

# DOES IDIOSYNCRATIC BUSINESS RISK MATTER FOR GROWTH?

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## **Abstract**

Several imperfections can prevent entrepreneurs from diversifying away the idiosyncratic risk of their business. As a result idiosyncratic risk discourages entrepreneurial activity and hinders growth, with the effects being stronger in economies with lower risk diversification opportunities. In accordance with this prediction, we find that OECD countries with low levels of risk diversification opportunities (as measured by the relevance of family firms or of widely held companies) perform relatively worse (in terms of productivity, investment, and business creation) in sectors characterized by high idiosyncratic risk. Differently from previous literature, we allow risk to be country specific. Since risk is endogenous to risk diversification opportunities, we instrument its value using sectoral risk in the United States, a country where idiosyncratic business risk can be more easily diversified away. Tackling the endogeneity of risk and recognizing that it varies by country magnifies the estimated effects of risk on growth. (JEL: F3, G1, O4)

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## **1. Introduction**

In standard Arrow–Debreu economies with complete markets, idiosyncratic risk can be fully diversified away and is irrelevant for equilibrium outcomes. But as emphasized by Townsend (1978) and Holmstrom (1979), among others, full risk diversification is costly and a great deal of theoretical research has analyzed how various financial frictions can prevent it, hampering aggregate productivity, output, and capital accumulation (Greenwood and Jovanovic 1990; Bencivenga and Smith 1991; Acemoglu and Zilibotti 1997; Meh and Quadrini 2006). More recently Angeletos (2007) and Castro, Clementi, and MacDonald (2004) have instead shown that the

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presence of undiversified risk can stimulate savings—because of either precautionary motives, or through an increase in entrepreneurial earnings—and can foster growth.

Despite much theoretical interest, there has been little empirical analysis of the effects of idiosyncratic risk on aggregate growth. A key issue in identifying the effects of idiosyncratic risk is that *observed risk*, typically measured by the volatility of some performance indicator, could be a very imperfect measure of the true *underlying risk* which determines agents' decisions. For example, principal agent models as in Holmstrom and Milgrom (1987) show that a trade-off generally exists between the benefits of risk-sharing and the provision of incentives. As a result the variability of agents' income (observed risk) only partially reflects the variability of exogenous shocks to output (underlying risk); see Guiso, Pistaferri, and Schivardi (2005) for empirical evidence. In Thesmar and Thoenig (2011), an increase in firms' stock market participation endogenously decreases the observed risk of private firms and increases that of publicly traded firms. Thesmar and Thoenig (2000), Aghion et al. (2010), and Bonfiglioli (2010) have also stressed that observed risk is endogenous to the market structure and to the risk diversification opportunities available in the economy.<sup>1</sup>

In this paper we provide evidence on the effects of idiosyncratic business risk on growth, accounting for the fact that observed risk is a distorted measure of underlying risk. To analyze this issue we consider a simple extension of the moral hazard model by Holmstrom and Tirole (1997) where risk-averse entrepreneurs can choose projects with different risk–return tradeoffs. To solve the ensuing agency problem (which is a source of financial frictions), entrepreneurs have to partially finance business ventures with their own wealth and so idiosyncratic business risk cannot be fully diversified away.<sup>2</sup> Because of this, entrepreneurs may choose projects that are strictly dominated from the point of view of a well-diversified portfolio because they have a lower idiosyncratic risk. This hinders innovation, entrepreneurial activity and growth. The model delivers two key predictions that are common to a vast class of models: first, the effects of idiosyncratic business risk on growth strictly depend on the risk diversification opportunities available to the entrepreneurs—with zero effects for big enough diversification opportunities and negative and increasing effects as diversifying risk becomes more difficult; second, the observed volatility of projects' returns is endogenous with respect to diversification opportunities, as entrepreneurs can endogenously reduce risk by choosing safer, more conservative projects.

To test the effects of idiosyncratic business risk on growth we use cross country-sector data for the group of OECD countries. Building on the methodology first introduced by Rajan and Zingales (1998), we consider a regression of sectoral growth on an interaction of the degree of country-level diversification opportunities of business

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1. Coles, Daniel, and Naveen (2006), Fischer (2008), Bartram, Brown, and Stulz (2009), and Panousi and Papanikolaou (2012) provide direct evidence that observed idiosyncratic risk is endogenous and is influenced by firms' decisions.

2. Bitler, Moskowitz, and Vissing-Jørgensen (2005) empirically document the contribution of entrepreneur's own wealth in solving agency problems. Hall and Woodward (2010) show that the idiosyncratic risk faced by entrepreneurs when starting new businesses is substantial.

owners and of sector-level idiosyncratic risk—after controlling for a full set of country and sector dummies and other time-varying attributes. Theory predicts that countries with high diversification opportunities perform relatively better in sectors characterized by high idiosyncratic risk—that is, the interaction term should be positive. As standard in the macro finance literature (see for example Campbell et al. (2001)), we measure the idiosyncratic risk of firms' activities using the volatility of individual firms' stock market returns. As stressed previously, a key problem in estimating the effects of risk on growth is that observed risk is endogenous to the diversification opportunities available in the economy. To tackle this issue, we instrument a country's sector-level idiosyncratic volatility with the analogous measure calculated in the United States. The identifying assumption is that sectoral risk in the United States is related to the risk that would have emerged in the other OECD countries if risk diversification opportunities were similar to those in the United States. We allow the relationship to vary by country, since differences in fundamentals (for example in geographic and climatic conditions as well as in exogenous trade and technological patterns) can make idiosyncratic risk country specific. Castro, Clementi, and Lee (2010) document that fundamentals affect risk.

In our model, differences in risk diversification are due to financial frictions but in practice several other factors, including cultural aspects or historical events, can limit entrepreneurs' ability to diversify away the risk of their businesses. To characterize the degree of diversification of business risk in the country and to identify its causal effects, we use direct indicators of the structure of business ownership as measured by the importance of family controlled firms or of widely held firms in the economy, as reported by La-Porta, Lopez-De-Silanes, and Shleifer (1999) and Faccio and Lang (2002). In a country where firms are more family owned or less widely held, equity owners are less diversified and the economy is more sensitive to idiosyncratic business risk, which squares well with the evidence in Moskowitz and Vissing-Jørgensen (2002).

Our findings indicate that countries with low levels of diversification opportunities perform relatively worse in sectors characterized by high idiosyncratic risk. The implied effects are apparent only after explicitly accounting for the fact that observed and underlying risk differ. We also find that accounting for cross-country differences in idiosyncratic risk leads to larger estimated effects. Results are robust to the potential endogeneity of risk diversification measures and hold true with alternative measures of growth performance (in terms of labor productivity, capital, value added, and business creation) as well as of diversification. For example using, as in Dyck and Zingales (2004), more direct measures of private benefits of controls or other legal determinants of financial frictions, that can hinder risk diversification.

Our empirical approach extends the methodology of Rajan and Zingales (1998), which has been extensively used in the growth literature (see for example Pagano and Schivardi 2003, Klapper and Rajan 2006, Ciccone and Papaioannou 2009, Pagano and Pica 2012). Typically the methodology hinges on assuming that the relevant sectoral characteristics (underlying risk in our case) are common across countries and that they can be directly computed from US data. Ciccone and Papaioannou (2007) extend the methodology to remove measurement error. Here we allow sectoral characteristics to

vary across countries and show how to test for country specific differences. We find that taking them into account magnifies the effects of risk on growth.

Much literature has analyzed the relationship between idiosyncratic business risk and firm level performance. Among others, Bulan (2005); Cummins, Hassett, and Oliner (2006), and Caggese (2010) analyze the effects of risk on firms' investment and innovation activities, but without addressing the issue of the endogeneity of risk and firms' ownership structure. As in this paper, Panousi and Papanikolaou (2012) find that the effects of risk on firms' investment are magnified after addressing the issue. Castro, Clementi, and MacDonald (2009) use the Rajan and Zingales' methodology with country-sector data to analyze the effect of idiosyncratic risk on sectoral employment size. Cūnat and Melitz (2011) and Manova (2007) use a similar approach but focus on the effects of risk on trade rather than on sectoral size. These three papers address the issue of the endogeneity of risk by assuming that underlying idiosyncratic risk is identical across countries and equal to the observed risk in the United States. We show instead that there are country specific differences in idiosyncratic risk and we find that the effects of risk on growth are magnified by taking them into account.

The paper is also related to Koren and Tenreyro (2007, 2008) and Jermann, and Quadrini (2007) who analyze how financial and technological progress affects both aggregate and idiosyncratic risk. In particular, Koren and Tenreyro (2008) argue that, due to nonconvexities in the innovation process, more-advanced economies can diversify business risk across a greater variety of products, which can explain why aggregate and idiosyncratic volatility both decrease with economic development. We have a different focus. First, our empirical analysis is based on OECD countries, mostly comprised of developed economies, for which differences in technology and in product variety might be limited. Second, we are interested in the causal effects of idiosyncratic risk on growth, which we identify using exogenous variation in risk across countries and sectors.

The remainder of the paper is structured as follows. Section 2 presents the theoretical framework. Section 3 introduces the empirical methodology. Section 4 describes the data. Section 5 presents results and discusses robustness. Section 6 concludes.

## 2. The Model

We use a simple model to discuss how limited opportunities to diversify away idiosyncratic business risk affect productivity growth. The model emphasizes the distinction between the observed variability of firm returns—in brief *observed risk*—and the variability that would be observed under perfect risk diversification opportunities—what we call *underlying risk*. As in Holmstrom and Tirole (1997) agency problems induce financial frictions, which limit entrepreneurs' ability to diversify away the idiosyncratic risk of their business. Productivity growth is endogenous due to technological spill-overs as in the Schumpeterian paradigm reviewed in Aghion and Howitt (1998). The model yields two results, common to

a vast class of models, which are important to identify the effects of idiosyncratic risk on growth. The first is that observed idiosyncratic risk is endogenous to the risk diversification opportunities of entrepreneurs. The second is that the effect of underlying idiosyncratic risk on productivity growth varies depending on risk diversification opportunities. The Online Appendix contains the full details of the model. Here we present the model's main features and results more intuitively.

We consider a representative sector in an economy with  $n$  independent sectors that differ only in the level of underlying idiosyncratic business risk. The sector at time  $t$  is characterized by a given technological level  $A_t$  which determines the size of entrepreneurial projects. There is a measure one of entrepreneurs who live one period and after death are replaced by a new independent identical cohort. Entrepreneurs differ in terms of risk propensity  $\tau$ , which is a draw from the CDF  $F$ . Greater  $\tau$  implies less curvature in the entrepreneur's utility function. Entrepreneurs can invest a fixed amount of capital  $A_t$  in either a risky or a safe project, with expected returns per unit of capital invested equal to  $\mu_r$  and  $\mu_s < \mu_r$ , respectively. The safe project yields the return  $\mu_s$  with certainty. The risky project yields a return  $\lambda$  with probability  $q$  and zero otherwise, so that its expected return is equal to  $\mu_r = q\lambda$  and the *variance* of the project's return is given by

$$\sigma = \mu_r \lambda - \mu_r^2.$$

The parameter  $\sigma$  measures the *underlying idiosyncratic risk* in the sector: given  $\mu_r$ , changes in  $\sigma$  have no consequences on the return of a well-diversified portfolio, but they can influence the choices of an undiversified entrepreneur. Increasing  $\sigma$  while keeping  $\mu_r$  fixed means that the probability of a successful innovation is lower but its value in case of success is higher. This implies a greater idiosyncratic risk in innovation activities.

Entrepreneurial activity determines innovation and productivity growth as in Grossman and Helpman (1991) and Aghion and Howitt (1998). We assume that the growth rate of the technology level  $A_t$  is proportional to the number of successful risky projects with a factor of proportionality  $\eta$  per unit size of the innovation, as measured by  $\lambda$ .<sup>3</sup> Given that the constant over time population level is normalized to one, output and productivity are equal, and in equilibrium they both grow at the same rate as technology.<sup>4</sup> The resulting productivity growth rate is then equal to

$$\gamma \equiv \frac{\Delta A}{A} = \eta q \lambda (1 - \rho) = \eta \mu_r (1 - \rho), \quad (1)$$

where  $(1 - \rho)$  denotes the measure of entrepreneurs investing in the risky project.

3. Here we are assuming that only successful risky projects induce a positive technological intertemporal externality but in practice we only need to assume that risky projects generate stronger spillovers than safer, more conservative projects.

4. The model is such that the economy is always in a steady state; see Acemoglu and Zilibotti (1997, 1999) and Koren and Tenreyro (2008) for models where the degree of financial market imperfections and market incompleteness depends on the development level of the economy.

The entrepreneur has just enough wealth to finance the project out of her own pocket. Still, she would like to sell the entire equity of the project and reinvests proceeds in a perfectly diversified portfolio, which bears no risk. But, as in Holmstrom and Tirole (1997), to solve moral hazard problems the entrepreneur has to retain a fraction  $\beta$  of the project equity, where  $\beta$  measures the severity of the moral hazard problem. So a fraction  $\beta$  of the project's idiosyncratic risk is born by the entrepreneur. When the moral hazard problem is more severe, the entrepreneur's ability to diversify away the idiosyncratic risk of her business is diminished. In equilibrium the entrepreneur will invest in the risky project if and only if her propensity to take risk is higher than a critical endogenously determined threshold  $\tau^*$ . The resulting measure of entrepreneurs investing in the risky project is then given by  $\rho = 1 - F(\tau^*)$ , which is decreasing in  $\beta$  since  $\tau^*$  is increasing in  $\beta$ . This is because with worse risk diversification opportunities (higher  $\beta$ ), investing in the high-risk-high-return project yields lower expected utility due to the greater risk.

Because safe projects are riskless, the average variance of projects returns is equal to the product of the underlying idiosyncratic risk of a risky project  $\sigma$  times the share of entrepreneurs that invest in them,  $(1 - \rho)$ . This means that

$$\omega = (1 - \rho)\sigma \quad (2)$$

measures the *observed* average idiosyncratic risk in the sector. In the Online Appendix we prove that, when financial frictions are low enough ( $\beta$  is close to zero), all entrepreneurs invest in the risky project ( $\rho = 0$ ) and observed and underlying risk are equal ( $\omega = \sigma$ ). But, when  $\beta$  is sufficiently high, observed risk is imperfectly related to underlying risk and the derivative  $\partial\omega/\partial\sigma$  is strictly less than one. In other words we have the following proposition.

**PROPOSITION 1.** *In economies with high risk diversification opportunities (low  $\beta$ ) the observed level of idiosyncratic risk  $\omega$  accurately measures the underlying idiosyncratic risk  $\sigma$ . When risk diversification opportunities are low, observed risk is endogenous and moves less than one-for-one with underlying risk. The attenuation effect is larger the lower the risk diversification opportunities.*

In the Online Appendix we also prove that an increase in underlying idiosyncratic risk has a negative impact on productivity growth,  $(\partial\gamma)/(\partial\sigma) \leq 0$ . This is because greater  $\sigma$  leads to a reduction in the share of entrepreneurs who invest in the high-risk-high-return project. Further, we prove that the effect is stronger the worse the risk diversification opportunities,  $(\partial^2\gamma)/(\partial\beta\partial\sigma) < 0$ . This is intuitive since idiosyncratic risk reduces productivity growth only if risk diversification opportunities are low enough. In brief we have the following proposition.

**PROPOSITION 2.** *An increase in underlying idiosyncratic risk  $\sigma$  reduces productivity growth  $\gamma$ . The effect is stronger the worse the risk diversification opportunities (larger  $\beta$ ).*

Consider now the  $n$  independent sectors, each characterized by a different level of idiosyncratic business risk, denoted by  $\sigma_j$ ,  $j = 1, \dots, n$ . Sectoral differences in

business risk might be due to differences in technology, in the degree of competition, or in the riskiness of innovation activities. Entrepreneurs have project opportunities in one sector. Sectoral productivity growth depends on the number of successful risky projects within the sector, exactly as in (1). The key assumption is that an innovation induces stronger technological spillovers within the sector than across sectors. Now consider two countries that differ in risk diversification opportunities  $\beta$ . Proposition 2 predicts that the country with worse diversification opportunities will grow relatively less in sectors with greater idiosyncratic risk. We can therefore relate the growth performance of a sector within a country to the corresponding level of idiosyncratic risk in the sector and then check how the relationship differs for countries with different risk diversification opportunities. In terms of the model this amounts to checking how  $\partial\gamma/\partial\sigma$  differs for countries with different  $\beta$ , which measures the sign and magnitude of the second order partial derivative  $(\partial^2\gamma)/(\partial\beta\partial\sigma)$ . Based on this logic, we test whether sectors with higher idiosyncratic risk perform relatively worse in countries with less risk diversification opportunities. The empirical challenge is that observed risk  $\omega$  is endogenous (see Proposition 1). As discussed in more detail in the Online Appendix, failing to recognize this leads to an important endogeneity bias.

### 3. Empirical Methodology

The empirical test is based on the following regression model:

$$\gamma_{ji} = a_0 + a_1\beta_i \cdot \sigma_{ji} + a'_2X_{ji} + u_{ji}, \quad (3)$$

where  $\gamma_{ji}$  is productivity growth of sector  $j$  in country  $i$ ,  $\beta_i$  is a measure of the lack of diversification opportunities in country  $i$  (a proxy for  $\beta$  in the model),  $\sigma_{ji}$  is the level of underlying idiosyncratic risk in sector  $j$  in country  $i$ —namely, the level of idiosyncratic risk that would be observed if risk diversification opportunities were sufficiently high (say for  $\beta$  sufficiently close to zero). Finally,  $X_{ji}$  are additional controls, including the log of the initial productivity level as well as sector and country dummies. Notice that the country dummy also captures possible technological spillovers across sectors. As in Rajan and Zingales (1998), the regression (3) identifies the effects of risk  $\sigma_{ji}$  on growth  $\gamma_{ji}$  by using within-country sectoral variability: for each country, we analyze how the relative performance of a sector varies depending on the corresponding relative level of idiosyncratic risk and we then analyze how the relationship differs for countries with different risk diversification opportunities. A negative  $a_1$  indicates that sectors with higher idiosyncratic risk perform relatively worse in countries where the ownership structure is less diversified.

The problem in estimating  $a_1$  is that we do not observe underlying risk  $\sigma_{ji}$  but only observed risk  $\omega_{ji}$ . To solve this problem we model the relationship between  $\omega$  and  $\sigma$  by assuming that

$$\omega_{ji} = c_{0i} + (1 - c\beta_i)\sigma_{ji} + \varepsilon_{ji}, \quad (4)$$

where  $c > 0$ . Here  $\omega_{ji}$  is a measure of the observed idiosyncratic risk in sector  $j$  and country  $i$  and  $c_{0i}$  is a (possibly) country-specific term.<sup>5</sup> The positive  $c$  coefficient implies that an increase in underlying risk translates into a less than one-for-one increase in observed risk. The attenuation effect is stronger the lower the risk diversification opportunities (i.e., the higher is  $\beta$ ). When risk diversification opportunities are high enough, observed and underlying risk are instead related one-for-one. This is a key implication of Proposition 1. Finally,  $\varepsilon_{ji}$  captures measurement error, which we assume to be independent from both  $\beta_i$  and  $\sigma_{ji}$ .

To estimate the model we need an instrumental variable condition. We assume that risk diversification opportunities in the United States are large enough to guarantee that observed idiosyncratic risk is a relatively accurate measure of underlying risk. Moreover, we assume that underlying risk in a given sector in the United States is related to the underlying risk in the corresponding sector in another country:

$$\sigma_{ji} = b_{0i} + \sum_{k=1}^K b_{ki}(\sigma_{jU})^k + v_{ji}, \quad (5)$$

where  $\sigma_{ji}$  is underlying risk in sector  $j$  in country  $i$ ,  $b_{0i}$  is a constant term (that in principle is country specific),  $\sigma_{jU}$  denotes the level of underlying idiosyncratic risk in sector  $j$  in the United States. This specifications allows for a non-linear relationship between underlying risk in country  $i$  and in the United States ( $K > 1$ ). The error term  $v_{ji}$  is assumed to be orthogonal to  $\beta_i$  and  $\sigma_{jU}$  at any power  $k$ . This specification encompasses several possibilities. One is that risk in the United States is a perfect measure of the underlying risk in any country:  $b_{1i} = 1$ ,  $b_{ki} = 0$  for  $k > 1$ . This is the assumption made by Rajan and Zingales (1998) to identify the effects of financial market imperfections on growth. In this case, one can directly include the US measure of underlying risk in regression (3) and estimate the effects of risk on the economic performance. Of course, this may be a strong assumption, that we would like to test empirically. Here we allow for the possibility that underlying risk differs across countries and it is variably related to the risk in the United States. In fact, countries differ in fundamentals: geographic and climatic conditions and exogenous technological patterns could differ, some countries entertain more direct economic relations with the United States than others (say Canada versus Greece) or have institutions more similar to those prevailing in the United States (such as common versus civil law countries). All this can affect underlying risk in the country and the degree of correlation with underlying risk in the United States.

To estimate the cross term coefficient  $a_1$  in equation (3) we can then use a two-stage least squares procedure: we can estimate the coefficients  $b_{ki}$ 's, then replace  $\sigma_{ji}$  in (3) with  $\sum_{k=1}^K b_{ki}(\sigma_{jU})^k$  and finally estimate equation (5) by OLS.<sup>6</sup> To estimate

5. In a series of unreported exercises, we have also experimented with replacing the country dummies with a set of country characteristics that might determine overall idiosyncratic risk, such as GDP per capita, measures of financial development and reliance on oil exports. Results were very similar to those obtained using country dummies.

6. Notice that if we were to replace  $\sigma_{ji}$  in (3) with  $b_{0i} + \sum_{k=1}^K (\sigma_{jU})^k$  the result would remain unchanged, because the term  $b_{0i}$  would just become part of the country fixed effect that we include in equation (3).



the coefficients  $b_{ki}$ 's we can use (5) to replace  $\sigma_{ji}$  in (4). This yields a regression model in terms of observables that can be estimated by nonlinear least squares. To identify the coefficient  $c$  we need some independent variation in the level of risk diversification opportunities for countries that share the same relationship to risk as the United States. Our identifying restriction is that the group of Scandinavian countries (Denmark, Norway, Sweden, and Finland) satisfy this property,  $b_{ki} = b_{k,SCAND}$  for  $i =$  Denmark, Norway, Sweden, and Finland. This seems a plausible assumption, since these countries bear important similarities in sectoral composition, in geographical, social, and climatic conditions, etc.<sup>7</sup>

As is standard in the literature, we will measure observed risk with indicators of the idiosyncratic variability of stock market returns Campbell et al. (2001). A less obvious choice is the measurement of diversification opportunities. In our model differences in risk diversification are due only to financial frictions. In reality, several other factors, including cultural aspects or exogenous shocks, can limit entrepreneurs' ability to diversify away risk. Given that we are interested in the causal effects of diversification of business owners on performance, rather than those of financial frictions per se, we start considering comprehensive, direct measures of diversification based on the structure of corporate ownership in the country. Heaton and Lucas (2000) and Calvet, Campbell, and Sodini (2007) show that entrepreneurs who obtain substantial income from their private business bear more idiosyncratic risk. Moskowitz and Vissing-Jørgensen (2002) document that owners of family businesses tend to hold a substantial portion of their overall personal wealth in the family firm and they are undiversified. So in a country where family businesses are diffuse, entrepreneurs bear more idiosyncratic risk and the importance of family firms (or conversely of widely held firms) can be used as a measure of the degree of diversification of entrepreneurs in the economy. These indicators are a more direct measure of the degree of diversification of business risk than indicators based on financial frictions alone. Of course, financial frictions do influence the ownership structure. For example, La-Porta et al. (1998) document that companies are less diversified and family firms are more common in countries with greater financial frictions while Burkart, Panunzi, and Shleifer (2003) show how agency problems can account for the finding. In the analysis that follows we also consider some indicators of financial frictions which, as in our model, could be an important source of cross country differences in risk diversification opportunities.

A possible additional concern is that risk diversification measures could be endogenous to country specific differences in sectoral performance. For example, as the variability of sectoral performance increases, the incentive to diversify risk across sectors also increases, possibly leading to a change in the country's business ownership structure. Diversification measures could also be affected by measurement error, that in principle could be at least partly related to the relative performance of sectors in the country, which would then become a source of bias in the estimates. Although this seems less of a concern compared to the endogeneity of observed risk,

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7. Of course identification requires some variation in the level of risk diversification opportunities within the group of countries, a condition that is satisfied by our data, as we show in what follows.

we will tackle it anyway by instrumenting the diversification measure using changes in the demographic structure of the country's population induced by World War II. We think of WWII as an exogenous shock to the possibility to transmit businesses from one generation to the next and thereby to the degree of diversification of a country's business structure. These instruments exhibit important cross-country variation and they are most likely exogenous to the current sectoral performance of countries.

#### 4. Data

We discuss the measure of idiosyncratic risk, sectoral performance, risk diversification and the instruments used. The Online Appendix provides further details and descriptive statistics.

##### 4.1. *Measures of Idiosyncratic Risk*

Data on observed idiosyncratic risk for the OECD countries are calculated using information on monthly stock market returns from Thomson Datastream, which provides information on a large set of listed firms in 42 developed and emerging markets including all OECD countries.<sup>8</sup> To construct a country-specific measure of sectoral idiosyncratic business risk, we closely follow the methodology in Campbell et al. (2001) and we decompose the overall volatility of yearly returns into a market and a firm component. The market is country specific.<sup>9</sup> Observed idiosyncratic risk is measured by the firm volatility component, which is computed for 36 sectors defined using the sectoral classification of Fama and French (1997).<sup>10</sup>

For the United States we have two different sources of data to calculate idiosyncratic risk. We can use Thomson Datastream, as for all other countries, or we can take directly the indicator of idiosyncratic risk constructed by Campbell et al. (2001), which is based on CRSP data. As stressed by Ince, and Porter (2006), measurement error is smaller in the CRSP data than in the Thomson Datastream data. To increase the power of the instruments we use both risk measures. Indeed the correlation between the Campbell et al. measure of risk and the analogous measure from Datastream is around

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8. Selection in the stock market differs across countries, which could lead to a bias in the measures of idiosyncratic volatility. See, for example, Thesmar and Thoenig (2011) and Himmelberg, Hubbard, and Love (2004) for empirical evidence. Because of the inclusion of country dummies in (4) and in (5), our methodology is robust to biases that equally affect all sectors in a country. Moreover, we instrument sectoral risk with US risk, which might further address other potential selection problems.

9. This assumption can be criticized on the grounds that financial markets are integrated and investors can invest internationally. But in practice the choice of the relevant market matters little, because the variance of the idiosyncratic component is large and dominates the market return component.

10. In principle we might want to allow for an industry component different from the firm component. We do not do this because, in the theory of Acemoglu and Zilibotti (1999), sector specific risk matters: with high sectoral variability financial contracts are less efficient because it is harder to separate firm-level risk from sector-level risk. In any case, we checked that results are little affected by this choice. This is because the firm component dominates the sectoral component.

80%, which suggests that there is some independent variation, that can be exploited to improve estimation efficiency. The country-level average value of idiosyncratic volatility varies from around 0.005 to 0.015 and is in the range of values computed by Campbell et al. for the United States. We also find substantial cross-sectoral variation, indicating that sectors do differ in terms of observed risk.

#### *4.2. Measures of Sectoral Performance*

Our first specification will focus on labor productivity growth measured as value added per worker at the yearly level. Productivity data are from the OECD-STAN database. STAN covers all sectors of the economy (at two digits) since 1970, although coverage varies by country and it is more comprehensive in more recent years. The number of sectors covered is generally high (above 20), with some exceptions including New Zealand and Portugal for which we have data for just four and six sectors, respectively. We also consider several other alternative measures of sectoral performance. The growth rate of value added, investment and capital labor ratio still come from the OECD-STAN database, while the index of business creation is taken from Bartelsmann, Scarpetta, and Schivardi (2005). See their paper for details.

Overall, average productivity growth is around 2% per year, with a minimum of 0.5% in New Zealand and a maximum of 3.2% in Finland.<sup>11</sup> Despite being from official sources, sectoral productivity might be subject to measurement error. For example, employment is calculated in terms of number engaged rather than in terms of full time equivalent. To eliminate the influence of outliers, in all regressions we exclude observations above and below the first and last percentile of the cross-country sector productivity growth distribution—which are equal to -3.1% and 23%, respectively. We will also experiment with different weighting schemes to reduce the potential effects of measurement error.

#### *4.3. Diversification Measures and their Instruments*

As argued previously, our preferred indicator of lack of diversification is the importance of family firms in the economy. Data on business ownership are taken from La-Porta, Lopez-De-Silanes, and Shleifer (1999) and Faccio and Lang (2002) for Western Europe and Mexico; Gadhoun, Lang, and Young (2005) for the United States; Claessens, Djankov, and Lang (2000) for East Asia. The data refer to one point in time in the mid-1990s. Ideally, one would like to have a full time series for the ownership structure. In reality, this is not likely to be a major problem, as ownership structure is very persistent. For example, Giacomelli, and Trento (2005) analyze the ownership structure of Italian firms in 1993 and 2003, finding very modest changes, most of which are due to

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11. These comparisons are just illustrative of the data and should not be taken as indicators of the country's overall performance, as average growth may refer to different periods and sectors in different countries. The country dummies in the regressions control for cross-country differences in average growth.

the privatization process that occurred over that decade. Firms are defined as family controlled if a single family or an individual is the majority shareholder and owns at least 20% of shares. As an alternative measure of risk diversification opportunities of businesses owners, we consider the share of widely held firms in the economy, defined as those where there is no shareholder who owns more than 10% of the shares. Due to data constraints, these papers focus just on listed companies. Our assumption is that their ownership structure reflects economy-wide properties.<sup>12</sup> We follow the methodology in Mueller and Philippon (2011) to improve the comparability of data across countries.

The instruments for risk diversification opportunities are based on World War II demographic changes in terms of military, civil, and Jewish casualties in relation to the size of the country's population before the start of the War in 1939. The idea is that war-related casualties have affected the demographic structure of the population, and thereby the possibility of transmitting businesses from one generation to the next. We use data on Jewish casualties because they might characterize differential effects of the War on the country's demographic structure and on the intergenerational transmission of businesses. As discussed previously, business ownership structure is very persistent, so the effects of the war are likely to be present 40 years later. We take data for total population in 1939 and war related casualties from Wikipedia.<sup>13</sup>

In our model, the strength of agency problems affects the possibility of diversifying away idiosyncratic risk. Given this, we also consider some legal determinants of private benefits of control (which are a source of agency problem), such as indicators of the quality of accounting standard, rule of law, and anti-director rights as calculated by Dyck and Zingales (2004); see their paper for details. This allows us to check if our results are robust to the specific measure of diversification opportunities used.

Table 1 reports descriptive statistics for the different risk diversification measures used. In general, family firms and widely held corporations are very common: they represent around 50% and 32% of the firms in the sample, respectively. There are also important cross-country differences, that indicate for example that Mexico and Continental Europe are much less diversified than the United Kingdom, the United States, and Japan. In general, the relevance of widely held corporations and family firms are closely correlated (the correlation coefficient is minus 0.88). The correlation matrix at the bottom of the table also shows that the family indicator is negatively related to all three indicators of private benefits of controls, consistent with the notion that agency problems are an obstacle to risk diversification.

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12. Of course, the share of family firms in the group of private and listed companies does differ. However, we only need to assume that a country with relatively more family firms among the listed corporations will have also relatively more family firms in the economy. This is reasonable because the ownership structure of private and listed companies is influenced by common country-specific factors.

13. See [http://en.wikipedia.org/wiki/World\\_war\\_ii\\_casualties](http://en.wikipedia.org/wiki/World_war_ii_casualties).

TABLE 1. Diversification measures.

Country	Family firms	Widely held firms	Rule of Law	Anti direct. rights	Accounting standards
AUS	.52	.44	10	4	75
AUT	.53	.11	10	2	54
BEL	.52	.2	10	0	61
CAN	.43	.49	10	5	74
DNK	.48	.33	10	2	62
ESP	.56	.26	7.8	4	64
FIN	.49	.29	10	3	77
FRA	.65	.14	9	3	69
GBR	.24	.63	8.6	5	78
GER	.65	.1	9.2	1	62
GRC	.78	.12	6.2	2	55
ITA	.6	.13	8.3	1	62
JPN	.1	.8	9	4	65
KOR	.48	.43	5.3	2	62
MEX	.82	.07	5.3	1	60
NLD	.36	.23	10	2	64
NOR	.39	.37	10	4	74
NZL	.41	.34	10	4	70
PRT	.6	.22	8.7	3	36
SWE	.47	.39	10	3	83
USA	.2	.65	10	5	71
Correlation matrix					
Family	1				
Wid. held	-.88	1			
Rule of law	-.48	.23	1		
Ant. rights	-.62	.74	.30	1	
Acc. stand.	-.43	.47	.36	.48	1

Notes: The table reports the values for the diversification measures for the countries used in the regressions, as well as the correlation matrix. See Section 4.3 for sources and definitions.

## 5. Results

We start by discussing the results of the first stage of the estimation procedure, that yields a characterization of the relationship between idiosyncratic risk in the United States and in other countries. We then turn to estimating the effects of risk on productivity growth in countries with different risk diversification opportunities. Finally, we discuss the results with the alternative measures of risk diversification and sectoral performance.

### 5.1. First Stage

As discussed in Section 3, we instrument observed sectoral risk in a country with US sectoral risk. Our instrumentation procedure entails the joint estimation of the  $b$  parameters in equation (5)—that characterizes the relationship between underlying risk in the United States and in other countries—and of the  $c$  parameter in equation (4)—that characterizes the relationship between observed and underlying risk within a country.

TABLE 2. First-stage regression.

	Campbell			Datastream			$H_0 : b_1 = b_2 = 0$ <i>p</i> -value
	$b_1$	S.E.	Corr.	$b_2$	S.E.	Corr.	
AUS	0.42	0.48	0.18	1.12**	0.45	0.72	.009
CAN	0.92*	0.52	0.89	0.73	0.59	0.36	.016
GRC	1.97**	0.77	0.69	-1.09	1.47	-0.29	.038
ITA	0.53	0.5	0.22	0.62	0.48	0.11	.116
JPN	0.58	0.45	0.52	0.73*	0.39	0.40	.020
KOR	0.07	0.55	-0.92	0.58	0.68	-0.28	.636
MEX	0.52	0.84	0.46	3.39	2.63	0.84	.366
NZL	-0.02	10.44	-0.70	-1.48	71.29	-0.47	.998
PRT	10.21***	1.11	0.55	-14.33***	1.97	-0.46	.000
AUT	0.82	0.85	0.37	-0.02	1.09	-0.53	.447
BEL	0.69	0.51	0.76	0.76	0.47	0.43	.034
ESP	1.06*	0.58	0.85	1.38*	0.84	0.61	.008
FRA	1.02**	0.51	0.83	1.44***	0.53	0.63	.000
GBR	0.98**	0.46	0.90	0.84**	0.4	0.43	.001
GER	0.65	0.5	0.70	0.86*	0.47	0.55	.020
NLD	0.85*	0.48	0.86	0.9**	0.43	0.49	.003
SCAND.	1.00**	0.49	0.84	1.29***	0.44	0.60	.000
Square	-26.35	27.25		-45.68	26.17		.088
Cube	336.27	472.33		571.06	415.83		.280
		Coeff.		S.E.			
$c^*$		.63*		.37			
$R^2$				0.06			
N. obs.				5,834			

Notes: The table reports the estimated coefficients of equations (4) and (5) in the main text. We allow for a country-specific linear coefficient on the US measure of idiosyncratic volatility from Campbell et al. (2001)  $b_1$  and from Thomson Datastream  $b_2$ , with the exception of the Scandinavian countries (Denmark, Finland, Norway, and Sweden) for which a common coefficient is imposed. We also include common quadratic and cubic terms. The standard error for  $c^*$  is obtained by bootstrapping. The columns under "Corr." report the correlation between the resulting measure of sector level idiosyncratic risk and the two US measures from CRSP and Datastream. See the Online Appendix for details.

\*Significant at 10%; \*\*significant at 5%; \*\*\*significant at 1%.

As previously discussed, we use measures of idiosyncratic risk in the United States from both Thomson Datastream and CRSP. To allow for possible nonlinear effects we model the relationship between US risk and country specific risk in equation (5) using a third degree polynomial ( $K = 3$ ). To keep the problem computationally manageable we allow only the two linear terms coefficients,  $k = 1$ , to differ across countries. Further details of the estimation procedure are reported in the Online Appendix.

Table 2 presents the results. The estimated value for  $c$  is positive, indicating that underlying and observed risk do differ. The estimated value of .63 together with our risk diversification measure implies that for all countries underlying and observed risk are positively related. The  $b$  parameters in equation (5) are statistically significant for at least one of the two volatility indicators in 14 out of 20 cases. In the case of Portugal and New Zealand the estimated coefficients are doubtful either because of their somewhat implausible magnitude or because of their sign (i.e., they are both negative). This is

probably due to the small number of available sectors, as well as of firms within each of them (see the descriptive analysis in the Online Appendix). We will check that our results are robust to the exclusion or inclusion of these countries. For the remaining countries, results square up with expectations. In particular, there is an almost exact one-for-one relationship between risk in the United States and in the United Kingdom and Canada. A joint test that both coefficients of the volatility indicators are zero is rejected for 15 out of 20 countries; for Italy, the acceptance is marginal ( $p$ -value of 10%), while it is more clear-cut for Korea, Mexico, New Zealand, and Austria. Overall there is evidence that sectoral idiosyncratic risk differs across countries, since a test strongly rejects the null that the  $b$  coefficients are equal across countries. Columns three and six of Table 2 report the correlation of the risk of different sectors in a country with US sectoral risks, for the two US measures.<sup>14</sup> The correlation tends to be high for most countries, especially with the Campbell et al. (2001) measure, but always well below one. The most noticeable exceptions are Korea and New Zealand, for which both correlations are negative, reflecting small or negative coefficients in the estimation procedure. Again, our results are robust to the exclusion of these countries. All in all, this evidence goes against the assumption commonly underlying the Rajan and Zingales (1998) methodology, that US sectoral measures can be applied as such to all other countries.

## 5.2. Main Results

We now discuss the estimates of the  $a_1$  coefficient in equation (3). We start by considering pure cross-section regressions, with growth and risk computed as time averages for the available years. In all regressions, we also include volatility not interacted, the log of initial productivity and country and sector dummies. Since it is unclear whether standard errors should be clustered at the country or at the sector level, standard errors are computed using the Huber–White method, which is robust to heteroskedasticity of unspecified form.<sup>15</sup> Following the previous discussion, we also start excluding New Zealand and Portugal. We show in what follows that all these specification choices have no major effects on the estimates. Column [1] in Table 3 reports the results when using observed country-sector volatility from the Datastream data, interacted with the measure of the importance of family firms in the country. We find that the interaction term is marginally significant at 10% and positive. This result would go against the idea that idiosyncratic risk has stronger negative effects on growth in countries with lower risk diversification opportunities. As discussed in the Online Appendix, a positive  $a_1$  coefficient is likely to be due to the fact that observed risk is endogenous, and that countries with worse risk diversification opportunities also have lower underlying risk.

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14. Due to the inclusion of country dummies in (4) and (5), we cannot directly compare risk levels across countries. This variation is however irrelevant for estimation results, since country specific differences in risk common across sectors are controlled by the country dummies in (3).

15. We have also tried clustering standard errors at the country or at the sector level. We generally find that standard errors become smaller, particularly so when clustering at the country level. In this respect the significance level of the reported estimates is somewhat conservative.

TABLE 3. Productivity growth, diversification and idiosyncratic risk.

	Volatility measure			
	Observed [1]	US-CRSP [2]	US-Datastr. [3]	Underlying [4]
Family*volatility	2.84* (1.55)	-7.98*** (2.84)	-6.47 (5.71)	-12.17*** (5.12)
Initial productivity	-.020** (.009)	-.018*** (.006)	-.019*** (.006)	-.020*** (.006)
R <sup>2</sup>	0.56	0.4	0.41	0.42
N. obs.	265	426	391	387

Notes: The dependent variable is the average growth rate of labor productivity at the sectoral level, computed over all the available years. Volatility is measured as: column [1], observed volatility, computed using Datastream; column [2], US volatility, computed by Campbell et al. (2001) using CRSP; column [3], US volatility computed using Datastream; column [4], underlying volatility computed using the procedure detailed in Section 3. All regressions include a full set of industry and country dummies. Robust standard errors in parentheses.

\*Significant at 10%; \*\*significant at 5%; \*\*\*significant at 1%.

To tackle the problem of endogeneity of observed risk, one could follow Rajan and Zingales (1998) in assuming that observed risk in the United States measures the level of underlying risk in any other country. Column [2] of Table 3 reports the results when using the US volatility measure by Campbell et al. (2001) based on CRSP data. Column [3] deals with the analogous measure calculated from Thomson Datastream. With the Campbell et al.'s measure, the coefficient on the interaction between family ownership and volatility is negative (-7.98) and highly significant (standard error 1.95), indicating that sectors with a higher idiosyncratic risk experienced lower productivity growth in countries where the ownership structure is less diversified. To give a better appreciation of the economic effect, other things equal, these estimates imply that the average productivity growth differential between an industry at the 75th percentile of the sectoral distribution of idiosyncratic risk (Textile) and one at the 25th percentile (Insurance and pension funds) is 0.8% higher in Canada (which corresponds to the 25th percentile of the family ownership distribution by country) than in Italy (which corresponds to the 75th percentile). When we use the measure of US idiosyncratic risk calculated from Thomson Datastream, the coefficient is again negative but not statistically significant at conventional levels (see column [3]). This could be the result of the substantial measurement error present in the Thomson Datastream volatility measure. To investigate this possibility we follow Ashenfelter and Krueger (1994) and instrument the volatility measure from Datastream with the analogous measure from CRSP. If the errors in the two measures are uncorrelated, this procedure eliminates any bias induced by measurement error. We obtain a point estimate substantially larger (again in absolute value) and significant at 5%, which confirms that measurement error in the Thomson Datastream data is significant.<sup>16</sup>

16. As a further check, we have also constructed an additional instrument following the procedure proposed by Ciccone and Papaioannou (2007). The idea is to run a regression of the form  $\omega_{ji} = d_i + d_j + \theta_j \times d_j \times \beta$ , where  $d_i$  and  $d_j$  are country and sector dummies while  $\theta_j$  is the industry-specific



The previous estimation hinges on assuming that sectoral underlying risk is the same across countries. Column [4] in Table 3 presents the results when we use the country specific measure of underlying risk discussed in the previous section. The coefficient now increases significantly in absolute value relative to the value obtained when imposing that underlying risk is equal across countries (from 7.98 to 12.17). This would again be consistent with the idea that countries with less diversified ownership structures also have lower underlying risk. Repeating the same comparative static exercise as above, we obtain that the difference in productivity growth between a sector with the idiosyncratic risk at the 75th percentile of the risk distribution (Machinery in Finland) and at the 25th percentile (Transport and Storage in Australia) would be 1.3% higher in Canada than in Italy.

### 5.3. Robustness Checks

To account for the endogeneity of family ownership, we instrument its interaction with volatility using demographic changes induced by WWII, also interacted. The first-stage regression, reported in the lower part of Column [1] of Table 4, indicates a positive effect of the ratio of civilian casualties over the country's population in 1939 on family ownership and a negative effect of the ratio of Jewish and military casualties over the country's population, with all effects being highly significant. A possible interpretation is that civilian casualties capture the destructive effects of WWII on the production system, with more destruction leading to more business creation after the war. Higher casualties among military and Jews may instead indicate a more dramatic reduction in the relatively young portion of the population, which has made it more problematic to transmit family businesses from the War generation to the next one. The instruments pass the Sargan test ( $p$ -value 0.44), which does not signal any endogeneity problems; the Anderson canonical correlation Likelihood Ratio test indicates that the rank condition is also satisfied ( $p$ -value 0.000) while the Cragg–Donald  $F$ -statistic does not suggest any weak instruments problem. The upper part of column [1] presents the second stage results. The interaction coefficient now falls to minus 14.6. The increase in the negative effects of risk on growth is most likely due to the fact that part of the negative correlation between the indicator of the importance of family firms and country underlying risk is endogenous, say due to the fact that with less underlying risk the demand for risk diversification falls. We have also experimented with alternative instruments. In particular Mueller and Philippon (2011) show that the quality of labor relations are an important determinant of family ownership. They also show that measures of the degree of confrontation between European liberal states and guilds and labor organizations in the eighteenth and nineteenth centuries, as constructed

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response to country level differences in diversification opportunities  $\beta_i$ . Then we used the estimated  $\hat{d}_j$  and  $\hat{\theta}_j$  to construct a (predicted) value of the volatility present in the country with the highest level of diversification opportunities in the sample (which is equal to 0.1). This is obtained by calculating  $\hat{\omega}_j = \hat{d}_j + 0.1 \times \hat{\theta}_j$  (see Ciccone and Papaioannou 2007, p. 454, for details). With this instrument, the estimates are similar to those in columns [2] and [3], but with higher standard errors.

TABLE 4. Robustness checks.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Family* volatility	-14.65** (7.07)	-8.55*** (3.29)	-8.56*** (3.21)	-10.94*** (3.86)	-9.70*** (3.86)	-17.11* (9.39)	-17.43* (9.49)
Ext. dep*						-.040 (.031)	-.054 (.044)
Find. dev. Initial prod.							
	-.020*** (.006)	-.013** (.005)	-.009** (.004)	-.019*** (.006)	-.020*** (.006)	-.027*** (.008)	-.027*** (.008)
R <sup>2</sup>	0.41	0.55	0.67	0.34	0.42	.42	.43
N. obs.	387	387	318	1010	395	213	213
Weight	NO	OWN	US	NO	NO	NO	NO
Repeated CS	NO	NO	NO	YES	NO	NO	NO
<b>First-stage IV regression</b>							
Military	-2.26*** (.519)						
Civilian	10.12*** (1.13)						
Jews	-16.08*** (3.40)						
LR stat. (p)	0.00						
Sargan (p)	0.44						
Cragg-Donald stat. (p)	0.00						

Notes: The dependent variable is average growth rate of labor productivity at the sectoral level, computed over all the available years. Volatility is the underlying volatility computed using the procedure detailed in Section 3. The first column reports the results from the IV regression where the interaction variable is instrumented with WWII casualties. Military, Civilian and Jews are casualties in each group over the population in 1939, interacted with the volatility measure. All other regressions are OLS. In column [2] we weight observations according to sectoral employment while in column [3] according to total country employment multiplied by the US sectoral share of employment. In column [4] we take five-year averages of the variables (rather than a single cross-section). In column [5] we repeat the basic regression of column [4] of Table 3 keeping the observations for Portugal and New Zealand in the sample. In columns [6] and [7] we add the interaction between external dependence and financial development measured by stock market capitalization over GDP in column [6] and private credit over GDP in column [7] as in Rajan and Zingales (1998). All regressions include a full set of industry and country dummies. Column [1] in the second panel reports the results of the first-stage regression where family is instrumented using WWII casualties. Robust standard errors in parentheses.

\*Significant at 10%; \*\*significant at 5%; \*\*\*significant at 1%.

by Crouch (1993), are strong predictors of the importance of family ownership in the country today. When using these alternative instruments for the family ownership indicator we find minor differences in the estimated coefficients (a coefficient of  $-12.9$  rather than  $-14.6$ ).

Sectoral employment varies greatly across countries and sectors. It goes from a few hundreds workers in computers and office Machinery in Greece to more than six millions workers in construction in Japan. To downplay the contribution of small sectors, possibly more subject to measurement error,<sup>17</sup> in column [2] of Table 4 we present the results when weighting the observations with the country specific

17. A regression of the square of the growth rate of productivity on log employment gives a coefficient of  $-.0032$  with a standard error of  $0.00086$ , indicating that smaller sectors have a more variable productivity pattern, possibly due to measurement error problems.

sectoral employment size. The coefficient drops (in absolute value) to  $-8.5$  and remains significant at 5%, indicating that our results are not driven by the behavior of small sectors. However, one problem is that this weighting scheme, although correcting for measurement error, might give rise to endogeneity problems. In fact, the patterns of sectoral specialization can be affected by the level of idiosyncratic risk—as emphasized by Cūnat and Melitz (2011) and Castro, Clementi, and MacDonald (2009)—or more generally by the level of economic development, see Imbs and Wacziarg (2003). As an alternative, in column [3] we weight observations using a measure of the size of the country (total employment) multiplied by the sectoral shares of employment in the United States, which are exogenous to the country's specialization patterns and can still correct for measurement error. We detect no substantial differences in the estimates with either weighting scheme. Only the fit of the regression improves substantially when weighting the observation with the US weights (the  $R^2$  goes from 0.4 to 0.67). This indicates that, while not changing substantially the results, the regressions with exogenous weights fit the data better.

Another concern is that we only use a cross-section, taking the average of both productivity growth and volatility over a potentially long period of time.<sup>18</sup> Indeed, volatility might have changed substantially over time at the sectoral level, in which case an overall average might lead to misleading results. We address this issue in column [4] of Table 4, where we compute average productivity and volatility separately for each of the six five-year periods from 1973 to 2003. We then run the same regression as before by pooling all repeated cross-sections. The results, reported in column [4], are very similar to those obtained with only cross-sectional data, indicating that time aggregation does not bias our results.<sup>19</sup>

So far we have excluded New Zealand and Portugal from the sample, since their first stage results were somewhat dubious (see Table 2). Column [5] of Table 4 shows that the results are unchanged when including them in the sample.

One final concern relates to the possibility that our measures might be correlated with other characteristics of the financial system, beyond diversification and risk. In particular, Rajan and Zingales (1998) have shown that sectors with a higher external financial dependence (as measured by the share of capital expenditures not covered by firm cash flows in the corresponding sector in the United States) grow relatively faster in countries with a more developed financial system. It could be that idiosyncratic risk is correlated with external dependence and risk diversification with financial development. In this case our estimated coefficients could simply reflect the effect isolated by Rajan and Zingales. To address this concern, we add to our regression the interaction between the measure of external dependence and financial development

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18. This is sometimes mitigated by the fact that the STAN data are often missing in initial years of the sample.

19. We have also experimented with time series regression with growth and volatility measures at the yearly level. In the regression we allow for two year lags in the effects of volatility on growth, since entrepreneurial choices and productivity may be sluggish to respond to changes in risk. We obtain a lower coefficient ( $-3.6$ , significant at 1%), possibly because, at yearly frequencies, US volatility might be a more noisy measure of volatility in other countries.

proposed by Rajan and Zingales (1998).<sup>20</sup> The correlation coefficient between external dependence and our measure of idiosyncratic risk is 0.24. The correlations between family ownership and the two measures of financial development used by Rajan and Zingales (1998)—the stock market capitalization over GDP ratio and the domestic credit to private sector over GDP ratio—are  $-0.42$  and  $-0.23$ , respectively. In the last two columns of Table 4 we report the results of the basic regression when also including the interaction between external dependence and either market capitalization (column [6]) or private credit (column [7]). As external dependence is only available for manufacturing sectors, the number of observations drops substantially. Yet in either specification the coefficient on the interaction between risk and diversification remain significant at 10% and large in absolute value ( $-17$ ). The interaction between external dependence and the financial development indicators are positive, as expected, but statistically insignificant. This might be due to two factors. First, we are considering only OECD countries, for which differences in financial development are substantially smaller than in the original Rajan and Zingales (1998) sample, which also includes developing countries. Second, they consider value added growth while here we focus on productivity growth: it might be that credit availability is more important for overall growth, while, as the model shows, diversification opportunities have effects on productivity growth, even when financial resources are available.

#### *5.4. Alternative Risk Diversification Measures*

One possible concern is that all our results so far are based on the importance of family firms. Family ownership might matter for performance for other reasons than risk diversification. For example, Caselli and Gennaioli (2005) argue that the ownership structure affects the selection of managerial talent. Table 5 presents the results with the alternative risk diversification measures discussed in Section 4.3: the share of widely held firms, indicators of the quality of the rule of law, anti-director rights and accounting standards.<sup>21</sup> The first is an alternative measure of the ownership structure of firms; the other three are indicators of legal determinants of financial frictions in the economy. Note that now a higher value of the indicator is associated with greater risk diversification opportunities, so the interaction term is expected to be positive. This happens to be the case with all four indicators, with only accounting standards turning out not to be statistically significant at the 10% level. We take this as an indication that the estimated coefficients are actually capturing the effects of risk diversification opportunities on growth.

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20. The Online Appendix explains how we adapted their sectoral classification (based on ISIC) to ours (based on STAN) and other data details.

21. To simplify comparison of results, the only difference relative to the previous tables is that the interaction term in equation (3) is computed using these alternative measures.

TABLE 5. Other measures of diversification.

	Widely held firms [1]	Rule of law [2]	Anti directors rights [3]	Accounting standards [4]
Diversification*volatility	12.98* (7.3)	1.16*** (.46)	1.09* (.62)	.21 (.14)
Initial productivity	-.020*** (.006)	-.020*** (.006)	-.020*** (.006)	-.020*** (.006)
R <sup>2</sup>	0.41	0.42	0.41	0.41
N. obs.	387	387	387	387

Notes: The dependent variable is average growth rate of labor productivity at the sectoral level, computed over all the available years. Volatility is the measure of underlying risk computed using the procedure detailed in Section 3. Widely held firms is the share of listed firms that are widely held. Rule of law, anti-director rights and accounting standards are the determinants of the Private Benefits from Control (PBC) proposed by Dyck and Zingales (2004); higher values of the indicators imply higher investor protection and lower PBC. Robust standard errors in parentheses.

\*Significant at 10%; \*\*\*significant at 1%.

### 5.5. Other Measures of Sectoral Performance

So far, we have focused the analysis on productivity growth. We now investigate whether our results hold true when we consider alternative measures of sectoral performance: value added growth, investment growth, capital-per-worker growth and business creation rates. The first is a natural measure of overall sectoral performance; the next two capture effects on capital accumulation; the last is an indicator of business creation. We expect that fewer opportunities to diversify risk will translate into lower investment and less business creation with greater effects in riskier sectors. The results appear in Table 6. Odd columns present the unweighted regressions while even columns present results with US weights. Results with alternative weighting schemes are similar and are omitted to save space. We find that the effects of risk and diversification on growth tend to hold true also when considering these alternative measures of performance, although results are statistically significant only when weighting observations. This might be because the number of observations falls substantially when considering these alternative measures, reducing the precision of the estimates.

## 6. Conclusions

We have analyzed the effects of idiosyncratic business risk on growth in OECD countries. We have found that countries with low levels of diversification perform relatively worse in sectors characterized by high idiosyncratic volatility. The implied effects are apparent only after taking into account that observed and underlying risk differs and are magnified by taking into account that risk varies by country.

Our findings can shed some light on the diverging productivity performance of the United States and Europe. Some authors (Ljungqvist and Sargent (1998) and Comin and Mulani (2006)) have argued that the degree of idiosyncratic business risk has increased

TABLE 6. Alternative performance measures: growth rate of value added, of investments, of investment per worker, entry rate.

	Value-added growth		Investment growth		Capital per worker growth		Entry rate	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Family* volatility	-1.59 (2.67)	-6.59** (2.62)	-11.11 (11.81)	-32.18*** (9.43)	-19.98 (13.94)	-29.40*** (8.82)	-4.38 (7.00)	-9.92* (5.33)
Initial level	-.036*** (.003)	-.021*** (.003)	-.002 (.010)	-.007*** (.003)	-.018* (.009)	.013** (.005)	-.007** (.003)	0.17 (.15)
R <sup>2</sup>	0.64	0.75	0.28	0.78	0.28	0.65	0.84	0.77
N. obs.	436	360	265	219	262	217	131	121
Weight	NO	YES	NO	YES	NO	YES	NO	YES

Notes: The dependent variable is average growth rate of real value added in columns [1] and [2], of real investment in columns [3] and [4], of investment per worker in columns [5] and [6], in the last two columns is average entry rate. All variables are at the sectoral level, computed over all the available years. The weights are computed as total country employment multiplied by the US sectoral share of employment. Robust standard errors in parentheses.

\* Significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%.

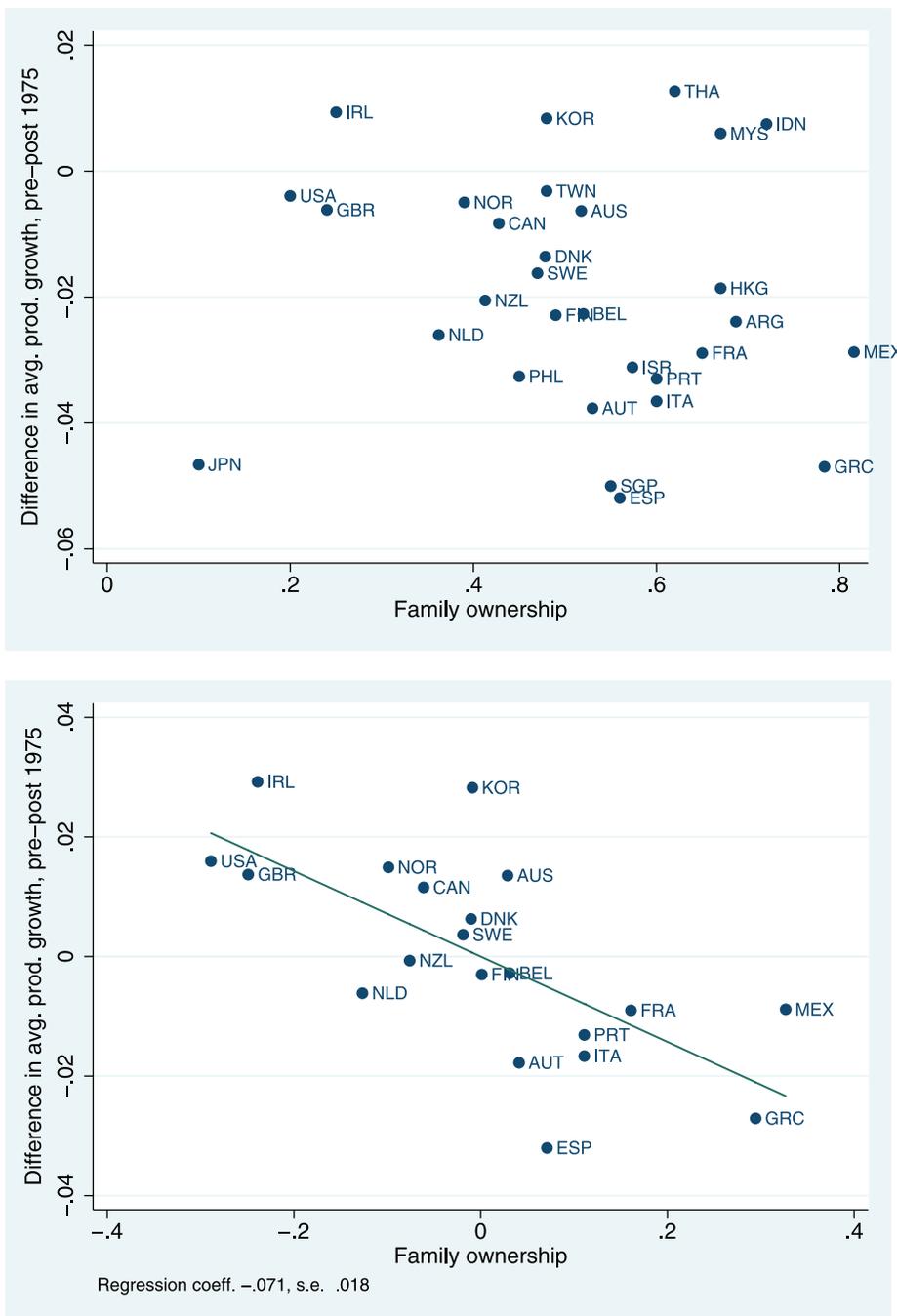


FIGURE 1. Productivity growth changes, pre-post 1975 versus family ownership. Source: the Penn World Tables. Heston, Summers, and Aten (2006).

since the mid-1970s, due to an acceleration in the pace of technological progress and to the increased globalization of product markets. Our findings imply that countries with worse risk diversification opportunities should have experienced a more pronounced fall in productivity growth. Figure 1 displays some suggestive evidence that supports this hypothesis. In the top panel we plot the difference in average productivity growth before and after 1975 against the share of family controlled firms.

The figure characterizes a negative relationship between changes in productivity growth and the importance of family firms, with the exception of Japan, which went through a major depression, arguably unrelated to idiosyncratic risk and ownership structure. In the bottom panel we restrict the sample to the group of OECD countries excluding Japan. The data line up nicely along a negatively sloped line. The large continental European economies, where family firms are more common, recorded a marked decrease in productivity growth. Productivity growth has instead accelerated in Anglo-Saxon countries, where the ownership structure allows better risk diversification. Our analysis suggests that the interaction of the increase in idiosyncratic risk with differences in risk diversification opportunities across countries can explain part of the US–Europe gap in productivity growth that has emerged over the last two decades, as well as the important differences across European countries. Further investigation of this issue is an exciting avenue for future research.

## Supporting Information

Additional Supporting Information may be found in the online version of this article:

Online Appendix

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