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Non-technical summary

This study analyzes the impact of five corporate governance mechanisms (owner concentration, owner type, owner complexity, financial pressure, and board size) and market discipline (product market competition) on productivity growth. We use a panel of 841 German manufacturing firms over the years 1986–1996.

We find that firms under concentrated ownership tend to show higher productivity growth, and this effect is larger for firms earning lower rents. Since we use rent as an inverse measure of the intensity of product market competition, this means that firms in more competitive markets show higher productivity growth, but only when owner control is tight. Additionally, we find that owner control and intense product market competition are complements; this stands in sharp contrast to the finding of Nickell et al. on the UK who find that they are substitutes.

Furthermore, also financial pressure from creditors has a positive impact on productivity growth. We find weak evidence that productivity grows faster for firms showing a large fraction of bank debt, and strong evidence that productivity grows faster when bank debt is high and at the same time firm performance is poor. Hence, creditors seem to be in a position to influence management decisions, which in turn affect productivity growth. And the creditors' position appears to be particularly strong for firms in financial distress.

We cannot confirm that the type of the ultimate owner has a particular impact on productivity growth. Likewise, we do not find evidence that complex ownership structures (e.g., cross ownership or pyramid structures) or large board size have an adverse impact on performance. One reason for the insignificant relation of board size and performance could be that the size of German supervisory boards is tightly regulated by law. Hence, board size is likely to be determined by other factors such as firm size and industry, not necessarily by considerations regarding optimal governance structure. In summary, our results suggest that corporate governance (ownership and capital structure of a firm) as well as market discipline (product market competition) are important governance devices. The combination of these mechanisms forms the basis for higher productivity growth.

Our findings have two policy implications. First, the beneficial impact of increased product market competition on productivity growth implies that competition policy should aim at fostering competition. In the European context this means that remaining obstacles to an integrated Internal Market should be removed. This is even more relevant as intense competition appears to reinforce the beneficial impact of tight owner control, which is dominant in continental Europe (La Porta et al., 1999). Second, we find a beneficial impact of creditors on productivity growth. While we do not explicitly test for the impact of 'housebank' relations, our results suggest that lending relationships in Germany cannot simply be dismissed as too inflexible and outdated, as often argued. However, we also find that creditors' influence depends on a strong creditor position, measured as a large fraction of bank debt. This implies

that reduced bank lending, for example as a consequence from increased securitization of loans, could negatively affect the banks' incentives or ability to monitor. One way to address a potential decline in monitoring by creditors could be to strengthen other parties involved in corporate governance. In the US and the UK, we observe an increasingly active participation of small shareholders such as pension funds, which appear to be able to influence particular corporate decisions (Smith, 1996; Carleton et al., 1998). For Germany, institutional investment continues to rise as well, not at least due the current transition in the pension system. The bottom line for public policy is to ensure a fair treatment of minority shareholders.

Finally, our findings have implications for future empirical research. First, we find a positive impact of ownership concentration on productivity growth, but only when we consider ownership at the ultimate level, not at the direct level. This suggests that *ultimate* ownership matters, not *direct* ownership. Hence, studies relying on measures of direct ownership, which are typically more easily to obtain, might come to misleading results. Second, we find that ownership concentration does not affect productivity growth when not taking into account product market competition. Only when using competition measures as well, we find a significant impact. This is a good example of a missing variables problem. Hence, studies investigating only one or a few of all mechanisms, which potentially affect productivity growth, might come to misleading results as well.

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Corporate governance, market discipline, and productivity growth

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Abstract: Using a large panel of German manufacturing firms over the years 1986–1996, this study examines the impact of corporate governance and market discipline on productivity growth. We find that firms under concentrated ownership tend to show significantly higher productivity growth. Financial pressure from creditors influences productivity growth positively, particularly for firms in financial distress. Regarding market discipline, productivity grows faster when competition on product markets is intense, but only when owner concentration is high. We do not find evidence that the type of the owner, ownership complexity, or the size of the supervisory board is significantly related to productivity growth.

Keywords: competition, corporate governance, productivity, ownership structure

JEL classification: D24, D43, G32

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1 Introduction

Continental Europe lags the US in terms of productivity growth. According to Börsch-Supan (1999), the resulting gap in total factor productivity has been around 20% for Germany and France throughout the entire period of 1970–1995. Researchers and policy makers alike recently recognize productivity as a major determinant of future generations' welfare. The corresponding interest in the sources of productivity is likely to increase as countries move away from pay-as-you-go financing into partially or fully funded pension systems: While total factor productivity is equally important for the (internal) rate of return under both types of pension systems, greater use of capital markets under a funded system could improve corporate governance and ultimately spur productivity growth, as argued by Börsch-Supan and Winter (1999). Hence, good corporate governance could help reduce the transition burden associated with a change in the pension scheme. In short, understanding the determinants of total factor productivity growth is important.

In a recent survey, Bartelsman and Doms (2000) identify four factors that are likely to influence productivity growth at the micro level: (1) government regulation altering the incentives for innovating, market entry, and gaining market share; (2) managerial ability and firm ownership determining the firm's choices on technology and inputs; (3) technology and human capital affecting efficiency in production; and (4) (international) competition on product markets making firms learn faster about new technologies. This study focuses on corporate governance and product market competition (and their interaction) as two important determinants of managerial behavior. Corporate governance is understood and measured as the system of firm's ownership structure, capital structure, and board structure.[1]

Empirical work on corporate governance, competition, and their relation to productivity is accumulating. Studies examining the role of competition include Green and Mayes (1991) and Nickell (1996) for the UK, Klette (1999) for Norway, Bottasso and Sembenelli (2001) for Italy, and Caves (1992), Porter (1992), and Börsch-Supan (1999) for a range of industrialized countries. Studies investigating the role of ownership structure encompass Nickell et al. (1997) for the UK and Januszewski et al. (2001) for Germany, and a study on the role of capital structure is Nickell and Nicolitsas (1999). Another strand of literature investigates different corporate governance mechanisms, such as the structure of the board (e.g., Yermack, 1996); however, empirical studies on board structure typically examine the impact on firm value or some accounting measure, but not the impact on productivity. A study that examines the impact of corporate governance (shareholder control and financial pressure), product market competition, and their interactions on productivity growth in UK firms is Nickell et al. (1997). Januszewski et al. (2001) conduct a similar analysis for German firms; however, they neglect the role of creditors. In contrast to the UK,

1 For theoretical analyses on the role of ownership structure, see Shleifer and Vishny (1986), on the role of capital structure, see Jensen (1986), and on the role of competition, see Hart (1983). We discuss these theoretical arguments in Section 2.

lending relationships in Germany are often characterized as long-term and comparatively stable, ensuring lending even to ailing firms (Mayer, 1988). Recently, this German 'housebank' system has been criticized as too inflexible in times of rapid economic change; hence, new evidence on creditors' governance role is desirable.

Using a panel of 841 German manufacturing firms over the years 1986–1996, this study analyzes the impact of five corporate governance mechanisms (ownership concentration, owner type, ownership complexity, financial pressure, and board size), product market competition, and their interactions on productivity growth. The present study adds to the literature on four important respects: First, we consider a larger range of governance mechanisms and their relation to productivity growth than previous studies. Second, to our knowledge this study is the first to examine the impact of financial pressure (from creditors) on productivity growth for a continental European country. Due to the methodological similarity, our results are directly comparable to those of Nickell et al. (1997) obtained for the UK. Third, we explicitly address potential endogeneity of our explanatory variables by using the GMM instrumental variables technique developed by Arellano and Bond (1991). This method is now standard in panel econometrics, however, it is not yet widely applied in studies on corporate governance with the exceptions of Nickell et al. (1997) and Januszewski et al. (2001). Finally, the data set used in this study is much larger than data sets used in previous work on corporate governance in Germany (e.g., Cable, 1985; Becht and Böhmer, 2000; Gorton and Schmid, 2000; Januszewski et al., 2001).

Our main findings are: Firms under concentrated ownership tend to show higher productivity growth, and this effect is larger when product market competition is intense. Hence, shareholder control and competition are complements. Financial pressure from creditors also has a positive impact on productivity growth, particularly for firms in financial distress. But we cannot confirm that financial pressure and competition stand in a substitutive relationship, as documented by Nickell et al. (1997) for the UK. Similar to Franks and Mayer (2000) and Januszewski et al. (2001), we cannot confirm that firms controlled via cross ownership or pyramid structures perform worse than other firms; and board size is not significantly related to productivity growth.

The paper is structured as follows: Section 2 briefly reviews the literature on corporate governance and market discipline, and how these monitoring mechanisms are related to productivity growth. The aim is to formulate a set of testable hypotheses. Section 3 describes the data sources used and how corporate governance and market discipline are measured in this study. Section 4 gives some preliminary evidence on the relation of corporate governance and market discipline to productivity growth. Section 5 presents an empirical model of productivity growth and details on the GMM estimation procedure. Section 6 contains the estimation results. Section 7 concludes.

2 Hypotheses

The classical problem of corporate governance is the separation of ownership and control. The literature on corporate governance discusses a variety of mechanisms that are supposed to alleviate this agency conflict. A common feature of all mechanisms is that they aim to align the interests of managers and owners of a firm (Shleifer and Vishny, 1997). In the following, we discuss mechanisms covered extensively in the literature and deduct hypotheses that are to be tested in the empirical analysis.[2] We distinguish between the firm's ownership structure, capital structure, board structure, and product market competition.

We expect that productivity growth is affected as follows:

Hypothesis 1 *Concentrated ownership increases productivity growth.*

Hypothesis 2 *The impact of ownership concentration is stronger when a firm is owned by a non-financial firm as a large blockholder, but weaker when a firm is owned by a large private or public blockholder.*

Hypothesis 3 *Complex ownership decreases productivity growth.*

Hypothesis 4 *A large fraction of bank debt increases productivity growth.*

Hypothesis 5 *The impact of bank debt is stronger when performance is poor.*

Hypothesis 6 *Small board size increases productivity growth.*

Hypothesis 7 *Intense product market competition increases productivity growth.*

The first hypothesis (**H1**) follows Shleifer and Vishny (1986) who argue that a large block provides the owner with an incentive to collect information and to monitor management. A large blockholder also has enough voting control to put pressure on management. In contrast, in firms with a dispersed shareholder structure free-riding behavior should make monitoring too costly (Grossman and Hart, 1980). The evidence on monitoring by blockholders indicates that large shareholders indeed play an active role in corporate governance. For Japan, Kaplan and Minton (1994) find that poorly performing management is more likely to be replaced by a large blockholder. For Germany, Franks and Mayer (2000) find little association of ownership

2 Note that in the literature, particularly in studies on financial economics, the goal is typically not to explain productivity but some other measure of firm performance. Therefore, results from empirical studies discussed below are sometimes not directly comparable.

concentration with managerial disciplining. In contrast, Januszewski et al. (2001) show that ownership concentration is positively related to productivity growth.

The second hypothesis (**H2**) is concerned with the type of the controlling blockholder. Pound (1988) notes that institutional investors such as banks should be effective monitors because they have frequent business contacts to their clients; on the other hand, these investors might become entrenched and support incumbent management. Therefore, investment or pension funds could be better monitors than banks or insurers. Similarly, non-financial firms as blockholders can be effective monitors when their investment is strategic; when operating in the same industry, information asymmetries are lower. In contrast, private blockholders typically have only limited access to monitoring competency within their family. For the US, the evidence on the role of institutional investors is mixed (Black, 1998). For Belgium, Renneboog (2000) finds that industrial companies resort to disciplinary actions when performance is poor. For Germany, focusing on accounting-based measures of performance, Edwards and Nibler (2000) cannot find evidence that the role of banks is different from that of other large corporate shareholders; in contrast, Gorton and Schmid (2000) find a positive impact. Focusing on productivity growth, Januszewski et al. (2001) find that financial institutions as blockholders are harmful for productivity growth.

The third hypothesis (**H3**) addresses the role of ownership complexity for corporate monitoring. Franks and Mayer (1995) note that cross holdings can exclude small investors from the control over management. Bebchuk et al. (2000) adds that pyramids and cross ownership function as anti-takeover devices, and therefore shelter management from capital market pressure. Ownership structures are particularly complex in continental Europe and Japan (La Porta et al., 1999). For Germany, Franks and Mayer (2000) cannot find evidence that managerial disciplining is smaller in firms controlled by pyramids, and Januszewski et al. (2001) cannot find evidence that productivity growth is lower for firms controlled by cross-held blockholders.

The fourth hypothesis (**H4**) focuses on the firm's capital structure and its effect on performance. Jensen (1986) argues that debt financing reduces free cash flow and therefore has a disciplinary effect on management. Management can use high leverage to signal credibly that they maximize profits. Likewise, any disciplinary impact creditors have on management should be the greatest when a large fraction of debt is bank debt. Previous evidence indicates that high gearing has a positive impact on performance (see Cable, 1985, for Germany; Nickell and Nicolitsas, 1999, for the UK; and Renneboog, 2000, for Belgium).

The fifth hypothesis (**H5**) recognizes that creditors are concerned about avoiding failure of the provided loans, but much less concerned about monitoring their client firms to ensure that they maximize profits (Stiglitz, 1985). Therefore, we expect banks to interfere in particular when performance is poor and when they are in a strong creditor position, i.e. when a large proportion of debt is bank debt. Similar arguments are put forward by Mayer (1988). He shows that institutionalized lending relationships, as exemplified by the German housebank system (see Edwards and

Fischer, 1994, for a detailed discussion), reduce information asymmetries, and as a consequence allow for (new) long-term lending even in times of financial difficulties.

The sixth hypothesis (**H6**) follows Jensen (1993) who argues that smaller boards control more effectively and therefore have a positive impact on performance. For the US, Yermack (1996) confirms that board size is negatively correlated with firm value. In Germany with its two-tier board structure, a supervisory board is required by law for public corporations, and in some cases also for private corporations. The number of supervisory board members is also regulated by law, with a minimum of three and a maximum of 21 members, depending on firm size and industry; for details, see Hopt (1997). Since firm's discretion is low regarding the size of the board, any empirical relation is likely to be weak.

Finally, the seventh hypothesis (**H7**) recognizes that even in the presence of weak internal monitoring, fierce product market competition may act to align managers' goals with the aim of efficient production; Allen and Gale (2000) provide a review. For example, Hart (1983) shows that an increase in product market competition reduces managerial slack. Other theoretical studies show that competition has no or a positive impact on agency costs. The empirical evidence is less ambiguous. Green and Mayes (1991), Caves (1992), Nickell et al. (1997), Bottasso and Sembenelli (2001), and Januszewski et al. (2001) document that increased product market competition is associated with higher productivity or higher productivity growth. In a recent study with Norwegian establishment-level data, Klette (1999) provides evidence for the positive relationship between price-cost margins, as a measure for product market competition, scale economies, and productivity.

3 Data and measurement issues

The sample used in this analysis is based on firm-level data for the years 1986–1996. The unbalanced panel comprises 841 German firms that operate in the manufacturing sector, with a total of 5,329 firm years. In contrast to previous empirical studies on corporate governance in Germany (e.g., Cable, 1985; Becht and Böhmer, 2000; Gorton and Schmid, 2000) we do not restrict our analysis to large firms listed on the stock exchange, but also include non-listed firms. This is significant because it alleviates the selection bias caused by restricting the analysis to listed firms. Companies from former Eastern Germany are included only after 1990. In this section, we explain the construction of our sample, the data sources used, and the economic principles that guide the construction of the variables used in this study; precise definitions of these variables can be found in Appendix B.

3.1 Data sources

The analysis of corporate governance and market discipline and their impact on productivity growth is based on three pillars of data. The first main pillar – balance

sheet data used to estimate productivity growth – comes from Hoppenstedt's Balance Sheet Database (henceforth, BSD). An important feature of this data source is that it contains information on listed and non-listed corporations, both public (*Aktiengesellschaft*, AG) and private (*Gesellschaft mit beschränkter Haftung*, GmbH). We take 1986 as the starting year because a change in disclosure rules makes data from annual reports before and after the year 1986 incompatible.[3] The last year of the sample is 1996. For the period 1986–1996, BSD contains 5,604 firms (31,294 firm years) for which consolidated balance sheet data are available. We eliminate all firms that do not operate primarily in the manufacturing sector because productivity in industries such as financial (bank or insurance) or non-financial services (wholesale or retail trade) is hard to compare with productivity in manufacturing. We also eliminate firms operating in the utility, traffic, and telecommunications industries, which were predominantly government-owned during the period of observation. Selection by industry leaves us with data on 1,835 firms.

The second main pillar – data on ownership structure and board size – is constructed from annual reports published by former Bayerische Hypotheken- und Wechsel-Bank (in short, Hypobank). These reports contain information on direct ownership of common stock for all listed and large non-listed German corporations. Hypobank reports the size and the name of a direct owner when the size of the ownership block exceeds five percent. However, the Hypobank data on *direct* ownership rights cannot readily be used because ownership complexity of German firms requires to examine *ultimate* firm ownership, as pointed out by Köke (2000). Therefore, this study reconstructs voting rights information in a bottom-up approach from information on direct ownership rights (see Section 3.2).

After matching ownership data, we are left with a sample of 1,090 firms. Because of missing values for important balance sheet items, another 122 firms must be eliminated. This selection procedure generates a sample of 968 firms (5,563 firm years) with at least one year of balance sheet and ownership data during the years 1986–1996. Since the dynamic panel estimator, which we apply in the empirical analysis, requires at least three consecutive years of data, we further eliminate 127 firms for which we have less than three years of consecutive data. The final sample contains 841 firms (5,329 firm years). For a summary of the selection procedure, see Table A1 in the Appendix.

The third main pillar – measures of product market competition – rests on several sources of data. Information on supplier concentration at the four-digit industry level is obtained from biennial reports of the Federal Anti-Trust Commission (Monopolkommission, 1996). Information on the value of imports and domestic production at the two-digit industry level is obtained from the Federal Statistical Office (Statistisches Bundesamt, Außenhandelsstatistik and Produktionsstatistik, Fachserie 4,

3 In 1985 several changes were introduced in German corporate law (§289 HGB), most of them triggered by the European Community's Fourth Company Law Directive on the harmonization of national requirements pertaining to financial statements.

Reihe 3.1). Based on these industry-level data we construct measures of competition, domestic and from abroad. In addition, we construct a firm-specific measure of competition based on balance sheet data (see Section 3.3).

The sample is fairly representative for the universe of large German corporations. Taking the number of all incorporated German firms in the year 1992 as a reference, coverage is high for listed firms (48.9%), all of which are public corporations. The sample includes all firms listed on any German stock exchange that mainly operate in the manufacturing sector. For non-listed firms, coverage is small for public corporations (8.9%) and weak for private corporations (0.02%). However, choosing corporations with total sales exceeding 100 million DM as the benchmark, the sample includes 66.1% of all large public corporations, and more than three percent of all large private corporations. For a more detailed analysis of sample representativeness, see Tables A2 and A3 in the Appendix.

Sample attrition is a concern since it might result in selection biases. To test for a potential selection bias, we analyze information on firms' survival status. For firms leaving the sample before 1996, information is obtained from BSD and telephone interviews. We find that 91 out of 146 firms that exit the sample before 1996 still existed in 1996 without a change in ultimate ownership – they simply changed their name or stopped reporting due to reasons determined within the firm. In 29 cases, operation was shut down due to liquidation or bankruptcy. In 24 cases, a firm had been taken over by another entity. And in two cases operation was shut down voluntarily. Hence, the majority of firm exits from the sample is not related to firm failure or acquisition.[4]

3.2 Measuring corporate governance

To measure corporate governance, this study uses data on ownership structure, capital structure, and board structure. In the following, we explain how these measures are constructed to test the hypotheses formulated in Section 2. We also provide some descriptive statistics.

The main variable used to measure ownership is an indicator whether a firm has an ultimately controlling owner or not ($CONTROL$). This measure takes into account complex ownership structures which are frequently encountered in large German firms. Therefore, it is not only based on measures of direct ownership, which can be misleading particularly for conglomerates (Becht and Böhmer, 2000; Köke, 2001). Similarly, it clearly identifies one single owner. This allows us to classify firms according to the type of their ultimate owner. For a detailed description of the concept of control, which is applied to identify the ultimate owner of each sample firm, see Appendix A.

4 See Köke (2000) for a more detailed analysis of selection, entry, and attrition biases in a panel of firms that is very similar to the one used here.

Table 1: Owner concentration

Concentration of ownership in a given year for the period 1986–1996. Measures of ownership concentration include the average size of the largest share block (BLOCK), the average Herfindahl index of owner concentration (HERF), and the fraction of firms for which an ultimate owner can be identified applying the concept of control (CONTROL). The size of the largest block and the sum of the three largest blocks are calculated at the direct level of ownership. The sample comprises 841 firms.

		Mean		Median	
	CONTROL	BLOCK	HERF	BLOCK	HERF
1986	80.2%	59.2%	46.3%	53.9%	36.1%
1987	84.3%	65.2%	53.4%	68.0%	50.0%
1988	86.0%	68.4%	57.6%	75.7%	57.8%
1989	87.3%	70.9%	60.3%	77.3%	60.3%
1990	88.9%	71.5%	60.9%	77.3%	60.4%
1991	89.6%	72.8%	62.3%	79.6%	63.4%
1992	90.6%	74.9%	65.1%	83.9%	70.4%
1993	91.7%	78.8%	70.2%	95.0%	90.3%
1994	91.0%	81.0%	74.1%	99.0%	98.0%
1995	90.5%	81.4%	75.1%	100.0%	100.0%
1996	90.2%	81.2%	74.9%	99.9%	99.8%
Average	89.2%	75.7%	66.9%	90.0%	81.0%
Correlation with CONTROL	1.000	0.641	0.511	0.641	0.511

To illustrate our main measure of ownership, Table 1 describes how average ownership concentration evolves over time. Besides $CONTROL$, Table 1 also presents two alternative measures of ownership concentration commonly used in the literature: the size of the largest block ($BLOCK$) and the Herfindahl index ($HERF$) calculated for all large share blocks. Note that $BLOCK$ as well as $HERF$ refer to the direct level of ownership. We find that ownership is highly concentrated. Examining ownership at the ultimate level, we identify a controlling owner for, on average, 89.2% of sample firms during the years 1986–1996. At the direct level of ownership, the largest block is also very large with 75.7% at the mean and 90.0% at the median. Similarly high concentration is found when using the Herfindahl index. Both $BLOCK$ and $HERF$ are highly correlated with $CONTROL$. Hence, collinearity problems would be likely when using all three measures simultaneously in the empirical analysis. The degree of ownership complexity in large German firms makes $CONTROL$ a more appealing measure of ownership concentration, hence $CONTROL$ is our preferred measure of ownership concentration in this study.

In addition, we measure ownership complexity ($CROSS$, $PYRAMID$) and we identify the type of the ultimate owner for each sample firm ($TYPE$). The largest fraction of firms is ultimately controlled by a non-financial firm (41.7%) or a private

owner (36.7%). Only 4.4% of sample firms are ultimately controlled by a bank, and 2.3% are controlled by other financial institutions. Note that actual voting power of banks might be greater in practice when banks make use of proxy voting. However, recent evidence suggests that proxy voting is extremely unlikely to significantly enhance bank voting power (Edwards and Nibler, 2000). Government agencies control 4.1% of the firms in our sample, and 10.8% of firms have dispersed ownership. Regarding ownership complexity, 7.5% of sample firms are controlled by a firm that belongs to the well-known web of German industrial and financial conglomerates (Wenger and Kaserer, 1998), and 50.2% of sample firms are controlled through a pyramid with at least one intermediate firm between the ultimate owner and the sample firm.

Regarding capital structure, the main measure used in this study is the ratio of bank debt to total debt ($BANK$). On average, 27.4% of the total debt burden consists of bank debt. As additional measures we use the ratio of total debt to total assets ($DEBT$), the ratio of total debt to book value of total equity ($LEVERAGE$), and the ratio of operating earnings to interest payments ($COVERAGE$). Our measure of board structure is an indicator whether the number of directors on the supervisory board is equal to the legally specified minimum or whether it is greater ($SMALL$). As discussed in detail in Appendix B, this minimum number depends on industry and firm size, but also on other firm characteristics, which are not observable to the researcher. Since not all sample firms have a supervisory board, we use an indicator whether such a board exists ($BOARD$). In our sample, 74.3% of firms have a supervisory board, and in 76.4% of firms the supervisory board consists of the legally specified minimum number of directors.

3.3 Measuring market discipline

To measure market discipline, this study uses data on product market competition. The main variable used to measure competition is the firm's rents from production ($RENT$), which can be interpreted as an ex post measure of market power. The motivation for using this measure is that firms operating in less competitive markets should be able to sell their products well above marginal cost, and therefore earn higher rents after covering their expenses (on capital, labor, and materials). The abstract definition of production rents, R_t, is as follows:

$$R_t = \frac{S_t - r_t^K p_t^K K_t}{Q_t} \tag{1}$$

The denominator, Q_t, is real output (value added), $p_t^Y Y_t - p_t^M M_t$.[5] The numerator is a measure of the firm's real operating surplus, S_t, less real cost of capital, $r_t^K p_t^K K_t$.

5 We have also used real sales, $p_t^Y Y_t$, in the denominator to check for robustness. All results reported below remain qualitatively unchanged.

In this notation, Y_t is nominal output, L_t, K_t, and M_t are nominal labor, capital, and materials inputs, while p_t^Y, p_t^L, p_t^K, and p_t^M are the corresponding prices. Finally, r_t^K is the user cost of capital, defined as $r_t^K = \delta + r_t$, where δ is the depreciation rate and r_t is the risk-free market interest rate.

In the literature (e.g., Nickell, 1996), raw operating surplus, S_t, is measured by 'earnings before interest, taxes, and depreciation' (also known as EBITDA). This quantity contains a number of balance-sheet items that can potentially distort the economic content of this variable, resulting in values of EBITDA that are downward-biased measures of raw operating surplus. This problem is particularly severe in Germany, where firms are entitled to retain a large fraction of earnings to build up reserves. In our sample, this effect is large enough to make the mean of the rents variable negative in the pooled sample, with the implication that, loosely speaking, a large number of firms make losses most of the time. We therefore do not use balance-sheet EBITDA as a measure of raw operating surplus. Instead, we use an economic definition of raw operating surplus: sales less costs for materials and labor, hence $S_t = p_t^Y Y_t - p_t^M M_t - p_t^L L_t$. In economic terms, this definition is equivalent to the definition of EBITDA. With this in mind, the abstract definition of firm rents in (1) can be re-written in terms of observable quantities as follows:

$$R_t = \frac{(p_t^Y Y_t - p_t^M M_t - p_t^L L_t) - r_t^K p_t^K K_t}{p_t^Y Y_t - p_t^M M_t} \,. \tag{2}$$

In addition to firm-specific rents, we use the market share of the six largest suppliers ($CR6$) and the respective Herfindahl index (HHI), both measured at the four-digit industry level, as proxy variables for competition. As a proxy for competition from abroad we use the ratio of imports to total market size (i.e., the sum of domestic production and imports), measured at the two-digit industry level ($IMPORT$).

There are two important caveats with respect to all measures of competition used in this paper. First, we acknowledge that these variables do not reflect some important facets of competition, namely potential entry and firm conduct. Second, as we do not have firm-specific data on market shares, we can only assign companies to their primary four-digit industry group, but we cannot adjust Herfindahl indices and concentration ratios using firms' market shares.

To illustrate our measures of competition, Table 2 describes the intensity of competition using all of these measures, separately for the 22 two-digit manufacturing industries contained in the sample. We find that German manufacturing firms earned rents of about 28% during the years 1986–1996. On average, the six largest suppliers cover about 47% of the domestic market, and imports make up for about one fourth of the total market. Table 2 also indicates some remarkable differences between industries. Imports represent a large fraction of the total market in clothing, leather, equipment for data processing, and other vehicles (e.g., ships). The market share of the six largest suppliers is low in clothing, wood, publishing and printing,

and metal products; in turn, concentration is extremely high in tobacco. Correspondingly, industries with low $RENT$ are textiles, metals, and other vehicles. As we could expect, $RENT$ is negatively correlated with industry concentration and import penetration. However, this correlation is weak. This implies that the empirical analysis should include firm-level as well as industry-level measures of competition.

Table 2: Firm- and industry-specific measures of competition

Firm- and industry-specific measures of competition, separately by two-digit industry. Measures of competition include the ratio of total operating surplus less costs of capital to value added ($RENT$), the market share of the six largest suppliers ($CR6$), the Herfindahl index of producer concentration (HHI), and the ratio of imports to total market size ($IMPORT$). The sample comprises 841 firms.

	Firm level	Industry level			Observ.	
	RENT	CR6	HHI	IMPORT	total	percent
Food (15)	45.8%	33.1%	4.2%	18.7%	676	12.7%
Tobacco (16)	48.6%	97.8%	20.3%	10.2%	55	1.0%
Textiles (17)	16.7%	45.2%	6.2%	46.4%	228	4.3%
Clothing (18)	55.2%	20.6%	1.4%	61.2%	84	1.6%
Leather (19)	46.7%	33.3%	3.2%	63.2%	24	0.5%
Wood (20)	36.0%	19.6%	1.6%	24.0%	30	0.6%
Paper (21)	30.1%	47.8%	6.7%	27.7%	168	3.2%
Publishing, printing (22)	30.9%	23.6%	1.9%	5.5%	57	1.1%
Coal, oil processing (23)	41.1%	81.8%	14.9%	38.4%	63	1.2%
Chemicals (24)	39.1%	60.1%	10.6%	26.1%	564	10.6%
Rubber/plastic products (25)	28.4%	34.2%	3.8%	19.6%	318	6.0%
Rock, stone, glass (26)	30.1%	51.9%	8.5%	17.6%	326	6.1%
Metals (27)	10.9%	56.7%	10.9%	26.2%	308	5.8%
Metal products (28)	27.6%	25.7%	2.7%	14.8%	280	5.3%
Machinery (29)	20.2%	37.9%	5.0%	16.7%	941	17.7%
Equ. for data processing (30)	27.3%	80.7%	23.5%	60.2%	191	3.6%
Equ. for power generation (31)	21.6%	42.6%	6.5%	31.1%	230	4.3%
Equ. for broadcasting and TV (32)	23.0%	60.5%	12.6%	48.4%	188	3.5%
Medical and optical instruments (33)	20.2%	41.2%	6.7%	33.6%	124	2.3%
Cars, car parts (34)	26.8%	67.5%	12.7%	20.8%	246	4.6%
Other vehicles (35)	2.6%	67.7%	19.2%	59.7%	163	3.1%
Furniture, jewelry, toys (36)	38.5%	32.4%	3.4%	25.7%	65	1.2%
Average	28.4%	46.6%	7.9%	26.1%	5,329	100.0%
Correlation with RENT	1.000	-0.034	-0.028	-0.067	–	–

4 Preliminary evidence

We begin our empirical analysis with some suggestive evidence based on a simple measure of productivity growth. In a first step, we estimate a standard two-factor Cobb-Douglas production function with value added as the dependent variable, labor and capital as independent variables (i.e., we indirectly account for materials as third input factor), and we interpret the residuals from this static regression as a measure of relative firm productivity (i.e., relative to the regression mean).[6] The concept of relative productivity has a long tradition in applied productivity analysis; see Doms et al. (1995) for an application. In a second step, we calculate the first difference of the predicted residuals to obtain a measure of productivity growth.

To get a first impression of the effects of corporate governance and market discipline on productivity growth, we split the sample into two groups: firms with positive and negative productivity growth. In Table 3, we report means of some key measures of corporate governance and market discipline for both splits. One reason for considering growth instead of levels of productivity is that some of our variables for corporate governance and market discipline should be highly endogenous to the level of productivity. Since productivity growth is less persistent than productivity levels, the endogeneity problem may be less severe if lagged values of corporate governance and market discipline are used; see also the discussion in Nickell (1996). In the econometric analysis reported below, we use productivity growth as dependent variable and address the potential endogeneity by using an instrumental variables approach. Here we simply use all variables that are supposed to explain productivity growth with a one year lag. Taking into account that corporate governance and market discipline might affect productivity growth in the long run rather than in the short run, we report results for three different forward-looking time horizons: zero years, two years, and four years. For example, for a time horizon of two years we calculate productivity growth as the average of productivity growth in year t, year $t+1$, and year $t+2$.

We find strong support for hypothesis **H1** that firms under concentrated ownership show significantly higher productivity growth (Table 3). For our measure of ownership concentration at the direct level, $BLOCK$, this result holds irrespective whether we consider short- or long-run productivity growth. However, for our measure of ownership concentration at the ultimate level, $CONTROL$, this holds only for long-run productivity growth, a five-year average. Regarding the type of ultimate owner, we find that a significantly larger fraction of firms under control of a private owner belongs to the group of firms with lower productivity growth. This suggests that productivity in privately-controlled firms tends to grow more slowly. Vice versa, productivity grows faster in firms under control of a non-financial firm; this supports hypothesis **H2**. In addition, productivity growth is higher in firms

6 To estimate this production function using OLS, we also include time and two-digit industry dummies; see Table 3.

controlled through a pyramid. We find no indication that cross ownership has an adverse impact on productivity growth.

Table 3: Bivariate analysis of corporate governance, market discipline, and productivity growth

Bivariate analysis of corporate governance and market discipline and their relation to productivity growth. Productivity growth is approximated by the first difference in the residuals from pooled OLS estimation of a two-factor Cobb-Douglas production function including time and two-digit industry dummies. Productivity growth is measured at three forward-looking time horizons: zero years (residual in year t), two years (average of residuals in years t through $t+2$), and four years (average of residuals in years t through $t+4$). All other variables are observed in year $t-1$. The test statistics are heteroskedastic t-tests of equal means. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

Forward-looking horizon	0 years		2 years		4 years	
Performance	negative	positive	negative	positive	negative	positive
Owner concentr. ($BLOCK$)	73.7%**	75.4%	69.3%***	72.6%	65.4%***	71.7%
Ultimate owner ($CONTROL$)	88.9%	89.0%	87.6%	88.0%	84.3%*	87.5%
Owner ($TYPE$ = private)	39.4%*	37.0%	43.2%	40.4%	43.4%	40.3%
Owner ($TYPE$ = financial firm)	6.6%	6.6%	7.0%	5.8%	7.0%	5.5%
Owner ($TYPE$ = non-fin. firm)	39.8%	40.9%	35.2%**	39.6%	31.6%***	39.9%
Owner ($TYPE$ = government)	3.0%**	4.5%	2.2%	2.2%	2.3%	1.8%
Cross ownership ($CROSS$)	7.8%	7.1%	7.0%	7.2%	6.7%	6.7%
Pyramid ($PYRAMID$)	45.6%***	50.4%	40.0%	42.5%	36.0%**	40.6%
Bank debt ($BANK$)	28.7%	27.8%	29.8%*	31.5%	31.1%	29.5%
Debt ratio ($DEBT$)	40.8%*	41.8%	39.6%	40.7%	39.2%	39.4%
Ind.-adj. return on assets (ROA)	4.7%***	-0.5%	4.7%***	-0.3%	4.4%***	0.6%
Financial distress ($LOSS$)	1.2%	1.4%	0.4%**	1.1%	0.3%	0.9%
Small board ($SMALL$)	75.2%	77.1%	76.8%	75.3%	75.7%	74.8%
Industry concentration ($CR6$)	47.6%**	46.2%	50.1%*	48.5%	50.1%	48.5%
Industry concentration (HHI)	8.3%***	7.6%	8.9%**	8.3%	8.7%	8.3%
Rent ($RENT$)	32.0%***	26.2%	32.0%***	26.9%	30.4%***	27.6%
Number of obs.	1,493	1,481	1,087	905	622	504

Regarding our measures of capital structure, there is weak evidence that firms are more productive when a large fraction of total debt is bank debt and when the total burden of debt is high. This implies that financial pressure from creditors appears to play some role in disciplining management. This notion is supported by the results on two measures of performance: firms tend to show significantly higher productivity growth when industry-adjusted return on assets is low or when operating income (EBITDA) is negative. Hence, the preliminary evidence supports hypotheses **H4** and **H5**. Regarding board size, we do not find evidence that productivity grows faster in firms with small boards.

Moreover, Table 3 indicates that firms facing intense competition show higher productivity growth. Both of our industry-level measures of competition, the market

share of the six largest suppliers ($CR6$) and the Herfindahl index of producer concentration (HHI), are significantly lower for firms with high productivity growth. The same holds for our measure of firm-level competition ($RENT$). Since all three measures are inverse measures of competition, these results strongly support hypothesis **H7**. Note that this result holds irrespective of whether we consider short-run or long-run productivity.[7]

In summary, the preliminary evidence suggests that in German manufacturing some elements of corporate governance, such as ownership concentration and bank debt, as well as market discipline reflected by product market competition, are positively related to productivity growth. However, this descriptive analysis is purely bivariate and ignores all potential endogeneity problems. In the remainder of this paper, we address these problems in a dynamic model of productivity growth estimated with instrumental variable techniques.

5 An empirical model of productivity growth

In this section, we derive an empirical model of productivity growth from the firm's production function, modelling explicitly the sources of total factor productivity. Specifically, we model the *level* of total factor productivity as a function of the firm's cumulated experience with corporate governance and market discipline. We therefore assume that productivity is shaped by the compound effect of past conditions under which the firm operated, such as intense product market competition or tight shareholder control. For vivid evidence on the compound effect of competition on productivity differentials between industrialized nations, see Porter (1992).

The starting point of our model is a Cobb-Douglas production function with two factor inputs,

$$Y_{it} = {L_{it}}^{\beta_L} {K_{it}}^{\beta_K} A_{it}\,, \tag{3}$$

where Y_{it} is value added, L_{it} is labor, K_{it} is capital, and A_{it} is a measure of total factor productivity for firm i in year t. Since we use value added as the output measure, which is defined as total sales less materials costs, we implicitly allow for materials as a third input.

As we are interested in the determinants of total factor productivity growth, we transform the production function (3) into a regression equation in several steps. First, we take logs and include lagged output besides the inputs of capital and labor, using a weight λ. This expansion takes into account potential persistence in output.

7 This result also holds when $RENT$ is measured relative to total sales instead of value added, when $RENT$ is measured as the average over two consecutive years, or when $RENT$ is measured as average rent within each three-digit industry.

We also include a fixed firm effect, α_i, to allow for unobserved firm heterogeneity. Since output can have a stochastic component, we add an error term, ϵ_{it}, which is assumed to be serially uncorrelated over time. This yields our basic log-linear empirical production function, with small letters denoting logs:

$$y_{it} = \lambda y_{it-1} + (1-\lambda)\beta_L l_{it} + (1-\lambda)\beta_K k_{it} + (1-\lambda)a_{it} + \alpha_i + \epsilon_{it}\,. \tag{4}$$

Second, taking first differences eliminates the fixed firm effect α_i. We obtain the differenced growth version of the Cobb-Douglas production function in (3):

$$\Delta y_{it} = \lambda \Delta y_{it-1} + (1-\lambda)\beta_L \Delta l_{it} + (1-\lambda)\beta_K \Delta k_{it} + \Delta a_{it} + \Delta\epsilon_{it}\,. \tag{5}$$

Finally, we specify the sources of productivity growth by using the level of corporate governance and product market competition in year $t-1$. Employing these variables in *levels* to explain productivity *growth* is appropriate here because we assume that the *level* of total factor productivity is influenced by the *compound* effect of all past states of corporate governance and competition. In particular, we specify productivity growth with our variables of interest, which follow from the hypotheses derived in Section 2. These variables include measures of ownership structure ($CONTROL$, $CROSS$, $TYPE$), capital structure ($BANK$), financial distress ($LOSS$), board structure ($SMALL$), and product market competition ($RENT$). Note that all of these variables enter with a one-year lag. To take into account cyclical effects on productivity growth, we add a contemporaneous industry-specific proxy variable that measures capacity utilization ($CYCLE$), and time effects μ to filter out productivity shocks. To control for growth effects related to firm size but unrelated to corporate governance and market discipline, we include lagged total assets ($ASSET$). Thus, productivity growth is modeled as

$$\begin{aligned}
\Delta a_{it} \;=\; & (\mu_t - \mu_{t-1}) + \gamma_1 CYCLE_{it} + \gamma_2 ASSET_{it-1} \\
& + \beta_1 CONTROL_{it-1} + \beta_2 CROSS_{it-1} + \beta_3 TYPE_{it-1} \\
& + \beta_4 BANK_{it-1} + \beta_5 LOSS_{it-1} \\
& + \beta_6 SMALL_{it-1} \\
& + \beta_7 RENT_{it-1}\,.
\end{aligned} \tag{6}$$

The empirical model of productivity growth is given by (5) together with (6). The structure of this model corresponds to the differenced panel model with lagged endogenous variables considered by Arellano and Bond (1991). They propose a generalized method of moments (GMM) estimator that allows to exploit lags of the lagged dependent variable as well as lags of the explanatory variables as instruments. In our application, using this approach addresses the potential endogeneity

problems with respect to the corporate governance and market discipline variables that enter the right-hand side of equation (5).[8]

Arellano and Bond (1991) show that endogenous variables lagged two or more periods are valid instruments, provided there is no serial correlation in the time-varying component of the error terms in equation (4); we test this condition for all specifications. The instruments we use are y_{it-j} for $j \geq 2$, and second lags of $CONTROL$, $DEBT$, $CR6$ and $ASSET$.[9] We test for instrument validity using a Sargan test of over-identifying restrictions.[10] We report those tests together with the estimation results and standard errors that are robust with respect to general heteroskedasticity in the next section.

While the Arellano-Bond approach can in principle deal with potential endogeneity problems in our application, there is a caveat. Blundell and Bond (1998) show that in autoregressive models with persistent series, the first-difference estimator can be subject to finite sample bias as a result of weak instruments. They argue that this bias could be greatly reduced by estimating a model with equations in both levels and first differences. We do not apply such a GMM system estimation procedure here because, as discussed above, we assume that the *level* of corporate governance and market discipline influences productivity *growth*. This suggests to use a first-difference estimator. This approach also has the advantage that we do not have to compare levels of productivity across firms and industries, but only changes in productivity. The disadvantage of potential finite sample bias remains, although our sample is much larger compared with those used for previous studies.

6 Estimation results

In the following, we examine the effects of corporate governance and market discipline on productivity growth. Section 6.1 presents estimation results for our empirical model of productivity growth. All regressions are estimated using the GMM method developed by Arellano and Bond (1991). First, we look at the impact of corporate governance (Table 4), then we investigate additional effects of market discipline and their interactions with corporate governance (Table 5). Section 6.2 examines the sensitivity of our main findings.

8 An alternative estimation approach for dynamic panel data models is the standard instrumental variables (IV) estimator proposed by Anderson and Hsiao (1981). However, since we have modeled the influence of corporate governance and market discipline on productivity *growth* using the parameterization in equation (6), the Anderson-Hsiao IV estimator is not readily applicable in our setting.

9 We also experimented with additional instruments, using all time-varying measures of ownership structure or competition. However, our main results did not change qualitatively; see Section 6.2.

10 Following Arellano and Bond (1991), we use the two-step version of the GMM estimator for obtaining the Sargan test statistic, while coefficient estimates are based on the one-step version. Arellano and Bond report that the one-step Sargan test is sensitive to heteroskedasticity, tending to over-reject the null.

6.1 Effects of corporate governance and market discipline

Starting with the analysis of firms' corporate governance, we hardly find any significant effect on productivity growth. Model (1) in Table 4 shows that ownership structure, measured either by ownership concentration, type of owner, or ownership complexity, is not significantly related to productivity growth. Hence, we do not find support for Hypotheses **H1**, **H2**, nor **H3**.[11] Note that this result contradicts the descriptive evidence from Section 4, where firms' ownership structure appears to be related to productivity growth. Note also that we obtain this result as long as not taking into account product market competition. As shown below, interacting corporate governance and competition changes this result.

Examining capital structure in Model (2), we find that the fraction of bank debt is positively related to productivity growth. This suggests that firms in which banks are potentially more influential are subject to tighter discipline, resulting in higher productivity growth. Hence, banks as creditors appear to perform an important monitoring function; this supports Hypothesis **H4**.

Taking into account that banks' influence should be particularly strong when the borrower's performance is poor, Model (3) additionally includes an indicator of financial distress ($LOSS$) and interacts bank debt and this measure of poor performance. We find that bank debt alone does not show any significant impact on productivity growth any longer. But the interaction of poor performance and bank debt is significantly positive. This suggests that a large fraction of bank debt has a disciplinary effect, but only when performance is poor. This result supports Hypothesis **H5**.

Turning to the third main element of governance, the board structure, we cannot confirm that board size is significantly related to productivity growth (**H6**). Controlling for the fact that not all sample firms have a supervisory board ($BOARD$), our indicator for small board size ($SMALL$) is positive but insignificant. As mentioned in Section 2, this result could be expected because in Germany the size of supervisory boards is tightly regulated by law, prescribing minimum and maximum numbers of directors. Hence, firm's discretion is low regarding the size of the board. Therefore, in the subsequent analysis we do not consider board size any longer.

11 When we use $PYRAMID$ instead as a measure of ownership complexity, we still do not find a significant relation.

Table 4: Effects of corporate governance on productivity growth

GMM regression results relating measures of corporate governance to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})			
Independent variables	Model (1)	Model (2)	Model (3)	Model (4)
Lagged output growth (Δy_{t-1})	0.027	0.028	0.002	0.001
	(0.159)	(0.159)	(0.133)	(0.132)
Labor growth (Δl_t)	0.803***	0.806***	0.801***	0.795***
	(0.165)	(0.165)	(0.159)	(0.161)
Capital growth (Δk_t)	-0.100	-0.114	-0.156	-0.132
	(0.228)	(0.223)	(0.202)	(0.213)
Business cycle ($CYCLE_t$)	0.012	0.012	0.010	0.010
	(0.019)	(0.019)	(0.019)	(0.019)
Owner concentration ($CONTROL_{t-1}$)	-0.014	-0.002	0.014	0.017
	(0.036)	(0.035)	(0.035)	(0.036)
Owner ($TYPE_{t-1}$ = private)	0.024	0.014	0.017	0.016
	(0.042)	(0.040)	(0.039)	(0.039)
Owner ($TYPE_{t-1}$ = financial)	-0.114	-0.111	-0.113	-0.107
	(0.090)	(0.091)	(0.088)	(0.087)
Owner ($TYPE_{t-1}$ = government)	0.141	0.141	0.110	0.107
	(0.199)	(0.199)	(0.198)	(0.200)
Cross ownership ($CROSS_{t-1}$)	-0.060	-0.059	-0.052	-0.052
	(0.065)	(0.065)	(0.064)	(0.064)
Bank debt ($BANK_{t-1}$)		0.105**	0.007	-0.003
		(0.053)	(0.049)	(0.047)
Financial distress ($LOSS_{t-1}$)			-0.898	-0.877
			(0.954)	(0.959)
$BANK_{t-1}$ * $LOSS_{t-1}$			8.237**	8.199**
			(3.855)	(3.865)
Board ($BOARD_{t-1}$)				0.001
				(0.048)
Small board ($SMALL_{t-1}$)				0.026
				(0.031)
Total assets ($ASSET_{t-1}$)	0.010	0.011	0.010	0.008
	(0.013)	(0.013)	(0.011)	(0.012)
Listed ($LISTED_t$)	0.029	0.018	0.030	0.022
	(0.027)	(0.028)	(0.025)	(0.026)
Intercept	-1.315	-1.263	-1.192	-1.185
	(1.798)	(1.597)	(1.761)	(1.753)
Number of obs.	3,647	3,647	3,647	3,647
Instrument validity (Sargan test)	p=0.497	p=0.456	p=0.315	p=0.286
First-order correlation of residuals	p=0.027	p=0.027	p=0.015	p=0.015
Second-order correlation of residuals	p=0.418	p=0.414	p=0.430	p=0.429
Constant returns to scale (Wald test)	p=0.301	p=0.279	p=0.223	p=0.261

Table 5: Effects of corporate governance and market discipline on productivity growth

GMM regression results relating measures of corporate governance and market discipline to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})					
	Model (5)		Model (6)		Model (7)	
Independent variables		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$
Lagged output growth (Δy_{t-1})	-0.019		-0.025		-0.025	
	(0.133)		(0.130)		(0.122)	
Labor growth (Δl_t)	0.825***		0.833***		0.833***	
	(0.167)		(0.166)		(0.161)	
Capital growth (Δk_t)	0.438		0.467		0.446*	
	(0.329)		(0.328)		(0.248)	
Business cycle ($CYCLE_t$)	0.011		0.012		0.012	
	(0.019)		(0.019)		(0.019)	
Industry concentration ($CR6_{t-1}$)	0.083		0.104		0.125	
	(0.093)		(0.097)		(0.094)	
Rent ($RENT_{t-1}$)	-0.127		0.168		0.130	
	(0.258)		(0.246)		(0.223)	
Owner concentr. ($CONTROL_{t-1}$)	0.231**	-0.684**	0.255**	-0.757**	0.367***	-1.072***
	(0.114)	0.319	(0.109)	(0.300)	(0.118)	(0.335)
Bank debt ($BANK_{t-1}$)	0.189***		0.484*	-1.019	0.082*	
	(0.072)		(0.277)	(0.783)	(0.047)	
Financial distress ($LOSS_{t-1}$)					-1.924*	
					(1.001)	
$BANK_{t-1}$ * $LOSS_{t-1}$					8.776**	
					(3.726)	
Total assets ($ASSET_{t-1}$)	0.020		0.022		0.019*	
	(0.015)		(0.015)		(0.011)	
Listed ($LISTED_t$)	0.054**		0.060**		0.063**	
	(0.026)		(0.027)		(0.028)	
Intercept	-1.270		-1.467		-1.522	
	(1.587)		(1.579)		(1.784)	
Number of obs.	3,647		3,647		3,647	
Instrument validity (Sargan test)	p=0.206		p=0.153		p=0.377	
First-order correlation of residuals	p=0.029		p=0.028		p=0.021	
Second-order correlation of residuals	p=0.524		p=0.486		p=0.513	
Constant returns to scale (Wald test)	p=0.464		p=0.392		p=0.356	

Table 5 additionally considers the impact of product market competition and its interaction with corporate governance. We do not include variables measuring ownership complexity and the type of the ultimate owner any longer because we

could not find evidence that they affect productivity growth (Table 4).[12] Note that the magnitude of the input coefficient on labor is hardly affected, and the input coefficient on capital remains insignificant. As in Table 4, the latter result is likely due to measurement error in capital stock, a common problem in productivity analysis. Note also that the coefficient on bank debt remains significantly positive.

The main result from Table 5 is that intense product market competition has a positive impact on productivity growth, but only in the presence of a strong ultimate owner. Model (5) shows that firms for which rents – our inverse firm-level measure of competition – are low experience higher productivity growth; however, this direct effect of rents is insignificant. But when we interact rents with our measure of tight owner control ($CONTROL$), as suggested by Nickell et al. (1997), we find that the interaction term is significantly negative. At the same time, the sign of ownership concentration is significantly positive. Taken together, this means that tight control by an ultimate owner has a positive impact on productivity growth, and that this effect is enhanced when competition on product markets is fierce. Hence, when taking into account competition we find strong support for Hypothesis **H1**. The evidence also supports Hypothesis **H7**, but only for firms under tight control.

Note that our industry-level measure of competition is not significantly associated with productivity growth. The business cycle proxy is also insignificant. These insignificant coefficients might be due to the fact that time and industry dummies absorb most of the variation in these industry-level variables. Also, we cannot assign industry-level competition variables to firms perfectly because we only have industry codes for the firms' primary products, as noted above.

In Model (6) we additionally interact rents with financial pressure ($BANK$), as also suggested by Nickell et al. (1997). We find that the positive impact of bank debt on productivity growth remains, but the interaction term is insignificant. This suggests that bank influence is not enhanced by fierce product market competition. Instead, in Model (7) we interact bank debt with our indicator of financial distress, as suggested by Model (3) of Table 4. As in Model (3), we find a significantly positive interaction term. This indicates that banks are in a position to influence productivity growth particularly when firm performance is poor; again this strongly supports Hypothesis **H5**. Note that the positive impact of shareholder control and its negative interaction with competition remains.

All versions of our GMM model are generally supported by the standard battery of specification tests. The Sargan tests do not reject the hypothesis of instrument validity. Also, the tests for second-order serial correlation of the residuals do not reject the null of zero correlation. Wald tests cannot reject the hypothesis of constant returns to scale. Finally, in all specifications we report, the slope coefficients and the

12 To check for robustness, we re-estimated all regressions in Table 5, including these additional ownership characteristics. We still could not find any consistent relation between these measures and productivity growth. At the same time, none of our main findings in Table 5 is qualitatively altered.

sets of time and industry dummy variables are jointly significant according to our Wald tests (not reported). Finally, note that firm size, which is included in all models as a control, does not have a significant impact on productivity growth. The dummy for listed firms is significantly positive in some of the specifications.

6.2 Sensitivity of results

To check the sensitivity of our main findings, we conduct a range of robustness tests. One concern is the selection of variables measuring corporate governance and market discipline. Table 6 examines whether two alternative measures of ownership concentration, the largest block ($BLOCK$) and the Herfindahl index ($HERF$), have an additional impact on productivity growth besides our preferred measure ($CONTROL$). In contrast to $CONTROL$, which measures concentration at the ultimate level of ownership, these alternative measures refer to the direct level of ownership. Taking Model (5) from Table 5 as the reference, we cannot find evidence that $BLOCK$ or $HERF$ have any additional impact on productivity growth. The other coefficients do not change qualitatively.

Next, we test the sensitivity of our finding that in Germany the impact of financial pressure is not enhanced or reduced when competition is intense, in particular because Nickell et al. (1997) find that they are substitutes. Table 7 examines whether two alternative measures of financial pressure, the debt ratio ($DEBT$) and interest coverage ($COVERAGE$), have an additional impact on productivity growth besides our preferred measure ($BANK$). Taking Model (6) from Table 5 as the reference, we find that both alternative measures are not significantly related to productivity growth, and all other results remain qualitatively unaffected.

In Table 8, we use two alternative measures of firm-level competition to address potential endogeneity issues. $RENTA$ is the average of the firm's rents over the past two years. This time aggregation should smooth short-run firm-specific shocks that affect output directly and hence affect rents. $RENTI$ is the year-specific average of our firm-specific rents measure across the respective three-digit industry. This cross-sectional aggregation also wipes out firm-specific shocks, and therefore avoids potential endogeneity problems associated with the rents variable. Taking Model (7) from Table 5 as the reference, we find that the interaction of rents and ownership concentration remains significantly negative. In addition, the positive impact of shareholder control as well as the positive interaction of bank debt and financial distress remain. However, using the industry-adjusted measure of rents in Model (7b), the direct impact of bank debt turns insignificant. Overall, this robustness check gives us some confidence that our general approach – controlling for endogeneity problems using an instrumental variables GMM method – is appropriate.

Table 6: Robustness tests: different measures of ownership structure

GMM regression results relating measures of corporate governance and market discipline to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})					
	Model (5)		Model (5a)		Model (5b)	
Independent variables		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$
Lagged output growth (Δy_{t-1})	-0.019		-0.023		-0.021	
	(0.133)		(0.129)		(0.131)	
Labor growth (Δl_t)	0.825***		0.833***		0.835***	
	(0.167)		(0.166)		(0.166)	
Capital growth (Δk_t)	0.438		0.506		0.518	
	(0.329)		(0.344)		(0.346)	
Business cycle ($CYCLE_t$)	0.011		0.011		0.011	
	(0.019)		(0.019)		(0.019)	
Industry concentration ($CR6_{t-1}$)	0.083		0.087		0.090	
	(0.093)		(0.095)		(0.096)	
Rent ($RENT_{t-1}$)	-0.127		-0.664		-0.479	
	(0.258)		(0.597)		(0.445)	
Owner concentr. ($CONTROL_{t-1}$)	0.231**	-0.684**	0.505**	-1.518**	0.419**	-1.258**
	(0.114)	(0.319)	(0.250)	(0.719)	(0.178)	(0.507)
Largest block ($BLOCK_{t-1}$)			-0.520	1.576		
			(0.456	(1.332)		
Herfindahl index ($HERF_{t-1}$)					-0.382	1.142
					(0.330)	(0.943)
Bank debt ($BANK_{t-1}$)	0.189***		0.154***		0.149**	
	(0.072)		(0.058)		(0.059)	
Total assets ($ASSET_{t-1}$)	0.020		0.019		0.020	
	(0.015)		(0.014)		(0.014)	
Listed ($LISTED_t$)	0.054**		0.063**		0.063**	
	(0.026)		(0.030)		(0.031)	
Intercept	-1.270		-1.089		-1.198	
	(1.587)		(1.600)		(1.620)	
Number of obs.	3,647		3,647		3,647	
Instrument validity (Sargan test)	p=0.206		p=0.273		p=0.262	
First-order correlation of residuals	p=0.029		p=0.030		p=0.030	
Second-order correlation of residuals	p=0.524		p=0.493		p=0.485	
Constant returns to scale (Wald test)	p=0.464		p=0.352		p=0.335	

Table 7: Robustness tests: different measures of capital structure interacted with competition

GMM regression results relating measures of corporate governance and market discipline to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})					
	Model (6)		Model (6a)		Model (6b)	
Independent variables		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$		Interaction $RENT_{t-1}$
Lagged output growth (Δy_{t-1})	-0.025		-0.029		0.009	
	(0.130)		(0.126)		(0.150)	
Labor growth (Δl_t)	0.833***		0.793***		0.838***	
	(0.166)		(0.153)		(0.168)	
Capital growth (Δk_t)	0.467		0.541*		0.543	
	(0.328)		(0.307)		(0.336)	
Business cycle ($CYCLE_t$)	0.012		0.014		0.012	
	(0.019)		(0.019)		(0.019)	
Industry concentration ($CR6_{t-1}$)	0.104		0.135		0.111	
	(0.097)		(0.104)		(0.100)	
Rent ($RENT_{t-1}$)	0.168		0.731		-0.006	
	(0.246)		(0.540)		(0.352)	
Owner concentration ($CONTROL_{t-1}$)	0.255**	-0.757**	0.233**	-0.636**	0.290**	-0.837**
	(0.109)	(0.300)	(0.102)	(0.284)	(0.121)	(0.331)
Bank debt ($BANK_{t-1}$)	0.484*	-1.019	0.486*	-0.682	0.464*	-0.773
	(0.277)	(0.783)	(0.289)	(0.798)	(0.279)	(0.803)
Debt ratio ($DEBT_{t-1}$)			0.177	-1.605		
			(0.486)	(1.415)		
Interest coverage ($COVERAGE_{t-1}$)					0.000	0.000
					(0.001)	(0.002)
Total assets ($ASSET_{t-1}$)	0.022		0.016		0.022	
	(0.015)		(0.013)		(0.016)	
Listed ($LISTED_t$)	0.060**		0.053*		0.076**	
	(0.027)		(0.028)		(0.034)	
Intercept	-1.467		-1.601		-1.623	
	(1.579)		(1.623)		(1.762)	
Number of obs.	3,647		3,647		3,628	
Instrument validity (Sargan test)	p=0.153		p=0.161		p=0.285	
First-order correlation of residuals	p=0.028		p=0.030		p=0.032	
Second-order correlation of residuals	p=0.486		p=0.512		p=0.193	
Constant returns to scale (Wald test)	p=0.392		p=0.284		p=0.324	

Table 8: Robustness tests: different measures of firm-level competition

GMM regression results relating measures of corporate governance and market discipline to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})					
	Model (7)		Model (7a)		Model (7b)	
Independent variables		Interaction $CONTROL_{t-1}$		Interaction $CONTROL_{t-1}$		Interaction $CONTROL_{t-1}$
Lagged output growth (Δy_{t-1})	-0.025		-0.048		-0.004	
	(0.122)		(0.124)		(0.131)	
Labor growth (Δl_t)	0.833***		0.828***		0.816***	
	(0.161)		(0.159)		(0.160)	
Capital growth (Δk_t)	0.446*		0.296		-0.099	
	(0.248)		(0.216)		(0.195)	
Business cycle ($CYCLE_t$)	0.012		0.011		0.009	
	(0.019)		(0.019)		(0.019)	
Industry concentration ($CR6_{t-1}$)	0.125		0.110		0.096	
	(0.094)		(0.091)		(0.088)	
Rent ($RENT_{t-1}$)	0.130	-1.072***				
	(0.223)	(0.335)				
Rent, time average ($RENTA_{t-1}$)			0.289	-1.011***		
			(0.255)	(0.337)		
Rent, ind. average ($RENTI_{t-1}$)					-0.184	-0.608**
					(0.297)	(0.295)
Owner concentr. ($CONTROL_{t-1}$)	0.367***		0.341***		0.203*	
	(0.118)		(0.116)		(0.105)	
Bank debt ($BANK_{t-1}$)	0.082*		0.070		0.053	
	(0.047)		(0.048)		(0.048)	
Financial distress ($LOSS_{t-1}$)	-1.924*		-1.760*		-1.041	
	(1.001)		(0.958)		(0.963)	
$BANK_{t-1}$ * $LOSS_{t-1}$	8.776**		8.831**		8.373**	
	(3.726)		(3.751)		(3.844)	
Total assets ($ASSET_{t-1}$)	0.019*		0.017		0.010	
	(0.011)		(0.011)		(0.010)	
Listed ($LISTED_t$)	0.063**		0.054**		0.043	
	(0.028)		(0.026)		(0.027)	
Intercept	-1.522		-1.442		-1.033	
	(1.784)		(1.750)		(1.696)	
Number of obs.	3,647		3,647		3,647	
Instrument validity (Sargan test)	p=0.377		p=0.265		p=0.576	
First-order correlation of residuals	p=0.021		p=0.018		p=0.015	
Second-order correlation of residuals	p=0.513		p=0.432		p=0.435	
Constant returns to scale (Wald test)	p=0.356		p=0.579		p=0.312	

Table 9: Robustness tests: different measures of capital structure interacted with financial distress

GMM regression results relating measures of corporate governance and market discipline to productivity growth. Estimates are obtained using the Arellano and Bond (1991) method. All regressions include time and two-digit industry dummies. Instruments are y_{it-j} for $j \geq 2$ and the second lags of $CONTROL$, $DEBT$, $CR6$, and $ASSET$. Asymptotic standard errors (reported in parentheses) are robust to general cross-section and time-series heteroskedasticity. *, **, *** indicates significance at the 0.10, 0.05, and 0.01 levels, respectively. For definitions, see Appendix B.

	Dependent variable: output growth (Δy_{it})					
	Model (7)		Model (7c)		Model (7d)	
Independent variables		Interaction $LOSS_{t-1}$		Interaction $LOSS_{t-1}$		Interaction $LOSS_{t-1}$
Lagged output growth (Δy_{t-1})	-0.025		-0.017		-0.016	
	(0.122)		(0.123)		(0.118)	
Labor growth (Δl_t)	0.833***		0.852***		0.845***	
	(0.161)		(0.149)		(0.147)	
Capital growth (Δk_t)	0.446*		0.512**		0.502**	
	(0.248)		(0.244)		(0.234)	
Business cycle ($CYCLE_t$)	0.012		0.012		0.012	
	(0.019)		(0.019)		(0.018)	
Industry concentration ($CR6_{t-1}$)	0.125		0.130		0.138	
	(0.094)		(0.095)		(0.092)	
Rent ($RENT_{t-1}$)	0.130		0.068		0.097	
	(0.223)		(0.231)		(0.237)	
Owner concentr. ($CONTROL_{t-1}$)	0.367***		0.370***		0.372***	
	(0.118)		(0.122)		(0.122)	
$RENT_{t-1}$ * $CONTROL_{t-1}$	-1.072***		-1.049***		-1.074***	
	(0.335)		(0.346)		(0.350)	
Financial distress ($LOSS_{t-1}$)	-1.924*		-1.119		-1.732	
	(1.001)		(1.969)		(1.117)	
Bank debt ($BANK_{t-1}$)	0.082*	8.776**	0.161**	9.488**	0.117	9.365**
	(0.047)	(3.726)	(0.081)	(4.172)	(0.084)	(3.929)
Debt ratio ($DEBT_{t-1}$)			-0.215	-1.780		
			(0.144)	(4.283)		
Leverage ($LEVERAGE_{t-1}$)					-0.021	-0.108
					(0.041)	(0.447)
Total assets ($ASSET_{t-1}$)	0.019*		0.020*		0.020*	
	(0.011)		(0.010)		(0.011)	
Listed ($LISTED_t$)	0.063**		0.062**		0.061**	
	(0.028)		(0.028)		(0.027)	
Intercept	-1.522		-1.479		-1.489	
	(1.784)		(1.772)		(1.794)	
Number of obs.	3,647		3,647		3,647	
Instrument validity (Sargan test)	p=0.377		p=0.254		p=0.269	
First-order correlation of residuals	p=0.021		p=0.024		p=0.022	
Second-order correlation of residuals	p=0.513		p=0.497		p=0.500	
Constant returns to scale (Wald test)	p=0.356		p=0.216		p=0.230	

To check whether our finding regarding financial pressure is robust against the definition of creditor influence, we examine two alternative measures, the debt ratio ($DEBT$) and leverage ($LEVERAGE$). Table 9 shows the results. Again using Model (7) from Table 5 as the reference, we find that these alternative measures do not have any additional explanatory power for productivity growth, and our main findings are unchanged. Only when using leverage as alternative measure, the direct impact of bank debt becomes insignificant.

Since the measure of industry-level competition ($CR6$) is insignificant across all specifications, we consider two alternative measures described in Section 3.3. Using the Herfindahl index of producer concentration (HHI) instead, its coefficient is also insignificant and the other coefficients remain similar. Using the import ratio as a measure of foreign competition in addition to $CR6$ or HHI, its coefficient remains insignificant as well, and the other coefficients hardly change. This lack of explanatory power in industry-level measures of competition is likely due to measurement problems, which are hard to overcome with currently available data, as mentioned above.

All of our results are robust against alternative definitions of the capital stock. We experimented with capital stock measures constructed using the method applied by Nickell (1996) and Nickell et al. (1997). They also apply a perpetual inventory method, but they do not assume a constant rate of depreciation. We experimented with annual depreciation rates of 4% and 12%, but our estimation results turned out to be robust.

Finally, we experimented with alternative sets of instrumental variables. Our main results regarding the impact of corporate governance and market discipline are robust against variations of the lag length chosen for the instruments. They are also robust against using additional instruments, particularly the second lags of all time-varying measures of ownership structure and competition. In summary, we are confident that our main findings from Section 6.1 are generally not sensitive against alternative specifications of explanatory variables or alternative sets of instruments.

7 Conclusions

This study analyzes the impact of five corporate governance mechanisms (owner concentration, owner type, owner complexity, financial pressure, and board size) and market discipline (product market competition) on productivity growth. We use a panel of 841 German manufacturing firms over the years 1986–1996.

We find that firms under concentrated ownership tend to show higher productivity growth, and this effect is larger for firms earning lower rents. Since we use rent as an inverse measure of the intensity of product market competition, this means that firms in more competitive markets show higher productivity growth, but only when owner control is tight. Our finding regarding the beneficial effect of competition is in line

with evidence from the UK (Nickell et al., 1997), Italy (Bottasso and Sembenelli, 2001), Germany (Januszewski et al., 2001), and other major Western economies (Caves, 1992; Porter, 1992). Our finding that tight owner control has a disciplinary effect is consistent with evidence from Japan (Kaplan and Minton, 1994), the UK (Nickell et al., 1997), and Germany (Januszewski et al., 2001). However, we find that owner control and intense product market competition are complements; this stands in sharp contrast to Nickell et al. who find that they are substitutes.

Furthermore, also financial pressure from creditors has a positive impact on productivity growth. We find weak evidence that productivity grows faster for firms showing a large fraction of bank debt, and strong evidence that productivity grows faster when bank debt is high and at the same time firm performance is poor. Hence, creditors seem to be in a position to influence management decisions, which in turn affect productivity growth. And the creditors' position appears to be particularly strong for firms in financial distress. This disciplinary effect of financial pressure is consistent with evidence from Germany on the early 1970's (Cable, 1985), and with recent evidence from the US (Zingales, 1998), the UK (Nickell and Nicolitsas, 1999), and Belgium (Renneboog, 2000).

We cannot confirm that the type of the ultimate owner has a particular impact on productivity growth. Likewise, we do not find evidence that complex ownership structures (e.g., cross ownership or pyramid structures) or large board size have an adverse impact on performance. One reason for the insignificant relation of board size and performance could be that the size of German supervisory boards is tightly regulated by law. Hence, board size is likely to be determined by other factors such as firm size and industry, not necessarily by considerations regarding optimal governance structure. We also cannot find evidence that financial pressure from creditors acts as a substitute for competition. This finding contrasts with Nickell et al. (1997) who document a substitutive relationship. In summary, our results suggest that corporate governance (ownership and capital structure of a firm) as well as market discipline (product market competition) are important governance devices. The combination of these mechanisms forms the basis for higher productivity growth.

Our findings have two policy implications. First, the beneficial impact of increased product market competition on productivity growth implies that competition policy should aim at fostering competition. In the European context this means that remaining obstacles to an integrated Internal Market should be removed. This is even more relevant as intense competition appears to reinforce the beneficial impact of tight owner control, which is prevalent in continental Europe (La Porta et al., 1999). Second, we find a beneficial impact of creditors on productivity growth. While we do not explicitly test for the impact of 'housebank' relations, our results suggest that lending relationships in Germany cannot simply be dismissed as too inflexible and outdated, as often argued. However, we also find that creditors' influence depends on a strong creditor position, measured as a large fraction of bank debt. This implies that reduced bank lending, for example as a consequence from increased securitization of loans, could negatively affect the banks' incentives or ability to monitor. One

way to address a potential decline in monitoring by creditors could be to strengthen other parties involved in corporate governance. In the US and the UK, we observe an increasingly active participation of small shareholders such as pension funds, which appear to be able to influence particular corporate decisions (Smith, 1996; Carleton et al., 1998). For Germany, institutional investment continues to rise as well, not at least due the current transition in the pension system. The bottom line for public policy is to ensure a fair treatment of minority shareholders.

Finally, our findings have implications for future empirical research. First, we find a positive impact of ownership concentration on productivity growth, but only when we consider ownership at the ultimate level, not at the direct level. This suggests that *ultimate* ownership matters, not *direct* ownership. Hence, studies relying on measures of direct ownership, which are typically more easily to obtain, might come to misleading results. Second, we find that ownership concentration does not affect productivity growth when not taking into account product market competition. Only when using competition measures as well, we find a significant impact. This is a good example of a missing variables problem (Börsch-Supan and Köke, 2000). Hence, studies investigating only one or a few of all mechanisms, which potentially affect productivity growth, might come to misleading results as well. Third, this study does not investigate whether the threat of a takeover has a disciplinary effect on managerial behavior. This is an important question because takeovers can be disciplinary (Jensen, 1988), and due to the repeal of the corporate capital gains tax the number of acquisitions and divestitures in Germany is expected to increase considerably.

A Concept of control

The identification of the ultimate owner for each firm is based upon German corporate law and involves two steps. First, we identify the ultimate owner for each direct shareholder using the following three rules. Rule 1 (strong ownership rule): A chain of control is pursued to the next level if the shareholder being analyzed is owned to 50% or more by a shareholder on the next level, while all other shareholders on the next level own less than 50%. Rule 2 (weak ownership rule): If rule 1 does not apply, a chain of control is pursued to the next level if the shareholder being analyzed is owned to 25% or more by a shareholder on the next level, while all other shareholders on the next level own less than 25%. Rule 3 (stop rule): If neither rule 1 nor rule 2 applies, a chain of control is not pursued further. These rules guarantee that no more than one ultimate owner is identified for each direct shareholder. Note that if a shareholder has split his ownership stake in a particular company into several smaller stakes, for example into two blocks of 50% held by two subsidiary firms, we combine these smaller stakes into one single block. We set the first cutoff point at 50% because German law allows an investor owning 50% of all shares to appoint management.[13] The second cutoff point is set at 25% because an investor owning 25% of the shares has the right to veto decisions. In a second step in determining the ultimate owner for each sample firm, we apply the three rules to all direct shareholders. This allows us to identify one single shareholder that is in ultimate control. When no single shareholder fulfills the criteria, this firm is seen to have no ultimate owner.

B Definition of variables

In the following, we describe how the variables used in the empirical analysis are constructed. All variables used in this study are appropriately deflated and measured in prices of 1991. Sources of price and cost indexes and other aggregate variables are given below, together with details on how we constructed each variable used in the empirical analysis.

Value added

The firm's value added, Y_t, is defined as output (total sales) less total materials costs. Real values are obtained using a two-digit industry-specific producer price index published by the Federal Statistical Office (Statistisches Bundesamt, Fachserie 17, Reihe 2, 1998) for output, and a combined input price index for materials. The latter does not vary by industry.

13 A 50% majority is sufficient to dismiss management after their regular period of office. But a majority of 75% is required to dismiss management during its period of office (§103(1) AktG).

Capital stock

The firm's capital stock, K_t, is defined as replacement costs of tangible assets including machines, buildings, and land, deflated using a combined input price index for capital goods and land, weighted by their empirical distribution (Statistisches Bundesamt, Fachserie 17, Reihe 2, and Fachserie 17, Reihe 4, 1998). Replacement costs of capital are calculated using the method of Bond et al. (1999). They adjust the historical cost values for inflation and then apply a perpetual inventory method with a constant annual depreciation rate of $\delta = 0.08$. Specifically,

$$p_t^K K_t = (1-\delta) p_{t-1}^K K_{t-1} \frac{p_t^K}{p_{t-1}^K} + p_t^K I_t \ , \tag{7}$$

where K_t is the capital stock, p_t^K is the price index for capital goods, I_t is real investment and δ the depreciation rate. The starting value is the net book value of tangible assets, adjusted for inflation in previous years.

Labor

The firm's labor input, L_t, is defined as the total number of employees.

Business cycle proxy

To control for business cycle effects, we use a survey-based index of capacity utilization at the two-digit industry level as a proxy variable ($CYCLE$). This index is part of the *ifo Geschäftsklima* and was obtained from the ifo Institut für Wirtschaftsforschung, Munich.

Corporate governance: ownership concentration

The construction of our preferred measure for ownership concentration ($CONTROL$), as well as two alternative measures ($BLOCK$ and $HERF$) are discussed in Section 3.2 and Appendix A.

Corporate governance: type of owner

We classify firms into five ownership categories ($TYPE$): private (including partnerships and foundations), financial firms (including banks and insurers), non-financial firms, government authorities. If a firm has no ultimate owner according to the concept of control as outlined in Appendix A, the ownership category is 'dispersed'.

Corporate governance: ownership complexity

Ownership complexity is measured with an indicator variable for cross ownership ($CROSS$) and pyramids ($PYRAMID$). $CROSS$ takes the value of one if a firm's ultimate owner is part of the web of industrial and financial German firms identified by Wenger and Kaserer (1998) and if the ultimate owner indirectly owns a share block in itself, zero otherwise. $PYRAMID$ takes the value of one when a firm is controlled via a pyramid, with at least one intermediate firm between the ultimate owner and the sample firm, zero otherwise.

Corporate governance: financial pressure

Financial pressure is measured using three alternative measures of creditor influence on management and a measure of financial distress. $BANK$ is the ratio of bank debt to total debt, $DEBT$ is the ratio of total debt to total assets, $LEVERAGE$ is the ratio of total debt to the book value of total equity, and $COVERAGE$ is the ratio of operating earnings before interest, taxes, and depreciation (also known as EBITDA) to interest payments. Financial distress ($LOSS$) is an indicator variable that takes the value of one when a firm reports negative EBITDA, zero otherwise.

Corporate governance: board size

Board size is measured with an indicator variable for small boards ($SMALL$) that takes the value of one if the firm's supervisory board has the minimum number of directors required by law, zero if the number of directors is larger than minimum. To control for the fact that not all sample firms have a supervisory board, we also include $BOARD$, an indicator variable that takes the value of one for firms having a board, zero otherwise. Determining the minimum number of directors is a complex process as different laws are to be applied, depending on firm size and industry (*Stock Corporation Law*, *Iron and Steel Codetermination Law* (1951), *Amendment to Codetermination Law* (1967), *Law on Codetermination* (1976)). In addition, a firm belonging to a group company (*Konzern*) can be subject to codetermination laws and therefore must comply with different requirements regarding board size, even when firm size is smaller than the thresholds specified in codetermination laws. However, a group company cannot be identified from our data; groups can only be identified by consulting individual corporate charters. Hence, $SMALL$ might contain some classification error for subsidiaries of conglomerates.

Market discipline: industry-level competition

We use three measures to proxy for industry-level competition. As a measure of foreign competition, we use import penetration ($IMPORT$), defined as the ratio of

the total value of imports to total market size. The latter is the sum of imports and domestic production, measured at the two-digit industry-level. Regarding industry concentration, we use the market share of the largest six producers, $CR6$, and the Herfindahl index of producer concentration, HHI, both of which are measured for four-digit output classes. This information is obtained from biennial reports of the German Federal Antitrust Commission, as reported in Monopolkommission (1996). Note that we cannot assign both competition measures perfectly to each firm for two reasons. First, for the construction of this measure, the Antitrust Commission uses information on firms' sales in individual market segments. Hence, there are several competition measures for each firm depending on sales structure. Unfortunately, our main source of data, the Hoppenstedt database, assigns firms only to one industry, the primary product market. Hence, our competition measure may contain some classification error for large firms. Second, the classification of industries used by the Antitrust Commission differs from the industry classification used in the Hoppenstedt database (European NACE code). Therefore, we had to assign some firms on an individual basis.

Market discipline: firm-level competition

The construction of our measure for firm-specific rents ($RENT$) is discussed in Section 3.3.

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Table A1: Sample selection procedure

Firm selection based on information available in the primary sources of data.

Selection criterion	Firms	Firm-years
Consolidated balance sheet data for the years 1986-1996	5,604	31,294
Manufacturing industries	1,835	12,063
Ownership data	1,090	6,735
No missing values	968	5,563
Three continuous years of data	841	5,329

Table A2: Sample representativeness

Sample representativeness regarding coverage of non-listed and listed firms, separately by type of firm, taking 1992 as the year of reference. Column (1) shows the number of all German corporations, and column (2) the total number of sample firms (all incorporated), separately for listed/non-listed public (AG, KGaA) and non-listed private firms (GmbH). Column (3) provides the fraction of sample firms that are listed or non-listed, separately by legal form. And column (4) relates the number of sample firms to the number of all German corporations, separately by type of firm. Data on the number of all German corporations are obtained from Statistisches Bundesamt, Umsatzsteuerstatistik, Fachserie 14, Reihe 8.

Listing	Legal form	All German corporations	Sample firms (all incorporated)		
			total	in percent of all sample firms	in percent of all German corporations by type of firm
		(1)	(2)	(3)	(4)
Yes	AG, KGaA	521	255	53.9%	48.9%
No	AG, KGaA	1,643	146	30.9%	8.9%
No	GmbH	359,358	72	15.2%	0.02%
Total		361,522	473	100.0%	0.1%

Table A3: Sample composition in 1992: Industry coverage

Sample representativeness regarding industry coverage, taking 1992 as the year of reference. The analysis can be conducted only for large firms because data obtained from Statistisches Bundesamt, Umsatzsteuerstatistik, Fachserie 14, Reihe 8, only cover large German firms. Diversified holding companies that cannot be assigned to a single major industry as well as firms producing in non-manufacturing industries are not contained in the sample.

Industry (Two-digit NACE-code)	All large German firms	Sample firms		
		total	in percent of total	in percent of all large German firms
Chemicals, oil (23,24)	103	46	9.7%	44.7%
Synthetics (25)	107	30	6.3%	28.0%
Rock, stone, glass (26)	117	31	6.6%	26.5%
Metals (27,28)	216	49	10.4%	22.7%
Machines (29,30,31,34,35)	577	158	33.4%	27.4%
Electronics (32,33,36)	377	30	6.3%	8.0%
Wood, paper, printing (20,21,22)	366	19	4.0%	5.2%
Leather, textiles (17,18,19)	185	34	7.2%	18.4%
Food (15,16)	237	76	16.1%	32.1%
Total	2,285	473	100.0%	20.7%