2: Example classification tree for Italy



### Figures A.2.1 to A.3.14: preliminary remarks on SHAP summary plots

The subsequent figures show the top 15 variables in terms of mean absolute SHAP value in each country. Since we have SHAP values for each observation in the testing data, we can see that the model features have a different impact on each observation. We plot the SHAP value for each firm in the testing data. When an observation is shown on the right, it is associated with the two-tier model, while on the left, it is associated with the one-tier model; the SHAP value (i.e. distance from the middle) shows how much it affected the probability of the prediction. Note that a positive or negative SHAP value does not mean that a particular observation either has or is predicted to have a particular model. The SHAP value only shows the marginal effect of the variable on the probability of prediction. Each variable's effect is very small in all of our models.

The colour indicates a standardised feature value where yellow is a low value and blue a high value. Each variable is scaled along a range of colours across the observed range of its values (i.e., yellow as the minimum, purple as the maximum value). Thus, a concentration of purple dots on the right means that a high value is associated with the two-tier model. For example, in Bulgaria, the variable with the highest average absolute SHAP value is “Listed Company”, where high values (i.e. 1 or TRUE) are found on the right and thus associated with the two-tier model (note: the listed company variable in the random forest model has three dummy values, namely “listed”, “unlisted” and “delisted”, which is why it is possible for both “listed” and “delisted” to appear in the output).

Figures A.2.1 through A.2.14 show how each variable pushes each observation in the direction of one-tier (yellow) or two-tier (purple). Variables are sorted by mean absolute SHAP values. Figures A.3.1 through A.3.14 provide the identical information in the form of SHAP variable plots (some of which were reproduced in section 5.2. The placement along the x axis corresponds in the summary plots corresponds to the placement along the y axis in the individual variable plots. The colours in the SHAP summary plots (ranging from yellow to purple) are shown along the x axis in the SHAP variable plots.

Figure A.2.1: SHAP Summary Plot for Bulgaria

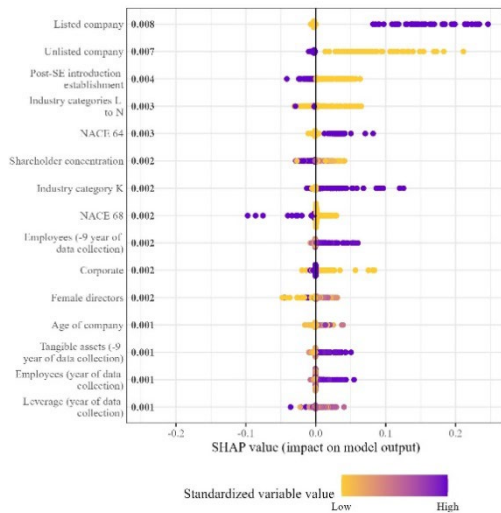


Figure A.2.2: SHAP Summary Plot for Croatia

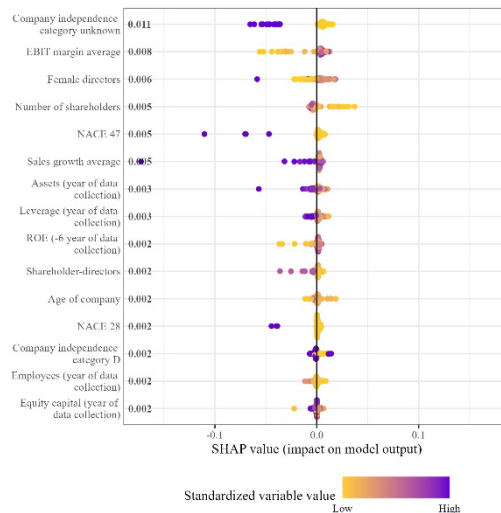


Figure A.2.3: SHAP Summary Plot for the Czech Republic

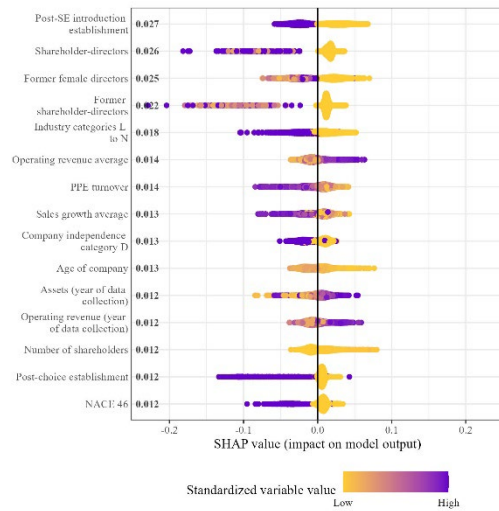


Figure A.2.4: SHAP Summary Plot for Denmark

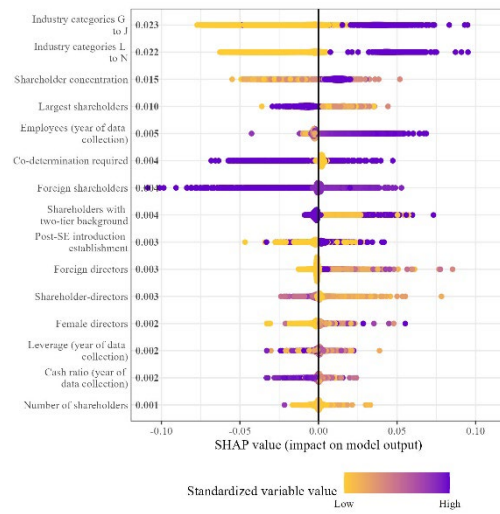


Figure A.2.5: SHAP Summary Plot for Finland

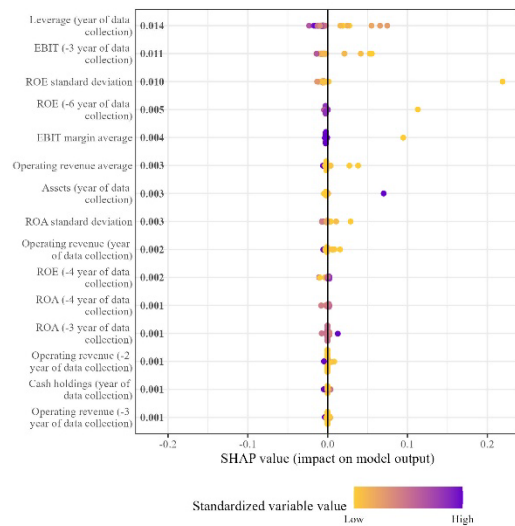


Figure A.2.6: SHAP Summary Plot for France

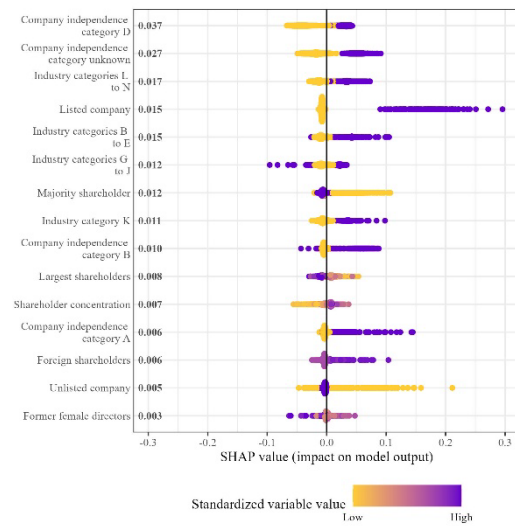


Figure A.2.7: SHAP Summary Plot for Hungary

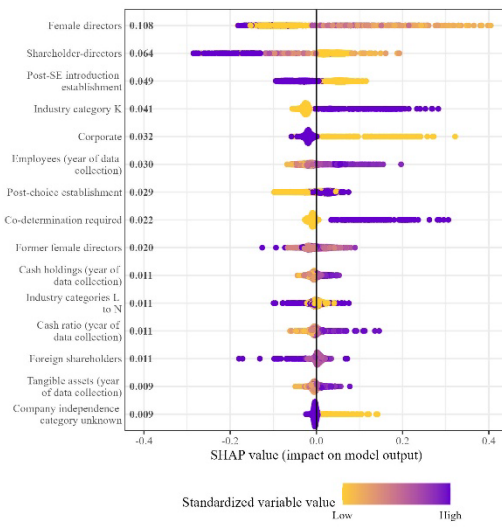


Figure A.2.8: SHAP Summary Plot for Lithuania

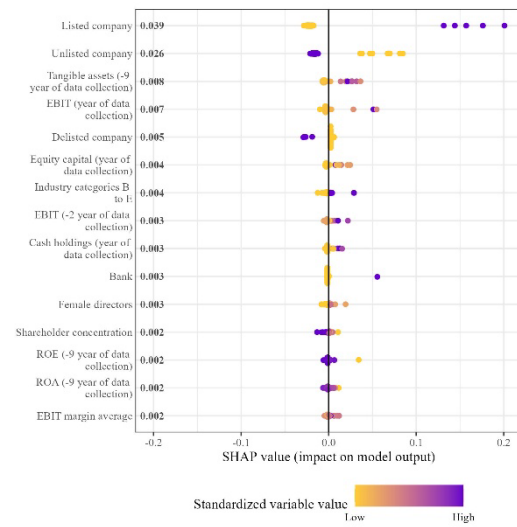


Figure A.2.9: SHAP Summary Plot for Luxembourg

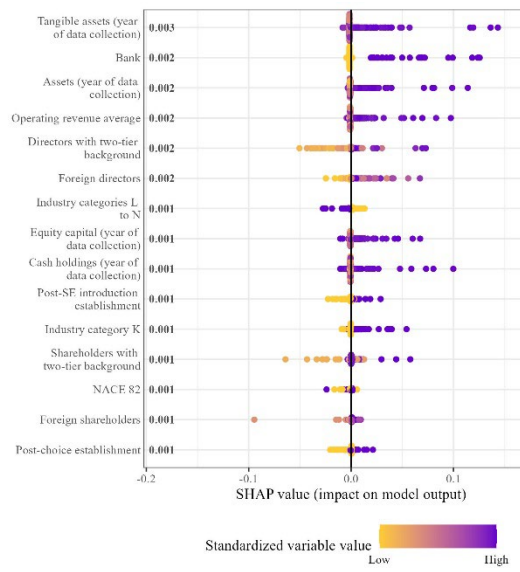


Figure A.2.10: SHAP Summary Plot for the Netherlands

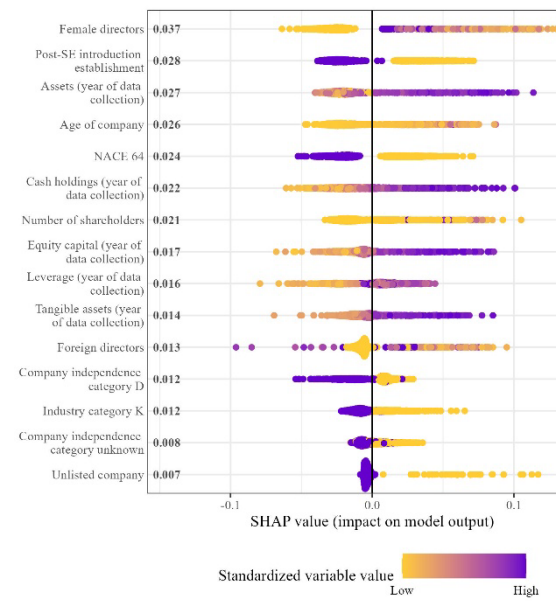


Figure A.2.11: SHAP Summary Plot for Romania

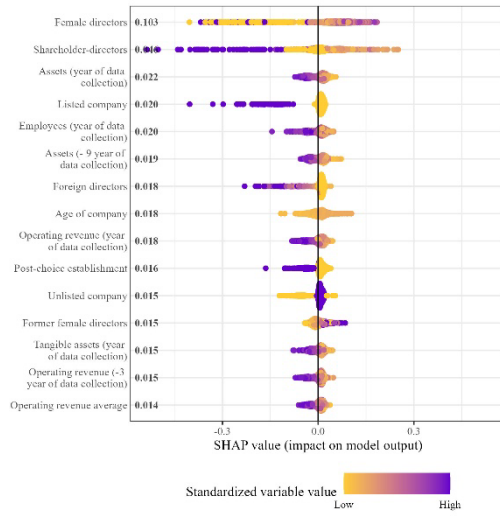


Figure A.2.12: SHAP Summary Plot for Slovenia

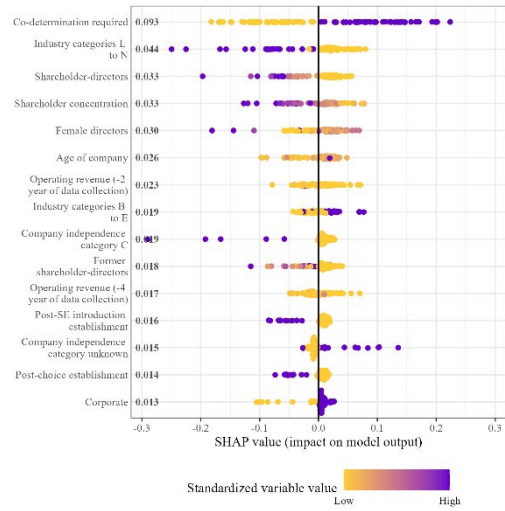


Figure A.2.13: SHAP Summary Plot for Italy

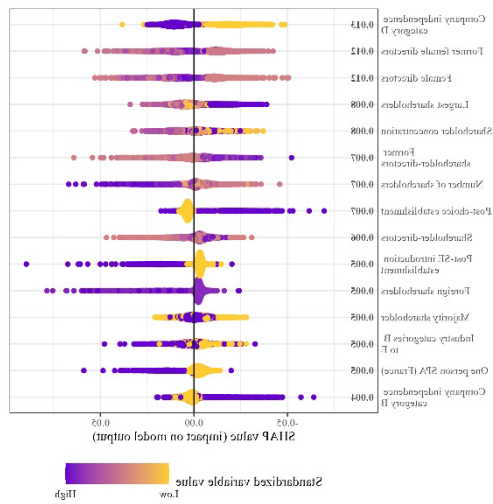


Figure A.2.14: SHAP Summary Plot for Portugal

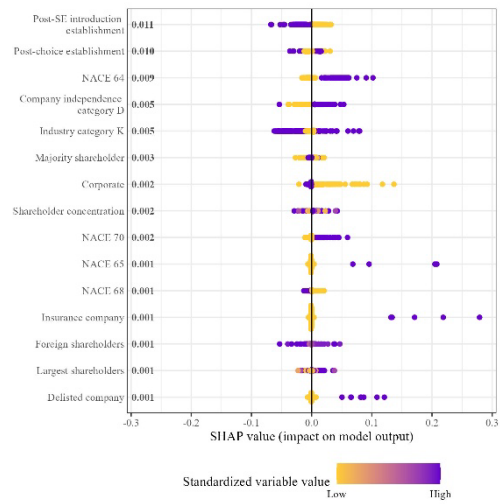


Figure A.3.1: SHAP Variable Plots for Bulgaria

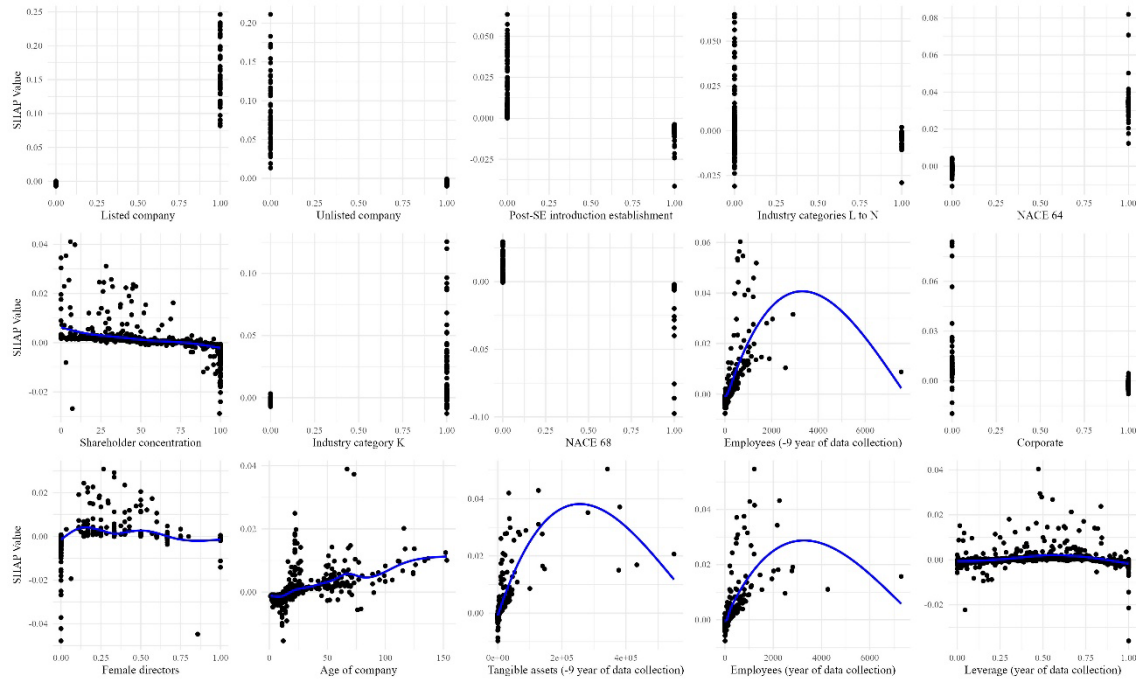


Figure A.3.2: SHAP Variable Plots for Croatia

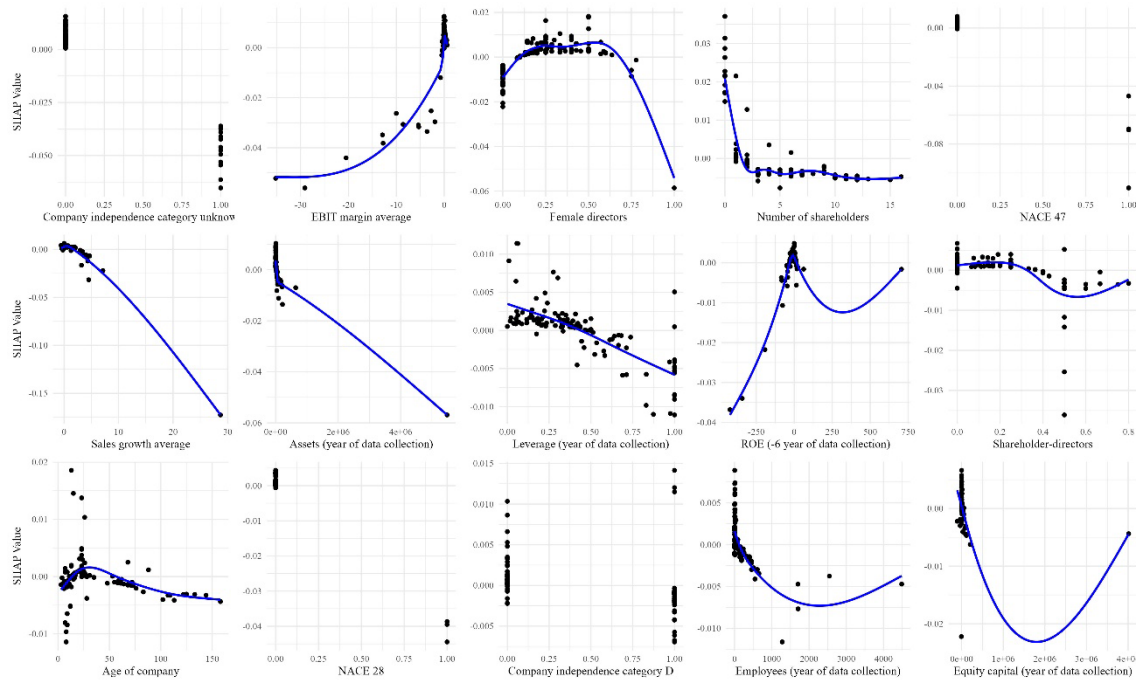


Figure A.3.3: SHAP Variable Plots for the Czech Republic

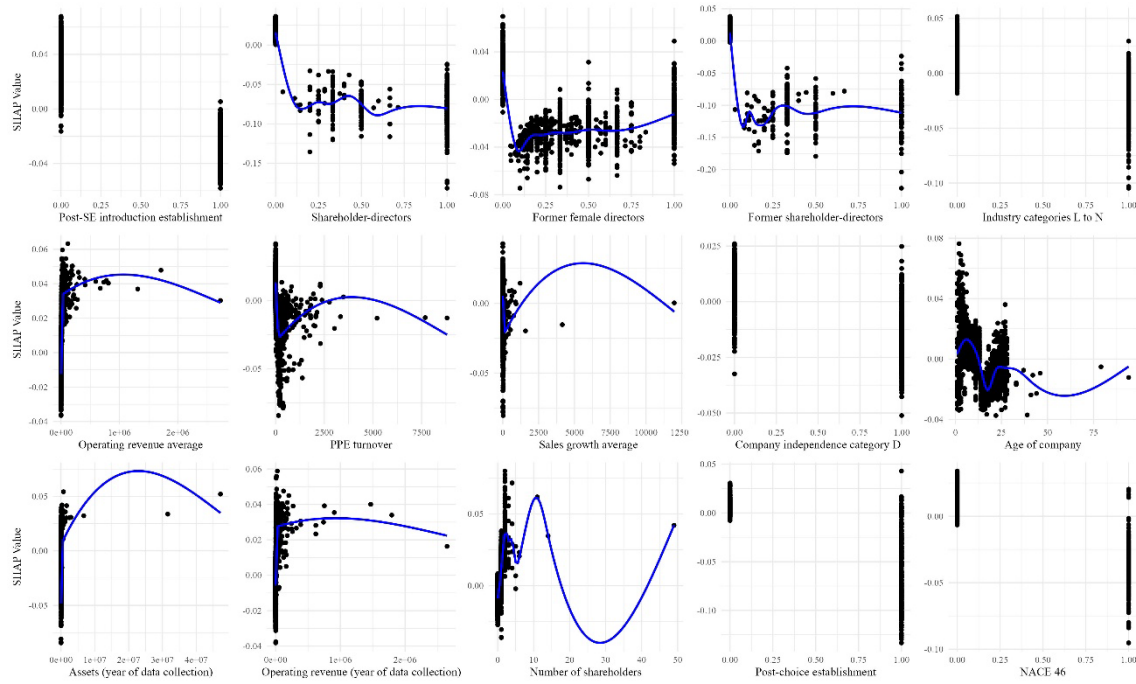


Figure A.3.4: SHAP Variable Plots for Denmark

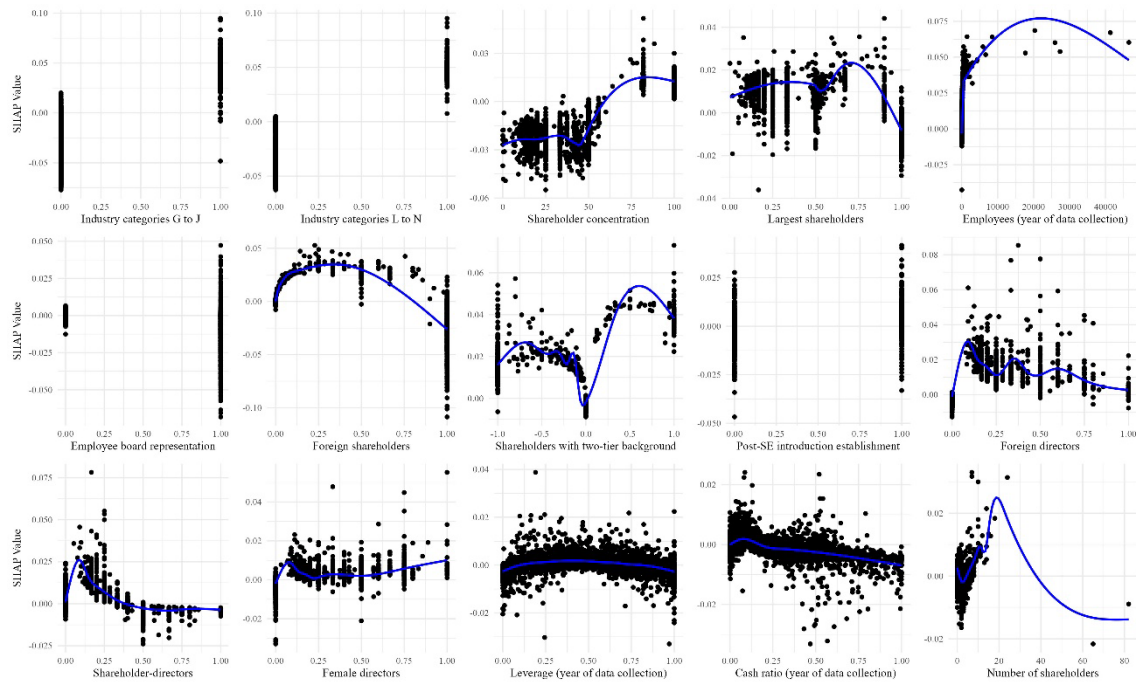


Figure A.3.5: SHAP Variable Plots for Finland

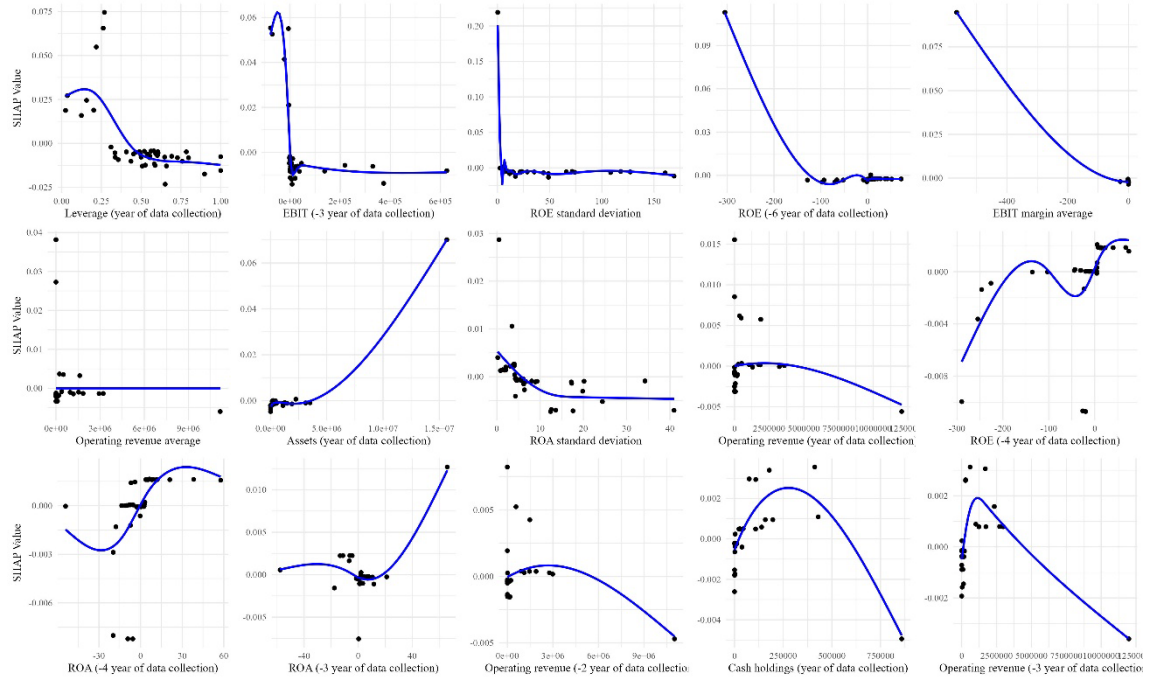


Figure A.3.6: SHAP Variable Plots for France

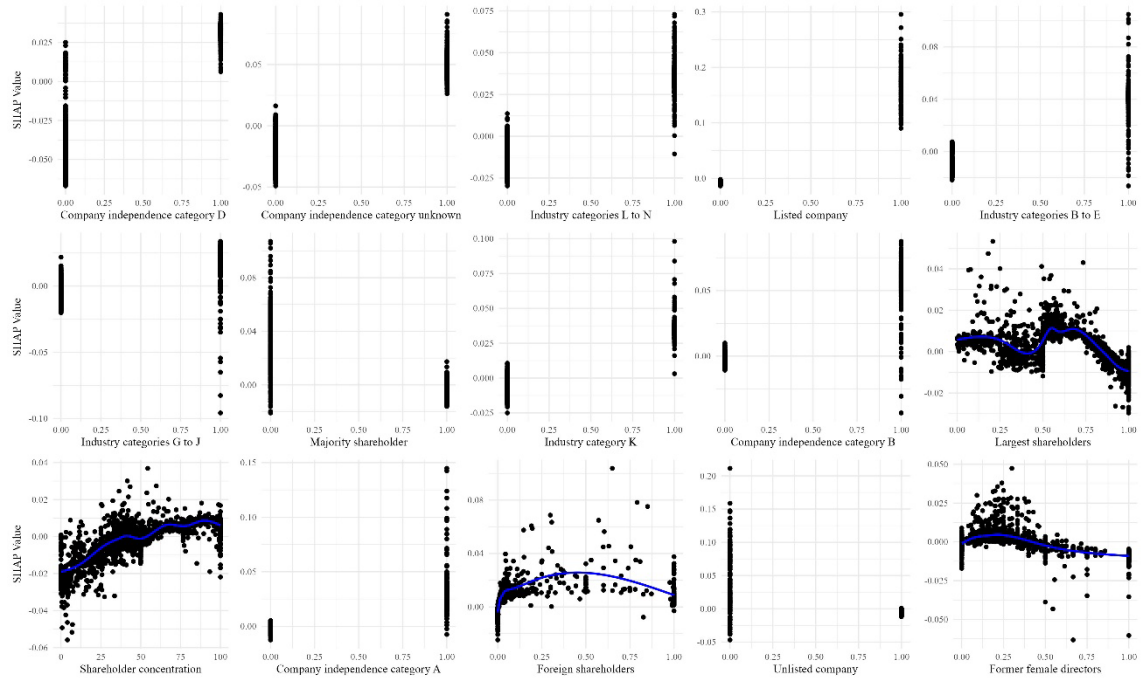


Figure A.3.7: SHAP Variable Plots for Hungary

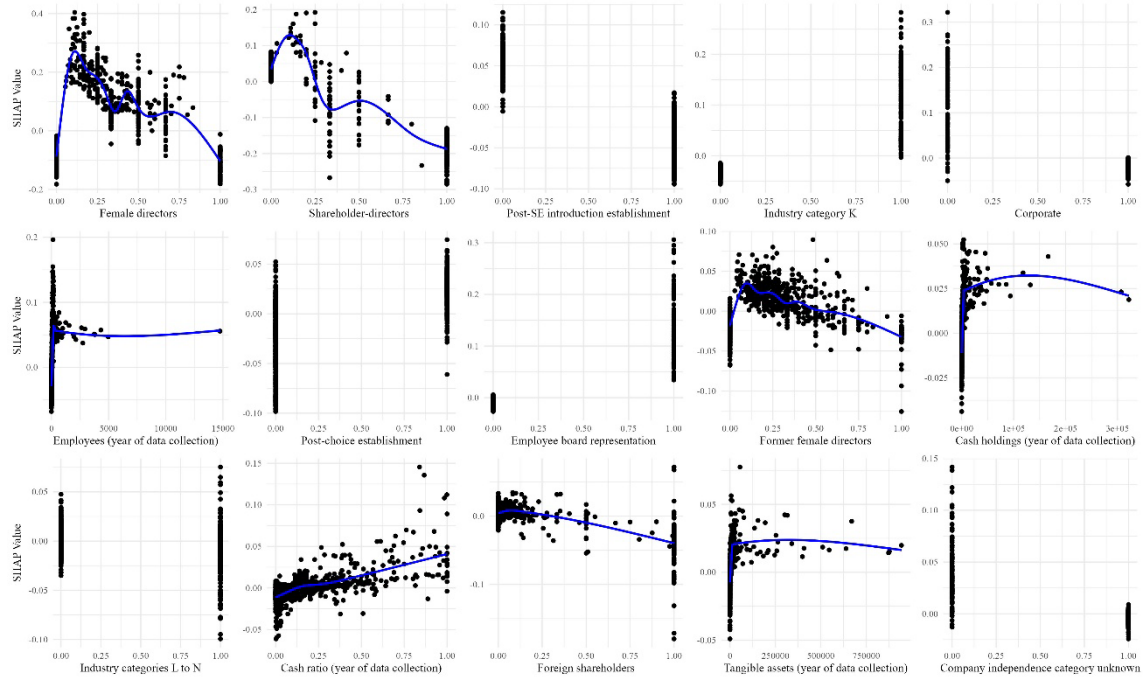


Figure A.3.8: SHAP Variable Plots for Lithuania

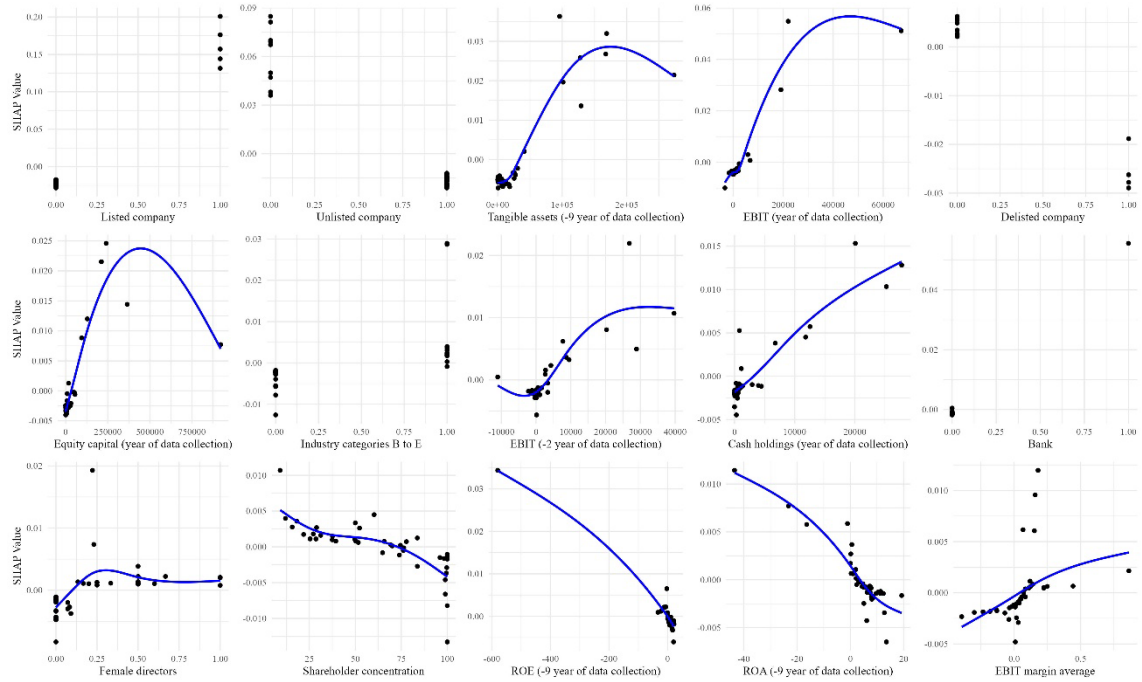


Figure A.3.9: SHAP Variable Plots for Luxembourg

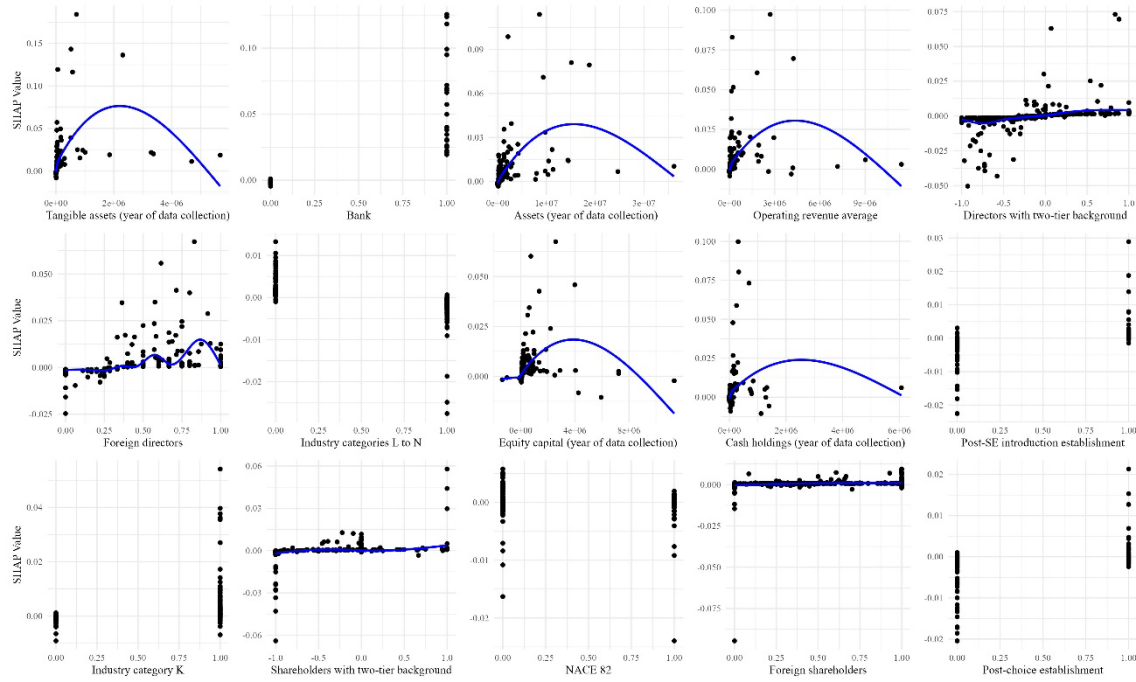


Figure A.3.10: SHAP Variable Plots for the Netherlands

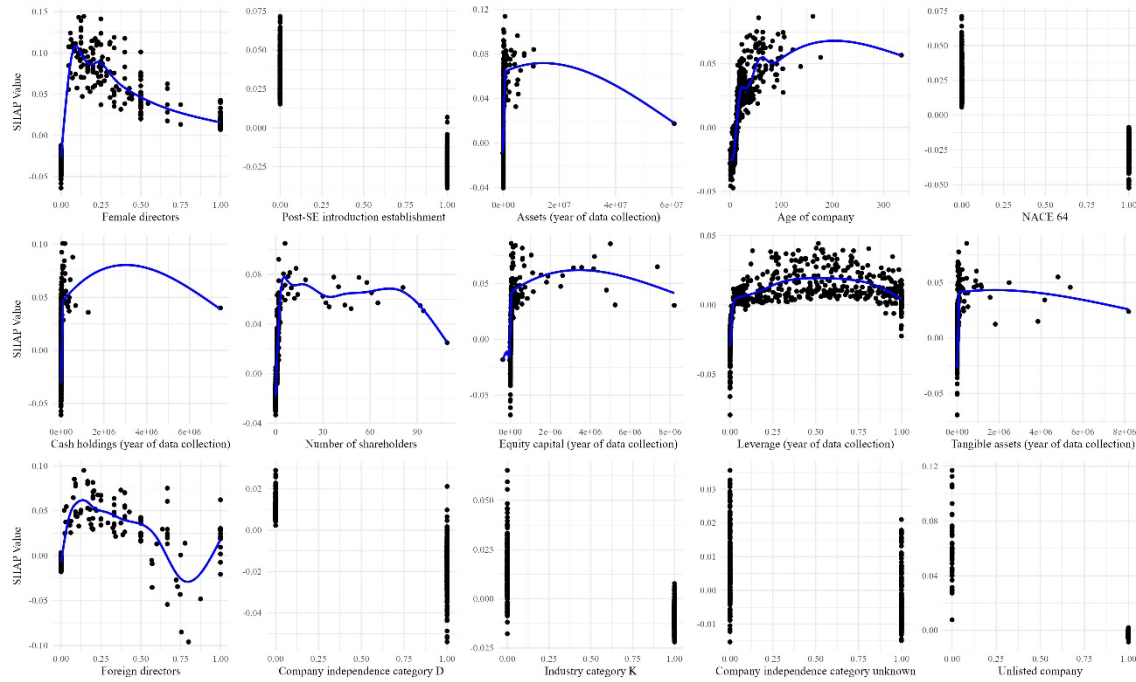


Figure A.3.11: SHAP Variable Plots for Romania

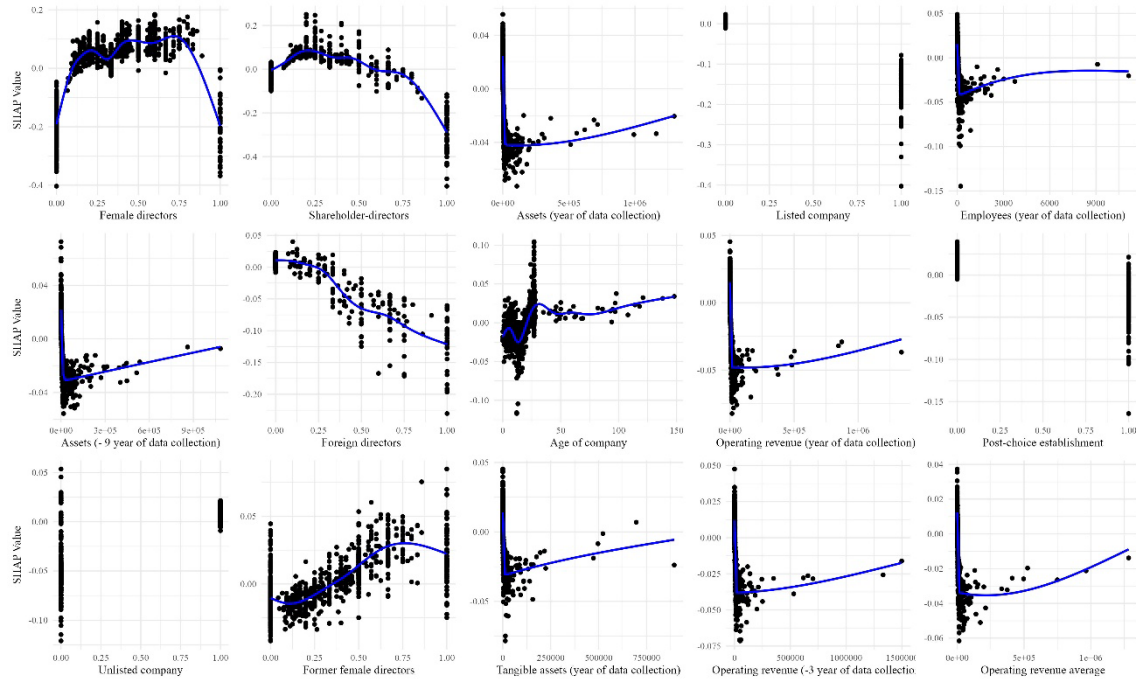


Figure A.3.12: SHAP Variable Plots for Slovenia

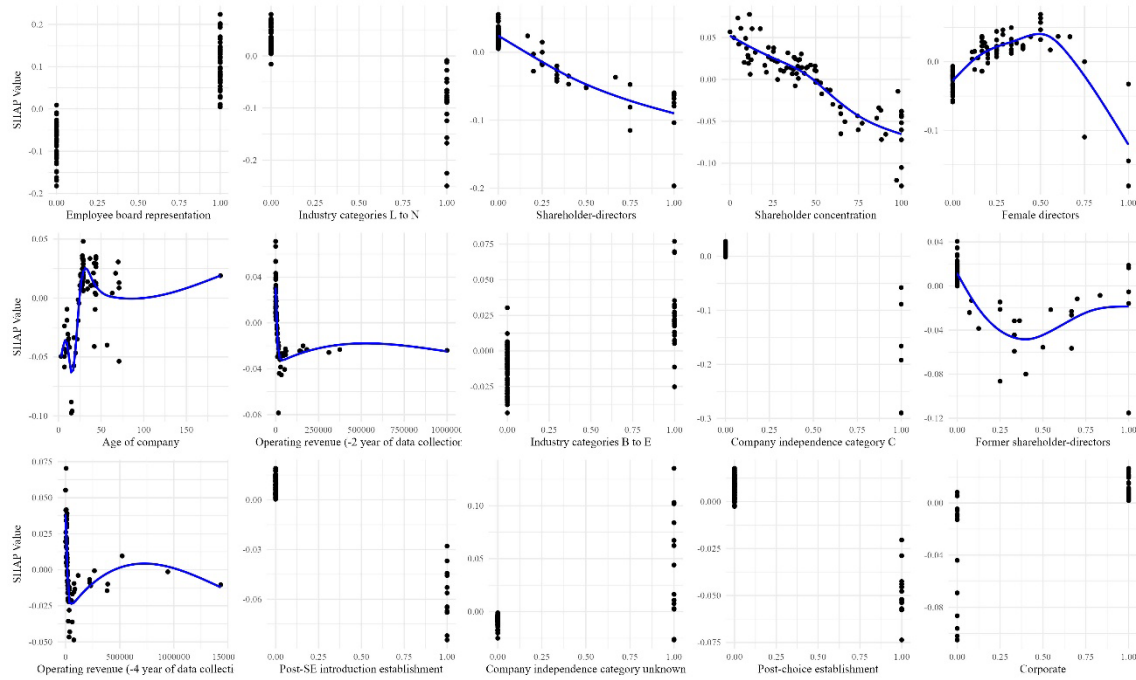


Figure A.3.13: SHAP Variable Plots for Italy

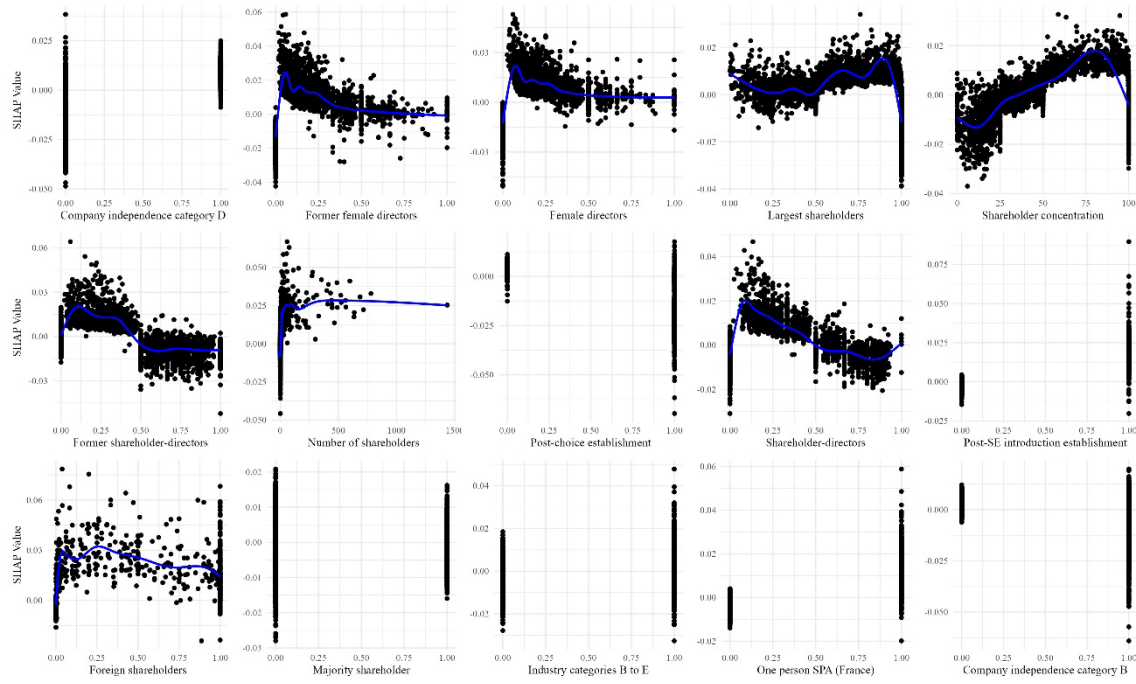
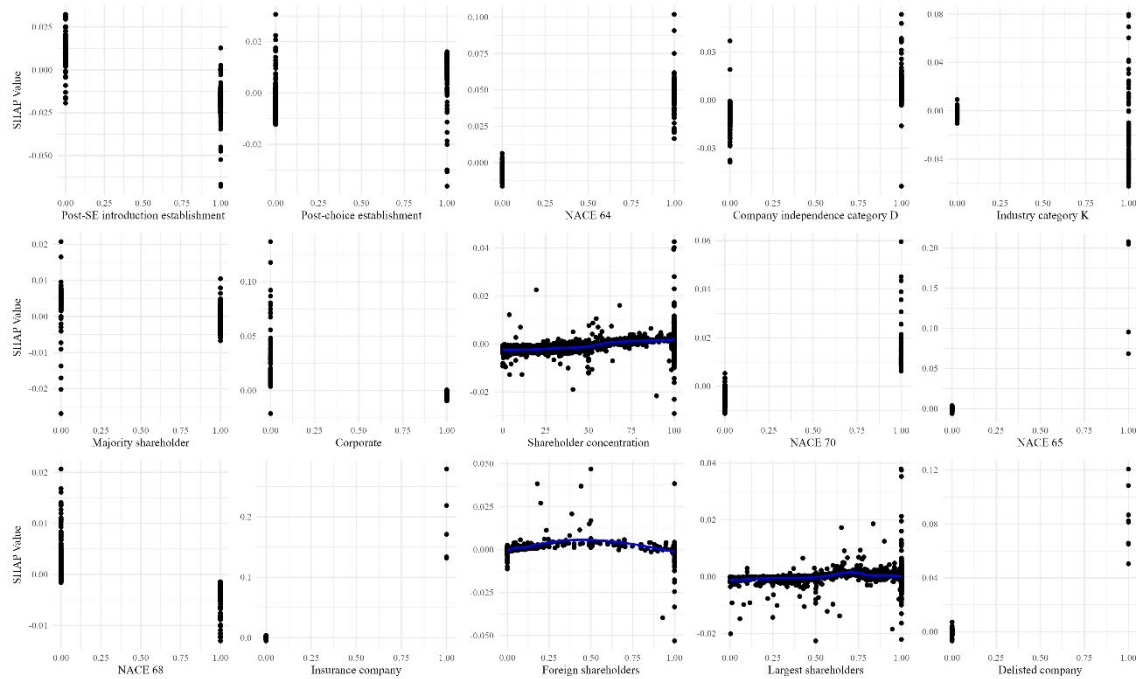


Figure A.3.14: SHAP Variable Plots for Portugal



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