# Horizontal and Vertical Firm Networks, Corporate Performance and Product Market Competition

Bischoff, Oliver and Buchwald, Achim

Monopolies Commission, Frankfurt University of Applied Sciences, Düsseldorf Institute for Competition Economics

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Oliver Bischoff [a,b] and Achim Buchwald [a,c]

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**Abstract:**

This paper sheds new light on the assessment of firm networks via multiple directorships in terms of corporate firm performance. Using a large sample of European listed firms in the period from 2003 to 2011 and system GMM we find a significant compensation effect on corporate firm performance for the initial negative effect of horizontal multiple directorships by product market competition. In markets with effective competition, horizontal multiple directorships turn out to be an efficient mechanism to increase firm performance and thus assure competitive advantages. By contrast, linkages between up- and downstream firms have no significant influence on financial performance, irrespective of the level of competition intensity.

**JEL-Classification:** C23, G32, G34, L14, L25, L40

**Keywords:** Horizontal and Vertical Firm Networks, Multiple Directorships, Corporate Governance, Product Market Competition, Dynamic Panel

## Contact Details:

[a]Monopolies Commission
Heilsbachstraße 16, 53123 Bonn, Germany
phone: +49-228/338882-43, e-mail: oliver.bischoff@monopolkommission.bund.de
phone: +49-228/338882-39, e-mail: achim.buchwald@monopolkommission.bund.de

[b]Frankfurt University of Applied Sciences
Faculty of Business and Law, Nibelungenplatz 1, 60318, Frankfurt am Main, Germany

[c]Düsseldorf Institute for Competition Economics
Universitätsstraße 1, 40225, Düsseldorf, Germany

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## 1. Introduction

This paper contributes to an intense debate over the causes and effects of director firm linkages held by the public[1], European political decision-makers[2] and academic research. When discussing the relationship between multiple directorships and corporate profitability the role of product market competition has been neglected in most cases so far. Our study contributes to filling this gap by analyzing the interaction effects of horizontal and vertical inter-firm networks via multiple directorships and product market competition on corporate firm performance. Using balanced panel data of interlocking directorships between more than 800 firms in 17 Western European countries from 2003-2011 and by specifying a dynamic approach we estimate a significantly positive impact of horizontal firm linkages through common directorships on corporate performance with higher levels of product market competition. Conversely, if competition intensity is comparatively low, we estimate the impact to be negative. With respect to vertical linkages and the total number of linkages we find no significant effects on corporate performance irrespective of the level of product market competition.

Based on these findings, several conclusions can be drawn. First, although inter-firm connections hamper firm performance, product market competition subsequently compensates for this negative effect. Market pressure, therefore, impacts firm networks and the need to gain (information) advantages over competitors through multiple directorships. Second, only horizontal linkages play a significant role in corporate performance implying that information gained by multiple directorships is more valuable when the information concerns the same

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[1] A recent prominent business cases was the appointment of Google's CEO Eric Schmidt to Apple's board of directors. Following the announcement Eric Schmidt was supposed to contribute to Apple's innovativeness by providing his industry-specific insights and experience. Three years later, Eric Schmidt resigned from Apple. In the press release, Apple explained that increasing rivalry between both firms in the market for operating systems intensified potential conflicts of interest. See http://www.apple.com/pr/library/2006/08/29Google-CEO-Dr-Eric-Schmidt-Joins-Apples-Board-of-Directors.html.

[2] E.g. European Commission (2011).

market as opposed to information concerning other markets.[3] Therefore, it may be possible that multiple directorships functions similarly to tacit collusion.

The remainder of this paper is organized as follows: Section 2 presents the literature review and summarizes the aims of the study. Section 3 describes the data sample and the empirical method. Section 4 discusses the results, and Section 5 concludes the paper.

## 2. Literature Review

International organizational networks via equity investments and interlocking directorates have received an increasing amount of attention in the field of economic research and social science. Despite substantial efforts to track and illustrate inter-firm relations, previous studies are often limited to the description of the structure and development of networks, whereas the empirical economic effects following the establishment of respective connections have not been sufficiently and systematically evaluated from a European transnational perspective. A number of theoretical approaches are suitable to describe and explain the motives and effects of firms with common directors (e. g. Mizruchi 1996, Adams et al. 2010).

From an institutional perspective, interlocking directorates might be a beneficial strategic instrument to facilitate coordination between legally independent organizations along the supply chain. Resource dependence theory suggests that dependencies may arise within the same industry or in vertical customer-supplier relations of up- and downstream firms (Pfeffer 1992). Similarly, building on transaction cost theory personal connections could be interpreted as an efficient mechanism for the exchange of goods and services (Williamson 1979). Closely linked to the latter, director linkages within the same industry allow firms to share internal or industry-specific information or to coordinate strategic decision-making, such as decisions regarding investments in new products or technologies (e. g. Grant and Baden-Fuller 2004).

Focusing on an individual perspective, researchers are interested in the specific individual

[3] It is also implied that the information process is supposed to be quicker when information is relevant for the same market compared to other (vertical) markets.

characteristics of outside directors with multiple mandates. From a knowledge based view, firms might acquire scarce and valuable knowledge and experiences through the co-optation of outside directors. This collaboration then improves the competences of the entire board (Grant 1996a, Kor 2003, Grant and Baden-Fuller 2004). Relevant factors can include industry-specific knowledge or experiences regarding new technologies, competition or regulation issues. This view is supported by a number of empirical studies that focus on the role of outside directors in terms of advising competences (e.g., Coles et al. 2012, Connelly et al. 2010, Kor and Sundaramurthy 2009, Linck et al. 2008, Adams and Ferreira 2007, Carpenter and Westphal 2001). Other papers have analyzed the role of outside directors for board monitoring in the field of corporate governance. Agency-theory states that outside directors are more independent and skilled and, therefore, increase the monitoring intensity in the boardroom (e.g., Ferris et al. 2003, Hermalin and Weisbach 1998, Fama and Jensen 1983, Fama 1980).

In addition to these anticipated positive arguments, director-linked firms might also weaken the monitoring process and, in turn, negatively influence firms' outcomes. This is the case if directors with multiple board positions face conflicts of interest. For instance, the directors might have incentives to accept a rather high number of parallel board mandates (Conyon and Read 2006, Fich and Shivdasani 2006, Perry and Peyer 2005) to maximize self interest (Fahlenbrach et al. 2010). Further, conflicts of interest can occur between sending and receiving firms (e.g., Dittmann et al. 2010 in the case of representatives from financial firms). Additionally, Aghion et al. (2013) argue that firm-outsiders face a lack of information on internal processes, which mitigates their ability to adequately monitor executives (similar Balsmeier et al. 2014). Firm networks via multiple directorships may also indicate strong and close social ties among the management elite rather than a targeted development of structural links between firms (Kang and Kroll 2013, Hillman et al. 2010, Hwang and Kim 2009, Mizruchi 1996, Useem 1984).

Previous empirical evidence on the relationship between multiple directorships and firm performance reveals mixed results. For instance, Field et al. (2013) concentrate on the advising

role of directors and document positive effects of a majority of board members with multiple directorships on firm value in the case of IPO firms. Fich and Shivdasani (2006) find a negative influence of "busy boards" on firm performance. Pathan and Faff (2013) detect that both board size and independent directors decrease the performance of banks. Conversely, Fahlenbrach et al. (2010) find no significant effect of CEOs on the operating performance of the appointing firm.

When coordination via firm networks is examined, the respective economic activities of the linked firms seem to be of high academic interest. Vertical linkages may reduce risk and uncertainties along the supply chain while improving the flow of information. In a comprehensive study, Dass et al. (2014) identify outside directors from US firms in up- and downstream industries and find a positive impact on firm value and performance. Coles et al. (2008) report that the presence and value of outside directors on the board is higher in complex firms with a higher number of business segments. Second, inter-firm relationships, particularly on a horizontal level, are also subject to work in the field of competition economics and law. Firms might be able to exploit networks via multiple directorships to their own advantage and therefore harm competition if the relationship is used for collusive behavior. This includes an informal coordination of strategy, such as changing marketing policies or prices (Gabrielsen et al. 2011, Moaevero Milanesi and Winterstein 2002, Motta 2009). A recent study of Buch-Hansen (2014) disclosed identified cartel cases and simultaneous interlocking directorates. Recent descriptive findings suggest that firms with horizontal and vertical director linkages are both associated with higher market power, as measured by the Lerner index, than unlinked firms. Conversely, the relationship is stronger in the case of intra-industry connections (Buchwald 2014, Monopolies Commission 2014).

Recent work has also addressed the relevance of competition for the relationship between corporate governance characteristics and firm performance. Giroud and Mueller (2011) find that firms with weak governance, as measured by various antitakeover and shareholder rights provisions, face lower performance and firm value if competition in the industry is weak.

Similarly, the introduction of business combination laws that weaken corporate governance by reducing the risk of hostile takeovers are associated with a decline in performance for firms operating in industries with low competition (Giroud and Mueller 2010). Ammann et al. (2011) provide supplementary evidence for a substitutive relationship between competition and corporate governance by showing that good governance mechanisms positively affect firm value solely in non-competitive markets. The previous findings suggest that indicators of corporate governance and the strength of competition are substitutes, indicating that competition limits the scope for opportunistic behavior and therefore aligns the interests of management and shareholders (Karuna 2007, Schmidt 1997). Further, empirical evidence reveals a selection of better qualified managers in competitive industries (van Reenen 2011).

With reference to the current state of research the next logical step is to analyze whether firm networks reflected by multiple directorships are beneficial for the connected firms under the consideration of product market competition. More concretely, if firm networks via multiple directorships are an indication for weak governance, due to conflicts of interest and other reasons, increasing competition intensity should compensate for the negative effect of firm linkages. Alternatively, if multiple directorships are a crucial and efficient mechanism to share knowledge and experiences, external advice and monitoring are supposed to be more valuable in competitive industries. As a consequence, firms might particularly benefit from connections to other firms in environments with strong competition. Providing evidence for this issue is the point of this study.

## 3. Data and Methodology

### 3.1. Data

For the present empirical study, we use a comprehensive dataset from the (Monopolies Commission 2014) including nearly all publicly listed firms in 17 European member states including Norway and Switzerland for the period from 2003 to 2011. Financial data, ownership information and industry classifications were obtained from Bureau van Dijk's "ORBIS"

database and merged with the "Officers & Directors" database of Thomson Reuters which includes detailed information on board members over time.[4] Within the framework of the analysis we dropped (a) subsidiaries of controlling ultimate owners and (b) firms operating in the financial sector. Additionally, the empirical analyses are based on a balanced panel of those firms which are observed in all nine years under consideration. This procedure leaves us with a total number of 833 European firms with 7,497 firm-year observations. Table I displays the summary statistics for the relevant variables. The specification and sources of the variables are described in Table A1 and all the pairwise correlation coefficients between the variables are displayed in Table A2 in the appendix.

***Table I Descriptive Statistics***

| Variable | Obs. | Mean | Median | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| ROA | 7,497 | 3.02 | 3.26 | 8.09 | -62.99 | 38.38 |
| ROCE | 7,497 | 4.23 | 4.82 | 12.78 | -113.76 | 55.28 |
| Tobin's Q | 6,857 | 1.25 | 1.09 | 0.74 | 0.07 | 10.47 |
| Competition | 7,497 | 0.97 | 0.97 | 0.02 | 0.65 | 1.00 |
| No. Links | 7,497 | 3.42 | 2 | 3.64 | 0 | 22 |
| Horizontal Links | 7,497 | 0.44 | 0 | 0.87 | 0 | 7 |
| Vertical Links | 7,497 | 2.98 | 2 | 3.28 | 0 | 21 |
| Board Size | 7,497 | 13.62 | 12 | 6.98 | 2 | 45 |
| Block | 7,497 | 0.30 | 0 | - | 0 | 1 |
| Firm Age | 7,497 | 54 | 35 | 50 | 1 | 493 |
| Employees | 7,497 | 15,476.52 | 1,504.00 | 46,859.75 | 2 | 639,904 |
| Debt Equity Ratio | 7,497 | 1.67 | 1.32 | 1.40 | 0.07 | 15.55 |

Source: Based on data described in section 3.

As dependent variables, we use return on assets (*ROA*) and return on capital employed (*ROCE*) as accounting-based indicators for financial performance, and alternatively use *Tobin's Q* as a market-based performance measure. In addition, we include a set of firm-specific explanatory variables in our empirical models: *Board Size* represents the total number of executive and non-executive members on the boards of directors. To account for ownership concentration, a dummy variable (*Block*) is used which takes a value of one if at least one

[4] Figure A1 in the appendix illustrates the complex thicket of connected firms via multiple directorships

investor holds 25 percent or a more of a firm's equity. *Firm Age* represents the number of years since the firm's founding, and firm size is expressed in the number of *Employees*. The proportion of liabilities and shareholders' equity (*Debt Equity Ratio*) is used as a proxy for firm leverage.

To measure the degree of director linkages on the firm-level, representing the main variable of interest, we use the total number of contacts to other firms within the sample (*No. Links*). In contrast to the majority of previous studies, which are limited to particular national economies, the current analysis is based on a cross-country design to account for the further development of a European internal market and the associated formation of transnational director firm linkages (Buchwald 2014, Heemskerk 2013). However, it is important to consider the still persistent technical differences in the composition of boards of directors and their role and characteristics in different institutional systems, particularly when contrasting the practices in so-called "liberal market economies" and "coordinated market economies" (e.g., Munari et al. 2010, Kogut 2012). For instance, institutional and legal differences between monistic boards in Anglo-Saxon countries and dualistic or mixed board structures inter alia in Germany, Norway or France (Heidrick & Struggles 2011), tend to influence both the supervising and advising intensity between executive and non-executive directors. It is argued, on the one hand, that information asymmetries seem to be lower in monistic boards emphasizing the cooperation between executive and non-executive directors. As a consequence, executives and the CEO in particular gain a relatively prominent position in the boardroom (Adams et al. 2005). On the other hand, two-tiered board systems place emphasis on the monitoring function of the supervisory boards. Although non-executive directors seem to be more independent in dualistic systems, there might be higher demand for external information and knowledge provided by outside directors on two-tiered boards (Balsmeier et al. 2014). Figure 1 illustrates different possible constellations of multiple directorships between one- and two-tiered board systems. In the current study, we focus on multiple directorships as a channel for the flow and exchange of

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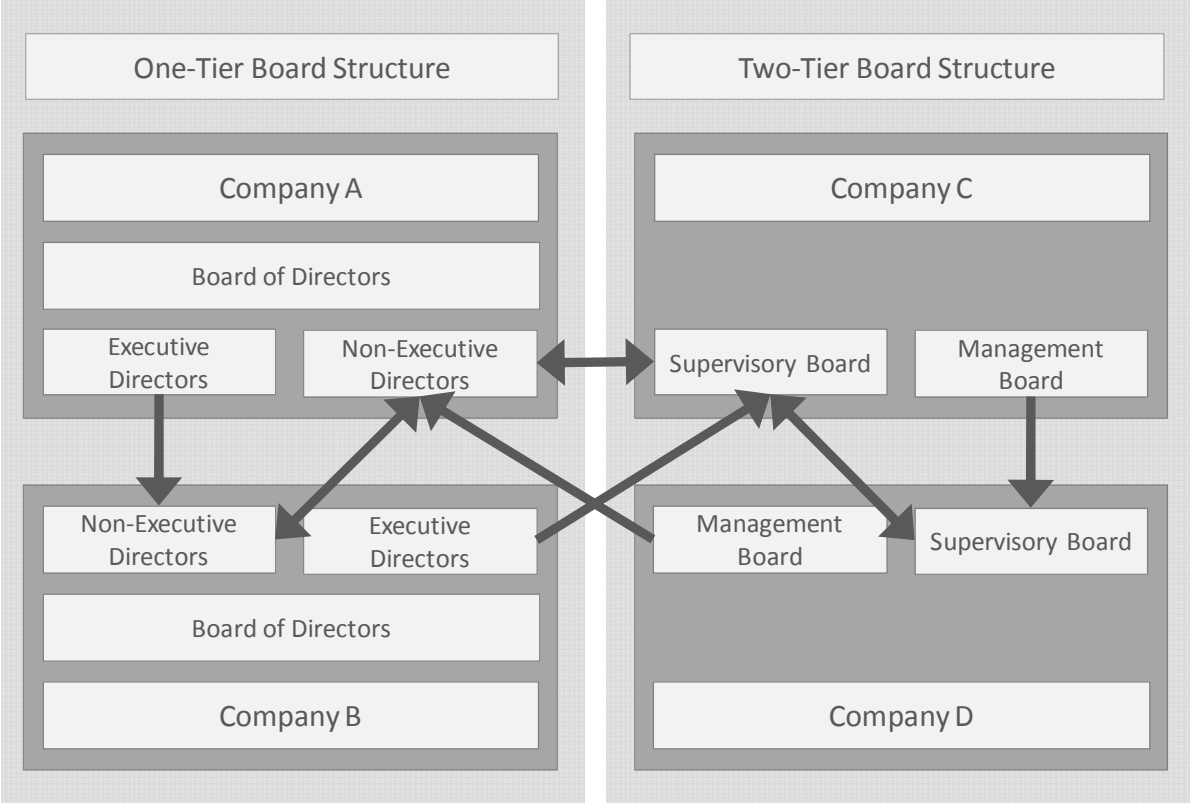
for the year 2011.

information between legally independent firms within and between industries. Therefore, we do not consider the possible direction of a link and refrain from distinguishing between sending and receiving firms (Fahlenbrach et al. 2010).

***Figure 1: Outside Directors on Monistic and Dualistic Boards***




Source: Own illustration.

Table I also shows the established number of connections within the same industry (*Horizontal Links*) and *Vertical Links* representing the total number of linkages to up- or downstream firms. When calculating horizontal and vertical linkages we account for the main business and all ancillary segments. The figures reveal that multiple directorships are more common between firms of different economic activities. On average, the sample firms are vertically connected to nearly three firms compared to 0.5 firms in the same industry.

Information on product market competition intensity on the industry level was obtained from the German Monopolies Commission (2014). Competition (*comp)* is calculated using individual Lerner indices of more than 700,000 firms on the two-digit NACE Rev. 2 industry

level in a certain country and year (Nickell 1996). Following Lerner (1934), the Lerner Index can be interpreted as a price-cost margin and indicates a firm's ability to realize earnings above its marginal costs. Compared to alternative measures of business concentration in a certain market, the Lerner index has several advantages (Aghion et al. 2005). The competition value can range between 0 and 1, with a value of 1 indicating perfect competition. The summary statistics in Table I reveal that average competition amounts to 0.97 and ranges from 0.65 to 1. Table A3 provides further information about the distribution of the sample firms across 66 two-digit industry-levels and reports the average pooled value of product market competition for each industry.

### 3.2. Econometrics

According to Wintoki et al. (2012) we assume a dynamic linear data generating process of a corporate firm's performance, depending on contemporary determinants as, such as the variables of interests, firm linkages and market competition, among others, and an autoregressive term that captures market imperfections affecting typical firms' corporate outcomes, such as those arising from, i. e., weak rational expectations of market agents and gradual learning (Muth 1961, Lovell 1986, Bebchuk et al. 2013). Through this assumption, we apply the so-called system GMM estimator (Arellano and Bover 1995 and Blundell and Bond 1998) throughout the paper. This method is potentially able to ensure consistent and efficient estimations using instrumental variable techniques in a fixed-effects context even if relevant explanatory variables are missing (avoiding omitted variable bias)[5] or are wrongly measured (avoiding errors in variables)[6] and if interdependent relationships between the respective performance measure and the explanatory variables are present (avoiding simultaneous equation bias). The consistency of the system GMM estimator essentially depends on the validity of instrumental variables that can be tested for[7] including on the validity of the so-called initial

[5] E.g. Hansen and Wernerfelt (1989).
[6] Griliches and Hausman (1986) point out that the bias resulting from errors in variables may be magnified when using panel data estimators.
[7] As far as the idiosyncratic error is not serially correlated and no overfitting bias is present, the problem of weak instruments, as discussed in e. g., Angrist and Krueger (2001) and Imbens (2014), is not of any

condition.[8] Instrumental variables are basically generated by the system GMM from the sample itself which consist of lags in levels and differences of the dependent and explanatory variables.[9] To lay the foundation of consistent estimations we choose the most careful model specification where almost all explanatory variables, particularly the variables of interest, are specified as endogenous and, thereore, have to be replaced by lags representing instrumental variables. In contrast, time dummies that are supposed to capture structural breaks are specified as strictly exogenous, and the variables *Firm Age*, *Board*, and *Block* are specified as predetermined. Regarding the data sample comprising firms from various industries, the inclusion of fixed-effects is necessary to control for time-invariant unobserved firm heterogeneity. To produce efficient results, the system GMM fully exploits information from the data sample because it estimates a system of equations in both first differences and levels so that no second wave must be dropped, which is the case in the so-called First Difference GMM method of Holtz-Eakin et al. (1988) and Arellano and Bond (1991).[10] We use balanced panel data because sample attrition is detected to be random (Wooldridge 2002). We also control for heteroskedasticity and for downward bias in standard errors in finite samples by using the two-step procedure correction method for the variance-covariance matrix subject to Windmeijer (2005).

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importance. See below the Arellano-Bond-Test and the Hansen-Test.

[8] The initial condition is $E[\mu_i \Delta ROA_{i,2}] = 0 \; \forall \; i = 1, \dots, N$ according to our model stated in equation 1. It is implied that deviations from long-run means must not be correlated with the fixed effects in the initial period, or in other words, deviations of the initial conditions from $\frac{1}{1-\theta}\left(\mu_i + \boldsymbol{B}_{i,t}^{T}\lambda\right)$ have to be uncorrelated with the level of $\frac{1}{1-\theta}\left(\mu_i + \boldsymbol{B}_{i,t}^{T}\lambda\right)$ where $\boldsymbol{B}_{i,t}^{T}$ represents the transposed matrix containing deterministic explanatory variables and $\lambda$ represents the corresponding coefficient vector, see Blundell and Bond (1998). For a non-technical explanation see Roodman (2009).

[9] According to the system GMM method, instrumental variables – lagged variables – are transformed in to differences to make them orthogonal respectively exogenous to the fixed effects, which would otherwise lead to the so-called Nickell bias of dynamic panel fixed effects estimations (Nickell 1981).

[10] Recent simulation studies confirm the usefulness of the system GMM when its fundamental assumptions of valid instruments and no serial correlation of the idiosyncratic error apply (Flannery and Hankins 2013, Dang et al. 2015). A further promising method is X-Differencing newly developed by Han et al. 2014).

For instance, the final linear panel data model for firm *i* at time *t* as shown in Table II, column (f), is as follows:

$$ROA_{i,t} = \alpha + \theta ROA_{i,t-1} + \boldsymbol{X}_{i,t}^{T}\beta + \gamma comp_{i,t} + \varphi HLinks_{i,t} + \omega VLinks_{i,t} + \rho HLinks_{i,t} * comp_{i,t} + \pi VLinks_{i,t} * comp_{i,t} + d_t + \mu_i + \varepsilon_{i,t}$$

$$\forall\, i = 1, \dots, N \wedge t = 2, \dots, T \wedge E\left[\mu_i \Delta ROA_{i,2}\right] = 0 \wedge E = \left[\mu_i \varepsilon_{i,t}\right] = 0 \wedge \varepsilon_{i,t} \sim i.i.d.(0; \sigma_{\varepsilon}^{2}), \quad (1)$$

where $\alpha, \theta, \gamma, \varphi, \omega, \rho, \pi$ represent scalars of parameters and $\beta$ displays a vector of parameters associated with the transposed matrix of variables $\boldsymbol{X}_{\mathrm{i,t}}^{T}$ containing further explanatory variables as well as $\mu_i$, $d_t$ and $\varepsilon_{i,t}$, denoting fixed-effects, time effects and idiosyncratic errors to be estimated, respectively.

## 4. Results

Table II displays the results from various model specifications where industry-adjusted ROA is the dependent variable. Specifications of the models (b), (d) and (f) are identical to the models (a), (c) and (e), respectively, up to the autoregressive term included, so that the former represent dynamic approaches and the latter represents static approaches. Additionally, model specification is getting consecutively relaxed from the basic specification in (a) and (b) until the final specification in (e) and (f).[11] Before starting with the results' discussion, we have to check for the estimations' validity. First, according to various panel unit root tests in Table A4, the selection of variables are stationary processes so that standard errors including test statistics are not biased.[12] Second, to ensure consistency of the system GMM (and of other GMM estimator), instrumental variables have to be valid from a statistical perspective, meaning that residuals are not serially correlated and no over-fitting is present. As the Arellano-Bond tests show, at least for the dynamic approaches, the first-differenced residuals are first-order but not second-order

[11] Note that in equilibrium, shocks are absent and the following relationship holds $ROA_{i,t} = ROA_{i,t-1}$, so that dynamic approaches become static approaches. Equation 1 can then be rewritten as follows including new parameters $\phi$ and $\psi$ etc.: $ROA_{i,t} = \frac{\alpha}{1-\theta} + \phi \frac{X_{i,t}^{T}}{1-\theta} + \psi \frac{comp_{i,t}}{1-\theta} + \cdots \; \forall\, i, t.$

[12] Stationarity implies convergence to equilibrium in the long run from a theoretical perspective.

serially correlated, which is supposed to be the case when the idiosyncratic error is white noise as assumed. The results simultaneously reveal the need for including an autoregressive term. Therefore, evidence is presented for an important requirement regarding the validity of moment conditions. According to the Hansen test, the null hypothesis of non-overidentification cannot be rejected and, thus, the instrumental variables are valid. That test result completes our validity check for the estimation method chosen.

Based on these tests, in the following, we concentrate on dynamic approaches, in particular on model (f), reflecting the most flexible type of model specification. In so doing, we estimate a negative impact of competition on firm performance, as expected. Firm performance is also negatively related to firm size, measured by the number of employees, and to firm debt, measured by the debt equity ratio.

Focusing on the variables of interests, horizontal and vertical firm linkages, exclusively horizontal firm linkages significantly decrease a firm's corporate performance, as depicted by the coefficient $\varphi$, whereas the marginal effect of vertical ties, depicted by the coefficient $\omega$, remains insignificant. This finding points to a negative assessment of multiple directorships within the same industry and could be explained by the fact that directors with multiple directorships might face various conflicts of interests. These conflicts could stem from potentially opportunistic behavior at the cost of shareholders (e.g., Fich and Shivdasani 2006 or Conyon and Read 2006). The negative coefficient is also in line with the explanation that outsiders face a lack of firm-specific knowledge, mitigating their ability to adequately contribute to corporate decision making (Grant 1996a, 1996b). Finally, this result could also point to conflicts of interest between the objectives of the linked firms. As a result, horizontal connections mitigate on average firm performance.

***Table II: The Influence of Director Firm Linkages on Corporate Firm Performance***

| | Model | | | | | |
|---|---|---|---|---|---|---|
| | **(a)** | **(b)** | **(c)** | **(d)** | **(e)** | **(f)** |
| | **ROA** | **ROA** | **ROA** | **ROA** | **ROA** | **ROA** |
| ROA (t-1) | | 0.259*** | | 0.250*** | | 0.238*** |
| | | (8.21) | | (7.87) | | (7.83) |
| Competition | -60.377*** | -43.699** | -71.521*** | -62.013** | -63.463*** | -60.034** |
| | (-2.85) | (-2.16) | (-2.78) | (-2.49) | (-2.68) | (-2.44) |
| No. Links | | | -3.647 | -1.772 | | |
| | | | (-1.23) | (-0.59) | | |
| No. Links x Competition | | | 3.776 | 1.796 | | |
| | | | (1.23) | (0.59) | | |
| Horizontal Links | | | | | -12.855* | -14.569** |
| | | | | | (-1.76) | (-2.06) |
| Vertical Links | | | | | -1.078 | 0.146 |
| | | | | | (-0.35) | (0.04) |
| Horizontal Links x Competition | | | | | 12.978* | 14.768** |
| | | | | | (1.73) | (2.03) |
| Vertical Links x Competition | | | | | 1.196 | -0.139 |
| | | | | | (0.38) | (-0.04) |
| Board Size | 0.008 | -0.006 | -0.021 | -0.033 | -0.008 | -0.052 |
| | (0.08) | (-0.06) | (-0.20) | (-0.35) | (-0.08) | (-0.55) |
| Block | -0.482 | -1.014* | -0.460 | -0.881 | -0.304 | -0.709 |
| | (-0.81) | (-1.80) | (-0.76) | (-1.54) | (-0.49) | (-1.29) |
| Log Firm Age | 0.130 | 0.207 | -0.572 | -0.343 | -0.528 | 0.022 |
| | (0.11) | (0.18) | (-0.48) | (-0.32) | (-0.44) | (0.02) |
| Log Employees | -2.726** | -4.836*** | -1.493 | -3.568*** | -1.694* | -4.008*** |
| | (-2.30) | (-3.99) | (-1.43) | (-3.06) | (-1.68) | (-3.34) |
| Debt Equity Ratio | -1.321*** | -0.411 | -1.487*** | -0.589** | -1.420*** | -0.601** |
| | (-3.83) | (-1.35) | (-4.76) | (-2.08) | (-4.56) | (-2.10) |
| Constant | 83.437*** | 80.983*** | 88.239*** | 91.975*** | 81.310*** | 92.463*** |
| | (3.57) | (3.78) | (3.27) | (3.59) | (3.36) | (3.70) |
| N | 7,497 | 6,664 | 7,497 | 6,664 | 7,497 | 6,664 |
| Groups | 833 | 833 | 833 | 833 | 833 | 833 |
| Instruments | 183 | 208 | 239 | 264 | 295 | 320 |
| Fixed effects and Time effects | Yes | Yes | Yes | Yes | Yes | Yes |
| F-Test (F-Statistic) | 5.50*** | 15.87*** | 4.58*** | 13.98*** | 4.68*** | 14.53*** |
| Arellano-Bond-Test - AR(1) (p − value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arellano-Bond-Test - AR(2) (p − value) | 0.002 | 0.826 | 0.002 | 0.763 | 0.002 | 0.694 |
| Hansen-Test (p − value) | 0.293 | 0.146 | 0.231 | 0.199 | 0.329 | 0.332 |
| Sargan-Test (p − value) | 0.000 | 0.001 | 0.978 | 0.000 | 0.998 | 0.055 |
| Diff-in-Hansen-Test (p − value) | 0.274 | 0.114 | 0.177 | 0.152 | 0.314 | 0.274 |

Notes: T-Statistics are in parentheses. The asterisks ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. AR(1) and AR(2) are tests for first-order and second-order serial correlation in the first-differenced residuals, under the null of no serial correlation. The Hansen test of over-identification is under the null that all instruments are valid. The Diff-in-Hansen tests of exogeneity is under the null that instruments used for the equations in levels are exogenous.
Source: Own calculations according to section 3.2.

To test the hypothesis that competition compensates for the negative effect of horizontal multiple directorships, we also include two interaction terms consisting of horizontal and vertical linkages on the one side and competition on the other side. The coefficient is significant only in the case of horizontal firm linkages. We therefore calculate the total marginal effect of horizontal firm linkages, *HLinks*, simply as follows:

$$\frac{\partial ROA_{i,t}}{\partial HLinks_{i,t}}\Big|[\cdot] = \varphi + \rho * comp_{i,t}, \tag{2}$$

where the sign depends on the level of product market competition, *comp*. In other words, according to our suggested approach, to analyze the effect of firm linkages on corporate performance measures, the level of market competition has to be considered as well. Because the coefficient of the interaction, $\rho$, term is significantly positive the marginal effect of horizontal links, *HLinks*, is negative if the level of market competition is lower than 0.987 and becomes positive if it is approximately greater than or equal to 0.987. The positive interaction clearly illustrates that market competition compensates for the negative effect of horizontal director firm linkages associated with weak governance. If competition increases, the negative effect declines. Higher market pressure, such as the threat of hostile takeover (Schmidt 1997, Shleifer and Vishny 1997), disciplines management and an appropriate assignment of mandates appears to be particularly important. In situations of fierce competition, horizontal multiple directors positively contribute to firm performance. This finding suggests a positive selection of better skilled managers in competitive environments.

If the intensity of competition and firm linkages within the same market increases simultaneously, the effect on corporate firm performance equals the coefficient of the interaction term:

$$\frac{\partial^2 ROA_{i,t}}{\partial HLinks_{i,t}\,\partial comp_{i,t}}\Big|[\cdot] = \rho = 14.768 > 0. \tag{3}$$

As a further robustness check, we initially estimate extensions of model (f) in Table II by dropping insignificant explanatory variables and, therefore, present more efficient specifications. The results displayed in Table A5 are quite similar to those in Table II,

confirming previous findings. In addition, we apply model specification (e) and (f) in Table II to alternative measures of both accounting and market performance. Table A6 exemplarily shows the result for return on capital employed (ROCE) and Tobin's Q. Although both estimations for ROCE revealed comparable results to those in Table II, estimations regarding Tobin's Q are not robust subject to the Hansen test.

## 5. Conclusion

In this paper, we shed new light on the assessment of firm networks in terms of corporate firm performance. This paper is the first to analyze the interaction of horizontal and vertical firm linkages via multiple directorships and product market competition on financial corporate measures. Using a large sample of European listed firms in the period 2003 to 2011 and the system GMM we find a significant compensation effect on corporate firms' performances for the initial negative effect of horizontal multiple directorships by product market competition. This finding highlights the moderating effect of product market competition: in industries with relative high competition, connections via multiple directorships seem to be a beneficial mechanism to gain competitive advantages. The interaction term of vertical linkages and competition has indeed no significant effect on firm performance.

From a firm's perspective, our results indicate that shareholders should carefully evaluate appointment decisions with respect to recent public recommendations for board diversity. Further, our results suggest that external factors such as market competition have to be considered when assessing the costs and benefits of multiple directorships.

Our findings are also relevant for political decision-makers in the field of competition policy. In general, horizontal linkages may be a mechanism to facilitate collaboration between competitors or, in particular with simultaneous financial interests, to exert influence on a firm's strategy or behavior. Thus, horizontal connections are potentially suitable to harm competition. However, our analyses reveal that the respective inter-firm connections are exclusively beneficial in situations of fierce competition.

The empirical results provide several reference points for future research. Efforts should be put into qualifying the type of director linkages, in particular in terms of the possible direction of the connections. The effect of respective linkages differs depending on the view of sending or receiving firms. Aditionally, the specific vertical linkages could be analyzed in more detail to be able to consider connections between up- and downstream firms. Moreover, with more detailed data at hand individual characteristics of multiple directors, such as specific qualifications following academic education or previous professional experience, could be considered in future, deeper analyses.

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# Appendix

## *Table A1: Variable Specification*

| *Variable* | *Description* | *Source* |
|---|---|---|
| ***Firm Characteristics*** | | |
| ROA | Industry-adjusted return on assets , calculated as the difference between a firm's ROA and the mean 2-digit industry ROA (NACE Rev. 2) | Bureau van Dijk |
| Return on Capital Employed | Industry-adjusted return on capital employed , calculated as the difference between a firm's ROCE and the mean 2-digit industry ROCE (NACE Rev. 2) | Bureau van Dijk |
| Tobin's Q | Industry-adjusted Tobin's Q, calculated as the difference between a firm's Tobin's Q and the mean 2-digit industry Tobin's Q (NACE Rev. 2) | Bureau van Dijk |
| Competition | Competition measure on the 2-digit industry-level (NACE Rev. 2), following (Aghion et al. 2005) | Bureau van Dijk |
| No. Links | Number of connections to other firms via interlocking directorates | ThomsonReuters |
| Horizontal Links | Number of connections to firms in the same industry | ThomsonReuters |
| Vertical Links | Number of connections to up- and downstream firms | ThomsonReuters |
| Board Size | Number of executive and non-executive directors on the board | ThomsonReuters |
| Block | Dummy variable that equals 1 if the largest shareholder owns at least 25 % of the capital stock | Bureau van Dijk |
| Firm Age | Firm age in years | Bureau van Dijk |
| Debt Equity Ratio | (Total Assets - Shareholders Funds) / Shareholders Funds | Bureau van Dijk |
| Employees | Number of employees | Bureau van Dijk |
| Debt Equity Ratio | (Total Assets - Shareholders Funds) / Shareholders Funds | Bureau van Dijk |

Source: See column Source.

***Table A2: Correlation Matrix***

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) ROA | 1.00 | | | | | | | | | | | |
| (2) ROCE | 0.93*** | 1.00 | | | | | | | | | | |
| (3) Tobin's Q | 0.30*** | 0.25*** | 1.00 | | | | | | | | | |
| (4) Competition | -0.19*** | -0.16*** | -0.22*** | 1.00 | | | | | | | | |
| (5) No. Links | 0.07*** | 0.08*** | 0.04*** | -0.04*** | 1.00 | | | | | | | |
| (6) Horizontal Links | 0.05*** | 0.05*** | 0.03*** | -0.07*** | 0.52*** | 1.00 | | | | | | |
| (7) Vertical Links | 0.06*** | 0.08*** | 0.03*** | -0.03** | 0.97*** | 0.31*** | 1.00 | | | | | |
| (8) Board Size | 0.07*** | 0.07*** | 0.05*** | -0.05*** | 0.54*** | 0.28*** | 0.53*** | 1.00 | | | | |
| (9) Block | -0.01 | -0.01 | -0.03** | -0.05*** | -0.12*** | -0.08*** | -0.11*** | 0.02 | 1.00 | | | |
| (10) Firm Age | 0.04*** | 0.03*** | -0.04*** | 0.04*** | 0.17*** | 0.09*** | 0.17*** | 0.19*** | 0.04*** | 1.00 | | |
| (11) Employees | 0.03** | 0.04*** | 0.00 | 0.00 | 0.46*** | 0.24*** | 0.45*** | 0.37*** | -0.07*** | 0.12*** | 1.00 | |
| (12) Debt Equity Ratio | -0.19*** | -0.08*** | -0.08*** | 0.11*** | 0.17*** | 0.06*** | 0.18*** | 0.16*** | 0.03** | 0.06*** | 0.21*** | 1.00 |

Notes: The asterisks ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Based on data described in section 3.

***Table A3: Distribution on the Industry-Level***

| 2-digit Code | Description | No. Observa-tions | Competition (pooled) |
|---|---|---|---|
| 01 | Crop and animal production, hunting and related service activities | 27 | 0.961 |
| 05 | Mining of coal and lignite | 36 | 0.987 |
| 06 | Extraction of crude petroleum and natural gas | 63 | 0.935 |
| 07 | Mining of metal ores | 63 | 0.916 |
| 08 | Other mining and quarrying | 27 | 0.970 |
| 09 | Mining support service activities | 54 | 0.931 |
| 10 | Manufacture of food products | 252 | 0.985 |
| 11 | Manufacture of beverages | 90 | 0.984 |
| 12 | Manufacture of tobacco products | 9 | 0.942 |
| 13 | Manufacture of textiles | 45 | 0.963 |
| 14 | Manufacture of wearing apparel | 81 | 0.971 |
| 15 | Manufacture of leather and related products | 9 | 0.961 |
| 16 | Manufacture of wood and of products of wood and cork, except furniture | 18 | 0.980 |
| 17 | Manufacture of paper and paper products | 207 | 0.986 |
| 18 | Printing and reproduction of recorded media | 90 | 0.978 |
| 19 | Manufacture of coke and refined petroleum products | 9 | 0.970 |
| 20 | Manufacture of chemicals and chemical products | 252 | 0.967 |
| 21 | Manufacture of basic pharmaceutical products and pharmaceutical preparations | 153 | 0.939 |
| 22 | Manufacture of rubber and plastic products | 135 | 0.975 |
| 23 | Manufacture of other non-metallic mineral products | 135 | 0.970 |
| 24 | Manufacture of basic metals | 207 | 0.976 |
| 25 | Manufacture of fabricated metal products, except machinery and equipment | 189 | 0.963 |
| 26 | Manufacture of computer, electronic and optical products | 792 | 0.957 |
| 27 | Manufacture of electrical equipment | 117 | 0.960 |
| 28 | Manufacture of machinery and equipment n.e.c. | 468 | 0.962 |
| 29 | Manufacture of motor vehicles, trailers and semi-trailers | 126 | 0.980 |
| 30 | Manufacture of other transport equipment | 135 | 0.972 |
| 31 | Manufacture of furniture | 54 | 0.971 |
| 32 | Other manufacturing | 189 | 0.941 |
| 33 | Repair and installation of machinery and equipment | 9 | 0.968 |
| 35 | Electricity, gas, steam and air conditioning supply | 90 | 0.972 |
| 36 | Water collection, treatment and supply | 18 | 0.991 |
| 37 | Sewerage | 9 | 0.966 |
| 38 | Waste collection, treatment and disposal activities; materials recovery | 9 | 0.966 |
| 39 | Remediation activities and other waste management services | 9 | 0.964 |
| 41 | Construction of buildings | 243 | 0.967 |
| 42 | Civil engineering | 63 | 0.972 |
| 43 | Specialised construction activities | 27 | 0.972 |
| 45 | Wholesale and retail trade and repair of motor vehicles and motorcycles | 63 | 0.992 |
| 46 | Wholesale trade, except of motor vehicles and motorcycles | 279 | 0.976 |
| 47 | Retail trade, except of motor vehicles and motorcycles | 243 | 0.983 |
| 49 | Land transport and transport via pipelines | 63 | 0.992 |

| 2-digit Code | Description | No. Observa-tions | Competition (pooled) |
|---|---|---|---|
| 50 | Water transport | 45 | 0.982 |
| 51 | Air transport | 63 | 0.986 |
| 52 | Warehousing and support activities for transportation | 135 | 0.983 |
| 53 | Postal and courier activities | 9 | 0.985 |
| 55 | Accommodation | 45 | 1.000 |
| 56 | Food and beverage service activities | 45 | 0.980 |
| 58 | Publishing activities | 351 | 0.954 |
| 59 | Motion picture, video and television programme production, sound recording and music publishing activities | 9 | 0.959 |
| 60 | Programming and broadcasting activities | 36 | 0.952 |
| 61 | Telecommunications | 216 | 0.972 |
| 62 | Computer programming, consultancy and related activities | 441 | 0.958 |
| 68 | Real estate activities | 333 | 0.985 |
| 69 | Legal and accounting activities | 9 | 0.892 |
| 70 | Activities of head offices; management consultancy activities | 90 | 0.974 |
| 71 | Architectural and engineering activities; technical testing and analysis | 108 | 0.954 |
| 72 | Scientific research and development | 18 | 0.982 |
| 73 | Advertising and market research | 90 | 0.966 |
| 74 | Other professional, scientific and technical activities | 72 | 0.964 |
| 77 | Rental and leasing activities | 54 | 0.984 |
| 78 | Employment activities | 63 | 0.972 |
| 79 | Travel agency, tour operator and other reservation service and related activities | 27 | 0.991 |
| 80 | Security and investigation activities | 27 | 0.969 |
| 81 | Services to buildings and landscape activities | 27 | 0.971 |
| 82 | Office administrative, office support and other business support activities | 27 | 0.970 |
| **Total** | | **7,497** | **0.968** |

Notes: 2-digit codes according to the Statistical Classification of Economic Activities in the European Community, NACE Rev. 2 (2008).

***Table A4: Panel Unit Root Tests***

| | **ROA** | **ROCE** | **Comp** | **HLinks** |
|---|---|---|---|---|
| Levin-Lin-Chu test[1] | -63.31*** | -58.13*** | -32.76*** | -16.05*** |
| Harris-Tzavalis test[2] | 0.18*** | 0.18*** | 0.28*** | 0.52*** |
| Breitung test[3] | -15.98*** | -16.15*** | -11.21*** | -6.46*** |
| Im-Pesaran-Shin test[4] | -15.30*** | -15.50*** | / | / |
| Fisher-type test[5] | 76.27*** | 80.88*** | 30.15*** | -10.54*** |

Notes: [1](Levin et al. 2002), [2] (Harris and Tzavalis 1999), [3] (Breitung 2001), [4] (Im et al. 2003), [5] (Choi 2001). All panel unit root tests presented test for non-stationarity under the null hypothesis. The asterisks ***, ** and * denote significance at the 1%, 5% and 10% level, respectively.
Source: Own calculations based on data described in section 3.

***Table A5: Various Specifications***

| | Model | | | | | |
|---|---|---|---|---|---|---|
| | **(g)** | **(h)** | **(i)** | **(j)** | **(k)** | **(l)** |
| | **ROA** | **ROA** | **ROA** | **ROA** | **ROCE** | **ROCE** |
| ROA (t-1) | 0.282*** | 0.256*** | 0.248*** | - | - | - |
| | (10.23) | (8.89) | (8.01) | | | |
| ROCE (t-1) | - | - | - | - | 0.271*** | 0.291*** |
| | | | | | (9.55) | (10.12) |
| Competition | -57.66*** | -94.39*** | -58.35** | -81.26*** | -117.29*** | -75.89** |
| | (-2.51) | (-3.93) | (-2.50) | (-3.71) | (-3.63) | (-2.54) |
| Horizontal Links | -14.74*** | -18.58*** | -15.90** | -22.37*** | -27.62*** | -23.97*** |
| | (-2.20) | (-2.59) | (-2.01) | (-2.70) | (-2.69) | (-2.74) |
| Vertical Links | -1.98 | -2.93 | - | - | -1.57 | -0.418 |
| | (-0.72) | (-0.79) | | | (-0.33) | (-0.13) |
| Horizontal Links x Competition | 15.09** | 18.99*** | 16.13** | 22.83*** | 27.96*** | 24.02*** |
| | (2.19) | (2.57) | (1.97) | (2.66) | (2.64) | (2.66) |
| Vertical Links x Competition | 1.86 | 3.01 | - | - | 1.54 | 0.112 |
| | (0.66) | (0.78) | | | (0.31) | (0.03) |
| Board Size | - | -0.145* | - | - | -0.247* | - |
| | | (-1.68) | | | (-1.80) | |
| Block | - | -0.582 | - | - | -1.17 | - |
| | | (-1.01) | | | (-1.15) | |
| Log Firm Age | - | 0.410 | - | - | 0.0377 | - |
| | | (0.42) | | | (0.03) | |
| Log Employees | - | -2.39** | -3.95*** | -2.14* | -2.120 | - |
| | | (-2.42) | (-3.36) | (-1.67) | (-1.29) | |
| Debt Equity Ratio | - | -0.649** | -0.398 | -1.08*** | -0.685 | - |
| | | (-2.40) | (-1.33) | (-3.60) | (-1.27) | |
| Constant | 58.76*** | 113.80*** | 88.96*** | 99.41*** | 137.92*** | 77.92*** |
| | (2.64) | (4.71) | (3.56) | (4.08) | (4.18) | (2.69) |
| N | 6,664 | 6,664 | 6,664 | 7,497 | 6,664 | 6,664 |
| Groups | 833 | 833 | 833 | 833 | 833 | 833 |
| Instruments | 176 | 313 | 176 | 148 | 313 | 176 |
| Fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Time Effects | Yes | No | Yes | Yes | No | Yes |
| F-Test (F-Statistic) | 13.24*** | 20.38*** | 16.81*** | 6.01*** | 18.05*** | 14.24*** |
| Arellano-Bond-Test - AR(1) (p − value) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Arellano-Bond-Test - AR(2) (p − value) | 0.968 | 0.848 | 0.768 | 0.003 | 0.278 | 0.246 |
| Hansen-Test (p − value) | 0.069 | 0.082 | 0.043 | 0.126 | 0.095 | 0.093 |
| Sargan-Test (p − value) | 0.003 | 0.030 | 0.000 | 0.383 | 0.203 | 0.054 |
| Diff-in-Hansen-Test (p − value) | 0.053 | - | 0.038 | 0.079 | - | 0.081 |

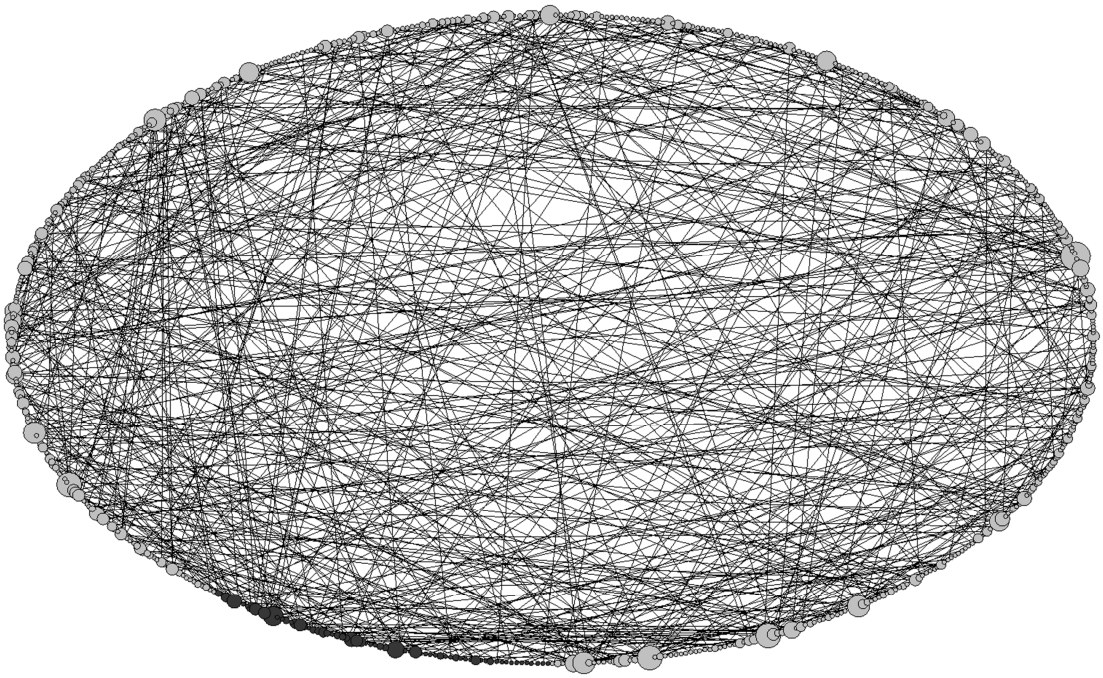
Notes: T-Statistics are in parentheses. The asterisks ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. AR(1) and AR(2) are tests for first-order and second-order serial correlation in the first-differenced residuals, under the null of no serial correlation. The Hansen test of over-identification is under the null that all instruments are valid. The Diff-in-Hansen tests of exogeneity is under the null that instruments used for the equations in levels are exogenous.
Source: Own calculations according to section 3.2.

***Table A6: Alternative Measures of Firm Performance***

| | Model | | | |
|---|---|---|---|---|
| | **(m)** | **(n)** | **(o)** | **(p)** |
| | **ROCE** | **ROCE** | **Tobin's Q** | **Tobin's Q** |
| ROCE (t-1) | - | 0.251*** | - | - |
| | | (8.24) | | |
| Tobin's Q (t-1) | - | - | - | 0.225*** |
| | | | | (6.60) |
| Competition | -93.007*** | -77.266** | -3.160 | -1.521 |
| | (-2.80) | (-2.36) | (-1.54) | (-0.94) |
| Horizontal Links | -25.266** | -23.438** | -1.004 | -0.614 |
| | (-2.32) | (-2.20) | (-0.96) | (-0.54) |
| Vertical Links | 0.072 | 2.229 | -0.587* | -0.449* |
| | (0.02) | (0.49) | (-1.76) | (-1.71) |
| Horizontal Links x Competition | 25.175** | 23.575** | 0.965 | 0.584 |
| | (2.24) | (2.15) | (0.89) | (0.50) |
| Vertical Links x Competition | -0.055 | -2.311 | 0.606* | 0.463* |
| | (-0.01) | (-0.49) | (1.76) | (1.71) |
| Board Size | -0.138 | -0.090 | 0.007 | 0.011 |
| | (-0.80) | (-0.62) | (0.78) | (1.31) |
| Block | -1.131 | -1.279 | -0.013 | 0.040 |
| | (-1.06) | (-1.36) | (-0.27) | (0.96) |
| Log Firm Age | -1.323 | -0.413 | -0.124 | -0.387*** |
| | (-0.77) | (-0.24) | (-1.13) | (-3.80) |
| Log Employees | -2.942* | -4.989** | -0.112 | -0.114 |
| | (-1.65) | (-2.46) | (-1.51) | (-1.42) |
| Debt Equity Ratio | -1.950*** | -0.753 | 0.009 | -0.009 |
| | (-4.21) | (-1.26) | (0.55) | (-0.37) |
| Constant | 126.048*** | 119.497*** | 4.257** | 3.555** |
| | (3.67) | (3.52) | (2.04) | (2.10) |
| N | 7,497 | 6,664 | 6,857 | 5,954 |
| Groups | 833 | 833 | 826 | 821 |
| Instruments | 295 | 320 | 295 | 320 |
| Fixed effects and Time effects | Yes | Yes | Yes | Yes |
| F-Test (F-Statistic) | 5.46*** | 13.23*** | 11.91*** | 16.76*** |
| Arellano-Bond-Test - AR(1) (p − value) | 0.000 | 0.000 | 0.000 | 0.000 |
| Arellano-Bond-Test - AR(2) (p − value) | 0.078 | 0.356 | 0.000 | 0.193 |
| Hansen-Test (p − value) | 0.703 | 0.322 | 0.000 | 0.000 |
| Sargan-Test (p − value) | 1.000 | 0.323 | 0.000 | 0.000 |
| Diff-in-Hansen-Test (p − value) | 0.665 | 0.256 | 0.000 | 0.000 |

Notes: T-Statistics are in parentheses. The asterisks ***, ** and * denote significance at the 1%, 5% and 10% level, respectively. AR(1) and AR(2) are tests for first-order and second-order serial correlation in the first-differenced residuals, under the null of no serial correlation. The Hansen test of over-identification is under the null that all instruments are valid. The Diff-in-Hansen tests of exogeneity is under the null that instruments used for the equations in levels are exogenous.
Source: Own calculations according to section 3.2

***Figure A1: European network of interlocking directorates***



Notes: The grey spots on the edge of the ellipse represent the firms in the sample. The connecting black lines symbolize linkages between two firms via multiple directorships. Source: Own illustration.