The London School of Economics and Political Science

Essays on the Interaction between Financial Development and Real Economy

Jan Bena

A thesis submitted to the Department of Finance of the London School of Economics for the degree of Doctor of Philosophy, London, April 2009

Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorization does not, to the best of my belief, infringe the rights of any third party.

Abstract

Economists disagree about the role of the financial sector in economic growth. My thesis contributes to this discussion. I show that better financial systems do promote productivity growth and that limited access to external finance interacts with product market competition in determining corporate investment.

The first chapter "The Effect of Financial Development on Corporate Growth in the EU Single Market" compares within-industry growth rates of similar EU 'single-market' firms facing financial systems of different depth and institutional quality as of 'single-market' inception. Moving from the least to the most developed financial market within the EU boosts firms' annual value-added growth by about three percentage points. Our results also suggest that the growth gap due to initially under-developed financial systems was closed by 2003.

In the second chapter "Which Firms Benefit More from Financial Development?" we test whether more developed financial systems foster corporate growth through tackling market frictions proxied by firm size and age. Our main finding is that more developed financial systems are able to overcome the relative opaqueness of younger firms. We also find that freshly incorporated firms in less financially developed countries have unusually high shares of equity capital in total assets. The two chapters provide evidence that limited access to external finance affects corporate structures and hinders economic growth.

In the last chapter "The Effect of Credit Rationing on the Shape of the Competition-Innovation Relationship" I study how financial constraints affect innovation activity. The novel theoretical results derive from an analysis of the interaction between the incentive effect of competition on innovation and the effect competition has on the degree of credit rationing. I find that the negative effect of financial constraints on

firm- and aggregate-level R&D investment is most pronounced at both high and low levels of competition. These predictions are supported by empirical evidence.

Acknowledgements

I would like to thank my doctoral supervisors Professor Antoine Faure-Grimaud and Professor Dimitri Vayanos for their immense support, guidance, helpful comments, and constructive criticism. I am indebted to many inspiring people for their time spent in discussing the work, especially Professor David Webb and Professor Patrick Bolton.

I would like to thank the Department of Finance together with the Financial Markets Group of the London School of Economics for their generous hospitality.

Contents

List of Figures

List of Tables

1. FINANCIAL DEVELOPMENT AND CORPORATE GROWTH IN THE EU SINGLE MARKET

(joint with Štěpán Jurajda)

1.1 Introduction

Understanding the positive association between financial market development and economic growth is crucial for guiding financial sector policies. Recent work in this area uses industry-level identification strategies to establish a causal link from finance to growth (Rajan and Zingales, 1998; Fisman and Love, 2004).[1] This progress on causality, however, comes at the cost of not providing a quantification of the finance-growth aggregate effect. Yet, from the policy perspective it is important to know the size of the finance-growth effect in order to compare alternative pro-growth policies.

In this paper, we therefore return to earlier country-level work on the finance-growth nexus that allowed, under strong assumptions, for a quantification of the effect of finance on growth, and we address several of the concerns that were raised regarding its validity. Specifically, we return to the identification strategy of King and Levine (1993) and Levine and Zervos (1998) who relate financial development indicators from an initial period to subsequent growth performance of a sample of countries. The key concern with this research design is that it is in general unable

[1] Levine (2005) surveys the literature on the relevant dimensions of financial development, the channels through which it affects growth, as well as the identification strategies used in estimating the growth effect of financial systems. We discuss how our study fits into this literature in detail in Section 2.

to disentangle the effect of financial development from the influence of other, potentially unobservable country-level determinants of growth. The other criticism of this country-level approach is that financial development may be a leading indicator of future growth because financial markets are forward-looking and initial-period differences in measures of financial system depth could, in fact, merely reflect differences in future growth opportunities.

To address these concerns, we introduce four improvements on their original approach. First, we study a highly homogenous set of countries where the assumption that heterogeneity in the initial level of financial development is orthogonal to other country-level determinants affecting growth is arguably most likely to hold. Specifically, we believe that the establishment of the 'single market' of the EU-15 economies in 1993 provides a unique opportunity to study the effect of financial development on growth. The EU-15 countries started sharing a common product market, but they differed markedly in their level of initial financial development.[2] The 'single market' removed trade barriers, harmonized product market regulation, and exposed technologically highly similar firms to common growth opportunities.[3] If reaping these growth opportunities required external finance provided by national financial systems, then only firms operating in countries with high levels of financial development were able to respond to these new opportunities by increasing their external financing and by growing. The 'single market' makes it likely that in the absence of differences in financial development growth of similar firms would be similar across the EU-15.[4] We therefore believe that country-level determinants of corporate growth (other than the level of financial development) are of relatively low importance in the EU-15 in comparison to the wide set of countries used in the existing cross-country research

[2] The within-EU differences in financial development are highlighted by Guiso et al. (2004) and Allen et al. (2006).

[3] For evidence on the rapid and synchronized implementation and effects of the Single Market Programme in manufacturing see Badinger (2007) or Bottasso and Sembenelli (2001).

[4] For recent evidence on EU business cycle synchronization see Camacho et al. (2008).

and hence can be assumed as heterogenous to financial development.

Second, one may be worried that, e.g., the Greek industrial structure and level of development as of the start of the 'single market' pre-destine the Greek economy to grow faster than the UK. However, it is less clear why a Greek and a UK firm sharing the same industry identity, size, age, and the same structure of firm financial indicators ought to grow at a different rate. We therefore contrast the growth experience of highly comparable companies facing different financial systems, rather than comparing the growth performance of countries or industries. In particular, we control for firm characteristics measured at the time of the establishment of the 'single market'. This effectively conditions on the pre-determined economic structure of countries at different levels of financial development in a fashion similar to our (weak) exogeneity assumption of initial financial development. We also control for the initial level of GDP to capture 'convergence' effects.

Third, we lower the influence of country-industry unobservables by excluding from the analysis those industries that appear to be affected by national regulations. It is natural to expect industry growth synchronization within the 'single market', which combines a high degree of regulatory and economic integration with technological similarity. An industry that shows no signs of growth synchronization is therefore likely to be affected by (time-changing) national regulation or large idiosyncratic shocks and should be excluded from the analysis of the finance-growth nexus. We therefore quantify the degree of industry growth 'synchronization' using measures of industry growth time co-movement across the EU-15 countries and "weed out"those industries that do not co-move in time, arguing that they would bring noise to the estimation of the finance-growth relationship.

Fourth, we directly control for the forward-looking nature of financial markets. In order to check for the possibility that current financial development reflects future growth opportunities, we control for differences in aggregate future growth opportunities implied by pre-existing industrial structure. (A similar strategy was recently employed by Bekaert et al., 2007.) Specifically, we use as a regressor a country-level growth rate computed as the average of the realized EU-15-wide industry growth rates over our sample period weighted by the country's initial-period industrial composition. In an alternative specification, we replace this industry-structure-induced future growth with country GDP growth predictions made by the OECD at the time of the establishment of the 'single market'.

In sum, our approach is to regress annual firm-level value-added growth from the first decade of the 'single market' on several dimensions of country financial infrastructure measured as of before the introduction of the 'single market', as well as on a set of firm-level pre-determined controls, industry-time dummies, and a limited number of country-level growth determinants. The parameters of interest are identified by cross-country variation in financial development, while industry-time fixed effects remove the growth patterns of EU-wide industry-level business cycles.

Despite the improvements we introduce, the King and Levine (1993) strategy is unable to fully control for the presence of country-specific policies or institutional features that affect growth and are correlated with the level of development of the financial sector. It may be that countries with more developed financial systems are also leading in terms of the effectiveness of their legal system etc., resulting in an upward bias in our finance-growth coefficients. Our estimates can therefore be viewed as providing a quantified upper bound on the growth effects of financial system development. On the other hand, the proxies the literature and our study use to capture the extent of financial sector development are clearly measured with error, which is likely to lead to a downward bias in the estimated effects.[5] These two potential biases may therefore partly offset each other.[6]

[5] The measurement error in different proxies of financial development is likely to be correlated, preventing the use of instrumental variable strategies that are typically employed to deal with attenuation biases.

[6] In a related line of research, Frankel and Romer (1999) report estimates of the effect of trade

We also investigate the significance of EU financial integration for corporate growth. Throughout our analysis, we rely on pre-determined initial levels of financial development as using time changes in the degree of financial development could be subject to temporal endogeneity. However, if EU integration leads to faster growth of financial markets in countries with initially low levels of financial development or if EU integration lowers the importance of national financial markets as firms increasingly obtain external finance in other EU-15 countries, then one would expect firm growth to increase faster over time, ceteris paribus, in initially low-financial development countries. We therefore interact our initial financial-development measures with time trend and ask to what extent an initial growth disadvantage due to lower financial development has been closed over the span of our sample frame.

We find a substantial positive association between initial level of financial development and subsequent growth of comparable companies. The magnitude of this relationship is not affected by controlling for the forward-looking nature of financial markets. Allowing for the presence of EU financial integration by interacting the initial financial development level with a time trend suggests that disadvantages in firm-level growth due to under-developed national financial markets were large initially but disappeared by 2003.

The structure of the paper is as follows: Section 2 relates our approach to the literature, Section 3 presents the methodology, and Section 4 contains the data description. Section 5 presents the results together with robustness checks, while Section 6 summarizes our findings.

1.2 Relationship to the Literature

Trying to disentangle the finance-growth nexus empirically raises a fundamental identification problem: one needs to isolate the part of the variation in financial

on growth based on ordinary-least-squares and instrumental-variable regressions that are of similar size, which is consistent with upward and attenuation biases being balanced.

development that is unrelated to current and future growth opportunities, which are inherently unobservable. Three approaches aiming to overcome the reverse causality problem have been proposed in the literature. First, the country-level strategy of King and Levine (1993), discussed above, relates financial development indicators from an initial period to subsequent growth performance of a sample of countries. Second, La Porta et al. (1998) and Levine et al. (2000) are examples of studies that search for instrumental variables predicting a country's level of financial development but unrelated to economic performance.[7] Third, Rajan and Zingales (1998) together with many follow-up studies rely on industry-country comparisons to provide qualitative evidence on the causal link from finance to growth.

The Rajan and Zingales (1998) approach is based on a quantification of the unobservable industry-specific need for tapping the financial system (using external finance) in a sample of countries. They assume that both the industry technology (driving the amount of external finance needed to expand production by one unit) and industry growth opportunities (driving the units of potential production expansion) are constant across countries. Next, they quantify industry differences in the use of external finance in the US, where listed firms presumably face a perfectly elastic supply of funds, and use this measure as a counterfactual for what industry differences in external finance use would be in economies as diverse as Sweden or Zimbabwe, were their financial systems as developed as that of the US. They regress industry growth from a sample of countries on country and industry fixed effects as well as on the interaction between US industry external finance dependence (EFD) and country financial development. Such regression asks whether industries predicted to be in more need of external finance grow faster in countries with more developed financial markets, conditional on all country- and industry-specific factors driving growth.

[7] This approach is made difficult by the scarcity of valid instruments and the need to combine data on many countries in order to avoid small-sample biases of instrumental variable estimators.

The Rajan-Zingales approach is a powerful tool for dealing with country-level reverse causality,[8] but there are no direct tests available of the validity of its underlying assumptions. The notion that relative growth opportunities of different industries remain constant along the development path is contradicted by much of trade economics. Similarly, the assumption of constant technological content of industries is threatened by recent empirical trade research, which highlights extensive intra-industry technology heterogeneity across countries at different income levels (Schott, 2003).

Fisman and Love (2004) relax some of the Rajan-Zingales assumptions and avoid the overt quantification of the industry structure of EFD. They assume that industry differences in the need for external finance are similar across countries and ask whether industry-growth co-movements across pairs of countries are more strongly correlated for pairs of countries with more developed financial markets. The findings based on both the Rajan-Zingales (1998) and the Fisman-Love (2004) approach suggest the presence of a causal link from financial market development to industry growth. However, their analyses do not lead to an estimate of the effect of financial development on growth whose magnitude would directly translate into economically measurable terms.[9]

In this paper, we follow the country-level strategy of King and Levine (1993) and relate initial-period indicators of country financial development to subsequent growth. However, similar to Rajan and Zingales (1998), we focus on growth deviations from global industry means.[10] Furthermore, we use micro data to perform

[8] It also speaks to one of the mechanisms underpinning the finance-growth effect—provision of external funds to reap growth opportunities. Levine (2005) highlights that financial systems (i) acquire and produce risk-return information for possible investments; (ii) monitor investments; (iii) facilitate trading, hedging, diversifying, and pooling of risk; (iv) mobilize savings; and (v) ease the exchange of goods and services that permits greater specialization and innovation.

[9] The Rajan-Zingales estimates measure only the percentage-point *difference* in growth of industries facing a different need for external finance.

[10] We control for EU-wide industry-level business cycles. Aghion et al. (2005) suggest that the

cross-country comparisons within industries by comparing the growth experience of highly similar firms facing different aggregate levels of financial development. Unlike Rajan and Zingales (1998), we do not control for country fixed effects; hence, our approach is problematic to the extent that financial markets develop faster to "off-set" the negative growth effect of high labour market rigidity or that they develop faster in countries with a specific legal framework, which also drives growth directly. We make such a strong assumption for two reasons. First, like Fisman and Love (2004), we want to avoid quantification of industry-level EFD, but, unlike them, we want to provide economically measurable estimates of the effect of financial development on growth. Second, we believe that the assumption of orthogonality of the growth-affecting unobservables to the country's financial development level is more likely to hold for the manufacturing sector of the EU-15 economies compared to the aggregate GDP growth in the extensive set of countries used in, e.g., King and Levine (1993).

Our estimation is complementary to that of Guiso et al. (2004), who also use extensive firm-level data from the EU to study the effect of financial development on growth, but who adhere fully to the Rajan-Zingales specifications and EFD measures. Our results, based on an alternative set of assumptions, are in accord with the conclusions of Guiso et al. (2004) that financial markets facilitate corporate growth. Unlike them, we quantify this effect in economically measurable terms. Finally, our indirect evidence on EU financial integration is related to studies directly measuring the extent of integration, e.g., Pagano and von Thadden (2004) or Baele et al. (2004).

effects of business cycle volatility on growth depend on the level of financial development. In their analysis, the interaction occurs during recessions; however, real GDP per capita grew in all EU-15 countries during our sample frame.

1.3 Methodology

We ask about the effect of financial development on firms' growth, controlling for all determinants of industry growth and several firm characteristics. Our basic regression specification is

$$G_{ijkt} = \alpha + \beta FD_i + \gamma GDP_i + \delta_{tj} + X'_{ijk}\zeta + \epsilon_{ijkt}, \tag{1.1}$$

where G_{ijkt} denotes the annual growth rate of the real value added of firm k in industry j in country i in year t, and where FD_i corresponds to a measure of predetermined financial development (determined before the start of our sample period in order to alleviate reverse causality). In all specifications, we control for a full set of industry-year dummies, δ_{tj}, which capture the (synchronized) time path of industry growth across the EU-15, and for a set of firm-specific initial-period characteristics X_{ijk} including firm size, age, leverage, tangibility, collateralization, as well as an indicator for quoted companies and a set of indicators for company concentration of ownership and legal form. Finally, we control for a country's growth potential by adding real GDP per capita (GDP_i), also as of before the beginning of our sample frame.

To interpret the β coefficient as corresponding to the effect of financial development, we assume that FD_i is not related to ϵ_{ijkt}. In particular, we assume that in the absence of differences in financial development and firm-type composition, industry growth synchronization would be near perfect. Clearly, we will be able to detect departures from synchronized growth driven by differences in financial development only in industries that face highly similar shocks to growth opportunities. In other words, we expect our regressions to be successful in detecting the finance-growth effect in industries that display a significant degree of growth synchronization. On the other hand, we have no clear interpretation for growth differences detected for 'single-market' industries, in which growth is mainly a matter of the firms' country of residence and may therefore be driven by local regulations or government policies.[11]

We therefore start our analysis by "weeding out" industries that lack any sign of growth synchronization across the economies of the EU-15. To this effect, we use annual industry value-added growth data for the EU-15 economies and apply Analysis of Variance (ANOVA) to examine the explanatory power of year factors as opposed to country identity for each industry separately. We then classify industries as synchronized or not based on two alternative criteria. First, we simply use the share of total country-year growth variability (sum of squares) explained by the year factors as a measure of industry co-movement. Second, we classify industries as synchronized or not based on the statistical significance of year and country factors. Details of the procedure are laid out in Section 1.5.[12]

Our analysis is based on the fact that the 'single market' combines a high level of regulatory and product market integration with substantial initial diversity in the development of countries' financial markets. However, the use of pre-determined levels of financial development, which alleviates reverse causality, also raises an important question. If subsequent EU integration leads to faster growth of financial markets in countries with initially low levels of financial development or, alternatively, if integration lowers the importance of local financial markets as firms increasingly obtain external finance in other EU-15 countries, then one would expect firm growth to increase faster over time, ceteris paribus, in initially low-FD countries. The presence

[11] Given the existing literature on the finance-growth nexus, it is likely that differences in financial development lower the degree of industry co-movements, but it is very unlikely that they fully decouple industry growth rates across highly economically integrated countries.

[12] We also go beyond industry groupings based on synchronization and use a continuous measure of synchronization—the share of total growth variability explained by the year factors in our ANOVA exercises. We then interact indicators of financial development with this measure of industry synchronization and use the interaction as an additional regressor in equation (1.1). It is important to clarify the interpretation of such 'synchronization interaction'. We maintain the assumption that the underlying finance-growth effect is the same across industries; however, we expect to be able to *detect* the effect better in those industries where growth shocks are more synchronized.

of such an effect would make it harder for us to detect the finance-growth relationship using specification (1.1). To check for the importance of financial integration, we therefore augment equation (1.1) with the interaction of the initial financial development level with a time trend:

$$G_{ijkt} = \alpha + \beta_0 FD_i + \beta_1 (t * FD_i) + \gamma GDP_i + \delta_{tj} + X'_{ijk}\zeta + \epsilon_{ijkt}. \tag{1.2}$$

This enriched specification, which does not rely on the likely endogenous observed annual changes in the depth of financial markets, allows us to measure to what extent an initial growth disadvantage due to lower financial development has been closed over the span of our sample frame.[13]

1.4 Data

We analyze EU-15 economies during the first decade of the single market's operation, before its extension to post-communist countries in 2004, using firm-, industry- and country-level data. Firm financial statements come from the Amadeus database. Industry measures of value-added growth are taken from the OECD STAN database. Finally, country-level measures of financial development come primarily from the World Bank.

1.4.1 Firm-Level Data

We use firm-level data from the Amadeus (Analyse MAjor Databases from EUropean Sources) database, created by Bureau Van Dijk from standardized commercial data collected by about 50 vendors across Europe. Among the key advantages of the data from our perspective is that they cover both listed and unlisted firms of all size categories. In principle, the database should cover most public and private

[13] It does not differentiate whether financial development matters less for firm growth because financial markets develop faster in initially under-developed economies or because firms increasingly rely on international sources of financing.

limited companies;[14] it includes up to 10 years of information per company, although coverage varies by country and generally improves over time. The database represents the best available firm-level EU-wide data source as argued in Gomez-Salvador et al. (2004).

These data have been tapped in the finance-growth literature by Guiso et al. (2004) and have also been recently used by Klapper et al. (2006) to study firm entry. Our selection of the analysis-ready sample follows the choices made by these two studies. Similar to Guiso et al. (2004), we use the 'TOP 250 thousand' module of the Amadeus data,[15] which we downloaded in May 2006. Following Klapper et al. (2006) we use only unconsolidated statements to avoid double counting and we also exclude all legal forms other than the equivalent of public and private limited liability corporations due to the uneven coverage of partnerships, proprietorships, and other minor legal forms. (Definitions of key variables and a listing of the included legal forms of firms by country are provided in the Data Appendix, in Tables 1.DA.1 and 1.DA.2, respectively.)

The dataset is drawn from EU-15 countries that were part of the EU 'single market': Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, and United Kingdom. As did Guiso et al. (2004) we exclude Luxembourg, because its financial sector is statistically anomalous, and we lose Ireland due to missing firm-level information. Firm coverage in the Amadeus data is incomplete before 1995 and so we use only observations from 1995-2003. Following Rajan and Zingales (1998) and Guiso et al. (2004), we focus

[14] There are exceptions to the rule. For example, small and medium size German firms are not legally forced to disclose (Desai et al., 2003).

[15] Firms selected as TOP 250,000 had to meet at least one of the following inclusion criteria: For UK, Germany, France, and Italy operating revenue at least 15 million euros, total assets at least 30 million euros, or the number of employees at least 150. For all other countries operating revenue at least 10 million euros, total assets at least 20 million euros, or the number of employees at least 100.

on manufacturing industries (ISIC 15 to 37). We exclude firms with missing size (total assets) as well as non-active firms. We also omit from analysis (i) companies in the top 1% of the size distribution, as such extremely large firms are likely to have access to international sources of finance, (ii) growth observations falling outside of the 5-to-95 percentile range of firms' value added growth rate, and (iii) firms with significant state ownership.[16] Since Greek firms do not report value added, we used sales as a surrogate for them.[17] Table 1.1 shows the final number of firm-year value-added growth observations used in the study for each country, together with simple firm-level descriptive statistics corresponding to these observations.[18] It is clear that coverage varies across countries; specifically, firm size in Germany is affected by non-reporting of small firms. Nevertheless, the data provide extensive coverage of most of the EU-15 economies and represent the best firm-level EU data source available to date.

1.4.2 Financial Development Indicators

Data on financial development are drawn from the World Bank's Financial Structure and Economic Development Database (March 2005 version) described in detail in Beck et al. (2000). To make our results comparable with those in the literature we use a number of measures of finance activity to proxy financial development. We start with the traditional measures of activity in the credit and stock markets, namely the ratio of private credit to GDP (variable *Private Bank Credit*) and the ratio of stock market capitalization and stock market total value traded to GDP (*Market Capitalization, Market Value Traded*). We also rely on a measure of total country-

[16] Specifically, we drop firms in which the state is as an ultimate owner of at least 10 percent of shares or a direct owner at least 10 percent of shares. There is virtually no sensitivity to the choice of the percentage threshold.

[17] See Guiso et al. (2004) for the use of sales instead of value added.

[18] We use IMF-IFS annual average exchange rates to convert all accounting data into millions of US dollars.

level finance activity equal to the sum of (i) stock market capitalization, (ii) bank credit to the private sector, and (iii) domestic debt securities issued by the private sector. This summary measure (*Total Capitalization*) is taken from Hartmann et al. (2006) and is expressed, again, as a fraction of country-level GDP. All proxies for financial development are averaged over the years 1990-1994, that is, mainly before the establishment of the 'single market'. We rely on time averages to avoid year-to-year fluctuations and use pre-firm-sample measures to alleviate reverse causality problems.

In addition to volume-of-finance-activity measures of financial development, we also use two proxies for the institutional quality of financial markets. First, we use an indicator of the 'quality of accounting standards' (*Accounting Standards*), produced by International Accounting and Auditing Trends (Center for International Financial Analysis & Research, Inc.). This indicator rated companies' 1990 annual reports on the basis of their inclusion or omission of 90 items in the balance sheets and income statements and ranges from 0 to 90. Second, we rely on a market-based measure of institutional quality. Specifically, we use equity block premia—the private control premia that correspond to benefits enjoyed by a controlling shareholder and not shared by other shareholders (*Control Premium*). Control premia derive from the effective level of limits to diversion and private-benefit extraction by controlling shareholders and, thus, reflect (the value of) a country's degree of investor protection. Dyck and Zingales (2004) estimate such equity block premia corresponding to transactions spanning the 1990-2000 period.[19] To keep the sign of the estimates of financial-development coefficients comparable across our various

[19] They show that the premia are higher in countries where capital markets are less developed, ownership is more concentrated, minority shareholders are less protected, law enforcement is weaker and the press has less influence in affecting owners' reputation. From our set of EU-15 countries, the Dyck-Zingales estimates are available for Austria, Denmark, Finland, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, and United Kingdom. The lowest (highest) level of the premium required to gain a controlling position in a firm is 1% (38%) in the UK (Austria).

specifications (financial-development measures), we use control premium values expressed as 0.38 minus the original Dyck-Zingales value estimates, where 0.38 is the highest level of the premium observed in the sample.

All indicators of financial development are summarized across our EU countries in Table 1.2. (Variable definitions are provided in the Data Appendix Table 1.DA.1.) It is clear that despite the extensive integration of EU national product markets up to 1994, there is still substantial diversity in the degree of financial development across the EU-15. The coefficient of variation is particularly high for our measures of stock-market activity and for the control premium measure.

1.5 *Results*

1.5.1 *Basic Estimates*

We start by presenting the results of our basic linear regressions of equation (1.1) in Table 1.3. The table presents selected coefficients from regressions of annual firm-level real value-added growth rates of manufacturing firms from the period 1995-2003 on country-level financial development indicators, most of which are measured in 1990-1994. The control variables are industry-year dummies based on the 3-digit ISIC classification, firm-level controls, and the 1993 country GDP per capita in millions of US dollars. The firm-level controls are age, size,[20] leverage, tangibility, collateralization, and indicators of being quoted, legal form type, and ownership concentration;[21] these controls are measured as of the first year a firm enters the sample and remain fixed over time.

The coefficient estimates in Table 1.3 suggest that initial financial development

[20] We measure firm size in percentage-point deviation from the median firm size in a given industry to reflect the fact that different industries are characterized by different optimal firm size (Kumar et al., 1999).

[21] Ownership concentration (company independence with regard to its shareholders) is divided into low, medium and high based on the presence of shareholders with an ownership share over 25% or 50%.

measures are related to company growth deviation from year-industry averages. The precisely estimated financial development coefficients are economically significant. Moving from the minimum to the maximum value of our financial development indicators results in an increase in value-added growth rate of about 3 percentage points in the case of all four measures based on volume of financial activity while it adds about 5 points in the case of our accounting quality measure. The effect is smaller, at about 1.5 of a percentage point, when using the control premium comparison. The magnitude of the private credit growth effect we estimate is about twice the size of the corresponding effect estimated across a more extensive set of countries in the country-level analysis of Levine and Zervos (1998).

The results in Table 1.3 are not sensitive to (i) alternatively using industry-year fixed effects based on a 2-digit industry classification, (ii) excluding leverage from the list of control variables, (iii) dropping firms with less than five years of value-added data available, or (iv) excluding those value-added growth observations where at least one of the two underlying levels of value added were negative. (We present some of these robustness checks for our preferred specification in Section 1.5.5.) We also note that aggregate GDP convergence effects are strongly detected by the data and that older and larger firms grow more slowly, as expected. Furthermore, we find that highly leveraged firms grow faster as do quoted companies and firms with initially high tangibility of assets.[22]

1.5.2 *Focusing on Synchronized Industries*

In order to lower the importance of country-industry unobservables, we divide the data into industry groups displaying different degrees of synchronization and re-estimate equation (1) for each sub-sample. First, we compute a quantitative measure

[22] Presumably, having obtained more external finance in the past helps reap current growth opportunities. Alternatively, growth opportunity attracts external finance and is strongly correlated over time at the firm level.

of synchronization for each industry based on the OECD STAN database. The measure equals the fraction of the total variation of industry-level annual value-added growth rate across countries and years explained by year factors in an ANOVA with year and country factors. We also calculate another measure of synchronization taken from an ANOVA exercise, where we additionally control for a country's aggregate growth rate (aggregate business cycle). Both measures are presented in Table 1.4. The "synchronized" fraction of growth variability (i.e., that linked to years) varies by almost a factor of seven when comparing the least synchronized industries of leather, office machinery, or precision instruments, to the most synchronized industries of food and beverages, petroleum, or basic metals.

Next, we divide industries into four groups based on quartiles of the first quantitative synchronization measure. Alternatively, we divide industries into groups based on a qualitative assessment of the degree of synchronization. We split the sample industries into three types based on the *p* value of the estimated country and year factors from our ANOVA exercises. In Table 1.4, we denote industries where year factors do not reach the 10% level of statistical significance as low-synchronization industries, we call industries where only the year factors but not the country factors are significant as high-synchronization industries, and we denote the remaining group, where both types of factors are important, as medium-synchronization industries.

We are now ready to estimate the finance-growth relationship for each "synchronization group" separately. The results are displayed in Table 1.5, where each presented parameter comes from a separate regression. The top panel of the table corresponds to the qualitative grouping, while the bottom panel lists results for the four quartiles of the first synchronization measure.[23] Using either type of "synchronization grouping", we detect little evidence of a finance-growth relationship for the

[23] The results are similar when we use the second quantitative synchronization measure of Table 1.4. We have also alternatively used an industry grouping based on ANOVAs estimated not with STAN at ISIC 2-digit level, but with the Amadeus data at ISIC 3-digit level. We obtained results very similar to those presented in Table 1.5.

group of least synchronized industries, while the estimated effect is significant and similar in more synchronized industry groups.[24]

In sum, our comparisons fully support the notion that we can effectively detect the effects of financial development on firm-level growth deviation from industry average in those industries where there is a synchronized time pattern of industry growth across all EU-15 economies.[25] The inclusion of low-synchronization industries only brings noise to our analysis and, therefore, we exclude the group of low-synchronization industries from the rest of our analysis. In the top panel of Table 1.6, we display the basic financial development coefficients re-estimated after excluding the group of low-synchronization industries. The parameter estimates are all somewhat larger compared to those presented in Table 1.3, as one would expect.

1.5.3 Financial Integration

In Section 1.3, we discussed the implications of EU financial integration for our estimation strategy. Specifically, faster financial development of initially financially under-developed countries hinders the detection of a finance-growth effect using our initial specification of equation (1.1). To check for the presence of such an integration process and to ask to what extent a growth disadvantage due to initially lower financial development has been closed over the span of our sample frame, we estimate equation (1.2), which allows for the interaction of initial financial development level

[24] We have re-estimated the regression for high-synchronization industries on a randomly chosen sub-sample mimicking the size of the low-synchronization group. We again obtained coefficients and significance levels nearly identical to those presented in Table 1.5.

[25] We have also estimated a regression specification for the whole sample, where we interacted the country-level measures of financial development with industry-level measures of growth co-movement. See note n. 12 for a discussion of this specification. The coefficient estimates for the interaction terms, which are available upon request, were positive and statistically significant—in line with our group-level analysis. If one were to base the magnitude of the estimated finance-growth effect on the highest observed level of synchronization in the data, the effect would be 1.5 to 3 times larger than that reported in Section 1.5.1.

with a time trend (starting from 1 in 1996).

The results presented in the second panel of Table 1.6 suggest that the positive influence of initially more developed financial markets on firm-level growth diminishes over time for all of our measures of financial development.[26] The precisely estimated parameter estimates imply that (i) the initial financial development growth effect from the mid 1990s is almost four times larger as the sample-period-average effect estimated in the top panel of Table 1.6, and (ii) the growth gap of similar firms operating in more and less financially developed EU-15 countries has been fully closed within the nine years of our sample frame. For example, taking the base-effect coefficient for total capitalization (0.076) and subtracting 7 years of the trend interaction corresponding to year 2002 (-0.012 * 7) results in a total effect of -0.008, which is for all practical purposes zero. Taking these estimates at face value, one would conclude that EU-15 financial integration was complete as of 2002, at least in terms of its effect on within-industry firm growth.[27]

The underlying integration process may be different for our various measures of financial development as suggested by a simple comparison of our financial development measures from the early 1990s to those from a recent period. Comparing the 1990-1994 averages of the ratio of private credit to GDP to the corresponding averages taken over the 2000-2004 period suggests that the country-level volume of private credit is now relatively similar across the EU-15 economies. In contrast, EU-15 countries with higher levels of stock market capitalization as of the early 1990s

[26] The non-reported coefficients corresponding to firm-level controls are little affected by the introduction of the time interaction with financial development level.

[27] As previously noted, our statistical inference reflects group-level variation in financial development by clustering residuals at the country level. Alternatively, we follow the suggestion of Wooldridge (2003) and break the estimation into two stages, one firm-level, the other country-level. Using this alternative procedure, we obtain similar, if sometimes smaller coefficient estimates, most of which remain statistically significant at conventional levels. These results are available upon request.

experienced a faster growth of their stock market size in the subsequent decade.[28] Hence, our results are consistent with a diminishing importance of local stock markets for firms' growth as well as with an equalization of access to private credit through faster growth of initially under-developed local banking sectors.

1.5.4 Controlling for Aggregate Growth Opportunities

A potential criticism of our approach is that financial development measures, based, e.g., on initial volumes of credit or equity, are misleading because they capture not only the development of the country's financial markets, but also reflect the demand for finance in the initial period, which, in turn, is driven by future country-level growth opportunities. We then put growth on the left hand side of our regressions, thus closing a full circle.

In order to assess the importance of this criticism and to allow for the co-determination of country-level growth opportunities and financial development measures, we additionally condition on predicted future country growth, calculated as follows. We take the time-averages of EU-15 future realized growth of all our industries and weight these growth rates by the initial-period country-level shares of each industry. This is the growth rate one would expect of a manufacturing sector in a particular country if one could perfectly forecast industry-specific growth at the EU-15 level from 1995 to 2003. We use the STAN value-added growth figures to calculate this "expected"growth rate. The perfect-foresight assumption is quite strong as companies are unlikely to know the global shocks to industry growth; hence, we hope that controlling for this variable in our regressions alleviates the worry that country-level financial development proxies simply reflect future growth opportunities.

[28] It is well known that the structure of the financial sector differs across countries (Allen and Gale, 2004), which in part reflects differences in firm type structure as firms of different type raise external finance through different channels (e.g., Beck et at., 2008). Our analysis conditions on pre-existing firm type structure.

The time interaction specification controlling for this 'future growth potential' is presented in the third panel of Table 1.6. Comparing the second and third panel, we see that our main results are little affected by this robustness check. A very similar set of results is obtained when alternatively controlling for a country's GDP growth forecast made at the start of the 'single market'.[29] It appears that our estimates are not driven by the forward-looking nature of financial markets.

1.5.5 Further Robustness Checks

In Table 1.7 we present our preferred specification from the third panel of Table 1.6, namely the specification with the financial development/time interaction controlling for predicted growth, together with a number of further robustness checks. First, we compare the estimates across firms of different size and find little sensitivity. Second, we assess the sensitivity of our estimates to excluding one country from the sample. We do so for each country in turn with the aim of discerning which countries may be driving our results. Given the general lack of sensitivity, we present the results after excluding the UK together with an alternative set of estimates based on excluding Greece—the most and the least financially developed country in our data, respectively. There is virtually no sensitivity to excluding any country with the exception of the United Kingdom. Clearly, the UK presents the most financially developed country in our sample and the strong growth performance of UK firms supports some of the estimated finance-growth effect. Excluding the United Kingdom results in much smaller and statistically insignificant effects of stock-market-based measures of financial activity, which is perhaps not surprising given that the UK stock market is unusually developed in the EU context. Omitting the UK also lowers the size of the finance-growth effect for the other three measures of financial

[29] The forecast for 1997-2000 was produced by the OECD in 1994. See the Appendix Table 1.DA.1 for details.

development, but they remain statistically significant.[30]

Finally, the bottom panel of Table 1.7 presents estimates based on subsamples of our main data that exclude either firms with less than four years of value-added data or those value-added growth observations where at least one of the two underlying levels of value added were negative. We also assess the sensitivity to excluding leverage as a control variable based on the argument that initial leverage may be more endogenous than other control variables. None of these checks points to any important sensitivity in our estimates.[31]

Up to now, we have avoided the influence of value-added growth outliers, present in any company-level financial data, by symmetrically excluding extreme values of annual growth from our linear 'mean' regressions. In our last robustness check, we alternatively apply median regressions, which are robust to outliers by design and allow us to use all available growth rate data (even observations falling outside the 5-to-95 percentile range). The results are shown in Table 1.8, the structure of which replicates that of Table 1.6. The clustered standard errors we report are bootstrapped. The presented pattern of median regression coefficients confirms our previous findings.

1.6 Conclusion

The Rajan-Zingales literature established the causal link from finance to growth, but the Rajan-Zingales (1998) or the Fisman-Love (2004) approach do not lead to a quantification of the aggregate finance-growth effect. We use the establishment of the EU 'single market' as a unique opportunity for revisiting the identifying as-

[30] When we return to the specification without the time interaction and exclude the UK, we obtain an effect of private credit on growth that is identical to that estimated by Levine and Zervos (1998).

[31] We also reach the same results when we use only non-quoted companies or only firms that are present in the data in all years, or when we additionally interact the initial GDP level with a time trend. These results are available upon request.

sumptions of King and Levine (1993), which allow one to estimate the economic magnitude of the finance-growth effect. Specifically, we relate pre-determined levels of financial development to subsequent growth and address some of the concerns with the validity of this approach. In contrast to early country-level research, we study a highly homogenous set of countries, focus on within-industry growth rates of similar companies, and control for country-level future growth potential implied by inherited industrial structure. To aid identification, the estimation is explicitly based on highly synchronized industries.

Using volume-of-finance-activity measures, we find that moving from the least to the most developed financial system within the EU-15 boosts the firm-level average annual value-added growth rate between 1995 and 2003 by up to three percentage points. The effects of institutional quality, proxied here by a measure of accounting standards and a measure of investor protection (control premia), are also positive and significant, but more varied in size. Excluding the UK reduces the effects of private credit and investor protection by about half and renders stock market activity effects statistically insignificant. Overall, our estimates of the size of the finance-growth effect are similar to those obtained by Levine and Zervos (1998) who contrast country-level growth rates across countries at widely different levels of economic as well as financial development.

Allowing for the presence of financial integration by interacting the initial financial development level with a time trend suggests that disadvantages in firm-level growth due to under-developed financial markets were much larger in the mid 1990s than in the late 1990s and that the growth gap related to country-level financial development was fully closed by 2003. Taking these findings at face value implies successful financial integration of the EU-15 area in the sense that real economic activity as measured by corporate growth is no longer affected by a firm's location, which is consistent with direct evidence on integration provided by, e.g., Pagano and von Thadden (2004).

Appendix: Tables

Tab. 1.1: Corporate Descriptive Statistics by Country: Firm-Year Data over 1995-2003

	Size		Growth		Age		Leverage		N
	Mean	Median	Mean	Median	Mean	Median	Mean	Median	
Austria	67.6	38.2	0.038	0.015	22.2	15.0	0.51	0.53	689
Belgium	47.6	15.9	0.016	0.010	22.7	18.0	0.62	0.65	9,091
Denmark	49.2	19.9	0.069	0.067	23.9	17.0	0.55	0.58	682
Finland	45.8	14.3	0.041	0.035	21.3	12.0	0.54	0.55	3,183
France	58.9	20.1	0.023	0.016	30.1	24.0	0.54	0.55	10,127
Germany	128.8	50.1	0.030	0.023	32.9	20.0	0.47	0.47	3,446
Greece	25.9	11.5	0.055	0.048	17.1	15.0	0.58	0.59	4,834
Italy	38.9	18.4	0.028	0.021	20.4	16.0	0.58	0.59	32,355
Netherlands	54.2	26.8	0.006	-0.004	37.2	30.0	0.52	0.51	1,026
Portugal	39.3	17.9	0.006	-0.003	26.8	22.0	0.58	0.61	1,387
Spain	39.7	16.7	0.051	0.044	22.0	19.0	0.58	0.59	16,884
Sweden	39.9	12.3	0.042	0.040	32.3	27.0	0.48	0.48	4,304
UK	62.8	19.9	0.060	0.061	29.6	22.0	0.63	0.64	13,636

Note: The number of firm-year observations in the sample, N, corresponds to observations with non-missing value-added growth rate. All firm variables are measured in the first year a firm enters the sample except age, which is measured as of 1995; age is the number of years since firm incorporation. Size (total assets) is in millions of US dollars. Growth is the annual value-added growth rate. Leverage is measured as long-term debt plus current liabilities divided by total assets. Before computing these statistics we remove growth outliers (we use only the 5-to-95 percentile range of growth values). See the Data Appendix for complete definitions and sources of variables.

Tab. 1.2: Financial Development: The EU-15 over 1990-1994

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
Mean	0.82	0.30	1.35	0.13	0.64	0.26
Median	0.85	0.23	1.45	0.09	0.62	0.31
S.D. / Mean	0.40	0.77	0.33	0.90	0.19	0.52
Min	0.32	0.10	0.51	0.03	0.36	0.00
Max	1.41	0.97	2.25	0.45	0.83	0.37
Min Country	Greece	Austria	Greece	Greece	Portugal	Austria
Max Country	Netherlands	UK	UK	UK	Sweden	UK
N	13	13	12	13	13	11

Note: We first compute the country average of each financial development measure in the period 1990-1994. Second, we present the Min, Max, Mean, and the Coefficient of Variation of the country averages from the first step across the EU-15. The two exceptions are Accounting Standards and Control Premium measures, which correspond to 1990 and 1990-2000, respectively. Ireland and Luxembourg are not included in this EU-15 comparison as they do not enter our firm-level analysis. See the Data Appendix for complete definitions and sources of variables.

Tab. 1.3: Financial Development and Corporate Growth: Basic Estimates

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
Financial Development	0.026**	0.033***	0.021***	0.070***	0.117***	0.041**
	(0.011)	(0.004)	(0.005)	(0.007)	(0.029)	(0.018)
Age	-0.044***	-0.045***	-0.046***	-0.046***	-0.044***	-0.043***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Size	-0.124***	-0.125***	-0.126***	-0.129***	-0.121***	-0.126***
	(0.025)	(0.026)	(0.026)	(0.024)	(0.027)	(0.028)
Leverage	0.055***	0.050***	0.050***	0.051***	0.054***	0.059***
	(0.010)	(0.012)	(0.012)	(0.012)	(0.010)	(0.011)
Tangibility	0.014*	0.013*	0.012	0.013*	0.013*	0.013
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.010)
Collateralization	-0.020	-0.018	-0.018	-0.016	-0.019	-0.021
	(0.015)	(0.016)	(0.016)	(0.017)	(0.015)	(0.017)
Quoted	0.017***	0.017***	0.017***	0.015***	0.017***	0.010
	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)	(0.007)
Private Limited Company	0.012***	0.010***	0.012***	0.008***	0.009***	0.013**
	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.005)
Real GDP	-4.304***	-4.232***	-5.331***	-4.162***	-4.756***	-2.978*
	(0.599)	(0.949)	(0.761)	(0.879)	(0.466)	(1.419)
N	100,535	100,535	99,871	100,535	100,533	86,866
R^2	0.16	0.16	0.16	0.16	0.16	0.15

Note: The dependent variable is the annual firm-level value-added growth rate of manufacturing firms in the period 1995-2003. All country-level financial development variables are predetermined except Control Premium, which covers the 1990-2000 period. Firm-level control variables come from the first year a firm enters the sample and remain fixed over time. Age is scaled down by 100 in all specifications, as is the measure of accounting standards. Size is measured as the percentage deviation of firm size (total assets) from the industry median firm size on a 3-digit ISIC level and is scaled down by 10,000. Leverage is measured as long-term debt plus current liabilities divided by total assets. Tangibility is measured as fixed assets divided by total assets while collateralization is defined as fixed assets plus inventories plus accounts receivables divided by total assets. Real GDP is country real GDP per capita in 1993 in millions of U.S. dollars. Quoted and Private Limited Company and are dummy variables with a base of non-quoted firms and Public Limited Companies, respectively. See the Data Appendix for complete definitions and sources of variables.
All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We always control for a constant and for 3-digit-ISIC industry-year dummies. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 1.4: Synchronized Industries: ANOVAS of Value-Added Growth Rates Across Countries and Years by Industry

	ISIC	Year/Country Two Factor Model			Robust to Country Growth	
		Year Factor SS	Synchronization Measure I	Synchronization Subsample	Year Factor SS	Synchronization Measure II
Food products and beverages	15	0.12**	0.35	Medium	0.11***	0.32
Tobacco products	16	0.58**	0.22	High	0.50***	0.19
Textiles	17	0.09**	0.21	Medium	0.04**	0.10
Apparel	18	0.15**	0.15	High	0.08	0.08
Leather	19	0.19	0.08	Low	0.14	0.06
Wood and cork	20	0.24**	0.13	Medium	0.14	0.07
Pulp and paper	21	0.53**	0.28	High	0.43***	0.23
Printing and publishing	22	0.11**	0.16	Medium	0.09***	0.13
Coke and refined petroleum	23	4.65**	0.32	High	5.12***	0.35
Chemicals	24	0.15**	0.14	Medium	0.10***	0.09
Rubber and plastics	25	0.14**	0.27	High	0.09***	0.16
Other non-metallic mineral products	26	0.15**	0.26	Medium	0.08***	0.13
Basic metals	27	0.72**	0.34	High	0.67***	0.32
Fabricated metal products	28	0.17**	0.22	Medium	0.10***	0.13
Machinery and equipment	29	0.15*	0.12	High	0.13	0.10
Office and computing machinery	30	2.85	0.07	Low	2.42	0.06
Electrical machinery	31	0.20*	0.12	High	0.18*	0.10
Radio, television and communication equipment	32	1.16**	0.16	Medium	0.89**	0.12
Medical, precision and optical instruments	33	0.06	0.05	Low	0.06	0.05
Motor vehicles	34	0.46**	0.17	High	0.23	0.08
Other transport equipment	35	0.30	0.10	Low	0.24	0.08
Manufacturing N.E.C.	36	0.07**	0.20	High	0.04*	0.11
Recycling	37	1.29**	0.18	High	1.51***	0.21

Note: The panel 'Year/Country Two Factor Model' presents first the total sum of squares (SS) of annual value-added growth rate across countries explained for a given industry by year factors in ANOVA two factor models (with year and country factors) estimated using the OECD STAN data; here, *, **, and *** denote significance of the year factors at 10%, 5%, and 1%, respectively. 'Synchronization Measure I' is the fraction of the total growth variation explained by year factors in these ANOVAs. The 'Synchronization Subsample' column assigns industries where the year factors do not reach the 10% level of statistical significance as low-synchronization industries. Next, industries where only the year factors, but not the country factors are significant are denoted as high- synchronization industries and the remaining group, where both types of factors are statistically important, as medium- synchronization industries. The panel 'Robust to Country Growth' shows analogous statistics based on alternative ANOVAs, where one controls not only for year and country factors, but also for country aggregate growth rate (business cycle).

Tab. 1.5: Financial Development and Corporate Growth: Industry Synchronization Groups

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
	Low-synchronization based on ANOVA: Year factor WEAK					
Financial Development	0.010	0.020*	0.011	0.042	0.081*	0.001
	(0.015)	(0.011)	(0.008)	(0.024)	(0.042)	(0.017)
N	6,243	6,243	6,179	6,243	6,243	5,896
R^2	0.12	0.12	0.12	0.12	0.12	0.12
	Medium-synchronization based on ANOVA: Year factor STRONG; Country factor STRONG					
Financial Development	0.029**	0.034***	0.023***	0.073***	0.139***	0.048**
	(0.010)	(0.004)	(0.005)	(0.006)	(0.029)	(0.020)
N	54,812	54,812	54,483	54,812	54,811	45,801
R^2	0.16	0.16	0.16	0.16	0.16	0.16
	High-synchronization based on ANOVA: Year factor STRONG; Country factor WEAK					
Financial Development	0.026**	0.032***	0.021***	0.069***	0.091***	0.043**
	(0.011)	(0.002)	(0.003)	(0.005)	(0.030)	(0.016)
N	39,480	39,480	39,209	39,480	39,479	35,169
R^2	0.14	0.14	0.14	0.14	0.14	0.14
	Synchronization Measure I: 1st quartile					
Financial Development	0.005	0.018**	0.008	0.034	0.085**	0.002
	(0.012)	(0.008)	(0.007)	(0.020)	(0.032)	(0.018)
N	10,314	10,314	10,227	10,314	10,313	9,548
R^2	0.13	0.13	0.13	0.13	0.13	0.12
	Synchronization Measure I: 2nd quartile					
Financial Development	0.028***	0.031***	0.020***	0.066***	0.116***	0.048**
	(0.009)	(0.003)	(0.003)	(0.007)	(0.025)	(0.015)
N	36,074	36,074	35,814	36,074	36,074	31,559
R^2	0.14	0.14	0.14	0.14	0.14	0.14
	Synchronization Measure I: 3rd quartile					
Financial Development	0.027*	0.031***	0.023***	0.066***	0.124***	0.055**
	(0.013)	(0.004)	(0.004)	(0.008)	(0.034)	(0.018)
N	18,705	18,705	18,589	18,705	18,704	16,002
R^2	0.14	0.15	0.15	0.15	0.15	0.15
	Synchronization Measure I: 4th quartile					
Financial Development	0.031**	0.038***	0.025***	0.085***	0.120***	0.041*
	(0.012)	(0.006)	(0.006)	(0.008)	(0.036)	(0.021)
N	35,442	35,442	35,241	35,442	35,442	29,757
R^2	0.17	0.17	0.17	0.17	0.17	0.17

Note: The dependent variable is the annual firm-level value added growth rate of manufacturing firms in the period 1995-2003. The top panel reports estimates based on subsamples of firms from industries assigned to groups (Low-, Medium-, and High-synchronization) based on p-values of year factor in ANOVAs of industry growth; see Table 4. In the bottom panel, we divide industries into four groups based on quartiles of the Synchornization Measure I from Table 4 and we estimate the finance-growth relationship for each group separately. All specifications are linear regressions with outliers removed (observations outside 5-to-95 percentile range of the dependent variable), include a constant and 3-digit ISIC industry-year dummies. See Table 3 notes for most definitions of variables. *, **, and *** denote coefficients significant at the 10%, 5%, and 1% level, respectively, based on robust standard errors clustered at the country level.

Tab. 1.6: Financial Development and Corporate Growth: Synchronized Industries

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
		Basic Estimates				
Financial Development	0.027**	0.034***	0.022***	0.072***	0.119***	0.045**
	(0.010)	(0.004)	(0.004)	(0.006)	(0.028)	(0.017)
N	94,292	94,292	93,692	94,292	94,290	80,970
R^2	0.16	0.16	0.16	0.16	0.16	0.16
		Time Interaction				
Financial Development	0.132**	0.147***	0.076***	0.296***	0.434**	0.173**
	(0.051)	(0.008)	(0.022)	(0.019)	(0.167)	(0.072)
Financial Development * Time	-0.021**	-0.025***	-0.012**	-0.049***	-0.065*	-0.028*
	(0.009)	(0.001)	(0.004)	(0.004)	(0.032)	(0.012)
N	94,292	94,292	93,692	94,292	94,290	80,970
R^2	0.16	0.17	0.16	0.17	0.16	0.16
Robustness to Controlling for Predicted Country Value-Added Growth Implied by Initial Industry Structure						
Financial Development	0.122**	0.144***	0.073***	0.288***	0.419**	0.165**
	(0.050)	(0.009)	(0.022)	(0.020)	(0.166)	(0.066)
Financial Development * Time	-0.022**	-0.025***	-0.012**	-0.049***	-0.066*	-0.028**
	(0.009)	(0.001)	(0.004)	(0.003)	(0.032)	(0.012)
Predicted Growth	5.326*	4.802***	4.013**	4.576**	2.559	6.480*
	(2.836)	(1.555)	(1.567)	(1.542)	(1.852)	(3.258)
N	94,292	94,292	93,692	94,292	94,290	80,970
R^2	0.16	0.17	0.16	0.17	0.16	0.16
Robustness to Controlling for OECD Prediction of Country GDP Growth						
Financial Development	0.137**	0.147***	0.076***	0.293***	0.433**	0.181**
	(0.056)	(0.009)	(0.023)	(0.020)	(0.171)	(0.074)
Financial Development * Time	-0.021**	-0.025***	-0.012**	-0.049***	-0.065*	-0.028*
	(0.009)	(0.002)	(0.004)	(0.004)	(0.032)	(0.013)
Predicted Growth	-0.320	0.606**	0.015	0.455*	0.025	-0.962
	(0.458)	(0.250)	(0.322)	(0.236)	(0.283)	(1.262)
N	94,290	94,290	93,692	94,290	94,290	80,970
R^2	0.16	0.17	0.16	0.17	0.16	0.16

Note: The estimation is based on data from which we exluded the low-synchronization group of the top panel of Table 5. The dependent variable is the annual firm-level value added growth rate of manufacturing firms in the period 1995-2003. We measure country growth opportunities (predicted growth) by either (i) the average of the realized 1995-2003 EU-15 industry-level growth rates weighted by the initial shares of value added of these industries in a given country or (ii) the country-specific GDP growth rate predicted in 1994 by OECD for the 1997-2000 period. All specifications are linear regressions with outliers removed (observations outside 5-to-95 percentile range of the dependent variable), include a constant and 3-digit ISIC industry-year dummies. See Table 3 notes for most definitions of variables. *, **, and *** denote coefficients significant at the 10%, 5%, and 1% level, respectively, based on robust standard errors clustered at the country level.

Tab. 1.7: Financial Development and Corporate Growth: Sensitivity Analysis with Synchronized Industries

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
	Basic Estimates					
Financial Development	0.122**	0.144***	0.073***	0.288***	0.419**	0.165**
Financial Development * Time	-0.022**	-0.025***	-0.012**	-0.049***	-0.066*	-0.028**
N	94,292	94,292	93,692	94,292	94,290	80,970
R^2	0.16	0.17	0.16	0.17	0.16	0.16
	Small Firms (Below Industry Median Firm Size)					
Financial Development	0.132**	0.152***	0.072**	0.325***	0.421**	0.147*
Financial Development * Time	-0.023**	-0.026***	-0.011**	-0.051***	-0.070**	-0.029**
N	47,658	47,658	47,392	47,658	47,657	39,912
R^2	0.18	0.18	0.18	0.18	0.18	0.17
	Big Firms (Above Industry Median Firm Size)					
Financial Development	0.107**	0.135***	0.068***	0.259***	0.388**	0.140**
Financial Development * Time	-0.021**	-0.024***	-0.012***	-0.047***	-0.066*	-0.028**
N	46,348	46,348	46,020	46,348	46,347	40,824
R^2	0.16	0.17	0.16	0.17	0.16	0.16
	Robustness to Removing United Kingdom					
Financial Development	0.041*	0.054	0.010	0.104	0.139*	0.080***
Financial Development * Time	-0.008*	-0.012	-0.001	-0.021	-0.015	-0.013**
N	81,573	81,573	80,973	81,573	81,571	68,251
R^2	0.19	0.19	0.19	0.19	0.19	0.19
	Robustness to Removing Greece					
Financial Development	0.141**	0.144***	0.081***	0.288***	0.435**	0.165**
Financial Development * Time	-0.025**	-0.025***	-0.014***	-0.049***	-0.069*	-0.028**
N	89,830	89,830	89,230	89,830	89,828	80,970
R^2	0.16	0.16	0.16	0.16	0.16	0.16
	Long-sample					
Financial Development	0.123**	0.143***	0.073***	0.289***	0.445**	0.163**
Financial Development * Time	-0.022**	-0.025***	-0.012**	-0.049***	-0.069**	-0.028**
N	91,153	91,153	91,126	91,153	91,153	77,948
R^2	0.16	0.16	0.16	0.16	0.16	0.16
	Negative-value-added-sample					
Financial Development	0.121**	0.144***	0.073***	0.288***	0.420**	0.164**
Financial Development * Time	-0.022**	-0.025***	-0.012**	-0.049***	-0.066*	-0.028**
N	94,259	94,259	93,659	94,259	94,257	80,939
R^2	0.16	0.17	0.16	0.17	0.16	0.16
	Removing Leverage as a Control Variable					
Financial Development	0.121**	0.150***	0.076***	0.298***	0.427**	0.168**
Financial Development * Time	-0.022**	-0.025***	-0.012**	-0.049***	-0.067*	-0.028**
N	94,292	94,292	93,692	94,292	94,290	80,970
R^2	0.16	0.16	0.16	0.16	0.16	0.16

Note: The estimation is based on data from which we exluded the low-synchronization group of the top panel of Table 5. All specifications control for predicted value-added country growth based on initial industry structure as in panel three of Table 6. 'Basic Estimates' repeats the third panel of Table 6. We then re-estimate the coefficients for subsamples of firms defined based on size: firms smaller/bigger than the industry median firm size on a 3-digit ISIC level. 'Robustness to Removing United Kingdom' and 'Robustness to Removing Greece' panels report the coefficients when the UK or Greece, respectively, are removed from the sample of countries. The 'Long-sample' panel restricts the sample to firms with at least four years of value-added data. The 'Negative-value-added-sample' panel excludes those value-added growth observations where at least one of the two underlying levels of value added were negative. 'Removing Leverage as a Control Variable' excludes leverage as a control variable from the regressions.
All specifications are linear regressions with outliers removed (observations outside 5-to-95 percentile range of the dependent variable), include a constant and 3-digit ISIC industry-year dummies. See Table 3 notes for most definitions of variables. *, **, and *** denote coefficients significant at the 10%, 5%, and 1% level, respectively, based on robust standard errors clustered at the country level.

Tab. 1.8: Financial Development and Corporate Growth: Median Regressions for Synchronized Industries

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards	Control Premium
			Basic Estimates			
Financial Development	0.033	0.039	0.025	0.086*	0.134***	0.045
	(0.020)	(0.027)	(0.015)	(0.047)	(0.041)	(0.080)
N	104,469	104,469	103,821	104,469	104,467	89,835
Pseudo R^2	0.07	0.07	0.07	0.07	0.07	0.07
			Time Interaction			
Financial Development	0.144*	0.175**	0.084*	0.352**	0.494**	0.177
	(0.073)	(0.083)	(0.047)	(0.163)	(0.215)	(0.124)
Financial Development * Time	-0.022*	-0.029*	-0.013	-0.057**	-0.074*	-0.028
	(0.012)	(0.015)	(0.008)	(0.025)	(0.040)	(0.024)
N	104,469	104,469	103,821	104,469	104,467	89,835
Pseudo R^2	0.07	0.08	0.07	0.08	0.08	0.07
Robustness to Controlling for Predicted Country Value-Added Growth Implied by Initial Industry Structure						
Financial Development	0.134*	0.170*	0.081*	0.340**	0.479**	0.172
	(0.078)	(0.087)	(0.047)	(0.140)	(0.226)	(0.365)
Financial Development * Time	-0.023*	-0.029**	-0.013	-0.057***	-0.075*	-0.029
	(0.012)	(0.014)	(0.009)	(0.020)	(0.043)	(0.055)
Predicted Growth	5.221	5.152	3.650	4.882	2.602	6.767
	(7.413)	(7.641)	(4.874)	(5.982)	(6.543)	(9.799)
N	104,469	104,469	103,821	104,469	104,467	89,835
Pseudo R^2	0.07	0.08	0.07	0.08	0.08	0.07
Robustness to Controlling for OECD Prediction of Country GDP Growth						
Financial Development	0.147*	0.173**	0.083*	0.346**	0.484**	0.184
	(0.077)	(0.070)	(0.047)	(0.146)	(0.227)	(0.380)
Financial Development * Time	-0.022*	-0.029**	-0.013	-0.057**	-0.073*	-0.028
	(0.012)	(0.012)	(0.008)	(0.023)	(0.040)	(0.061)
Predicted Growth	-0.158	0.830	0.240	0.685	0.236	-0.921
	(1.191)	(1.170)	(1.246)	(1.481)	(1.086)	(2.791)
N	104,467	104,467	103,821	104,467	104,467	89,835
Pseudo R^2	0.07	0.08	0.07	0.08	0.08	0.07

Note: The data and equation specification are the same as in Table 6. All specifications are median regressions. In all panels we include the value-added-growth outliers, which were not used in the previous tables (i.e., observations outside 5-to-95 percentile range of the dependent variable). See Table 3 notes for a list of all control variables and the Data Appendix for definitions of variables. *, **, and *** denote significance at the 10%, 5%, and 1% level based on bootstrapped standard errors clustered at the country level.

Tab. 1.DA.1: Definition of Variables

	Amadeus Firm-level Variables
VA	Firm-level value added in current prices deflated by PPI. As PPI we use Eurostat's not seasonally adjusted domestic output price index (in national currency) which covers total industry (excluding construction). Source: Amadeus.
VA_Growth	Annual firm-level growth rate of real value added based on VA. The formula for VA_Growth we use is $(VA_t - VA_{t-1}) / ABS(½ VA_t + ½ VA_{t-1})$. Source: Amadeus.
VA_ShortPanel	0/1 variable, equal 1 if less than five years of value added data are available for a firm and 0 otherwise. Source: Amadeus.
VA_Negative	0/1 variable, equal 1 if the current or one lag value added figure used while calculating annual firm growth (VA_Growth) was negative and 0 otherwise. Source: Amadeus.
Age	The number of years since firm's incorporation (STATDATE - YEARINC) scaled down by 100. It is calculated as of 1995 and remains fixed over time. Source: Amadeus.
Size	The percentage deviation of firm's total assets (TOAS) from the industry median firm size on 3-digit ISIC level, scaled down by 10,000. It is calculated as of the first year a firm enters the sample and remains fixed over time. Source: Amadeus.
Leverage	Measured as a long term debt (LTDB) plus current liabilities (CULI) divided by total assets (TOAS). It is calculated as of the first year a firm enters the sample and remains fixed over time. Source: Amadeus.
Tangibility	Tangibility is measured as fixed assets (FIAS) divided by total assets (TOAS). It is calculated as of the first year a firm enters the sample and remains fixed over time. Source: Amadeus.
Collateralization	Collateralization is defined as fixed assets (FIAS) plus inventories (STOK) plus accounts receivables (DEBT sic) divided by total assets (TOAS). It is measured as of the first year a firm enters the sample and remains fixed over time. Source: Amadeus.
Quoted	0/1 variable, equal 1 if the firm is publicly listed company and 0 otherwise. Source: Amadeus.
Private Limited Company	0/1 variable, equal 1 if the firm is 'Limited Liability Company' (Company whose capital is divided into shares which cannot be offered to the general public. The liability of its members is limited to the amount of their shares.) and 0 if the firm is 'Limited Company'. (Company whose capital is divided into shares which can be offered to the general public and whose members are only liable for its debts to the extent of any amount unpaid on their shares.) Source: Amadeus.
	Financial Development Country-level Variables
Private Bank Credit	Private credit by deposit money banks and other financial institutions to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
Market Capitalization	Stock market capitalization to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
Market Value Traded	Stock market total value traded to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
Total Capitalization	The sum of (i) stock market capitalisation, (ii) bank credit to the private sector and (iii) domestic debt securities issued by the private sector to GDP. Average over the period 1990-1994. Source: Hartmann et al. (2006), Chart 1.
Accounting Standards	Index created by examining and rating companies' 1990 annual reports on their inclusion or omission of 90 items in balance sheets and income statements and published by the Center for International Financial Analysis & Research, Inc. The maximum is 90, the minimum 0 and we scaled it down by 100. Source: The Center for International Financial Analysis & Research.
Control Premium	The control premium corresponding to 1990-2000 estimates by Dyck and Zingales (2004). We take the estimated country fixed effects from their Table III, column (1), and use the value of 0.383 minus the country-level premium, where 0.383 is the maximum premium level in the sample corresponding to Austria.
	OECD STAN Industry-level Variables
VA_ISIC2	Value added by industry (ISIC 2-digit level) and country in current prices and local currency deflated by country-level PPI. As PPI we use Eurostat's not seasonally adjusted domestic output price index (in national currency) which covers total industry (excluding construction). Source: OECD STAN.
VA_ISIC2_ Growth	Growth rate of real value added by industry (ISIC 2-digit level) and country. We first take annual growth rates $(VA\_ISIC2_t - VA\_ISIC2_{t-1}) / VA\_ISIC2_{t-1}$ and then compute a compounded average of these annual growth rates. Source: OECD STAN.
VA_ISIC2_Share	Share of real industry value added (VA_ISIC2) on the total value added of a country. We use average over 1990-1994. Source: OECD STAN.
	Country Growth Predictions
VA_Predicted_ Growth	Predicted future country growth of value added. We compute the time-averages of EU-15 realized growth of manufacturing industries (ISIC 2-digit level) during 1995-2002 (VA_ISIC2_ Growth) and weight these growth rates by the initial-period country-level shares (average over 1990-1994) of each industry (VA_ISIC2_Share).
GDP_Predicted_Growth	The average GDP growth rate for the period 1997 to 2000 predicted as of 1994. Source: Table 15 of the OECD Economic Outlook No. 56, December 1994, OECD, Paris.

Tab. 1.DA.2: Legal Forms in the EU-15

Country	Limited Companies	Limited Liability Companies
Austria / Germany	Aktiengesellschaft (AG, AG & Co KG)	Gesellschaft mit beschraekter Haftung (GmbH, GmbH & Co KG, Einzelfirma)
Belgium	Naamloze Vennootschap (NV), Société Anonyme (SA)	Besloten Vennootschap, (E)BVBA; Société Privée a Responsabilité Limite, SPRL(U)
Denmark	Limited Company, Company with Limited Liability (A/S)	Private Limited Company (ApS)
Finland	Osakeyhtiö a julkinen (OYJ)	Osakeyhtiö (OY)
France	Société Anonyme (SA)	Société a Responsabilité Limite (SARL)
Greece	SA	Limited liability company (EPE), Sole shareholder limited liability company
Italy	Societa Per Azioni (SPA)	Societa a Responsabilita Limitata (SRL, SCARL)
Netherlands	Naamloze Vennootschap (NV)	Besloten Vennootschap (BV)
Portugal	Sociedade Anónima (SA)	Sociedade por Quotas Responsibilidada Limitada (LDA)
Spain	Sociedad Anónima (SA)	Sociedad Limitada (SL)
Sweden	AB - Public Limited	AB - Private Limited
United Kingdom	Guarantee; Public, A.I.M.; Public, investment trust; Public, not quoted; Public, quoted; Unlimited	Private

Note: In order to ensure comparability of sampled firms across countries, we include only companies from the two broad categories: Limited Companies (companies whose capital is divided into shares which can be offered to the general public and whose members are only liable for its debts to the extent of any amount unpaid on their shares) and Limited Liability Companies (companies whose capital is divided into shares which cannot be offered to the general public. The liability of its members is limited to the amount of their shares). We exclude partnerships (at least one partner is liable for the firm's debts), sole proprietorships (there is only one shareholder), and cooperatives. We follow Bureau van Dijk's grouping of the firms' types. See Klapper et al. (2006) for a similar approach.

References

Aghion, Philippe; Angeletos, George-Marios; Banerjee, Abhijit; Manova, Kalina; 2005, "Volatility and Growth: Credit Constraints and Productivity-Enhancing Investment,"NBER Working Paper No. 11349.

Allen, Franklin; Bartiloro, Laura; Kowalewski, Oskar; 2006, "The Financial System of the EU,"Working Paper 05-44, Wharton Financial Institutions Center, University of Pennsylvania.

Allen, Franklin; Gale, Douglas; 2004,"Comparative Financial Systems: A survey."In S. Bhattacharya, W. Boot and A. Thakor (eds.), *Credit, Intermediation, and the Macroeconomy: Readings and Perspectives.* Oxford: Oxford University Press.

Badinger, Harald; 2007, "Has the EU's Single Market Programme Fostered Competition? Testing for a Decrease in Mark-up Ratios in EU Industries,"*Oxford Bulletin of Economics and Statistics*, Vol. 69, Issue 4, pp. 497-519.

Baele, Lieven; Ferrando, Annalisa; Hördahl, Peter; Krylova, Elizaveta; Monnet, Cyril; 2004, "Measuring Financial Integration in the Euro Area,"European Central Bank Paper Series No. 14.

Beck, Thorsten; Demirgüç-Kunt, Asli; Levine, Ross; 2000, "A New Database on the Structure and Development of the Financial Sector," *World Bank Economic Review*, Vol. 14, Issue 3, pp. 597-605.

Beck, Thorsten; Demirgüç-Kunt, Asli; Maksimovic, Vojislav; 2008, "Financing Patterns Around the World: Are Small Firms Different?,"*Journal of Financial Economics*, Vol. 89, Issue 3, pp. 467-487.

Bekaert, Geert; Harvey, Campbell; Lundblad, Christian; Siegel, Stephan; 2007, "Global Growth Opportunities and Market Integration,"*Journal of Finance*, Vol. 62, Issue 3, pp. 1081-1137.

Bottasso, Anna; Sembenelli, Alessandro; 2001,"Market Power, Productivity and the EU Single Market Program: Evidence from a Panel of Italian Firms,"*European Economic Review*, Vol. 45, Issue 1, pp. 167-186.

Camacho, Maximo; Pérez-Quirós, Gabriel; Sáiz Matute, Lorena; 2008, "Do European Business Cycles Look Like One?"*Journal of Economic Dynamics and Control*, Vol. 32, Issue 7, pp. 2165-2190.

Desai, Mihir; Gompers, Paul; Lerner, Josh; 2003, "Institutions, Capital Constraints and Entrepreneurial Firm Dynamics: Evidence from Europe,"NBER Working Paper No. 10165.

Dyck, Alexander; Zingales, Luigi; 2004, "Private Benefits of Control: An International Comparison,"*Journal of Finance*, Vol. 109, Issue 2, pp. 537-600.

Fisman, Raymond; Love, Inessa; 2004, "Financial Development and Intersectoral Allocation: A New Approach," *Journal of Finance*, Vol. 59, Issue 6, pp. 2785-2807.

Frankel, Jeffrey A.; Romer, David; 1999, "Does Trade Cause Growth?" *American Economic Review*, Vol. 89, Issue 3, pp. 279-399.

Gómez-Salvador, Ramón; Messina, Julián; Vallantic, Giovanna; 2004, "Gross Job Flows and Institutions in Europe," *Labour Economics*, Vol. 11, Issue 4, pp. 469-485.

Guiso, Luigi; Jappelli, Tullio; Padula, Mario; Pagano, Marco; 2004, "Financial Market Integration and Economic Growth in the EU," *Economic Policy*, CEPR, CES, MSH, Vol. 19, pp. 523-577.

Hartmann, Philipp; Ferrando, Annalisa; Fritzer, Friedrich; Heider, Florian; Lauro, Bernadette; Lo Duca, Marco; 2006, "The Performance of the European Financial System," mimeo, ECB.

King, Robert G.; Levine, Ross; 1993, "Finance and Growth: Schumpeter Might Be Right," *Quarterly Journal of Economics*, Vol. 108, Issue 3, pp. 717-737.

Klapper, Leora; Laeven, Luc; Rajan, Raghuram G.; 2006, "Entry Regulation as a Barrier to Entrepreneurship," *Journal of Financial Economics*, Vol. 82, pp. 591-629.

Kumar, Krishna B.; Rajan, Raghuram G.; Zingales, Luigi; 1999, "What Determines Firm Size?," NBER Working Paper No. 7208.

La Porta, Rafael; Lopez-de-Silanes, Florencio; Shleifer, Andrei; Vishny, Robert W.; 1998, "Law and Finance," *Journal of Political Economy*, Vol. 106, Issue 6, pp. 1113-1155.

Levine, Ross; 2005, "Finance and Growth: Theory and Evidence." In P. Aghion and S. Durlauf (eds.), *Handbook of Economic Growth*. New York: Elsevier North-Holland.

Levine, Ross; Loayza, Norman; Beck, Thorsten; 2000, "Financial Intermediation and Growth: Causality and Causes," *Journal of Monetary Economics*, Vol. 46, Issue 1, pp. 31-77.

Levine, Ross; Zervos, Sara; 1998, "Stock Markets, Banks, and Economic Growth," *American Economic Review*, Vol. 88, Issue 3, pp. 537-558.

Pagano, Marco; von Thadden, Ernst-Ludwig; 2004, "The European Bond Markets under EMU," *Oxford Review of Economic Policy* Vol. 20, Issue 4, pp. 531-554.

Rajan, Raghuram G.; Zingales, Luigi; 1998, "Financial Dependence and Growth," *American Economic Review*, Vol. 88, Issue 3, pp. 559-86.

Schott, Peter K.; 2003, "One Size Fits All? Heckscher-Ohlin Specialization in Global Production," *American Economic Review*, Vol. 93, Issue 3, pp. 686-708.

Wooldridge, Jeffrey M.; 2003, "Cluster-Sample Methods in Applied Econometrics," *American Economic Review*, Vol. 93, Issue 2, pp. 133-138.

2. WHICH FIRMS BENEFIT MORE FROM FINANCIAL DEVELOPMENT?

(joint with Štěpán Jurajda)

2.1 Introduction

There is growing interest in the differential effect of financial development on firms of different age and size as well as on firm entry (Guiso et al., 2004a; Beck et al., 2004). This literature applies the Rajan and Zingales (1998) identification strategy to estimate the effect of country-level financial development across industries with different predicted need for external finance and asks whether this effect differs across firms of different size. Recently, this line of research also focuses on the effect of financial development on firm entry (by firm size) and on the impact on post-entry growth of surviving entrants (Klapper et al., 2006; Aghion et al., 2007).

Specifically, Guiso et al. (2004a) use the Amadeus database of European firms to compare the Rajan-Zingales firm-growth effects for companies above and below 400 employees and find somewhat larger impacts of financial development on smaller firms. Beck et al. (2004) focus on an industry's share of firms with fewer than 20 employees and suggest that financial development is particularly helpful in supporting growth of small firms in both developed and developing countries. Klapper et al. (2006) use the Amadeus data to study the effect of a country's business environment and institutions on entry of new firms. They find that firm entry is higher in industries predicted to be in more need of external finance in countries that have a higher level of financial development. Klapper et al. (2006) also suggest, similar to other existing studies, that entrants are on average larger in countries with a lower level of financial development. Finally, Aghion et al. (2007) study a database of firm entry and growth rates by industry and size group across 16 industrialized and emerging economies. They find that financial development boosts entry of small firms in industries predicted to be more dependent on external finance. They also find a positive effect on post-entry growth of surviving entrants six years after entry.

In this paper, we study the post-entry growth of recent entrants and compare their experience with that of the incumbents—a strategy advocated by Aghion et al. (2007, p.764), although not feasible in their study due to data limitations. Similar to Guiso et al. (2004a) and Klapper et al. (2006), we use the Amadeus data (described in Section 2.4) and study European companies. However, we depart from this literature in that we do not apply the Rajan and Zingales (1998) identification strategy, although we do use the method of difference-in-differences on which their approach is based.

The Rajan and Zingales (1998) strategy was developed to avoid the fundamental identification problem of measuring the effect of finance on growth, which would call for isolating the part of the variation in financial development that is unrelated to unobservable current and future growth opportunities.[1] Rajan and Zingales assume that different industries have a different, technologically determined need for external finance. They form a proxy for this need based on several assumptions and regress industry growth from a sample of countries on country and industry fixed effects as well as on the *interaction* between a proxy of industry external finance dependence

[1] Few studies are able to solve this identification problem. Finding a valid instrument for country-level financial development is difficult, as is securing large enough samples in order to avoid small-sample biases of instrumental variable estimators. Guiso et al. (2004b) solve the identification problem by looking within a country and focusing on historically predetermined variation in local financial development. They suggest that small firms grow faster in regions of Italy that feature more developed credit markets, which is consistent with small firms being more constrained than large firms in their operation and growth through access to external finance. Theirs is an important finding, but it addresses only within-country differences in financial development.

and a measure for country financial development. Their regressions suggest that industries predicted to be in greater need of external finance grow faster in countries with more developed financial markets, conditional on all (potentially unobservable) country- and industry-specific factors driving growth.

However, their quantification of external finance need is based on the assumption that cross-industry differences in the need for external finance are the same across countries; this in turn requires that industry technology as well as shocks to growth opportunities, which drive the need for production expansion and use of external finance, are not country-specific, but global. Thus, their method may not be applicable when industry growth opportunities differ or when there is significant technology heterogeneity across countries (Schott, 2003).

In this paper, we therefore develop an alternative approach stemming from the motivation for studying firms of different size and age that spurred the empirical literature described above. Finance theory surveyed in Levine (1997) contends that financial development can foster corporate growth because financial intermediaries play a key role in overcoming market frictions due to moral hazard and asymmetric information. These frictions give rise to financial constraints and represent a fundamental source of external finance costs, which ought to be lowered through financial development. Efficient financial institutions provide external finance even to informationally opaque businesses, that is to firms with little information available on their economic and financial status.

There is much survey evidence suggesting that small and young firms from both developed and developing countries are constrained in their access to external finance. (We discuss this literature in Section 2.2, where we also argue that evidence based on non-subjective data is needed to complement the survey-based findings.) Applying the logic of finance theory, it is therefore likely that company size or age serve as effective proxies for the extent of market frictions, particularly the extent of information asymmetries, that firms face.[2] If small and young firms are on average more financially constrained than larger and older companies, they should benefit disproportionately from the development of financial institutions and markets. In this study, we test this notion by asking whether differences in financial development across EU-15 economies affect growth rates of firms differently for young and old firms as well as for firms of different size. Specifically, we measure the growth effect of the interaction between a firm's age (size) and a country's level of financial development.

This approach helps to uncover the *mechanism* of the finance-growth effect in a novel way. In the Rajan-Zingales framework, the mechanism is based on external sources of finance being more costly than internal ones. Hence, lowering the overall costs of external finance benefits disproportionately those firms that face higher need of external finance (for industry-specific, presumably technological reasons). In contrast, in our study the mechanism consists of lowering the relative costs of external finance for businesses that are more informationally opaque because of their size or age. Our mechanism is therefore closely tied to the underlying fundamental source of external finance costs: information asymmetry. It corresponds to the screening and evaluation process performed by financial intermediaries deciding upon granting external finance.

Relying on a large firm-level data set covering EU-15 firms with more than 100 employees or more than 20 million Euro of total assets between 1995 and 2003, the Amadeus database, we regress firms' average value-added growth rates on an interaction of firms' size or age with several dimensions of country-level financial

[2] Young firms are affected by information asymmetry because they have short history. The reason why size is related to information asymmetry could be that the costs for financial intermediaries of evaluating a request for external financing by a small company may exceed the benefits. It is not clear how the extent of moral hazard varies with firm size; see Martin and Sayrak (2003) for a recent survey. The banking literature usually relates opaqueness to firm age and size; recent examples are Berger et al. (2001) and Berger et al. (2002).

infrastructure. We hesitate to use a linear specification of the interaction of financial development indicators with firm size and age because it is not clear that information asymmetry decreases proportionately with firms' age or size and because we wish to impose few functional form restrictions. Hence, we interact financial development with indicators of a firms' position in quintiles of the firm size or age distribution.[3] Our regressions further condition on a set of firm-level pre-determined controls and a full set of country and industry dummies. We therefore ask whether, for example, Greek financial institutions differ significantly from those of the UK in their ability to overcome information asymmetry (identify profitable projects) of young and/or small companies relative to their ability to provide external finance for projects of older and/or larger companies.

We find little significant difference in the effect of financial development between medium-sized and large firms in our data. On the other hand, using the oldest companies as the benchmark group, there is strong evidence of a disproportionate positive effect of financial development on all except perhaps the youngest firms. Specifically, we recover an inverted-U shape of the interaction between age and financial development, such that firms of approximately median age appear to benefit the most from financial development. Next, we explore several explanations for the age shape of the financial-development growth effect. Our key explanation is that freshly incorporated companies in less financially developed countries adjust to the state of financial systems by having unusually high shares of equity capital in total assets. In other words, in less financially developed environments the entry process is selective such that among potential startups only those endowed with high equity capital shares do enter. These entrants therefore do not need as much external finance in early stages of company existence, which helps to explain why, in our basic

[3] Similar to the approach of Beck et al. (2004) or Rajan and Zingales (1998), ours is therefore a group-level interaction approach. However, our groups are formed based on firm-level information (firm size or age), whilst the Rajan-Zingales literature relies on interactions based on group-level (industry) average characteristics.

specifications, very young firms appear to benefit less from financial development. Indeed, we find that among those youngest companies that have low shares of equity capital in total assets, there is a strong disproportionate effect of financial development. We conclude that financial development fosters growth of young companies even within a set of some of the most developed countries of the world.

The structure of the paper is as follows: In the next section we relate our approach to the existing literature. Section 3 presents our methodology while Section 4 describes the data. Section 5 covers the empirical analysis and Section 6 summarizes the findings.

2.2 Relationship to the Existing Literature

In firm surveys, small and young companies in both the developed and developing world report having less access to external finance than larger and older companies.[4] Survey responses are also used to ask about the effect of financing obstacles on firm growth. For example, Beck et al. (2005) suggest that the effect that the difference in financial development across a wide set of both developed and developing countries has on a firms' growth is strongest for the smallest companies. It is widely held that the main reason why small and young firms report lower access to external financing and benefit disproportionately from financial development is their information opaqueness. Firm survey evidence is thus consistent with the notion that financial development reduces the negative effects of information asymmetry and offers an effective way of promoting small firm growth—an important conclusion from a policy standpoint.[5]

[4] Age and size explain a large share of the variation in firms' self-reported financing obstacles in the World Business Environment Survey, which covers much of the developing world (Beck et al., 2006). Similarly, the presence of financial constraints is negatively related to firm age in the survey of Italian firms studied by Angelini and Generale (2005).

[5] See also Bergell and Udell (1998) for an early discussion of small-firm finance and Beck and Demirgüç-Kunt (2006) for a recent survey of this topic.

Yet, it is imperative that these conclusions based on firms' subjective assessments are compared to those reached with non-subjective data. For example, it is not clear that firms of different age compare their unsatisfied need for external finance against the same benchmark; it could be that such firms differ in their ability to evaluate the potential gains from using additional external finance.[6] Further, the estimation of growth consequences of self-assessed financial constraints is plagued by potential reverse causality problems if firms that fail to grow (and remain small) because of internal problems tend to blame financial intermediaries for failing to provide external finance.

Unfortunately, it is fundamentally difficult to form a valid *firm-level* indicator of financial constraints. These constraints are difficult to measure because they arise from the interaction of the quality of a financial system, a firm's inherently unobservable growth opportunity, and financing-related firm-level indicators, which firms can adjust based on expected financing needs.[7] On the other hand, it is possible to compare the growth experience of firm *types* that are likely to differ in how sensitive they are to the efficiency of financial systems across different levels of financial development. Such difference-in-differences strategy is at the core of the Rajan and Zingales (1998) approach, where the firm types correspond to industries with different external finance need. In our study, the firm types correspond to age and size groups that likely face different degrees of information asymmetry. Each strategy helps to uncover a different finance-growth mechanism, as discussed in the Introduction. Our estimates are therefore not directly comparable to those in the existing literature estimating the Rajan-Zingales mechanism, including, e.g., Aghion et al.

[6] Along similar lines, investment-cash flow sensitivities could be higher for smaller and/or younger firms in comparison to larger and more mature firms because (i) financial constraints are more binding for small and young firms or (ii) such firms learn from their cash flow about their uncertain growth prospect.

[7] Hajivassiliou and Savignac (2007) illustrate the endogeneity of traditional firm proxies for financing constraints based on firm wealth or accumulated profits.

(2007) or Guiso et al. (2004a).[8]

On the other hand, one can compare the focus of the existing studies to ours. We study the differences in the effect of financial development across firms of different size and age combinations. The only study focusing on the effect of financial development on young firms is Aghion et al. (2007) who use the Rajan-Zingales methodology to estimate the effect on growth of surviving entrants after three to seven years of company existence. In our study, we follow the growth experience of surviving entrants at all age levels and contrast it with that of the incumbents (i.e., older companies).

A key study in the literature differentiating the finance-growth effects by firm size is Beck et al. (2004). They use cross-industry, cross-country data from 44 countries and 36 manufacturing industries and focus on the interaction between financial development indicators and US industries' share of employment by firms with less than 20 employees. They employ industry-induced variation in firm size, as such variation is likely to be related to industry technology differences and not to firm-specific unobservables,[9] and find that industries with a higher share of very small firms in the US grow faster when served by more developed financial systems.

Although we also compare the growth experience of firms of different size across countries at different levels of financial development, our findings are not comparable to those of Beck et al. (2004) for three reasons. First, they focus on very small firms (with less than 20 employees) in developing countries, while we study firms with at least 100 employees or more than 20 million Euro of total assets (see Section 2.4 for data description) in some of the most developed countries.

[8] One would like to combine both strategies and differentiate firms by both their industry level of external finance dependence and their degree of information asymmetry approximated by age or size. An ideal approach would work with age- and size-specific estimates of external finance dependence. We leave such estimation for future research.

[9] Their use of industry-level data is no doubt also the consequence of the lack of reliable firm-level data for the wide set of countries they analyze.

Second, they rely on industry-level indicators of firm size while we work with firm-level size directly. Their use of industry data may not be innocuous to the estimation of the size-related differences in the growth effect of financial development. Beck et al. (2004) choose to concentrate on an industry's share of very small firms. They therefore do not explore the size shape of the finance-growth relationship and effectively assume that the same specific size threshold (having 20 employees) explains the severity of size-related market frictions in all industries. Further, the existence of substantial dispersion of firm size within industries implies that their industry growth-rate averages are based on firms of all sizes. Even two industries that exhibit a similar share of very small companies do not necessarily share a similar firm size distribution. In other words, any strategy that uses an industry indicator for firm size implies size miss-classification for a significant share of firms, which ultimately underlie industry-level growth rates. In contrast, our use of firm-level measures of size and growth improves precision and allows us to trace out the finance-growth effect differences across firms of different size. Using firm-level data also allows us to compare estimates based on different sources of size variation: within- as well as across-industry.[10]

Third, a potential problem with the Beck et al. (2004) approach is that it is not clear that countries at widely different levels of economic development, such as those included in their sample of 44 economies, will share similar size structure of their industries in absence of differences in financial development—an assumption invoked in their approach.[11] In this study, we compare the growth experience of firms across a set of highly comparable economies. We analyze firms operating in the EU-15 'single market' under harmonized product market regulation. The high

[10] Across-industry variation in size is likely to be driven by technology and hence unrelated to firm unobservables. We therefore test for the importance of using across- as opposed to within-industry size variation. It is less clear that industry differences in age are driven by technology.

[11] The evidence on similarity of industry firm size across countries is based on the most developed economies (e.g., Kumar et al., 1999).

degree of similarity of the analyzed firms in terms of both growth opportunities and technology contrasts with much of the existing finance-growth literature. It assists in correctly measuring the finance-growth relationship. For example, using industry fixed effects to control for common industry growth shocks is highly realistic within the EU-15 group.[12] Fortunately for our empirical exercise, significant differences persisted in financial system development across the EU-15 economies at the time of the start of the 'single market', despite extensive product market integration, as documented by, e.g., Guiso et al. (2004a) or Allen et al. (2006).

2.3 Methodology

Our goal is to investigate differences in the effect of financial development on corporate growth across firms of different age or size. Applying the difference-in-differences framework, we ask about these differences using linear regressions of average firm value-added growth rates on (i) a set of firm-level control variables including age and size, (ii) country and industry fixed effects, and (iii) the interaction of a country's level of financial development with selected firm-level characteristics: age and/or size. In line with the existing literature, we therefore control for all observable as well as unobservable industry- and country-level determinants of growth.

We view the establishment of the EU 'single market', which harmonized product market regulation, as an opportunity to compare the growth performance of firms that increasingly face similar growth opportunities—those of the harmonized EU-15-wide market. Investment that would allow firms to benefit from these opportunities is likely to take place in the early stages of the 'single market' formation. Hence, our indicators of financial development are measured as of the beginning of the

[12] For recent evidence on EU business cycle synchronization see Camacho, et al. (2005). In Bena and Jurajda (2007), we confirm the presence of 'synchronized' EU-15 growth patterns at industry level.

'single market' in 1993.[13] Similarly, our firm-level controls are measured as close to this benchmark as possible—as of the beginning of the firm data. Put simply, we control for the starting position of firms entering the 'single market' and measure the difference that initial financial development makes for their growth.

A basic regression specification, which asks whether firms of different age or size grow at different rates across financial systems of differential depth, is of the following form:

$$G_{ijk} = \alpha + \beta \left(FD_i * Z_{ijk} \right) + Z_{ijk}\eta + \gamma_i + \delta_j + X^{'}_{ijk}\zeta + \epsilon_{ijk}, \tag{2.1}$$

where G_{ijk} denotes the time-averaged growth rate of the real value added of firm k in industry j in country i, and where FD_i corresponds to a measure of country financial development. The variable Z_{ijk} represents firm size (age) and is entered as both a base effect and in the financial-development interaction. Country and industry dummies are denoted as γ_i and δ_j, respectively, and we also condition on a set of firm-specific initial-period characteristics X_{ijk} including firm age (size), firm financial indicators such as leverage, tangibility and collateralization, as well as an indicator for quoted companies and a set of indicators for company concentration of ownership and legal form.

However, Equation (2.1) implicitly assumes that the degree of information asymmetry varies proportionately with firms' age or size, which may be a restrictive assumption. In order to impose as little structure as possible on the key interaction relationship of our regressions, we therefore use a semi-parametric specification that interacts a country's level of financial development with a step-function in firm's age or size. More specifically, we interact FD_i with a set of indicators for the firm's position in one of the quintiles or deciles of the age or size distribution, measured

[13] We investigate the sensitivity to the timing of the measurement of financial development in Section 2.5.2.

again as of the beginning of our data:

$$G_{ijk} = \alpha + \sum_{v=1}^{V} \beta_v \left(FD_i * I_{ijkv}\right) + \eta_v + \gamma_i + \delta_j + X'_{ijk}\zeta + \epsilon_{ijk}, \qquad (2.2)$$

where the set of binary indicator variables I_{ijkv} denotes the position of a firm in one of the quintiles (deciles) of the firms' age or size distribution, depending on the question we ask, while the fixed effects η_v capture the average growth rate of firms of the corresponding size or age group.

2.4 Data

We work with data from a set of countries where industries face highly synchronized shocks and share a highly similar technology content of industrial classification—the countries of the EU's 'single market'—during the 1995-2003 period, which covers the first years of the market's operation before its extension to post-communist countries. Firm-level financial statements and descriptive data, which allow us to compare the growth experience of highly similar firms residing in different countries, come from the Amadeus database. Country-level measures of financial development come primarily from the World Bank. We introduce these data sources in this section and complement the description with detailed tables in the Data Appendix.

2.4.1 Firm-Level Data

We use firm-level data from the Amadeus (Analyse MAjor Databases from EUropean Sources) database, created by Bureau Van Dijk from standardized commercial data collected by about 50 vendors across Europe. Among the key advantages of the data from our perspective is that they cover both listed and unlisted firms of a wide variety of size and age categories and that they provide corporate descriptive statistics including growth together with a detailed source-of-finance accounts. In principle, the database should cover most public and private limited companies,[14]

[14] There are exceptions to the rule. For example, small and medium size German firms are not legally forced to disclose (Desai et al., 2003).

although coverage varies by country and generally improves over time. The firm and industry coverage of these data is an order of magnitude better compared to other existing firm samples as argued by Gomez-Salvador et al. (2004).

These data have been tapped in the finance-growth literature only recently, by Guiso et al. (2004a) to estimate Rajan-Zingales type regressions relying on US measures of industry external finance dependence, and by Klapper et al. (2006) to study firm entry. Our selection of the analysis-ready sample follows the choices made by these two studies. Similar to Guiso et al. (2004a), we use the 'TOP 250 thousand' module of the Amadeus data,[15] which we downloaded in December 2006. Following Klapper et al. (2006) we use only unconsolidated statements to avoid double counting, and we also exclude all legal forms other than the equivalent of public and private limited liability corporations due to the uneven coverage of partnerships, proprietorships and other minor legal forms. Definitions of key variables and a listing of the included legal forms of firms by country are provided in the Data Appendix, in Tables 2.DA.1 and 2.DA.2, respectively.

The dataset is drawn from EU-15 countries that were part of the European Internal Market in 1995: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdom. Similar to Guiso et al. (2004a), we exclude Luxembourg, because its financial sector is statistically anomalous, and we lose Ireland due to missing firm-level information. Firm coverage in the Amadeus data is incomplete before 1995 and after 2003 so we use only observations from 1995-2003.[16] Another reason why we do not use pre-1995

[15] Firms selected as TOP 250,000 had to meet at least one of the following inclusion criteria: For UK, Germany, France, and Italy operating revenue at least 15 million euros, total assets at least 30 million euros, or the number of employees at least 150. For all other countries operating revenue at least 10 million euros, total assets at least 20 million euros, or the number of employees at least 100.

[16] Some firms are not present in the data for the whole period. In order to avoid potential biases from the combination of differential improvements in firm coverage across countries with time-changing aggregate growth rates, we replace the firm-level average growth rates available in

data is that Finland, Austria and Sweden joined the EU only in that year.

Following Rajan and Zingales (1998) and Guiso et al. (2004a), we focus on manufacturing industries (NACE 15 to 37). We exclude firms with missing total assets as well as non-active firms. We also omit from the analysis growth observations falling outside of the 5-to-95 percentile range of firms' value added growth rate and firms with significant state ownership.[17] Since Greek firms do not report value added, we used sales as a surrogate for them.[18]

Table 2.1 shows the final number of firm average value-added growth observations used in the study for each country,[19] together with simple firm-level descriptive statistics corresponding to these observations.[20] Next, Appendix Figures 2.A.1 and 2.A.2 present the EU-15-wide as well as the country-specific distribution of firm age and size, respectively. The firm size distribution is skewed, as expected. The firm coverage varies across countries; specifically, firm size in Germany is affected by non-reporting of small firms. Nevertheless, the data provide extensive coverage of most of the EU-15 economies and represent the best firm-level EU data source available

the data with residuals from a regression of all observed firm-level annual growth rates on year dummies. Further, in order to lower noise in the average growth rates, we rely only on companies that report value added for at least 5 years.

[17] Specifically, we drop firms in which the state is as an ultimate owner of at least 10 percent of shares or a direct owner of at least 10 percent of shares. There is virtually no sensitivity to the choice of the percentage threshold.

[18] See Guiso et al. (2004) for the use of sales instead of value added. We check for the sensitivity of excluding Greece from the analysis in Section 2.5.2.

[19] The presence of negative value-added growth rates complicates taking a compounded average. The reported growth rates therefore correspond to simple time averages of annual real value-added growth rates of the sampled companies taken over the 1995-2003 period.

[20] The primary reason why only about 15 thousand firms remains in our data from the TOP 250 thousand Amadeus module is that more than two-thirds of all firms in Amadeus are from non-manufacturing sectors. Our sample is further reduced as we only use companies with limited liability legal form that are reported as active and are incorporated in one of the EU15 countries. Finally, to enter our sample, a firm has to report the year of incorporation and its total assets have to be at least USD 1,000.

to date.

2.4.2 Financial Development Indicators

Data on financial development are drawn from the World Bank's Financial Structure and Economic Development Database (March 2005 version) described in detail in Beck et al. (2000). To make our results comparable with those in the literature we use a number of measures of finance activity to proxy financial development. We start with the traditional measures of activity in the credit and stock markets, namely the ratio of private credit to GDP (PCDMBANKOFINSTGDP) and the ratio of stock market capitalization and stock market total value traded to GDP (STMCAPGDP and STMTVTGDP, respectively). We also rely on a measure of total country-level finance activity equal to the sum of (i) stock market capitalization, (ii) bank credit to the private sector and (iii) domestic debt securities issued by the private sector. This summary measure (Total Capitalization) is taken from Hartmann et al. (2006) and is expressed, again, as a fraction of country-level GDP. All proxies for financial development are averaged over the years 1990-1994, that is, as of the establishment of the 'single market'.[21]

In addition to volume-of-finance-activity measures of financial development, we also use a proxy for the institutional quality of financial markets. Specifically, we follow Beck et al. (2004) and use an indicator of the 'quality of accounting standards' (ACCOUNT), produced by International Accounting and Auditing Trends (Center for International Financial Analysis & Research, Inc.). This indicator rates companies' 1990 annual reports on the basis of their inclusion or omission of 90 items in the balance sheets and income statements and ranges from 0 to 90.

All five indicators of financial development are summarized across our EU coun-

[21] We rely on time averages to avoid year-to-year fluctuations. In Section 2.5.2, we check for the sensitivity to using measures of financial development based on a later period.

tries in Table 2.2.[22] It is clear that despite the extensive integration of EU-15 national product markets up to 1994, there is still substantial diversity in the degree of financial development across the EU-15. The coefficient of variation is particularly high for our measures of stock-market activity. The bottom panel of Table 2.2 presents correlations (with statistical significance levels) among our different measures of financial development. The correlations suggest that these measures, although closely related, are nevertheless meaningfully different.

2.5 Results

2.5.1 Basic Estimates

Our analysis of average firm-level value-added growth rates covering 1995-2003 asks about age- and size-related differences in the effect of financial development on corporate growth following the introduction of the EU-15 'single market'. We estimate linear growth regressions conditioning on country and industry fixed effects, firm-specific controls, and the interaction of country financial development with a step function in firm size and/or age, as described in Equation (2.2) in Section 2.3. More specifically, we use industry dummies based on the 3-digit ISIC classification and rely on the following set of firm-level controls: age, size, leverage, tangibility, collateralization, share of equity capital on total assets (equity endowment) and indicators of being quoted, legal form type and ownership concentration; these controls are measured as of the first year a firm enters the sample. We drop firm observations falling outside of the 5-to-95 percentile range of value-added growth. The semi-parametric step-function interaction specifications are based on quintiles of the age or size distribution and allow for a non-proportional relationship between information asymmetry and firm size or age; they define the base (comparison) group as consisting of companies in the top 20% of the size or age distribution. We expect the growth rates of

[22] A detailed definition of each measure is provided in the Data Appendix Table 2.DA.1.

smaller and younger firms to be more sensitive to financial development because of information asymmetries.[23]

The basic set of results is presented in Table 2.3, which lists coefficients of interest: both firm age and size quintile base effects and the interactions of these base step functions with national financial development indicators. Each column corresponds to the choice of a particular indicator of financial development. The base size effect (at the bottom of the table), which consists of four size quintile steps, is precisely estimated and suggests, as expected, that smaller firms, in terms of total assets, on average grow substantially faster than larger companies. The size-growth gradient appears to be somewhat convex—the group of smallest companies grows particularly fast. Similarly, we recover a downward sloping age-growth gradient as the estimated base age step-function coefficients suggest that youngest companies grow on average faster than older ones.

The upper half of Table 2.3 presents the interactions with financial development. We estimate a decidedly non-linear shape of the age-financial development interaction. The youngest companies in our data appear not to benefit from the development of financial systems more than the oldest companies. On the other hand, companies located towards the center of the age distribution benefit disproportionately. The inverted-U age shape of the financial-development growth effect is remarkably similar across our different measures of financial development.[24]

In contrast to the age interaction with financial development indicators, the inter-

[23] One may expect very large and/or old firms to have access to international sources of finance and thus be less sensitive to differences in the development of national financial markets, which provides additional motivation for the use of the interaction of financial development with a step function in size or age. We can alternatively use median-age and median-size firms as the base group. Such specification checks whether country unobservables as well as financial development levels affect large and old companies differently from those at the median age and size. We have compared the main results presented in this paper to those (unreported) ones where we alternatively use the near-median firms as the base group. The two batteries of results were fully consistent.

[24] This finding is consistent with estimates reported by Aghion et al. (2007, p. 764).

action of company size (groups) is not significant in Table 2.3, irrespective of the type of financial development measure we use. Not only are the interaction coefficients statistically insignificant, they are also small, negative and similar in magnitude across the company size groups. In short, we detect no size-related differences in the growth effect of financial development.

2.5.2 *Initial Robustness Checks*

To provide initial robustness checks, we estimate several simple variants of the growth regressions of Table 2.3. First, we use decile steps in age or size instead of the quintile-step specification. Figure 2.1 visually presents both size- and age-financial development interactions (graphs on the left), as well as the base size and age effects (graphs on the right). The top (bottom) two graphs show parameter estimates corresponding to the size (age) groups. The decile age-finance interactions underscore the presence of an inverted-U age shape of the effect of financial development. Similarly, the decile specifications confirm the earlier finding of little evidence for the presence of a differential growth effect of finance across firms of different size, ceteris paribus.

Second, we estimate the age and size interactions separately. Table 2.3 conditioned on both age and size interactions simultaneously because of the obvious correlation between size and age. In an alternative specification, we re-estimate Equation (2.2) with only one of the interactions at a time. Such specification is potentially questionable because it is not clear to what extent the age interaction is merely a proxy for the size interaction and vice versa. However, we obtain coefficients that are near identical to those presented in Table 2.3. (These results are presented in Appendix Table 2.A.1.) The finding of no finance-size interaction is therefore robust to allowing age-related size differences to help estimate the size interaction, which is reassuring. These results also suggest that, in the subsequent analysis, we can focus on specifications with only the age-finance interactions.

Third, we replace the semi-parametric step-function interactions with fully parametric specifications. Estimates based on linear (Equation (2.1)) and cubic interactions for either age or size are presented in Appendix Table 2.A.2. The results based on linear interactions between financial development and firm size or age are confusing and suggestive of misspecification. The coefficient estimates suggest that larger firms benefit less from financial development compared to smaller companies, but we cannot precisely estimate the underlying base effect of company size on its growth, which is disturbing given the well-established negative relationship between a firm's size and its rate of growth.[25] The estimates of the linear age interaction coefficients are mostly positive, which contradicts much of the survey evidence discussed in Section 2.2. Clearly, these puzzling results are the consequence of forcing the interaction relationship to be linear. This is confirmed by the cubic specification estimates, which strongly support the presence of an inverted-U age interaction effect, and which also show little consistent evidence of significant size-related differences in the effect of financial development.

Fourth, a natural extension of our basic approach is to ask about the importance of the *combination* of small size and young age for the interplay between information asymmetries and financial development. Hence, we also estimate a size-age-financial development interaction. We use a relatively parsimonious specification of this 'triple' interaction in that we allow the quintile age-financial development interaction to be different for companies of below-median and above-median size. As before, the base comparison group consists of the oldest companies. The estimates (presented in Appendix Table 2.A.3) suggest that a similar inverted-U age-financial development interaction is present for both small (below median size) and large (above median size) companies. Again, company size appears to play little role.

Fifth, we also use an alternative estimation technique. In Appendix Table 2.A.4, we present results based on a median regression. Up to now, we have avoided the

[25] For example, Dunne et al. (1989) show that employment growth rates of US manufacturing firms decline with both company age and size.

influence of value-added growth outliers, present in any company-level financial data, by symmetrically excluding extreme values of growth rates from our linear 'mean' regressions. Here, we therefore alternatively employ median regressions, which are robust to outliers by design and allow us to use all available growth rate data (that is, even observations of average growth rates falling outside the 5-to-95 percentile range). The estimated coefficients are quantitatively highly similar to those presented in Table 2.3. The only cost of using a median regression is that we lose statistical significance of the inverted-U interaction parameters in most of the estimated specifications.[26] We conclude that our basic results are robust to a battery of robustness checks motivated by data-related as well as econometric questions.[27]

2.5.3 Interpreting the Basic Estimates

Our initial robustness checks confirm both the lack of the size interaction effect and the inverted-U shape of the age-related differences in the growth effects of financial development. The age interaction coefficients in Table 2.3 imply economically substantial differences in corporate growth: Moving from the minimum to the maximum value of our volume-of-finance-activity measures increases the average annual growth rate of a firm of median age (corresponding to the third quintile of the age distribution) compared to an otherwise comparable firm of age above the 80th age

[26] The clustered standard errors we report are bootstrapped.

[27] We have performed several additional robustness checks, in addition to those presented in the Appendix, with little effect on the parameters of interest: (i) We replaced industry fixed effects with industry-country dummies. (ii) We replaced financial-development indicators averaged over 1990-1994, i.e., before significant progress in EU financial integration, with those averaged over 1995-1998, i.e., before the introduction of the common currency in most of the EU-15 economies. (iii) We excluded Greece, the country for which only sales but no value added data was available. (iv) We used alternative definitions of the dependent variable: First, we replaced mean value-added growth rates with median value-added growth rates. Second, we used sales instead of value added to define company growth.

percentile by about 2 percentage points.[28]

How can one interpret these findings? First, what is the meaning of no differences in the effect of financial development between medium-sized and large firms? Our results are consistent with medium-sized firms being small not because of inadequate access to external finance, but because of having already reached their optimum size or because of internal problems. It could be that important size-related information asymmetries arise only for very small firms that do not satisfy our sample inclusion criteria, i.e., firms with fewer than 100 employees and less than 20 million Euro of total assets. Alternatively, it could be that our results are affected by the use of firm-level size measures; we explore this possibility in the next Section.

Second, what could be the underlying process that results in the inverted-U age shape of the financial development effect? Taking our estimates at face value, what does it mean that the highest benefits from financial development are experienced by median-aged firms—about 18 years after incorporation? One possibility is that the youngest firms are so informationally opaque that they have no access to external finance even in the most developed financial systems. As firms age, they gain access to external financing and, as a consequence, get closer to realizing their full growth potential. More financially developed systems start providing external financing earlier in company life. Such mechanism would result in the inverted-U age shape we estimate.[29] Alternatively, the inverted-U age shape could correspond

[28] For example, when considering the total capitalization interaction coefficient, the 2.6 percentage-point effect corresponds to comparing a 20 year old firm to a 40 year old company across the UK and Greece. The estimated difference in growth effects is about twice as large when we replace volume-of-finance-activity measures with our proxy for institutional development—the accounting standards index.

[29] A theoretical model that would generate this pattern is one in which: (i) corporate growth increases with a firm's external finance use, (ii) the debt capacity of the firm increases as its opaqueness decreases, and (iii) more developed financial institutions are more efficient at overcoming information asymmetries. The model of Tirole (2006), p. 171, section 4.4, would have most of these features if one were to identify the model's distinction between observable and unobservable outside

to other age-related variables affecting access to external financing, not information asymmetry. Below, we therefore ask in more detail what could explain the lack of a disproportionate financial-development growth effect for the youngest companies; this analysis also helps us to eliminate some of the alternative interpretations of the age profile of the finance-growth nexus.

2.5.4 Comparing Within- to Across-Industry Size Variation

The size-finance interactions in Table 2.3 are based on variation in firms' size that is driven by both across-industry technological differences and within-industry firm-level size differences. However, using within-industry differences in firm size as a source of identification raises an important concern. Companies that do not grow because of internal problems, and so remain smaller relative to a typical firm in their industry, may not be able to benefit from financial development. In other words, to interpret the estimates based on within-industry size variation as corresponding to information asymmetry, one assumes that deviations of company size from the respective industry mean size are unrelated to firms' unobservables directly affecting growth, but are related to firms' access to external finance. It is therefore important that we compare results based on within-industry size variation to findings based on across-industry (technology related) size variation, which is unlikely to be related to firm unobservables.

In Table 2.4, we estimate across-industry size interactions similar in spirit to those estimated by Beck et al. (2004). Specifically, the top panel of Table 2.4 presents a set of linear size-financial development interaction coefficients based on the EU-15-wide *industry median size* measured at the ISIC 3-digit industry level. That is, we replace the firm's size measure with company size typical of the firm's industry. All specifications include country and industry fixed effects and they also condition on firm-level controls used in specifications reported in Table 2.3. The estimated

growth opportunity with the distinction between high and low financial development, respectively.

interaction coefficients of interest are always negative, but never reach conventional levels of statistical significance. Even though these regressions employ company-level data, they implicitly measure the relationship between industry size (interacted with financial development) and industry growth rates. One potential problem with this approach is that even unusually small or large firms, relative to the industry typical size, are used to estimate the relationship between industry size and industry growth rate. To check for the importance of this measurement error, we exclude unusually small and unusually large firms, relative to industry typical size, from the estimation. These results, which rely only on firms that fall within the 40-60 percentile industry-specific size range, are presented in the second set of coefficients in the top panel of Table 2.4. The estimated parameters suggest that there is little relationship between corporate growth rates and the interaction of industry size with country financial development.

In the bottom part of Table 2.4, we re-introduce within-industry variation in firm size by interacting financial development with *firm-specific* size. However, we do so only for the companies that fall within the 40-60 percentile size range used in the previous specification.[30] Although based on firm-specific information (on both size and growth), such regressions correspond mainly to across-industry size comparisons. In the linear interaction specification, we obtain positive size interaction estimates that are, however, very imprecise. When using our basic step-function interaction specification, we obtain noisy estimates that are qualitatively similar to those presented in Table 2.3.

In sum, we find no evidence of a differential effect of financial development on firms of different size, irrespective of the type of size variation we employ. The fact that solely across- and solely within-industry comparisons lead to the same conclusion is reassuring. The notion that size-related unobservables are not causing our size-finance interactions based on within-industry size differences to be insignificant is

[30] We obtain highly similar evidence when using a 30-70 percentile range instead.

further supported by unreported regressions, in which we repeat the basic estimation of the size interaction coefficients from Table 2.3 after omitting our set of firm-level controls from the regressions. The interaction parameters of interest are not materially affected, which, to the extent that company observables and unobservables are correlated, is consistent with unobservables having only negligible effect on our estimation.[31]

2.5.5 *Age and Intangibles*

An important concern with the interpretation of the financial development interaction estimates as corresponding to information asymmetries has to do with the potentially different reliance of young firms on intangible assets. If financial development reduces the need for collateral or tangible assets, this may disproportionately improve access to external finance for those companies that use intangibles heavily. If young firms use intangibles more than old ones do, then our estimates thus far could correspond to the effect of intangibles, not to a reduction in the importance of information asymmetries with financial development.

To check for this alternative interpretation, we proceed in two steps. First, we estimate regressions (available upon request) of company tangibility on our basic set of firm-level control variables including size and age. We find that younger (as well as smaller) companies actually display a statistically significantly higher share of tangible assets.[32] Second, in Table 2.5 we compare the age shape of the financial development effect across firms with low (below median) and high (above median) share

[31] Similar comparisons have been employed in the analysis of gender or racial discrimination, e.g., by Hirsch and Schumacher (1992). See also Altonji et al. (2005) for estimation of binary treatment effects that use the extent of selection on observed characteristics as a guide to the extent of selection on unobservables.

[32] It could be that those young companies that are constrained in their access to finance (presumably because of information asymmetries), use a high share of tangible assets in order to improve their access to external finance.

of tangible assets.[33] We recover the familiar inverted-U age interactions with financial development for both groups of companies. In fact, by allowing the estimation to differentiate between low- and high-tangibility companies, the disproportionate growth benefit from financial development of median-aged companies compared to the oldest firms is highly similar across the two groups that differ in their share of tangible assets. The estimates are also highly comparable to those presented in Table 2.A.1.[34]

2.5.6 *Within-Industry Relative Age*

Our regressions are estimated based on simple (absolute) measures of firms' age or size. Specifically, our basic regressions interact financial development indicators with years since company incorporation and with company total assets expressed in a common currency. To interpret these basic estimates as corresponding to the effect of information asymmetries, one implicitly assumes that the degree of information asymmetry varies with size and age to the same (potentially non-linear) degree in different industries. However, if financial intermediaries use a different technology to evaluate projects of firms in different industries, i.e., industry-specific screening techniques, it is possible that the size (age) benchmark against which one measures the degree of information asymmetry differs across industries. A firm, which is young in absolute terms, could still be relatively old within its industry.

It may be that what matters for information asymmetry is the deviation of a given firm from the typical industry-specific size or age. We therefore form an alternative measure of age and size based on relative within-industry differences, where each

[33] We also allow the base quintile age growth gradient to be different for companies of below-median and above-median tangibility and we directly control for the growth gap among low- and high-tangibility firms.

[34] In order to check to what extent young age proxies for more than different asset intangibility, we also estimated the age-financial development interaction jointly with an interaction of financial development with an asset tangibility measure. The age-financial development interaction was similar.

firm's size or age is expressed as the percentage deviation from the industry median size or age.[35] The relative measure results in substantially different size and age rankings, i.e., the classification of firms into age or size groups. When assigning firms to quintiles of the firm size (age) distribution, we assign 28% (18%) of companies to a different quintile when using the absolute instead of the relative within-industry measure.

In Table 2.6, we ask whether those firms that are ranked differently based on the absolute and the relative within-industry age measure experience differential effects of financial development. The top panel of the Table presents the base age step function together with the interaction between the age step function and financial development indicators, similar to that presented in Table 2.3. In addition, we ask whether the age-finance interaction is different for those firms that are ranked as younger based on the within-industry comparison compared to the simple (absolute) age quintile ranking. If these relatively young firms are subject to strong information asymmetry despite being old in absolute terms, we would expect that the peak of the inverted-U shape for these firms will occur at higher absolute age level. In other words, in order to gain access to external finance, these firms must get older in terms of the industry-specific age ranking, even if they appear old in an all-industry comparison. This is indeed what we find in the top panel of Table 2.6, where the size of the median-age step in the financial-development interaction is lower while the next, fourth quintile step is much higher for the relatively young companies.

The bottom panel of the Table then asks the same question for the relatively old firms, i.e., those companies that appear young based on absolute age, but are relatively old in terms of their industry age distribution. For these companies, we would expect that the peak of the inverted-U interaction will occur earlier. The

[35] Clearly, the *base* size (age) growth effects in our main specifications are already based on relative within-industry measures since conditioning on industry dummies transforms the data into deviations from industry averages.

results confirm our expectations in that there is little of a disproportionate effect for these firms in the fourth absolute age quintile, which happens to be the fifth and last age quintile for them in terms of within-industry age rankings. Furthermore, the inverted-U shape for the relatively old firms is relatively flat across the second and third absolute age quintile, instead of having a strong peak at the third quintile step.

In sum, we find this evidence supportive of the notion that relative within-industry age rankings, as opposed to absolute age comparisons, are related to access to external finance. Given that financial intermediaries are well known to segment their operations by industries, we find this evidence suggestive of within-industry relative age (company history) being related to the degree of information asymmetry.[36]

2.5.7 Equity Endowment of Youngest Companies

Our initial expectation, based on finance theory and survey evidence, was that there would be disproportionately high effect of financial development on growth of the youngest companies because they are strongly affected by information asymmetries. It is therefore important to understand why we find less evidence for a disproportionate effect of financial development on the youngest companies compared to those of near-median age. In this Section, we investigate an explanation based on selective entry due to financial system development. The hypothesis is that startups in less financially developed economies expect that after incorporation it may be hard (or take longer) to raise additional external finance; hence, these startups are likely to incorporate only if they can marshal an unusually high amount of initial equity (in comparison to otherwise similar startups in more financially developed systems). Such selective entry of firms endowed with high equity capital shares in

[36] In unreported specifications, we find little effect of controlling for firms' relative within-industry size position.

less financially developed countries would then make the youngest companies in less financially developed economies temporarily less sensitive to their respective financial environments, which is consistent with our estimated interactions coefficients.

To provide evidence on this hypothesis, we ask whether the share of equity capital on total assets, which we refer to as equity endowment, differs for otherwise similar newly incorporated companies across different financial systems. The top panel of Table 2.7 reports estimates of interest from regressions of company equity endowment on our set of firm characteristics, including age and a dummy for being within one year of incorporation. We also interact our indicators of financial development with the dummy for freshly incorporated firms. As always, we control for a set of industry and country fixed effects. Conditional on the differences in equity endowment of all firms across different financial systems, which are absorbed in the country dummies, we ask whether the age gradient of equity endowment differs across countries. Specifically, we focus on the equity endowment difference between the startups and all older companies. The coefficients on the interaction between the startup indicator (Incorporation) and financial development are all negative and some are statistically significant, while the base startup effect is positive and significant, as expected. (These findings are not affected by the specification of the base age effect.) In comparison to older companies, startups feature an unusually high share of equity on total assets, but this gap between startups and older firms is smaller in more financially developed economies, consistent with our hypothesis.

The implications of such adjustment to national financial development for our estimation of age-related growth effect differences are clearly visible in the second panel of Table 2.7, where we present estimates from our standard firm growth regressions. The novelty is that we now allow the age-finance interaction to be different for firms with equity endowment below the 30th percentile of the equity endowment EU-15-wide distribution. In simple terms, we interact the age-finance interaction with a dummy indicator for having low equity endowment, i.e., a dummy for higher external finance use.[37] The results are striking. Focusing on the youngest companies with low share of equity capital on total assets, i.e., recently incorporated firms that are likely to need external finance to grow, we find a strong and statistically significant age-finance interaction coefficient. The difference in the age shape of the financial development effect related to equity endowment disappears over company life, such that by median age (i.e., about 18 years after incorporation) company equity endowment is not related to financial development growth effects. (This is consistent with our hypothesis of better access to external finance among the older companies.) The estimated disproportionate growth effect for the youngest firms with low equity endowment is sometimes as large or larger than that recorded at the peak of the inverted-U age-finance interaction estimated earlier. Hence, it is likely that the reason why we are not able to find strong disproportionate growth effects of financial development for *all* youngest companies has to do with the selective entry of more equity-endowed firms in less financially developed countries.

2.5.8 *Firm Entry and Exit*

One other potential explanation for the finding of no disproportionate effect of financial development on the youngest companies is related to the effects of financial development on firm entry. A poor financial system may prevent firms from reaching their optimal size and the measurement of such corporate growth effect is the object of our analysis. However, a poor financial system may also prevent entry of profitable companies. Our analysis of firm growth is therefore complementary to that of Klapper et al. (2006) and Aghion et al. (2007), who study the effect of county-level financial institutions on entry of new firms. Applying the Rajan-Zingales identification strategy at industry level, they find, among other results, that firm entry is higher in industries predicted to be in more need of external finance in countries

[37] Firms with low equity endowment rely on external finance availability as only a small fraction of their total assets is financed through equity.

that have a higher level of financial development. Klapper et al. (2006) also suggest, similar to other existing studies, that entrants are on average larger in countries with a lower level of financial development.[38]

Similar to Aghion et al. (2007), our study focuses on the growth effects of financial development after firm entry (incorporation). It is therefore important that we consider the implications for our estimation of the potentially different (unobservable) growth potential of firms entering in countries that differ in their degree of financial development. The differences in firm entry processes across countries could induce differences in unobservable entrant quality in our sample. As a hypothetical example, if entering companies in the highly financially developed UK environment are on average of lower growth potential than entrants in less financially developed Greece, then the higher effect of financial development on growth of young companies may be obscured by this sample selection on unobservable growth potential.[39]

However, we believe that this issue does not significantly affect our estimation. First, our estimation controls for the difference in growth rates of firms of different sizes; hence, to the extent that growth potential at entry is proxied by size at entry (as in Beck and Demirgüç-Kunt, 2006), our estimation is unlikely to be affected by the higher fraction of larger entrants in less financially developed countries.

Second, we use the 'TOP 250 thousand' module of the Amadeus data, which means that we do not study the growth of very small entrants. More specifically, our data cover firms with an operating revenue of at least 10 million Euro or total assets above 20 million Euro or more than 100 employees (or any combination of these conditions). The fact that we analyze post-entry growth of firms of a certain

[38] Alfaro and Charlton (2006) provide similar evidence. Beck and Demirgüç-Kunt (2006) survey the literature on the interplay between financial systems and firm size distribution.

[39] Aghion et al. (2007) estimate the finance-growth relationship using firm growth six years after entry. This strategy addresses the issue of selective entry on unobservable growth potential to the extent that entrants in highly financially developed countries with low growth potential have not survived until the sixth year.

minimum size ought to minimize selection effects that remain after conditioning on size, i.e., growth potential differences of entrants of identical size across different financial systems.[40]

Third, to provide first-step evidence on the importance of the size-related sample selection criteria for dealing with potentially different unobservables at firm entry, we re-estimated our main specifications after excluding from the data all firms in the bottom quintile of the EU-15-wide firm size distribution. This corresponds to imposing even stricter firm selection criteria in terms of size than those used by the 'TOP 250 thousand' module of the Amadeus data. The estimates, available on request, were highly similar to those presented in Table 2.3, suggesting that potential differences in firm quality at entry are not related to firm size, given the use of the 'TOP 250 thousand' data module.

So far we have discussed the implications of firm entry being affected by financial development for our estimation. By the same token, however, it is also possible that a selective exit of companies from our sample related to the level of financial development affects our estimation. For example, it could be that a highly developed financial system "weeds out,"through competitive pressure, companies that would survive in a less financially developed environment.[41] In this regard, we note that our estimation is based on average (or median) growth rates during our sample period. As a result, companies that disappear from our data towards the end of the sample frame are still represented in the data. We have also re-estimated our main

[40] Our presentation of the argument about selectivity is based on the unobservable quality of projects (growth potential). A similar line of argument could be built around the degree of information opaqueness, such that a Greek entrant may be expected to feature a lower level of opaqueness compared to the average entering UK company.

[41] Indeed, our preliminary analysis suggests that a firm is more likely to exit from Amadeus databases between 1997 and 2003 if it operates in a more financially developed environment and that this exit 'gap' is larger across countries for younger and smaller companies. However, given that there is little information on the reason for exit from the database (e.g., bankruptcy, merger, non-reporting), we hesitate to draw conclusions.

specifications based on two alternative samples, which differ in the degree of survival-related sample selection. First, we omitted all companies that disappear from the Amadeus database before the end of our data in 2003. Such *additional* sample selection ought to magnify any sample selection bias, but we obtain results (available upon request), which are fully consistent with those based on our main sample. Second, we additionally include companies that have less than 5 annual value-added observations available in the Amadeus database during our sample period.[42] Again, there was little difference in the estimates when compared to our main results.

2.6 Conclusion

We employ the difference-in-differences strategy to measure the ability of national financial systems to foster corporate growth through tackling financial frictions proxied by firm size and age. We study the effects of financial development on firm growth conditional on firms having reached a certain minimum size (having at least 100 employees or more than 20 million Euro of total assets), such that we capture these effects after the initial selection of projects at entry has taken place. Our estimation contrasts the growth performance of comparable companies operating within the EU-15 'single market', where they face harmonized product market regulation and common industry structure of growth opportunities, but where they must cope with significantly different national financial systems. Our estimates are robust to excluding potentially endogenous firm-specific variables and using alternative sources of variation in firm size. We have also ruled out several interpretations of our estimates based on age- and size-specific covariates interacting with financial development.

Using both across-industry and within-industry comparisons, we find little evidence of a differential effect of financial development on firms of different size, conditional on firms being of a certain minimum size. Since we do not study very small

[42] Such companies were not used in all of our estimation so far, see note n. 16.

firms, our findings are not inconsistent with the notion that financial market development benefits very small firms disproportionately, as suggested recently by the study of firm entry by Klapper et al. (2006). Taken at face value, our evidence implies that medium-sized firms are medium-sized for reasons unrelated to financial system development. This would weaken the credit-constraint rationale for the support provided by the EU to medium-sized enterprises as the EU classifies into the SME category those firms with fewer than 250 employees and balance sheet totals below 43 million Euro, i.e., many of the small firms present in our data.

Our main finding is that firms of approximately median age benefit more from financial development in comparison to old firms. In fact, we estimate an inverted-U shape for the age-financial development interaction, which is consistent with very young firms having relatively little access to the financial systems of EU-15 economies. However, we uncover an alternative and more appealing explanation for the lack of disproportionate growth effects of financial development among the youngest companies. We find that freshly incorporated firms in less financially developed countries typically have unusually high shares of equity capital in total assets.

The literature on firm entry (e.g., Klapper et al., 2006) detected that entrants are on average larger in countries with a lower level of financial development. Our new evidence points to important differences in the capital structure of startups across different financial development levels—differences that are consistent with difficult access to external finance for youngest companies in less developed countries. Startups in less financially developed economies expect that after incorporation it may be hard to raise additional external finance; hence, they incorporate only if they can marshal an unusually high amount of initial equity. This temporarily 'protects' these entrants from the lack of external financing implied by less developed financial systems. Consequently, when focusing on those youngest companies that have low shares of equity capital, there is a disproportionate positive effect of financial development, consistent with the notion that more developed financial systems are better at tackling age-related information asymmetry. Financial development therefore appears to offer an effective way of promoting the growth of young firms even within a set of comparable highly developed economies.

Using volume-of-finance-activity measures[43] we find that moving from the least to the most developed financial system within the EU-15 results in a value-added growth rate advantage of a median-aged firm over a firm positioned in the top quintile of the age distribution of about 2 percentage points. The age-related difference in the effects of institutional quality, proxied here by a measure of accounting standards, is at least as large. Similar growth effects are experienced by those very young companies that are not rich in equity capital.

Finally, we also provide some evidence that information asymmetry is related not only to absolute age of firms, but also to their relative, within-industry age. Such finding is consistent with the existence of industry-specific screening techniques used by financial institutions to evaluate requests for external finance. The age benchmark against which one measures the degree of information asymmetry may be different across industries.

[43] We note that our use of volume-of-finance indicators of financial development implies that our findings are consistent with the notion that *deeper* financial markets are more *efficient* in overcoming information asymmetry. Wurgler (2000) and Braun (2006) imply that deeper financial systems display better allocative efficiency.

Appendix A: Figures

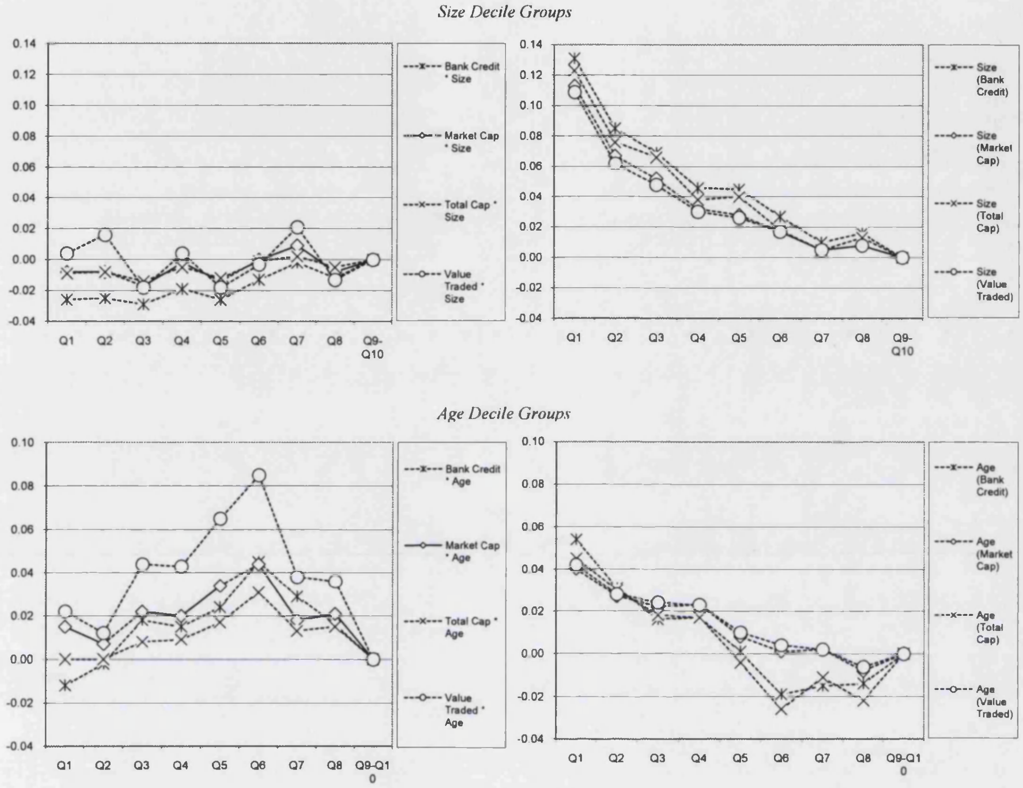

Fig. 2.1: Financial Development (FD) and Corporate Growth: Age and Size Decile Groups

Note: The left two graphs of the Figure report estimates obtained by interacting financial development measures with a step function based on (i) a firms position in deciles of the firm size distribution (top left graph) and (ii) the corresponding age effect (bottom left graph). The two graphs on the right report the respective base effects. Age (the number of years since a firms incorporation as of 1995) is scaled down by 100 while Size (total assets) is in millions of US dollars. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies.

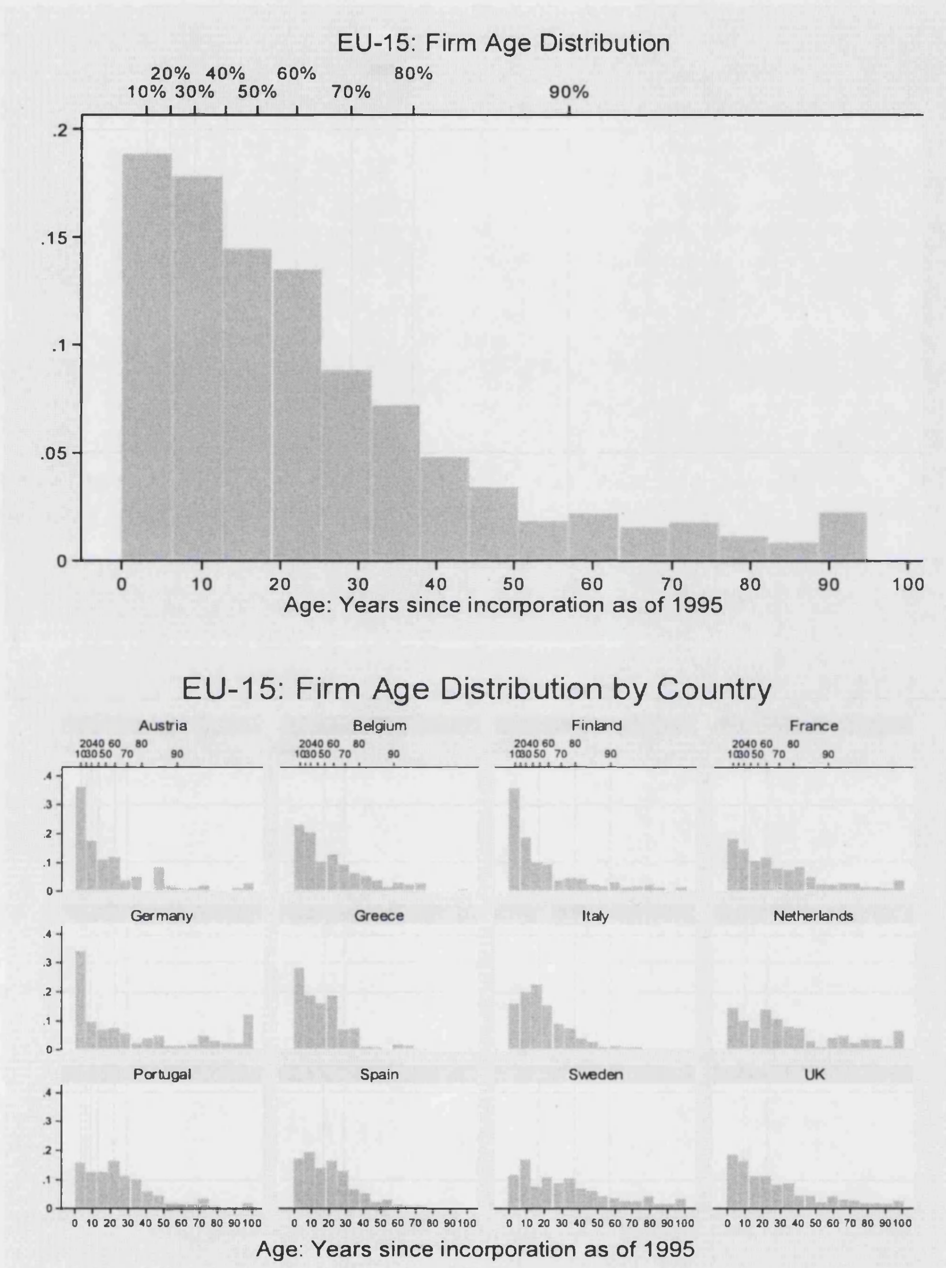

Fig. 2.A.1: EU-15: Firm Age Distribution

Note: Age (the number of years since firm incorporation as of 1995) is measured along the horizontal axis. The upper horizontal axis of each graph indicates deciles of the EU-15-wide age distribution. Before plotting the histograms we remove growth outliers (we use only the 5-to-95 percentile range of average firm value-added growth rate) and firms with less than 5 years of value-added data available. See the Data Appendix for complete definitions and sources of variables.

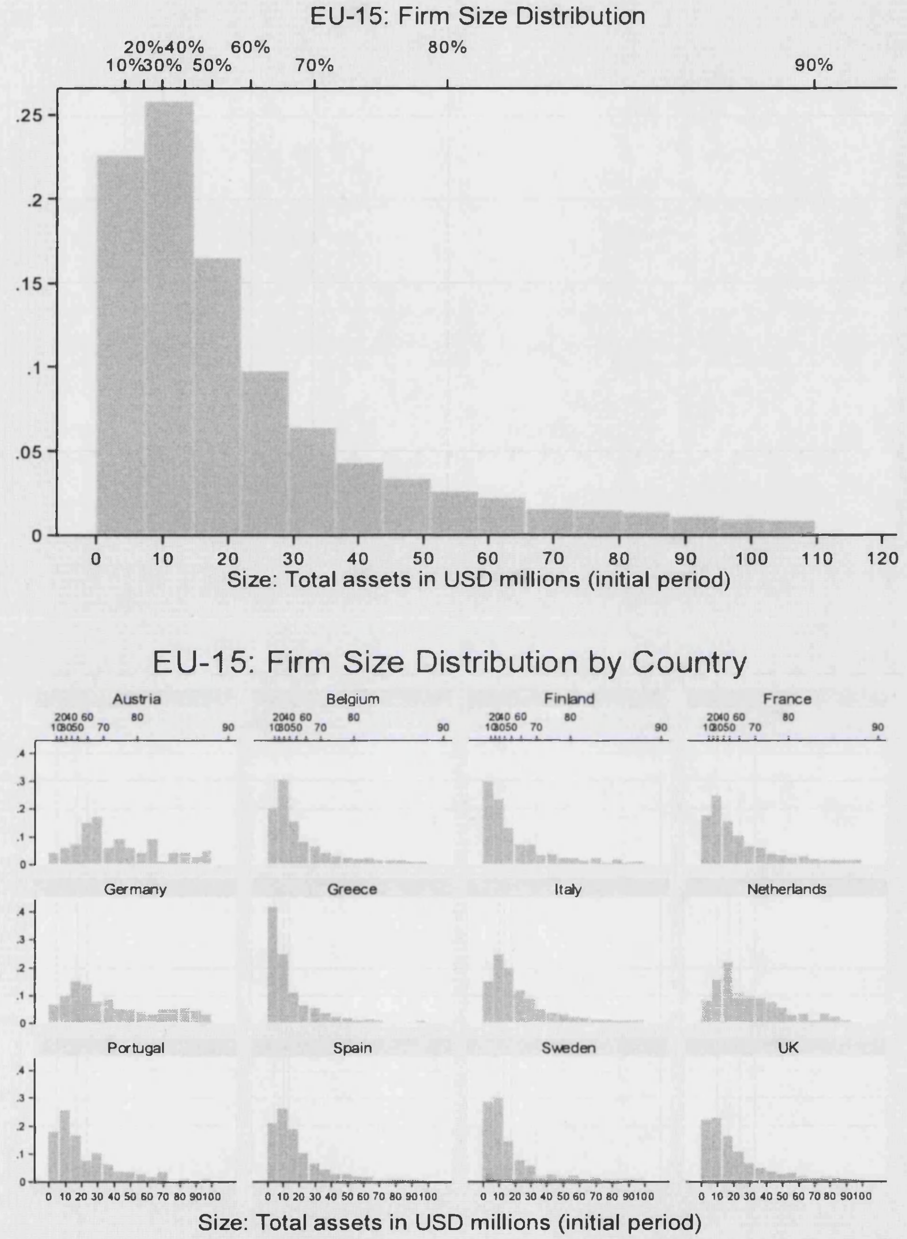

Fig. 2.A.2: EU-15: Firm Size Distribution

Note: Size (total assets in millions of US dollars as of the first year a firm enters the sample) is measured along the horizontal axis. The upper horizontal axis of each graph indicates deciles of the EU-15-wide size distribution. Before plotting the histograms we remove growth outliers (we use only the 5-to-95 percentile range of average firm value-added growth rate) and firms with less than 5 years of value-added data available. See the Data Appendix for complete definitions and sources of variables.

Appendix B: Tables

Tab. 2.1: Corporate Descriptive Statistics by Country: Firm Data over 1995-2003

	Size			Age			Growth			N
	Mean	Median	S.D.	Mean	Median	S.D.	Mean	Median	S.D.	
Austria	120.4	45.8	308.1	19.3	10.0	22.4	0.021	0.013	0.167	122
Belgium	71.4	15.3	243.8	22.4	17.0	20.1	0.010	0.001	0.096	1,367
Finland	57.2	15.0	177.4	20.5	10.0	22.7	0.048	0.037	0.110	499
France	109.1	19.5	765.6	29.3	23.0	25.0	0.024	0.014	0.086	1,488
Germany	381.0	78.1	1632.1	33.2	19.0	33.9	0.002	-0.007	0.087	473
Greece	23.5	9.0	62.8	16.3	14.0	14.1	0.062	0.050	0.089	658
Italy	49.3	17.8	324.7	20.1	16.0	15.7	0.030	0.020	0.083	4,599
Netherlands	204.8	28.5	878.2	35.7	30.0	28.5	-0.001	-0.015	0.088	174
Portugal	54.7	17.6	208.0	27.5	22.0	21.7	0.004	-0.010	0.083	211
Spain	46.0	15.5	168.0	21.6	18.0	17.0	0.053	0.047	0.082	2,375
Sweden	70.2	11.9	345.6	33.3	28.0	25.6	0.045	0.039	0.093	983
UK	89.4	18.8	379.6	28.7	22.0	25.1	0.057	0.052	0.109	2,230

Note: The number of firm observations in the sample, N, corresponds to observations with non-missing average value-added growth rate. Size (total assets) is in millions of US dollars. Age is the number of years since firm incorporation. Growth is the average real value-added growth rate over 1995-2003. Size is measured as of the first year a firm enters the sample while Age is as of 1995. Before computing these statistics we remove growth outliers (we use only the 5-to-95 percentile range of average firm value-added growth rate) and firms with less than 5 years of value-added data available. See the Data Appendix for complete definitions and sources of variables.

Tab. 2.2: Financial Development: The EU-15 over 1990-1994

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
		Basic Statistics			
Mean	0.86	0.31	1.35	0.13	0.64
Median	0.89	0.22	1.45	0.07	0.63
S.D. / Mean	0.38	0.80	0.33	0.94	0.20
Min	0.32	0.10	0.51	0.03	0.36
Max	1.41	0.97	2.25	0.45	0.83
Min Country	Greece	Austria	Greece	Greece	Portugal
Max Country	Netherlands	UK	UK	UK	Sweden
N	12	12	12	12	12
		Correlations			
Private Bank Credit	1.00				
Market Capitalization	0.57*	1.00			
Total Capitalization	0.71**	0.79***	1.00		
Market Value Traded	0.64**	0.90***	0.80***	1.00	
Accounting Standards	0.60**	0.57*	0.67**	0.51*	1.00

Note: We first compute the country average of each financial development measure in the period 1990-1994 (the exceptions is Accounting Standards, which correspond to 1990). Second, we present the Mean, Median, Coefficient of Variation, Min, and Max of the country averages from the first step across EU-15 countries. Denmark, Ireland, and Luxembourg are not included in this EU-15 comparison as they do not enter our firm-level analysis. The reported country-level financial development variables are used as explanatory variables in our regressions. See the Data Appendix for complete definitions and sources of variables.

Tab. 2.3: Financial Development (FD) and Corporate Growth: Age and Size Quintile Groups

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
FD * Age Q1	-0.004	0.009**	0.002	0.010	0.009
	(0.007)	(0.004)	(0.004)	(0.009)	(0.025)
FD * Age Q2	0.013**	0.015***	0.007**	0.030***	0.044**
	(0.005)	(0.002)	(0.002)	(0.005)	(0.018)
FD * Age Q3	0.020**	0.023***	0.015***	0.042***	0.088***
	(0.008)	(0.005)	(0.003)	(0.008)	(0.018)
FD * Age Q4	0.010**	0.007**	0.007**	0.014**	0.040***
	(0.003)	(0.003)	(0.002)	(0.005)	(0.010)
FD * Size Q1	-0.020	-0.007	-0.007	0.013	-0.038
	(0.033)	(0.021)	(0.012)	(0.036)	(0.096)
FD * Size Q2	-0.021	-0.010	-0.009	-0.008	-0.065
	(0.023)	(0.014)	(0.010)	(0.023)	(0.062)
FD * Size Q3	-0.018	-0.008	-0.006	-0.011	-0.050
	(0.013)	(0.008)	(0.006)	(0.014)	(0.036)
FD * Size Q4	-0.008	-0.001	-0.002	0.002	-0.019
	(0.007)	(0.003)	(0.003)	(0.006)	(0.024)
Age Q1	0.027***	0.020***	0.020***	0.022***	0.018
	(0.005)	(0.003)	(0.005)	(0.002)	(0.016)
Age Q2	0.006	0.012***	0.007*	0.012***	-0.013
	(0.004)	(0.002)	(0.003)	(0.002)	(0.012)
Age Q3	-0.007	0.001	-0.011**	0.003	-0.050***
	(0.005)	(0.002)	(0.004)	(0.002)	(0.012)
Age Q4	-0.007*	-0.002	-0.008**	-0.001	-0.026***
	(0.003)	(0.002)	(0.004)	(0.002)	(0.007)
Size Q1	0.100***	0.086***	0.094***	0.082***	0.110
	(0.030)	(0.012)	(0.020)	(0.013)	(0.066)
Size Q2	0.057**	0.043***	0.052***	0.040***	0.082*
	(0.020)	(0.009)	(0.016)	(0.009)	(0.043)
Size Q3	0.036**	0.023***	0.030**	0.022***	0.054*
	(0.012)	(0.006)	(0.011)	(0.006)	(0.025)
Size Q4	0.014**	0.008**	0.011*	0.007**	0.020
	(0.006)	(0.003)	(0.005)	(0.003)	(0.016)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.21	0.21	0.21	0.21	0.21

Note: The dependent variable is the time average of annual firm-level real value-added growth rates of manufacturing firms in the period 1995-2003. The Table reports estimates obtained by interacting financial development measures with two step functions, one based on a firm's position in quintiles of the firm age distribution, the other based on quintiles of the firms' size. Estimates are based on the absolute measure of firm age (the number of years since a firm's incorporation as of 1995) scaled down by 100 and the absolute measure of firm size (total assets in millions of US dollars). All country-level financial development variables are predetermined.

We also include (non-reported here) firm-level control variables: Leverage, measured as long-term debt plus current liabilities divided by total assets; Tangibility, measured as fixed assets divided by total assets; Collateralization, defined as fixed assets plus inventories plus accounts receivables divided by total assets; Trade credit, measured as accounts payables divided by total assets; and Equity endowment, measured as equity capital divided by total assets. Tangibility, Collateral, and Trade Credit are measured as the percentage deviation from the respective industry median on a 3-digit ISIC level and are scaled down by 10,000. Age and Size (as well as all other firm-level control variables) come from the first year a firm enters the sample and remain fixed over time.

We also include indicators for ownership concentration, a dummy for quoted firms, and a dummy for firms that have a Private Limited Company legal form. See the Data Appendix for complete definitions and sources of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.4: Financial Development (FD) and Corporate Growth: Using Across-Industry Size Variation

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
		All Firms			
FD * Industry Size	-0.419	-0.509	-0.271	-1.150	-2.059
	(0.548)	(0.382)	(0.265)	(0.777)	(1.548)
Firm Size	-0.003	-0.004*	-0.003	-0.003	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
N	14,740	14,740	14,740	14,740	14,740
adjusted R^2	0.10	0.10	0.10	0.10	0.10
		Firms Near Industry Median Size			
FD * Industry Size	-0.294	0.459	0.144	0.783	-0.006
	(0.706)	(0.557)	(0.411)	(1.212)	(1.915)
Firm Size	-0.757	-0.743	-0.751	-0.740	-0.753
	(0.453)	(0.456)	(0.455)	(0.455)	(0.455)
N	3,006	3,006	3,006	3,006	3,006
adjusted R^2	0.10	0.10	0.10	0.10	0.10
		Firms Near Industry Median Size			
FD * Firm Size	0.014	0.796	0.520	1.217	0.793
	(0.700)	(0.734)	(0.466)	(1.355)	(2.305)
Firm Size	-0.764	-0.993**	-1.453*	-0.893**	-1.276
	(0.654)	(0.463)	(0.741)	(0.430)	(1.556)
N	3,006	3,006	3,006	3,006	3,006
adjusted R^2	0.10	0.10	0.10	0.10	0.10
		Firms Near Industry Median Size			
FD * Firm Size Q1	-0.008	-0.016	-0.009	-0.032	-0.025
	(0.017)	(0.009)	(0.009)	(0.018)	(0.035)
FD * Firm Size Q2	-0.011	-0.032***	-0.022***	-0.058**	-0.053
	(0.022)	(0.007)	(0.007)	(0.019)	(0.061)
FD * Firm Size Q3	-0.006	-0.012	-0.004	-0.022	-0.029
	(0.018)	(0.009)	(0.010)	(0.017)	(0.038)
FD * Firm Size Q4	-0.002	-0.019**	-0.010	-0.040**	-0.014
	(0.020)	(0.007)	(0.007)	(0.014)	(0.062)
Firm Size Q1	0.016	0.015	0.023	0.015	0.027
	(0.018)	(0.009)	(0.016)	(0.008)	(0.025)
Firm Size Q2	0.016	0.018**	0.038***	0.015	0.042
	(0.018)	(0.008)	(0.012)	(0.009)	(0.039)
Firm Size Q3	-0.000	-0.001	0.001	-0.002	0.014
	(0.017)	(0.007)	(0.016)	(0.006)	(0.027)
Firm Size Q4	0.002	0.007	0.015	0.006	0.010
	(0.014)	(0.004)	(0.011)	(0.004)	(0.039)
N	3,006	3,006	3,006	3,006	3,006
adjusted R^2	0.10	0.10	0.10	0.10	0.10

Note: The top panel of the Table reports estimates from linear specifications, in which we interact financial development variables with industry median firm size (on ISIC 3-digit level). In all specifications we control for the set of firm-level control variables used in Table 3. The second set of results is analogous to the first one, except that we only use companies falling into the 40-60 percentile range of industry-specific size distributions. This sub-sample is then used in the bottom panel, where we interact financial development with firm-level size. Firm size is measured using total assets in millions of US dollars as of the first year a firm enters the sample and remains fixed over time. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available.

We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at ISIC 3-digit-level in the first two panels, clustered at firm level in the third panel, and clustered at country level in the last panel) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.5: Financial Development (FD) and Corporate Growth: Age Quintile Groups by Tangibility (TAN)

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
FD * Age Q1 * TAN low	-0.003	0.001	0.001	0.012	0.035
	(0.017)	(0.010)	(0.006)	(0.019)	(0.058)
FD * Age Q2 * TAN low	0.020**	0.015***	0.006	0.032**	0.076**
	(0.007)	(0.004)	(0.004)	(0.011)	(0.026)
FD * Age Q3 * TAN low	0.035**	0.042***	0.025***	0.082***	0.144***
	(0.013)	(0.004)	(0.003)	(0.009)	(0.044)
FD * Age Q4 * TAN low	0.029**	0.030***	0.023***	0.060***	0.111***
	(0.010)	(0.005)	(0.004)	(0.009)	(0.032)
FD * Age Q1 * TAN high	-0.006	0.020**	0.001	0.026	0.016
	(0.013)	(0.007)	(0.010)	(0.019)	(0.047)
FD * Age Q2 * TAN high	0.015	0.026***	0.011	0.054***	0.054
	(0.012)	(0.004)	(0.007)	(0.011)	(0.041)
FD * Age Q3 * TAN high	0.036**	0.038***	0.024***	0.072***	0.138***
	(0.012)	(0.004)	(0.003)	(0.010)	(0.041)
FD * Age Q4 * TAN high	0.016**	0.012**	0.007	0.020*	0.066***
	(0.007)	(0.005)	(0.004)	(0.010)	(0.020)
TAN low	0.002	0.001	0.002	0.001	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Age Q1 * TAN low	0.043**	0.040***	0.039***	0.039***	0.017
	(0.014)	(0.005)	(0.008)	(0.006)	(0.039)
Age Q2 * TAN low	0.015*	0.025***	0.021***	0.026***	-0.020
	(0.008)	(0.004)	(0.006)	(0.005)	(0.020)
Age Q3 * TAN low	-0.010	0.004	-0.017**	0.007**	-0.078**
	(0.009)	(0.003)	(0.006)	(0.003)	(0.029)
Age Q4 * TAN low	-0.019**	-0.006*	-0.027***	-0.004	-0.069***
	(0.007)	(0.003)	(0.006)	(0.002)	(0.021)
Age Q1 * TAN high	0.038***	0.027***	0.032**	0.030***	0.023
	(0.007)	(0.006)	(0.011)	(0.004)	(0.030)
Age Q2 * TAN high	0.017*	0.019***	0.014	0.021***	-0.008
	(0.008)	(0.004)	(0.008)	(0.004)	(0.026)
Age Q3 * TAN high	-0.010	0.005	-0.015***	0.007*	-0.074**
	(0.007)	(0.004)	(0.004)	(0.003)	(0.026)
Age Q4 * TAN high	-0.009	-0.000	-0.006	0.001	-0.041**
	(0.008)	(0.004)	(0.008)	(0.004)	(0.015)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.12	0.12	0.12	0.12	0.12

Note: The Table reports estimates of a triple-interaction specification, in which we multiply the interaction of financial development measures with a step function based on firms' position in quintiles of the firm age distribution by a dummy variable for 'Low tangibility' firms (those with below-median tangibility) or by a dummy variable for 'High tangibility' firms (those with above-median tangibility). Estimates are based on the absolute measure of firm age (the number of years since a firm's incorporation as of 1995) scaled down by 100. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.6: Financial Development (FD) and Corporate Growth: Absolute vs. Relative Age Quintile Groups

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
	Industry-wise Relatively Younger Firms				
FD * Age Q2 * Relat_Young	-0.012	-0.011	-0.007	-0.029	-0.018
	(0.011)	(0.020)	(0.005)	(0.050)	(0.010)
FD * Age Q3 * Relat_Young	-0.009	-0.015*	-0.004	-0.037*	-0.006
	(0.005)	(0.008)	(0.003)	(0.018)	(0.007)
FD * Age Q4 * Relat_Young	0.014***	0.036***	0.009***	0.072***	0.018***
	(0.004)	(0.003)	(0.002)	(0.007)	(0.004)
FD * Age Q5 * Relat_Young	0.001	0.010	0.001	0.023	-0.001
	(0.005)	(0.008)	(0.003)	(0.017)	(0.006)
FD * Age Q1	-0.006	0.012	0.000	0.019	0.019
	(0.013)	(0.008)	(0.008)	(0.019)	(0.040)
FD * Age Q2	0.017	0.022***	0.009	0.046***	0.060
	(0.010)	(0.004)	(0.006)	(0.011)	(0.033)
FD * Age Q3	0.036**	0.041***	0.025***	0.080***	0.139***
	(0.013)	(0.004)	(0.003)	(0.009)	(0.042)
FD * Age Q4	0.021**	0.016***	0.013***	0.030***	0.083***
	(0.007)	(0.004)	(0.003)	(0.007)	(0.021)
Age Q1	0.041***	0.033***	0.036***	0.034***	0.024
	(0.010)	(0.005)	(0.009)	(0.004)	(0.027)
Age Q2	0.016*	0.022***	0.018**	0.023***	-0.010
	(0.008)	(0.004)	(0.008)	(0.004)	(0.023)
Age Q3	-0.010	0.005	-0.016**	0.007**	-0.075**
	(0.008)	(0.003)	(0.004)	(0.003)	(0.027)
Age Q4	-0.014**	-0.003	-0.016**	-0.001	-0.054***
	(0.006)	(0.003)	(0.006)	(0.003)	(0.015)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.12	0.12	0.12	0.12	0.12
	Industry-wise Relatively Older Firms				
FD * Age Q1 * Relat_Old	-0.019**	-0.027**	-0.009**	-0.066**	-0.024**
	(0.007)	(0.009)	(0.004)	(0.024)	(0.008)
FD * Age Q2 * Relat_Old	-0.005	-0.010	-0.004	-0.014	-0.009
	(0.007)	(0.009)	(0.003)	(0.015)	(0.008)
FD * Age Q3 * Relat_Old	-0.011	-0.019**	-0.006*	-0.040**	-0.014*
	(0.006)	(0.007)	(0.003)	(0.013)	(0.007)
FD * Age Q4 * Relat_Old	-0.027**	-0.039**	-0.015**	-0.083**	-0.035***
	(0.003)	(0.011)	(0.002)	(0.026)	(0.004)
FD * Age Q1	-0.006	0.013*	0.001	0.022	0.019
	(0.013)	(0.007)	(0.008)	(0.017)	(0.040)
FD * Age Q2	0.017	0.022***	0.009	0.045***	0.061
	(0.011)	(0.004)	(0.006)	(0.011)	(0.034)
FD * Age Q3	0.037**	0.042***	0.025***	0.081***	0.141***
	(0.013)	(0.004)	(0.003)	(0.009)	(0.042)
FD * Age Q4	0.026***	0.024***	0.016***	0.047***	0.090***
	(0.007)	(0.004)	(0.003)	(0.009)	(0.022)
Age Q1	0.042***	0.033***	0.036***	0.034***	0.025
	(0.010)	(0.005)	(0.009)	(0.004)	(0.027)
Age Q2	0.016*	0.022***	0.017*	0.023***	-0.011
	(0.009)	(0.004)	(0.008)	(0.004)	(0.023)
Age Q3	-0.010	0.004	-0.016**	0.007**	-0.075**
	(0.008)	(0.003)	(0.004)	(0.003)	(0.027)
Age Q4	-0.015**	-0.003	-0.017**	-0.002	-0.054***
	(0.006)	(0.003)	(0.006)	(0.003)	(0.015)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.12	0.12	0.12	0.12	0.12

Note: The Table reports estimates of a triple-interaction specification, in which we multiply the interaction of financial development measures with a step function based on firms' position in quintiles of the absolute firm age distribution by a dummy variable for 'Relatively Younger' firms (top panel) or by a dummy variable for 'Relatively Older' firms (bottom panel). 'Relatively Younger' is an indicator of a firm being assigned to a lower quintile of firm age distribution when using the relative measure of firm age (the percentage deviation of a firm's age from the industry median firm age on a 3-digit ISIC level) compared to the quintile obtained by using the absolute firm age distribution. Analogously, 'Relatively Older' is an indicators of a firm being assigned to a higher quintile of firm age distribution when using the relative measure of firm age compared to the quintile obtained by using the absolute firm age distribution. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables.

All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.7: Financial Development (FD) and Equity Endowment (EE)

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
Financial Development and Equity Endowment: Newly Incorporated Firms					
FD * Incorporation	-0.047	-0.058**	-0.030	-0.136**	-0.106
	(0.028)	(0.022)	(0.017)	(0.053)	(0.083)
Incorporation	0.065**	0.047***	0.069**	0.046***	0.098
	(0.026)	(0.015)	(0.026)	(0.013)	(0.060)
Age	-0.100***	-0.100***	-0.100***	-0.100***	-0.100***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
N	14,740	14,740	14,740	14,740	14,740
adjusted R^2	0.14	0.14	0.14	0.14	0.14
Financial Development and Corporate Growth: Age Quintile Groups by Equity Endowment					
FD * Age Q1 * Low EE	0.016	0.035***	0.010*	0.079***	0.017
	(0.012)	(0.010)	(0.006)	(0.017)	(0.013)
FD * Age Q2 * Low EE	0.018**	0.024**	0.011**	0.051**	0.022**
	(0.007)	(0.008)	(0.003)	(0.018)	(0.009)
FD * Age Q3 * Low EE	0.001	0.003	0.000	0.007	-0.004
	(0.007)	(0.009)	(0.003)	(0.018)	(0.008)
FD * Age Q4 * Low EE	-0.001	-0.003	-0.000	-0.006	-0.004
	(0.004)	(0.004)	(0.002)	(0.007)	(0.005)
FD * Age Q1	-0.015	-0.002	-0.004	-0.011	0.006
	(0.010)	(0.006)	(0.006)	(0.016)	(0.034)
FD * Age Q2	0.003	0.007	0.002	0.016	0.029
	(0.010)	(0.007)	(0.005)	(0.016)	(0.031)
FD * Age Q3	0.032**	0.035***	0.024***	0.067***	0.139***
	(0.012)	(0.008)	(0.003)	(0.015)	(0.041)
FD * Age Q4	0.021***	0.020***	0.014***	0.038***	0.085***
	(0.006)	(0.004)	(0.003)	(0.008)	(0.020)
Low EE	0.007**	0.009***	0.007***	0.009***	0.008***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)
Age Q1	0.045***	0.034***	0.038***	0.035***	0.030
	(0.009)	(0.005)	(0.008)	(0.004)	(0.025)
Age Q2	0.022**	0.024***	0.022***	0.024***	0.005
	(0.008)	(0.004)	(0.007)	(0.004)	(0.021)
Age Q3	-0.007	0.005	-0.014***	0.008**	-0.074**
	(0.008)	(0.003)	(0.004)	(0.003)	(0.027)
Age Q4	-0.013**	-0.003	-0.015**	-0.001	-0.052***
	(0.006)	(0.003)	(0.006)	(0.003)	(0.014)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.12	0.12	0.12	0.12	0.12

Note: Top panel: The dependent variable is the fraction of firm's equity capital on total assets—Equity endowment (EE). Incorporation is a binary variable equal to unity if a firm enters the sample with age 0 or 1. Bottom panel: The dependent variable is the time average of annual firm-level real value-added growth rates of manufacturing firms in the period 1995-2003. The panel reports estimates of a triple-interaction specification, in which we multiply the interaction of financial development measures with a step function based on firms' position in quintiles of the firm age distribution by a dummy variable for 'Low equity endowment' firms (those with below 30th percentile of Equity endowment). Estimates are based on the absolute measure of firm age. In both panels, Equity endowment is measured as of the first year a firm enters the sample and remains fixed over time. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables.

All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.A.1: Financial Development (FD) and Corporate Growth: Age/Size Quintile Groups

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
	Firm's Position in Quintile of the Size Distribution				
FD * Size Q1	-0.022	-0.005	-0.007	0.017	-0.038
	(0.034)	(0.021)	(0.013)	(0.037)	(0.099)
FD * Size Q2	-0.022	-0.008	-0.009	-0.005	-0.062
	(0.023)	(0.013)	(0.010)	(0.023)	(0.063)
FD * Size Q3	-0.019	-0.006	-0.006	-0.009	-0.046
	(0.013)	(0.008)	(0.006)	(0.014)	(0.037)
FD * Size Q4	-0.007	0.001	-0.001	0.003	-0.015
	(0.007)	(0.003)	(0.003)	(0.006)	(0.024)
Size Q1	0.102***	0.086***	0.094***	0.081***	0.109
	(0.030)	(0.012)	(0.021)	(0.013)	(0.067)
Size Q2	0.056**	0.041***	0.050**	0.039***	0.079*
	(0.020)	(0.009)	(0.016)	(0.008)	(0.043)
Size Q3	0.036**	0.022***	0.028**	0.021***	0.051*
	(0.012)	(0.006)	(0.011)	(0.006)	(0.026)
Size Q4	0.013*	0.007**	0.009	0.006**	0.017
	(0.006)	(0.003)	(0.006)	(0.003)	(0.016)
N	14,740	14,740	14,740	14,740	14,740
adjusted R^2	0.20	0.20	0.20	0.20	0.20
	Firm's Position in Quintile of the Age Distribution				
FD * Age Q1	-0.006	0.011	0.000	0.018	0.019
	(0.013)	(0.007)	(0.008)	(0.018)	(0.040)
FD * Age Q2	0.016	0.021***	0.009	0.044***	0.060
	(0.010)	(0.004)	(0.006)	(0.011)	(0.034)
FD * Age Q3	0.035**	0.039***	0.025***	0.075***	0.139***
	(0.013)	(0.004)	(0.003)	(0.009)	(0.042)
FD * Age Q4	0.022***	0.018***	0.014***	0.035***	0.081***
	(0.007)	(0.004)	(0.003)	(0.007)	(0.021)
Age Q1	0.041***	0.033***	0.036***	0.034***	0.024
	(0.010)	(0.005)	(0.009)	(0.004)	(0.027)
Age Q2	0.016*	0.022***	0.017**	0.023***	-0.010
	(0.009)	(0.004)	(0.008)	(0.004)	(0.023)
Age Q3	-0.010	0.005	-0.016***	0.007**	-0.074**
	(0.008)	(0.003)	(0.004)	(0.003)	(0.027)
Age Q4	-0.014**	-0.003	-0.015**	-0.001	-0.051***
	(0.006)	(0.003)	(0.006)	(0.003)	(0.014)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.12	0.12	0.12	0.12	0.12

Note: The top panel reports estimates obtained by interacting financial development measures with a step function based on a firm's position in quintiles of the firm size distribution while the bottom panel reports estimates obtained by interacting financial development measures with a step function based on a firm's position in quintiles of the firm age distribution. Age (the number of years since a firm's incorporation as of 1995) is scaled down by 100 while Size (total assets) is in millions of US dollars. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.A.2: Financial Development (FD) and Corporate Growth: Parametric Specification

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
	Size: Linear Specification				
FD * Size	0.002	-0.023***	-0.004	-0.025*	-0.040
	(0.014)	(0.007)	(0.006)	(0.014)	(0.025)
Size	-0.006	0.004	0.003	0.001	0.023
	(0.013)	(0.003)	(0.010)	(0.004)	(0.017)
N	14,740	14,740	14,740	14,740	14,740
R^2	0.11	0.11	0.11	0.11	0.11
	Size: Cubic Specification				
FD * Size	0.072***	-0.023	0.018	0.038	-0.033
	(0.024)	(0.016)	(0.012)	(0.032)	(0.066)
FD * $Size^2$	-0.018**	0.005*	-0.004	-0.019***	0.015
	(0.007)	(0.003)	(0.003)	(0.006)	(0.017)
FD * $Size^3$	0.001**	-0.000***	0.000	0.001***	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Size	-0.101***	-0.027***	-0.062***	-0.045***	-0.015
	(0.023)	(0.008)	(0.020)	(0.008)	(0.044)
$Size^2$	0.021***	0.004***	0.012**	0.010***	-0.004
	(0.007)	(0.001)	(0.005)	(0.002)	(0.011)
$Size^3$	-0.001***	-0.000	-0.000*	-0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	14,740	14,740	14,740	14,740	14,740
adjusted R^2	0.12	0.12	0.12	0.12	0.12
	Age: Linear Specification				
FD * Age	0.043***	-0.002	0.022***	0.008	0.017
	(0.013)	(0.012)	(0.008)	(0.023)	(0.038)
Age	-0.103***	-0.063***	-0.097***	-0.065***	-0.076***
	(0.012)	(0.006)	(0.012)	(0.005)	(0.026)
N	14,740	14,740	14,740	14,740	14,740
R^2	0.11	0.11	0.11	0.11	0.11
	Age: Cubic Specification				
FD * Age	0.336***	0.169**	0.197***	0.402**	0.917***
	(0.087)	(0.085)	(0.052)	(0.170)	(0.273)
FD * Age^2	-0.794***	-0.492**	-0.479***	-1.171**	-2.354***
	(0.243)	(0.229)	(0.144)	(0.458)	(0.739)
FD * Age^3	0.487***	0.329*	0.299***	0.798**	1.472***
	(0.185)	(0.168)	(0.109)	(0.339)	(0.545)
Age	-0.468***	-0.263***	-0.475***	-0.262***	-0.812***
	(0.074)	(0.036)	(0.075)	(0.033)	(0.182)
Age^2	0.872***	0.424***	0.907***	0.422***	1.812***
	(0.211)	(0.100)	(0.216)	(0.092)	(0.496)
Age^3	-0.469***	-0.207***	-0.500***	-0.208***	-1.065***
	(0.164)	(0.075)	(0.168)	(0.070)	(0.367)
N	14,740	14,740	14,740	14,740	14,740
adjusted R^2	0.12	0.12	0.12	0.12	0.12

Note: The top two panels report estimates obtained by interacting financial development measures with firm size while the bottom two panels report estimates obtained by interacting financial development measures with firm age. Age (the number of years since a firm's incorporation as of 1995) is scaled down by 100 while Size (total assets) is in millions of US dollars. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at firm level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.A.3: Financial Development (FD) and Corporate Growth: Age Quintile Groups by Firm Size

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
FD * Age Q1 * Small	-0.005	0.011	0.001	0.036	0.016
	(0.024)	(0.017)	(0.012)	(0.029)	(0.071)
FD * Age Q2 * Small	0.012	0.020**	0.011	0.052***	0.035
	(0.018)	(0.008)	(0.007)	(0.014)	(0.054)
FD * Age Q3 * Small	0.026*	0.028***	0.017***	0.063***	0.108**
	(0.014)	(0.004)	(0.004)	(0.010)	(0.037)
FD * Age Q4 * Small	0.014	0.009*	0.008*	0.027**	0.051
	(0.012)	(0.005)	(0.004)	(0.012)	(0.033)
FD * Age Q1 * Big	-0.000	0.011*	0.009*	0.010	-0.000
	(0.015)	(0.006)	(0.005)	(0.013)	(0.037)
FD * Age Q2 * Big	0.022**	0.016***	0.007	0.036***	0.074**
	(0.010)	(0.003)	(0.004)	(0.009)	(0.027)
FD * Age Q3 * Big	0.025*	0.033***	0.022***	0.055***	0.085*
	(0.013)	(0.007)	(0.005)	(0.010)	(0.041)
FD * Age Q4 * Big	0.019***	0.017***	0.013***	0.027***	0.067***
	(0.004)	(0.005)	(0.003)	(0.007)	(0.014)
Big	-0.031***	-0.031***	-0.031***	-0.031***	-0.032***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Age Q1 * Small	0.050**	0.042***	0.045**	0.041***	0.035
	(0.020)	(0.008)	(0.017)	(0.007)	(0.048)
Age Q2 * Small	0.024	0.027***	0.020*	0.027***	0.010
	(0.014)	(0.004)	(0.010)	(0.004)	(0.036)
Age Q3 * Small	-0.003	0.008**	-0.006	0.009**	-0.054*
	(0.011)	(0.003)	(0.006)	(0.003)	(0.025)
Age Q4 * Small	-0.011	-0.003	-0.010	-0.003	-0.034
	(0.011)	(0.004)	(0.008)	(0.004)	(0.023)
Age Q1 * Big	0.014	0.010**	0.000	0.012**	0.014
	(0.014)	(0.004)	(0.008)	(0.004)	(0.025)
Age Q2 * Big	-0.005	0.007*	0.002	0.007*	-0.036*
	(0.009)	(0.003)	(0.005)	(0.004)	(0.019)
Age Q3 * Big	-0.011	-0.002	-0.022***	0.001	-0.048*
	(0.008)	(0.003)	(0.006)	(0.003)	(0.026)
Age Q4 * Big	-0.012***	-0.002	-0.015**	-0.001	-0.041***
	(0.003)	(0.002)	(0.005)	(0.002)	(0.010)
N	14,874	14,874	14,874	14,874	14,874
adjusted R^2	0.17	0.17	0.17	0.17	0.17

Note: The Table reports estimates of a triple-interaction specification, in which we multiply the interaction of financial development measures with a step function based on firms' position in quintiles of the firm age distribution by a dummy variable for 'Small' firms (those with below-median total assets) or by a dummy variable for 'Big' firms (those with above-median total assets). Estimates are based on the absolute measure of firm age (the number of years since a firm's incorporation as of 1995) scaled down by 100. See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. All specifications are linear regressions with outliers removed (using the 5-to-95 percentile range of the dependent variable). We also remove firms with less than 5 years of value-added data available. We always control for 3-digit-ISIC industry and country dummies, not shown. Robust standard errors (clustered at country level) are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 2.A.4: Median Regressions

	Private Bank Credit	Market Capitalization	Total Capitalization	Market Value Traded	Accounting Standards
FD * Age Q1	-0.009	0.004	-0.007	0.001	0.015
	(0.021)	(0.045)	(0.019)	(0.055)	(0.044)
FD * Age Q2	0.018	0.021	0.008	0.047	0.070*
	(0.015)	(0.027)	(0.014)	(0.033)	(0.039)
FD * Age Q3	0.013	0.017	0.011*	0.028	0.077***
	(0.011)	(0.022)	(0.006)	(0.023)	(0.022)
FD * Age Q4	0.006	0.007	0.005	0.010	0.049***
	(0.009)	(0.027)	(0.005)	(0.017)	(0.017)
FD * Size Q1	-0.007	0.007	-0.002	0.037	0.019
	(0.045)	(0.116)	(0.035)	(0.115)	(0.105)
FD * Size Q2	-0.004	0.004	-0.002	0.023	-0.010
	(0.025)	(0.069)	(0.021)	(0.062)	(0.071)
FD * Size Q3	-0.009	0.001	-0.001	0.011	-0.012
	(0.017)	(0.045)	(0.014)	(0.054)	(0.051)
FD * Size Q4	0.009	0.012	0.004	0.026	0.049*
	(0.012)	(0.022)	(0.009)	(0.036)	(0.028)
Age Q1	0.031	0.023*	0.034	0.024***	0.015
	(0.019)	(0.013)	(0.025)	(0.007)	(0.032)
Age Q2	0.002	0.009	0.005	0.010***	-0.030
	(0.012)	(0.007)	(0.018)	(0.003)	(0.026)
Age Q3	0.000	0.004	-0.005	0.006**	-0.041***
	(0.008)	(0.006)	(0.010)	(0.003)	(0.015)
Age Q4	-0.001	0.000	-0.005	0.001	-0.030**
	(0.009)	(0.007)	(0.008)	(0.003)	(0.012)
Size Q1	0.102**	0.094***	0.099*	0.090***	0.084
	(0.041)	(0.029)	(0.050)	(0.017)	(0.071)
Size Q2	0.047**	0.042**	0.045	0.041***	0.050
	(0.023)	(0.019)	(0.031)	(0.010)	(0.047)
Size Q3	0.031**	0.023*	0.024	0.022***	0.032
	(0.015)	(0.013)	(0.021)	(0.008)	(0.033)
Size Q4	0.006	0.008	0.007	0.009*	-0.020
	(0.010)	(0.007)	(0.014)	(0.004)	(0.018)
N	16,081	16,081	16,081	16,081	16,081
pseudo R^2	0.09	0.09	0.09	0.09	0.09

Note: Data and equation specification are the same as in Table 3. All specifications are median regressions. We include the value-added-growth outliers, which were not used in the previous tables (i.e., observations outside 5-to-95 percentile range of the dependent variable). See Table 3 notes for a list of additional firm-level control variables and the Data Appendix for definitions of variables. We remove firms with less than 5 years of value-added data available. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively, based on bootstrapped standard errors (reported in parentheses) clustered at the country level.

Tab. 2.DA.1: Definition of Variables

	Firm-level Variables
VA	Firm-level value-added in current prices deflated by PPI. As PPI we use Eurostat's not seasonally adjusted domestic output price index (in national currency) which covers total industry (excluding construction). Source: Amadeus.
VA_Growth	Annual firm-level growth rate of real value-added based on VA. The formula for VA_Growth we use is $(VA_t - VA_{t-1}) / ABS(½ VA_t + ½ VA_{t-1})$. In our estimations, we use residuals from regression of all observed firm-level annual growth rates (VA_Growth) on year dummies. Source: Amadeus.
VA_Avg	Simple average of the annual real firm-level value-added growth rates (VA_Growth) over the years a firm is available in the database for the period 1995-2003. Source: Amadeus.
VA_Med	Median of the annual real firm-level value-added growth rates (VA_Growth) over the years a firm is available in the database for the period 1995-2003. Source: Amadeus.
Age	The number of years since firm's incorporation (STATDATE - YEARINC) scaled down by 100. It is calculated as of 1995 and remains fixed over time. Source: Amadeus.
Size	Firm's total assets (TOAS) in millions of US dollars. We use IMF-IFS annual average exchange rates to convert total assets into US dollars. It is calculated as of the initial-period (the first year a firm enters the sample) and remains fixed over time. Source: Amadeus.
Leverage	Measured as a long term debt (LTDB) plus current liabilities (CULI) divided by total assets (TOAS). It is calculated as of the initial-period (the first year a firm enters the sample and remains fixed over time). Source: Amadeus.
Tangibility (TAN)	Tangibility is defined as fixed assets (FIAS) divided by total assets (TOAS). We use the percentage deviation of firm's tangibility from the industry median firm tangibility on 3-digit ISIC level, scaled down by 100. It is calculated as of the initial-period (the first year a firm enters the sample and remains fixed over time). Source: Amadeus.
Collateralization	Collateralization is defined as fixed assets (FIAS) plus inventories (STOK) plus accounts receivables (DEBT) divided by total assets (TOAS). We use the percentage deviation of firm's collateralization from the industry median firm collateralization on 3-digit ISIC level, scaled down by 100. It is calculated as of the initial-period (the first year a firm enters the sample and remains fixed over time). Source: Amadeus.
Equity Endowment (EE)	Firm's equity capital (CAPI) scaled by total assets (TOAS). It is calculated as of the initial-period (the first year a firm enters the sample) and remains fixed over time. Source: Amadeus.
Quoted	0/1 variable, equal 1 if the firm is publicly listed company and 0 otherwise. Source: Amadeus.
Private Limited Company	0/1 variable, equal 1 if the firm is 'Limited Liability Company' (Company whose capital is divided into shares which cannot be offered to the general public. The liability of its members is limited to the amount of their shares.) and 0 if the firm is 'Limited Company' (Company whose capital is divided into shares which can be offered to the general public and whose members are only liable for its debts to the extent of any amount unpaid on their shares.) Source: Amadeus.
Independence	Set of four 0/1 variables capturing firm's concentration of ownership structure (INDEPIND). INDEPIND_A equal 1 for a firm with no recorded shareholder with an ownership over 24.99% (either direct or total) and 0 otherwise. INDEPIND_B equal 1 for a firm with no recorded shareholder with an ownership percentage (direct or total) over 49.99%, but having one or more shareholders with an ownership percentage over 24.99% and 0 otherwise. INDEPIND_C equal 1 for a firm with a recorded shareholder with an ownership (direct or total) over 49.99% (also equal to 1 when firm indicates that the company has an Ultimate Owner) and 0 otherwise. INDEPIND_U equal 1 for a firm not falling into the categories A, B, or C indicating an unknown degree of independence. Source: Amadeus.
Incorporation	0/1 variable, equal 1 if the firm enters the sample with Age 0 or 1. Source: Amadeus.
	Financial Development Country-level Measures
PCDMBANKOFINSTGDP	Private credit by deposit money banks and other financial institutions to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
STMCAPGDP	Stock market capitalization to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
STMTVTGDP	Stock market total value traded to GDP. Average over the period 1990-1994. Source: The Word Bank Financial Structure and Economic Development Database.
Total Capitalization	The sum of (i) stock market capitalisation, (ii) bank credit to the private sector and (iii) domestic debt securities issued by the private sector to GDP. Average over the period 1990-1994. Source: Hartmann et al. (2006), Chart 1.
ACCOUNT	Index created by examining and rating companies' 1990 annual reports on their inclusion or omission of 90 items in balance sheets and income statements and published by the Center for International Financial Analysis & Research, Inc. The maximum is 90, the minimum 0 and we scaled it down by 100. Source: The Center for International Financial Analysis & Research, Inc.

Tab. 2.DA.2: Legal Forms in the EU-15

Country	Limited Companies	Limited Liability Companies
Austria / Germany	Aktiengesellschaft (AG, AG & Co KG)	Gesellschaft mit beschraekter Haftung (GmbH, GmbH & Co KG, Einzelfirma)
Belgium	Naamloze Vennootschap (NV), Société Anonyme (SA)	Besloten Vennootschap, (E)BVBA; Société Privée a Responsabilité Limite, SPRL(U)
Denmark	Limited Company, Company with Limited Liability (A/S)	Private Limited Company (ApS)
Finland	Osakeyhtiö a Julkinen (OYJ)	Osakeyhtiö (OY)
France	Société Anonyme (SA)	Société a Responsabilité Limite (SARL)
Greece	SA	Limited liability company (EPE), Sole shareholder limited liability company
Italy	Societa Per Azioni (SPA)	Societa a Responsabilita Limitata (SRL, SCARL)
Netherlands	Naamloze Vennootschap (NV)	Besloten Vennootschap (BV)
Portugal	Sociedade Anónima (SA)	Sociedade por Quotas Responsibilidada Limitada (LDA)
Spain	Sociedad Anónima (SA)	Sociedad Limitada (SL)
Sweden	AB - Public Limited	AB - Private Limited
United Kingdom / Ireland	Guarantee; Public, A.I.M.; Public, investment trust; Public, not quoted; Public, quoted; Unlimited	Private

Note: In order to ensure comparability of sampled firms across countries, we include only companies from the two broad categories: Limited Companies (companies whose capital is divided into shares which can be offered to the general public and whose members are only liable for its debts to the extent of any amount unpaid on their shares) and Limited Liability Companies (companies whose capital is divided into shares which cannot be offered to the general public. The liability of its members is limited to the amount of their shares). We exclude partnerships (at least one partner is liable for the firm's debts), sole proprietorships (there is only one shareholder) and cooperatives. We follow Bureau van Dijk's grouping of the firms' types. See Klapper et al. (2006) for a similar approach.

References

Aghion, Philippe; Fally, Thibault; Scarpetta, Stefano; 2007, "Credit Constraints as a Barrier to the Entry and Post-Entry Growth of Firms," *Economic Policy*, CEPR, CES, MSH, Vol. 22, Issue 52, pp. 731-779.

Alfaro, Laura; Charlton, Andrew; 2006, "International Financial Integration and Entrepreneurship," mimeo, Harvard Business School.

Allen, Franklin; Bartiloro, Laura; Kowalewski, Oskar; 2006, "The Financial System of the EU," Working Paper 05-44, Wharton Financial Institutions Center, University of Pennsylvania.

Altonji, Joseph G.; Elder, Todd E.; Taber, Christopher R.; 2005, "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools," *Journal of Political Economy*, Vol. 113, Issue 1, pp. 151-184.

Angelini, Paolo; Generale, Andrea; 2005 "Firm Size Distribution: Do Financial Constraints Explain It All? Evidence from Survey Data," Bank of Italy Discussion Paper No. 549.

Beck, Thorsten; Demirgüç-Kunt, Asli; 2006, "Small and medium-size enterprises: Access to finance as a growth constraint," *Journal of Banking and Finance*, Vol. 30, pp. 2931-2943.

Beck, Thorsten; Demirgüç-Kunt, Asli; Laeven, Luc; Levine, Ross; 2004, "Finance, Firm Size, and Growth," NBER Working Paper No. 10983, forthcoming in the *Journal of Money, Credit, and Banking.*

Beck, Thorsten; Demirgüç-Kunt, Asli; Laeven, Luc; Maksimovic, Vojislav; 2006, "The determinants of financing obstacles," *Journal of International Money and Finance*, Vol. 25, pp. 932-952.

Beck, Thorsten; Demirgüç-Kunt, Asli; Levine, Ross; 2000, "A New Database on the Structure and Development of the Financial Sector," *World Bank Economic Review*, Vol. 14, Issue 3, pp. 597-605.

Beck, Thorsten; Demirgüç-Kunt, Asli; Maksimovic, Vojislav; 2005, "Financial and legal constraints to firm growth: Does firm size matter?" *Journal of Finance*, Vol. 60, pp. 137-177.

Bena, Jan; Jurajda, Štěpán; 2007, "Financial Development and Growth in Direct Firm-Level Comparisons," CERGE-EI Working Paper No. 317.

Berger, Allen N.; Klapper, Leora; Udell, Gregory F.; 2001, "The Ability of Banks to Lend to Informationally Opaque Small Businesses," *Journal of Banking and Finance*, Vol. 25, pp. 2127-2167.

Berger, Allen N.; Miller, Nathan H.; Petersen, Mitchell A.; Rajan, Raghuram G.; Stein, Jeremy C.; 2002, "Does Function Follow Organizational Form? Evidence From the Lending Practices of Large and Small Banks," NBER Working Paper No. 8752.

Braun, Matías; 2006, "Financial Contractibility and Asset Hardness,"mimeo, Harvard University.

Camacho, Maximo; Pérez-Quirós, Gabriel; Sáiz Matute, Lorena; 2005, "Are European Business Cycles Close Enough to be Just One?"CEPR Discussion Paper No. 4824.

Desai, Mihir; Gompers, Paul; Lerner, Josh; 2003, "Institutions, Capital Constraints and Entrepreneurial Firm Dynamics: Evidence from Europe,"NBER Working Paper No. 10165.

Dunne, Timothy; Roberts, Mark J.; Samuelson, Larry; 1989, "The Growth and Failure of US Manufacturing Plants,"*Quarterly Journal of Economics*, Vol. 104, pp. 671-698.

Gómez-Salvador, Ramón; Messina, Julián; Vallantic, Giovanna; 2004, "Gross Job Flows and Institutions in Europe,"*Labour Economics*, Vol. 11, Issue 4, pp. 469-485.

Guiso, Luigi; Jappelli, Tullio; Padula, Mario; Pagano, Marco; 2004a, "Financial Market Integration and Economic Growth in the EU,"*Economic Policy*, CEPR, CES, MSH, Vol. 19, pp. 523-577.

Guiso, Luigi; Sapienza, Paola; Zingales, Luigi; 2004b, "Does Local Financial Development Matter?"*Quarterly Journal of Economics* Vol. 119, Issue 3, pp. 929-969.

Hajivassiliou, Vassilis; Savignac, Frederique; 2007, "Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects,"mimeo, LSE.

Hartmann, Philipp; Ferrando, Annalisa; Fritzer, Friedrich; Heider, Florian; Lauro, Bernadette; Lo Duca, Marco; 2006, "The Performance of the European Financial System,"mimeo, ECB.

Hirsch, Barry T.; Schumacher, Edward J.; 1992, "Wages, Sorting on Skill, and the Racial Composition of Jobs,"*Journal of Human Resources*, Vol. 27, Issue 4, pp. 602-628.

Klapper, Leora; Laeven, Luc; Rajan, Raghuram G.; 2006, "Entry Regulation as a Barrier to Entrepreneurship,"*Journal of Financial Economics*, Vol. 82, pp. 591-629.

Kumar, Krishna B.; Rajan, Raghuram G.; Zingales, Luigi; 1999, "What Determines Firm Size?"NBER Working Paper No. 7208.

Levine, Ross; 1997, "Financial Development and Economic Growth: Views and Agenda,"*Journal of Economic Literature*, Vol. 35, No. 2., pp. 688-726.

Martin, John D.; Sayrak, Akin; 2003, "Corporate Diversification and Shareholder Value: A Survey of Recent Literature,"*Journal of Corporate Finance*, Vol. 9, pp. 37-57.

Rajan, Raghuram G.; Zingales, Luigi; 1998, "Financial Dependence and Growth," *American Economic Review*, Vol. 88, Issue 3, pp. 559-86.

Schott, Peter K.; 2003, "One Size Fits All? Heckscher-Ohlin Specialization in Global Production," *American Economic Review*, Vol. 93, Issue 3, pp. 686-708.

Tirole, Jean; 2006, *The Theory of Corporate Finance*, Princeton University Press.

3. THE EFFECT OF CREDIT RATIONING ON THE SHAPE OF THE COMPETITION-INNOVATION RELATIONSHIP

3.1 *Introduction*

Product market competition is the driving force of innovation. Competing firms invest in R&D in order to innovate and achieve higher market shares or higher total factor productivity growth.[1] The competition-to-productivity argument guided reforms ranging from the EU's 'Single-Market Programme' and product market reforms in other developed countries to the economic transition of many emerging economies in Central and Eastern Europe or Asia.[2] However, competition pressure may not be sufficient for reaching high innovation levels and therefore innovation-enhancing policies implemented through an increase in competition may fail.

The three most frequently cited obstacles to innovation by firms in the European Community Innovation Surveys are high cost of innovation, lack of financing, and economic risk.[3] According to the surveys, large firms are more innovative than small firms by a factor of three to four when innovativeness is measured by R&D spending. A smaller proportion of large firms also reports lack of financing among the most significant obstacles to innovation. These survey findings are consistent with

[1] See Aghion, Harris, Howitt, and Vickers (2001); Blundell, Griffith, and Van Reenen (1999); Nickell (1996); or, more recently, Griffith, Harrison, and Simpson (2006).

[2] See Buigues, Ilzkovitz, and Lebrun (1990) for the EU; Nicoletti and Scarpetta (2005) for OECD countries; Bolton and Roland (1992), Boubakri, Cosset, and Guedhami (2004), Djankov and Murrell (2002), Li (1999), or Roland (2001) for emerging economies.

[3] See Jaumotte and Pain (2005a, 2005b).

small firms finding it more difficult to raise external finance,[4] fund R&D projects, and therefore innovating less. Access to external finance may be one of the key determinants of innovation success. As innovation activities typically involve intangible assets, are complex, and carry high risk, the quality of the financial system is likely to be important for securing outside financing for high-technology companies, especially in their early stage, and therefore for achieving high innovation levels.[5]

To understand what role external finance plays in R&D, I develop a theory of innovation that examines how the *interaction* between competition and financial constraints determines R&D activity and test the predictions of my theory empirically. Specifically, I extend the dynamic model of the step-by-step innovation race of Aghion, Bloom, Blundell, Griffith, and Howitt (2005), who analyze how competition affects aggregate innovation activity. In Aghion et al. (2005), firms innovate by spending effort that is unbounded, and they incur no financial cost while innovating. Their analysis thus omits finance, potentially a very important element in a theory of innovation. The novel feature I add to the current theory of competition and innovation is that firms innovate by investing cash in R&D and, due to financial frictions, face financial constraints limiting their ability to raise external finance and therefore to invest.

In the model of the step-by-step innovation race, competition drives incentives to innovate by technology leaders and followers. Specifically, the innovation incentives of technology leaders and followers depend upon the difference between post-

[4] See Beck and Demirgüç-Kunt (2006) and Beck, Demirgüç-Kunt, and Maksimovic (2005) for evidence that the effect financial development has on a firm's growth is strongest for the smallest companies. Berger and Udell (2006) devise a framework to study the financing of small and medium enterprises.

[5] In their analysis of the Alternative Investment Market (AIM) of the London Stock Exchange, Arcot, Black, and Owen (2007) show that AIM has become an important source of funding for early-stage high-technology companies internationally. They argue that the key driver behind AIM's success and growth is the fact that AIM is embedded in the cluster of skills, experience, and resources which has been built up in the City over many years.

and pre-innovation rents. If competition reduces pre-innovation rents, it increases the incremental payoff from innovating and encourages R&D investments aimed at 'escaping competition'. In contrast, if competition reduces post-innovation rents, it discourages innovation (this is the so-called Schumpeterian effect). When I introduce financial constraints into this framework, competition interacts with financial constraints so that two new ways in which competition affects innovation activity emerge: the 'lack-of-internal funds effect' and the 'strategic effect'. Intuitively, the two effects work as follows.

First, competition—through altering profits and hence internal funds—limits the amount firms can invest in R&D on their own. Therefore, in the absence of frictionless financial market, firms may not invest optimally, i.e., according to the difference between post- and pre-innovation rents determined by competition, as their internal funds may be insufficient. The non-trivial dual effect of competition on innovation incentives through rents and, at the same time, internal funds and the degree of credit rationing has not been explored to date. I develop this idea into a structural model of the wedge between the optimal unconstrained and constrained-feasible R&D investment in which the fundamental parameter is competition.

Second, competition—by affecting how much firms can invest in R&D as well as how much they would like to invest—determines which firms are constrained and which are not. In industry equilibrium, firms choose their R&D strategies depending on whether their competitors are constrained or not. Constrained competitors are forced to invest less in R&D, which increases the post-innovation rents of unconstrained firms, and hence gives them extra innovation incentives. In other words, unconstrained firms react strategically to the fact that their competitors are constrained by increasing their R&D investment. As a result, there is a new channel through which competition sets incentives to innovate; in addition to the direct effect through rents, there is an indirect strategic effect.

I show that the effect of competition on aggregate innovation intensity differs depending on whether firms have frictionless access to external finance or are subject to financial constraints. In the presence of constraints, the wedge between the first-best and financially-constrained aggregate innovation intensity is positive at both intense and very relaxed levels of competition. When I compare the steady state equilibria of industries with very intense and extremely intense (very relaxed and extremely relaxed) competition levels, the wedge is larger in industries with more extreme competition levels. The intuition behind these results is as follows. When intensely competing firms employ the same technology, they aim at high R&D investments in order to 'escape competition' by innovating and securing monopoly rents as technology leaders. At the same time, the intensely competing firms have low internal funds so the wedge between the preferred and feasible R&D investment is large when external finance is not available. A different intuition explains the surprising positive wedge when competition is relaxed. Technology laggards have stronger incentives to invest in R&D when their post-innovation rents, i.e., the rents achieved after matching current technology leaders, is high. This is when competition between firms operating the same technology is relaxed. Without frictionless access to external finance, the laggards' profits might be too low to allow high R&D investment induced by relaxed competition and the positive wedge arises. These results are consistent with the interpretation provided by Fazzari, Hubbard, and Petersen (1988, 2000) and contested by Kaplan and Zingales (1997, 2000) for a positive correlation between cash flow and investment.[6] More interestingly, my model can be used to guide empirical tests in this area: R&D-cash flow sensitivity is particularly strong when competition is very intense and very relaxed.

The theory of innovation closest to my model is that of Aghion, Dewatripont, and Rey (1999) who analyze the incentive effects of competition and financial market

[6] Cleary, Povel, and Raith (2007) conduct an extensive theoretical and empirical analysis of the investment-cash flow sensitivity problem and explain why the two literatures arrive at opposite results. Riddick and Whited (2008) document how difficult it is to assess the cost of external finance based on a firm's saving behavior.

discipline on growth when firms are non profit-maximizing. They model the finance-incentive channel as a corporate governance mechanism of financial markets that elicits innovation activity from slacking managers by enforcing financial contracts and denying renegotiation.[7] However, their analysis leaves out the effect of competition on the degree of credit rationing, the central argument of my model. In contrast to Aghion, Dewatripont, and Rey (1999), I show that finance has real consequences for innovation even if firms are profit-maximizing. In another related study, Povel and Raith (2004) build on an extensive industrial organization literature[8] to analyze the interaction of financing and output market decisions in a static duopoly framework in which one firm is financially constrained and can borrow to finance production costs. They derive debt as an optimal contract and find that, compared with a situation in which both firms are unconstrained, the financially constrained firm produces less while its unconstrained rival produces more. The mechanism of my model is different from Povel and Raith (2004) in that I use a dynamic model of innovation race in which competition drives R&D investments of individual firms, the firms' investments determine the aggregate industry structure, and the industry structure feeds back into firms' individual decisions.[9] The focus of my analysis is to compare steady state equilibria when competing firms have frictionless access to external finance with those when firms are financially constrained.

To empirically test the predictions of my theory, I examine whether the competition-innovation pattern varies across countries with different levels of financial develop-

[7] Köke and Renneboog (2005) investigate the effect of corporate governance and competition on productivity growth empirically. Giroud and Mueller (2007, 2008) verify that firms in non-competitive industries benefit relatively more from good corporate governance.

[8] The effect of exogenously imposed debt on product market decisions is studied in, e.g., Brander and Lewis (1986) or Chevalier and Scharfstein (1996). More recently, Faure-Grimaud (2000) and Maurer (1999) use models where financial contracting is optimally determined together with product market decisions.

[9] Akdoğu and MacKay (2008) empirically investigate how industry structure affects firms' investment decisions by changing the value of the real options they face.

ment.[10] Financial development plays a key role in overcoming market frictions, which represent a fundamental source of external finance cost and give rise to financial constraints.[11] Financial development proxies the presence of financial constraints at the country level. Applying a difference-in-differences methodology on cross-industry, cross-country European data from the period 1995-2004, I ask whether, for example, Italian financial institutions differ significantly from those of the UK in their ability to provide external finance to firms in industries with very intense and very relaxed competition levels relative to their ability to provide external finance to firms in industries with intermediate competition levels.

Using industries with intermediate competition levels as the benchmark group, there is strong evidence of a disproportionate positive effect of financial development on R&D investment in industries where competition is very intense. The corresponding evidence for industries where competition is relaxed is weaker, but I still find that R&D investment is disproportionately lower in countries with low financial development compared to countries with highly developed financial systems. In other words, the competition-innovation relationship has an inverted-U shape in less financially developed systems relative to the benchmark pattern observed in countries with highly developed financial systems.

These findings add to an extensive literature on the finance-growth nexus[12] and suggest a new mechanism for how financial development promotes growth. Financial development helps corporate growth as better financial systems allow financing of firms that invest in R&D projects independently of their industry's current profitability determined by competition.

[10] Aghion et al. (2005) investigate the shape of the relationship between competition and innovation and find an inverted-U pattern using a two-digit SIC industry panel of 354 industry-year observations based on an unbalanced panel of 311 UK firms.

[11] See the survey by Levine (1997).

[12] See King and Levine (1993), Rajan and Zingales (1998), Fisman and Love (2004), or Bena and Jurajda (2007).

The paper proceeds as follows. The next section develops the theory of innovation based on competition and financial constraints and derives testable predictions. Section 3.3 explains the empirical model and presents results. Section 3.4 concludes. Proofs are in the Appendix.

3.2 A Theory of Innovation Based on Competition and Financial Constraints

3.2.1 Model

Using a dynamic model of a step-by-step innovation race between financially constrained firms, I analyze how product market competition affects innovation activity. The economy has a continuum of industries indexed by $i \in [0, 1]$. Each industry is a duopoly with respect to production and innovation. The duopolists participate in an innovation race and maximize the expected discounted sum of profits from supplying their goods to consumers over an infinite horizon. Time is continuous and the unit mass of identical and infinitely-lived consumers have preferences

$$U \equiv \int_0^\infty \left\{ \int_0^1 \ln Y_i(t) di - L(t) \right\} e^{-rt} dt,$$

where $Y_i(t)$ is the output of industry i at date t, $L(t)$ is labor supplied at date t, and $1 > r > 0$ is the rate of time preference. The micro-model of the interaction between duopolists is analogous to that of Aghion, Bloom, Blundell, Griffith, and Howitt (2002). The logarithmic preferences imply that, in equilibrium, consumers spend a constant proportion of income on the output of each industry i at all dates t. The demand functions facing the two firms in any industry i depend on the degree of substitutability between the two goods duopolists produce. Each firm takes the wage as given and produces output using labor as the only input according to a constant-returns-to-scale production function. The unit costs of production of the two firms are independent of the quantities produced.

There is an infinite sequence of technology levels $k = 0, 1, 2, \ldots$. Each firm engages in R&D in order to acquire the next technology level. The technological advantage decreases the firm's unit cost of production relative to its competitor. The state of an industry is described by the pair of technology levels $(k, k-m)$ of a current industry leader and a laggard. m is the laggard's technological gap. To obtain a closed-form solution, I assume that the technological gap between the firms cannot exceed one level.[13] At any date t, an industry is in one of two states: neck-and-neck, $m = 0$; or unleveled, $m = 1$.

The equilibrium profit of each firm depends on the relative unit production cost of the two firms, the degree of substitutability between the two goods, and the nature of product market competition. Similarly to Aghion et al. (2005), I follow the reduced-form approach and define π_1 (π_{-1}) to be the profit flow of the leader (the laggard) in the unleveled state and π_0 to be the profit flow of each firm in the neck-and-neck state, where $\pi_1 \geq \pi_0 \geq \pi_{-1} > 0$ and $\Pi \equiv \pi_1 - \pi_{-1} > 0$. Note that the monopoly rent brought about by technological leadership Π is independent of the leader's technology level k.[14]

The intensity of competition is modeled as the degree to which the two firms in the neck-and-neck state are able to collude against consumers, which is captured by parameter $\Delta \in \left[\frac{1}{2}, 1\right]$ in the profit flow $\pi_0 \equiv \pi_{-1} + (1-\Delta)\Pi$.[15] If competition is intense, $\Delta = 1$, each firm earns profit flow π_{-1} equal to the laggard's profit flow in the unleveled state. In the opposite case, if competition is relaxed, $\Delta = \frac{1}{2}$, each firm earns profit flow $\pi_{-1} + \frac{1}{2}\Pi$ as the two firms share, in the same proportion, a collusion

[13] The knowledge spillover between the leader and the laggard is such that if the firm, which is already one step ahead, innovates, the lagging firm automatically learns the leader's previous technology. Aghion et al. (2005) use the same assumption. Aghion et al. (2001) analyze the case when $m > 1$ and show that the main conclusions are qualitatively equivalent to the one-lag model.

[14] As discussed in Aghion, Harris, and Vickers (1997), in a variety of product market competition settings—including Bertrand and Cournot—firms' equilibrium profit flows depend only on the technological gap and not on the technology level.

[15] An increase in the degree of substitutability between the two goods leads to an analogous reduced-form parameterization of profit flow π_0.

rent equal to the monopoly rent derived from technological leadership Π.[16]

Moving one technological step ahead happens at the rate determined by the amount of cash invested in R&D. In the unleveled state, if the laggard invests y in R&D he innovates and catches up with the leader with a Poisson hazard rate ('innovation intensity') $\sqrt{y} + h$. Parameter $1 > h \geq 0$ captures the intensity of the innovation spillover effect.[17] The leader does not invest in R&D as she derives no advantage by innovating. In the neck-and-neck state, by investing x in R&D each firm moves one technological step ahead (becomes the leader) with innovation intensity $\sqrt{x}$.

Finally, I assume that the firms have no access to external finance. In both states, no firm can invest more than its current profit, $x \leq \pi_0$ and $y \leq \pi_{-1}$.[18] This assumption is strong for two reasons. Firms cannot transfer cash across states of the industry, and they do not have access to any risk-sharing technology (financial system) that allows cash transfers across industries. To study the model including these characteristics is interesting, but not the focus of this paper. This paper answers the question: What is the consequence of financial constraints for innovation activity? Therefore, I contrast the first-best equilibria derived when financial constraints are not present (e.g., when firms decide their R&D investments based on their incentives

---

[16] For simplicity, in the version of the model presented here, the monopoly rent derived from technological leadership Π is independent of competition (i.e., the advantage of a cost reduction achieved by innovation does not depend on competition). As argued in Boone (2008), more intense competition (brought about by more aggressive interaction among existing firms) makes more efficient firms benefit disproportionately more relative to less efficient firms, which means that Π increases with competition. This reinforces the model's predictions: The wedge between the first-best and financially-constrained aggregate innovation intensity is even higher.

[17] The predictions of the model about the effect of financial constraints on innovation activity do not depend on whether the innovation spillover effect is present or not. As existing literature typically studies this class of models including the innovation spillover, I solve the model when $h > 0$.

[18] I assume the simplest form of financial constraints. No results are changed if firms can only invest a fraction of their profits: $x \leq \alpha\pi_0$ and $y \leq \beta\pi_{-1}$, where $\alpha \in (0, 1]$, $\beta \in (0, 1]$.

only) with corresponding equilibria under no access to external finance.

3.2.2 Unconstrained Equilibrium

I analyze the symmetric stationary Markov equilibrium. Proposition 3.2.1 presents the equilibrium R&D investment x (y) in the neck-and-neck (the unleveled) state which solves each neck-and-neck firm's (the laggard's) optimization problem ignoring the financial constraints.

Proposition 3.2.1: 1. In the neck-and-neck state, each firm invests

$$x = \left(\sqrt{(h+r)^2 + \Delta\Pi} - (h+r)\right)^2.$$

2. In the unleveled state, the laggard invests

$$y = \left(\sqrt{(h+r)^2 + \Delta\Pi} - \sqrt{(h+r)^2 + \Pi + x}\right)^2.$$

In the next Corollary, I present comparative static properties of equilibrium R&D investments x and y with respect to the intensity of competition, technological leadership rent, innovation spillover intensity, and rate of time preference.

Corollary 3.2.2: 1. In the neck-and-neck state, each firm's R&D investment satisfies

$$\frac{\partial x}{\partial \Delta} > 0,\ \frac{\partial x}{\partial \Pi} > 0,\ \frac{\partial x}{\partial h} < 0, \text{ and } \frac{\partial x}{\partial r} < 0.$$

2. In the unleveled state, the laggard's R&D investment satisfies

$$\frac{\partial y}{\partial \Delta} < 0,\ \frac{\partial y}{\partial \Pi} > 0,\ \frac{\partial y}{\partial h} < 0, \text{ and } \frac{\partial y}{\partial r} < 0.$$

In the neck-and-neck state, an increase in competition decreases current profit π_0 and increases the incremental payoff from innovating for fixed π_1. Therefore, the incentive to innovate and the R&D investment of each firm in the neck-and-neck state increases with competition—the 'escape-competition' effect (Aghion, Harris, and Vickers, 1997).[19] In contrast, the laggard's R&D investment decreases with competition. This is because for a given technological leadership rent Π, the laggard's incentive to innovate increases with profit π_0 he gets when he catches up with the leader. As profit π_0 decreases if competition intensifies, more intense competition lowers the incremental payoff from successful innovation and disincentivizes R&D investment (the so-called Schumpeterian effect).

In both states, the firms' R&D investments increase with the technological leadership rent and decrease with the innovation spillover intensity and rate of time preference. The former result obtains because the difference between the value of being the leader and the laggard increases with the technological leadership rent. The latter result obtains because an increase in the innovation spillover intensity (the rate of time preference) crowds out incentives to innovate by investing in R&D in both states (lowers payoffs from innovating through heavier discounting).

As the economy has a continuum of industries of mass one and each industry is either in the unleveled or in the neck-and-neck state, the aggregate innovation intensity is the weighted sum of the two firms' innovation intensities in the neck-and-neck state and the laggard's innovation intensity in the unleveled state, $I \equiv 2\lambda\sqrt{x} + (1-\lambda)\left(\sqrt{y} + h\right)$. Weights λ and $(1-\lambda)$ are the fractions of industries in the two states, respectively. Fraction λ is endogenous as it depends on the firms' R&D investments in the two states. Corollary 3.2.3 presents the steady state[20] equilibrium aggregate innovation intensity as a function of R&D investments x and y, as well as its comparative static properties with respect to the intensity of competition and

[19] In the extreme case, when $\Delta = 1$, the profit of each firm in the neck-and-neck state is $\pi_0 = \pi_{-1}$ and the incremental payoff from a successful innovation is Π. In contrast, when $\Delta = \frac{1}{2}$, the profit of each firm in the neck-and-neck state is $\pi_0 = \pi_{-1} + \frac{1}{2}\Pi$ as each firm already enjoys a collusion rent equal to half of the technological leadership rent. In this case, the incremental payoff from successful innovation is only $\frac{1}{2}\Pi$.

[20] In the steady state, the flow of industries from the neck-and-neck state to the unleveled state matches the opposite flow, $2\lambda\sqrt{x} = (1-\lambda)\left(\sqrt{y} + h\right)$.

innovation spillover intensity.

Corollary 3.2.3: 1. The aggregate innovation intensity is

$$I = \frac{4\sqrt{x}\left(\sqrt{y}+h\right)}{2\sqrt{x}+\sqrt{y}+h}.$$

2. When the innovation spillover effect is absent, the aggregate innovation intensity decreases with competition: $\frac{\partial I}{\partial \Delta} < 0$ when $h = 0$.

3. When the innovation spillover intensity is sufficiently high, the competition-aggregate innovation relationship has an inverted-U shape: $\frac{\partial I}{\partial \Delta} > 0$ for $\Delta \in \left[\frac{1}{2}, \Delta_{peak}\right)$ and $\frac{\partial I}{\partial \Delta} < 0$ for $\Delta \in (\Delta_{peak}, 1]$.

4. The aggregate innovation intensity has an inverted-U shape with respect to the innovation spillover intensity: $\frac{\partial I}{\partial h} > 0$ for $h \in [0, h_{peak})$ and $\frac{\partial I}{\partial h} < 0$ for $\Delta \in (h_{peak}, 1]$.[21]

Aggregate innovation intensity I is established as an endogenous combination of the 'escape-competition' and the Schumpeterian effects that drive firm-level R&D investments in the two states. If there is no innovation spillover effect ($h = 0$), most industries are in the unleveled state in which only the Schumpeterian effect operates, and the aggregate innovation intensity always decreases with competition. A positive innovation spillover effect ($h > 0$) makes more industries switch from the unleveled to the neck-and-neck state and the Schumpeterian effect no longer dominates. When the innovation spillover intensity is sufficiently high, the fraction of industries that are in the neck-and-neck state is high enough for the 'escape-competition' effect to win over the Schumpeterian effect. The 'escape-competition' effect wins earlier if competition is low as, in this case, the laggards invest a lot in R&D which pushes the fraction of industries that are in the neck-and-neck state further up. As a result, the aggregate innovation intensity increases with competition at low competition

[21] Explicit formulas for threshold quantities Δ_{peak} and h_{peak} are in Appendix C.

levels while it decreases with competition at high competition levels.[22]

Interestingly, despite the fact that the firms' R&D investments are decreasing in the innovation spillover intensity in both states, the aggregate innovation intensity has an inverted-U shape with respect to h. This result obtains because higher innovation spillover intensity reduces the firms' incentives to invest in R&D in both states, but the laggard innovates more often for any R&D investment level. At low levels of innovation spillover intensity, most industries are in the unleveled state where only the laggards invest in R&D. In this case, if the innovation spillover intensity increases, the negative effect on the laggards' incentives to invest in R&D is dominated by their extra innovating due to a higher innovation spillover. As a result, the aggregate innovation intensity increases if the innovation spillover effect increases from an initially low level. At high levels of innovation spillover intensity, more industries are in the neck-and-neck state where both firms invest in R&D and—as they employ the same technology—do not innovate due to the innovation spillover effect. Therefore, if the innovation spillover intensity is high and increases, the negative effect on incentives to invest in R&D dominates and the aggregate innovation intensity decreases.

3.2.3 Binding Financial Constraints

In the previous section, I solved for the equilibrium in the absence of financial constraints. Proposition 3.2.4 characterizes the parameter space for which the unconstrained equilibrium of Proposition 3.2.1 does not exist as the financial constraints are violated, i.e., $x > \pi_0$ or $y > \pi_{-1}$.

Proposition 3.2.4: 1. In the neck-and-neck state, each firm's R&D investment exceeds profit, $x > \pi_0$, if and only if

$$\pi_{-1} < \frac{\pi_1}{2} \text{ and } \frac{\pi_1}{2\Pi} < \Delta \text{ and } h + r < \frac{2\Delta\Pi - \pi_1}{2\sqrt{\pi_1 - \Delta\Pi}}.$$

[22] This confirms Aghion et al.'s (2005) competition-innovation inverted-U result. Interestingly, the necessary condition for the inverted-U is $h > 0$. I verified that the same necessary condition is present in Aghion et al. (2005).

The necessary condition for $x > \pi_0$ is $\Delta > \overline{\Delta}$, where $\overline{\Delta}$ is the competition level at which the financial constraint of a firm in the neck-and-neck state is just satisfied

$$\overline{\Delta} \equiv \frac{\pi_1 + (h+r)\left(\sqrt{(h+r)^2 + 2\pi_1} - (h+r)\right)}{2\Pi}.$$

2. In the unleveled state, when $h = 0$ and $r = 0$, the laggard's R&D investment exceeds profit, $y > \pi_{-1}$, if and only if

$$\left(\pi_{-1} < \frac{2-\sqrt{2}}{4}\pi_1\right) \text{ or } \left(\pi_{-1} = \frac{2-\sqrt{2}}{4}\pi_1 \text{ and } \Delta < 1\right) \text{ or}$$
$$\left(\frac{2-\sqrt{2}}{4}\pi_1 < \pi_{-1} < \frac{3-\sqrt{3}}{6}\pi_1 \text{ and } \Delta < \frac{(\Pi - \pi_{-1})^2}{4\pi_{-1}\Pi}\right).$$

When $h + r > 0$, the necessary condition for $y > \pi_{-1}$ is $\Delta < \underline{\Delta}$, where $\underline{\Delta}$ is the competition level at which the laggard's financial constraint is just satisfied

$$\underline{\Delta} \equiv \frac{(\Pi - \pi_{-1})^2 + 4(h+r)^2\left[\Pi - 2\pi_{-1} - 2(h+r)\sqrt{\pi_{-1}}\right]}{4\left(\sqrt{\pi_{-1}} + h + r\right)^2 \Pi}.$$

Since firms' R&D investments are increasing in the technological leadership rent in both states, a high-enough leadership rent is sufficient for the firms' financial constraints to become binding. In contrast, the effect of competition on financial constraints is opposite in the two states. A firm in the neck-and-neck state becomes financially constrained if competition is intense enough, while the laggard's financial constraint is binding when competition is relaxed. This follows from the fact that the R&D investment of a firm in the neck-and-neck state (of the laggard) increases (decreases) with competition and therefore it hits the limit set by the profit at a high (low) competition level. In Proposition 3.2.4, I present the threshold competition intensities $\underline{\Delta}$ ($\overline{\Delta}$) at which the financial constraint of the laggard (of a firm in the neck-and-neck state) is just satisfied.

Quantities $\underline{\Delta}$ and $\overline{\Delta}$ split all admissible competition levels into three regions: (i) The relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, in which the laggard is financially constrained; (ii) The intermediate competition region, $\Delta \in (\underline{\Delta}, \overline{\Delta})$, in which the unconstrained equilibrium of Proposition 3.2.1 exists; (iii) The intense competition region, $\Delta \in [\overline{\Delta}, 1]$, in which the firms in the neck-and-neck state are constrained. The necessary and sufficient condition for the existence of these three competition regions, i.e., $\frac{1}{2} < \underline{\Delta} < \overline{\Delta} < 1$, is stated in Appendix C while proving Proposition 3.2.4.

An increase in the innovation spillover intensity (in the rate of time preference) makes the financial constraints binding for a smaller set of competition levels in both states ($\underline{\Delta}$ decreases and $\overline{\Delta}$ increases). This is because, for given profits π_1, π_{-1} and competition level Δ, a higher innovation spillover intensity (rate of time preference) decreases the firms' R&D investments in both states. Similarly, an increase in π_1 (or a decrease in π_{-1}) makes the set of competition levels for which the financial constraints are binding larger.[23]

To summarize, the effect of a competition increase (decrease) on the degree to which firms' financial constraints are binding is non-trivial. Technology laggards become less (more) constrained while firms operating similar technology become more (less) constrained. These results are illustrated in Figure 3.1.

3.2.4 Financially Constrained Equilibrium

In this section, I describe the firms' equilibrium R&D investments and the equilibrium aggregate innovation intensity in the presence of financial constraints. Proposition 3.2.5 presents the equilibrium R&D investments which solve the optimization problem of a firm in the neck-and-neck state and the optimization problem of the laggard when their financial constraints are binding.

Proposition 3.2.5: Consider the model under the set of parameters $\{\pi_1, \pi_{-1}, h, r\}$ such that $\frac{1}{2} < \underline{\Delta} < \overline{\Delta} < 1$.

1. In the relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, the laggard's R&D investment is $y_c = \pi_{-1}$, while each firm in the neck-and-neck state invests x_u.

[23] See the proof of Proposition 3.2.4 in Appendix C for a complete comparative static analysis of threshold intensities $\underline{\Delta}$ and $\overline{\Delta}$.

2. In the intense competition region, $\Delta \in [\overline{\Delta}, 1]$, the laggard's R&D investment is y_u, while each firm in the neck-and-neck state invests $x_c = \pi_0$.[24]

In Corollary 3.2.6, I compare R&D investments x_u and y_u with their counterparts derived in the case of no financial constraints (Proposition 3.2.1).

Corollary 3.2.6: Consider the model under the set of parameters $\{\pi_1, \pi_{-1}, h, r\}$ such that $\frac{1}{2} < \underline{\Delta} < \overline{\Delta} < 1$.

1. In the relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, each firm's R&D investment in the neck-and-neck state satisfies

$$x_u > x \text{ for } \Delta \in \left[\frac{1}{2}, \underline{\Delta}\right) \text{ and } x_u = x \text{ at } \Delta = \underline{\Delta}.$$

2. In the intense competition region, $\Delta \in [\overline{\Delta}, 1]$, the laggard's R&D investment satisfies

$$y_u > y \text{ for } \Delta \in \left(\overline{\Delta}, 1\right] \text{ and } y_u = y \text{ at } \Delta = \overline{\Delta}.$$

Relative to the model of section 3.2.2 with no financial constraints, the laggard's R&D investment has to be lower in the relaxed competition region as his financial constraint binds. This decreases the probability that the laggard catches up with the leader, and that means the industry is in the unleveled state with a higher probability at any point in time, which increases (decreases) the value of being the leader (the laggard) for given π_1, π_{-1}, h, and r. For the same reason, the incremental payoff from becoming the leader (the laggard) if a firm is currently in the neck-and-neck state increases (decreases) and therefore its R&D investment is higher, $x_u > x$. At the threshold competition intensity $\underline{\Delta}$, the R&D investment of each firm in the neck-and-neck state is the same as in the case with no financial constraints, $x_u = x$. The laggard's incentive is to maximize the probability of leaving the unleveled state, his financial constraint is binding, and his R&D investment is limited at $y_c = \pi_{-1}$ for all $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$.

[24] Explicit formulas x_u and y_u are in Appendix C.

The presence of financial constraints changes the way competition affects the firms' R&D investments. Within the relaxed competition region, a higher competition level does not make the laggard invest less in R&D. His financial constraint is binding and he invests all his profit—the Schumpeterian effect of higher competition does not unfold. In contrast, the 'escape-competition' effect of the neck-and-neck state is stronger in comparison to the case with no financial constraints, as the incremental payoff achieved when a firm becomes the leader is higher.

A similar intuition works when firms in the neck-and-neck state are constrained. Relative to the no-financial-constraints model, the R&D investment of each firm in the neck-and-neck state has to be lower within the intense competition region as their financial constraints are binding. Lower neck-and-neck state R&D investment means that the industry is in this state with a higher probability at any point in time. For given π_1, π_{-1}, h, and r, this increases the incremental payoff of the laggard from switching into the neck-and-neck state and therefore induces him to invest more in R&D, $y_u > y$. At the threshold competition intensity $\overline{\Delta}$, the laggard's R&D investment is the same as in the case with no financial constraints, $y_u = y$. The laggard's extra incentive to switch to the neck-and-neck state and to increase his R&D investment above y is lower the higher the competition level. This is because intense competition reduces π_0 and makes the neck-and-neck state less desirable. The value of a firm in the neck-and-neck state is lower, the bigger the deviation of its R&D investment from the optimal unconstrained level. Therefore, the financial constraints in the neck-and-neck state are binding and the equilibrium R&D investment of each firm is limited at $x_c = \pi_0$ for all $\Delta \in [\overline{\Delta}, 1]$.

In contrast to the case without financial constraints, a higher competition level within the intense competition region is associated with *lower* R&D investments of firms in the neck-and-neck state. These firms want to invest a lot to escape very high competition but, as π_0 decreases with competition, they have only a small amount of cash available, which makes the effect of a competition increase particularly strong.

The wedge between the no-financial-constraints and the financially-constrained R&D investment is larger the closer the competition level is to its maximum level. The presence of financial constraints in the neck-and-neck state reverses the 'escape-competition' effect.

Quantities x_u, x_c, y_u, and y_c are presented in Figure 3.2. The R&D investment of a firm in the neck-and-neck state (the laggard) in the relaxed competition region, x_u (y_c), is depicted using the red (light) solid lines in the top (bottom) right graph of Figure 3.2. The same two graphs depict the R&D investment of a firm in the neck-and-neck state (the laggard) in the intense competition region, x_c (y_u). Finally, for ease of comparison, the blue (dark) dashed lines depict the corresponding optimal R&D investments in the no-financial-constraints model.

Corollary 3.2.7 presents the steady state equilibrium aggregate innovation intensity as a function of R&D investments x_u and y_c (x_c and y_u) in the relaxed (intense) competition region. It also compares the aggregate innovation intensity with the one derived in the case of no financial constraints (Corollary 3.2.3).

Corollary 3.2.7: Consider the model under the set of parameters $\{\pi_1, \pi_{-1}, h, r\}$ such that $\frac{1}{2} < \underline{\Delta} < \overline{\Delta} < 1$.

1. In the relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, the aggregate innovation intensity is $I_{\{x_u,y_c\}} = \frac{4\sqrt{x_u}\left(\sqrt{y_c}+h\right)}{2\sqrt{x_u}+\sqrt{y_c}+h}$ and satisfies
$$I_{\{x_u,y_c\}} < I \text{ for } \Delta \in \left[\frac{1}{2}, \underline{\Delta}\right) \text{ and } I_{\{x_u,y_c\}} = I \text{ at } \Delta = \underline{\Delta}.$$

2. In the intense competition region, $\Delta \in [\overline{\Delta}, 1]$, the aggregate innovation intensity is $I_{\{x_c,y_u\}} = \frac{4\sqrt{x_c}\left(\sqrt{y_u}+h\right)}{2\sqrt{x_c}+\sqrt{y_u}+h}$ and satisfies
$$I_{\{x_c,y_u\}} < I \text{ for } \Delta \in \left(\overline{\Delta}, 1\right] \text{ and } I_{\{x_c,y_u\}} = I \text{ at } \Delta = \overline{\Delta}.$$

The aggregate innovation intensities $I_{\{x_u,y_c\}}$ and $I_{\{x_c,y_u\}}$ are derived using the steady state condition that the flow of industries from the neck-and-neck state to the unleveled state matches the opposite flow. The flows are determined by the firms'

R&D investments $\{x_u, y_c\}$ and $\{x_c, y_u\}$ in the relaxed and the intense competition region, respectively. The aggregate innovation intensities $I_{\{x_u,y_c\}}$ and $I_{\{x_c,y_u\}}$ are strictly below the unconstrained aggregate innovation intensity inside both extreme competition regions and are equal to it at the threshold competition levels $\underline{\Delta}$ and $\overline{\Delta}$.

Quantities I, $I_{\{x_u,y_c\}}$, and $I_{\{x_c,y_u\}}$ are displayed in the top left graph of Figure 3.2. The blue inverted-U line which depicts the aggregate innovation intensity of the model with no financial constraints has three segments: The solid middle part, where the unconstrained equilibrium of Proposition 3.2.1 exists; and the two dashed parts, which depict the aggregate innovation intensity of Corollary 3.2.3 ignoring financial constraints. The aggregate innovation intensities of the model with financial constraints are depicted in the same graph using solid red lines in both constrained regions: $I_{\{x_u,y_c\}}$ for $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$ and $I_{\{x_c,y_u\}}$ for $\Delta \in [\overline{\Delta}, 1]$.

When I compare the steady state equilibria of industries with very intense and extremely intense (very relaxed and extremely relaxed) competition levels, the wedge between the unconstrained and the financially constrained aggregate innovation intensity is larger in the industries with extreme levels. The competition-innovation relationship has a more pronounced inverted-U shape in the presence of financial constraints. The wedge is especially marked if the competition level is close to its maximum. In this case, the R&D investments of both firms in the neck-and-neck state are severely constrained by their low profits. The result of low R&D investments is that many industries are in the neck-and-neck state, thus many industries invest only a small amount in R&D, and the aggregate innovation intensity is very low. Without access to external finance the firms are trapped in the neck-and-neck state and the economy is in high competition, low profit, and low innovation equilibrium.

The negative direct effect of financial constraints on aggregate innovation intensity is partially offset by the fact that the unconstrained firm strategically increases its R&D investment if it faces a constrained competitor. To illustrate the magnitude of this effect, the top left graph of Figure 3.2 also depicts (red dashed lines) the aggregate innovation intensities under the assumption that the unconstrained firm does not change its R&D investment in response to the fact that its competitor is constrained.[25]

Finally, to facilitate intuition on how the firms' R&D investments are combined into the aggregate innovation intensity in industry equilibrium, the bottom left graph of Figure 3.2 shows the equilibrium probabilities of an industry to be in the neck-and-neck state as a function of competition.

3.2.5 Testable Predictions

The main aggregate-level prediction follows from Corollary 3.2.7, which states that the effect of competition on aggregate innovation intensity differs depending on whether firms have frictionless access to external finance or are subject to financial constraints. In the presence of constraints, there is a positive wedge between the first-best and financially-constrained aggregate innovation intensity at both intense and very relaxed levels of competition. In addition, when I compare the steady state equilibria of industries with very intense and extremely intense (very relaxed and extremely relaxed) competition levels, the wedge is larger in industries with more extreme competition levels. Empirically, one can contrast the competition-innovation pattern across economies with/without financial constraints, e.g., across countries with highly- and less developed financial systems. Specifically, the slope of the competition-innovation pattern in less financially developed systems is steeper relative to the benchmark observed in countries with highly developed financial systems for very relaxed as well as intense competition levels. The slope is the same at intermediate competition levels (see the top left graph of Figure 3.2). This prediction is tested in section 3.3.

[25] The red dashed lines show the aggregate innovation intensity determined as follows. For $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, the laggard invests $y_c = \pi_{-1}$ and each firm in the neck-and-neck state invests x (part one of Proposition 3.2.1). For $\Delta \in [\overline{\Delta}, 1]$, each firm in the neck-and-neck state invests $x_c = \pi_0$ and the laggard invests y (part two of Proposition 3.2.1).

In addition, there are multiple micro-level predictions that are testable if one is able to (i) empirically distinguish the neck-and-neck from the unleveled industries; (ii) measure innovation at the firm level; and (iii) identify financially constrained firms. First, the model has predictions about firms in industries with low productivity dispersion (firms in the neck-and-neck state) and high competition (the intense competition region according to the notation of my model). When firms in such industries have frictionless access to external finance, higher competition is associated with higher innovation (part one of Corollary 3.2.2), while the opposite holds if the same firms are financially constrained (part two of Proposition 3.2.5). Second, the model has predictions about relatively low-productive firms in industries with high productivity dispersion (laggards in the unleveled state) and low competition (the relaxed competition region of my model). When firms in such industries have frictionless access to external finance, higher competition is associated with lower innovation (part two of Corollary 3.2.2), while innovation does not change with competition if the same firms are financially constrained (part one of Proposition 3.2.5). I test the firm-level predictions in Bena (2008) using European Patent Office data matched with financial statements from the Amadeus database for the period 1997-2005.

3.3 Empirical Analysis

In this section I explain the empirical model, describe the data, and present the results from testing whether the aggregate predictions of the theory are consistent with real data.

3.3.1 Methodology

Consistent with the theory, my empirical approach maintains that the primary channel through which competition affects innovation is economic rent.[26] Rents are determined by competition, but they also depend on productivity which is driven by innovation (Griffith, Harrison, and Simpson, 2006). Therefore, trying to disentangle the effect of competition on innovation empirically raises a fundamental identification problem: one needs to isolate the part of variation in competition that is unrelated to innovation. I address the endogeneity by using a set of instruments that provides an exogenous variation in the degree of competitiveness across industries and countries. The instruments indicate (ex-ante) the industry-country pairs expected to be affected by introduction of the EU's product market reform ('single market' launched in 1993) because of the pre-existing barriers to competition. The corresponding empirical model is

$$R\&D_{ict} = \alpha_1 + \beta_1 \cdot \varphi\left(Margin_{ict}\right) + \eta_i + \gamma_c + \delta_t + \zeta_{ict} \tag{3.1a}$$

$$Margin_{ict} = \alpha_2 + SMP'_{ic} \cdot \beta_2 + \eta_i + \gamma_c + \delta_t + \varepsilon_{ict}, \tag{3.1b}$$

where $Margin_{ict}$ denotes a price-cost margin of industry i in country c in year t, and $R\&D_{ict}$ denotes total R&D expenditures. Function $\varphi()$ stands for non-linear semi-parametric specifications, as my model predicts a non-linear pattern. $Margin_{ict}$ is an endogenous variable in the innovation equation $(3.1a)$. Vector SMP'_{ic} contains

[26] Existing empirical work also uses economic rent: Gorodnichenko, Švejnar, and Terrell (2007), Griffith, Harrison, and Simpson (2006), Nickell (1996), or Nickell, Nicolitsas, and Dryden (1997). Alternatives to the price-cost margin (economic rent) are measures of market concentration (concentration ratios, Herfindahl-Hirschman index, number of firms), the elasticity of a firm's profit with respect to its cost level (Boone, van Ours, and van der Wiel, 2007), and the relative profit difference (Boone, 2008). Contrary to first-hand intuition, Sutton (2007) shows that, under general assumptions, an increase in competition leads to higher concentration and a lower number of firms surviving in the market. This is due to the reallocation effect: If competition increases, more efficient firms gain at the expense of less efficient firms (intensive margin), and less efficient firms leave the market (extensive margin). Boone's measures correct for the reallocation effect but require detailed firm-level data that are unavailable in a large cross-section.

L instruments excluded from (3.1a). Industry, country, and year dummies that control for industry-, country-, and annual-specific unobservable exogenous factors in both equations are denoted as η_i, γ_c, and δ_t, respectively. The inclusion of dummy variables transforms the data relative to industry-, country-, and annual means and the main coefficient of interest β_1 is identified by comparing affected (not affected) industries in a subset of countries with the same industries that are not affected (are affected) in the counterpart countries.

The empirical measures of competition and innovation used in (3.1a) have theoretical counterparts as follows. According to the model, the empirical measure of competition, $Margin_{ict}$, has an expected value of $2\lambda\pi_0 + (1-\lambda)(\pi_1 + \pi_{-1})$ and is strictly decreasing in theoretical measure of competition Δ in both the unconstrained as well as financially constrained equilibrium. Similarly, the empirical measure of innovation activity, $R\&D_{ict}$, has an expected value of $2\lambda x + (1-\lambda)y$ and is strictly increasing in Δ in the unconstrained equilibrium. Therefore, when there are no financial constraints the model predicts that $R\&D_{ict}$ decreases with $Margin_{ict}$; in other words, more intense competition as measured by the price-cost margin leads to a higher innovation activity as measured by R&D investment. In the financially constrained equilibrium, the empirical measure of innovation, $R\&D_{ict}$, has an expected value of $2\lambda x_u + (1-\lambda)y_c$ in the relaxed competition region (strictly increasing in Δ), while it has an expected value of $2\lambda x_c + (1-\lambda)y_u$ in the intense competition region (strictly decreasing in Δ). Moreover, there is a wedge between the first-best and financially constrained empirical measure of innovation activity, $R\&D_{ict}$, when the empirical measure of competition, $Margin_{ict}$, is both high (intense competition region) and low (relaxed competition region).

To test the main prediction of the model, I investigate the competition-innovation pattern across countries with different levels of financial development. As the quality of the financial system is important in overcoming market frictions and securing outside financing for intangible and high-risk projects (like R&D), financial development proxies the severity of financial constraints at the country level. My main set of results comes from the parsimonious full-interaction specification

$$R\&D_{ict} = \alpha_1 + \sum_{j\in\{H,L\}} \beta_1^j \cdot \varphi\left(Margin_{ict}\right) \cdot FD_c^j + \eta_i + \gamma_c + \delta_t + \zeta_{ict}, \qquad (3.2)$$

which replaces equation (3.1a). Term $\sum_{j\in\{H,L\}} \beta_1^j \cdot \varphi\left(Margin_{ict}\right) \cdot FD_c^j$ stands for the interaction of the industry price-cost margin with the indicator variables equal to unity for countries with above/below median values of financial development measure (FD_c^H and FD_c^L, respectively). In the spirit of Rajan and Zingales (1998), the interaction term together with the country- and industry-level fixed effects helps to overcome the endogeneity between innovation and financial development. The interaction term contains only that part of the variation in financial development that is unrelated to unobservable current and future growth opportunities which drive current innovation activity at the country- and industry level. Regression (3.2) asks whether the above/below median development of financial markets alters the way in which product market competition affects innovation activity conditional on all country-, industry-, and year-specific factors. The indicators of financial development are measured as of the beginning of the EU's 'single market'.

I estimate the empirical model using the generalized method of moments (Hansen, 1982) and instrumental variables estimators.[27] The correlation of instruments with the price-cost margin is examined by the fit of the first-stage regression (3.1b). I use Bound, Jaeger, and Baker (1995) statistics: The R^2 of the first-stage regression with the included instruments 'partialled-out' and the F-test of the joint significance

[27] GMM estimators are more efficient in the presence of heteroskedasticity and no worse asymptotically than IV estimators if heteroskedasticity is not present (Baum, Schaffer, and Stillman, 2003). Also, while the consistency of the IV coefficient estimates is not affected by the presence of heteroskedasticity, the classic IV estimates of the standard errors are inconsistent and the usual forms of diagnostic tests for endogeneity and overidentifying restrictions are invalid if heteroskedasticity is present. On the other hand, IV is preferable to GMM in small samples if the error is homoskedastic. My results are very similar regardless of what estimation method I use, which is reassuring.

of excluded instruments. As I have multiple endogenous regressors in specification (3.2) I also report the statistic proposed by Shea (1997): The 'partial-R^2' measure that takes the intercorrelation among instruments into account. Typically, I have more excluded instruments than endogenous regressors (equations (3.1a) and (3.2) are overidentified), which allows testing moment conditions.[28] In the case of the GMM and heteroskedastic-robust IV estimator I report the J statistic; in the case of the standard IV estimator I report Sargan's statistic (Sargan, 1958). As $Margin_{ict}$ and $R\&D_{ict}$ are stable over time (annual factors explain almost no variation, see ANOVAs in Table 3.A.6), the error terms in equations (3.1a), (3.1b), and (3.2) are likely to exhibit some degree of autocorrelation. Therefore, my preferred estimator is a GMM estimator with autocorrelation-consistent or heteroskedastic-and-autocorrelation-consistent standard errors.

3.3.2 Data

Industry-Level Variables

The industry-country-level variables: price-cost margin and R&D expenditures come from Eurostat's Structural Business Statistics database. This database is based on detailed data on all enterprises and is available at NACE 3-digit level for the manufacturing sector of all EU countries. For robustness, I use capital expenditures as an alternative to R&D in all specifications. Capital expenditures are highly correlated with R&D and better covered across industries and countries. Typically, capital expenditures regressions are based on more than twice as many observations compared to analogous R&D specifications. See Table 3.1 for coverage and basic descriptive statistics and Table 3.DA.1 for the exact definition of the variables.

[28] Define vector $Z_{ict} \equiv [SMP'_{ic}\ \eta_i\ \gamma_c\ \delta_t]$ that contains all exogenous variables (excluded and included instruments). Under the assumption $E[Z_{ict} \cdot \zeta_{ict}] = 0$, excluded instruments give L moment conditions $g_{ict}(\widehat{\beta}) = Z'_{ict} \cdot \widehat{\zeta}_{ict} = Z'_{ict} \cdot (R\&D_{ict} - X_{ict} \cdot \widehat{\beta})$, where $X_{ict} \equiv [\varphi(Margin_{ict})\ \eta_i\ \gamma_c\ \delta_t]$ consists of both endogenous and exogenous regressors in (3.1a). The case with equation (3.2) is analogous.

EU 'Single Market Programme' Instrumental Variables

The list of country-sectors most affected by the introduction of the EU's 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform) comes from Buigues, Ilzkovitz, and Lebrun (1990), part of the Cecchini report.[29] The list was composed mainly on the basis of the following structural criteria: (i) The level of non-tariff barriers (standards, frontier formalities, limited access to public procurement, differences in VAT and excise duties, etc.), which measures the degree of protection of the sectors; (ii) The dispersion of prices for identical products between EU member states, which measures the level of fragmentation of the EU market; (iii) The rate of penetration by imports, which measures the share of domestic demand accounted for by imports.

The indicators were constructed for 120 industrial sectors out of which 40 sectors were identified as ones where non-tariff barriers impede intra-EU trade. The selected 40 sectors represent about 50 percent of industrial value-added in the EU (ranges from 55 percent in Germany to 39 percent in Spain). Finally, national experts were requested to verify the pertinence of the list of 40 sectors relevant at the EU level for their own countries. Table 3.4 provides basic characteristics of the industry-country pairs affected by the reform while Table 3.DA.1 lists the affected industries and follows Buigues, Ilzkovitz, and Lebrun (1990) in classifying them into six groups.

Financial Development Indicators

Data on financial development are drawn from the World Bank's Financial Structure and Economic Development Database (March 2005 version) described in detail in Beck, Demirgüç-Kunt, and Levine (2000). To make my results comparable with those in the literature I use a number of measures of finance activity to proxy financial development. I start with traditional measures of activity in the credit and stock markets, namely the ratio of private credit to GDP and the ratio of stock market

[29] These instruments were recently used by Griffith, Harrison, and Simpson (2006).

capitalization and stock market total value traded to GDP. All proxies for financial development are averaged over the years 1990-1994, that is, as of the establishment of the 'single market'.[30]

In addition to volume-of-finance-activity measures of financial development, I also use a proxy for the institutional quality of financial markets. Specifically, I follow Beck et al. (2004) and use the indicator of the 'quality of accounting standards', produced by International Accounting and Auditing Trends (Center for International Financial Analysis & Research, Inc.). This indicator rates companies' 1990 annual reports on the basis of their inclusion or omission of 90 items in the balance sheets and income statements and ranges from 0 to 90.

All four indicators of financial development are summarized across the EU countries in Table 3.2. Despite the extensive integration of EU national product markets up to 1994, there is still substantial diversity in the degree of financial development across the EU. The coefficient of variation is particularly high for the measures of stock market activity. The middle panel of Table 3.2 presents correlations (with statistical significance levels) among different measures of financial development. The correlations suggest that these measures, although closely related, are nevertheless meaningfully different. The bottom panel of Table 3.2 classifies EU countries into high/low financial development groups based on above/below median values of each financial development measure. Table 3.3 summarizes price-cost margin and R&D/capital expenditures in low-, medium-, and high-competition-level industries separately for high/low financial development country groups.

3.3.3 Results

Table 3.5 reports estimates of equation (3.1a) with linear specification obtained using OLS, IV, and GMM estimators. Regardless of the method used, there is a significant negative relationship between price-cost margin and R&D/capital expenditures,

[30] I rely on time averages to avoid year-to-year fluctuations.

which means a positive relationship between competition and R&D/capital expenditures. The IV and GMM coefficients are larger than the ones obtained by OLS. Table 3.5 confirms the prediction of the model and is consistent with results obtained by Griffith, Harrison, and Simpson (2006). Specifications (2) and (3) of Table 3.5 are rejected using the Hansen J-test but the preferred ones, (4) and (5), are not. The instruments in the first-stage regression are highly significant.[31]

Table 3.6 reports estimates of high/low financial development full-interaction specification (3.2) obtained using the GMM estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors. Table 3.6 also reports analogous estimates obtained using the GMM estimator with standard errors clustered at the country-industry level. These results reveal that the negative relationship between competition and R&D/capital expenditures comes mainly from less financially developed countries, whereas there is no significant pattern in the high financially developed country group.

Tables 3.7 and 3.8 report the results from the test of the main model's prediction. The slope of the competition-innovation pattern in less financially developed systems is steeper relative to the benchmark observed in countries with highly developed financial systems for intense (Table 3.7) as well as relaxed competition levels (Table 3.8). The estimates in Tables 3.7 and 3.8 are obtained using analogous regressions to the ones in Table 3.6. The only difference is that in Table 3.7 I only interact the bottom 25 percent of the price-cost margin variable (i.e., the industry-country cells with very intense competition levels) with financial development. In line with the model, the coefficients in front of the interaction term between the price-cost margin and the low FD country group dummy are positive and significant in all specifications, while it is never significant and sometimes negative for the interaction term with the high FD country group dummy. In less financially developed countries, within the most competitive industries an increase in competition leads to a reduction

[31] See Table 3.A.7 for the full first-stage regression results.

in R&D/capital expenditures. In the most financially developed countries, there is no significant effect of competition on R&D/capital expenditures within the most competitive industries.

Table 3.8 focuses on the upper 50 percent of the price-cost margin variable, i.e., the industry-country cells with relaxed competition. In contrast to Table 3.7, the coefficients in front of the interaction term between the price-cost margin and the low FD country group dummy are negative and significant in all specifications. The coefficients in front of the interaction term with the high FD country group dummy are typically negative, but only marginally significant. In less financially developed countries, within the relaxed competition industries an increase in competition leads to an increase in R&D/capital expenditures.

The results of Tables 3.7 and 3.8 are depicted in Figure 3.3. The competition-innovation relationship recovered empirically for high/low FD country groups closely mimics the theoretical competition-innovation pattern of the unconstrained/financially constrained regime depicted in Figure 3.2.

In non-reported regressions, I tried different threshold levels of the profit-cost margin variable to define intense and relaxed competition regions. These alternative specifications led to results analogous to those reported in Tables 3.7 and 3.8. To illustrate the robustness of results to threshold definitions and to further explore the difference in the competition-innovation relationship between high and low FD country groups, Figure 3.4 depicts fitted lines obtained from high/low financial development full-interaction specifications analogous to the ones reported in the top panel of Table 3.6 but estimated separately on all quintiles of the price-cost margin variable.

3.3.4 Robustness checks

Tables 3.A.1 and 3.A.2 show robustness to autocorrelation and clustering. The estimates are fully robust to autocorrelation but the estimates' significance is lost when

I cluster standard errors at the industry-country level. This loss of significance is of minor concern, if one assumes that industry-country-level variables (R&D/capital expenditures and price-cost margin) represent—in each year—the equilibrium of the model developed in the first half of the paper.

Tables 3.A.3, 3.A.4, and 3.A.5 report estimates of specifications in which instead of high/low financial development country group full-interaction specifications I interact the price-cost margin with continuous measures of financial development. For all practical purposes, the results are unchanged and robust to this alternative type of interaction.

3.4 Conclusion

This paper examines how the R&D investment of financially constrained firms and endogenously determined aggregate innovation activity depend on product market competition. The novel findings come from an analysis of the interaction between competition and lack of external finance. The presence of financial constraints affects innovation through two channels: The constraints set an upper bound on firms' R&D investments, and they also change their incentives to innovate—firms change their R&D strategies depending on whether their competitors are financially constrained or not. This demonstrates the importance of analyzing the impact of financial frictions on firms' individual decisions in a model of market interaction.

I show that if firms finance R&D activities only out of current profits, they underinvest the most in industries with intense and very relaxed competition. On the aggregate level, the presence of financial constraints results in a stronger inverted-U competition-innovation pattern than when firms have frictionless access to external finance. The key to these results is the assumption that, in order to innovate, firms need to invest cash in R&D and that competition affects the amount they can invest. The paper models this idea in a very tractable way.

In the empirical part I find that the interaction between competition and financial development is an important determinant of the shape of the aggregate competition-innovation relationship, which is consistent with the presented theory. Relative to the competition-innovation pattern in the most financially developed countries, the competition-innovation relationship has an inverted-U shape in less financially developed systems. This finding is established when I identify the causal impact of competition on innovation by exploiting a major EU product market reform, the introduction of the 'single market', and is robust to a number of alternative specifications. The empirical analysis helps to explain why the shape of the competition-innovation pattern has not been fully resolved to date; it may be that many papers in this area do not control for the presence of financial constraints, an important determinant of this relationship.

This paper contributes to policy discussions by stressing the importance of external finance supply for innovation success. The theoretical argument and empirical analysis developed in this paper suggest that innovation-enhancing policies implemented through competition reforms ought to be complemented by promoting financial development.

Appendix A: Figures

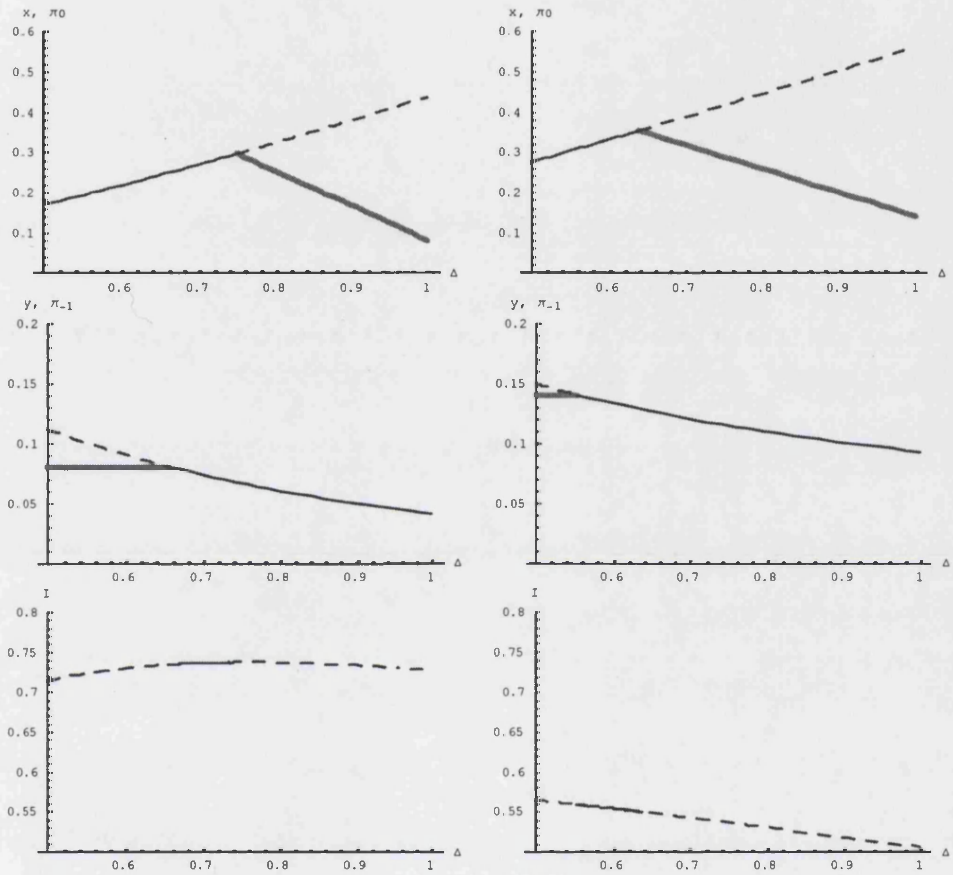

Fig. 3.1: Innovation Intensity: Unconstrained Equilibrium

Note: The top (middle) two graphs depict the R&D investment of each firm in the neck-and-neck state (of the laggard) as a function of competition, while the bottom two graphs show the aggregate innovation intensity. The blue (dark) solid lines are the R&D investments from Proposition 3.2.1 depicted for competition levels at which the financial constraints do not bind. The blue dashed lines depict the same quantities ignoring financial constraints. The red (light) solid lines depict profit π_0 (π_{-1}) each firm in the neck-and-neck state (the laggard) gets for competition levels at which the financial constraints are binding. In the top (middle) graphs, red lines connect to blue ones at threshold competition levels $\overline{\Delta}$ ($\underline{\Delta}$); in the bottom graphs the dashed lines switch to solid ones at $\underline{\Delta}$ and back to dashed ones at $\overline{\Delta}$ (see Proposition 3.2.4). Parameters: Left: $\pi_1 = 0.94$, $\pi_{-1} = 0.08$, $h = 0.30$, $r = 0.02$; Right: $\pi_1 = 0.73$, $\pi_{-1} = 0.14$, $h = 0.00$, $r = 0.02$.

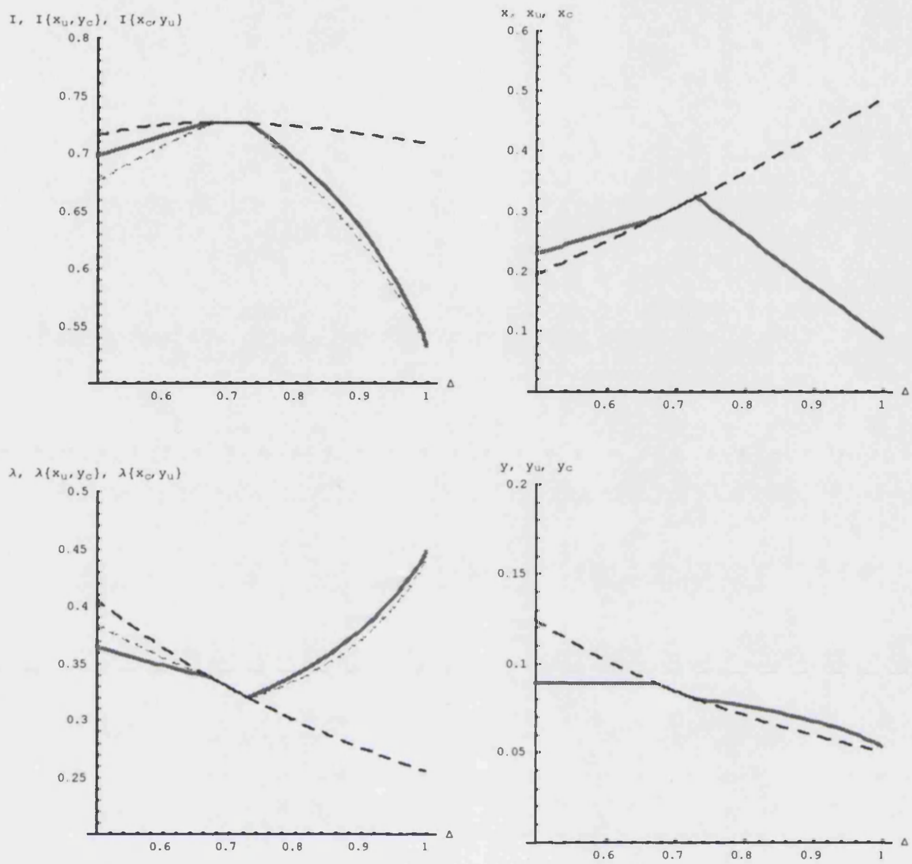

Fig. 3.2: Innovation Intensity: Financially Constrained Equilibrium

Note: The top (bottom) graph on the right depicts the firm's R&D investments in the neck-and-neck (the laggard's R&D investment in the unleveled) state as a function of competition: (i) The blue (dark) solid lines are the firm's R&D investments from Proposition 3.2.1 depicted for intermediate competition levels at which the unconstrained equilibrium exists, $\Delta \in (\underline{\Delta}, \overline{\Delta})$; (ii) The blue dashed lines depict the same quantities if financial constraints are ignored in the relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, and the intense competition region, $\Delta \in [\overline{\Delta}, 1]$; (iii) The red (light) solid lines are the firm's R&D investments from Proposition 3.2.5 if financial constraints are binding. The top left graph shows the corresponding aggregate innovation intensities, while the bottom left graph shows the fraction of industries in the neck-and-neck state. Parameters: $\pi_1 = 0.95$, $\pi_{-1} = 0.09$, $h = 0.25$, $r = 0.02$.

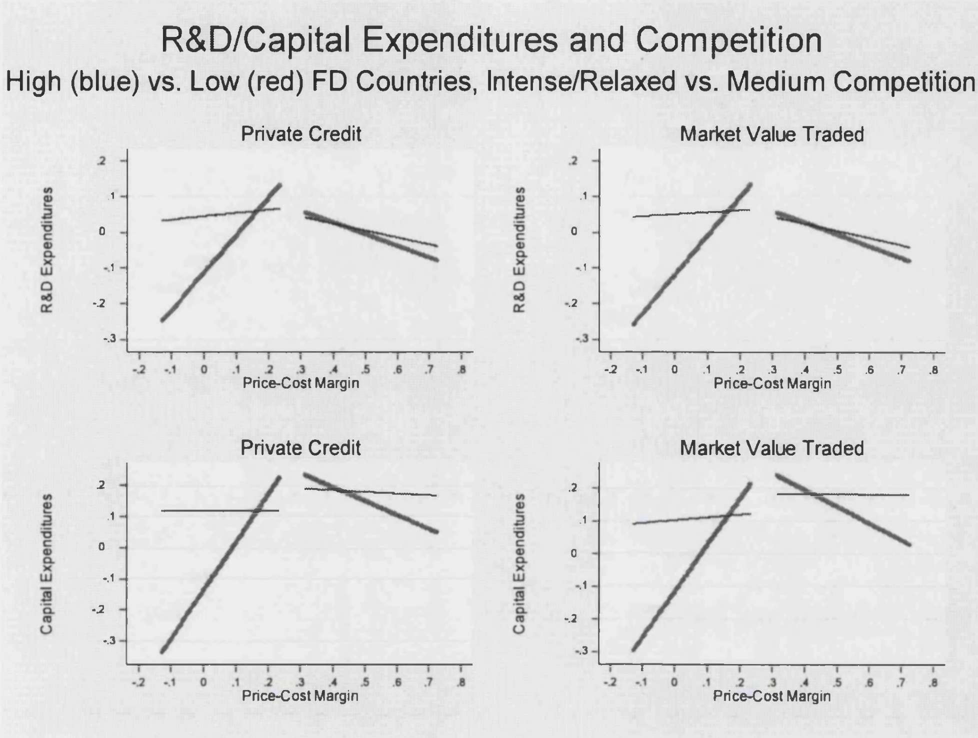

Fig. 3.3: R&D/Capital Expenditures and Competition: Empirical Relationship

Note: The Figure depicts fitted lines obtained from high/low financial development full-interaction specifications based on 0 to 25 percent of the profit-cost margin variable from Table 3.7 columns (2) and (6), and similar specifications based on 50 to 100 percent of the profit-cost margin variable from Table 3.8 columns (2) and (6). The dependent variable in the top two graphs is R&D expenditures while the dependent variable in the bottom two graphs is capital expenditures. Red (light) line: Fitted regression line based on the coefficient in front of the low financial development country group interaction variable; Blue (dark) line: Fitted regression line based on the coefficient in front of the high financial development country group interaction variable. Thick (thin) line denotes significance (no significance) at the 5% level.

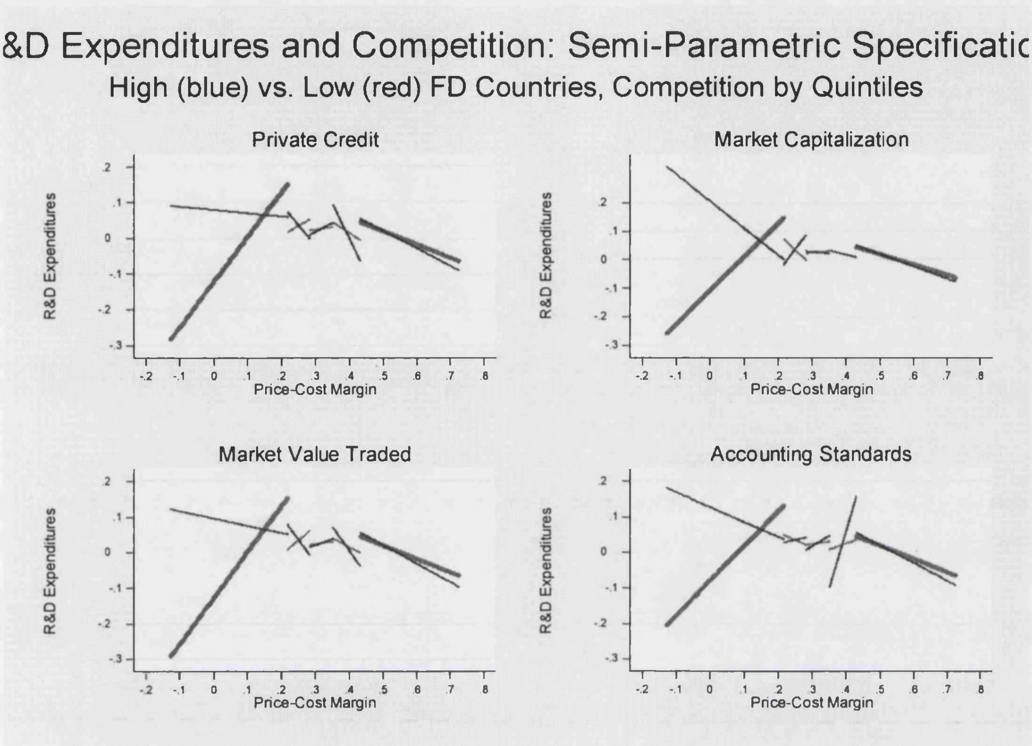

Fig. 3.4: R&D Expenditures and Competition: Semi-Parametric Specification

Note: The Figure depicts fitted lines obtained from high/low financial development full-interaction specifications analogous to the ones reported in the top panel of Table 3.6 but estimated separately on all quintiles of the profit-cost margin variable. The dependent variable is R&D expenditures in all graphs. Red (light) line: Fitted regression line based on the coefficient in front of the low financial development country group interaction variable; Blue (dark) line: Fitted regression line based on the coefficient in front of the high financial development country group interaction variable. Thick (thin) line denotes significance (no significance) at the 5% level.

Appendix B: Tables

Tab. 3.1: EU 'single-market' Industry-Country-Year Data in 1995-2004

	CapEx				R&D				Margin			EU-SMP
	Mean	Median	S.D.	N	Mean	Median	S.D.	N	Mean	Median	S.D.	1993
					by Country							
Austria	0.143	0.129	0.076	902	0.044	0.021	0.067	912	0.315	0.309	0.119	No
Belgium	0.162	0.142	0.089	547	0.027	0.005	0.063	652	0.337	0.332	0.114	Yes
Denmark	0.160	0.141	0.083	775	-	-	-	0	0.297	0.294	0.100	Yes
Finland	0.142	0.123	0.088	889	-	-	-	0	0.352	0.343	0.115	No
France	0.139	0.121	0.070	859	0.051	0.017	0.097	740	0.249	0.236	0.113	Yes
Germany	0.118	0.106	0.058	559	0.052	0.019	0.076	587	0.249	0.247	0.100	Yes
Ireland	0.141	0.122	0.089	607	-	-	-	0	0.399	0.402	0.145	Yes
Italy	0.180	0.161	0.083	981	0.022	0.004	0.056	277	0.414	0.422	0.103	Yes
Netherlands	0.126	0.109	0.070	836	-	-	-	0	0.358	0.349	0.111	Yes
Portugal	0.239	0.226	0.109	509	0.001	0.000	0.005	534	0.366	0.364	0.131	Yes
Spain	0.134	0.116	0.077	974	0.027	0.012	0.047	168	0.359	0.351	0.109	Yes
Sweden	0.148	0.131	0.077	880	0.050	0.010	0.093	259	0.287	0.278	0.127	No
UK	0.122	0.107	0.066	836	0.035	0.009	0.084	593	0.390	0.386	0.122	Yes
					by NACE 2-digit Industry							
15 - Food products and beverages	0.203	0.184	0.089	720	0.007	0.004	0.008	340	0.427	0.422	0.105	-
17 - Textiles	0.143	0.127	0.080	544	0.009	0.005	0.010	259	0.297	0.300	0.092	-
18 - Apparel	0.099	0.080	0.070	205	0.001	0.000	0.002	96	0.335	0.319	0.138	-
19 - Leather	0.093	0.083	0.047	204	0.004	0.003	0.006	89	0.314	0.307	0.099	-
20 - Wood, products of wood and cork	0.176	0.160	0.089	419	0.002	0.001	0.002	167	0.347	0.326	0.109	-
21 - Pulp, paper and paper products	0.198	0.180	0.088	169	0.006	0.005	0.004	75	0.418	0.419	0.100	-
22 - Printing and publishing	0.149	0.129	0.091	236	0.001	0.001	0.002	112	0.371	0.366	0.116	-
23 - Coke, refined petroleum products and nuclear fuel	0.214	0.203	0.124	46	0.021	0.007	0.029	32	0.558	0.584	0.133	-
24 - Chemicals	0.161	0.138	0.084	509	0.067	0.050	0.076	250	0.412	0.422	0.116	-
25 - Rubber and plastics	0.161	0.155	0.063	170	0.030	0.014	0.041	78	0.337	0.339	0.088	-
26 - Other non-metallic mineral products	0.173	0.158	0.088	597	0.008	0.004	0.010	281	0.391	0.386	0.132	-
27 - Basic metals	0.175	0.161	0.080	351	0.014	0.007	0.016	179	0.333	0.323	0.122	-
28 - Fabricated metal products	0.131	0.117	0.066	554	0.008	0.004	0.010	262	0.301	0.305	0.099	-
29 - Machinery and equipment	0.111	0.100	0.050	549	0.073	0.037	0.143	268	0.293	0.298	0.102	-
31 - Electrical machinery	0.126	0.115	0.066	469	0.050	0.037	0.049	218	0.300	0.307	0.123	-
32 - Radio, television and communication equipment	0.165	0.141	0.100	211	0.194	0.172	0.161	112	0.302	0.301	0.149	-
33 - Medical, precision and optical instruments	0.096	0.086	0.053	387	0.067	0.048	0.074	188	0.323	0.314	0.131	-
34 - Motor vehicles	0.173	0.159	0.096	237	0.062	0.019	0.079	117	0.302	0.291	0.128	-
35 - Other transport equipment	0.117	0.104	0.062	325	0.060	0.020	0.087	153	0.252	0.261	0.131	-
36 - Manufacturing N.E.C.	0.121	0.109	0.067	445	0.019	0.005	0.049	213	0.348	0.335	0.106	-
37 - Recycling	0.248	0.242	0.101	136	0.001	0.000	0.002	62	0.468	0.496	0.119	-

Note: The number of observations, N, corresponds to industry-country-year observations with non-missing values of 'CapEx' and 'Margin' ('R&D' and 'Margin') across 101 three-digit NACE manufacturing industries in 13 EU countries over the period 1995-2004. 'CapEx' is defined as gross investments in tangible goods divided by value-added. 'R&D' is defined as total intra-mural R&D expenditure divided by value-added. 'Margin' is defined as operating profit and is scaled by value-added. 'EU-SMP 1993' indicates which countries participated in the EU 'Single Market Programme' at its inception in 1993. Austria, Finland, and Sweden joined the EU in 1995. The statistics in the bottom panel are based on the 'EU-SMP 1993' countries only—my main sample. Before computing the statistics (Mean, Median, and Standard Deviation), I remove outliers by using the 1-to-99 percentile range of the variables. See the Data Appendix for complete definitions and sources of variables.

Tab. 3.2: Financial Development: EU 'single-market' Countries in 1990-1994

	Private Credit	Market Capitalization	Market Value Traded	Accounting Standards
		Basic Statistics		
Mean	0.79	0.34	0.15	62
Median	0.72	0.27	0.12	62
S.D. / Mean	0.39	0.73	0.83	0.18
Min	0.42	0.13	0.04	36
Max	1.41	0.97	0.45	78
Min Country	Denmark	Belgium	Belgium	Belgium
Max Country	Netherlands	UK	UK	UK
N	10	10	10	9
		Correlations		
Private Credit	1.00			
Market Capitalization	0.58*	1.00		
Market Value Traded	0.66**	0.89***	1.00	
Accounting Standards	0.48	0.66*	0.65*	1.00
		High/Low Financial Development Country Groups		
Austria	High	Low	Low	Low
Belgium	Low	High	Low	Low
Denmark	Low	High	Low	Low
Finland	Low	Low	Low	High
France	High	High	High	High
Germany	High	Low	High	Low
Ireland	Low	Low	High	-
Italy	Low	Low	Low	Low
Netherlands	High	High	High	High
Portugal	Low	Low	Low	Low
Spain	Low	Low	Low	High
Sweden	High	High	High	High
UK	High	High	High	High

Note: The top panel: I first compute the country average of each financial development measure in the period 1990-1994 (the exception is Accounting Standards, which corresponds to 1990). Second, I present the Mean, Median, Coefficient of Variation, Min, and Max of the country averages from the first step across 10 EU countries that participated in the EU 'Single Market Programme' at its inception in 1993 (see Table 1). The bottom panel classifies countries into a high or low financial development group based on above/below median levels of the respective financial development measure. The financial development measures and high/low indicators are used as explanatory variables in regressions. See the Data Appendix for complete definitions and sources of variables.

Tab. 3.3: Descriptive Statistics by Competition and Financial Development

	Intense Competition Margin < 25pct		Medium Competition 25pct < Margin < 75pct		Relaxed Competition Margin > 75pct	
			Private Credit			
	High	Low	High	Low	High	Low
Margin	0.189	0.227	0.319	0.363	0.471	0.500
CapEx	0.096	0.128	0.111	0.154	0.140	0.176
R&D	0.022	0.003	0.014	0.002	0.008	0.000
N - CapEx	999	824	2,046	1,717	1,019	878
N - R&D	756	362	933	764	399	337
			Market Capitalization			
	High	Low	High	Low	High	Low
Margin	0.194	0.224	0.315	0.367	0.471	0.503
CapEx	0.107	0.105	0.125	0.144	0.135	0.176
R&D	0.015	0.015	0.011	0.002	0.005	0.000
N - CapEx	945	913	1,945	1,821	963	896
N - R&D	603	580	907	708	475	278
			Market Value Traded			
	High	Low	High	Low	High	Low
Margin	0.182	0.231	0.320	0.354	0.489	0.486
CapEx	0.097	0.118	0.114	0.147	0.127	0.193
R&D	0.022	0.003	0.014	0.002	0.008	0.001
N - CapEx	913	909	1,858	1,922	926	955
N - R&D	701	390	916	802	303	439
			Accounting Standards			
	High	Low	High	Low	High	Low
Margin	0.202	0.235	0.332	0.337	0.485	0.479
CapEx	0.097	0.117	0.112	0.152	0.140	0.193
R&D	0.017	0.015	0.014	0.003	0.008	0.001
N - CapEx	862	1,443	1,766	1,688	877	847
N - R&D	550	597	626	987	325	466

Note: The Table reports Median of 'Margin', 'CapEx', and 'R&D' across 10 EU countries that participated in the EU 'Single Market Programme' at its inception in 1993 (see Table 1). Medians are reported individually for industries characterized by 'Intense Competition' (defined as the first quartile of 'Margin' variable), 'Medium Competition' (defined as the second together with the third quartile of 'Margin' variable), and 'Relaxed Competition' (defined as the fourth quartile of 'Margin' variable) separately for high/low financial development country groups (see Table 2). 'N - CapEx' is the number of industry-country-year observations with non-missing values of 'CapEx' and 'Margin'; 'N - R&D' is the number of industry-country-year observations with non-missing values of 'R&D' and 'Margin'. See the Data Appendix for complete definitions and sources of variables.

Tab. 3.4: EU 'Single Market Programme' (SMP): Industry-Country Pairs Affected by the Reform

	SMP Group 1		SMP Group 2		SMP Group 3		SMP Group 4.1		SMP Group 4.2		SMP Group 4.3	
	N	Empl	N	Empl	N	Empl	N	Empl	N	Empl	N	Empl
					by Country							
Belgium	2	4.0	6	0.9	8	1.6	9	1.3	7	1.1	21	1.4
Denmark	2	4.8	6	0.7	8	1.6	7	2.5	6	2.5	12	1.0
France	2	2.4	6	1.7	8	2.4	9	3.5	9	1.4	21	1.6
Germany	2	6.1	6	1.0	7	5.6	9	1.2	9	1.2	17	1.6
Ireland	2	2.6	6	0.6	8	1.2	9	1.1	9	0.6	21	1.0
Italy	2	1.9	6	0.6	8	1.0	9	1.7	9	1.1	21	1.8
Netherlands	2	7.3	5	0.5	8	1.1	9	1.3	9	1.4	17	0.7
Portugal	1	0.1	6	0.7	8	0.8	9	2.1	6	0.4	21	2.3
Spain	2	1.3	6	0.7	8	1.4	9	0.9	9	0.7	21	1.3
UK	2	2.9	3	1.1	8	1.0	9	2.3	7	1.6	21	1.2
					by NACE 2-digit Industry							
15 - Food products and beverages			1	1.0	3	2.6					1	1.1
17 - Textiles											4	5.5
18 - Apparel							2	8.2				
19 - Leather											1	1.5
22 - Printing and publishing							2	3.0				
24 - Chemicals			1	1.7							4	3.4
25 - Rubber and plastics							1	4.1			1	1.2
26 - Other non-metallic mineral products											4	3.6
28 - Fabricated metal products			2	1.4					1	0.7		
29 - Machinery and equipment							1	1.0	6	6.3		
31 - Electrical machinery					4	5.3					1	1.0
32 - Radio, television and communication equipment	1	2.8			1	3.5	1	1.5				
33 - Medical, precision and optical instruments	1	2.8									1	2.8
34 - Motor vehicles			1	0.7			1	5.0				
35 - Other transport equipment			1	0.4					2	2.4		
36 - Manufacturing N.E.C.							1	0.3			3	6.5
37 - Recycling											1	1.2

Note: The Table lists the number (columns 'N') of NACE 3-digit industries identified (ex ante) to be affected by introduction of the 'Single Market Programme' (SMP) of the EU in 1993 (EU-wide product market reform), and the typical size of an affected industry (columns 'Empl') measured as the median percentage share of affected industries in total manufacturing employment (average over 1985-1987) as presented in Buigues et al. (1990). The top panel of the Table counts the affected industries by country while the bottom panel groups the affected industries by NACE 2-digit industry codes.
Based on the type of pre-existing barriers to competition, the affected industries were divided into six groups; SMP Group 1: High-technology, public-procurement markets; SMP Group 2: Traditional public-procurement and regulated markets (High price dispersion); SMP Group 3: Traditional public-procurement and regulated markets (Low price dispersion); SMP Group 4.1: Sectors with moderate non-tariff barriers (Consumer goods); SMP Group 4.2: Sectors with moderate non-tariff barriers (Investment goods); SMP Group 4.3: Sectors with moderate non-tariff barriers (Intermediate goods). See the Data Appendix for complete definitions and sources of variables.

Tab. 3.5: R&D / Capital Expenditures and Competition

	(1) OLS robust	(2) IV robust	(3) GMM	(4) GMM autocorrelation	(5) GMM clustered
	R&D	R&D	R&D	R&D	R&D
Margin	-0.079***	-0.465***	-0.505***	-0.465***	-0.512**
	(0.014)	(0.107)	(0.105)	(0.106)	(0.201)
Sargan statistic	-	-	-	1.622	-
p-value	-	-	-	*0.445*	-
Hansen J statistic	-	6.893**	6.893**	-	2.080
p-value	-	*0.032*	*0.032*	-	*0.354*
N	3,551	3,551	3,551	3,551	3,551
R-squared	0.58	0.39	0.34	0.39	0.34
		First-Stage Regression Statistics: Margin			
Partial R-squared	-	0.019	0.019	0.019	0.019
F-statistic	-	19.58***	19.58***	15.06***	5.89***
p-value	-	*0.000*	*0.000*	*0.000*	*0.000*
	CapEx	CapEx	CapEx	CapEx	CapEx
Margin	-0.024**	-0.443***	-0.432***	-0.442***	-0.425**
	(0.011)	(0.124)	(0.123)	(0.143)	(0.193)
Sargan statistic	-	-	-	4.309	-
p-value	-	-	-	*0.116*	-
Hansen J statistic	-	6.072**	6.072**	-	2.531
p-value	-	*0.048*	*0.048*	-	*0.282*
N	7,483	7,483	7,483	7,483	7,483
R-squared	0.45	0.26	0.27	0.26	0.27
		First-Stage Regression Statistics: Margin			
Partial R-squared	-	0.006	0.006	0.006	0.006
F-statistic	-	14.82***	14.82***	10.61***	3.66**
p-value	-	*0.000*	*0.000*	*0.000*	*0.012*

Note: The sample consists of 101 three-digit NACE manufacturing industries across 10 countries that participated in the EU 'Single Market Programme' at its inception in 1993 (see Table 1) over the period 1995-2004. The dependent variable in the first (second) panel is 'R&D' ('CapEx'). 'Margin' is instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications are as follows: (1) classical linear regression with heteroskedastic-robust standard errors; (2) instrumental variables (IV) estimator with heteroskedastic-robust standard errors (using Eicker-Huber-White "sandwich" variance-covariance matrix); (3) feasible heteroskedastic-efficient two-step generalized methods of moment (GMM) estimator; (4) GMM estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors; (5) GMM estimator with standard errors clustered at the country-industry level.

Sargan (Hansen J) statistics correspond to tests of overidentifying restrictions. Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.6: Competition: Financial Development (FD) Full Interaction Specification

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin * FD Low	-0.552***	-0.557**	-0.510***	-0.562***	-0.561***	-0.564**	-0.467***	-0.476**
	(0.129)	(0.225)	(0.115)	(0.201)	(0.136)	(0.228)	(0.107)	(0.212)
Margin * FD High	-0.149	-0.157	-0.275	-0.308	-0.144	-0.151	-0.045	-0.058
	(0.278)	(0.337)	(0.234)	(0.271)	(0.287)	(0.344)	(0.363)	(0.365)
F-test	1.52	2.37	0.82	1.37	1.47	2.34	1.47	2.46
p-value	*0.217*	*0.124*	*0.367*	*0.241*	*0.225*	*0.126*	*0.226*	*0.117*
Sargan statistic	0.014	-	0.890	-	0.009	-	0.127	-
p-value	*0.906*	-	*0.346*	-	*0.923*	-	*0.722*	-
Hansen J statistic	-	0.016	-	1.097	-	0.010	-	0.101
p-value	-	*0.900*	-	*0.295*	-	*0.919*	-	*0.751*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.47	0.47	0.52	0.49	0.45	0.45	0.49	0.49
	*First-Stage Regression Statistics: Margin * FD Low*							
Partial R-squared	0.021	0.021	0.025	0.025	0.019	0.019	0.027	0.027
Shea Partial R-squared	0.022	0.022	0.027	0.027	0.019	0.019	0.027	0.027
F-statistic	15.92***	6.36***	19.34***	7.6***	14.35***	6.02***	20.71***	9.36***
p-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.001*	*0.000*	*0.000*
	*First-Stage Regression Statistics: Margin * FD High*							
Partial R-squared	0.004	0.004	0.005	0.005	0.004	0.004	0.003	0.003
Shea Partial R-squared	0.004	0.004	0.005	0.005	0.005	0.005	0.003	0.003
F-statistic	3.21**	3.52**	3.71**	3.89***	3.34**	3.43**	2.19*	3.63**
p-value	*0.022*	*0.015*	*0.011*	*0.009*	*0.019*	*0.017*	*0.087*	*0.013*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin * FD Low	-0.662***	-0.727**	-0.504***	-0.557**	-0.799***	-0.927**	-0.461***	-0.583**
	(0.219)	(0.311)	(0.152)	(0.224)	(0.297)	(0.396)	(0.168)	(0.269)
Margin * FD High	0.228	0.449	-0.171	-0.173	0.081	0.243	0.036	0.121
	(0.468)	(0.807)	(0.294)	(0.335)	(0.395)	(0.704)	(0.283)	(0.507)
F-test	2.34	1.83	1.11	0.97	2.17	1.83	2.58	2.07
p-value	*0.126*	*0.176*	*0.292*	*0.324*	*0.141*	*0.176*	*0.108*	*0.150*
Sargan statistic	0.867	-	3.382*	-	0.786	-	2.966*	-
p-value	*0.352*	-	*0.066*	-	*0.375*	-	*0.085*	-
Hansen J statistic	-	0.312	-	1.971	-	0.269	-	1.250
p-value	-	*0.576*	-	*0.160*	-	*0.604*	-	*0.264*
N	7,483	7,483	7,483	7,483	7,483	7,483	7,483	7,483
R-squared	0.77	0.71	0.83	0.82	0.75	0.69	0.84	0.81
	*First-Stage Regression Statistics: Margin * FD Low*							
Partial R-squared	0.006	0.006	0.008	0.008	0.005	0.005	0.008	0.008
Shea Partial R-squared	0.006	0.006	0.009	0.009	0.004	0.004	0.008	0.008
F-statistic	9.78***	3.36**	13.12***	4.49***	7.25***	2.69**	11.27***	3.91***
p-value	*0.000*	*0.018*	*0.000*	*0.004*	*0.000*	*0.045*	*0.000*	*0.009*
	*First-Stage Regression Statistics: Margin * FD High*							
Partial R-squared	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
Shea Partial R-squared	0.001	0.001	0.003	0.003	0.002	0.002	0.003	0.003
F-statistic	2.33*	0.68	3.77***	0.62	3.60***	0.78	3.77***	1.04
p-value	*0.072*	*0.563*	*0.010*	*0.602*	*0.013*	*0.508*	*0.010*	*0.376*

Note: The data are the same as in Table 5. The dependent variable in the top (bottom) panel is 'R&D' ('CapEx'). 'Margin * FD Low' stands for 'Margin' variable interacted with 0/1 variable equal 1 for low financial development countries. 'Margin * FD High' is defined analogously. See Table 2 for definitions of High/Low financial development country groups. 'Margin * FD Low' and 'Margin * FD High' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use the generalized method of moments (GMM) estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors; specifications (2), (4), (6), and (8) use the GMM estimator with standard errors clustered at the country-industry level. F-test is the test of the difference of coefficients 'Margin * FD Low' and 'Margin * FD High' in the second-stage regression.

Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.7: 'Intense' Competition: Financial Development (FD) Full Interaction Specification

	(1) IV robust	(2) GMM	(3) IV robust	(4) GMM	(5) IV robust	(6) GMM	(7) IV robust	(8) GMM
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin <25pct) * FD Low	1.047***	1.057***	1.254***	1.063**	1.088***	1.089***	0.985***	0.941***
	(0.343)	(0.338)	(0.470)	(0.463)	(0.361)	(0.355)	(0.345)	(0.331)
(Margin <25pct) * FD High	0.073	0.091	0.109	-0.659	0.058	0.059	-0.108	-0.181
	(0.276)	(0.255)	(0.631)	(0.539)	(0.297)	(0.269)	(0.358)	(0.319)
F-test	12.48***	12.61***	1.75	4.30**	11.21***	11.62***	9.43***	10.29***
p-value	*0.000*	*0.000*	*0.186*	*0.038*	*0.001*	*0.001*	*0.002*	*0.001*
Hansen J statistic	0.029	0.029	5.453**	5.453**	0.000	0.000	0.204	0.204
p-value	*0.866*	*0.866*	*0.020*	*0.020*	*0.988*	*0.988*	*0.652*	*0.652*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.32	0.31	0.06	0.06	0.26	0.26	0.12	0.15
	*First-Stage Regression Statistics: (Margin <25pct) * FD Low*							
Partial R-squared	0.014	0.014	0.006	0.006	0.012	0.012	0.009	0.009
Shea Partial R-squared	0.012	0.012	0.005	0.005	0.011	0.011	0.008	0.008
F-statistic	9.31***	9.31***	3.67**	3.67**	7.82***	7.82***	6.31***	6.31***
p-value	*0.000*	*0.000*	*0.012*	*0.012*	*0.000*	*0.000*	*0.000*	*0.000*
	*First-Stage Regression Statistics: (Margin <25pct) * FD High*							
Partial R-squared	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003
F-statistic	3.78***	3.78***	4.07***	4.07***	3.92***	3.92***	4.59***	4.59***
p-value	*0.010*	*0.010*	*0.007*	*0.007*	*0.008*	*0.008*	*0.003*	*0.003*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin <25pct) * FD Low	1.516**	1.556**	1.774*	1.783*	1.381**	1.417**	0.913**	1.035**
	(0.672)	(0.670)	(1.016)	(0.997)	(0.566)	(0.564)	(0.451)	(0.442)
(Margin <25pct) * FD High	0.006	-0.006	-2.224	-2.234	0.090	0.089	-0.463	-0.522
	(0.249)	(0.248)	(1.577)	(1.565)	(0.237)	(0.237)	(0.481)	(0.479)
F-test	5.42**	5.84**	2.80*	2.91*	6.52**	6.96***	3.40*	4.50**
p-value	*0.020*	*0.016*	*0.094*	*0.088*	*0.011*	*0.008*	*0.065*	*0.034*
Hansen J statistic	0.714	0.714	0.002	0.002	0.563	0.563	1.893	1.893
p-value	*0.398*	*0.398*	*0.962*	*0.962*	*0.453*	*0.453*	*0.169*	*0.169*
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.67	0.66	0.01	0.01	0.68	0.67	0.76	0.73
	*First-Stage Regression Statistics: (Margin <25pct) * FD Low*							
Partial R-squared	0.002	0.002	0.004	0.004	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
F-statistic	3.19**	3.19**	5.30***	5.30***	5.54***	5.54***	4.13***	4.13***
p-value	*0.023*	*0.023*	*0.001*	*0.001*	*0.001*	*0.001*	*0.006*	*0.006*
	*First-Stage Regression Statistics: (Margin <25pct) * FD High*							
Partial R-squared	0.005	0.005	0.001	0.001	0.007	0.007	0.002	0.002
Shea Partial R-squared	0.005	0.005	0.001	0.001	0.006	0.006	0.002	0.002
F-statistic	10.11***	10.11***	2.94**	2.94**	11.76***	11.76***	4.47***	4.47***
p-value	*0.000*	*0.000*	*0.032*	*0.032*	*0.000*	*0.000*	*0.004*	*0.004*

Note: The Table is analogous to Table 6 except I interact 0 to 25 percent of the 'Margin' variable. '(Margin <25pct) * FD Low' and '(Margin <25pct) * FD High' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use instrumental variables (IV) estimator with heteroskedastic-robust standard errors (using Eicker-Huber-White "sandwich" variance-covariance matrix); specifications (2), (4), (6), and (8) use feasible heteroskedastic-efficient two-step generalized methods of moment (GMM) estimator. F-test is the test of the difference of coefficients '(Margin <25pct) * FD Low' and '(Margin <25pct) * FD High' in the second-stage regression.

Hansen J statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.8: 'Relaxed' Competition: Financial Development (FD) Full Interaction Specification

	(1) IV robust	(2) GMM	(3) IV robust	(4) GMM	(5) IV robust	(6) GMM	(7) IV robust	(8) GMM
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin >50pct) * FD Low	-0.342**	-0.327***	-0.365**	-0.370***	-0.345**	-0.330***	-0.332**	-0.320***
	(0.085)	(0.074)	(0.089)	(0.086)	(0.085)	(0.075)	(0.087)	(0.075)
(Margin >50pct) * FD High	-0.215	-0.194	-0.270**	-0.284***	-0.218	-0.198	-0.189	-0.169
	(0.186)	(0.178)	(0.119)	(0.099)	(0.184)	(0.176)	(0.205)	(0.193)
F-test	0.70	0.76	0.76	0.74	0.68	0.74	0.76	0.87
p-value	*0.404*	*0.384*	*0.383*	*0.391*	*0.409*	*0.389*	*0.383*	*0.352*
Hansen J statistic	0.137	0.137	0.047	0.047	0.139	0.139	0.080	0.080
p-value	*0.711*	*0.711*	*0.829*	*0.829*	*0.710*	*0.710*	*0.778*	*0.778*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.37	0.40	0.33	0.31	0.35	0.39	0.38	0.40
	*First-Stage Regression Statistics: (Margin >50pct) * FD Low*							
Partial R-squared	0.020	0.020	0.019	0.019	0.018	0.018	0.020	0.020
Shea Partial R-squared	0.017	0.017	0.018	0.018	0.016	0.016	0.014	0.014
F-statistic	19.5***	19.5***	12.79***	12.79***	18.56***	18.56***	19.71***	19.71***
p-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	*First-Stage Regression Statistics: (Margin >50pct) * FD High*							
Partial R-squared	0.003	0.003	0.006	0.006	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.003	0.003	0.005	0.005	0.003	0.003	0.002	0.002
F-statistic	13.05***	13.05***	18.45***	18.45***	15.12***	15.12***	12.14***	12.14***
p-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin >50pct) * FD Low	-0.444**	-0.447***	-0.399**	-0.397***	-0.509**	-0.511***	-0.366**	-0.378***
	(0.136)	(0.135)	(0.111)	(0.111)	(0.166)	(0.166)	(0.133)	(0.131)
(Margin >50pct) * FD High	0.052	0.052	-0.106	-0.100	0.009	0.009	0.051	0.050
	(0.221)	(0.221)	(0.129)	(0.128)	(0.221)	(0.221)	(0.175)	(0.175)
F-test	3.82*	3.86**	3.98**	4.08**	3.28*	3.30*	4.36**	4.63**
p-value	*0.051*	*0.049*	*0.046*	*0.044*	*0.070*	*0.069*	*0.037*	*0.031*
Hansen J statistic	0.062	0.062	1.219	1.219	0.031	0.031	0.314	0.314
p-value	*0.803*	*0.803*	*0.270*	*0.270*	*0.860*	*0.860*	*0.576*	*0.576*
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.74	0.74	0.77	0.77	0.69	0.69	0.79	0.79
	*First-Stage Regression Statistics: (Margin >50pct) * FD Low*							
Partial R-squared	0.004	0.004	0.005	0.005	0.003	0.003	0.005	0.005
Shea Partial R-squared	0.004	0.004	0.005	0.005	0.003	0.003	0.005	0.005
F-statistic	6.94***	6.94***	11.62***	11.62***	5.96***	5.96***	6.16***	6.16***
p-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.001*	*0.001*	*0.000*	*0.000*
	*First-Stage Regression Statistics: (Margin >50pct) * FD High*							
Partial R-squared	0.001	0.001	0.003	0.003	0.002	0.002	0.002	0.002
Shea Partial R-squared	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
F-statistic	4.34***	4.34***	6.34***	6.34***	4.28***	4.28***	6.20***	6.20***
p-value	*0.005*	*0.005*	*0.000*	*0.000*	*0.005*	*0.005*	*0.000*	*0.000*

Note: The Table is analogous to Table 6 except I interact 50 to 100 percent of the 'Margin' variable. '(Margin >50pct) * FD Low' and '(Margin >50pct) * FD High' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use instrumental variables (IV) estimator with heteroskedastic-robust standard errors (using Eicker-Huber-White "sandwich" variance-covariance matrix); specifications (2), (4), (6), and (8) use a feasible heteroskedastic-efficient two-step generalized methods of moment (GMM) estimator. F-test is the test of difference of coefficients '(Margin >50pct) * FD Low' and '(Margin >50pct) * FD High' in the second-stage regression.

Hansen J statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.1: 'Intense' Competition: Robustness to Autocorrelation and Clustering

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin <25pct) * FD Low	1.047***	1.071	1.254***	1.040	1.088***	1.090	0.985***	0.922
	(0.270)	(0.664)	(0.436)	(0.749)	(0.285)	(0.686)	(0.292)	(0.612)
(Margin <25pct) * FD High	0.073	0.091	0.108	-0.322	0.058	0.059	-0.108	-0.144
	(0.411)	(0.561)	(0.628)	(0.955)	(0.429)	(0.591)	(0.534)	(0.711)
F-test	5.44**	3.09*	1.67	1.07	5.13**	2.88*	4.28**	2.45
p-value	*0.020*	*0.079*	*0.196*	*0.301*	*0.024*	*0.090*	*0.039*	*0.117*
Sargan statistic	0.023	-	2.569	-	0.000	-	0.129	-
p-value	*0.878*	-	*0.109*	-	*0.989*	-	*0.720*	-
Hansen J statistic	-	0.012	-	1.409	-	0.000	-	0.070
p-value	-	*0.914*	-	*0.235*	-	*0.993*	-	*0.791*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.32	0.30	0.06	0.15	0.26	0.26	0.12	0.18
	*First-Stage Regression Statistics: (Margin <25pct) * FD Low*							
Partial R-squared	0.014	0.014	0.006	0.006	0.012	0.012	0.009	0.009
Shea Partial R-squared	0.012	0.012	0.005	0.005	0.011	0.011	0.008	0.008
F-statistic	11.68***	2.84**	5.21***	1.59	10.15***	2.53*	7.44***	2.83**
p-value	*0.000*	*0.037*	*0.001*	*0.190*	*0.000*	*0.056*	*0.000*	*0.038*
	*First-Stage Regression Statistics: (Margin <25pct) * FD High*							
Partial R-squared	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.003	0.003	0.002	0.002	0.003	0.003	0.003	0.003
F-statistic	2.63**	2.29*	1.60	1.39	2.55*	2.59*	2.81**	2.20*
p-value	*0.048*	*0.078*	*0.188*	*0.245*	*0.054*	*0.052*	*0.038*	*0.087*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin <25pct) * FD Low	1.513**	1.673	1.774	1.788	1.379***	1.515	0.911**	1.139
	(0.589)	(1.218)	(1.125)	(1.676)	(0.525)	(1.016)	(0.405)	(0.763)
(Margin <25pct) * FD High	0.005	0.006	-2.224	-2.239	0.089	0.105	-0.462	-0.569
	(0.321)	(0.450)	(1.738)	(2.666)	(0.305)	(0.426)	(0.502)	(0.801)
F-test	5.99**	2.00	2.27	1.03	6.51**	2.41	3.76*	1.84
p-value	*0.014*	*0.157*	*0.132*	*0.311*	*0.011*	*0.120*	*0.053*	*0.175*
Sargan statistic	0.935	-	0.002	-	0.660	-	2.129	-
p-value	*0.333*	-	*0.964*	-	*0.417*	-	*0.145*	-
Hansen J statistic	-	0.239	-	0.001	-	0.183	-	0.636
p-value	-	*0.625*	-	*0.979*	-	*0.668*	-	*0.425*
N	7,483	7,483	7,483	7,483	7,483	7,483	7,483	7,483
R-squared	0.67	0.63	0.01	0.02	0.68	0.65	0.76	0.70
	*First-Stage Regression Statistics: (Margin <25pct) * FD Low*							
Partial R-squared	0.002	0.002	0.004	0.004	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003
F-statistic	3.98***	1.08	7.04***	2.25*	4.9***	1.92	4.93***	1.41
p-value	*0.008*	*0.355*	*0.000*	*0.082*	*0.002*	*0.124*	*0.002*	*0.238*
	*First-Stage Regression Statistics: (Margin <25pct) * FD High*							
Partial R-squared	0.005	0.005	0.001	0.001	0.007	0.007	0.002	0.002
Shea Partial R-squared	0.005	0.005	0.001	0.001	0.006	0.006	0.002	0.002
F-statistic	9.74***	5.75***	1.78	0.86	12.39***	6.9***	3.33**	1.37
p-value	*0.000*	*0.001*	*0.149*	*0.460*	*0.000*	*0.000*	*0.019*	*0.251*

Note: The Table is analogous to Table 7 except here I use the generalized method of moments (GMM) estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors in specifications (1), (3), (5), and (7); the and GMM estimator with standard errors clustered at the country-industry level in specifications (2), (4), (6), and (8). F-test is the test of difference of coefficients '(Margin <25pct) * FD Low' and '(Margin <25pct) * FD High' in the second-stage regression. Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.2: 'Relaxed' Competition: Robustness to Autocorrelation and Clustering

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin >50pct) * FD Low	-0.342**	-0.323**	-0.365**	-0.376**	-0.345**	-0.325**	-0.332**	-0.316**
	(0.084)	(0.148)	(0.092)	(0.149)	(0.085)	(0.148)	(0.086)	(0.149)
(Margin >50pct) * FD High	-0.215	-0.186	-0.270*	-0.284	-0.218	-0.190	-0.189	-0.166
	(0.226)	(0.275)	(0.149)	(0.181)	(0.223)	(0.273)	(0.260)	(0.291)
F-test	0.39	0.52	0.38	0.49	0.38	0.51	0.40	0.55
p-value	*0.533*	*0.473*	*0.538*	*0.486*	*0.539*	*0.476*	*0.525*	*0.457*
Sargan statistic	0.028	-	0.015	-	0.028	-	0.016	-
p-value	*0.867*	-	*0.902*	-	*0.866*	-	*0.899*	-
Hansen J statistic	-	0.036	-	0.015	-	0.037	-	0.021
p-value	-	*0.849*	-	*0.902*	-	*0.848*	-	*0.886*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.37	0.41	0.33	0.30	0.35	0.40	0.38	0.41
	*First-Stage Regression Statistics: (Margin >50pct) * FD Low*							
Partial R-squared	0.020	0.020	0.019	0.019	0.018	0.018	0.020	0.020
Shea Partial R-squared	0.017	0.017	0.018	0.018	0.016	0.016	0.014	0.014
F-statistic	15.27***	7.14***	14.59***	7.86***	13.79***	7.07***	15.19***	7.32***
p-value	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
	*First-Stage Regression Statistics: (Margin >50pct) * FD High*							
Partial R-squared	0.003	0.003	0.006	0.006	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.003	0.003	0.005	0.005	0.003	0.003	0.002	0.002
F-statistic	2.33*	3.17**	4.28***	3.93***	2.58*	3.54**	2.31*	2.76**
p-value	*0.073*	*0.024*	*0.005*	*0.009*	*0.052*	*0.015*	*0.075*	*0.041*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
(Margin >50pct) * FD Low	-0.444**	-0.455**	-0.398**	-0.441***	-0.509**	-0.521**	-0.366**	-0.393*
	(0.146)	(0.220)	(0.128)	(0.171)	(0.182)	(0.248)	(0.136)	(0.201)
(Margin >50pct) * FD High	0.052	0.069	-0.106	-0.093	0.009	0.020	0.051	0.067
	(0.253)	(0.482)	(0.183)	(0.212)	(0.254)	(0.482)	(0.194)	(0.381)
F-test	3.05*	1.48	2.61	2.25	2.57	1.31	3.77*	2.04
p-value	*0.081*	*0.223*	*0.107*	*0.134*	*0.109*	*0.252*	*0.052*	*0.153*
Sargan statistic	0.056	-	1.010	-	0.027	-	0.347	-
p-value	*0.812*	-	*0.315*	-	*0.870*	-	*0.556*	-
Hansen J statistic	-	0.021	-	0.615	-	0.009	-	0.101
p-value	-	*0.884*	-	*0.433*	-	*0.923*	-	*0.751*
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.74	0.73	0.77	0.75	0.69	0.69	0.79	0.78
	*First-Stage Regression Statistics: (Margin >50pct) * FD Low*							
Partial R-squared	0.004	0.004	0.005	0.005	0.003	0.003	0.005	0.005
Shea Partial R-squared	0.004	0.004	0.005	0.005	0.003	0.003	0.005	0.005
F-statistic	6.68***	2.89**	8.59***	4.11***	4.96***	2.34*	6.97***	3.20**
p-value	*0.000*	*0.035*	*0.000*	*0.007*	*0.002*	*0.072*	*0.000*	*0.023*
	*First-Stage Regression Statistics: (Margin >50pct) * FD High*							
Partial R-squared	0.001	0.001	0.003	0.003	0.002	0.002	0.002	0.002
Shea Partial R-squared	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002
F-statistic	2.21*	0.71	4.28***	1.01	2.71**	0.64	3.01**	0.99
p-value	*0.085*	*0.547*	*0.005*	*0.387*	*0.044*	*0.588*	*0.029*	*0.397*

Note: The Table is analogous to Table 8 except here I use the generalized method of moments (GMM) estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors in specifications (1), (3), (5), and (7); and the GMM estimator with standard errors clustered at the country-industry level in specifications (2), (4), (6), and (8). F-test is the test of difference of coefficients '(Margin >50pct) * FD Low' and '(Margin >50pct) * FD High' in the second-stage regression. Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.3: R&D / Capital Expenditures and Competition: Financial Development (FD) Continuous Interaction

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin	-0.864**	-0.944**	-0.472***	-0.536**	-0.478***	-0.546**	-0.761**	-0.833**
	(0.427)	(0.372)	(0.118)	(0.212)	(0.120)	(0.213)	(0.334)	(0.324)
Margin * FD	0.620	0.654	0.035	0.077	0.131	0.233	0.647	0.671
	(0.642)	(0.500)	(0.244)	(0.236)	(0.581)	(0.548)	(0.695)	(0.570)
Sargan statistic	0.687	-	1.611	-	1.580	-	0.867	-
p-value	*0.407*	-	*0.204*	-	*0.209*	-	*0.352*	-
Hansen J statistic	-	0.918	-	2.038	-	2.023	-	1.174
p-value	-	*0.338*	-	*0.153*	-	*0.155*	-	*0.279*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.50	0.46	0.49	0.45	0.49	0.44	0.53	0.49
			First-Stage Regression Statistics: Margin					
Partial R-squared	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Shea Partial R-squared	0.010	0.010	0.030	0.030	0.025	0.025	0.021	0.021
F-statistic	15.06***	5.89***	15.06***	5.89***	15.06***	5.89***	15.06***	5.89***
p-value	*0.000*	*0.001*	*0.000*	*0.001*	*0.000*	*0.001*	*0.000*	*0.001*
			*First-Stage Regression Statistics: Margin * FD*					
Partial R-squared	0.012	0.012	0.014	0.014	0.011	0.011	0.011	0.011
Shea Partial R-squared	0.006	0.006	0.022	0.022	0.015	0.015	0.012	0.012
F-statistic	9.39***	5.43***	10.86***	4.92***	8.73***	4.28***	8.68***	5.43***
p-value	*0.000*	*0.001*	*0.000*	*0.002*	*0.000*	*0.005*	*0.000*	*0.001*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin	-1.408**	-1.869*	-0.613**	-0.610**	-0.849**	-0.784*	-1.740**	-1.740**
	(0.627)	(1.018)	(0.276)	(0.309)	(0.384)	(0.415)	(0.682)	(0.818)
Margin * FD	1.570*	2.031	2.038	2.829	5.992	6.120	3.285**	3.293
	(0.898)	(1.320)	(1.631)	(1.818)	(3.738)	(3.771)	(1.600)	(2.152)
Sargan statistic	2.871*	-	3.683*	-	0.762	-	0.001	-
p-value	*0.090*	-	*0.055*	-	*0.383*	-	*0.974*	-
Hansen J statistic	-	1.773	-	2.160	-	0.398	-	0.000
p-value	-	*0.183*	-	*0.142*	-	*0.528*	-	*0.982*
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.77	0.70	0.74	0.59	0.60	0.58	0.79	0.79
			First-Stage Regression Statistics: Margin					
Partial R-squared	0.006	0.006	0.006	0.006	0.006	0.006	0.005	0.005
Shea Partial R-squared	0.003	0.003	0.006	0.006	0.004	0.004	0.008	0.008
F-statistic	9.91***	3.21**	9.91***	3.21**	9.91***	3.21**	6.95***	2.16*
p-value	*0.000*	*0.023*	*0.000*	*0.023*	*0.000*	*0.023*	*0.000*	*0.091*
			*First-Stage Regression Statistics: Margin * FD*					
Partial R-squared	0.004	0.004	0.001	0.001	0.001	0.001	0.002	0.002
Shea Partial R-squared	0.002	0.002	0.001	0.001	0.001	0.001	0.004	0.004
F-statistic	6.24***	1.67	1.18	0.68	1.97	1.00	3.07**	0.82
p-value	*0.000*	*0.172*	*0.314*	*0.564*	*0.116*	*0.392*	*0.027*	*0.486*

Note: The data and the equation specification are analogous to the ones used in Table 5 except here I interact 'Margin' with continuous measures of financial development (see Table 2). The dependent variable in the first (second) panel is 'R&D' ('CapEx'). 'Margin' and 'Margin * FD' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use the GMM estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors; specifications (2), (4), (6), and (8) use the GMM estimator with standard errors clustered at the country-industry level. Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions.

See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.4: 'Intense' Competition: Financial Development (FD) Continuous Interaction Specification

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin <25pct	2.575***	2.510*	0.764*	0.325	1.154***	0.823	2.853***	2.872*
	(0.808)	(1.365)	(0.438)	(0.542)	(0.393)	(0.673)	(0.870)	(1.570)
(Margin <25pct) * FD	-2.757**	-2.722*	0.383	0.269	-5.889	-5.909	-4.285**	-4.536*
	(1.209)	(1.639)	(1.844)	(2.241)	(4.816)	(5.795)	(1.775)	(2.614)
Sargan statistic	0.063	-	3.797*	-	2.642	-	0.513	-
p-value	*0.801*	-	*0.051*	-	*0.104*	-	*0.474*	-
Hansen J statistic	-	0.030	-	3.072*	-	1.237	-	0.170
p-value	-	*0.863*	-	*0.080*	-	*0.266*	-	*0.680*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.29	0.31	0.05	0.50	0.04	0.05	0.41	0.40
			First-Stage Regression Statistics: Margin <25pct					
Partial R-squared	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Shea Partial R-squared	0.009	0.009	0.007	0.007	0.007	0.007	0.011	0.011
F-statistic	4.47***	2.57*	4.47***	2.57*	4.47***	2.57*	4.47***	2.57*
p-value	*0.004*	*0.054*	*0.004*	*0.054*	*0.004*	*0.054*	*0.004*	*0.054*
			*First-Stage Regression Statistics: (Margin <25pct) * FD*					
Partial R-squared	0.003	0.003	0.002	0.002	0.001	0.001	0.003	0.003
Shea Partial R-squared	0.005	0.005	0.002	0.002	0.001	0.001	0.007	0.007
F-statistic	2.78**	2.57*	1.55	2.02	0.75	0.98	2.63**	2.30*
p-value	*0.040*	*0.054*	*0.200*	*0.109*	*0.523*	*0.401*	*0.048*	*0.077*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin <25pct	2.895**	3.518	3.353	3.184	2.237**	2.364	2.496***	2.905
	(1.296)	(2.744)	(2.777)	(3.493)	(1.020)	(1.888)	(0.878)	(2.021)
(Margin <25pct) * FD	-2.854**	-3.516	-12.595	-12.316	-12.978*	-13.649	-3.728**	-4.329
	(1.370)	(2.713)	(11.063)	(13.391)	(6.267)	(10.802)	(1.472)	(3.188)
Sargan statistic	2.092	-	0.295	-	0.124	-	2.916*	-
p-value	*0.148*	-	*0.587*	-	*0.725*	-	*0.088*	-
Hansen J statistic	-	0.686	-	0.100	-	0.033	-	0.504
p-value	-	*0.408*	-	*0.752*	-	*0.857*	-	*0.478*
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.65	0.55	0.65	0.61	0.46	0.41	0.85	0.84
			First-Stage Regression Statistics: Margin <25pct					
Partial R-squared	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003
Shea Partial R-squared	0.002	0.002	0.001	0.001	0.001	0.001	0.011	0.011
F-statistic	6.65***	5.41***	6.65***	5.41***	6.65***	5.41***	5.47***	4.36***
p-value	*0.000*	*0.001*	*0.000*	*0.001*	*0.000*	*0.001*	*0.001*	*0.005*
			*First-Stage Regression Statistics: (Margin <25pct) * FD*					
Partial R-squared	0.004	0.004	0.001	0.001	0.003	0.003	0.003	0.003
Shea Partial R-squared	0.002	0.002	0.000	0.000	0.001	0.001	0.009	0.009
F-statistic	8.03***	6.40***	2.83**	3.11**	5.28***	4.71***	4.74***	4.54***
p-value	*0.000*	*0.000*	*0.037*	*0.026*	*0.001*	*0.003*	*0.003*	*0.004*

Note: The data are the same as in Table 5. The dependent variable in the top (bottom) panel is 'R&D' ('CapEx'). 'Margin <25pct' stands for 0 to 25 percent of the 'Margin' variable, '(Margin <25pct) * FD' stands for 0 to 25 percent of the 'Margin' variable interacted with continuous measures of financial development (see Table 2). 'Margin <25pct' and '(Margin <25pct) * FD' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use the GMM estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors; specifications (2), (4), (6), and (8) use the GMM estimator with standard errors clustered at the country-industry level. Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions.

See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.5: 'Relaxed' Competition: Financial Development (FD) Continuous Interaction Specification

	(1) GMM autocorrelation	(2) GMM clustered	(3) GMM autocorrelation	(4) GMM clustered	(5) GMM autocorrelation	(6) GMM clustered	(7) GMM autocorrelation	(8) GMM clustered
	R&D	R&D	R&D	R&D	R&D	R&D	R&D	R&D
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin >50pct	-0.478**	-0.485**	-0.365**	-0.401**	-0.360**	-0.395**	-0.449**	-0.462**
	(0.228)	(0.228)	(0.098)	(0.168)	(0.094)	(0.162)	(0.189)	(0.208)
(Margin >50pct) * FD	0.236	0.229	0.083	0.087	0.199	0.205	0.249	0.240
	(0.376)	(0.315)	(0.177)	(0.151)	(0.407)	(0.341)	(0.403)	(0.342)
Sargan statistic	0.010	-	0.155	-	0.137	-	0.025	-
p-value	*0.919*	-	*0.694*	-	*0.711*	-	*0.873*	-
Hansen J statistic	-	0.011	-	0.144	-	0.127	-	0.025
p-value	-	*0.917*	-	*0.705*	-	*0.721*	-	*0.875*
N	3,551	3,551	3,551	3,551	3,551	3,551	3,551	3,551
R-squared	0.35	0.33	0.29	0.21	0.30	0.22	0.36	0.32
	First-Stage Regression Statistics: Margin >50pct							
Partial R-squared	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Shea Partial R-squared	0.013	0.013	0.018	0.018	0.016	0.016	0.028	0.028
F-statistic	8.48***	3.62**	8.48***	3.62**	8.48***	3.62**	8.48***	3.62**
p-value	*0.000*	*0.013*	*0.000*	*0.013*	*0.000*	*0.013*	*0.000*	*0.013*
	*First-Stage Regression Statistics: (Margin >50pct) * FD*							
Partial R-squared	0.006	0.006	0.011	0.011	0.008	0.008	0.006	0.006
Shea Partial R-squared	0.007	0.007	0.018	0.018	0.013	0.013	0.016	0.016
F-statistic	4.68***	2.75**	8.41***	4.36***	6.68***	3.15**	4.73***	2.93**
p-value	*0.003*	*0.042*	*0.000*	*0.005*	*0.000*	*0.024*	*0.003*	*0.033*
	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx	CapEx
	Private Credit		*Market Capitalization*		*Market Value Traded*		*Accounting Standards*	
Margin >50pct	-1.099**	-1.293*	-0.375**	-0.439	-0.339**	-0.283	-0.776**	-0.783**
	(0.501)	(0.745)	(0.167)	(0.281)	(0.160)	(0.283)	(0.324)	(0.379)
(Margin >50pct) * FD	1.154	1.332	0.140	0.605	1.702	2.575	1.554	1.500
	(0.742)	(0.998)	(0.883)	(1.299)	(1.801)	(2.403)	(1.401)	(2.374)
Sargan statistic	0.592	-	4.450	-	4.010**	-	0.343	-
p-value	*0.442*	-	*0.035*	-	*0.045*	-	*0.558*	-
Hansen J statistic	-	0.251	-	1.387	-	1.734	-	
p-value	-	*0.616*	-	*0.239*	-	*0.188*	-	
N	7,483	7,483	7,483	7,483	7,483	7,483	6,876	6,876
R-squared	0.66	0.59	0.76	0.78	0.78	0.68	0.80	0.82
	First-Stage Regression Statistics: Margin >50pct							
Partial R-squared	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001
Shea Partial R-squared	0.002	0.002	0.004	0.004	0.004	0.004	0.011	0.011
F-statistic	3.16**	1.45	3.16**	1.45	3.16**	1.45	2.22*	1.06
p-value	*0.024*	*0.226*	*0.024*	*0.226*	*0.024*	*0.226*	*0.084*	*0.363*
	*First-Stage Regression Statistics: (Margin >50pct) * FD*							
Partial R-squared	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Shea Partial R-squared	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
F-statistic	1.78	0.60	0.47	0.37	0.48	0.44	0.29	0.10
p-value	*0.149*	*0.613*	*0.702*	*0.775*	*0.693*	*0.725*	*0.833*	*0.960*

Note: The data are the same as in Table 5. The dependent variable in the top (bottom) panel is 'R&D' ('CapEx'). 'Margin >50pct' stands for 50 to 100 percent of the 'Margin' variable, '(Margin >50pct) * FD' stands for 50 to 100 percent of the 'Margin' variable interacted with continuous measures of financial development (see Table 2). 'Margin >50pct' and '(Margin >50pct) * FD' are instrumented using the EU 'Single Market Programme' variables described in Table 4. The estimated specifications (1), (3), (5), and (7) use the GMM estimator with autocorrelation-consistent and heteroskedastic-and-autocorrelation-consistent standard errors; specifications (2), (4), (6), and (8) use the GMM estimator with standard errors clustered at the country-industry level. Sargan (Hansen J) statistic corresponds to tests of overidentifying restrictions. (Shea) Partial R-squared is for the EU 'Single Market Programme' variables in the first-stage regressions; similarly, F-statistic is the test of the joint significance of these variables in the first-stage regressions.

See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. I always control for 3-digit-NACE industry, country, and year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.A.6: ANOVAs: EU 'single-market' Countries in 1995-2004

	CapEx		R&D		Margin	
Industry	15.77	65%	10.10	90%	38.80	62%
	(101)		(101)		(101)	
Country	7.19	30%	0.96	9%	23.27	37%
	(10)		(7)		(10)	
Year	1.13	5%	0.01	0%	0.60	1%
	(10)		(10)		(10)	
Model	24.11	45%	11.16	57%	62.79	52%
Total	54.17		19.48		120.92	
N	7,483		3,551		7,483	
R-squared	0.44		0.56		0.51	

Note: The Table presents three-factor (Industry, Country, Year) ANOVAs of 'CapEx', 'R&D', and 'Margin' for 10 EU countries that participated in the EU 'Single Market Programme' at its inception in 1993 (see Table 1). Numbers in cells refer to the partial sum of squares while the numbers in parentheses refer to the number of indicators. Percentages show the fraction of the model's (total) variation explained by a given factor (model). I remove outliers by using the 1-to-99 percentile range of the dependent variable. All factors are significant at the 1% level, p-values not shown. See the Data Appendix for complete definitions and sources of variables.

Tab. 3.A.7: First-Stage: Competition and the EU 'Single Market Programme' (SMP) Instruments

	(1) OLS robust	(2) OLS robust	(3) OLS robust	(4) OLS robust
	Margin	Margin	Margin	Margin
Affected Industries Classified as SMP Group 1	-0.003		-0.002	
	(0.004)		(0.004)	
Affected Industries Classified as SMP Group 2	0.036***	0.036***	0.037***	0.037***
	(0.009)	(0.009)	(0.009)	(0.009)
Affected Industries Classified as SMP Group 3	-0.011***	-0.011***	-0.010**	-0.010**
	(0.004)	(0.004)	(0.004)	(0.004)
Affected Industries Classified as SMP Group 4.1	-0.013***	-0.013***	-0.014***	-0.014***
	(0.003)	(0.003)	(0.003)	(0.003)
Affected Industries Classified as SMP Group 4.2	0.001		-0.001	
	(0.006)		(0.005)	
Affected Industries Classified as SMP Group 4.3	-0.002***	-0.002***	-0.002**	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Industry dummies	Yes	Yes	No	No
Country dummies	Yes	Yes	No	No
Industry-year dummies	No	No	Yes	Yes
Country-year dummies	No	No	Yes	Yes
F-statistic	8.67***	12.88***	7.75***	11.55***
p-value	*0.000*	*0.000*	*0.000*	*0.000*
Partial R-squared	0.008	0.008	0.009	0.009
N	7,483	7,483	7,483	7,483
R-squared	0.52	0.52	0.58	0.58

Note: The sample consists of 101 three-digit NACE manufacturing industries across 10 countries that participated in the EU 'Single Market Programme' (SMP) at its inception in 1993 (see Table 1) over the period 1995-2004. The dependent variable is 'Margin' while regressors are based on the EU 'Single Market Programme' variables described in Table 4. The 'Affected Industries Classified as SMP Group 1' variable is created as follows: First, I take 0/1 variables equal 1 for NACE 3-digit industry-country pairs from the list of 'SMP Group 1' industries identified (ex ante) to be affected by the introduction of the EU's 'Single Market Programme' in 1993 (EU-wide product market reform). Second, I interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). The remaining EU 'Single Market Programme' regressors are defined analogously for 'SMP Group 2', 'SMP Group 3', 'SMP Group 4.1', 'SMP Group 4.2', and 'SMP Group 4.3' industry groups.

Partial R-squared is for the EU 'Single Market Programme' variables; similarly, F-statistic is the test of the joint significance of these variables. See the Data Appendix for complete definitions and sources of variables. I remove outliers by using the 1-to-99 percentile range of the dependent variable. In specifications (1) and (2) I control for 3-digit-NACE industry, country, and year dummies; in specification (3) and (4) I control for 3-digit-NACE industry-year and country-year dummies, not shown. Standard errors are reported in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

Tab. 3.DA.1: Definition of Variables

	Industry-level Variables
VA	Industry-country-year-level (period 1995-2004) value-added at factor cost (v12150). Value-added is the difference between what was produced and what was used as "inputs" by production. It is the main indicator of the wealth created in a company. Source: Eurostat, Structural Business Statistics, Detailed data on all enterprises.
CapEx	Industry-country-year-level (period 1995-2004) gross investment in tangible goods (v15110) divided by value-added (VA). Source: Eurostat, Structural Business Statistics, Detailed data on all enterprises.
R&D	Industry-country-year-level (period 1995-2004) total intra-mural R&D expenditure (v22110) divided by value-added (VA). Total intra-mural expenditures are all expenditures for Research & Development undertaken within the company, regardless of the source of funds. Source: Eurostat, Structural Business Statistics, Detailed data on all enterprises.
Margin	Industry-country-year-level (period 1995-2004) gross operating surplus (v12170) divided by value-added (VA). Gross operating surplus is surplus generated by operating activities after the labor factor input has been recompensed. It is the balance available to the company which allows it to recompense the providers of funds and debt, to pay taxes, and eventually to finance all or part of its investment. Income and expenditure classified as financial or extraordinary in company accounts is excluded from the gross operating surplus. Source: Eurostat, Structural Business Statistics, Detailed data on all enterprises.
	EU 'Single Market Programme' Variables
Affected Industries Classified as SMP Group 1	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 1 - High-technology, public-procurement markets') considered is: 322 - Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy; 331 - Manufacture of medical and surgical equipment and orthopaedic appliances. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.
Affected Industries Classified as SMP Group 2	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 2: Traditional public-procurement and regulated markets (High price dispersion)') considered is: 159 - Manufacture of beverages; 244 - Manufacture of pharmaceuticals, medicinal chemicals and botanical products; 282 - Manufacture of tanks, reservoirs and containers of metal; manufacture of central heating radiators and boilers; 283 - Manufacture of steam generators, except central heating hot water boilers; 342 - Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers; 352 - Manufacture of railway, tramway locomotives, rolling stock. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.
Affected Industries Classified as SMP Group 3	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 3: Traditional public-procurement and regulated markets (Low price dispersion)') considered is: 155 - Manufacture of dairy products; 156 - Manufacture of grain mill products, starches and starch products; 158 - Manufacture of other food products; 311 - Manufacture of electric motors, generators and transformers; 312 - Manufacture of electricity distribution and control apparatus; 313 - Manufacture of insulated wire and cable; 316 - Manufacture of electrical equipment n.e.c.; 321 - Manufacture of electronic valves and tubes and other electronic components. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.
Affected Industries Classified as SMP Group 4.1	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 4.1: Sectors with moderate non-tariff barriers (Consumer goods)') considered is: 181 - Manufacture of leather clothes; 182 - Manufacture of other wearing apparel and accessories; 221 - Publishing; 223 - Reproduction of recorded media; 252 - Manufacture of plastic products;297 - Manufacture of domestic appliances n.e.c.; 323 - Manufacture of television and radio receivers, sound or video recording or reproducing apparatus and associated goods; 341 - Manufacture of motor vehicles; 362 - Manufacture of jewellery and related articles. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.

Tab. 3.DA.1: Definition of Variables (cont.)

Affected Industries Classified as SMP Group 4.2	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 4.2: Sectors with moderate non-tariff barriers (Investment goods)') considered is: 286 - Manufacture of cutlery, tools and general hardware; 291 - Manufacture of machinery for the production and use of mechanical power, except aircraft, vehicle and cycle engines; 292 - Manufacture of other general purpose machinery; 293 - Manufacture of agricultural and forestry machinery; 294 - Manufacture of machine-tools (split into DK2941, DK2942 and DK2943 in NACE Rev.1.1); 295 - Manufacture of other special purpose machinery; 296 - Manufacture of weapons and ammunition; 351 - Building and repairing of ships and boats; 353 - Manufacture of aircraft and spacecraft. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.
Affected Industries Classified as SMP Group 4.3	First, we take 0/1 variables equal 1 for NACE 3-digit industry-country pairs identified ex-ante to be affected by the introduction of the EU 'Single Market Programme' (SMP) in 1993 (EU-wide product market reform). The list of industries (denoted 'SMP Group 4.3: Sectors with moderate non-tariff barriers (Intermediate goods)') considered is: 151 - Production, processing, preserving of meat, meat products; 171 - Preparation and spinning of textile fibres; 172 - Textile weaving; 174 - Manufacture of made-up textile articles, except apparel; 175 - Manufacture of other textiles; 193 - Manufacture of footwear; 241 - Manufacture of basic chemicals; 242 - Manufacture of pesticides and other agro-chemical products; 245 - Manufacture of soap, detergents, cleaning, polishing; 246 - Manufacture of other chemical products; 251 - Manufacture of rubber products; 261 - Manufacture of glass and glass products; 262 - Manufacture of non-refractory ceramic goods other than for construction purposes; manufacture of refractory ceramic products; 263 - Manufacture of ceramic tiles and flags; 264 - Manufacture of bricks, tiles and construction products; 315 - Manufacture of lighting equipment and electric lamps; 332 - Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment; 364 - Manufacture of sports goods; 365 - Manufacture of games and toys; 366 - Miscellaneous manufacturing n.e.c.; 372 - Recycling of non-metal waste and scrap. Second, we interact the indicator variables with the percentage share of each affected industry in total manufacturing employment in each country (average over 1985-1987). Source: Buigues et al. (1990), Table 26 of statistical Annex, p. XVI.
	Financial Development Country-level Measures
PCDMBANKOFINSTGDP	Private credit by deposit money banks and other financial institutions to GDP. Average over the period 1990-1994. Source: The World Bank Financial Structure and Economic Development Database.
STMCAPGDP	Stock market capitalization to GDP. Average over the period 1990-1994. Source: The World Bank Financial Structure and Economic Development Database.
STMTVTGDP	Stock market total value traded to GDP. Average over the period 1990-1994. Source: The World Bank Financial Structure and Economic Development Database.
ACCOUNT	Index created by examining and rating companies' 1990 annual reports on their inclusion or omission of 90 items in balance sheets and income statements and published by the Center for International Financial Analysis & Research, Inc. The maximum is 90 while the minimum is 0. Source: The Center for International Financial Analysis & Research, Inc.
FD High	0/1 variable, equal to 1 if a country has above-median value of financial development among the 10 countries that participated in the EU's 'Single Market Programme' at its inception in 1993. 'FD High' is constructed separately for each financial development measure listed above. Source: The World Bank Financial Structure and Economic Development Database.
FD Low	0/1 variable, equal to 1 if a country has below-median value of financial development among the 10 countries that participated in the EU's 'Single Market Programme' at its inception in 1993. 'FD Low' is constructed separately for each financial development measure listed above. Source: The World Bank Financial Structure and Economic Development Database.

Appendix C: Proofs

Proof of Proposition 3.2.1

Consider the value functions of the leader, of each firm in the neck-and-neck state, and of the laggard when their rival's strategy is characterized by the R&D investment pair $\{\overline{x}, \overline{y}\}$ in the two states. Let V_1, V_0, and V_{-1} denote the steady state values of being currently the leader in the unleveled state, a firm in the neck-and-neck state, and the laggard in the unleveled state, respectively. V_0 is obtained from the optimization problem

$$V_0 = \max_x \left\{ (\pi_0 - x)\, dt + e^{-rdt} \left[\sqrt{x} V_1 dt + \sqrt{\overline{x}} V_{-1} dt + \left[1 - \left(\sqrt{x} + \sqrt{\overline{x}} \right) dt \right] V_0 \right] \right\}.$$

V_1 and V_{-1} are determined analogously. For dt small, $e^{-rdt} \approx 1 - rdt$, the terms of order $(dt)^2$ can be ignored, and the system of equations becomes

$$\begin{aligned} rV_0 &= \max_x \left\{ (\pi_0 - x) + \sqrt{x}\,(V_1 - V_0) - \sqrt{\overline{x}}\,(V_0 - V_{-1}) \right\}, \\ rV_{-1} &= \max_y \left\{ (\pi_{-1} - y) + (\sqrt{y} + h)\,(V_0 - V_{-1}) \right\}, \\ rV_1 &= \pi_1 - \left(\sqrt{\overline{y}} + h \right) (V_1 - V_0)\,. \end{aligned} \tag{3.3}$$

The first line of (3.3), which describes the optimization problem of each firm in the neck-and-neck state, reads as follows. The annuity value of being a firm in the neck-and-neck state at date t, rV_0, equals current profit flow minus R&D investment flow, $\pi_0 - x$, plus capital gain, $V_1 - V_0$, in case the firm innovates and becomes the leader (which happens with intensity $\sqrt{x}$), minus capital loss, $V_0 - V_{-1}$, in case the firm's competitor innovates and the firm becomes the laggard (which happens with intensity $\sqrt{\overline{x}}$). In the second line of (3.3), the annuity value of being the laggard at date t, rV_{-1}, equals current profit flow minus R&D investment flow, $\pi_{-1} - y$, plus the expected capital gain $(\sqrt{y} + h)\,(V_0 - V_{-1})$ in case the laggard innovates and catches up with the leader. Finally, the annuity value of being the leader at date t, rV_1, equals current profit flow π_1 minus expected capital loss $(\sqrt{\overline{y}} + h)\,(V_1 - V_0)$in case the laggard innovates and the industry switches to the neck-and-neck state. The first order conditions are $V_1 = 2\sqrt{x} + V_0$ and $V_{-1} = -2\sqrt{y} + V_0$ for a firm in the neck-and-neck state and the laggard, respectively. System of equations (3.3) together with FOCs and symmetry ($x = \overline{x}$, $y = \overline{y}$) leads to

$$\begin{aligned} \pi_0 &= rV_0 + 2\sqrt{x}\sqrt{y} - x, \\ \pi_1 &= rV_0 + 2\sqrt{x}\,(h + r + \sqrt{y}), \\ \pi_{-1} &= rV_0 - 2(h+r)\sqrt{y} - y. \end{aligned} \tag{3.4}$$

Solving (3.4) when $\pi_0 \equiv \pi_{-1} + (1-\Delta)(\pi_1 - \pi_{-1})$ and simplifying using $\Pi \equiv \pi_1 - \pi_{-1}$ and $H \equiv h + r$ gives

$$\left\{ \begin{array}{l} x = \Pi\Delta + 2H\left(H - \sqrt{H^2 + \Pi\Delta}\right), \\ y = 4H^2 + (1+2\Delta)\Pi - 2H\sqrt{H^2 + \Pi\Delta} - \\ 2\sqrt{\left(H^2 + \Pi\Delta\right)\left(3H^2 + (1+\Delta)\Pi - 2H\sqrt{H^2 + \Pi\Delta}\right)} \end{array} \right\}. \tag{3.5}$$

Further simplification yields the results presented in Proposition 3.2.1. Solution (3.5) is the only one with $x \geq 0$ and $y \geq 0$ for $\Pi > 0$ and $H \geq 0$ (within the class of symmetric stationary Markov equilibria). In the special case when $r = 0$ and $h = 0$ result (3.5) simplifies to

$$\left\{ x = \Pi\Delta,\ y = \Pi\left[1 + 2\left(\Delta - \sqrt{\Delta(1+\Delta)}\right)\right] \right\}. \tag{3.6}$$

Proof of Corollary 3.2.2

Comparative static results obtained by differentiating the R&D investment of a firm in the neck-and-neck state (part one of Proposition 3.2.1) and simplifying using $\Pi \equiv \pi_1 - \pi_{-1}$, $H \equiv h + r$, and $\Omega \equiv \sqrt{H^2 + \Delta\Pi} > H$ are

$$\frac{\partial x}{\partial \Delta} = \Pi\left(1 - \frac{H}{\Omega}\right) > 0,\ \frac{\partial x}{\partial \Pi} = \Delta\left(1 - \frac{H}{\Omega}\right) > 0, \text{ and } \frac{\partial x}{\partial H} = -\frac{2\left(\Omega - H\right)^2}{\Omega} < 0.$$

Similarly, comparative static properties of the laggard's R&D investment in the unleveled state (part two of Proposition 3.2.1) are

$$\begin{aligned} \frac{\partial y}{\partial \Delta} &= \Pi\left(2 - \frac{H}{\Omega} - \frac{2H^2 + \Pi - 3H\Omega + 2\Omega^2}{\Omega\sqrt{2H^2 + \Pi - 2H\Omega + \Omega^2}}\right) < 0, \\ \frac{\partial y}{\partial \Pi} &= 1 + 2\Delta - \frac{\Delta H}{\Omega} - \frac{(1+4\Delta)H^2 + 2\Delta(1+\Delta)\Pi - 3\Delta H\Omega}{\Omega\sqrt{2H^2 + \Pi - 2H\Omega + \Omega^2}} > 0, \text{ and} \\ \frac{\partial y}{\partial H} &= 8H - \frac{2H^2}{\Omega} - 2\Omega + \frac{2\left(3H^4 + 5\Delta H^2\Pi + \Omega^4 - H\Omega\left(2H^2 + \Pi + 4\Omega^2\right)\right)}{\Omega\sqrt{2H^2 + \Pi - 2H\Omega + \Omega^2}} < 0. \end{aligned}$$

As $0 < x < \Pi$ and $0 < y < \Pi$, if the technological leadership rent satisfies $\Pi \leq 1$ so that $0 < \sqrt{x} < 1$ and $0 < \sqrt{y} < 1$, innovation intensities $\sqrt{x}$ and $\sqrt{y}$ are well-defined probabilities.

Proof of Corollary 3.2.3

In the steady state, the flow of industries from the neck-and-neck state to the unleveled state matches the opposite flow

$$2\lambda\sqrt{x} = (1-\lambda)\left(\sqrt{y}+h\right). \tag{3.7}$$

Solving (3.7) for λ gives the steady state fraction of industries in the neck-and-neck state

$$\lambda = \frac{\sqrt{y}+h}{2\sqrt{x}+\sqrt{y}+h}. \tag{3.8}$$

Substituting (3.7) and (3.8) into the definition of the aggregate innovation intensity $I \equiv 2\lambda\sqrt{x} + (1-\lambda)\left(\sqrt{y}+h\right)$ and simplifying gives

$$I = \frac{4\sqrt{x}\left(\sqrt{y}+h\right)}{2\sqrt{x}+\sqrt{y}+h}, \tag{3.9}$$

where x and y are the R&D investments from Proposition 3.2.1. Differentiating (3.9) with respect to Π, r, Δ, and h and applying the comparative static results derived in Corollary 3.2.2 gives

$$\frac{\partial I}{\partial \Pi} = \frac{2\left(\sqrt{y}+h\right)^2\sqrt{y}\frac{\partial x}{\partial \Pi} + 4x^{\frac{3}{2}}\frac{\partial y}{\partial \Pi}}{\sqrt{x}\left(2\sqrt{x}+\sqrt{y}+h\right)^2\sqrt{y}} > 0, \tag{3.10}$$

$$\frac{\partial I}{\partial r} = \frac{2\left(\sqrt{y}+h\right)^2\sqrt{y}\frac{\partial x}{\partial r} + 4x^{\frac{3}{2}}\frac{\partial y}{\partial r}}{\sqrt{x}\left(2\sqrt{x}+\sqrt{y}+h\right)^2\sqrt{y}} < 0, \tag{3.11}$$

$$\frac{\partial I}{\partial \Delta} = \frac{2\left(\sqrt{y}+h\right)^2\sqrt{y}\frac{\partial x}{\partial \Delta} + 4x^{\frac{3}{2}}\frac{\partial y}{\partial \Delta}}{\sqrt{x}\left(2\sqrt{x}+\sqrt{y}+h\right)^2\sqrt{y}} >< 0, \text{ and} \tag{3.12}$$

$$\frac{\partial I}{\partial h} = \frac{2\left[\left(\sqrt{y}+h\right)^2\sqrt{y}\frac{\partial x}{\partial h} + 2x^{\frac{3}{2}}\left(2\sqrt{y}+\frac{\partial y}{\partial h}\right)\right]}{\sqrt{x}\left(2\sqrt{x}+\sqrt{y}+h\right)^2\sqrt{y}} >< 0. \tag{3.13}$$

Substituting the R&D investments from Proposition 3.2.1 into (3.9) and applying restrictions $r = 0$, $h = 0$ gives

$$I = \sqrt{\Pi}\frac{4\sqrt{\Delta}\sqrt{1+2\Delta-2\sqrt{\Delta(1+\Delta)}}}{2\sqrt{\Delta}+\sqrt{1+2\Delta-2\sqrt{\Delta(1+\Delta)}}}. \tag{3.14}$$

Differentiating (3.14) with respect to Δ and solving equation $\frac{\partial I}{\partial \Delta} = 0$ reveals that $\frac{\partial I}{\partial \Delta} > 0$ for $\Delta < \frac{1}{3}$ while $\frac{\partial I}{\partial \Delta} < 0$ for $\Delta > \frac{1}{3}$. This proves statement two in Corollary 3.2.3.

Analyzing (3.12) when $r > 0$ and $h > 0$ reveals that there exist $0 < h^- < h^+ < 1$ such that when $h \in (h^-, h^+)$: $\frac{\partial I}{\partial \Delta} > 0$ for $\Delta \in \left[\frac{1}{2}, \Delta_{peak}\right)$ and $\frac{\partial I}{\partial \Delta} < 0$ for $\Delta \in (\Delta_{peak}, 1]$. Condition $\frac{\partial I}{\partial \Delta} = 0$ determines Δ_{peak} as a solution to the implicit equation $\frac{4x^3}{\left(\frac{\partial x}{\partial \Delta}\right)^2} = \frac{\left(\sqrt{y}+h\right)^4 y}{\left(\frac{\partial y}{\partial \Delta}\right)^2}$. Analyzing (3.13) when $r > 0$ and $h > 0$ reveals that there exist $0 < h_{peak} < 1$ such that $\frac{\partial I}{\partial h} > 0$ for $h \in [0, h_{peak})$ and $\frac{\partial I}{\partial h} < 0$ for $\Delta \in (h_{peak}, 1]$. Condition $\frac{\partial I}{\partial h} = 0$ determines h_{peak} as a solution to the implicit equation $\frac{4x^3}{\left(\frac{\partial x}{\partial h}\right)^2} = \frac{\left(\sqrt{y}+h\right)^4 \left(\frac{\partial x}{\partial h} - 2\sqrt{y}\right)^2 y}{\left[\left(\frac{\partial y}{\partial h}\right)^2 - 4y\right]^2}$.

Examples of peaks of the two inverted-Us: For $\pi_1 = 0.9$, $\pi_{-1} = 0.2$, $r = 0.03$, $h = 0.15$, solution to equation $\frac{\partial I}{\partial \Delta} = 0$ is at $\Delta = 0.554$, the equilibrium R&D investment of a firm in the neck-and-neck state is $x = 0.219 < \pi_0 = 0.512$, the equilibrium R&D investment of the laggard in the unleveled state is $y = 0.107 < \pi_{-1}$, and the aggregate innovation intensity is $I = 0.632$. For $\pi_1 = 0.9$, $\pi_{-1} = 0.2$, $r = 0.03$, $\Delta = 0.6$, solution to equation $\frac{\partial I}{\partial h} = 0$ is at $h = 0.399$, the equilibrium R&D investment of a firm in the neck-and-neck state is $x = 0.188 < \pi_0 = 0.340$, the equilibrium R&D investment of the laggard in the unleveled state is $y = 0.030 < \pi_{-1}$, and the aggregate innovation intensity is $I = 0.689$.

Proof of Proposition 3.2.4

Part one is obtained by solving the system of inequalities

$$\left\{x > \pi_{-1} + (1-\Delta)(\pi_1 - \pi_{-1}),\ \pi_1 > \pi_{-1} > 0,\ \frac{1}{2} \leq \Delta \leq 1,\ H > 0\right\},$$

where $H \equiv h + r$and x is from Proposition 3.2.1 for parameters $\{\pi_1, \pi_{-1}, \Delta, H\}$. The threshold competition intensity of a firm in the neck-and-neck state, $\overline{\Delta}$, presented in part one of Proposition 3.2.4 solves $x = \pi_0$ for Δ. Similarly, part two of Proposition 3.2.4 is obtained by solving the system of inequalities

$$\left\{y > \pi_{-1},\ \pi_1 > \pi_{-1} > 0,\ \frac{1}{2} \leq \Delta \leq 1\right\} \text{ for parameters } \{\pi_1, \pi_{-1}, \Delta\}$$

under a simplifying restriction $H = 0$. The laggard's threshold competition intensity, $\underline{\Delta}$, presented in part two of Proposition 3.2.4 solves $y = \pi_{-1}$ for Δ when $H > 0$.

Solving the system of inequalities

$$\{\overline{\Delta} < 1,\ \pi_1 > \pi_{-1} > 0,\ H > 0\} \text{ for parameters } \{\pi_1, \pi_{-1}, H\}$$

gives

$$\overline{\Delta} < 1 \Longleftrightarrow \left(\pi_{-1} < \frac{\pi_1}{2} \text{ and } H < \frac{\Pi - \pi_{-1}}{2\sqrt{\pi_{-1}}}\right).$$

Similarly, solving the system of inequalities

$$\left\{\frac{1}{2} < \underline{\Delta},\ \pi_1 > \pi_{-1} > 0,\ H > 0\right\} \text{ for parameters } \{\pi_1, \pi_{-1}, H\}$$

gives

$$\begin{aligned} \frac{1}{2} &< \underline{\Delta} \Longleftrightarrow \left(\pi_{-1} < \frac{3-\sqrt{3}}{6}\pi_1 \text{ and } H < HIGH(\pi_1, \pi_{-1})\right) \text{ or} \\ &\left(\frac{3+\sqrt{3}}{6}\pi_1 < \pi_{-1} \text{ and } H < \overline{H}(\pi_1, \pi_{-1})\right), \end{aligned}$$

where

$$\begin{aligned} HIGH(\pi_1, \pi_{-1}) &\equiv \frac{\sqrt{\frac{\pi_1^2 - 26\pi_1\pi_{-1} + 41\pi_{-1}^2}{\pi_{-1}} + \frac{\sqrt[3]{SUB_{HIGH}^2} + \pi_1^4 - 4\pi_1^3\pi_{-1} + 38\pi_1^2\pi_{-1}^2 - 20\pi_1\pi_{-1}^3 + 49\pi_{-1}^4}{\pi_{-1}\sqrt[3]{SUB_{HIGH}}}}}{4\sqrt{3}} \text{ and} \\ SUB_{HIGH} &\equiv \pi_1^6 - 6\pi_1^5\pi_{-1} + 63\pi_1^4\pi_{-1}^2 - 140\pi_1^3\pi_{-1}^3 + 567\pi_1^2\pi_{-1}^4 + 210\pi_1\pi_{-1}^5 - 343\pi_{-1}^6 + \\ &+48\sqrt{6}\pi_1\sqrt{\pi_{-1}^7\left(\pi_1^3 - 5\pi_1^2\pi_{-1} + 43\pi_1\pi_{-1}^2 - 49\pi_{-1}^3\right)}. \end{aligned}$$

Threshold function $\overline{H}(\pi_1, \pi_{-1})$ is available upon request. Solving the system of inequalities

$$\{\underline{\Delta} < \overline{\Delta},\ \pi_1 > \pi_{-1} > 0,\ H > 0\} \text{ for parameters } \{\pi_1, \pi_{-1}, H\}$$

gives

$$\underline{\Delta} < \overline{\Delta} \Leftrightarrow \left(\pi_{-1} < \frac{3-\sqrt{5}}{4}\pi_1 \text{ and } LOW(\pi_1, \pi_{-1}) < H\right) \text{ or } \left(\frac{3-\sqrt{5}}{4}\pi_1 \leq \pi_{-1}\right),$$

where

$$\begin{aligned} LOW(\pi_1, \pi_{-1}) &\equiv \sqrt{\pi_{-1}\left(1 + \frac{\pi_1^2}{\sqrt[3]{6}\sqrt[3]{SUB_{LOW}}}\right) - \pi_1 + \frac{\sqrt[3]{SUB_{LOW}}}{2\pi_{-1}\sqrt[3]{6^2}}} \text{ and} \\ SUB_{LOW} &\equiv 9\pi_1^4\pi_{-1}^2 + \sqrt{81\pi_1^8\pi_{-1}^4 - 48\pi_1^6\pi_{-1}^6}. \end{aligned}$$

By combining the conditions for $\frac{1}{2} < \underline{\Delta}$, $\overline{\Delta} < 1$, and $\underline{\Delta} < \overline{\Delta}$ I obtain the necessary and sufficient condition for the existence of three competition regions: (i) The relaxed competition region, $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$, in which the laggard is financially constrained; (ii) The intermediate competition region, $\Delta \in (\underline{\Delta}, \overline{\Delta})$, in which the unconstrained equilibrium of Proposition 3.2.1 exists; (iii) The intense competition region, $\Delta \in [\overline{\Delta}, 1]$, in which the firms in the neck-and-neck state are constrained, i.e., $\frac{1}{2} < \underline{\Delta} < \overline{\Delta} < 1$; as follows

$$\left(\pi_{-1} < \frac{3-\sqrt{5}}{4}\pi_1 \text{ and } LOW(\pi_1, \pi_{-1}) < h + r < HIGH(\pi_1, \pi_{-1})\right) \text{ or}$$
$$\left(\frac{3-\sqrt{5}}{4}\pi_1 \leq \pi_{-1} < \frac{3-\sqrt{3}}{6}\pi_1 \text{ and } h + r < HIGH(\pi_1, \pi_{-1})\right).$$

By differentiating, the threshold competition intensity of a firm in the neck-and-neck state, $\overline{\Delta}$, satisfies

$$\frac{\partial \overline{\Delta}}{\partial \pi_1} = \frac{H^2 - \pi_{-1} - \frac{H(H^2+\pi_{-1}+\pi_1)}{\sqrt{H^2+2\pi_1}}}{2\Pi^2} < 0,$$
$$\frac{\partial \overline{\Delta}}{\partial \pi_{-1}} = \frac{\pi_1 + \left(\sqrt{H^2+2\pi_1} - H\right) H}{2\Pi^2} > 0, \text{ and}$$
$$\frac{\partial \overline{\Delta}}{\partial H} = \frac{1}{\Pi}\left(\frac{H^2+\pi_1}{\sqrt{H^2+2\pi_1}} - H\right) > 0.$$

Similarly, the laggard's threshold competition intensity, $\underline{\Delta}$, satisfies

$$\frac{\partial \underline{\Delta}}{\partial \pi_1} = \frac{8H^2\sqrt{\pi_{-1}}\left(H+\sqrt{\pi_{-1}}\right) + (\Pi - \pi_{-1})\pi_1}{4\left(H+\sqrt{\pi_{-1}}\right)^2 \Pi^2} > 0 \Longleftrightarrow$$
$$\Longleftrightarrow \left(\pi_{-1} \leq \frac{\pi_1}{2}\right) \text{ or } \left(\frac{\pi_1}{2} < \pi_{-1} \text{ and } \underline{H}_1(\pi_1, \pi_{-1}) < H\right),$$
$$\frac{\partial \underline{\Delta}}{\partial \pi_{-1}} = \pi_1^2 \frac{\pi_{-1} - \Pi - 4H^2 - 3H\sqrt{\pi_{-1}}}{4\left(H+\sqrt{\pi_{-1}}\right)^3 \Pi^2 \sqrt{\pi_{-1}}} - H\left(\frac{\sqrt{\pi_{-1}}}{\Pi^2} + \frac{(H^2 - 2\pi_{-1})\pi_1}{\left(H+\sqrt{\pi_{-1}}\right)^2 \Pi^2 \sqrt{\pi_{-1}}}\right) < 0 \Longleftrightarrow$$
$$\Longleftrightarrow \left(\pi_{-1} \leq \frac{\pi_1}{2}\right) \text{ or } \left(\frac{\pi_1}{2} < \pi_{-1} < \widehat{\pi_{-1}}(\pi_1) \text{ and } \underline{H}_2(\pi_1, \pi_{-1}) < H\right) \text{ or}$$
$$\left(\widehat{\pi_{-1}}(\pi_1) \leq \pi_{-1} \text{ and } \underline{H}_3(\pi_1, \pi_{-1}) < H\right), \text{ and}$$
$$\frac{\partial \underline{\Delta}}{\partial H} = \frac{4\left(H+\sqrt{\pi_{-1}}\right)\sqrt{\pi_{-1}}\left[\pi_1 - \left(H+\sqrt{\pi_{-1}}\right)^2\right] - \pi_1^2}{2\left(H+\sqrt{\pi_{-1}}\right)^3 \Pi} < 0.$$

Threshold functions $\underline{H}_1(\pi_1, \pi_{-1})$, $\underline{H}_2(\pi_1, \pi_{-1})$, $\underline{H}_3(\pi_1, \pi_{-1})$, and $\widehat{\pi_{-1}}(\pi_1)$ are available upon request.

Proof of Proposition 3.2.5

Assume that the laggard invests π_{-1} in the relaxed competition region $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right]$. The system of equations (3.3) together with the FOC for a firm in the neck-and-neck state, $V_1 = 2\sqrt{x_u} + V_0$, the restriction on laggard's R&D investment $y_c = \pi_{-1}$, and symmetry ($x_u = \overline{x}_u$, $y_c = \overline{y}_c$) leads to

$$\begin{aligned} \pi_0 &= rV_0 + \sqrt{x_u}\,(V_0 - V_{-1}) - x_u, \\ \pi_1 &= rV_0 + 2\sqrt{x_u}\,(h + r + \sqrt{\pi_{-1}}), \\ rV_{-1} &= (h + \sqrt{\pi_{-1}})\,(V_0 - V_{-1}). \end{aligned} \tag{3.15}$$

Solving (3.15) when $\pi_0 \equiv \pi_{-1} + (1-\Delta)(\pi_1 - \pi_{-1})$ and simplifying using $\Pi \equiv \pi_1 - \pi_{-1}$ and $H \equiv h + r$ gives

$$\begin{aligned} x_u &= \frac{(3\Delta - 2)\Pi + 2\left(H + 2\sqrt{\pi_{-1}}\right)H - SUB_{x_u}}{9} + \frac{(SUB_{x_u} + \pi_1)\pi_1}{18\left(H + \sqrt{\pi_{-1}}\right)^2}, \text{ where} \\ SUB_{x_u} &\equiv \sqrt{\pi_1^2 + 4\left(H + \sqrt{\pi_{-1}}\right)^2\left[\left(H + \sqrt{\pi_{-1}}\right)^2 + 3\Delta\Pi - \pi_1\right]}. \end{aligned} \tag{3.16}$$

Assume that a firm in the neck-and-neck state invests π_0 in the intense competition region $\Delta \in [\overline{\Delta}, 1]$. The system of equations (3.3) together with the FOC for the laggard, $V_{-1} = -2\sqrt{y_u} + V_0$, the restriction on R&D investment of a firm in the neck-and-neck state $x_c = \pi_0$, and symmetry ($x_c = \overline{x}_c$, $y_u = \overline{y}_u$) leads to

$$\begin{aligned} rV_0 &= \sqrt{\pi_0}\,(V_1 - V_0) - 2\sqrt{\pi_0}\sqrt{y_u}, \\ \pi_1 &= rV_1 + (h + \sqrt{y_u})\,(V_1 - V_0), \\ \pi_{-1} &= rV_0 - 2\sqrt{y_u}\,(h + r) - y_u. \end{aligned} \tag{3.17}$$

Eliminating V_0 and V_1 from (3.17), applying $\pi_0 \equiv \pi_{-1} + (1 - \Delta)(\pi_1 - \pi_{-1})$ and simplifying using $\Pi \equiv \pi_1 - \pi_{-1}$ and $H \equiv h + r$ gives equation

$$y_u + 2H\sqrt{y_u} + \pi_{-1} = \frac{\left[\pi_1 - 2\left(y_u + H\sqrt{y_u}\right)\right]\sqrt{\pi_1 - \Delta\Pi}}{\sqrt{y_u} + H + \sqrt{\pi_1 - \Delta\Pi}}, \tag{3.18}$$

which defines y_u implicitly. Explicit solution of (3.18), though complicated, exists and is available upon request.

Proof of Corollary 3.2.6

The substitution of the threshold competition intensity $\underline{\Delta}$ from Proposition 3.2.4 into x_u (Proposition 3.2.5) and into x (Proposition 3.2.1) verifies that $x_u = x = \left(\frac{\pi_1}{2(H+\sqrt{\pi_{-1}})} - \sqrt{\pi_{-1}}\right)^2$ at $\Delta = \underline{\Delta}$. This result together with the fact that x_u is continuous,

$$\frac{\partial x_u}{\partial \Delta} = \frac{\Pi}{3}\left(1 + \frac{\pi_1 - 2\left(H+\sqrt{\pi_{-1}}\right)^2}{\sqrt{\pi_1^2 + 4\left(H+\sqrt{\pi_{-1}}\right)^2\left[\left(H+\sqrt{\pi_{-1}}\right)^2 + 3\Delta\Pi - \pi_1\right]}}\right) > 0, \text{ and}$$

$x_u > x$ when $\Delta = \frac{1}{2}$ establishes that $x_u > x$ for all $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right)$.

The substitution of the threshold competition intensity $\overline{\Delta}$ from Proposition 3.2.4 into y_u (Proposition 3.2.5) and into y (Proposition 3.2.1) verifies that

$$y_u = y = \frac{1}{4}\left[\sqrt{2}SUB_{\underline{\Delta}} - 2\sqrt{H^2 + \Pi + \left(H - \frac{SUB_{\underline{\Delta}}}{\sqrt{2}}\right)^2}\right]^2$$

at $\Delta = \overline{\Delta}$, where $SUB_{\underline{\Delta}} \equiv \sqrt{\pi_1 + H\left(H + \sqrt{H^2 + 2\pi_1}\right)}$. Fact that $y_u > y$ for all $\Delta \in (\overline{\Delta}, 1]$ is established using numerical simulations. These simulations are available upon request.

Proof of Corollary 3.2.7

In the steady state, the flow of industries from the neck-and-neck state to the unleveled state matches the opposite flow $2\lambda\sqrt{x_u} = (1-\lambda)\left(\sqrt{y_c} + h\right)$. Solving for λ and substituting into the definition of the aggregate innovation intensity $I \equiv 2\lambda\sqrt{x_u} + (1-\lambda)\left(\sqrt{y_c} + h\right)$ gives $I_{\{x_u, y_c\}} = \frac{4\sqrt{x_u}\left(\sqrt{y_c}+h\right)}{2\sqrt{x_u}+\sqrt{y_c}+h}$, where x_u and y_c are the R&D investments from Proposition 3.2.5. The aggregate innovation intensity $I_{\{x_c, y_u\}}$ is derived analogously.

Corollary 3.2.6 says that $x_u = x$ and $y_c = y$ at $\Delta = \underline{\Delta}$. Therefore, it must be that $I_{\{x_u, y_c\}} = I$ at $\Delta = \underline{\Delta}$. Similarly, as $x_c = x$ and $y_u = y$ at $\Delta = \overline{\Delta}$, it must be that $I_{\{x_c, y_u\}} = I$ at $\Delta = \overline{\Delta}$. Facts that $I_{\{x_u, y_c\}} < I$ for $\Delta \in \left[\frac{1}{2}, \underline{\Delta}\right)$ and $I_{\{x_c, y_u\}} < I$ for $\Delta \in \left(\overline{\Delta}, 1\right]$ are established using numerical simulations. These simulations are available upon request.

References

Acharya, Viral V.; Subramanian, Krishnamurthy; 2007, "Bankruptcy Codes and Innovation," Working Paper, London Business School.

Aghion, Philippe; Bloom, Nick; Blundell, Richard; Griffith, Rachel; Howitt, Peter; 2002, "Competition and Innovation: An Inverted-U Relationship," Institute for Fiscal Studies Working Paper No. 02/04.

Aghion, Philippe; Bloom, Nick; Blundell, Richard; Griffith, Rachel; Howitt, Peter; 2005, "Competition and Innovation: An Inverted-U Relationship," *Quarterly Journal of Economics*, Vol. 120, No. 2, pp. 701-728.

Aghion, Philippe; Blundell, Richard; Griffith, Rachel; Howitt, Peter; Prantl, Susanne; 2006, "Entry and Productivity Growth: Evidence from Micro-level Panel Data," *Journal of European Economic Association, Papers and Proceedings*, Vol. 2, No. 2-3, pp. 265-276.

Aghion, Philippe; Dewatripont, Mathias; Rey, Patrick; 1999, "Competition, Financial Discipline and Growth," *Review of Economic Studies*, Vol. 66, No. 4, pp. 825-852.

Aghion, Philippe; Harris, Christopher; Vickers, John; 1997, "Competition and Growth with Step-by-Step Innovation: An Example," *European Economic Review, Papers and Proceedings*, Vol. 41, pp. 771-782.

Aghion, Philippe; Harris, Christopher; Howitt, Peter; Vickers, John; 2001, "Competition, Imitation and Growth with Step-by-Step Innovation," *Review of Economic Studies*, Vol. 68, No. 3, pp. 467-492.

Aghion, Philippe; Howitt, Peter; 1992, "A Model of Growth through Creative Destruction," *Econometrica*, Vol. 60, pp. 323-351.

Aghion, Philippe; Howitt, Peter; 1998, "Endogenous Growth Theory," Cambridge MA, MIT Press.

Akdoğu, Evrim; MacKay, Peter; 2008, "Investment and Competition," *Journal of Financial and Quantitative Analysis*, Vol. 43, No. 2, pp. 299-330.

Arcot, Sridhar; Black, Julia; Owen, Geoffrey; 2007, "From Local to Global: The Rise of AIM as a Stock Market for Growing Companies," London School of Economics comprehensive report analyzing growth of AIM commissioned by the London Stock Exchange.

Baum, Christopher F.; Schaffer, Mark E.; Stillman, Steven; 2003, "Instrumental Variables and GMM: Estimation and Testing," *Stata Journal*, Vol. 3, No. 1, pp. 1-31.

Beck, Thorsten; Demirgüç-Kunt, Asli; 2006, "Small and Medium-Size Enterprises: Access to Finance as a Growth Constraint," *Journal of Banking & Finance*, Vol. 30, pp. 2931-2943.

Beck, Thorsten; Demirgüç-Kunt, Asli; Maksimovic, Vojislav; 2005, "Financial and Legal Constraints to Growth: Does Firm Size Matter?" *Journal of Finance*, Vol. 60, No. 1, pp. 137-177.

Beck, Thorsten; Demirgüç-Kunt, Asli; Levine, Ross; 2000, "A New Database on the Structure and Development of the Financial Sector," *World Bank Economic Review*, Vol. 14, No. 3, pp. 597-605.

Bena, Jan; 2008, "Competition, Financial Constraints, and Firms' Decision to Innovate," mimeo, LSE.

Bena, Jan; Jurajda, Štěpán; 2007, "Which Firms Benefit More from Financial Development?" CEPR Discussion Paper No. 6392, CEPR.

Berger, Allen N.; Udell, Gregory F.; 2006, "A More Complete Conceptual Framework for SME Finance," *Journal of Banking & Finance*, Vol. 30, No. 11, pp. 2945-2966.

Blundell, Richard; Griffith, Rachel; van Reenen, John; 1995, "Dynamic Count Data Model of Technological Innovations," *Economic Journal*, Vol. 105, pp. 333-344.

Blundell, Richard; Griffith, Rachel; van Reenen, John; 1999, "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms," *Review of Economic Studies*, Vol. 66, No. 3, pp. 529-554.

Bolton, Patrick; Roland, Gerard; 1992, "Privatization in Central and Eastern Europe," *Economic Policy*, No. 15, pp. 276-309.

Boone, Jan; 2008, "A New Way to Measure Competition," *Economic Journal*, Vol. 118, No. 531, pp. 1245-1261.

Boone, Jan; van Ours, Jan C.; van der Wiel, Henry; 2007, "How (Not) to Measure Competition," CEPR Discussion Paper No. 6275, CEPR.

Boubakri, Narjess; Cosset, Jean-Claude; Guedhami, Omrane; 2004, "Privatization, Corporate Governance and Economic Environment: Firm-Level Evidence from Asia," *Pacific-Basin Finance Journal*, Vol. 12, No. 1, pp. 65-90.

Bound, John; Jaeger, David A.; Baker, Regina; 1995, "Problems with Instrumental Variables Estimation when the Correlation Between the Instruments and the Endogenous Explanatory Variable is Weak," *Journal of the American Statistical Association*, Vol. 90, No. 430, pp. 443-450.

Brander, James; Lewis, Tracey; 1986, "Oligopoly and Financial Structure: The Limited Liability Effect," *American Economic Review*, Vol. 76, pp. 956-970.

Buigues, Pierre; Ilzkovitz, Fabienne; Lebrun, Jean-François; 1990, "The Impact of the Internal Market by Industrial Sector: The Challenge for Member States," *European Economy*, Special Issue.

Chevalier, Judith A.; Scharfstein, David S.; 1996, "Capital Market Imperfections and Countercyclical Markups: Theory and Evidence," *American Economic Review*, Vol. 86, pp. 703-725.

Cleary, Sean; Povel, Paul; Raith, Michael; 2007, "The U-Shaped Investment Curve: Theory and Evidence," *Journal of Financial and Quantitative Analysis*, Vol. 42, No. 1, pp. 1-40.

Djankov, Simeon; Murrell, Peter; 2002, "Enterprise Restructuring in Transition: A Quantitative Survey," *Journal of Economic Literature*, Vol. 40, No. 3, pp. 739-792.

Faure-Grimaud, Antoine; 2000, "Product Market Competition and Optimal Debt Contracts: The Limited Liability Effect Revisited," *European Economic Review*, Vol. 44, pp. 1823-1840.

Fazzari, Steven M.; Hubbard, Glen R.; Petersen, Bruce C.; 1988, "Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity*, Vol. 1, pp. 141-195.

Fazzari, Steven M.; Hubbard, Glen R.; Petersen, Bruce C.; 2000, "Investment-Cash Flow Sensitivities are Useful: A Comment on Kaplan-Zingales," *Quarterly Journal of Economics*, Vol. 115, pp. 695-705.

Fisman, Raymond; Love, Inessa; 2004, "Financial Development and Intersectoral Allocation: A New Approach," *Journal of Finance*, Vol. 59, No. 6, pp. 2785-2807.

Giroud, Xavier; Mueller, Holger; 2008, "Corporate Governance, Product Market Competition, and Equity Prices," ECGI - Finance Working Paper No. 219, European Corporate Governance Institute (ECGI).

Giroud, Xavier; Mueller, Holger; 2007, "Does Corporate Governance Matter in Competitive Industries?" ECGI - Finance Working Paper No. 185, European Corporate Governance Institute (ECGI).

Gorodnichenko, Yuriy; Švejnar, Jan; Terrell, Katherine; 2007, "Globalization and Innovation in Emerging Markets," IZA Discussion Paper No. 3299, Institute for the Study of Labor (IZA).

Griffith, Rachel; Harrison, Rupert; Simpson, Helen; 2006, "Product Market Reform and Innovation in the EU," IFS Working Paper No. 06/17, Institute for Fiscal Studies.

Hajivassiliou, Vassilis; Savignac, Frederique; 2007, "Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects," FMG Discussion Paper No. 594, London School of Economics - Financial Markets Group (FMG).

Hansen, Lars Peter; 1982, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica*, Vol. 50, No. 3, pp. 1029-1054.

Jaumotte, Florence; Pain, Nigel; 2005a, "From Ideas to Development: The Determinants of R&D and Patenting," OECD Economics Department Working Papers, No. 457, OECD Publishing.

Jaumotte, Florence; Pain, Nigel; 2005b, "From Innovation Development to Implementation: Evidence from the Community Innovation Survey," OECD Economics Department Working Paper No. 458, OECD Publishing.

Kamien, Morton I.; Schwartz, Nancy L.; 1972, "Market Structure, Rivals' Response, and the Firm's Rate of Product Improvement," *Journal of Industrial Economics*, Vol. 20, No. 2, pp. 159-172.

Kaplan, Steven N.; Zingales, Luigi; 1997, "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?" *Quarterly Journal of Economics*, Vol. 112, pp. 169-215.

Kaplan, Steven N.; Zingales, Luigi; 2000, "Investment-Cash Flow Sensitivities are not Valid Measures of Financing Constraints," *Quarterly Journal of Economics*, Vol. 115, pp. 707-712.

Köke, Jens; Renneboog, Luc; 2005, "Do Corporate Control and Product Market Competition Lead to Stronger Productivity Growth? Evidence from Market-Oriented and Blockholder-Based Governance Regimes," *Journal of Law and Economics*, Vol. 48, pp. 475-516.

Levine, Ross; 1997, "Financial Development and Economic Growth: Views and Agenda," *Journal of Economic Literature*, Vol. 35, No. 2, pp. 688-726.

Li, Huagang; 1999, "State Factories in Transition—Openness, Competition, and Productivity," *Journal of Development Economics*, Vol. 58, No. 2, pp. 429-462.

Maurer, Boris; 1999, "Innovation and Investment under Financial Constraints and Product Market Competition," *International Journal of Industrial Organization*, Vol. 17, No. 4, pp. 455-476.

Nickell, Stephen J.; 1996, "Competition and Corporate Performance," *Journal of Political Economy*, Vol. 104, No. 4, pp. 724-746.

Nickell, Stephen J.; Nicolitsas, Daphne; Dryden, Neil; 1997, "What Makes Firms Perform Well?" *European Economic Review*, Vol. 41, No. 3-5, pp. 783-796.

Nicoletti, Giuseppe; Scarpetta, Stefano; 2005, "Regulation and Economic Performance: Product Market Reforms and Productivity in the OECD," OECD Economics Department Working Paper No. 460, OECD Publishing.

Povel, Paul; Raith, Michael; 2004, "Financial Constraints and Product Market Competition: Ex Ante vs. Ex Post Incentives," *International Journal of Industrial Organization*, Vol. 22, No. 7, pp. 917-949.

Rajan, Raghuram G.; Zingales, Luigi; 1998, "Financial Dependence and Growth," *American Economic Review*, Vol. 88, No. 3, pp. 559-586.

Riddick, Leigh A.; Whited, Toni M.; 2008, "The Corporate Propensity to Save," *Journal of Finance*, forthcoming.

Roland, Gerard; 2001, "Ten Years After ... Transition and Economics,"IMF Staff Papers, Vol. 48, Special Issue, International Monetary Fund, pp. 29-52.

Sargan, John D.; 1958, "The Estimation of Economic Relationships using Instrumental Variables,"*Econometrica*, Vol. 26, No. 3, pp. 393-415.

Scherer, Fredrick; 1967, "Market Structure and the Employment of Scientists and Engineers,"*American Economic Review*, Vol. 57, pp. 524-531.

Schmidt, Klaus M.; 1997, "Managerial Incentives and Product Market Competition,"*Review of Economic Studies*, Vol. 64, No. 2, pp. 191-213.

Schumpeter, Joseph; 1943, "Capitalism, Socialism and Democracy,"London: Allen Unwin.

Shea, John; 1997, "Instrument Relevance in Multivariate Linear Models: A Simple Measure,"*Review of Economics and Statistics*, Vol. 79, No. 2, pp. 348-352.

Stock, James H.; Yogo, Motohiro; 2005, "Testing for Weak Instruments in Linear IV Regression,"in Andrews D.W.K. and Stock J.H., eds., *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, Cambridge University Press, pp. 80-108.

Sutton, John; 2007, "Market Structure: Theory and Evidence,"in Armstrong, Mark and Porter, eds., *Handbook of Industrial Organization*, Elsevier, 1st Ed., Vol. 3, pp. 2301-2368.