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ABSTRACT

What Determines Firm Size?*

Motivated by theories of the firm, which we classify as ‘technological’ or ‘organizational,’ we analyse the determinants of firm size across industries and across countries in a sample of 15 European countries. We find that, on average, firms facing larger markets are larger. At the industry level, we find that firms in the utility sector are large, perhaps because they enjoy a natural, or officially sanctioned, monopoly. Capital intensive industries, high wage industries and industries that do a lot of research and development have larger firms, as do industries that require little external financing. At the country level, the most salient findings are that countries with efficient judicial systems have larger firms and, correcting for institutional development, there is little evidence that richer countries have larger firms. Interestingly, institutional development, such as greater judicial efficiency, seems to be correlated with lower dispersion in firm size within an industry. The effects of interactions (between an industry's characteristics and a country's environment) on size are perhaps the most novel results in the Paper and are the best guide for discriminating between theories. As the judicial system improves, the difference in size between firms in capital intensive industries and firms in industries that use little physical capital diminishes, a finding consistent with ‘Critical Resource’ theories of the firm. Finally, the average size of firms in industries dependent on external finance is larger in countries with better financial markets, suggesting that financial constraints limit average firm size.

JEL Classification: D23, G30, K40, L20
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NON-TECHNICAL SUMMARY

Organizational size seems important for various economic phenomena: wages, investment, financial policy, stock returns, etc. But what determines the size of economic organizations?

In this Paper, we analyse the determinants of firm size across industries and across countries in a sample of 15 European countries. We find that, on average, firms facing larger markets are larger. At the industry level, we find firms in the utility sector are large, perhaps because they enjoy a natural, or officially sanctioned, monopoly. Physical capital intensive industries, high wage industries and industries that do a lot of research and development have larger firms, as do industries that require little external financing.

At the country level, the most salient findings are that countries with efficient judicial systems have larger firms and, contrary to conventional wisdom, there is little evidence that richer countries have larger firms. Interestingly, institutional development, such as greater judicial efficiency, seems to 'level the playing field' and is correlated with lower dispersion in firm size within an industry.

The effects of interactions (between an industry's characteristics and a country's environment) on size are perhaps the best guide for discriminating between theories. We find that the relative size of firms in capital intensive industries diminishes as the judicial system becomes more efficient. This is in large measure because the average size of firms in industries that are not physical asset intensive is larger in countries with better judicial systems.

Finally, the average size of firms in industries dependent on external finance is larger in countries with better financial markets, suggesting that financial constraints may also keep firms small.

Why is it that a small country like Finland has such large successful firms such as Nokia? This question is not of minor importance. In recent years, a great deal of attention has been paid to the process of economic growth. An interesting aspect of growth is that much of it takes place through the growth in the size of existing organizations. For instance, in the sample of 43 countries they study, Rajan and Zingales (1998a) find that 2/3rd of the growth in industries over the 1980s comes from the growth in the size of existing establishments, and only 1/3rd from the creation of new ones. What determines the size of economic organizations? Are there any constraints to size and, hence, any potential constraints to growth?

Organizational size seems important for various economic phenomena. For example, the work by Gertler and Gilchrist (1994) suggests that small firms account for a disproportionate share of the manufacturing decline that follows the tightening of monetary policy. Size has been found to be an important influence on stock returns (see Banz (1981)). Similarly, various phenomena in corporate finance - the extent to which a firm levers up, the quantity of trade credit it uses, the compensation its top managers get, all seem related to firm size.[1] But what determines firm size?

The data we have on the distribution of firm size across industries in 15 European countries are particularly useful for answering this question. These are all fairly well-developed countries, so the minimum conditions for the existence of firms such as a basic respect for property rights, the widespread rule of law, and the educational levels to manage complex hierarchies exist. A number of first order factors such as war, economic system, or respect for basic property rights that would otherwise affect firm size are held constant in this sample. This enables us to focus on more subtle economic and institutional factors for which there is some variation across this sample of countries. We also have a large number of industries, and the variation between industries in their use of different factors can give us some understanding of the effects of production technology on firm size. Finally, the interactions between institutional and technological effects give us perhaps the clearest insights into the determinants of firm size.

We start by documenting broad patterns in firm size across industries and countries. We find that, on average, firms facing larger markets are larger. At the industry level, we find firms in the utility sector are large, perhaps because they enjoy a natural, or officially sanctioned, monopoly. Physical capital intensive industries, high wage industries, and industries that do a lot of R&D have larger firms, as do industries that require little external financing. While

[1]For the link between firm size and leverage see the extensive literature cited in Harris and Raviv (1990) or Rajan and Zingales (1995), for size and trade credit see Petersen and Rajan (1997), and for compensation, see Jensen and Murphy (1990), and the literature cited there.

we are not aware of studies that examine these precise correlations, or of studies that examine these patterns across a number of countries, some of these correlations are not surprising given the past literature on intra-industry patterns (see Audretsch and Mahmood (1995), Caves and Pugel (1980), Klepper (1996), Sutton (1991), for example).

At the country level, the most salient findings are that countries with efficient judicial systems have larger firms, and, contrary to conventional wisdom, there is little evidence that richer countries have larger firms. Interestingly, institutional development, such as greater judicial efficiency, seems to "level the playing field" and is correlated with lower dispersion in firm size within an industry. The effects of interactions (between an industry's characteristics and a country's environment) on size are perhaps best able to discriminate between theories. We find that the relative size of firms in capital intensive industries diminishes as the judicial system becomes more efficient. This is in large measure because the average size of firms in industries that are not physical asset intensive is larger in countries with better judicial systems. Taken together, our evidence is consistent not only with theories that emphasize the fundamental importance of ownership of physical assets in determining the boundaries of the firm, but also with theories that suggest other mechanisms than ownership can expand firm boundaries when the judicial system improves. Finally, the average size of firms in industries dependent on external finance is larger in countries with better financial markets, suggesting that financial constraints may also keep firms small.

These findings indicate an answer to the question that starts this paper. Assuming our correlations are indeed evidence of causality, firms in Finland are large despite the country's small size, probably because it has a very efficient judicial system as compared to say Spain or Italy, and its financial system, as measured by its accounting standards, is well developed.

A caveat is in order. The theories are not really comprehensive, and since our proxies are not detailed enough to allow us to devise precise tests, our empirical work should be viewed as exploratory analysis motivated by theory, rather than actual tests. We do believe this is a useful exercise, for the patterns that are discovered can be used to motivate more comprehensive theory that is amenable to testing. In section 1, we discuss the theories, in Section 2 we present the data used and discuss their broad patterns. We report partial correlations of size with industry specific characteristics (section 3), country specific variables (section 4), and interactions between the two (section 5). We discuss the results in section 6 and conclude with avenues for future research.

1 Existing Theories

We classify theories broadly as technological, organizational, and institutional, based on whether they focus on the production function, the process of control, or environmental influences. Clearly, the classification will be somewhat arbitrary because some theories combine elements of different approaches. Moreover, space constraints do not permit us the luxury of being exhaustive, and the theories discussed below should only be viewed as representative.

1.1 Technological Theories

Adam Smith (1776) suggested that the extent of specialization was limited by the size of the market. If a worker needs to acquire task-specific human capital, there is a "set-up" cost incurred every time the worker is assigned to a new task. It is, therefore, reasonable to expect workers to perform specialized tasks and to expect a firm to hire more workers when its production process becomes more specialized. Therefore, one would expect not only the extent of specialization but also the size of firms to be limited by the size of the market that is being served.

¿From the perspective of our study, we would expect firm size to be correlated with the overall size of the market. However, Smith's prediction has not remained unchallenged. Becker and Murphy (1992) point to the existence of multiple firms serving most markets to argue that specialization is not limited by the size of the market. In their theory, coordination costs play a major role in limiting the size of firms before the size of the market becomes binding.[2] Given these conflicting predictions, whether market size is relevant for firm size is, therefore, an empirical question.

Lucas (1978) uses a neoclassical model to study the size distribution of firms. He assumes that the "talent for managing" is unevenly distributed among agents, with firm output increasing in this talent. A firm is identified with a manager, and the capital and labor under the manager's control. The central aspects of the model are the decision an agent faces between becoming a manager or an employee, and the decision a manager faces on the optimal choice of the levels of employment and capital in her firm. In equilibrium, only the most talented become managers, and the unique size (number of employees) of the marginal manager's firm minimizes average

[2] In a world in which contracts are incomplete, the existence of multiple firms does not necessarily imply that the size of the market is not a constraint on firm size. If employment contracts are incomplete, an individual may not specialize if he fears being taken advantage of by a monopolist firm. In a manner reminiscent of the literature on second-sourcing (see Shepard (1987), for example), multiple firms may be required so that an individual in any one of the firms specializes. The degree of specialization may then be constrained by both the necessity for competitive alternatives, and the size of the market.

cost. If the elasticity of substitution between capital and labor in the production function is less than one, average firm size increases with per capita wealth – an increase in per capita capital raises wages relative to managerial rents, inducing marginal managers to become employees, and increasing the ratio of employees to managers. Lucas finds a regression of firm size on per capita GNP (a proxy for per capita capital) based on US time series data reveals a positive relationship between the two variables. The implication for our study is that more capital intensive technologies would result in larger firms.

Rosen (1982) considers a hierarchical organizational structure, where improved labor productivity at any given level has effects that successively filter through all lower levels. In particular, there are three layers in the hierarchy – management, supervision, and production. The process of management involves making discrete and indivisible choices and is therefore subject to scale economies. However, there are strong diminishing returns in supervision because the manager loses control as firm size increases. The trade-off between managerial scale economies and the loss of control results in determinate firm sizes. In equilibrium, persons with the highest skills are placed in the highest positions of the largest and deepest firms. A key result is that the multiplicative productivity interactions mentioned above make the equilibrium distribution of firm size more skewed than the underlying distribution of talent. Rosen notes that this is consistent with data – sizeable concentration ratios are seen even in industries where competitive conditions might be expected to apply. His result that larger firms have more capable personnel also suggests a positive correlation between the level of available human capital and firm size.[3]

Kremer (1993) focuses more directly on human capital, and less on hierarchies. He models human capital as the probability that a worker will successfully complete a task. Each task is performed by one worker, so the output of the firm (a sequence of tasks) depends on the product of the skill levels of all workers. The hierarchy of managers and subordinates in Lucas (1978) and Rosen (1982) gives way to an equilibrium with sorting of workers with the same human capital. Kremer shows that firms using technologies that need several tasks will employ highly skilled workers because mistakes are more costly to such firms. While Kremer admits that his model is not a fully worked out theory of the firm, he speculates that the number of tasks and number of workers are likely to be positively correlated, and the model is therefore consistent with the stylized fact that richer (higher human capital) countries specialize in complicated

[3] It should be noted that the connection in Rosen's model is between the human capital level of *managers* and firm size. However, proxies for human capital are available at the general level rather than at the managerial level. The model of Kremer (1993) discussed below, which has no hierarchy, has a more direct connection between the general level of human capital and firm size.

products and have larger firms.

Another implication of the model is that firm size should be positively correlated with the wage per worker. This is because a higher wage implies a higher quality worker, and all other things constant, implies that more workers can be used in the production process. The lack of a hierarchical structure in Kremer's model makes the relationship between average human capital of the *workforce* and average firm size more explicit, unlike the models of Lucas and Rosen where the human capital of managers, who typically constitute a small fraction of the workforce, is what matters. But the absence of hierarchy also makes the theory more relevant to a production process, and less to a firm.

1.2 Organizational Theories

Organizational theories fall into three broad categories. One set of theories – often referred to as Contracting Cost theories (see, for example, Alchian and Demsetz (1972) and Jensen and Meckling (1976)) – suggest little difference in the contracts at work 'inside a firm' and in the market. Instead, the firm is simply a particular configuration of contracts characterized by a central common party to all the contracts, who also has the residual claim to the cash flows. Centralization helps mitigate problems of metering inputs and controlling agency costs. Since the contracts in a firm are no different from contracts in the market place, these theories are silent on whether improvements in contractability – for example, because of improvements in the legal system - have any effect on the size of firms.

A second set of theories, loosely grouped as 'Transaction Cost' theories (see Klein, Crawford and Alchian 1978) and Williamson (1975, 1985)) offer more guidance as to whether a transaction should take place between two arm's length entities or within a firm, where a firm can be loosely defined as an entity with a common governance structure. The advantage of doing a transaction within a firm is that the firm brings incentives to bear that cannot be reproduced in an arm's length market. Unfortunately, factors that typically determine the extent of integration in these theories, such as asset specificity and informational asymmetry, are hard to proxy for even with detailed data, let alone in a relatively macro-level study such as ours. We will have little to say about these theories.

The third set of theories, which can collectively be described as "Critical Resource" theories of the firm (see Grossman and Hart (1986) for the seminal work in this area and Hart (1995) for an excellent survey of the early literature), however, offer greater grist for empirical mills. The starting point of these theories is that transactions can either be fully governed by contracts enforced by courts or by other mechanisms that confer power in non-contractual ways to one or the other party to the transaction. The non-contractual source of power is usually a critical resource that is valuable to the production process. A variety of (non-contractual) mechanisms attach the critical resource to one of the parties in a way that maximizes the creation of surplus.

For example, the Property Rights approach (see Grossman and Hart (1986), Hart and Moore (1990)) emphasizes physical assets as the primary critical resource, and ownership as the mechanism that attaches this resource to the right agent. According to this view, ownership differs from ordinary contracts because it confers on the owner the residual rights of control over the asset (the right to decide in situations not covered by contract). The power associated with the common ownership of physical assets is what makes the firm different from ordinary market contracting.

More recent developments of this theory (see Rajan and Zingales (1998b, 1998c), for example) emphasize, first, that the critical resource can be different from an alienable physical asset and, second, mechanisms other than ownership can help bonds develop between various agents who participate in the production process. In general, these mechanisms work by fostering complementarities between agents, and between agents and the critical resource. The agent who controls the critical resource can threaten to destroy the complementarities, and thus gets some power over other agents. This facilitates transactions even when contracts are inadequate. The firm then consists of the critical resource and the agents who are tied to it via complementarities. Thus these recent developments (also see Holmstrom (1999) and Holmstrom and Roberts (1998)) suggest a larger boundary for the firm than the set of commonly owned assets.

From an empirical perspective, these theories suggest that the quantity of physical assets over which ownership can be exerted is one determinant of firm size, but the boundaries of the firm are also expanded by mechanisms other than ownership, some of which are aided by the law. In particular, Rajan and Zingales (1998c) analyze a stylized model where an entrepreneur has a critical resource with which she wants to produce. In order to produce, she has to offer employees access to the resource and its mode of employ. There are constant returns to scale in production (so that technology does not limit the size of the firm) but extreme increasing returns to scale in marketing so that a larger firm captures a disproportionate share of the market. The problem is that the entrepreneur's property rights to the critical resource are not fully secure. As a result, she has to limit the number of employees who have access to the resource. The reason is that while she has a "noyeaux dur" of employees who have specialized to the firm's business, have high switching costs, and are therefore loyal, new unspecialized employees have low switching costs. If there are a sufficient number of them, they will know that they can capture a large market share if they band together and make away with a copy of the critical resource. Thus the entrepreneur can employ only a few new employees, and has to wait until they specialize and become loyal before admitting new ones. It turns out that not only does this fear of expropriation limit the rate of growth of the number of employees in the firm, it also limits its eventual size.

The implications of this model are quite stark. So long as the government respects property rights broadly, physical assets are hard to make away with. So the entrepreneur is protected against expropriation if the critical resource consists of physical assets. More generally, even a modicum of respect for property rights confers substantial power on the owner of physical assets, and allows her to exercise control over a large number of employees. Thus physical capital intensive firms will typically be larger.

But as legal institutions improve, the entrepreneur gets other forms of protection. For example, patent rights protect her intellectual property, while non-compete clauses restrain employees from departing. Thus firms that rely on other forms of critical resources, such as brand names, intellectual property, or innovative processes, should become larger as the legal environment improves.[4]

1.3 Institutional theories

There are many channels through which institutions can affect firm size beyond that predicted by the technological and organizational theories. We group these channels into two main categories: regulatory and financial.

1.3.1 Regulatory theories

Many costly regulations apply only to larger firms (for example the obligation to provide health insurance in the United States or Union Laws in Italy). This tilts the playing field towards small firms. Other regulations, such as strong product liability laws, favor the creation of separate legal entities that can avail of the protection afforded by limited liability. This should lead to smaller firms. For instance, each taxi cab in New York is a separate firm. This effect has been found to be important in explaining the time variation of size of firms in the United States (Ringleb and Wiggins (1990)).

[4] Of course, in the limit if there is perfect enforceability, complete contracts can be written, and there is no distinction between firm and market. In practice, however, we are probably quite far from this utopia.

High corporate taxes could also drive many economic activities into the informal sector, and reduce the incentive to create large firms. Some have argued that this is why Italy has so many small firms (a "fact" we will check).[5] Of course, one could also argue that large firms can afford the staff to indulge in creative tax accounting, thus giving them a comparative advantage in a high tax environment. This is why the effect of taxes on firm size is potentially ambiguous.

Also some aspects of the extensive literature on industry market structure (see Caves (1998) and Sutton (1991, 1997) for excellent surveys) falls under the rubric of regulatory theories. Anti-trust laws could limit the size of firms. Conversely, by restricting entry and conferring monopolies, other regulation could increase the average size of firms. For example, in most European countries, railways are Government owned and are huge, with size only limited by the market.

More generally, barriers to entry could be important in determining average firm size. Hopenhayn (1992) develops a dynamic model of firm size based on entry costs and firm-level productivity shocks. He identifies two conflicting effects. Output price increases with entry cost leading to higher employment, but the threshold productivity level at which firms exit decreases, which increases the fraction of firms with lower employment. Whether increased barriers to entry increases or decreases average firm size is therefore an empirical question.

1.4 Financial theories

A potential obstacle to firm growth is also the availability of external funds. If this is an important issue, firm size should be positively correlated with financial development and, more generally, with factors promoting the development of financial markets. La Porta et al. (1997a) find that a country with a Common Law judicial system, and having strict enforcement of the law, has a more developed financial system. This would suggest that there is an additional, indirect, channel through which sound laws and judicial efficiency affect firm size - through their effect on financial market development.

Rajan and Zingales (1998a), however, find that financial market development affects both the growth in the average size of existing establishments and the growth in the *number* of new establishments in industries dependent on external finance (though disproportionately the former). Thus, the theoretical effect of the development of financial markets on the average size of firms is ambiguous. One the one hand, more firms will be born, reducing the average size of

[5] For example, Pagano, Panetta, and Zingales (1998) argue that this is a reason why so few Italian firms go public. By limiting the access to the public equity market, this effect may also limit the size of firms.

firms. On the other hand, existing firms will be able to grow faster, increasing the average size of firms. Whether the average size of firms in industries that rely on external finance is larger, thus, is ultimately an empirical question, which we will try to resolve.

We have attempted in the preceding paragraphs to describe some important technical, legal, and institutional influences on firm size. Most of these effects are country specific. Given the large number of possible effects and the limited number of countries we have data for, we will not attempt to capture them all, but we will typically control for them by inserting country fixed effects.

1.5 Existing Empirical Literature

Much of the evidence we already have comes indirectly from the vast literature on market structure. One focus of this literature has been on the distribution of firms and their growth rates in various industries in a country over time. Papers have tried to find evidence for the Law of Proportional Effects or Gibrat's law, which states that the rate of growth of a firm is independent of size (in general, the evidence is not consistent with it).

There have also been studies on the cross-sectional determinants of firm size (see Mata (1996), for example) but, more typically, studies have been within industry rather than across industries (Caves and Pugel (1980), for example) or have examined entry and exit (Audretsch and Mahmood (1995), for example). More important, there have been few cross-country studies focusing on the effects of institutional differences on firm size. The two most related papers here are Davis and Henrekson (1997) and La Porta et al. (1997b).

Davis and Henrekson study whether the institutional structure in Sweden forces a tilt (relative to the U.S.) towards industries that are dominated by large firms. They find this to be true. Their interest, however, is in the relative distribution of employment across sectors, not in the determinants of firm size *per se*. In fact, the US establishment coworker mean (number of employees at the average worker's place of employment) is over twice the corresponding Swedish value, even though US employment is more heavily concentrated in industries dominated by smaller production units.

La Porta et al. (1997b) examine whether an indicator of the level of trust prevailing in a country affects the share of GDP represented by large organizations (defined as the 20 largest publicly traded corporations by sales). They find a positive correlation. Their focus, however, is on the relative importance of large organizations, while our focus is on the determinants of the absolute size of organizations.

2 The Data

In 1988, Directorate-General XXIII of the European Commission and Eurostat launched a project to improve the collection and compilation of statistics on small and medium enterprises. This project led to the publication of *Enterprises in Europe* by the European Commission in 1994. This data set contains statistics on enterprises, employment, and production for all economic sectors (except agriculture) in the European Union (EU) and the European Free Trade Agreement (EFTA) countries.

One of the explicit purposes of this effort was to assemble "comparable and reliable statistics which make it possible to identify the relative importance of different categories of enterprises." (*Enterprises in Europe*, Third Report, v.I, p. xxii). In spite of the effort to homogenize the statistical criteria *Eurostat* warns that several methodological differences in the classification and coverage of units remain. Thus, the cross-country analysis should be interpreted with caution, while the cross-sector analysis or interactions, which control for country fixed-effects, are less sensitive to this problem. With all its limitations this is the first source we know of that provides comparable data on firm size across countries.

2.1 The Theoretical Unit of Interest and the Empirical Unit.

A problem in studying firm size is that the theories have different approaches to defining the firm, and this may be at variance with the available data. As we have seen, technological theories (e.g., Lucas (1978)) focus on the allocation of productive inputs such as physical capital, managerial talent, and human capital, across various activities and the effect this has on the size of the production process. They do not focus on the specifics of how hierarchical control is exerted. These theories would not, for example, make much of a distinction between Toyota and its supplier network, and General Motors (a much more vertically integrated firm) and its supplier network, since both feed into broadly similar production processes. More generally, since technological theories are primarily concerned with the nature of a firm's activity as captured by variants of the neoclassical production function, in the words of Lucas (1978), "what we may hope for is not serious organization theory, but perhaps some insights into why organization theory matters economically."

Organizational theories (e.g., Alchian and Demsetz (1972), Fama and Jensen (1983), Williamson (1985), and Grossman and Hart (1986)), on the other hand, focus on how hierarchical control is exerted. The production function plays, at best, a secondary role in these theories. For example, the Property Rights view asserts that control exerted through an arm's length contract

(General Motors over its suppliers) is not the same thing as control exerted through ownership (General Motors over its divisions). According to this view, the economic definition of a firm corresponds to the legal view - a firm is a set of commonly owned assets. More recent developments (see Rajan and Zingales (1998b,c), for example) go further and suggest that if the economic distinction between transactions that are firm-like and market-like turns on whether hierarchical, non-contractual, control is exerted, common ownership is neither necessary nor sufficient to define the economic limits of a firm. Toyota may exert much more control over its suppliers who are tied to it by a long history of specific investment than General Motors, which puts supply contracts up for widespread competitive bidding. In other words, Toyota and its suppliers, although distinct legal entities, could be thought of as a firm in the economic sense, while General Motors and its suppliers are distinct economic and legal entities. In short, with notable exceptions, the firm described by the theories does not correspond to the legal entity.

The data that are available, however, are for the legal entity. The unit of analysis is the enterprise, defined as "the smallest combination of legal units that is an organizational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activity at one or more location" (*Enterprises in Europe*, Third Report, v.II, p. 5).

The starting point of the definition, thus, is the legal entity. The emphasis on the "smallest combination of legal units" is important. Conversations with *Eurostat* managers indicates that subsidiaries of conglomerates are treated as firms in their own right, as are subsidiaries of multinationals.[6] Some subjectivity, however, is introduced because *Eurostat* looks also for autonomy in decision making in drawing the boundary of the enterprise. To this extent, the enterprise corresponds to the economic entity discussed above – the economic realm over which centralized control is exercised.

The definition used for the enterprise is, therefore, a combination of the "legal" and what we call the "economic" firm. To make some headway, we have to assume that it is also a good proxy for the length of the production process. All we really need is the plausible assumption that factors that permit a longer chain of production should also increase the average size of the autonomous legal entity called the firm.

[6] Foreign subsidiaries of a multinational with headquarters in a particular country do not, therefore, add to the enterprise's size in the country of the parent.

2.2 What Do We Mean by Average Size?

Enterprises in Europe provides us with the size distribution of firms (number of employees) in each NACE two-digit industry (we use "industry" interchangeably with "sector") in European countries belonging to the EU and the EFTA.[7] We exclude from the analysis Iceland, Luxembourg, and Liechtenstein because of their extremely small size. We also drop Ireland, because data are not consistently reported. This leaves us with 15 countries. For all these countries, data are available for either 1991 or 1992. Further details on the data are presented in the data appendix.

An immediate question is whether we should measure the size of a firm in terms of its output, its value added, or the number of its employees. Value added is clearly preferable to output, because the complexity of the organization has to do with the value of its contribution not with the value of the output sold. *Enterprises in Europe* reports that value added per employee is fairly stable across different size-classes. Thus, a measure of firm size based on the number of employees is likely to be very similar to a measure based on value-added. Yet, coordination costs, which are present both in the technological and the organizational theories of the firms, are in terms of number of employees, not their productivity. Thus, a measure based on the number of employees is preferable.

We have data on how many firms and employees belong to each firm size bin (e.g., there are 30,065 employees and 109 firms in the bin containing 200-499 employees in NACE 16 (Electricity) in Germany).[8] There are a number of ways of summarizing the data. Which measure is more appropriate depends on the purpose.

The next question, therefore, has to do with what we are trying to measure. The theories we have described suggest the determinants of the optimal scale of firms. Yet all the firms in an industry are not likely to be at that scale. Furthermore, there is entry and exit, firms grow substantially when young, and there is inter-industry variation in these rates of growth (see Caves (1998) and Pakes and Ericson (forthcoming)). We have a cross-section, and do not know how many firms enter or exit from the industry in a typical year. Despite this problem, since we have countries at relatively similar stages of development, industries should be at similar stages of the product life cycle across countries (see Klepper (1996) for a formalization of the effects of the PLC). Hence, the cross-country and interaction effects should indeed reflect the effects of

[7] NACE is the general industrial classification of economic activities within the EU. Two-digit NACE industry roughly corresponds to two-digit SIC sectors.

[8] We use "bin" and "size class" interchangeably.

institutional differences on average size. More important, Sutton (1997, p52) argues that most entry and exit has relatively little effect on the largest firms in the industry (which are likely to have achieved the optimal scale). Therefore, while we cannot resolve this problem completely, we can minimize its effects by choosing the appropriate measure of firm size.

This leads us to the last issue, which is what is the most appropriate measure of average firm size for our data. The simple or firm weighted average, obtained by dividing the total employment in the country-sector combination by the total number of firms in that combination, is inappropriate for two reasons. First, it ignores the richness of the data on the *distribution* of firm size. Second, and most important, it could give us a number that has little bearing on the size of firm that has the greatest share in the sector's production. Consider, for instance, automobile manufacture in Spain. 78% of the employees in this sector work for 29 firms which, on average, employ 38,302 employees. There are, however, 1,302 self-employed people, who account for an equal number of firms. Taken together with the intermediate categories, the simplest measure would suggest that the average firm has only 570 employees.

Given that our intent is to analyze the determinants of the size of firms that carry out the bulk of the economic activity in a sector, and also we want to weight large firms more heavily so as to minimize the effects of entry and exit, we chose instead to compute a weighted average size as follows; The average firm size in each size bin is first calculated by dividing the number of employees by the number of firms. The average size for the entire sector is then calculated as the weighted sum of these bin averages, using as weights the proportion of the total sectoral employment in that bin. This produces a "employee-weighted" average of firm size.

$$Employee\ \ Weighted\ \ Average\ \ Number\ \ of\ \ Employees = \sum_{bin=1}^{n} \left(\frac{N_{bin}^{Emp}}{N_{Sector}^{Emp}} \right) \left(\frac{N_{bin}^{Emp}}{N_{bin}^{Firms}} \right)$$

where N_{bin}^{Emp} is the total number of employees in a bin, N_{Sector}^{Emp} is the total number of employees in the sector, and N_{bin}^{Firms} is the total number of firms in a bin. In the above example of automobile manufacture in Spain this measure gives an average firm size of 3,002 employees.

In contrast to the firm-weighted simple average, the employee-weighted average emphasizes the larger firms.[9] For the remainder of this paper when we refer to firm size without qualification,

[9] We are not the first to adopt such a convention. Our employee-weighted measure is closer to the Davis and Henrekson's measure of the coworker mean (number of employees at the average worker's place of employment) than is an equally weighted average. Also, we do not fully succeed in emphasizing the largest firms since we do not have the distribution of size within bins, especially the largest. So, for instance, if much of the employment in an industry is concentrated in a single large firm, but there are 15 smaller firms in the largest bin, our calculated employee weighted average would tend to understate the true employee weighted average.

we mean the employee-weighted average (or the log of the employee-weighted average in the regressions).

2.3 Cross-Industry Patterns in Firm Size

Table 1 presents the summary statistics on different measures of size by industry. For now, focus on employee size measured by the number of employees (the first five columns of Table 1). There are 55 sectors on which we have data, though from the last column indicating the frequency of countries reporting, we can see that coverage across countries is not uniform: the coverage is broadest for "Food and Tobacco" (NACE 41) and most sparse for "Public Administration" (NACE 91). In this table, each measure of size is obtained by averaging the measure for that sector across all countries reporting that sector.

Note first that the simple average and the employee weighted average can present a very different picture. For example, "Air Transport" has the third largest firms by the latter measure with an average of 6335 employees, but has only the twelfth largest firms with an average of 135 employees by the former measure. This is because most employees belong to a few large airlines (hence the higher employee weighted average), but there are also many tiny firms in the air transport industry providing ancillary services (hence the low simple average). In what follows, we focus on employee weighted measures.

The largest sectors, by far, are "Communication", "Railways", "Air transport", and "Electricity". The sizes of the largest firms in these sectors are also significantly higher than those for the other sectors. Given the typically high degree of Government ownership and intervention in these sectors, we collectively label them "Utilities" (although they do not correspond exactly to the definition of utilities in the U.S.) and present country level statistics with and without them in Table 2.

The smallest sectors are "Letting of real estate", "Scrap and waste", "Personal services", "Repair of consumer goods", and "Renting, leasing". While one might be tempted to conclude that firms in the service sector are small, this would be incorrect. Firms in financial services like Banking or Insurance are about the same size as firms in Motor Vehicles, the non-utility manufacturing sector with the largest firms.

The sixth column of Table 1 presents the mean of residuals across countries from the regression:

$$\log \left(Employee\ weighted\ average\ size_{c,s} \right) = cons + \alpha_c \cdot d_c + \varepsilon_{c,s}$$

where, d_c is a vector of country dummies. The aim is to study the employee weighted average size when the country effects are purged. A comparison of the ranking of sectors purged of country effects with the ranking of the sectors based on the original average gives us an idea of the importance of country effects. Spearman's rank correlation coefficient between the average with and without country effect is 0.86 when all sectors are included, and 0.95 when the utility sectors are dropped. The ranking of the largest 4 sectors (which include the utility sectors) is preserved across both means. These coefficients seem to indicate that while there may well be country effects, they are likely to be overshadowed by sectoral effects.

Indeed, a two-way analysis of variance of the employee weighted average size on country and sector shows that close to 63% of the total variation in size comes from sectoral effects while about 2.5% comes from country effects. The corresponding numbers when the simple average is used are 26% and 1.4%.

The simple average (or, equivalently, the firm weighted average) is less than the employee weighted median for nearly all sectors, suggesting that employees typically belong to larger firms in a sector – a right-skewness in the distributions of average size across countries.

In Table 1 B, we present the dispersion in firm size in the various sectors. The formulas used in computing this and other statistics are given in the appendix. The weighted coefficient of variation of firm size within a sector (the employee weighted standard deviation across bins divided by the employee weighted mean averaged for that sector across countries) is likely to be small if the industry is concentrated (so that most of the employment is in a few large firms) or if there is a well-defined optimal scale of operations (so that most firms cluster around that scale). It is highest for the service industries such as "Personal Services", "Agents", "Hotels and Catering", "Repair of Consumer Goods" while it is lowest for "Extraction of Solid Fuels", "Communications", and "Nuclear Fuels". Capital intensive industries seem to be less dispersed, though it is hard to tell which of the above forces is responsible.[10]

Finally, the employee weighted skewness is typically negative (39 of 55 sectors negative) suggesting that even though the mass of employees is concentrated in larger firms, there are enough employees in small firms to bring the weighted mean down. The industries where weighted skewness is positive are ones such as "Agents" where most employees are in tiny firms (most employees are in the bin with firms of average size 2) but there are enough employees in large firms to take the employee weighted average up to 107.

[10] Yet another possibility is that service industries are less precisely defined - "Agents" could encompass a wide variety of activities. However, "Hotels and Catering" is quite precise, and this sector also has a high coefficient of variation.

2.4 Cross-Country Patterns in Firm Size

In Table 2, we present summary statistics on average size by country. Table 2A presents data for all the sectors, while Table 2B for different subsamples. The broadest coverage is for Italy and the sparsest coverage for Austria and Denmark. In this table, the "mean" for a country is the mean across sectors of the average firm size.

Greece, Portugal, and Austria have firms with the smallest employee weighted average size, though correcting for industry effects (column six), Norway's firms are also relatively small. The UK and Italy have firms with the highest average size, in fact, substantially higher than the remaining countries. Since Italy is reputed to have many small firms, it might come as a surprise that it has the second highest average size. As we will see, this is partly because of the composition of industries in Italy.

When we look at the total number of firms in the country, Italy has by far the most firms. One must be careful, though, because the number of sectors reported differ by country. This might explain the relatively low number of firms in Austria and Denmark (beyond the size of the country). The anomalous observation is Greece, which reports a sizeable number of sectors, but appears to have very few firms. The reason is that only enterprises with more than 10 employees are reported in Greece. While this biases the average size upwards, our employee-weighted average minimizes the effect. Nevertheless, we will check that none of our results depend on this.

The last column presents the mean of residuals across countries from the regression:

$$\log\left(Employee\ weighted\ average\ size_{c,s}\right) = cons + \beta_s \cdot d_s + \varepsilon_{c,s}$$

where, d_s is a vector of sector dummies. The aim is to study the employee weighted size in a country when the sector effects are purged. Spearman's rank correlation coefficient between the means with and without sector effects is 0.45, significantly lower than the figures presented above for the sector tables. The ranking is preserved only for UK. Interestingly, Finland which is ranked sixth in average size falls only marginally to seventh after purging industry effects. Thus Finland's large firms are not simply because of industry effects.

As mentioned earlier, the utilities sectors need to be treated differently. The first column in Table 2B presents the mean for the country distributions when the utilities sectors are excluded. The mean drops for several countries, with the drop for Italy being the most dramatic (2244 to 545). Spearman's rank correlation coefficient between the means with and without utilities is 0.78. UK, Germany, and France now have the highest averages, while Greece, Portugal, and Austria continue to have the smallest averages (they do not have coverage for utilities in the first place and are therefore unaffected by the exclusion).

Since manufacturing excludes utilities, the means for manufacturing sectors alone are very similar to those when utilities are excluded. In fact, the Spearman coefficient between the means without utilities and for manufacturing alone is 0.89.

It is hard to discern any obvious patterns in Table 2B. A rich country like Switzerland has firms of very small average size, while small countries like Denmark have large firms. Remarkably, UK has the largest firms according to almost any classification considered. While we cannot rule out differences in the definition of firms in the United Kingdom, no other country preserves its rank so consistently.

Finally, Table 2C indicates that Italy, Spain and Portugal have the highest employee weighted coefficient of variation for firm size. Austria, Belgium, and the United Kingdom have relatively low dispersion of firm size.

2.5 Other Summary Statistics

We present in Table 3 the summary statistics of the explanatory variables used in the subsequent analysis as well as their cross-correlations. The definitions of all these variables is contained in the Data Appendix.

Two facts are worth pointing out. First, in spite of the homogeneity of the sample (all the countries are European and would be classified as developed), there is some variation in most of the explanatory variables. For example, per capita income varies between \$6,783 (Greece) and \$16,245 (Switzerland) and the measure for human capital varies between 3.827 years (Portugal) and 10.382 (Norway).

The second fact is that some of these measures are highly correlated. For example, judicial efficiency has a correlation of 0.9 with human capital. This can make it difficult to separate the effect of the two.

3 Cross-Industry Correlations

We start our analysis by examining the correlation between industry-level factors and firm size.

3.1 Predictions and Proxies

As a proxy for the size of the actual market we use the log of total employment in the industry in that country.[11] There are two problems with this measure. First, theories (e.g., Smith (1776)) obviously refer to the potential market. Second, and following from the first, there may be spurious correlation between average firm size and our measure of the market size. For example, in the case of monopolies, there will be a one-to-one correspondence between average firm size and our proxy for the size of the market. To correct for this, we instrument our measure of market size with the logarithm of GDP and country population. These country level variables should be uncorrelated with industry level constraints, but should be correlated with the size of the potential market, hence they should be good instruments.

While we do not have a direct measure of capital stock in an industry to enable us to calculate physical capital intensity, we have the gross investment in an industry. Dividing this by the number of workers in that industry, we have investment per worker. In order to obtain a more exogenous measure, we take the mean of this variable across all the countries for which we have this data.[12]

The expenditure on Research and Development is not available for the European countries in our sample; but from Compustat, we obtain the median R&D to sales ratio for U.S. firms in each industry over the 1980s, and use it as a proxy for R&D investment made by European firms in the same industry. We calculate wages per worker in the same way as investment per worker above.

Finally, Rajan and Zingales (1998a) compute an industry's dependence on external funds as the fraction of capital expenditure in that industry in the United States funded from external sources. We use the Rajan and Zingales measure of external dependence and weight it by the investment per worker in an industry to get the amount per worker that has to be raised from external sources.

The maintained assumption in using these proxies is that there are technological characteristics of certain industries that should carry over countries. Of course, since we are primarily interested in the sign of coefficients, what we really require is that the relative relationship between industries carry over rather than the precise levels. In other words, if Drugs and Pharmaceuticals is more research intensive in the United States than Leather goods, it will continue

[11] Whenever we require the logarithm of a variable, we always add one before taking logs.

[12] This includes the United States. As we will see, dropping the United States in the calculation does not change the results qualitatively. Neither does taking medians. All industry variables are winsorized at the 5% and 95% levels to reduce the effects of outliers.

to be so in Italy. This is also the maintained assumption in Rajan and Zingales (1998a). While this assumption allows us to use independent variables that are likely to be truly exogenous, and also overcome the paucity of data, a failure of this assumption means, of course, that some of our independent variables are noise and should have little explanatory power.

3.2 Results

We report in Table 4 the estimates for a regression of log firm size on characteristics of the industry. In the first column we report the estimates from a regression of log employee weighted average size on industry characteristics where the size of the market (measured as total sectoral employment) is instrumented. Robust standard errors are reported and they correct for clustering of the residuals at the industry level. The effect of market size is positive and highly statistically significant (henceforth, "significant" will denote significance at the 10% level or better). An increase in log employment in the industry from the twenty fifth percentile to the seventy fifth percentile increases log size by about 27% of the inter-quartile range. Thus the size of the market does matter, perhaps because it affects the extent of possible specialization.

We also include investment per worker, R&D to sales, wages per worker, and amount financed externally per worker. The first three explanatory variables are positively correlated with size, while the amount financed externally is negatively correlated. While we expected investment, wages, and R&D expenditure to be positively correlated, we had no strong prior on the sign of the correlation between the amount financed externally and size.

The magnitudes of the effects are also considerable. According to the estimates in column I, an increase in investment per worker, R&D to sales, wage per worker, and amount financed externally from the 25th percentile to the 75th percentile of the variable changes log firm size by 14%, 13%, 37%, and -29% of its inter-quartile range respectively. The explanatory power of the regression is also considerable ($R^2 = 0.32$).

What do we make of all this? If industries are located in specific areas and there is a high cost to labor mobility, or if agents have industry specific human capital, then Lucas' model could be applied industry by industry in a country. The positive partial correlation between investment per worker and size is consistent with Lucas (1978). It is also consistent with Critical Resource theories of the firm where a firm of larger size is easier to control when the critical resource is physical capital. Finally, the correlation may reflect a larger minimum economic scale for physical capital intensive industries (though we have no theoretical argument for such a conjecture).[13]

From the perspective of extant technological theories, one would expect investment in R&D and investment in physical capital to be correlated. Thus we should expect a positive correlation between size and R&D expenditure. Similarly, from the perspective of Critical Resource theories, if the critical resource is intellectual property and it is protected to some extent by patent laws, we should expect such a correlation.[14]

The positive correlation between wages per worker and size is consistent with the thrust of Lucas's (1978) notion that the incentive to become an entrepreneur is relatively small when wages are high. It is also consistent with Kremer's (1993) view that if wages are a proxy for the quality of a worker, higher wages should be associated with larger firms.

Finally, the negative correlation between the amount financed externally and size suggests the adverse effects on average size of financial constraints on the growth of existing firms dominate the positive effects on average size of reduced entry by new firms in financially dependent industries (though, of course, the way we measure size is biased towards minimizing the latter effect).

The pattern of correlations with size allow us to draw only tentative conclusions about the effect of entry barriers on firm size. The necessity of large per capita expenditures on investment and R&D in an industry, which are reasonable proxies for technological barriers to entry, increase average firm size. One would have expected the cost of externally funding these investments to also be one of the proxies for barriers to entry. However, the result discussed in the previous paragraph highlights the weakness of this variable as a proxy – even established firms are adversely affected by the need for external financing. Thus, based on the quantity of investment alone we have to conclude that barriers to entry have a positive effect on firm size.

In summary, the partial correlations are consistent with multiple theories. Nevertheless, the correlations are useful in that they provide a minimum set of patterns that theories should fit.

3.3 Robustness

Before we turn to cross-country correlations, we check the robustness of our findings. We re-estimate the regression in Table 4 (column I) dropping one variable at a time so as to check that

[13] We are not the first to find such a relationship. For example, Caves and Pugel (1980) find that size is correlated with capital intensity within industry.

[14] The relationship between firm size and total firm R&D investment within an industry is well known (see Cohen and Klepper (1996) for references). However, our finding is across industries and countries. More important, the correlation we find is between the intensity of R&D (i.e., per unit) and size, while it has generally been found (Klepper (1996), p577) that R&D does not rise more than proportionally with firm size within industry.

the specification is robust. The variables never change sign (estimates available from authors) though the high correlation of capital intensity with amount financed externally and wages per worker make the magnitude of its coefficient volatile. The next step is to check that the observed correlations are robust to the introduction of country effects. If they are not, one would suspect that the estimated effects do not relate as much to the nature of the technology used in an industry as to the institutional environment in a particular country. So in Table 4 (II), we introduce country indicators (coefficients of indicators not reported) in the estimated model. The one problem with introducing country indicators is that we cannot instrument market size with country level variables such as log GDP because the instruments will become perfectly collinear with the country indicators. That we do not instrument perhaps explains why the coefficient estimate for market size in Table 4 (II) is more than twice what it is in Table 4 (I), even though all other coefficient estimates are much closer in magnitude to their corresponding values.

Recall that we computed investment per worker and wage per worker by taking means for the industry across a number of countries including the United States. If we drop the United States, we lose a number of industries for which we have per-worker data only from the United States. Therefore, the number of observations in Table 4 (III) is smaller. The coefficient estimates remain qualitatively similar even with the changed explanatory variable and the lower number of observations. However, both the coefficient estimate for capital intensity and R&D intensity are measured much more imprecisely, and they become statistically insignificant. The coefficient of wage per worker is borderline statistically significant.[15]

In summary, the results seems fairly robust. Signs are stable. Using different methods to calculate the explanatory variables, different dependent variables, or different sub-samples, does not alter the results significantly.

4 Cross-country correlations

Let us now examine the partial correlations of country level variables with firm size.

[15] We can also compute the median investment and wage per worker for an industry across countries (instead of the mean). We find that the coefficient estimates are all significant and have the same sign as before.

4.1 Proxies

We include the log of per capita income as a measure of a country's wealth, and human capital, measured as the average years of schooling in the population over age 25 in the year 1985. The latter comes from the Barro-Lee database. Our measure of judicial efficiency, is an assessment by Business International Corporation of the "efficiency and integrity of the legal environment as it affects business" for each country, coded on a scale of zero to ten.

4.2 Results

In Table 5, we present estimates of the effect of cross-country variables. In all the estimations we include industry fixed effects and the size of the market, which is instrumented by the log of GDP.[16] The standard errors are not only robust to heteroskedasticity but also corrected for potential clustering at the country level.

We start by examining the effect of log per capita income in column I. Per capita GDP has a positive and significant correlation with firm size. As we shall soon see, when we include measures of institutional development, the coefficient turns negative and significant.

In Table 5 (column II), we include human capital. Human capital has a positive and significant coefficient, consistent with the theories proposed by Rosen (1982), Becker and Murphy (1992), and Kremer (1993). Interestingly, the sign on log per capita income becomes negative, though it is statistically insignificant.

Next we include the efficiency of the judicial system (column III). The coefficient estimate is positive and highly significant. An increase in judicial efficiency from the 25th percentile to the 75th percentile changes log firm size by 52% of its inter-quartile range. The large positive correlation is consistent with Critical Resource theories, legal and financial theories, and co-ordination cost theories of the firm: An efficient legal system eases management's ability to use critical resources other than physical assets as sources of power, which leads to the establishment of firms of larger size (see Rajan and Zingales (1998c)). It also protects outside investors better and allows larger firms to be financed (see La Porta et al. (1997a,1998)). Finally, an efficient legal system reduces co-ordination costs and allows larger organizations (Becker and Murphy (1992)).

Note that the coefficient on log of per capita income is now negative and significant at the 5% level. Therefore the "stylized fact" that richer countries have larger firms seems true only

[16] Of the two instruments used earlier, log GDP and log population, we can use only one otherwise they would be perfectly collinear with per capita GDP.

when we examine the obvious difference between the size of firms in really poor countries where there is little industry to speak of, and those in the rich developed countries, and when we do not correct for differences in institutions.[17] Within the set of industrialized countries, however, there seems to be little evidence of a significant positive partial correlation between per capita GDP and size.[18]

Recall that the size of firms in Greece is possibly biased upwards. Unlike in Table 4, we cannot include country indicators in these regressions. Therefore, it is important to check that our results are robust to excluding Greece. In fact, they are stronger.

We also inserted (not reported) a number of other variables to our basic specification in Column III, one at a time. We include Ginarte and Park (1997)'s index of the protection given to patent rights in different countries, the statutory corporate tax rate in the country in 1991, and the quality of accounting standards which Rajan and Zingales (1998a) argue is a good proxy for the extent of financial sector development in a country. We also include proxies for regulatory constraints and a measure of product liability. It turns out that none of these variables remains significant when judicial efficiency is included (though accounting standards comes in positive and significant when on its own, or included with the specification in Column II), while judicial efficiency always remains positive and highly statistically significant and log per capita income negative and significant. To some extent, the problem is that some of these variables are strongly correlated. For example, judicial efficiency has a correlation of 0.90 with our measure of human capital, 0.65 with accounting standards, and -0.40 with the corporate tax rate. This is a traditional problem with cross-country regressions - all measures of institutional and human capital development are typically highly correlated, so it is hard to tell their effects apart. Nevertheless, it is interesting that judicial efficiency seems to dominate the effects of other variables.

This cross-country analysis should be interpreted with caution because it is most sensitive to differences in the definition of enterprise across countries. Nevertheless, two results seem to emerge. First, the correlation between per-capita income and firm size is not as clear as previously thought and may, in fact, be a proxy for institutional development. Second, judicial

[17] See Gollin (1998) for an example of a study that focuses on economic development and firm formation.

[18] One could argue that our dependent variable is a proxy for labor intensity, and high per capita income countries could be substituting cheap capital for labor. This would yield a negative correlation between size and per capita income. To check that this is not driving our result, we would need data on sales. Unfortunately, data on sales present in *Enterprises in Europe* are sporadic. Nevertheless, we experimented with the limited sample available. Even with sales weighted average sales as dependent variable, the coefficient estimate for per capita income is never significantly positive.

efficiency seems to have the most clear cut correlation with firm size.

5 Interactions

Not only could cross-country regressions be biased by differences in the definition of the enterprise, but also we have very few degrees of freedom. Hence, it is hard to estimate anything with accuracy, and know whether something is really a proxy for what it purports to be. Rajan and Zingales (1998a) suggest one way to reduce both these problems: they test predictions that rely on an interaction between country and industry characteristics, after controlling for both country and industry effects. By doing so, not only do we use more of the information in the data, but also we test a more detailed implication of the theory, which helps distinguish theories that have the same prediction for direct or level effects. Organizational theories which model the micro mechanisms in greater detail are more amenable to such tests.

5.1 Theoretical Predictions

As we have seen, greater judicial efficiency leads to bigger firms. According to Critical Resource theories this effect is due to the strengthening of control rights. In all the countries in our sample, basic property rights over physical assets are protected, and guarantee owners a certain degree of power. However, the increased protection afforded to intellectual property, management techniques, firm-client relationships, etc., by a more efficient judicial system should allow more resources (even inalienable ones) to come into their own as sources of power. Therefore, we should expect judicial efficiency to particularly enhance management's control rights for firms with relatively few physical assets resulting in larger firms in such industries. This will imply the interaction between judicial efficiency and investment per worker should be negatively correlated with size. Note that this is not a direct implication of theories like Lucas (1978), which emphasize the rents created for workers by physical capital but not its control properties, or Becker and Murphy (1992) who refer to the co-ordination benefits of a better judicial system without emphasizing specific channels through which it works.

We have seen empirically that the average size of firms is negatively correlated with their need for external finance. This suggests imperfect financial markets constrain size. The development of financial markets should alleviate such a constraint. Therefore, we should expect industries that have to finance more externally will be larger in countries with better developed financial markets - a positive coefficient for the interaction term. Moreover, La Porta et al. (1997a, 1998) suggest that the efficiency of the legal system should affect the financial system. The inclusion of both the interaction between judicial efficiency and capital intensity, and accounting standards and external dependence allows us to distinguish the direct effects of judicial efficiency on firm size (as in the Critical Resource theory) and its indirect effect through financial development (as in legal and financial theories).

5.2 Results

One of the advantages of looking at interaction effects is that we can include both country and industry indicators to absorb all the direct effects. Thus we do not need to worry about which country or industry variables to include. The problem, however, is that we cannot instrument the size of the market because the instruments are collinear with the country indicators. We will check that this does not drive the results.

In Table 6, we report estimates for the interaction variables included individually (along with market size, country indicators, and industry indicators). Capital intensive industries have smaller firms in countries with better judicial systems. An increase in judicial efficiency from its 25th percentile to its 75th percentile causes the difference in log average size between firms in industries at the 75th percentile of capital intensity and firms in industries at the 25th percentile of capital intensity to diminish by approximately 12% of the inter quartile range of size. Put differently, as the legal system improves, the evidence indicates that the difference in size between automobile manufacturers and consulting firms should decrease.

Firms in financially dependent industries are relatively larger when financial markets are more developed. The estimates in column II suggest that an increase in a country's financial development from the 25th percentile to the 75th percentile results in the difference in log average size between firms in industries at the 75th percentile amount-financed-externally and firms in industries at the 25th percentile of amount-financed-externally to increase by approximately 9% of the inter quartile range of size.

We also include both interaction variables simultaneously. The coefficients on both terms increase suggesting that each effect is somewhat obscured when only one term is included. Finally, recall that with country indicators, we cannot instrument market size. To check that this does not drive the results, we drop the country indicators, include country level explanatory variables in column IV, and instrument market size. The interactions that were significant in column III continue to be significant, and their magnitudes are qualitatively similar.[19]

[19] We also estimate the coefficients when investment per worker is calculated only using European data (not

To summarize, the negative correlation between the judicial efficiency/capital intensity interaction and firm size can be explained by the Critical Resource theories of the firm. We also find evidence that financial development helps firms become larger, in part because it alleviates constraints on firms dependent on external finance.

The importance of the interaction effects lies in giving us greater assurance that the main effects (such as the effect of capital intensity or judicial efficiency on firm size) are correlated, at least in part, for the particular theoretical reasons we attribute to them. Perhaps a greater reason to focus on interaction effects is their value in distinguishing otherwise hard-to-disentangle level effects. Specifically, in the cross-country regressions, judicial efficiency swamped the effects of accounting standards on size. This is a common feature of cross-country regressions where most indicators of development are highly correlated with each other. By interacting judicial efficiency with capital intensity, and accounting standards with financial dependence, not only are we able to use the country-sector data to provide information, but also we distinguish the effects of judicial efficiency from accounting standards better.

5.3 Why Does a Better Judicial System Reduce the Impact of Capital Intensity on Size?

But we can go still further in evaluating the detailed implications of the Critical Resource theory. We cannot, as yet, tell whether the interaction effect between judicial efficiency and capital intensity comes from capital intensive firms becoming smaller, or firms with relatively few physical assets becoming larger, as judicial efficiency improves. The distinction is important because it enables us to tell apart some nuances in Critical Resource Theory. We have argued that improved judicial efficiency will enable management to gain control from legal devices other than ownership rights over physical assets. This suggests that the effect should largely come from the increase in size of firms in industries that are not physical capital intensive. There is, however, another explanation. If the residual rights coming from property rights to physical assets are what distinguish firms from markets, then as judicial efficiency improves, contractability improves, and the residual rights associated with physical assets become less important. Also, physical assets become easier to finance for departing employees, therefore becoming less unique and well protected, and again residual control rights associated with them diminish. This implies that capital intensive firms should become smaller with improvements

reported). The interaction coefficients retain their significance and sign even though we lose a number of industries. The results are qualitatively similar when we use medians to aggregate the per worker industry characteristics across countries rather than means.

in judicial efficiency, which could also explain the result.

To test this, we replace the interaction variable with judicial efficiency multiplied by indicators if an industry is in the highest or lowest tertile of physical capital intensity in Table 6B. The coefficient on the interaction between judicial efficiency and the highest tertile indicator is negative but not significant. Most of the action comes from the lowest tertile indicator which is positive and significant. This suggests that the effects of improvements in judicial efficiency come primarily from the growth in the size of firms that are not physical capital intensive.

However, one last check is warranted. Since judicial efficiency is correlated with per capita income, perhaps what we are measuring is the growth in the tertiary sector as per capita incomes improve. Of course, there is no obvious reason why the growth in the tertiary sector should result in the growth in average size of firms in that sector, given that we control for the size of the sector. Nevertheless, we also include the indicators interacted with log per capita GDP in Table 6B (II). The interaction between judicial efficiency and the indicator for low capital intensity is still positive and statistically significant. The interaction between judicial efficiency and high capital intensity is still negative, though now almost significant.

In sum, we believe that the interaction effect bolsters the explanations Critical Resource theories offer for the direct influence of capital intensity and judicial efficiency on firm size. While not conclusive, this suggests these theories are worthy of further investigation. Furthermore, while Becker and Murphy (1992) do not discuss the precise channels through which increases in legal efficiency will increase the size of firms, the evidence is broadly consistent with their theory also.

6 Discussion

This is undoubtedly an exploratory study. Nevertheless, we believe we have uncovered a number of regularities that can provide some guidance for future empirical and theoretical work. Our main finding is that firms in capital-intensive industries are larger, as are firms in countries with efficient judicial systems. More detailed findings can help tell theories apart. In particular, we find that firms in capital intensive industries are relatively smaller when located in countries with efficient judicial systems. This suggests that organizational theories may have some hope of explaining the substantial variation in firm size. Finally, financial constraints do seem to affect the size of firms.

Our findings suggest another potential answer, other than industry effects (which are, to some extent, endogenous) to the question that started this paper. Finland's judicial efficiency is rated 10, the highest on the scale (a position shared with a number of other countries). Its accounting standards are rated 77, which put it third in the sample after Sweden and the U.K. This may explain why the average size of its firms is larger than that of larger countries such as Italy (judicial efficiency 6.75, accounting standards 62) or Spain (judicial efficiency 6.25, accounting standards 64) whose standing on these measures places them close to, or in the bottom quartile.

The cross-industry results are consistent with the technological theories. This fact is of considerable importance given that the bulk of the variation in size, as indicated by an analysis of variance, is due to sectoral effects. However, the cross-country evidence is mixed. For example, log per capita income has, if anything, a negative correlation with firm size after correcting for institutional variables that should be irrelevant in technological theories. Similarly, the level of human capital has an insignificant correlation with firm size after we correct for the efficiency of the judicial system.

This result is to be expected, as technological theories often abstract from institutional features that vary across countries and affect firm formation. They instead focus on the organization of a typical sector within a given economy, and are thus most likely to be consistent with time-series evidence, as in Lucas (1978), or cross-industry evidence, as in part of our study.

One way to get at more detailed implications of technological theories may be to examine the influences on the dispersion of firm size within industry. For example, Kremer's (1993) results on assortative matching based on human capital, and higher human capital firms undertaking more complex processes (larger firms) can be combined to get the implication that greater inequality in human capital would be correlated with greater dispersion in firm size. Rosen's (1982) model has a similar implication - with more skilled managers running large firms and less skilled managers running small firms. As a measure of inequality in human capital we compute the coefficient of variation in educational attainments.[20] In Table 7, we regress the weighted coefficient of variation of firm size against this measure of inequality. We find, as predicted, the coefficient on inequality to be positive and highly statistically significant.

One could, however, argue that institutional development could reduce the importance of factors like talent and incumbency for the exercise of managerial control, and levels the playing

[20]Barro and Lee (1993) have data on the % of population over 25 in 4 categories of educational attainment – none, primary, secondary, higher – for each country. They also have years of education attainment of each type – PYR25, SYR25, and HYR25. We assign the following years of education to the four-category frequency distribution mentioned above: 0, PYR25, PYR25+SYR25, and PYR25+SYR25+HYR25. The coefficient of variation is then computed the usual way and used as a measure of human capital inequality. All human capital data is for the year 1985.

field. For example, greater judicial efficiency could help even small entrants secure their property, thus ensuring they reach optimal scale for production. Therefore, we would expect measures of institutional development to be negatively correlated with dispersion. This is, in fact, the case. When we include judicial efficiency in column II, it is strongly negatively correlated with the weighted coefficient of variation of firm size, and inequality in human capital, while still positive, is no longer statistically significant. Finally, the inclusion of per capita in column III does not change our conclusions.

Given our cross-sectional data, we could have more convincing tests of technological theories if we could exploit the way differences in institutional environments across countries affect the use of particular technologies and organizational structures. Tests for interactions, however, are hard to tease out of the technological theories since they do not model micro mechanisms in as detailed a way as organizational theories do. Nevertheless, such tests are possible. For instance, a more subtle implication of Kremer (1993) is that when the value added in a particular technology is high, human capital will be more important. So for such technologies, firm size will be larger when the human capital available in the country is better. This suggests a positive correlation between firm size and the interaction of human capital in the country with value added per worker. Unfortunately, the correlation is negative and insignificant when we include only this interaction together with market size, and country and industry indicators (coefficients not reported). When we include this interaction in the model in Table 6 A, column III, neither the interaction term, nor human capital is statistically significant (coefficients not reported). The variables that were found to be significant in that model continue, however, to be significant. Accompanied by the usual caveats, the prediction is not borne out.

A final caveat is in order. Even if one can devise more careful tests that discriminate between technological and organizational explanations of the size of firms, it is likely that they will be biased in favor of the latter. The firm in our dataset is defined as the legal entity, and the focus of some organizational theories is precisely on that entity. Clearly, they should have more explanatory power. By contrast, technological theories focus more on the technological limits to production. The unit of observation to test such theories should be the length of a production process from raw material input to final output. This may extend across several firms. Unfortunately, we do not have data on the length of processes, hence the bias.

7 Conclusion

It would be overstatement to suggest that we have actually tested theories. What we have done is found interesting partial correlations. Our search for these correlations has been motivated by specific theories, and to that extent, we have found evidence consistent with some theories. In particular, we find that institutional factors such as the efficiency of the judicial system and the development of financial markets as well as technological factors such as capital intensity and market size seem to influence the size of firms.

An important question, which we plan to address in future work, is whether size differences matter for the level and growth of productivity. If, in fact, the policy variables that we have found correlated with firm size are causal, they might have implications for growth. Rajan and Zingales (1998a) suggest that financial development does, in fact, facilitate growth. Since a substantial part of growth comes from the growth in average size of organizations, one channel through which financial development helps is by making possible the financing of large firms.

One could ask whether increases in judicial efficiency have similar effects. A related point is that judicial efficiency is highly correlated with human capital, and most likely with other forms of organizational capital. It is likely that the same underlying process of development is responsible for increases in the efficiency of judicial enforcement as well as other forms of capital. If this is the case, one might not be able to influence judicial efficiency, and hence firm size, without paying attention to the underlying causes. In other words, it might be worth exploring the true nature of the correlation between human capital and judicial efficiency, as well as the policy variables that might affect them. More research is clearly needed.

Table 1:

Different Measures of Firm Size by Industrial Sector

The source of the data is *Enterprises in Europe* which provides us with the distribution of firm size in each NACE two-digit industry in a number of European countries in 1991-92. The average number of employees computed weighting the average number of employees per firm in each bin of the distribution by the fraction of firms in that bin. The employee-weighted mean is computed weighting the average number of employees in each bin of the distribution by the fraction of total industry employees present in each bin. Employee-weighted mode is the average number of employees per firm in the bin that contains the most number of employees. Employee-weighted median is the average number of employees per firm in the bin that contains the median employee in the industry. Relative size correcting for country effects is the average residual for that sector obtained after regressing the logarithm of employee weighted size on country indicators after removing a fixed country effect. It can be interpreted as the relative deviation of the size of firms in that sector after purging country effects.

A: Different Measures (average across countries)

	Average number of employees	Number of firms in the sector	Employee weighted average number of employees	Employee weighted mode number of employees	Employee weighted median number of employees	Relative size correcting for country effect	N
Extraction solid fuels	232	41	987	1,133	1,133	0.09	6
Coke ovens	207	5	300	348	348	-1.28	4
Extraction petroleum	441	19	1,239	1,399	1,398	-0.28	5
Oil refining	216	60	1,075	1,314	1,303	0.82	7
Nuclear fuels	116	6	365	418	418	0.04	3
Electricity	173	826	4,122	4,749	4,391	1.89	8
Water supply	41	538	477	858	369	-0.15	5
Extraction-metal	150	244	644	859	728	-0.48	7
Production-metal	136	714	1,412	2,012	1,936	1.41	10
Extraction-other	15	2,556	183	404	65	-0.93	9
Manufacture-non metal	22	4,924	395	685	302	0.07	13
Chemical industry	80	2,295	1,087	1,647	1,438	0.99	12
Man-made fibers	224	19	927	1,113	1,113	0.74	6

	Average number of employees	Number of firms in the sector	Employee weighted average number of employees	Employee weighted mode number of employees	Employee weighted median number of employees	Relative size correcting for country effect	N
Manufacture- metal	19	18,972	243	275	68	-0.48	14
Mechanical engineering	33	8,861	510	995	286	0.24	14
Office machinery	44	743	1,179	1,602	1,574	0.50	10
Electrical engineering	41	6,650	960	1,609	1,241	0.91	14
Motor vehicles	99	1,218	1,938	2,455	2,328	1.31	12
Other means transportation	54	1,268	1,414	2,074	1,837	1.32	12
Instrument engineering	19	5,006	391	865	165	0.00	10
Food and tobacco	26	17,691	493	1,015	419	0.29	15
Textile	27	7,761	324	618	273	-0.08	11
Leather goods	11	2,416	142	189	51	-1.23	10
Footwear and clothing	17	16,012	234	388	89	-0.52	12
Timber and furniture	10	21,098	174	130	38	-1.03	12
Paper products and publishing	25	11,654	446	939	267	0.16	15
Rubber and plastic	29	4,871	477	861	316	0.09	11
Other manufacturing	9	8,295	140	10	45	-0.99	10
Building and civil engin.	10	112,814	224	10	28	-0.54	12
Wholsale distrib.	8	57,289	160	186	31	-0.78	12
Scrap and waste	5	2,269	30	3	13	-2.45	4
Agents	3	84,499	107	2	5	-2.42	8
Retail distribution	5	254,448	435	2	17	0.07	8
Hotels and catering	5	100,698	130	3	10	-0.97	8
Repair of consumer goods	7	39,146	64	45	13	-1.81	8
Railways	1,536	2,319	16,253	14,625	14,630	3.35	6
Other land transport	6	54,156	320	417	26	-0.13	8
Inland water transport	21	263	372	788	364	0.02	4
Sea transport	82	225	910	1,454	1,051	1.04	4
Air transport	135	140	6,335	7,525	7,525	3.09	5
Supporting services	23	4,070	849	1,341	937	0.73	6
Travel agents	12	5,787	236	550	92	-0.53	8
Communication	2,846	443	27,273	28,256	28,256	4.20	5
Banking and finance	86	3,929	1,857	2,564	2,564	1.70	7
Insurance	155	712	1,224	1,642	1,569	1.25	8
Auxiliary services	5	192,325	325	503	33	-0.44	10
Renting, leasing	5	6,030	75	135	22	-1.58	7
Letting of real estate	3	22,350	46	2	6	-2.31	6
Public administration	6	332,215	544	2	24	-0.48	1
Sanitary services	18	5,813	508	1,136	166	-0.03	8
Education	5	16,953	103	3	17	-1.97	6
Research and development	19	881	344	633	182	-0.05	5
Medical and others	8	73,263	286	513	291	-0.73	5
Recreational services	6	36,150	522	725	64	0.23	7
Personal services	3	48,044	58	2	2	-2.11	8

B: Dispersion in Firm Size (average across countries)

	Simple coefficient of variation	Employee weighted coefficient of variation	Employee weighted skewness
Extraction solid fuels	1.19	0.12	-0.26
Coke ovens	0.69	0.32	-0.54
Extraction petroleum	1.53	0.37	-0.61
Oil refining	2.02	0.44	-0.56
Nuclear fuels	1.49	0.26	-0.32
Electricity	4.53	0.58	-0.73
Water supply	4.09	0.86	-0.58
Extraction-metal	1.72	0.50	-0.53
Production-metal	3.36	0.63	-0.74
Extraction-other	3.39	1.32	-0.42
Manufacture-non metal	3.95	1.18	-0.57
Chemical industry	3.44	0.77	-0.84
Man-made fibers	1.40	0.37	-0.26
Manufacture- metal	3.60	1.53	0.25
Mechanical engineering	4.04	1.19	-0.59
Office machinery	4.62	0.58	-0.79
Electrical engineering	4.70	0.86	-0.90
Motor vehicles	4.27	0.68	-0.52
Other means transportation	5.21	0.68	-0.71
Instrument engineering	4.60	1.19	-0.98
Food and tobacco	4.52	1.12	-1.04
Textile	3.55	1.14	-0.77
Leather goods	3.07	1.34	-0.08
Footwear and clothing	3.82	1.55	-0.11
Timber and furniture	3.73	1.73	0.32
Paper products and publishing	4.45	1.19	-0.99
Rubber and plastic	3.94	1.19	-0.29
Other manufacturing	3.99	1.55	0.60
Building and civil engin.	5.28	1.99	0.49
Wholsale distrib.	4.30	1.92	0.09
Scrap and waste	2.02	1.56	0.60
Agents	3.72	2.57	0.42
Retail distribution	9.08	2.19	0.52
Hotels and catering	4.86	2.56	0.42
Repair of consumer goods	3.03	2.52	0.16
Railways	5.10	0.38	-0.08
Other land transport	7.15	1.93	-0.07
Inland water transport	4.47	0.94	-0.81
Sea transport	3.77	0.72	-0.91
Air transport	7.07	0.42	-0.43
Supporting services	6.09	0.95	-0.68
Travel agents	4.16	1.55	-0.62
Communication	8.16	0.24	-0.24
Banking and finance	5.92	0.59	-0.64
Insurance	2.91	0.58	-0.75
Auxiliary services	7.21	2.06	0.09

B: Dispersion in Firm Size (average across countries)

	Simple coefficient of variation	Employee weighted coefficient of variation	Employee weighted skewness
Renting, leasing	3.80	1.89	0.20
Letting of real estate	3.27	1.96	0.54
Public administration	9.35	1.72	0.58
Sanitary services	5.38	1.15	-0.78
Education	3.75	1.71	0.55
Research and development	4.43	0.96	-0.82
Medical and others	5.84	1.91	-0.24
Recreational services	9.65	1.65	-0.30
Personal services	4.01	2.81	0.34

Table 2:

Firm Size by Country

The source of the data is *Enterprises in Europe* which provides us with the distribution of firm size in each NACE two-digit industry in a number of European countries in 1991-92. The simple mean is computed weighting the average number of employees per firm in each bin of the distribution by the fraction of firms in that bin. The employee-weighted mean is computed weighting the average number of employees each bin of the distribution by the fraction of total industry employees present in each bin. Employee-weighted mode is the average number of employees per firm in the bin that contains the most number of employees. Employee-weighted median is the average number of employees per firm in the bin that contains the median employee in the industry. Relative size correcting for industry effects is the average residual for that sector obtained after regressing the logarithm of employee weighted size on industry indicators. It can be interpreted as the relative deviation of the size of firms in that country after purging industry effects. Utilities are defined as NACE sector 16 (Production and distribution of Electricity), 71 (Railways), 75 (Air Transport), 79 (Communication). Manufacturing is defined as NACE sectors 30 to 49.

A: Different Measures

	Average number of employees	Number of firms in the country	Employee weighted average number of employees	Employee weighted mode number of employees	Employee weighted median number of employees	Relative size correcting for industry effect	Number of sectors with data
AUSTRIA	77	8,124	318	427	287	-0.03	8
BELGIUM	323	177,973	1,317	1,566	1,367	0.16	53
DENMARK	22	53,400	528	1,178	303	0.14	8
FINLAND	166	199,942	1,197	1,519	1,235	0.03	47
FRANCE	40	1,555,064	1,243	1,510	1,222	0.52	29
GERMANY	69	2,159,489	951	1,364	949	0.69	33
GREECE	47	8,342	254	320	226	-0.81	22
ITALY	101	3,242,062	2,244	2,462	2,346	-0.20	54
NETHER	32	154,364	482	842	379	-0.09	17
NORWAY	96	83,018	350	520	305	-0.44	33
PORTUGAL	21	280,185	299	527	234	-0.60	17
SPAIN	71	2,373,379	1,050	1,346	1,136	-0.13	49
SWEDEN	28	132,662	614	774	509	0.45	16
SWITZ	63	268,653	1,316	1,537	1,378	-0.31	50
UK	38	1,165,907	2,525	3,183	2,674	0.84	25

B: Different Subsamples

Country	Mean without utilities	Mean in manufacturing alone	Mean in mechanical engineering	Mean in food and drink
AUSTRIA	318	366	369	194
BELGIUM	631	566	615	363
DENMARK	528	688	823	904
FINLAND	519	555	660	719
FRANCE	706	798	NA	376
GERMANY	900	1007	751	293
GREECE	254	233	73	241
ITALY	545	691	292	290
NETHER	443	556	105	422
NORWAY	347	243	730	403
PORTUGAL	299	341	155	216
SPAIN	558	750	118	292
SWEDEN	576	681	479	635
SWITZ	321	242	581	373
UK	1041	1087	1187	1486

C: Dispersion in Firm Size (average across industries

Country	Simple coefficient of variation	Employee weighted coefficient of variation	Employee weighted skewness
AUSTRIA	1.68	0.94	-0.20
BELGIUM	3.51	0.97	-0.36
DENMARK	4.75	1.27	-0.89
FINLAND	5.59	1.10	-0.51
FRANCE	5.20	1.28	-0.27
GERMANY	4.50	1.31	-0.61
GREECE	1.72	1.01	-0.07
ITALY	4.35	1.70	-0.05
NETHER	3.89	1.28	-0.45
NORWAY	3.00	1.15	-0.23
PORTUGAL	4.18	1.32	-0.33
SPAIN	4.69	1.62	-0.25
SWEDEN	5.49	1.11	-0.38
SWITZ	3.73	1.19	-0.22
UK	7.13	0.97	-0.54

Table 3:

Summary Statistics

A detailed description of all the variables as well as their sources is contained in the data appendix.

A: Summary statistics

Country variables	Mean	Median	Std. Deviation	Minimum	Maximum	N
Per capita income	12,642	13,281	2,698	6,783	16,245	15
Human capital	7.949	8.572	1.905	3.827	10.382	15
Inequality in human capital	0.295	0.265	0.135	0.127	0.625	15
Judicial efficiency	8.767	9.500	1.616	5.500	10.000	15
Accounting standards	64.600	64.000	11.488	36.000	83.000	15
Sectoral variables						
Investment per worker	0.009	0.006	0.007	0.002	0.025	36
R&D intensity	0.015	0.005	0.023	0.000	0.078	53
Sector wage	0.028	0.028	0.010	0.013	0.062	36
External dependence	0.004	0.002	0.004	-0.001	0.015	34
Variables that change by country and sector						
Log of size of firms	5.582	5.643	1.454	0.693	9.697	410
Size of the market	10.584	10.900	2.246	1.099	14.940	410
Judicial efficiency x investment per worker	0.068	0.049	0.053	0.009	0.254	343
External dependence x financial development	0.220	0.138	0.223	-0.077	1.123	329

B: Correlation across country variables

Country variables	log size of firms	Log per capita income	Human Capital	Inequality in human capital	Judicial Efficiency
Log per capita income	0.423				
Human capital	0.382	0.715			
Inequality in human capital	-0.145	-0.572	-0.682		
Judicial efficiency	0.467	0.762	0.901	-0.673	
Accounting standards	0.553	0.585	0.696	-0.535	0.651

C: Correlation across sectoral variables

Sectoral variables	log size of firms	Capital intensity	R&D intensity	Sector wage
Investment per worker	0.135			
R&D intensity	0.177	-0.130		
Sector wage	0.270	0.632	0.330	
External dependence	-0.095	0.522	0.236	0.526

D: Correlation across variables that change both by country and sector

Variables that change by country and sector	log size of firms	Market size	Jud. eff x cap. int.
Size of the market	0.349		
Judicial efficiency x investment per worker	0.156	-0.379	
External dependence x financial development	-0.055	-0.344	0.495

Table 4:

Cross-Industry Determinants of Firm Size

The dependent variable is the logarithm of the weighted number of employees per firm in each NACE two-digit industry in each country. The size of the market is measured as the logarithm of total employment in a NACE two-digit industry in a country. Investment per worker is from *OECD's ISIS Database*. The average across European countries and the US is used. Wage per worker is from the same database, and the average across European countries and the US is used. R&D to sales is the median ratio of R&D over sales between 1980 and 1989 computed for U.S. public companies in the same NACE two-digit sector. The source is *Compustat-Business Segment file*. Amount financed externally is the product of capital expenditures that U.S. companies in the same NACE two-digit sector finance externally (see Rajan and Zingales, 1998) and investment per worker calculated above. Estimates in column I and III have been obtained by instrumental variable estimation, where the instruments for the size of the market are the logarithm of population and GDP. Column II reports OLS estimates with fixed country effects. In column III, we compute the per worker explanatory variables using only the industries for which European data exist. Heteroskedasticity-robust standard errors are reported in parenthesis. The standard errors are also adjusted for the possible dependence of observations in the same industry across different countries.

	I	II	III
Size of the market	0.19	0.35	0.24
	(0.05)	(0.08)	(0.06)
Investment per worker	40.40	46.37	28.88
	(22.62)	(24.69)	(35.34)
R&D intensity	12.37	12.42	9.59
	(5.84)	(5.85)	(7.10)
Sector wage	58.03	65.20	67.92
	(19.10)	(20.38)	(39.58)
External dependence	-140.04	-110.29	-122.84
	(50.13)	(55.02)	(67.48)
R-squared	0.32	0.43	0.36
N	334	334	230

Table 5:

Cross-Country Determinants of Firm Size

The dependent variable is the logarithm of the weighted number of employees per firm in each NACE two-digit industry in each country. The size of the market is measured as the logarithm of total employment in a NACE two-digit industry. Per capita income is the log of per capita income in 1990. The data are from the *Penn World Table, Mark 5.6.* Human capital is measured as the average number of school years (Barro-Lee, 1993). Judicial efficiency is an assessment of the "efficiency and integrity of the legal environment as it affects business". It is an average of the index between 1980 and 1983. Accounting standards are a measure of the transparency of annual report produced by the Center for International Financial Analysis and Research. The table reports the instrumental variable estimates, where the instrument for the size of the market is the logarithm of population. Heterosckedasticity-robust standard errors are reported in parenthesis. The standard errors are also adjusted for the possible dependence of the errors of observations in the same countries across different industries. Industry fixed effects are included in all columns.

	I	II	III
Size of the market	0.19	0.36	0.39
	(0.09)	(0.08)	(0.05)
Per capita income	0.67	-0.59	-1.00
	(0.32)	(0.52)	(0.39)
Human capital		0.22	0.00
		(0.07)	(0.09)
Judicial efficiency			0.30
			(0.09)
R-squared	0.68	0.74	0.75
N	461	461	461

Table 6:

Interaction Effects

The dependent variable is the logarithm of the weighted number of employees per firm in each NACE two-digit industry in each country. The size of the market is measured as the logarithm of total employment in that NACE two-digit industry in a country. Per capita income is the log of per capita income in 1990 as reported by the *Penn World Table, Mark 5.6*. Judicial efficiency is an assessment of the "efficiency and integrity of the legal environment as it affects business." Accounting standards are a measure of the informativeness of annual reports in a country as measured by the Center for International Financial Analysis and Research. Investment per worker is from *OECD's ISIS Database*. The average across European countries and the US is used. Wage per worker is from the same database, and the average across European countries and the US is used. R&D to sales is the median ratio of R&D over sales computed for U.S. public companies in the same NACE two-digit sector over the period 1980-89. The source is *Compustat-Business Segment file*. Amount financed externally is the product of capital expenditures that U.S. companies in the same NACE two-digit sector finance externally (see Rajan and Zingales, 1998) and investment per worker calculated above. As in Rajan and Zingales (1998a) financial development is proxied for by the accounting standards. Columns I-III of Panel A and Panel B are estimated by OLS and contain industry fixed effects and country fixed effects. Column IV of Panel A is estimated using IV and does not include country fixed effects. In panel B, low investment per worker is a dummy equal to one for sectors in the lowest tertile of investment per worker. High investment per worker is a dummy equal to one for sectors in the highest tertile of investment per worker. Heteroskedasticity-robust standard errors are reported in parenthesis.

Panel A

	I	II	III	IV
Size of the market	0.65	0.58	0.59	0.26
	(0.06)	(0.07)	(0.07)	(0.06)
Judicial efficiency X	-12.68		-20.17	-19.03
investment per worker	(5.99)		(5.58)	(6.08)
External dependence X		3.56	5.95	7.20
financial development		(1.64)	(1.59)	(2.08)
Judicial efficiency				0.30
				(0.08)
Accounting standards				-0.02
				(0.01)
R-squared	0.72	0.72	0.74	0.67
N	348	334	334	334

Panel B

	I	II
Size of the market	0.60	0.60
	(0.07)	(0.07)
Judicial efficiency x	-0.09	-0.17
high investment per worker	(0.07)	(0.11)
Judicial efficiency x	0.23	0.18
low investment per worker	(0.07)	(0.10)
GDP per capita x		0.71
high investment per worker		(0.75)
GDP per capita x		0.48
low investment per worker		(0.60)
External dependence x	4.78	4.74
financial development	(1.53)	(1.53)
R-squared	0.74	0.74
N	334	334

Table 7:

The Determinants of Dispersion in Firm Size

The dependent variable is the weighted coefficient of variation of the number of employees per firm in each NACE two-digit industry in each country. Inequality in human capital is measured as the product of the percentage of the population with the highest educational achievement and percentage of the population with the lowest educational achievement. The numbers are from Barro-Lee, 1993. Judicial efficiency is an assessment of the "efficiency and integrity of the legal environment as it affects business." Per capita income is the log of per capita income in 1990 as reported by the *Penn World Table, Mark 5.6.* All estimates are obtained by OLS and contain industry fixed effects. Heteroskedasticity-robust standard errors are reported in parentheses. The standard errors are also adjusted for the possible dependence of the errors of observations in the same countries across different industries.

	I	II	III
Inequality in human capital	1.22	0.25	0.09
	(0.51)	(0.56)	(0.45)
Judicial efficiency		-0.12	-0.19
		(0.03)	(0.05)
GDP per capita			0.60
			(0.24)
R-squared	0.68	0.71	0.72
N	463	463	463

A Formulas for Statistical Measures

Let e_i denote the employment in bin i, and $n_i$denote the number of firms in bin i for any given country-sector combination. Omit country-sector subscripts for convenience. Let E denote the total employment for the country-sector and N the total number of firms. The simple average is given by:

$$av = \sum_i \left(\frac{n_i}{N}\right)\left(\frac{e_i}{n_i}\right) = \frac{E}{N}.$$

The employee-weighted average is given by:

$$ewav = \sum_i \left(\frac{e_i}{E}\right)\left(\frac{e_i}{n_i}\right).$$

The simple variance is given by:

$$\begin{aligned} var &= \sum_i \left(\frac{n_i}{N}\right)\left[\left(\frac{e_i}{n_i}\right) - av\right]^2 \\ sd &= \sqrt{var}. \end{aligned}$$

The analagous quantity for the employee-weighted variance is:

$$\begin{aligned} ewvar &= \sum_i \left(\frac{e_i}{E}\right)\left[\left(\frac{e_i}{n_i}\right) - ewav\right]^2 \\ ewsd &= \sqrt{ewvar}. \end{aligned}$$

The simple coefficient of variation is given by:

$$cv = \frac{sd}{av}.$$

The analagous one for the employee-weighted measure is:

$$ewcv = \frac{ewsd}{ewav}.$$

The "employee-weighted mode" is defined by:

$$ewmode = \arg\max\left(\left(\frac{e_i}{E}\right)\left(\frac{e_i}{n_i}\right)\right).$$

The average size of the modal bin is reported.

The employee-weighted median will be the first i for which $\frac{1}{ewav}\sum_i \left(\frac{e_i}{E}\right)\left(\frac{e_i}{n_i}\right)$ becomes ≥ 0.5.

Pearson's measure for employee-weighted skewness is $\frac{(ewmean - ewmode)}{ewsd}$.

B Data Appendix

In this appendix, we discuss the data sources and the construction of our regression variables. In the interest of brevity, we present only the main points on the construction of a unified database from disparate sources. More comprehensive notes are available from the authors.

Employee-weighted average firm size:

- **Data source(s):** *Enterprises in Europe* (1994), which provides us with the distribution of size of firms in each NACE two-digit industry (sector) of selected European countries. Data is available for either 1991 or 1992 for all countries.
- **Construction of variable:** The average firm size (number of employees) in each size class is first calculated by dividing the number of employees by the number of firms. The average size for the entire sector is then calculated as the weighted sum of these bin averages, using as weights the employees in the size class as a fraction of total sectoral employment.
- **Scope of Variable:** Country-sector
- **Notes:**
  - The size classification varies considerably across countries, as does coverage. All sectors for which the bin employment does not add up to total employment are eliminated.
  - When data for multiple, related sectors are combined in the source, we attribute the combined figures to the smallest sector number. For instance combined data for Chemical industry (NACE 25) and Man-made fibres industry (NACE 26) are presented as the former.
  - Total employment numbers are used. If data for total employment is either not available or sparsely available, we use salaried employment.

Size of the market:

- **Data source(s):** *Enterprises in Europe* (1994).
- **Construction of variable:** The logarithm of the total employment in a NACE two-digit industry is used.
- **Scope of Variable:** Country-sector

Investment per worker:

- **Data source(s):** *OECD: Industrial Structure Statistics (ISIS)* (1997), which provides us with data on production, value added and investment in each ISIC sector of selected OECD countries. Data is available from 1970 to 1995, though coverage is not uniform. Employment data used to calculate per worker quantities is also from the same database.
- **Construction of variable:** The total sectoral investment (gross capital formation) from *ISIS* is divided by total employment from *Enterprises in Europe* to get the investment per worker, and adjusted by the exchange rate to get the figure in US dollars. The average value across all countries is computed for each sector, to get a sector-level variable.
- **Scope of Variable:** European & U.S. Sector
- **Notes:**
  - The use of investment per worker for capital per worker is based on the assumption that the economies studied were at their steady states. Direct data on capital per worker, at the sectoral level, is difficult to obtain for the countries being studied.
  - The investment data is for the year closest to the one for employment data.
  - Data for ISIC – Revision 2 classification is used wherever available; else, the data is for ISIC – Revision 3. These ISIC codes were translated to NACE codes; the translation used is available upon request. The ISIC data is available at the 3-digit level, and sometimes even at the 4-digit level; this facilitates a fairly complete translation of codes.
  - The market exchange rate (average over the year) provided by ISIS is used to convert investment in local currency to US dollars.

Value added per worker:

- **Data source(s):** *OECD: Industrial Structure Statistics (ISIS)* (1997).

- **Construction of variable:** The total value added from ISIS is divided by total employment from Enterprises in Europe to get the value added per worker, and adjusted by the exchange rate to get the figure in US dollars. The average value across all countries is computed for each sector, to get a sector-level variable.
- **Scope of Variable:** European & U.S. Sector
- **Notes:**
  - While the exact details on how value added is computed for each country varies, the general definition is the difference between gross output and industrial input. Industrial input consists of industrial materials, industrial services and fuel and power used in the production of output.
  - The items on year of data, classification conversion, and the use of market exchange rates mentioned under "capital intensity" apply here as well.

Wages per worker:

- **Data source(s):** *OECD: Industrial Structure Statistics (ISIS)* (1997).
- **Construction of variable:** The total wages from ISIS is divided by total employment from Enterprises in Europe to get the wages per worker, and adjusted by the exchange rate to get the figure in US dollars. The average value across all countries is computed for each sector, to get a sector-level variable.
- **Scope of Variable:** European & U.S. Sector
- **Notes:**
  - The items on year of data, classification conversion, and the use of market exchange rates mentioned under "capital intensity" apply here as well.

R & D intensity:

- **Data source(s):** *COMPUSTAT – Business Segment File.*
- **Construction of variable:** The median ratio of R & D over sales is computed for the analogue of the NACE 2-digit sectors among publicly traded U.S. companies.
- **Scope of Variable:** US Sector
- **Notes:**
  - We use only single-segment firms and we map three-digit SIC codes into NACE sectors. These data, as well as the program to compute them, are available from the authors.

External dependence:

- **Data source(s):** *COMPUSTAT – Business Segment File*, *OECD: Industrial Structure Statistics (ISIS)* (1997).
- **Construction of variable:** The fraction of capital expenditures that is financed externally for the analogue of the NACE 2-digit sectors among publicly traded U.S. companies is multiplied by the investment per worker in that sector for the European country. In other words, this is an estimate of external financing per worker in the given country-sector combination.
- **Scope of Variable:** Country-sector
- **Notes:**
  - See Rajan and Zingales (1998a) for further details.

Utility & Transport sector:

- **Data source(s):** *Enterprises in Europe* (1994).
- **Construction of variable:** This is a dummy variable that is set to 1 if the NACE sector is one of Production and Distribution of Electricity (16), Railways (71), Air Transport (75), or Communication (79).
- **Scope of Variable:** Sector dummy

Per capita income:

- **Data source(s):** *Penn World Table* (Mark 5.6), which provides us with country level data on real GDP, goverment expenditure, and human capital.
- **Construction of variable:** The logarithm of per capita GDP ("RGDPCH" in PWT) is used for the relevant year.
- **Scope of Variable:** Country

Human capital:

- **Data source(s):** *Barro and Lee's dataset for a panel of 138 countries* (1994).
- **Construction of variable:** The average schooling years in the total population over age 25, for the year 1985, is used ("human85" in Barro and Lee).
- **Scope of Variable:** Country
- **Notes:**
  - This is an attainment variable that changes very slowly over time. Therefore, the use of 1985 data is not seen as a serious limitation.

Human capital inequality:

- **Data source(s):** *Barro and Lee's dataset for a panel of 138 countries* (1994).
- **Construction of variable:**
  Barro and Lee (1993) have data on the
- **Scope of Variable:** Country

Judicial efficiency:

- **Data source(s):** *Business International Corporation.*
- **Construction of variable:** This variable is an assessment of the "efficiency and integrity of the legal environment as it affects business." Data is found in a scale form, with scores ranging from zero to ten, where the lower scores mean lower efficiency levels.
- **Scope of Variable:** Country
- **Notes:**
  - It is an average of the index between 1980 and 1983.

Tax rate:

- **Data source(s):** *Corporate Taxes: A Worldwide Summary.*
- **Construction of variable:** This is the corporate tax rate in each country in the year 1991.
- **Scope of Variable:** Country

Patent protection:

- **Data source(s):** *Ginarte and Park* (1997).

- **Construction of variable:** This is an index that combines several dimensions of patent protection.
- **Scope of Variable:** Country
- **Notes:**
  - See Ginarte and Park (1997).

Financial development:

- **Data source(s):** *Center for International Financial Analysis and Research.*
- **Construction of variable:** Financial development is proxied by a measure of accounting standards. This variable measures the transparency of annual reports.
- **Scope of Variable: Country**
- **Notes:**
  - **See Rajan and Zingales (1998a) for further details.**

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