Productivity and Finance: The Intangible Assets Channel*

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Abstract

This paper revisits the traditional analytical framework linking finance and growth by explicitly taking into account the rise of intangible assets. Using a panel of developed countries from 1995 to 2015, we provide evidence both at the sectoral and at the firm level that financial frictions act as a drag on productivity growth and that these effects are more pronounced for intangible intensive sectors. Our measure of sector-level intangible intensity adds a new dimension in describing the technological characteristics of a sector by capturing its innovation potential, distinct from financial dependence. These findings, which are robust to alternative specifications, shed light on the role of financial factors in explaining the productivity slowdown in developed economies and provide support for using intangible intensity as a new dimension to proxy the relative exposure of industries to financing frictions. Finally, our paper provides new insights on how financial frictions propagate to the real economy.

JEL Classification: G010, G210

Keywords: Intangible assets, Productivity Growth, Financial Development

1 Introduction

Over the last two decades, many advanced economies experienced a sharp slowdown of productivity growth (Andrews et al. (2016), Syverson (2017)). Among a wide range of potential explanations, such as slowing technological diffusion, misallocation, weak business dynamism and measurement error, several authors emphasized the increased role played by financing frictions.[1] The evidence confirms that financial constraints induce sluggish investment, preventing firms to implement more innovative and productive projects, both in manufacturing and services industries.

Interestingly, over the same period, intangible assets have grown in importance in many advanced economies. Intangible assets stemming from research and development, new software, patenting, organization and distribution networks have become a pivotal component of the production function for many firms. The high-tech sector, which relies heavily on intangible capital, has increased its share of sales, income and valuation (Crouzet and Eberly (2018)). The fast development of new technologies combined with the well-documented productivity slowdown suggest that these two phenomena could be linked.[2]

One potential explanation is that intangible assets are more difficult to finance. First, intangible assets are mostly non rival assets and are therefore associated with more uncertainty and more acute asymmetry of information. Beyond the intrinsic higher uncertainty linked to investment projects into intangible assets, firms might be reluctant to provide precise signals about non-rival projects to capital markets, thereby reinforcing the uncertainty for investors. Second, most intangible assets are closely tied to human capital, creating contracting issues arising from inalienability of human capital (Hart and Moore, 1994). Consequently, intangible assets are harder to redeploy and have a significantly lower liquidation value as they tend to be more firm-specific, reducing the share debtors can capture in case of default. For the same reason, intangible assets also offer little guarantee or

[1] See for example Levine and Warusawitharana (2012), Kalemli-Ozcan et al. (2018), Manaresi and Pierri (2017), Mian et al. (2017) and Duval et al. (2017).

[2] There is ample evidence that innovative intangible capital and productivity are positively related. Innovation increases efficiency and creates new demand. It also leads to a more efficient allocation of resources across firms, as companies that successfully invest in intangibles gain market shares and eventually displace inefficient ones. Refer to Hall (2011) for a review of the literature.

collateral in the capital raising process. Human capital, organizational networks and brand value, for example, are more difficult to pledge. As a result, firms with relatively more intangible assets are more likely to face difficulties in raising capital (and obtaining loans), more likely to be financially constrained and less able to catch investment opportunities (Almeida and Campello, 2007).

This paper brings the focus on the role of intangible assets in shaping the relationship between productivity and finance. Most of the literature has focused on one dimension of the sector in evaluating the exposure to financial constraints: the external finance dependence (Rajan and Zingales (1998)). However, recent studies have found no signicant effect of financial development on sectors dependent on external finance (Cecchetti and Kharroubi (2015); Fisman and Love (2004); Pagano and Pica (2012)). Our paper introduces another structural dimension that is different from, but complimentary to, external dependence: the intangible intensity. We argue that the dependence on intangible assets generates additional frictions. In addition to capturing a possible collateral constraint, intangible intensity also captures the innovation potential of the sector. To the best of our knowledge, this paper is among the first studies to test empirically the mechanisms linking financial frictions, intangible assets and productivity, both at the sectoral and at the firm level, and brings novel evidence into the debate on what could potentially resume productivity growth.

An important challenge in assessing the link between productivity and intangible assets is the estimation of intangible capital. While broad measures of intangible capital at the macroeconomic and sectoral level have more recently calculated by Corrado et al. (2016), firm-level estimations are generally missing across most advanced economies (with the notable exception of the work by Peters and Taylor (2017) using U.S. data). Their international comparisons reveal significant cross-country differences in the stock of intangibles and in their composition across sectors, suggesting that financing constraints may play an significant role. It is therefore important to find a measure of intangible intensity that captures the *potential* for such investment in each sector.

We estimate intangible assets from U.S. firm-level data following the methodology described in Peters and Taylor (2017). Intangible intensity is defined as the ratio between intangible assets and total assets of the median firm in each sector. A critical element of the empirical approach is the fact that intangible intensity is completely exogenous to our sectoral or firm level productivity. Our final data, both for the sectoral and the firm level analysis, subsequently excludes all U.S. sectors or firms (listed and unlisted). The underlying assumption is that, in the absence of financial constraints, the production function for a given sector implies an optimal asset mix between tangible and intangible capital. Intangible intensity is thus akin to a sectoral technological characteristic that, in a frictionless world, should not vary across countries. Using U.S. as our benchmark is motivated, as in Rajan and Zingales (1998), by its well-developed and relatively frictionless financial markets, particularly with respect to listed firms in the years preceding the financial crisis. In such an environment, the intangible assets equilibrium level comes closer to optimal levels.

By running our analysis at two different levels (sector and firm level), our analysis allows us to identify a full range of interactions between financial frictions, intangible assets and productivity. The sectoral-level analysis draws the attention to macroeconomic implications that financial development has on intangible intensive sectors, pointing to possible imbalances that are now amplified by the new technologies. The firm-level allows us to disentangle whether these results come from within firms constraints or from a misallocation of resources across firms. While our analysis permits to isolate unambiguously the former channel, the allocative effects are equally important and deserves further investigation.

In the sectoral level analysis, our identification strategy relies on the work of Rajan and Zingales (1998). Using a similar methodology, our paper exploits cross-sector differences in intangible intensity in countries with different levels of financial development. Extending their framework from a cross-section to a panel-data structure also allows us to use interacted fixed effects to control for a wide array of potentially omitted variables and reverse causality concerns.

Our results at the sectoral level suggest that, for the sample of developed countries we study, the positive impact of financial development on productivity growth works mainly through the expansion of intangible intensive sectors, which are likely to have a higher innovation potential. First, we find that intangible intensive sectors experience higher labor productivity growth in economies with well-developed financial systems. Second, we find that the effect of financial development is significant and positive among sectors having both higher intangible intensity and higher external financial dependence, while no significant effect of financial development is found for sectors dependent on internal finance[3] . Finally, we provide evidence that financial development benefits disproportionately sectors relying more on equity than debt. Our results further suggest a significant positive role for well-established venture capital. Our results are robust to the inclusion of additional explanatory variables potentially correlated with financial development that might possibly drive a link between intangible intensity and productivity growth.

The economic impact of financial development on sectors that have relatively more intangible assets is large. For example, our main results suggest that a sector that has about 66% of assets in intangibles (such as Computer Equipment) experiences an annual labour productivity growth that is 1.2 percentage points larger in financially well-developed countries compared to the same sector in financially less-developed countries.

Further, our sectoral level analysis allows identifying a possible mechanism by which financial frictions propagate to the real economy. Our conjecture is that an identical increase in pledgable collateral in two industries that have different intangible intensity levels will generate a different impact on R&D. We find that financial development boosts investment in R&D disproportionately more in intangible intensive sectors when capital stock grows larger. This result suggests that intangible intensive sector are relatively more collateral constrained and that the positive effect of the relaxation of the collateral constraint brought by financial development propagates to labor productivity through innovation brought by a higher rise in R&D.

At the firm level, our analysis relies on panel firm level data extracted from the Orbis database. Our sample covers about 1.4 million unique firms from 29 countries, including both manufacturing and services industries, during the 1995-2015 period. To test that financial constraints are more binding in relatively more intangible intensive sectors, our empirical strategy relies on a fixed effects panel data model, where the dependent variable is firm level productivity. The effect of interest is

[3]This result is in line with recent studies showing no significant effects of financial development on sectors dependent on external finance (Cecchetti and Kharroubi (2015); Fisman and Love (2004); Pagano and Pica (2012)).

captured by the interaction term between a firm level time-varying measure of financial constraints and a sector-varying measure of intangible intensity. The model includes firm fixed effects to absorb the unobserved firm-specific heterogeneity that simultaneously affect financial conditions and production, firm level time-varying controls to account for potential omitted variable bias and higher order fixed effects to control for all country-sector time varying shocks (country by sector by time dummies). Hence, our identification occurs by exploiting within firm variance in a given country, sector and year. We further check the cross-sectional stability of the relation of interest by estimating, for each year, repeated cross-sectional regressions in the spirit of Fama and MacBeth (1973) and Kashyap and Stein (2000), controlling for country-sector specific characteristics.

Our results confirm that the detrimental impact of financial constraints on productivity is larger in intangible intensive sectors, suggesting that intangible intensity captures a new dimension of the relative exposure of industries to financing frictions. In our baseline panel specification, moving from the 25^{th} to the 75^{th} percentile in the distribution of the financial constraints index explains 14% of the change in productivity in high intangible intensive sectors and only 10% in low intangibles intensive sectors. The differential effect is significant at the 1% level and substantial in size, as it implies a 40% increase in the relevance of financing frictions. These findings are consistent to a wide range of robustness checks, including alternative firm level financial constraints measures, various productivity estimates, different sectoral intangible intensity variables and several sample splits. Moreover, the effect remains highly significant (as well as stable over time), if we exclusively exploit cross-sectional variation.

The rest of the paper is organized as follows. Section 2 offers a literature review. Section 3 presents the sectoral and the firm level datasets along with some stylized facts. Section 4 presents the methodology and results of the sectoral analysis, while section 4 focuses on the firm-level analysis. Section 5 concludes.

2 Extended literature review

The paper is related to two main strands of the literature. The first strand investigates the impact of financial constraints on firm innovation and productivity. The second strand examines the effect of intangible investments on productivity, devoting particular attention to the measurement of intangible assets.

2.1 The impact of financial constraints on innovation and productivity

The relationship between financial frictions and innovation has been studied from both a theoretical and an empirical perspective (see the surveys by Hall and Lerner (2010) and Kerr and Nanda (2015)). Facing financial constraints, firms cut their investment in R&D to reduce liquidity risks (Bond et al. (2005), Aghion et al. (2010), Aghion et al. (2012) and De Ridder (2016)). More broadly, they invest less in intangible assets, which are more difficult to pledge as collateral (Garcia-Macia (2015) and Duval et al. (2017)). Financially constrained firms are more likely to invest in tangible assets in order to increase their debt capacity, providing a guarantee and an enforceable outside option for creditors (Almeida and Campello (2007) and Campello and Hackbarth (2012)). Further, Caggese (2016) finds that constrained firms might undertake less radical innovation, suggesting that financial markets might actively shape not only the extent but also the nature of the R&D undertaken (Kerr and Nanda (2015)). In line with this argument, Acharya and Xu (2017) provide evidence that in industries dependent on external finance, public firms have a better innovation profile compared to their private counterparts.

In general, most studies show that higher credit availability spurs firms innovation. For instance, Benefratello et al. (2008) and Cornaggia et al. (2015) show that local banking development affects the probability of innovation and that increased banking competition following deregulation events boosts innovation activities in private small firms more than in large corporations. However, Brown et al. (2009)Hall and Lerner (2010) find that small young firms, which are relatively more constrained, face difficulties to finance investment in intangibles with debt, and as a result, innovative activities can be prohibitive especially in the presence of high initial fixed costs (Midrigan and Xu (2014)).[4]

Moving to the literature examining the link between financial constraints and productivity at the firm level, most papers found evidence of a significant negative relationship. Firms facing high financing frictions might not be able to capture profitable and productive investment opportunities. For instance, Kalemli-Ozcan et al. (2017) document that the decline in investment in the aftermath of the recent financial crisis was more severe for firms linked to weaker banks. Levine and Warusawitharana (2016) show that firms facing more severe financing frictions exhibit a higher future productivity sensitivity to debt growth, confirming their model prediction that an increase in financial constraints leads to reduced productivity growth. Exploiting a large matched firm-bank dataset, covering credit relationships of Italian corporations over more than a decade, Manaresi and Pierri (2017) show that higher credit availability is associated with higher productivity growth and that positive credit shocks induce more innovation, IT adoption, exporting activity and better management practices. Focusing on eleven advanced economies, Duval et al. (2017) show that firms that entered the Great Financial Crisis with weaker balance sheets experienced a sharper decline in total factor productivity growth relative to their less vulnerable counterparts after the crisis. Accordingly, Ferrando and Ruggieri (2015) find a negative estimate for the elasticity of TFP with financial constraints, especially with respect to small and young firms. Butler and Cornaggia (2011), exploiting an exogenous shift in demand for U.S. corn and a triple differences testing procedure, demonstrate that productivity increased the most for firms operating in counties with greater access to finance.[5]

2.2 Intangible assets and their impact on productivity

A large literature emphasizes the role of a broad range of intangible assets in stimulating productivity growth at the firm level. Comparing the findings of several studies, Hall (2011) highlights

[4]In support of these claims, Peters and Taylor (2017) show that the cost of generating innovations is significantly smaller for firms that are maintaining ongoing R&D investment rather than beginning to invest in R&D.

[5]The misallocation literature also points to the fact that financing frictions could have negative effects on the efficient allocation of inputs across firms, harming aggregate productivity (for example Buera et al. (2011), Midrigan and Xu (2014), Moll (2014), Gamberoni et al. (2016), Larrain and Stumpner (2017) and Franco (2018).

that, even tough measures of innovation are still imperfect, there is evidence of a positive relationship between intangible capital, innovation, productivity and growth. The effect is stronger with respect to product rather than process innovation.[6] Overall, there is a growing recognition that, aside from investments into R&D, patents or software, which have been for a long time perceived as key drivers of innovation, other types of intangible assets such as databases, designs, managerial skills, organization and distribution networks have become increasingly important (Andrews and De Serres (2012)). In particular, these new types of intangible assets are complementary to the traditional ones, implying that efficiency depends precisely on the ability of firms to contemporaneously invest on both (McAfee and Brynjolfsson (2012); Crass and Peters (2014); Andrews et al. (2018)).

Intangible assets are more difficult to measure compared to tangibles, as most related expenses are not capitalized on balance sheets. The literature has made significant progress in this regard, and more recently a few papers started to estimate their size and their contribution to productivity growth. For example, Corrado et al. (2005, 2009, 2012, 2013) and Corrado and Hulten (2010, 2014) estimate intangible assets at the aggregate country-sector level. Following their contributions, the role of intangible assets for aggregate growth has been re-assessed. Corrado et al. (2005) and Corrado and Hulten (2010) show that intangibles had overtaken tangibles to become the largest source of growth; further, they find that the full recognition of intangibles, due to the adjustments in real output figures, could induce a change in U.S. measured productivity of approximately 0.25 percentage points per year in recent years.

More recently, following previous work by Lev and Radhakrishnan (2005), Eisfeldt and Papanikolaou (2013), Falato et al. (2013) and Eisfeldt and Papanikolaou (2014), Peters and Taylor (2017) suggest a new approach to estimate intangible assets at the firm level, according to which intangible capital is measured as the sum of knowledge and organizational capital. The authors reexamine the neoclassical theory of investment based on the original Tobin's q proxy and show that,

[6] The empirical findings on the latter are relatively more noisy, because revenue productivity measures incorporate market-power. It follows that firms' revenue productivity falls when they become more efficient if they operate in the inelastic portion of their demand curve.

despite being originally designed to explain physical investment, it explains intangible investment equally well and total investment (tangible plus intangible) even better. Further, they develop a new Tobin's q measure accounting for intangible capital and they find it better captures firms' investment opportunities in increasingly service and technology based economies.

3 Data and stylised facts

3.1 Construction of intangible intensity variable

We construct a measure of intangible intensity aggregated at the sectoral level, using firm-level U.S. data. This variable is used both for the sectoral-level analysis and for the firm-level analysis.

While most developed economies have shifted towards more technology- and service- based industries, and intangible assets (such as software, distribution networks or human capital competencies) have grown in importance, international accounting standards fail to recognize them as assets on balance sheets. Instead, intangible investments have been historically treated as intermediate input expenses. As a result, national official measures largely underestimate intangible assets.[7] Nevertheless, intangible investment presumes foregoing consumption today for future profits, fitting in the same capital definition framework as tangible capital.

Intangible capital has been estimated at the macro level using national financial accounts levels and flows by Corrado and Hulten (2010), Corrado and Hulten (2014), Corrado et al. (2009). Their arguments and methodology have been widely accepted and several papers started to document aggregated estimates of intangible assets by sector, and more recently, by country. These calculations show that intangible assets have been growing at fast rates in all OECD economies in some cases even faster than tangible capital (Figure 3, Panel A). These international comparisons also reveal significant cross-country differences in the stock of intangibles and in their composition (Figure 3, Panel B). However, estimates at the firm level have been more difficult to construct, especially

[7] Following the most recent international guidelines for the compilation of national accountsthe System of National Accounts 2008 (SNA), the Bureau of Economic Analysis (BEA) in the U.S. started to recognize expenditures by business, government, and nonprofit institutions on research and development (R&D) as fixed assets and recorded R&D spending as investment in gross domestic product (GDP) as part of the comprehensive revision of the national income and product accounts (NIPAs) released on July 31, 2013.

across countries, due to different reporting requirements of the associated expenses.

Our measure of intangible capital at the firm and at the sectoral level builds on the work of Peters and Taylor (2017), using firm-level U.S data from Compustat. Similar methodologies are described in Eisfeldt and Papanikolaou (2013), Eisfeldt and Papanikolaou (2014), Falato et al. (2013), Lev and Radhakrishnan (2005). Once estimated, intangible intensity is defined as the ratio of intangible assets to total assets (tangible and intangible).

Intangible assets are calculated as the sum between externally purchased and internally created intangible capital. According to the U.S accounting standards, the *externally* and *internally* created intangible capital are subject to different rules. Intangible assets that are purchased externally (patents or through a firm acquisition) are included on balance sheet as part of intangible assets (Compustat item *intan*). These intangible assets are further separated based on whether assets are directly identifiable (such as a patents) in which case they are booked under *Other Intangible Assets*. If not identifiable, they are classified as *Goodwill*. Intangible assets that are created internally are expensed on the income statement and almost never appear as assets on the balance sheet. The balance sheet item includes however a few small exceptions when the internally created intangibles are capitalized on balance sheet (ex. legal costs, consulting fees, registration fees incurred in developing a patent or trademark). Peters and Taylor (2017) strategy to estimate internal intangible capital consists in capitalizing intangible investments as reported in income statements.

Intangible capital can be further classified in knowledge- or organization- based capital based on the type of expenses that are capitalized. Knowledge-based capital includes a firms R&D spending to develop knowledge, patents, or software while the organization-based is computed by using a fraction of the Selling, General and Administrative expense (SG&A), which includes advertising to build brand capital, human capital, customer relationships and distribution systems. Both expenses are then capitalized into our measure of intangible capital stock. We estimate intangible capital for all U.S. firms, after excluding utilities, financial firms and firms categorized as public service. Our main measure of intangible capital intensity is then calculated as the ratio of the cumulative sum of intangible assets to the cumulative sum of total assets at firm level, from 1990 to 2006. This procedure allows us to incorporate the possibility of having lumpy intangible investment expenses across years. For each sector, we then find the median-firm intangible intensity ratio.

Intangible intensity is calculated on the period 1990-2006 i.e. before the onset of the financial crisis in order to avoid incorporating the period of worsening financial conditions that followed the crisis. Indeed, we consider intangible intensity to be akin to a sectoral technological constraint, an optimum that can be attained when there are no strong financial constraints. Our reasoning relies on the assumption that financing constraints were non existent or very lax in the US between 1990 and 2006.

In our empirical analysis we propose several variations of the intangible capital intensity by industry. The first measure (a) $IntangIntens(Smooth)$ is calculated at the firm level as the sum of intangible assets over the sum of total assets over the 17-year period. For each sector, we then find the median-firm intangible intensity ratio. The second measure (b) is calculated for each firm-year. For each firm, we then find the firm median over the period and then, for each sector, the industry median ($IntangIntens(Median)$). Finally, the third measure (c) is the median intangible intensity of all firms in a sector by year ($IntangIntens$). This last variable is defined at industry-year level. Table 1 shows all these variations for intangible intensity along with their two components, the knowledge and the organizational pieces.

3.2 Construction of variables used in the sectoral level analysis

Our sectoral level analysis covers a panel of 32 economies and 30 industries over the period 1990 to 2014. Our final panel is defined at country-sector-year level, and due to the lack of productivity data at sector level. We describe below the construction of our variables of interest.

External finance dependence revised

To measure sectoral external financial dependence, we first use the standard calculation as proposed by Rajan and Zingales (1998) using U.S. firm level data from Compustat, under the presumption that only tangible assets could be financed through external capital.[8] For each firm,

[8]However, we expand the calculations over all sectors, not only manufacturing.

we calculate the ratio between cumulative capital expenditures minus cumulative cash flow from operations and cumulative capital expenditures for each firm, from 1990 to 2006. As with intangible intensity, we then collapse the firm-level data at the industry median level using the same 30–industry definitions presented in Table 1. Similarly, we define the dependence on external equity finance as the ratio of the net amount of equity issues to capital expenditures, and the dependence on external debt finance as the ratio of the net amount of debt issues to capital expenditures.[9]

Second, while standard sectoral measures of dependency to external finance presume that only tangible assets need financing from external sources, we extend the standard index by adding R&D investment as a component of total capital investment. Most R&D investments are already marketable, such as patents, brands and licenses, often allowing firms to raise capital against them. Figure 7 shows the change in external financial dependence measure after including R&D.

Finally, our third measure incorporates all intangible capital investment into the calculation of the financial dependence. However, SG&A expenses are already included in the calculation of operating cash flows. As a result, their inclusion in the numerator as part of total investments will simply be a redistribution of expenses from cash flow to expenditure in the numerator. In most of the empirical analysis we will therefore mostly focus on the second measure.[10]

We refine our measures of financial dependency by looking at equity versus debt dependency (Table 2, columns 4 and 5). As above, we assume that the mix between equity and debt finance in the U.S. reflects a technological feature of sector (linked for instance to the relative importance of risky projects that need to be financed). We calculate dependence on external equity finance as the ratio of the net amount of equity issues to tangible and R&D investment (in line with our definition of financial dependence), and the dependence on external debt finance as the ratio of the net amount of debt issues to capital expenditures[11]. By incorporating information on the type

[9] While the last two measures could capture other types of expenditures during the sample period, our assumption is that this noise will be absorbed by the cumulative nature of these calculations. Debt dependence is more likely affected by institutional factors such as the debt-tax bias, tax deductibility limits, etc.

[10] For most firms the denominator will be significantly higher, resulting in a re-scaled version of our second measure.

[11] Similar to Table 1, the two components of external dependency may not add up to the total for two main reasons. First, net equity and debt issuance could potentially include capital raised for reasons that unrelated to investment objectives. Our conjecture is that this noise will be absorbed by the cumulative nature of these calculations over long periods. Second, the columns present sector median-firm values and the median firm could be different across the

of investor prevalent in each sector, the external equity dependence variable captures yet another angle of the technology that relates to the length and risk of investment. Along the same idea, the external debt dependency reflects, through the type of investor, the low risk and stable cash flows nature of the investment.

Financial development

Our analysis relies on the idea that the development of financial markets and institutions have an impact on productivity by relaxing financial constraints and easing access to capital. This requires broad measures of finance availability and access to finance, which we proxy in the following ways.

First, akin to the standard empirical literature (Rajan and Zingales (1998)) we use ratios of the size of credit to GDP and market capitalization to GDP. To control for reverse causality, we use initial values at the beginning of the estimation period. Second, we use the IMF global index (a multidimensional index) that offers a more refined measure of financial development (Svirydzenka (2016)). We particularly focus on three indices computed over the period 1980-2013: the global index, the overall development of financial markets and the overall development of financial institutions. For summary statistics, please refer to Appendix Table A-1.

Labor productivity

The analysis focuses on labour productivity as this variable is directly affected by capital deepening (in both tangible and intangible assets). Our data on Labor Productivity (LP) is calculated as value added per employee at the sectoral level and comes from the OECD database. For this reason, we define industries based on the NACE2 classification, which is roughly similar to ISIC4 rev2. Our final panel is thus defined at country-sector-year level.

3.3 Construction of variables used in the firm level analysis

The firm level data we use are obtained from the Orbis database, which is provided by the consulting firm Bureau Van Dijk. Orbis is an umbrella product that combines information from regulatory and other sources in order to collect balance sheet and ownership data about companies worldwide.

two dimensions.

To ensure the comparability of firm level information across countries and sectors, we adopt the data cleaning procedures routinely applied at the OECD, which are based on insights from Gal (2013), Kalemli-Ozcan et al. (2015), Gal and Hijzen (2016) and Gopinath et al. (2017). We consider exclusively full year unconsolidated accounts and perform some basic checks to evaluate implausible values, excessively large shifts in relevant variables over short periods of time and relationships violating accounting norms. In order to obtain internationally comparable values over time, all firm level nominal variables are deflated by using two digits industry deflators - when these deflators are missing, we fill in missing values using higher order inflation (e.g. grouped 2 digits, 1 digit, macro-sectors); then, we apply country-industry level PPPs, using as a reference 2005 US dollars. We include only firms with more than 3 employees that report at least for three consecutive periods.

The following subsections provide an overview on how the main variables employed in the analysis are constructed, while Table A-6 reports their basic pooled descriptive statistics.

Productivity

Our main dependent variable is (log) firm level productivity. As we do not observe firm level prices, but only 2-digits industry deflators, all the productivity measures employed are revenue based.[12]

We use the the logarithm of total factor productivity, estimated through the GMM Wooldridge (2009) value added based procedure, as our baseline measure. This measure overcomes the OLS simultaneity biasand also internalizes the Ackerberg, Caves and Frazer (2006) critique on the estimation of the labor coefficient in both Olley and Pakes (1996) and Levinsohn and Petrin (2003) semi-parametric approaches. We proxy the capital input with the deflated value of fixed assets, the labor input with the number of employees and adopt intermediate inputs (e.g., material costs) as an instrument for unobserved productivity.

[12] Revenue based productivity is influenced by producer-specific demand, as, for example, higher prices would lead to higher productivity estimates, confounding quality changes with increased market power. Ghilchirst (2017) shows that, during the recent financial crises, financially constrained firms tended to raise prices; hence, especially in the second half of the sample period, the price effect would work against our findings.

Financial Constraints

Firm-level financing constraints are not directly observable using balance sheet information. Starting with the influential paper by Fazzari et al. (1998)and Kaplan and Zingales (1997), the literature has proposed a wide range of competing measures.[13] Lamont et al. (2001) proposes the famous Kaplan-Zingales (KZ) index, which is built using the scores of the ordered logit model in Kaplan and Zingales (1997).[14] Other papers, such as Whited and Wu (2006), follow a different path that does not rely on the above two-steps procedures, but rather on a structural model initially proposed by Whited (1992).[15] A third strategy, which avoids the assumptions behind either an a-priori partitioning or a structural model, is proposed by Musso and Schiavo (2008). They develop a class ranking index, building a score from a number of proxies.[16]

Acknowledging that this large strand of literature studying direct measures of financial frictions at the firm level is inconclusive and that each method entails adhoc choices which might impact on our findings, we use several alternative measures. First, we use two traditional indices proposed in the literature developed by Whited and Wu (2006) and Ferrando et al. (2015), modified to reduce the problem of coefficients out of sample extrapolation. Second, we propose a new synthetic index, from now on referred to as DFS Index, which builds on the insights from Musso and Schiavo (2008).

All indices fulfill several criteria. They combine information from several measures. The reliance on a single variable would not allow us to fully assess firms financial conditions: a firm might be illiquid, but strong fundamentals could compensate for the temporary financial distress; or, similarly, a firm might be highly leveraged but liquid and, thus, able to catch investment opportunities. Second, in order to allow the exploitation of within firm variation, they are time-varying. Third,

[13]For a comprehensive review of the literature, see Silva and Carreira (2012).

[14]An analogous procedure is followed by Hadlock and Pierce (2010). Given the qualitative nature of the a-priori classifications, which extensively limits the range of firms that could be included in the analysis, subsequent users of these indices proceed by extrapolating out coefficients to their own sample.

[15]Their approach consists in estimating the Euler equation resulting from the model, where the structural parameter for the shadow cost of capital is projected into the following variables: cash flow to assets, a dummy capturing whether the firm pays a dividend, long-term debt to total assets, size, sales growth, and industry sales growth. The resulting vector of coefficients is then used to build a continuous index.

[16]Proxies include size, profitability, current ratio, cash flow generating ability, solvency, trade credit over total assets and repaying ability. For each firm, each dimension enters the index as a ranked deviation from sector-year mean. The rank is assigned based on the position of the firm-year observation in the resulting distribution.

they take into account potentially different degrees of financial constraints, going beyond a sharp classification of firms into a constrained and an unconstrained category.

Our first measure is the Whited and Wu (2006) index, constructed by extrapolating out of sample Whited and Wu's reported coefficient estimates:

$$\begin{aligned} WW\ Index = (-0.091 * CashFlowOverTotalAssets) + (-0.062 * DummyPositiveProfits) + \\ +(0.021 * LongTermDebtOverTotalAssets) + (-0.044 * LogTotalAssets) + \\ +(0.102 * AverageSalesGrowth) + (-0.035 * FirmSalesGrowth) \end{aligned} \tag{1}$$

The variables entering the equation with a negative sign are expected to lessen financial constraints the higher their value, while the opposite holds for those with a positive loading.[17] The main concern with the practice of out-of-sample extrapolation of index coefficients is parameter stability across firms and over time - an issue that is even more compelling in our case, as our cross-country sample differs in several dimensions from the Compustat data used by Whited and Wu (2006).

To reduce these concerns and take into account cross-country and cross-sector heterogeneity with respect to the contribution of each characteristic in shaping firms overall financial condition, we also compute, based on the WW index, two relative measures of financing frictions.[18] First, we take the median value of the index for each country-sector pair and calculate the deviation from the country-sector median for each firm; we then split into deciles the distribution of the deviations, so that higher deciles contain relatively more financially constrained firms (WW_cat). Second, to explicitly control for the potentially different variability of financing constraints within countries and sectors, we build a second alternative version of the index by classifying firms into deciles according to the distribution of the normalized - separately within each country-sector - WW scores (WW_norm).

[17] Due to data availability, we deviate from the original index by substituting the dummy variable that captures whether the firm pays a dividend with a dummy variable that takes value 1 if a company reports strictly positive net profits and 0 otherwise.

[18] For the sake of clarity, the original version of the index, calculated as in xx, will be labelled WW_num throughout the paper. Further, notice that sectors are defined at the 2-digits level, according to Nace Rev.2 classification.

Next, we adopt two different versions of the index developed by Ferrando et al. (2015) based on the SAFE survey, extrapolating coefficients out of sample as in Ferrando and Ruggieri (2018):

$$
\begin{aligned}
SAFE\ Index = -1.88 + (0.71 * FinancialLeverageRatio) + (-0.51 * ROA) + \\
+(-0.28 * InterestCoverageRatio) + (-1.20 * CashHoldings) + \\
+(-0.21 * TangibleFixedAssets) + (-0.05 * LogTotalAssets)
\end{aligned}
\tag{2}
$$

First, given that the sample underlying the SAFE survey is relatively more similar to ours if compared to Compustat data, we simply take the deciles of the distribution of the index (SAFE_vA). Second, we follow the same strategy used to obtain the WW_cat index by calculating deciles of the distribution of the deviations from the median value of the SAFE score in each country-sector pair (SAFE_vB).

As a second set of measures, we propose a new synthethic index (DFS Index), which builds on the approach of Musso and Schiavo (2008) and does not suffer from the concerns associated to coefficients extrapolation. It collapses information from eight variables: size (proxied by total assets), age, financial leverage ratio (ratio of short plus long term financial debt over total assets), return on assets (ROA), current ratio (current assets over current liabilities), cash to assets ratio (cash holdings over total assets), interest coverage ratio (ratio of ebitda over interest payments) and the ratio of shareholder funds over total liabilities.

For each of the eight variables, we calculate the deviation from the country-sector-(year) median.[19] The resulting distributions of deviations from the median are clustered into quintiles, so that, for each firm-year observation, we have eight scores that range from 1 to 5, in which 1 contains the smallest value (e.g., observations that are far below the group median).[20] We use economic theory and findings from the literature to classify variables depending on their positive (financial

[19] We develop two versions of the DFS index. In one of the two (vA), the reference group is given by a country-sector-year cell; in the other (vB), the time dimension is disregarded and each country-sector becomes the reference group. The latter will be our baseline index.

[20] A small value could be indicative either of a constrained or an unconstrained firm, depending on the variable considered. For example, being in the first quintile of the cash to assets ratio (deviations from the median) distribution suggests that the firm is not liquid and, thus, relatively constrained compared to its peers; on the contrary, a similarly low value on the financial leverage ratio would suggest that the firm is not leveraged relative to its peers and, thus, unconstrained.

leverage ratio) or negative (the other seven variables) loading with respect to financial constraints and homogeneize the scores accordingly, to always have low scores indicating unconstrained firms.[21] Following Musso and Schiavo (2008), we aggregate the information in two ways: the sum of the eight scores; the number of variables for which the firm belongs to the fifth (more constrained) category. The resulting indices are rescaled on a $0 - 10$ basis, with higher values being associated to more constrained firms. Finally, in order to keep into account the correlations across the variables included in the index and avoid the excessive loading resulting from those carrying related content, we elaborate an additional aggregation strategy based on a principal component analysis (first component) performed over the eight scores.[22]

All the indices - the traditional ones and the DFS, with all their variants - are highly and positively correlated with each other , suggesting that indeed they capture similar information, as one would expect.[23]

3.4 Stylised facts

Rise of intangible assets

Results show that the importance of intangible assets in the United-States has grown over time, with the ratio of intangible assets to total assets coming closer to that of the tangible capital stock in 2006, for our selected industries (Figure 4 Panel A). Importantly, intangible assets that are not yet recognized on balance sheets have grown over time confirming that disregarding those assets may underestimate the importance of intangible assets in the economy. Figure 4 Panel B shows, accordingly, that the ratio between intangible assets to total assets, tangible and intangible,

[21] Loosely speaking, for the seven variables with a negative loading, we invert the score based on quintiles. For example, observations in the fifth quintile of the profitability distribution (very profitable) are given a score equal to one, as being profitable is supposed to relax financial constraints; those in the fourth are given a score equal to two and so on, to have low scores indicating unconstrained firms.

[22] It follows that, in the end, we have five variants of the DFS index: sum of the eight scores and each country-sector-year as the reference group (DFS_vA); count of variables for which the firm belongs to the fifth category and each country-sector-year as the reference group (DFS_vA2); sum of the eight scores and each country-sector as the reference group (DFS_vB); sum of variables for which the firm belongs to the fifth category and the eight scores and each country-sector as the reference group (DFS_vB2); principal component analysis and each country-sector as the reference group (DFS_PCA).

[23] Moreover, again unsurprisingly, they are negatively correlated with productivity, either expressed in levels or in growth rates.

has been increasing over time. The figure also suggests that intangible assets investments are more sensitive to financial constraints than tangible assets as reflected in the decreased intangible intensity following the global financial crisis.[24]

Figure 5 shows that intangible assets constitute an important share of assets in all sectors, both manufacturing and services, though some differences emerge on the relative importance of knowledge and organizational capital. Figure 6, Panel B shows the increase of intangible intensity over time.

The share of intangible assets is sizable in most sectors, but there is also substantial variation, with the highest intangible intensity reaching over 70% in Programming and Information and Pharmaceuticals, and intangible intensity being the lowest in Basic Metals, Mining and Transport. Wide differences emerge also on the relative importance of knowledge and organizational capital (Figure 5), suggesting that exposure to financial frictions may differ even across sectors with similar overall intangible intensity depending on its composition. The data reveal that Pharmaceutical, and Programming and Information sectors have the highest intangible intensity ratios in the sample, albeit a different composition, and that most of these assets are off balance sheet.

Evolution of financial dependence

Table 2 shows these three measures for financial dependence from 1990 to 2006. As in Rajan and Zingales (1998), financial dependence captures one dimension of the technological dimension of the sector that relates to the length of the investment projects, the cash collection expected period and risks (in the absence of financial constraints). We focus on the period preceding the crisis as firms likely operated during this time with minimum financial constraints, attaining the desired optimum level of capital.

Several stylized facts emerge from our calculations. In line with the expectation that the rise of intangible assets has been associated with stronger need for external finance, taking into account intangible investments tends to increase the extent of dependency of financially dependent sectors

[24] Intangible intensity is calculated from 1990 to 2006 to avoid incorporating the period of worsening financial conditions following the crisis.

(see Table 2 and Figure 6).

Looking at financial dependence calculated over two different windows, from 1985 to 1995 and from 1995 to 2005, Figure 6 reveals that financial dependence has become more negative over time. This could be a reflection of the fact that the structure of finance in many sectors has changed, and some sectors show a stronger reliance on internal funding (see Doidge et al. (2017), Falato et al. (2013), Peters and Taylor (2017)). However, and most important for our analysis, the ranking of sectors remained generally the same.

Intangible intensity and external financial dependency: two distinct structural dimensions of sectors

The proxies for intangible intensity and external financial dependency based on US firm-level data are both relatively stable over time and mutually uncorrelated, suggesting that they measure independent structural characteristics of sectors. The correlation of the measures over time (between 1995 and 2005) is high: it is estimated at 85% for the external financial dependency measure and at 95% for the intangible intensity index. The level of sectoral financial dependency has varied over time for some sectors, but the relative ranking of sectors along the financial dependency dimension appears broadly persistent. At the same time, both the ranking and the level of intangible intensity appear to be time invariant (see Figure 6). Moreover, intangible-intensive sectors can be both externally and internally financial dependent (see Figure 8). Some industries, and in particular those that rely more on organizational capital (such as distribution networks) and less on long term investments (such as research and development), are more likely to harvest cash on their investments more quickly and thus have a lower demand for external capital. The lack of correlation between the two measures suggests that they capture different sector characteristics, which once combined could affect in a non-linear way the impact of financial development on productivity growth.

4 Sector Level Analysis

4.1 Empirical approach: Linking finance, intangible intensity and productivity

In this section, we develop testable hypotheses and one potential channel through which financial market development affects the labor productivity growth of intangible intensive sectors, guided by economic theory and empirical findings.

4.1.1 Main hypotheses

Hypothesis 1: *Intangible intensive industries experience higher productivity growth in well-developed financial systems.*

Industries with relatively higher intangible assets encounter more difficulties in raising capital and obtaining loans due to the lower pledgable value of the underlying assets (e.g. human capital, brand value). The value of these assets is specific to the firm, and once separated, these assets have a significantly lower resale value. A lower liquidation value reduces the share debtors can capture in case of default, creating contracting problems (Hart and Moore (1994)). As a result, firms with higher collateral value should have easier access to external funds and their collateral constraint should be relatively less binding (Almeida and Campello (2007)). Provided that different countries are in different stages of financial development, the same industry, facing the same technological constraint, should grow and benefit disproportionately more in more developed financial markets.

Hypothesis 2: *Financial development matters for the productivity growth of industries that have both high external financial dependence and high intangible assets intensity.*

Not all intangible intensive sectors need external finance. Figure 7 shows that some industries, and in particular those that rely more on organizational capital (such as distribution networks) and less on long term investments (such as research and development), are more likely to harvest cash on their investments more quickly and thus have a lower demand for external capital. Our hypothesis is that intangible assets intensity and high financial dependence are complementary. Sectors with both high intangible assets intensity and high financial dependence are sensitive to financial constraints and they will grow faster in countries that have well developed financial systems.

Hypothesis 3: *Financial development matters for the productivity growth of intangible intensive industries that rely heavily on external equity finance.*

The characteristics of intangible assets and their specificity to firm operations create more uncertainty for the potential providers of capital. Asymmetric information can generate adverse selection and moral hazard problems, leading to credit rationing (Stiglitz and Weiss (1981)). The long term nature of intangible investments combined with their riskiness and low pledgable value makes them more suitable for equity financing. Our prediction is that intangible intensive sectors will experience faster productivity growth when equity financing is more likely to be available (Carpenter and Petersen (2002)).

4.1.2 Estimation strategy and identification

To investigate the role of intangible in shaping the relationship between financial development and productivity, our identification strategy relies on the methodology used by Rajan and Zingales (1998). They propose a fixed-effects panel identification where sector-level variables (such as financial dependency) are interacted with country-level variables (such as financial development). Using a similar approach, we interact both sector-level intangible assets intensity and external financial dependency with country-level financial development.

The empirical validity of this approach relies on several assumptions which include: i) U.S listed firms operated in a relatively less constrained environment during the pre-crisis period (1990-2006), fully taking advantage their investment opportunities and building intangible capital at desired levels, ii) the industry-level mix between intangible and tangible assets reflects a technological characteristic (related for instance to the length of the investment projects, the cash collection expected period and risks) iii) the technological characteristics of a given sector in the U.S carry over to the same sector in other countries, especially among our sample of developed economies.

Additionally, our identification occurs by exploiting the three dimensions of our panel data, which allow us to control for shocks specific to a country in a given year (such as unobserved macro-economic shocks) or industry invariant shocks that are common to all countries (such as technological shocks). In our main specification, we include country-time and sector fixed effects. However, our main results are robust to the inclusion of more restrictive fixed effects structures (such as country-year and sector-year or country-sector and country-time fixed effects).[25]

Concerns regarding reverse causality, that is the fact that productivity growth could be stimulating financial development, are mitigated in this framework. It is less likely that sector-level productivity growth affects country-level financial development. The risk of reverse causality is also reduced by calculating intangible intensity and external financial dependency based on U.S firm-level data from 1990 to 2006 (excluding US from our sample).

An additional concern is that omitted macro variables could affect productivity growth when interacted with intangible intensity or financial dependence: those variables could be correlated to financial development and affect productivity growth through intangible intensity. For this reason, we include additional country-year variables into our baseline estimation (as discussed below).

When we interpret regression results, our focus is on the interaction coefficient, which captures the impact of financial development on labor productivity growth for sectors with relatively higher levels of intangible assets intensity and/or higher external financial dependency.

4.2 Setup of the baseline estimation

To test whether the impact of financial development on labour productivity varies based on the intangible intensity of the sector, the following regression is estimated:

$$\Delta logLP_{c,j,t+1} = \beta_0 + \beta_1 IntK_{j,t} + \beta_2 (FinDEV_{c,t} \times IntangIntens_{j,t}) + \\ + \beta_2 LP_{c,j,t} + \beta_3 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1} \quad (3)$$

where c, j and t refer to the three dimensions of our panel: country, industry and year. $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. $FinDEV$ refers to our measure for financial development, $IntangIntens$ refers to the intangible asset intensity of the sector. $\eta_{c,t}$ are country-year fixed effects and control for shocks specific to a country in a given

[25] These results are presented in the Appendix.

year (such as government policies and country-wide reforms). μ_j are industry fixed effects and control for industry invariant shocks that are common to all countries. We cluster standard errors by industry.[26]

We use several measures for intangible asset intensity. The $IntangIntens(smooth)$ and $IntangIntens(median)$ are time-invariant, while $IntangIntens(lag)$ has a time component. The inclusion of country-time fixed effect improves the identification strategy by reducing the risk of omitted variable bias. However, it also implies that the effect of financial development cannot be directly estimated as country-year fixed effects absorb all the variation.

To test the validity of Hypothesis 1, that is that productivity of sectors intensive in intangible (or alternatively dependent on external finance) benefit relatively more from financial development, we focus on the coefficient of the interaction term (β_2), which is expected to be positive and significant.

We extend our baseline specification by including into the regression other (potentially omitted) macro variables that are correlated with our measures for financial development and affect labor productivity growth through the intangible intensity channel. If fast growing countries experience high productivity growth that is unrelated to financial development, then the interaction coefficient between financial development and intangible assets intensity should become insignificant when these additional variables are included in the regression.

Our country-level candidates are GDP growth, inflation and labor market restrictiveness. GDP growth captures new investment opportunities which are potentially stronger in intangible-intensive sectors and is highly correlated with financial development (King and Levine (1993)). Inflation can lead to lower productivity growth through misallocation of resources (Frenkel and Mehrez (2000)) and intangible-intensive sectors, where the information asymmetry is more severe, could suffer the most. Inflation is correlated to financial development, notably through monetary policy and the availability of credit. Excessively restrictive labour regulations can affect sectoral productivity if they lead to labour market rigidities and skills mismatches (**?**). The effect can be stronger for more intangible-intensive sectors, which depend more on human capital.

[26] Results are robust to alternative clustering specifications, such as joint clustering on sector and country-year.

4.2.1 Impact intangible intensity conditional of financial dependence

The baseline model allows assessing the impact of financial development on sectoral productivity conditional on the intangible intensity of each sector. As discussed above (see Figure 8) while intangible and financial dependence may be linked, these two concepts are not interchangeable. The impact of financial development on the productivity of intangible intensive sectors may also depend on the extent to which they rely on external finance. To test the combined effect of intangible intensity and dependency to external finance on the relationships between finance, productivity and intangible assets, the baseline model is extended to include a triple interaction:

$$\begin{aligned} \Delta logLP_{c,j,t+1} = \beta_0 + \beta_1(FinDEV_{c,t} \times IntangIntens_j) \\ +\beta_2(FinDEV_{c,t} \times IntangIntens_j \times FinDEP_j) \\ +\beta_3(FinDEV_{c,t} \times FinDEP_j) + \beta_4 LP_{c,j,t} \\ +\beta_5 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1} \end{aligned} \quad (4)$$

The triple interaction makes the interpretation of the results more difficult as the effect of financial development is now conditional on both the level of external financial dependence and the level of intangible intensity. The effect of financial development depends on the combination of the estimated coefficients β_1, β_2 and β_3, their variance and the value at which IntangIntens and FinDEP are estimated (Braumoeller, 2004).[27] We hence calculate the marginal effect of financial development on labour productivity growth at different levels of the intangible intensity and different degrees of external financial dependency based on the following equation:

$$\frac{\delta(\Delta logLP_{c,j,t+1})}{\delta FinDev} = \beta_1 IntangIntens_j + \beta_2(IntangIntens_j \times FinDEP_j) + \beta_3 FinDEP_j \quad (5)$$

The economic question asked is whether external financial dependency amplifies even further the exposure to financial frictions. For an easier interpretation of the results, the external financial dependency variable is transformed into a categorical variable $dFinDEP$ taking value 1 for industries that are dependent on external finance (positive financial dependency) and 0 for industries

[27] Note that depending on the measure of intangible intensity used, time or time-invariant, additional terms will be included in the regression.

that are not (negative financial dependency). In this framework, the effect of financial development on labour productivity, conditional on intangible intensity, is captured by 1 for low financial dependency sectors and approximated by $\beta_1+\beta_3$ for high financial dependency sectors.[28]

4.2.2 Testing the type of financing

To identify the effect of the composition of finance on productivity growth of intangible-intensive sectors, two approaches are adopted. First, we estimate a variant of Eq. 1 by replacing the variable for financial development by a country-level variable capturing either the size of venture capital or the size of the private equity market. This allows to directly estimate the contribution of those suppliers of funds to productivity growth. Second, we estimate a variant of Eq. 2 by using only the component of external financial dependency measuring financial dependency on equity. By incorporating information on the type of investor prevalent in each sector, the external equity dependence variable captures another structural feature of sectors that relates to the typical length and risk of investment. A positive coefficient for the interacted term is interpreted as indirect evidence that the effect of financial development on productivity growth operates via the development of equity markets.

4.2.3 Testing potential channels

Finally, we also estimate alternative models to provide further evidence on the channels that lead to higher productivity growth. Our baseline model suggests that sectors with a high intangible intensity benefit the most from financial development. One explanation is that innovative sectors, which contribute the most to productivity, might have difficulties to access finance because intangible assets are more difficult to pledge as a collateral (see for example Berger and Udell (1990)).[29]

[28]The sum of $\beta_1+\beta_3$ is the second derivative of LP growth with respect IntangIntens in equation 3. It indicates the slope of the global effect of financial development, which is a close approximation of the effect of financial development on labour productivity growth, conditional on the level of intangible assets intensity for sectors that depend on external finance.

[29]In a similar vein, Hottenrott and Demeulemeester (2017) find that public R&D grants generate favourable impacts on the recipients, mainly through a liquidity channel. Aghion et al. (2012) use asset tangibility as a measure of existing credit constraints at the industry level, making the point that low collateral strains more the high growth industries.

If this is the case, we should observe an increase in R&D when the collateral constraint is relaxed.

To test this collateral channel, we use the growth of tangible capital as a proxy for a relaxation of the collateral constraint: more tangible assets can be pledged. We regress the growth in R&D on the growth of tangible capital in the sector interacted with its intangible intensity:

$$\begin{aligned}\Delta \log RD_{c,j,t+1} = \beta_0 + \beta_1(\log K_{c,j,t}) + \beta_2(\Delta \log K_{c,j,t} IntK_j) \\ + \beta_3 \Delta \log K_{c,j,t} + \eta_{c,t} + \mu_j + s_{c,j,t+1}\end{aligned} \quad (6)$$

We also estimate the following equation, including as an additional control the lag value added at the country-sector level:

$$\begin{aligned}\Delta RD_{c,j,t+1} = \beta_0 + \beta_1(logK_{c,j,t} \times IntangIntens_j) + \beta_2(logK_{c,j,t} \times FinDEV_{c,t}) + \\ + \beta_3(FinDEV_{c,t} \times IntangIntens_j \times logK_{c,j,t}) + \beta_4 IntangIntens_j + \\ + \beta_5 VA_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1}\end{aligned} \quad (7)$$

To facilitate the interpretation of our results, we use a categorical variable for financial development ($dFinDEP$), using country-year medians.

4.3 Sector level: Results

4.3.1 Baseline specification

In this section, we examine how financial market development affects labor productivity growth through intangible intensive assets sectors. Table 3 reports our baseline results from estimating Eq. 3. The coefficient estimates of the interaction terms between financial development ($FinDEP$) and intangible intensity ($IntnagIntens$) are identified from the industry variation across countries and capture the differential effect that financial development have across these highly intangible sectors.

We start by estimating Eq. 3 using different measures for intangible intensiveness with time invariant measures of financial development (market capitalization to GDP and domestic credit to GDP at the beginning of the sample). We report these results in Table 3. The positive sign of the coefficient suggests that intangible intensive sectors experience disproportionately higher productivity growth in countries with well-developed financial systems. The sign and the magnitude of the interaction coefficient are consistent and robust across all our proxies for intangible intensity. In Table 4 we estimate the same Eq. 3 by using various time-varying measures for financial development and the $IntangIntens(smooth)$ measure for intangible intensity.

4.3.2 Robustness checks and refinements of the baseline

In Table 4 we further distinguish intangible intensity by knowledge capital and organization capital. Our results indicate that the effect of financial development on productivity growth is stronger for sectors relatively more intensive in knowledge capital compared to sectors relatively more intensive in organizational capital.

Our results are also robust to the inclusion of other country-level variables that might generate higher productivity growth for intangible-intensive sectors. Table 5 shows that the interaction between intangible intensity and financial development remains significant after we include several other country-year variables as discussed in section 4.1.2. We allow for the possibility that errors are correlated at country-year and sector-year level. We include different clustering levels in Table A-4 in the Appendix.

Finally, we include country-year other combination of fixed effects: (a) country-year country-sector fixed effects to control for shocks that are country and sector specific (see Table A-5 in the Appendix) and (b) country-year and sector-year fixed effects to control for sector-specific shocks (see Table 16).

4.3.3 Combined effect of financial dependence and intangible intensity

To test how the interplay between intangible intensity and financial dependence affects how financial development impacts productivity, we interact financial development, intangibles intensity and a dummy for high and low financial dependence $dFinDEP1$ (based on U.S. sample medians). Our results, presented in Table 6, reveal that industries intensive in intangible assets benefit from financial development when they are also dependent on external finance (while the effect of financial development is not significant when they are less dependent from external finance). This result suggests that intangible assets intensity and external dependency complement each other in generating a positive and significant effect of financial frictions on productivity growth. Those sectors with an intensity in intangible assets above 56% account broadly for one-third of the sample (see Table 1).

No significant effect of financial development is found for sectors that are dependent on external finance but characterized by lower intangible intensity or sectors that are less dependent on external finance but intangible-intensive. Overall, our results might explain why some recent studies have not found any effect of financial development when intangible intensity was not taken into account. They also underline the importance of combining those two structural traits of sectors, intangible intensity and financial dependence, in order to assess the effect of financial development.

In Table 6 we also control for the robustness of that result by distinguishing between positive dependency on external finance and negative dependency on external finance $FinDEP2$ (i.e. when sectors on average rely on internal finance). Our results are robust to these changes. The combined effects of intangible intensity and external financial dependency (as shown in equation 3) are illustrated in Figure 9.

These findings suggest that financial development, supported by appropriate policies, could help countries tapping on the stronger productivity growth potential of intangible-intensive sectors. The economic impact is substantial. For example, a sector that has about 66% of assets in intangible assets (such as Computer Equipment) experiences annual labour productivity growth that is one percentage point larger in Japan (i.e. a country at the 75% percentile of financial development) than Portugal (at the 25% percentile of financial development). Moreover, policies are likely to be most effective at boosting productivity if they lead to lower financial frictions primarily for sectors highly intensive in intangible assets and dependent on external finance.

4.3.4 Type of finance

We now examine whether the impact of financial development on productivity growth operates through the diversification of finance (equity/debt). The underlying assumption is that the mix between equity and finance in the U.S. also reflects a technological feature: some sectors have a higher share of risky activities and require more equity for instance. We replace generic dependence on external finance in Eq. 5) with equity and debt external dependence. Equity financing is generally preferred to finance innovative activities that are both risky and long lasting. Therefore, higher reliance on equity could generally be perceived as a signal for innovation. Sectors are distinguished according to their reliance on equity financing. For an easier interpretation of the results we create a dummy variable $dEquityFinDEP$ based on the cross industry U.S. sector medians. We present our results in Table 7.

Our triple interaction coefficients confirm our conjecture and suggest a significant and positive effect of financial development on productivity growth in externally dependent intangible-intensive sectors that rely more on equity finance while the effect is not significant for externally dependent intangible-intensive sectors that rely less on equity finance.

To complement our finding on the role of equity markets, we provide a direct test of the importance of equity financing for productivity, looking at the impact of venture capital and private equity. We therefore interact $IntangIntens$ with different measures of the size of private equity and venture capital market relative to GDP, across countries. We present these results in Table 15. Venture capital is a subset of private equity and refers to equity investment made in early, maturity and buyout stage of business developed by enterprises not quoted on the stock market.[30,31] Our results suggest that access to venture capital or private equity incrementally boosts the productivity of intangible-intensive sectors. This provides additional evidence that venture capitalists play a key

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[30]Data are extracted from EUROSTAT and due to a collection break in 2006, granular data is only available before 2006.

[31]Venture capital investment is compiled based on the data collected by the INVEST Europe (formerly named European Private Equity & Venture Capital Association EVCA) survey of all private equity and venture capital companies. Private equity can be further used to expand working capital, to make acquisitions, to strengthen a companys balance sheet and for buyouts.

role for supporting innovation and closing the investment gap for young innovative firms.

Overall, these results suggest that policies aimed at strengthening equity markets and more specifically venture capital could promote productivity growth of the most innovative sectors. A wide range of policies can potentially affect the size and the role of private equity markets for innovation, either by directly reducing the cost of investing in private equity or by shaping the expectations on future returns from those investments such as tax policies (e.g. tax deduction associated to investment in corporation, bias in the tax system in favour of debt, tax relief on capital gains), innovation policies (regulation governing exit options from venture capital investment and the type of institutional investors which is allowed to invest, intellectual property rights regulation, R&D tax reliefs) and the business legal environment (labour and product market regulation, disclosure rules). Investigating the respective impact of those policy instruments on the development of private equity markets is left for future research.

4.3.5 Exploring potential channels

So far, we have estimated the effect of financial development by comparing productivity growth of highly intangible intensive sectors and low intangible intensive sectors. Having established i) that the effect of financial development on labor productivity is higher for sectors which are more intangible intensive and ii) that financial development matters for the labor productivity of sectors more dependent on equity, we now turn to the possible mechanisms explaining this result. A possible explanation could be that financial development in credit markets helps relaxing the collateral constraint which is relatively more binding for intangible intensive sectors (collateral channel). Then, the rise in intangible assets brought by relaxation of financial constraint can lead to innovation and hence productivity gains (innovation channel).

The collateral channel relies on the idea that intangible intensive industries have less access to debt financing due to a lower collateral value of intangible assets. Financial development can relax their collateral constraint by increasing the overall amount of credit, increase the collateral value of intangible (through improved accounting rules for instance) or even by favoring financial instruments alternative to debt and that require no collateral. If intangible intensive industries are relatively more constrained, they will benefit more from financial development. As intangible assets are a natural support for innovation, additional intangible investments will be converted into relatively higher productivity gains.

As shown in the first column of Table 14, the coefficient on the term interacting the growth in tangible capital and intangible intensity in equation 6 is positive and significant. This result suggests that the effect of a relaxation of the collateral constraint, proxied here by a growth of pledgeable tangible capital, has a stronger effect on the labor productivity of the most intangible-intensive sectors. This result constitutes suggestive evidence in support of the hypothesized mechanism: financial development could act through a relaxation of the collateral constraint that is relatively more binding for sectors with less tangible capital to pledge: the most intangible-intensive ones.

Additionally, the test provides an indirect support for the innovation channel. The dependent variable is R&D growth. Therefore, our result could suggest that the rise in intangible brought out by financial development through a relaxation in the collateral constraint propagates to the real economy through innovation: a rise in R&D can lead to higher labor productivity because of the innovation it generates. We also find that the coefficient on the triple interaction term in equation 7 is positive and significant for most definitions of intangible intensity.

5 Firm Level Analysis

5.1 Firm-level: Empirical approach

We test our hypothesis that the impact of financial constraints on productivity is more binding in intangible intensive industries compared to non-intensive ones by estimating the following panel fixed effects model:

$$Y_{icst} = \beta_0 + \beta_1 FC_{ics,t-1} + \beta_2(FC_{ics,t-1} \times Z_s) + \beta_3 \boldsymbol{X_{ics,t-1}} + \beta_4(\boldsymbol{X_{ics,t-1}} \times Z_s) + \\ + \delta_i + \delta_{cst} + \epsilon_{icst} \quad (8)$$

The subscripts i, c, s, t stand for firm, country, sector and time, respectively; the dependent variable Y is the log of total factor productivity; the variable FC captures financial constraints at the firm level, while Z_s is our intangible intensity measure; the vector $\boldsymbol{X}$ includes a set of firm level controls - namely, the log of total assets, ebitda and age; δ_i indicates firm fixed effects and δ_{cst} country by sector by time dummies.[32]

We estimate equation 8 by OLS, taking into account the possibility of arbitrary heteroskedasticity (White correction).[33] The parameters of interest are the within coefficients β_1 and β_2, that we expect to be both negative, so that changes in financial constraints reduce productivity and do so by more in intangibles intensive sectors relative to non intensive ones.

To attenuate the natural concerns with respect to the potential endogeneity plaguing the relationship between financing frictions, intangible assets and productivity, we proceed as follows. First, we use a rich fixed effects structure: firm fixed effects absorb the unobserved firm-specific heterogeneity that might simultaneously affect financial conditions and production; the triple interacted country-sector-year fixed effects control for the effects of all time varying shocks at the country-sector level, so that we take into account, for example, that certain countries are in a growth and investment phase or that certain (countries and) sectors are developing faster, attracting relatively more funds. To clarify, given our fixed effects structure, identification occurs by exploiting exclusively within firm variation in a given country-sector-year cell. Second, intangible intensity is calculated at sector level by aggregating information from U.S. listed firms Compustat data; having excluded U.S. firms from the analysis, this choice ensures that our measure is completely exogenous to productivity.

Third, we include all firm level regressors with a time lag to further reduce the simultaneity bias and use the usual set of firm level controls employed by the literature, together with their interactions with intangible intensity, to control for the potential omitted variable bias arising from firm time-varying characteristics.[34] Moreover, the relative (to the reference group, such as the

[32]If not otherwise stated, the same notation is used throughout the paper.

[33]Moreover, we also run several robustness checks to be sure that cross-correlations within specific clusters do not impact on the residuals.

[34]Indeed, any omitted time-varying variable which is positively correlated with financial constraints would lead to spurious confirmation of our story. The three controls included are expected to reflect relevant changes affecting each firm over time, without plaguing the model with the extremely high collinearity that horse-racing numerous additional regressors would cause.

country-sector) nature of our financial constraints indices reduces by construction concerns with respect to the correlation between financing frictions and intangible intensity.[35]

Besides performing common robustness checks to be sure our findings do not depend on either measurement or statistical choices, we provide additional evidence by adopting an alternative empirical framework in the spirit of Fama and MacBeth (1973) and Kashyap and Stein (2000). More specifically, given that in our baseline the use of firm fixed effects allows to exploit exclusively within firm variation, we isolate cross-sectional effects by running, separately for each year in the sample, the following regression:

$$\Delta Y_{ics} = \beta_0 + \beta_1 FC_{ics} + \beta_2(FC_{ics} \times Z_s) + \beta_3 \boldsymbol{X_{ics}} + \beta_4(\boldsymbol{X_{ics}} \times Z_s) + \beta_5 Y_{ics} + \delta_{cs} + \epsilon_{ics} \tag{9}$$

The operator Δ stands for the first difference of the variable it precedes; given that TFP is expressed in log terms, its first difference is a good approximation of the rate of growth of productivity. Identification would occur exclusively through cross-sectional variation across firms within country-sector cells and we expect again β_1 and, crucially, β_2 to be negative. Firm level explanatory variables, including TFP levels to control for potential convergence effects, enter the estimated equation with a lag. While, of course, one could not infer causality from this model, it is an effective way to check the cross-sectional stability of the relation of interest.

5.2 Firm-level: Results

Firm Level: Baseline results

Table 8 and Table 9 report our baseline findings, which are based on the categorical intangible intensity measure ($0-1$, with respect to the median sector). In Table 9, we use the conventional indices used in the literature, while in Table 9 the several versions of our DFS index. Independently of the firm-level financial constraints measure chosen, firms facing higher constraints experience lower productivity growth and, as conjectured, the effect is significantly larger in intangible intensive

[35] Indeed, the correlation is bounded in the $(-0.02, 0.03)$ interval, depending on the financial constraints index chosen. A high correlation would have implied that we were simply looking at the relationship between the square of financing frictions and productivity.

sectors.

The magnitude of the effect is substantial. Consider, for example, the second model in Table 9 , in which we use the DFS_vB index to proxy for financial constraints.[36] Compare two firms, one at the 75^{th} (DSF_vB = 6.56) and one at the 25^{th} (DSF_vB = 3.75) percentile of the financial constraints distribution; their difference in terms of financial constraints (2.81) explains 14.4% of their changes in productivity if they operate in highly intangible intensive sectors, while 10.3% in low intangible ones.[37] The 4.1% differential effect, as shown by the interacted term Financial Constraints Index * Intangible Intensity, is significant at the 1% level and implies a 40% increase in the relevance of financing frictions; moreover, its size is consistent across indices, varying between 5.5% (WW_num) and 1.2% (SAFE_vB).[38]

Overall, these findings are in line with the results from the sectoral level analysis.

Firm Level: Alternative Intangible Intensity Measures

In the baseline framework, we measure intangible intensity with a $0-1$ categorical variable to reduce the potential attenuation bias arising from the extent to which the benchmark country (U.S.) differs from a frictionless economy. A natural concern, given the nature of the empirical approach and the relevant role played by our intangible intensity measure, is whether the $0-1$ partition in low versus high intangible intensive sectors is too extreme. To address it, the first specification in Table 10 employs the continuous measure of intangible intensity (IntK_cont). Results are equally significant and similarly relevant in size.

The comparison between two firms at the mean of the financial constraints distribution, but

[36]From now on, for the sake of brevity, the discussion proceeds by using this index as the benchmark. We choose the DFS_vB index for two reasons. First, each country-sector is the most appropriate reference group: on the one side, it allows to compare firms with the majority of their competitors; on the other side, it is large enough to guarantee a sufficient number of observations within each group in our data. Second, the sum of the scores is the most comprehensive aggregation strategy, so that all dimensions are taken into account.

[37]Indeed, the standard deviation of our dependent variable (TFP) equals 0.82%; the regression coefficient equals -0.030 for non-intensive sectors, while $(-0.030-0.012) = -0.042$ for highly intangible intensive sectors. The reported effects are calculated as follows: [Coefficient * (P75index - P25index)] / TFP Standard Deviation.

[38]It is worth noticing how the control variables included in the analysis have, in general, the expected sign. The full effect of total assets and profitability on productivity changes is strongly positive, albeit their differential impact on intangible intensive sectors differs: total assets are slightly less relevant in these sectors, while the role of profitability is consistently higher. The evidence about age is more noisy, but relatively older firms are found to have an advantage in innovative sectors (e.g., higher reputation, credit history).

one belonging to a sector in the first quartile of the intangible intensity distribution (e.g., Coke and Petroleum) and one to a sector in the fourth quartile (e.g., Computer Equipment), shows that financial constraints explain approximately 3.7% more of the variation in productivity in the latter sector compared to the former.

In specification (2), we use an alternative continuous proxy for intangible intensity, while in specifications (3) and (4) we distinguish between the knowledge and the organizational components of intangible intensity.[39] The effect of interest is confirmed in all specifications. The size of the differential effect is larger with respect to organizational intensive sectors rather than knowledge intensive ones; this finding might be explained by the fact that knowledge assets, such as patents, are relatively less difficult to be pledged as collaterals if compared to human capital or distribution networks.

Firm Level: LP as dependent variable

We repeat our calculations by employing value added based (log) labor productivity as dependent variable. Even though the approach by Wooldridge (2009) addresses most of them, the estimation of total factor productivity might raise several measurement issues, that are absent when dealing with labor productivity.[40] Table 13 and Table 12 show that our results are unchanged independently of the intangible intensity and financial constraints measures used: the effect is still highly significant and its size comparable. Indeed, when comparing a firm at the 75^{th}% and another firm at the 25^{th}% percentile of the financial constraints distribution, the overall portion of labor productivity changes explained by financing frictions is slightly lower than the one on of TFP (6.8% and 11.3% for low and high intangible intensive sectors respectively), but the size of the differential effect is unaffected (4.3%).

[39]In specification (1), intangible intensity is measured as the sum of intangible assets over the sum of total assets over the period for each U.S. listed firm with available data in Compustat; firm level estimates are aggregated at sector level by taking the median-firm intangible intensity ratio of each sector. In specification (2), we calculate the ratio of intangibles over total assets for each firm-year; then, for each firm, we find the median value over the period and, finally, take the industry median for each sector.

[40]See the data section for a discussion of the advantages of the Wooldridge (2009) methodology.

6 Conclusions

This paper examines how intangible assets shape the relationship between industry productivity and financial development. While past research has mainly focused on the frictions induced by dependency to external finance, we add a new and distinct structural dimension of sectors, intangible intensity, which can be a source of financial frictions. This approach is motivated by the rise of intangible assets in OECD countries over the last two decades and the observation that some countries have not exhausted the growth potential associated with these assets. Taken at face value, the results suggest that financial frictions in intangible sectors have been a barrier to productivity growth in financially less-developed countries.

We provide new empirical evidence that sectors with more intangible assets grow faster in economies with a well-developed financing sector. We also find that financial development matters for the productivity growth of sectors relying more on external finance. Overall, our results show that financial development does not have a uniform effect across sectors, as the effect on labor productivity varies depending on the combination of intangible intensity and the sectoral preferred financial structure. Therefore, our results point to more refined policy recommendations as overall effects on labor productivity are heterogeneous.

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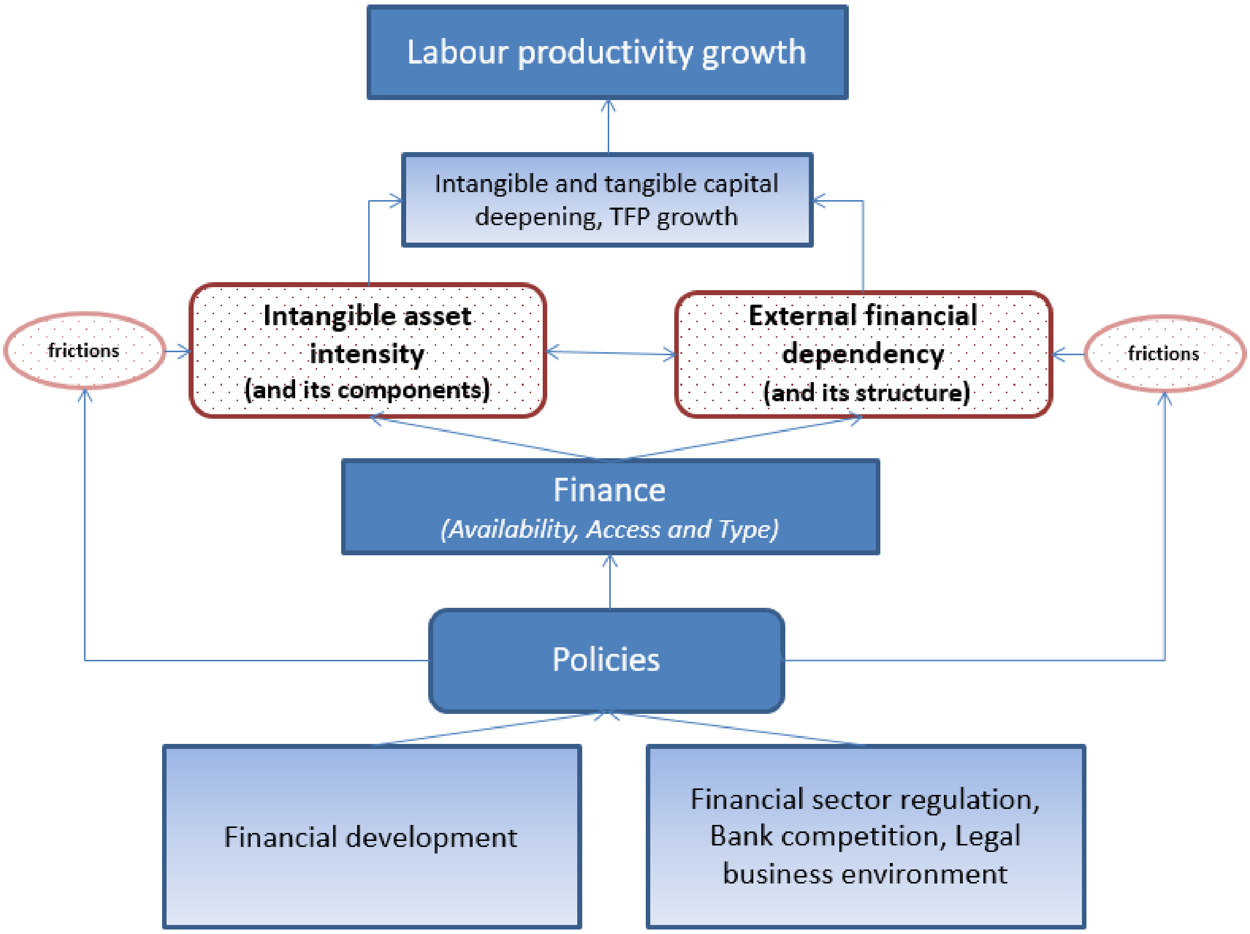


Figure 1: The conceptual framework.

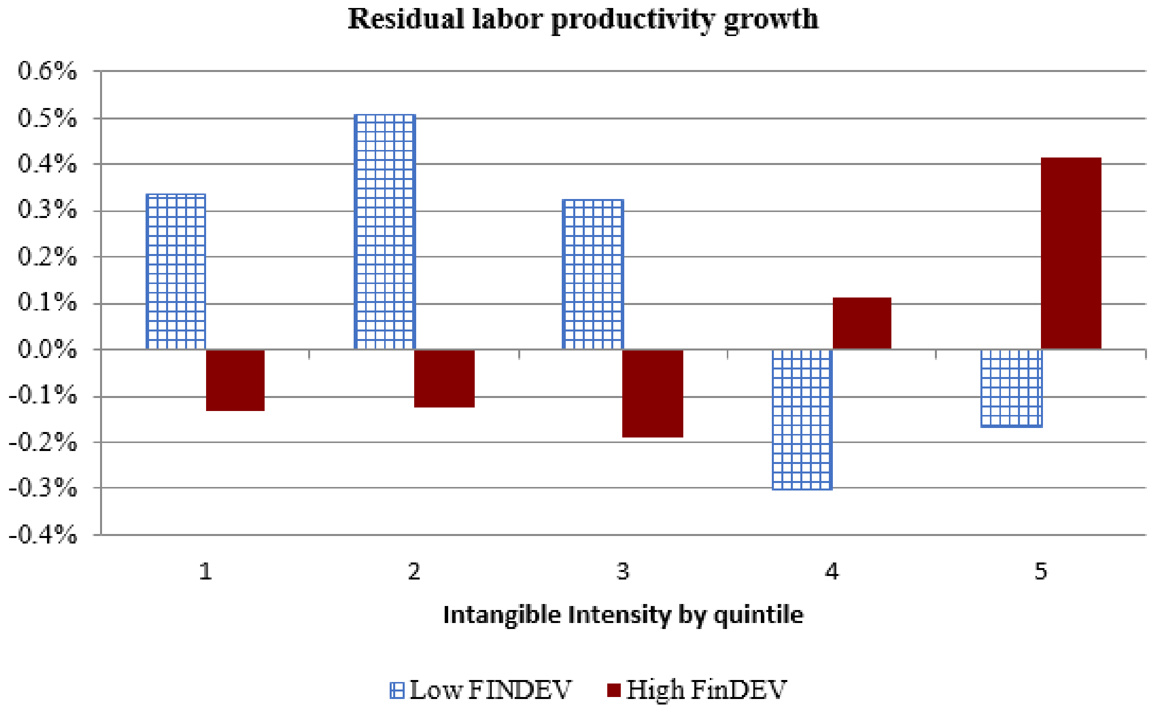
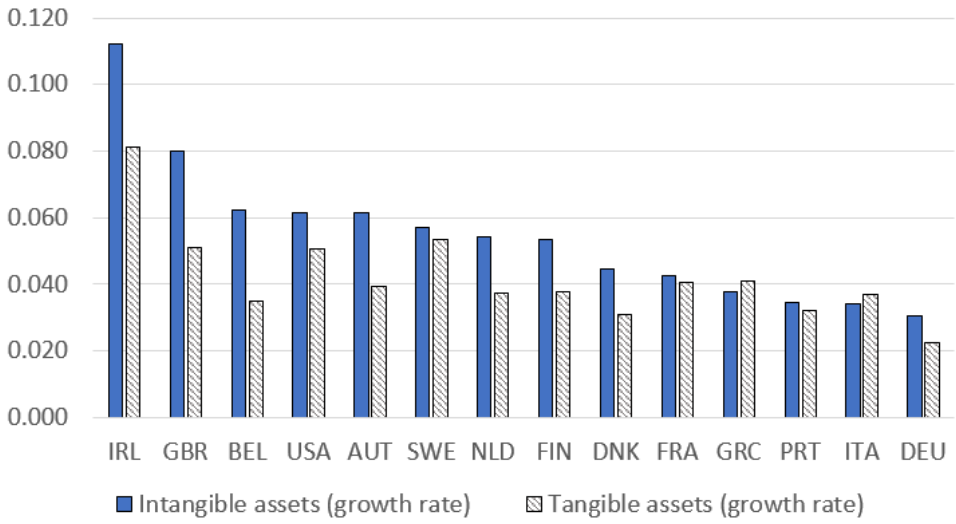


Figure 2: The effects of financial development on productivity growth conditional on intangible intensity. The figure shows the labour productivity growth across countries (excluding U.S.) by intangible intensity quintiles after removing the effects of catching-up, capital stock and sector and country-year fixed effects. Labour productivity is calculated as value added per employee. Intangible asset intensity is defined as the median sector-level value of the ratio between intangible assets and total assets. It is calculated for all U.S. listed firms in Compustat from 1990-2006, excluding financial, utilities and public service. Source: OECD, STAN database, Compustat.

Panel A: Average growth rate of tangible and intangible assets, 1995-2014



Panel B: Investment in intangible assets (as a percentage of GDP) across countries

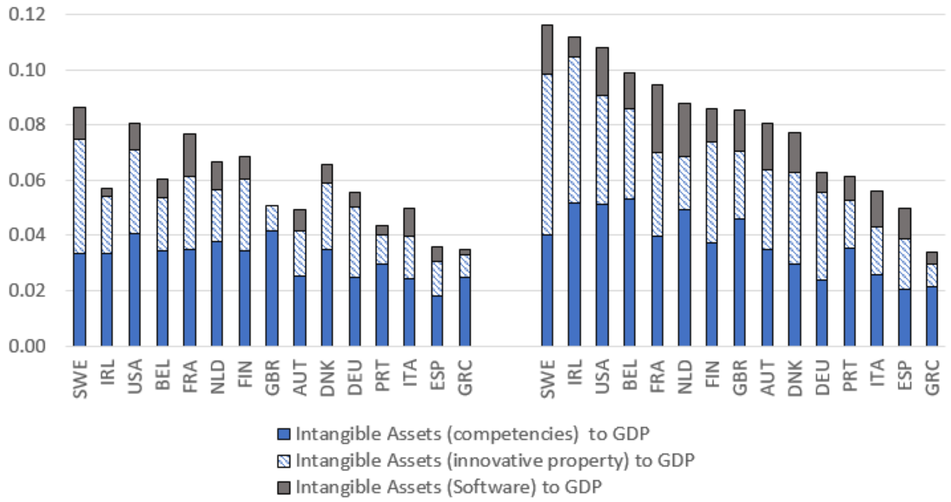
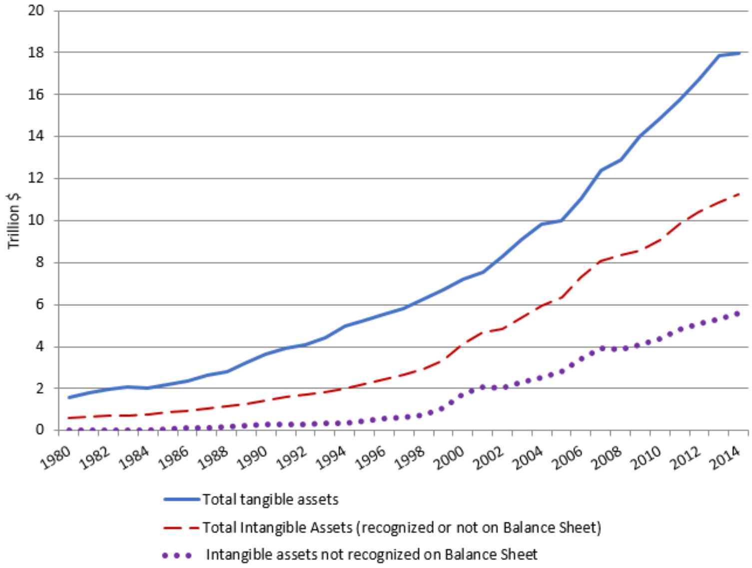


Figure 3: Intangible assets across countries. Panel A shows the average of the yearly growth rates in either the stock of intangible capital (blue bars) or the stock of tangible capital (dashed bars) for selected OECD countries during the 1995-2014 period (the only exceptions are Italy and Portugal, for which we evaluate the 2000-2014 period, due to limited data availability in earlier years). The stock of intangible assets is calculated as in Corrado et al. (2016). Panel B This figure shows the rise in the stock of intangible assets as a share of GDP by comparing the intangibles to GDP ratio in 1995 (the only exception is Portugal, for which we use 2000, the first available date) and 2014 in a sample of OECD countries. Intangible assets are calculated as in Corrado et al. (2016). Source: IntanInvest, OECD National Accounts Database.

Panel A: Intangible and Tangible Assets in the United States



Panel B: Intangible Assets Intensity (ratio of intangible assets to total assets) in the United States

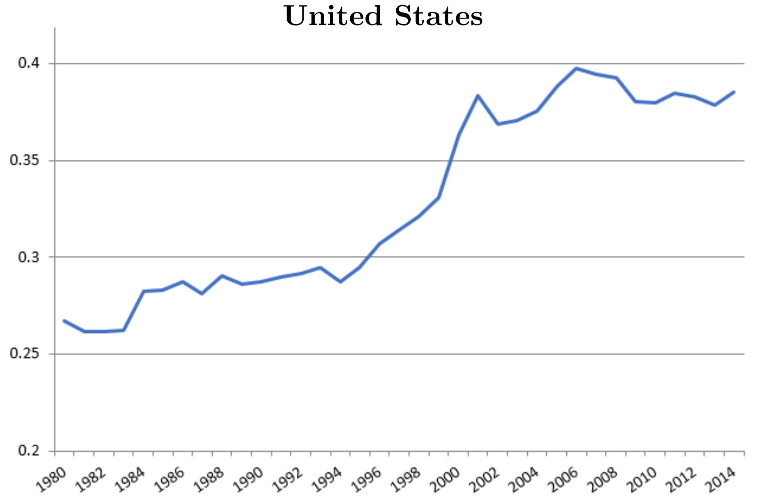


Figure 4:
Intangible and tangible assets across countries. Panel A shows intangible assets estimated based on the methodology described in Peters and Taylor (2017). Tangible capital stock is defined as the cumulative investment in plant and equipment. The dotted line shows the level of intangibles that is not recognized on balance sheet according to the U.S. accounting standards. Panel B shows the intangible asset intensity which is defined as the median sector-level value of the ratio between intangible assets and total assets. It is calculated for all U.S. listed firms in Compustat from 1990-2006, excluding financial, utilities and public service. Source: Compustat.

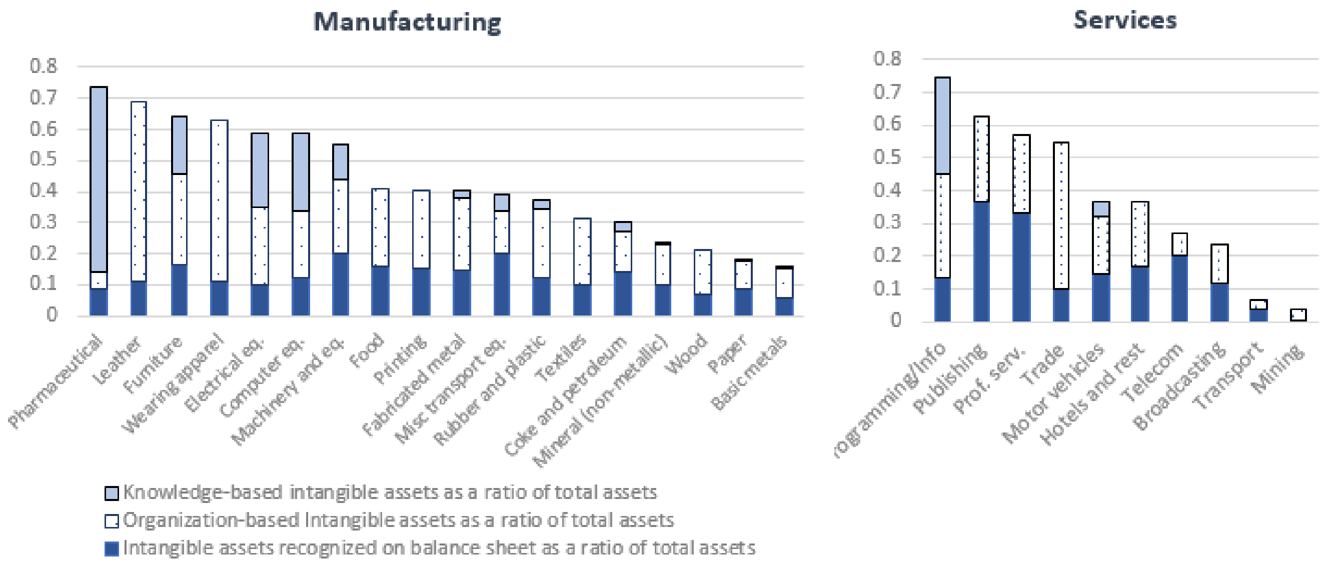


Figure 5: Organization and knowledge based intangible assets by sector. Intangible asset intensity is defined as the median sector-level value of the the ratio between intangible assets and total assets. It is calculated for all U.S. listed firms in COMPUSTAT from 1990-2006. Intangible assets are differentiated into knowledge- and organization- based assets, as in Peters and Taylor (2017). The sample includes all U.S listed firms excluding financial, utilities and public service. Source: Compustat.

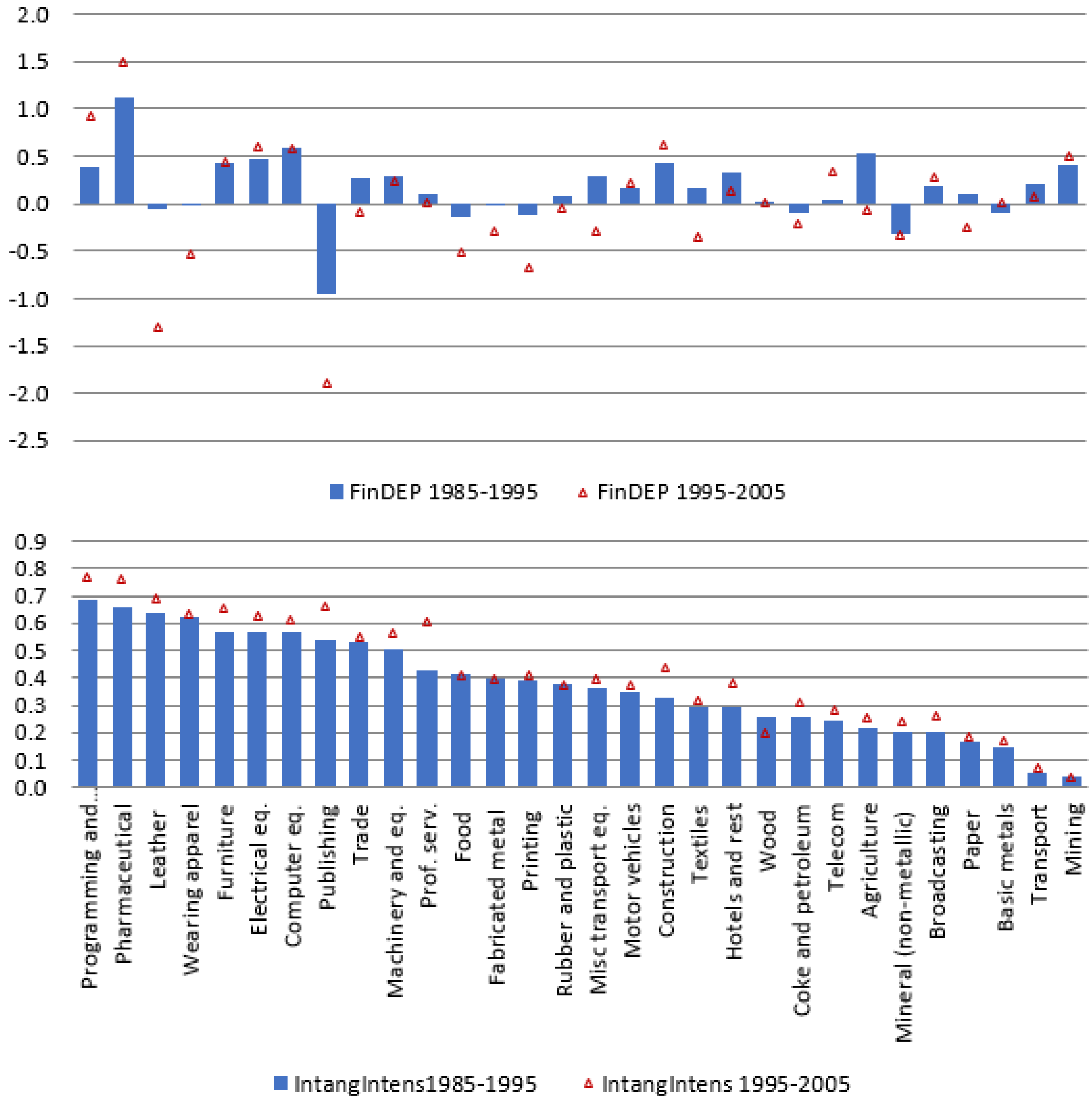


Figure 6: External Financial Dependency and Intangible Assets Intensity over time. External financial dependency is defined as the ratio between cumulative capital expenditures (including R&D) minus cumulative cash flow from operations and cumulative capital expenditures calculated at firm level over a 10-year rolling window from 1980 to 2006. The sample includes all U.S firms, excluding financial, utilities and public service. Negative value indicates reliance on external finance. Source: Compustat

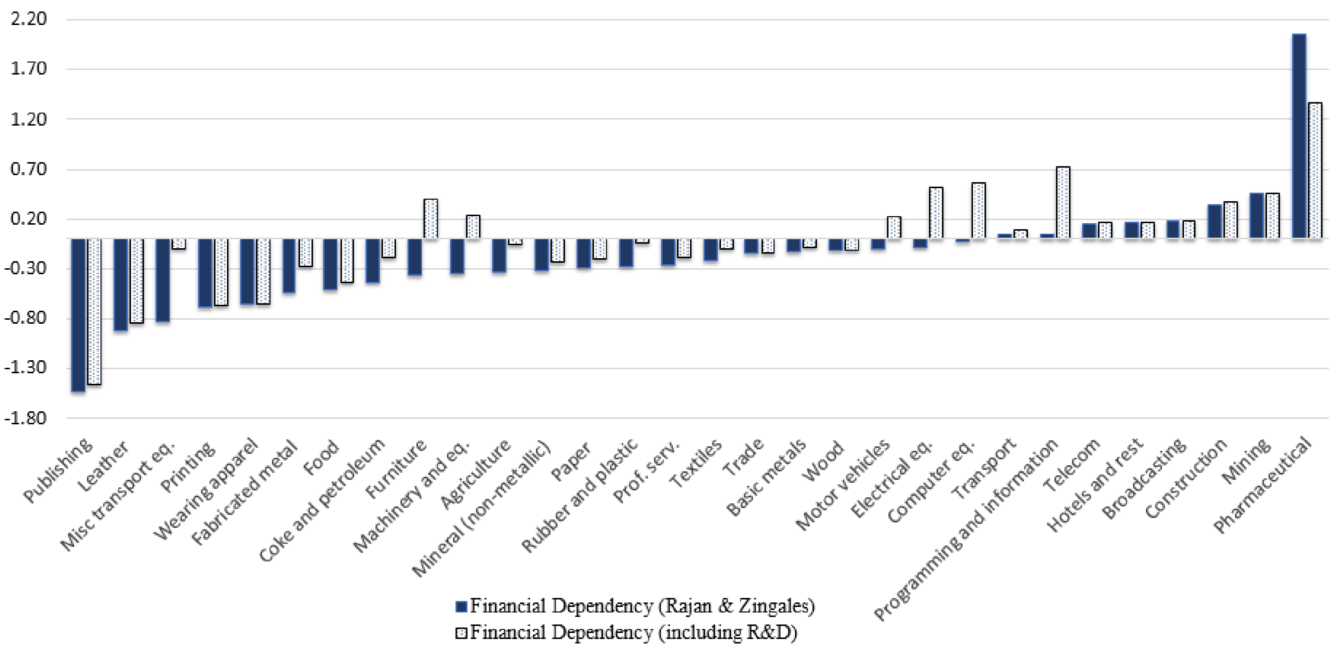


Figure 7: Financial Dependency with and without intangibles. External financial dependency is calculated as in Rajan and Zingales (1998), extended over 1990-2006. External financial dependency (including R&D) is the external financial dependency that includes R&D expenditures. It is defined as the ratio between cumulative capital expenditures (including R&D) minus cumulative cash flow from operations and cumulative capital expenditures calculated at firm level from 1980 to 2006. For more details see Box 1. The sample includes all U.S firms in Compustat, excluding financial, utilities and public service. Source: Compustat

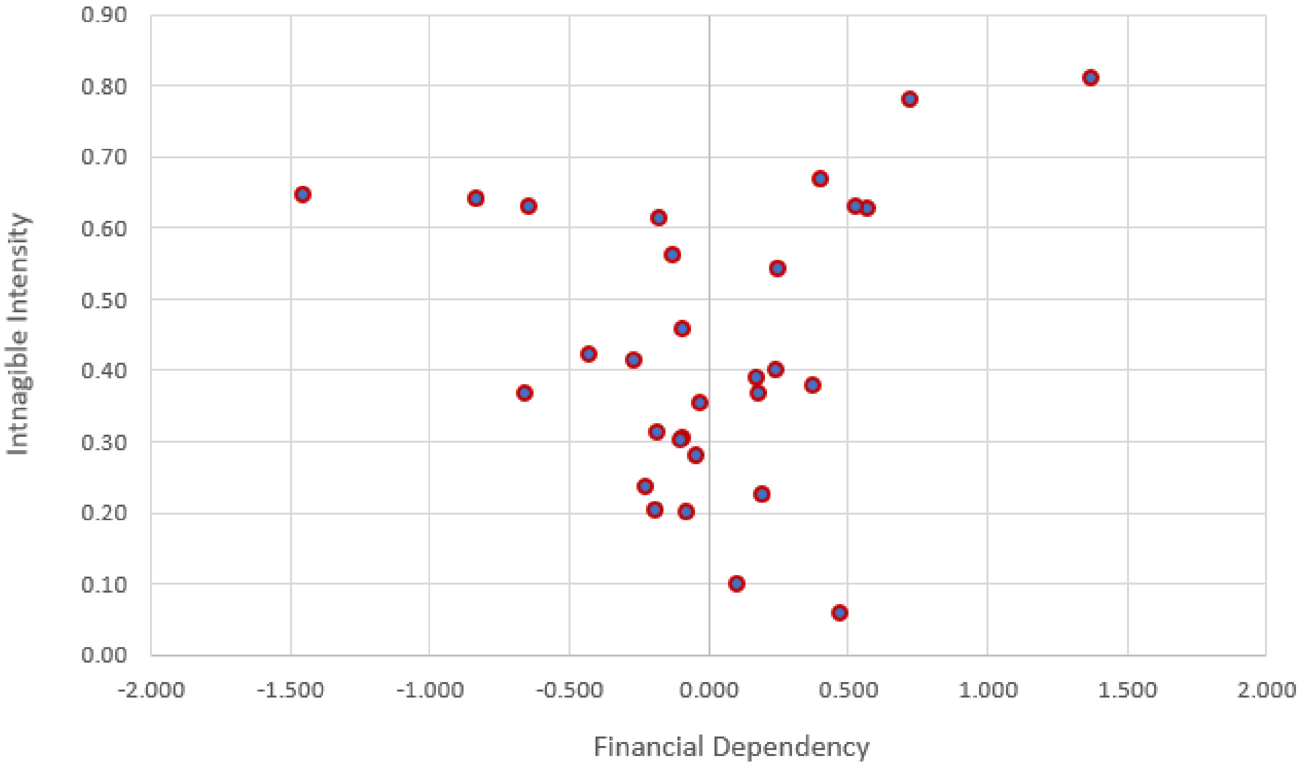


Figure 8: External financial dependency and intangible asset intensity are independent phenomena. Financial dependency is the ratio between cumulative capital expenditures (and R&D) minus cumulative cash flow from operations and cumulative capital expenditures (and R&D) calculated as firm level from 1990 to 2006. Intangible asset intensity is defined as the median sector-level value of the ratio between intangible assets and total assets. It is calculated for all U.S. listed firms in Compustat from 1990-2006, excluding financial, utilities and public service. Source: Compustat.

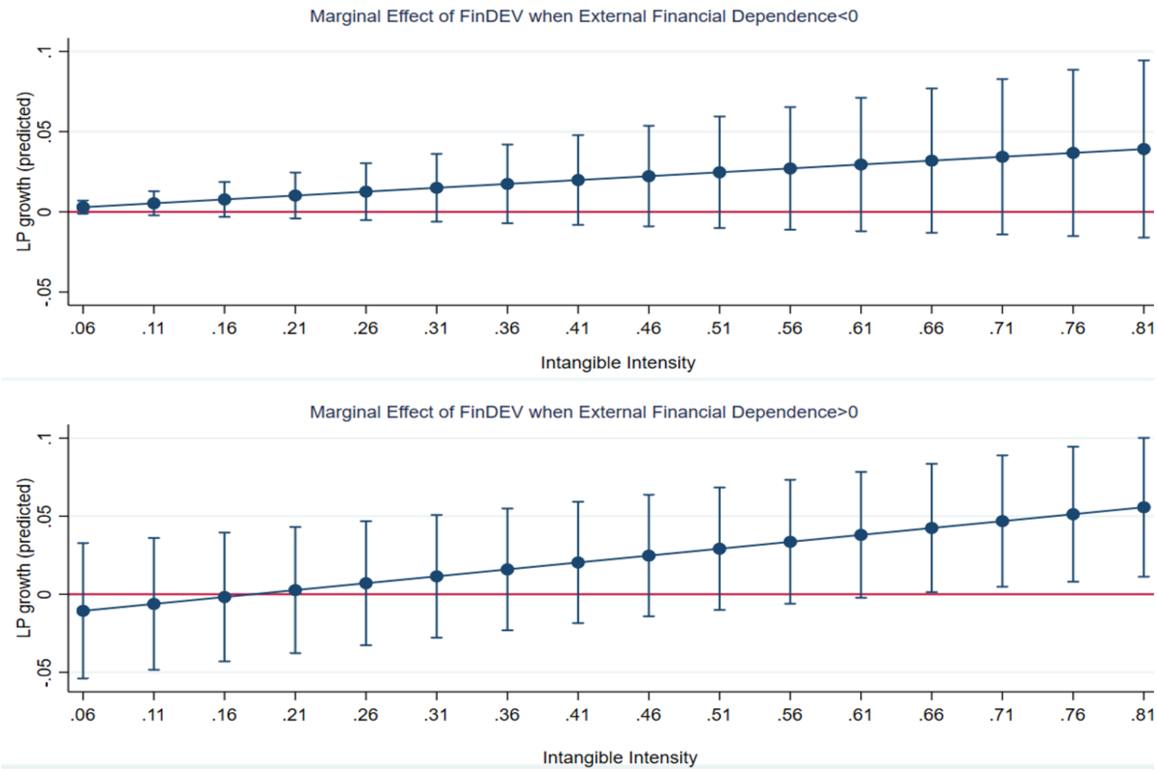


Figure 9: The effects of financial development on productivity growth conditional on intangible intensity and external financial dependency. The figure shows the marginal effects (equation 3) separately for positive financial dependency (on top) and negative financial dependency (on bottom). Marginal effects are estimated using the regression presented in Table 2, column 6. Vertical lines report confidence intervals and show non-significant effects when the value zero is within the interval.

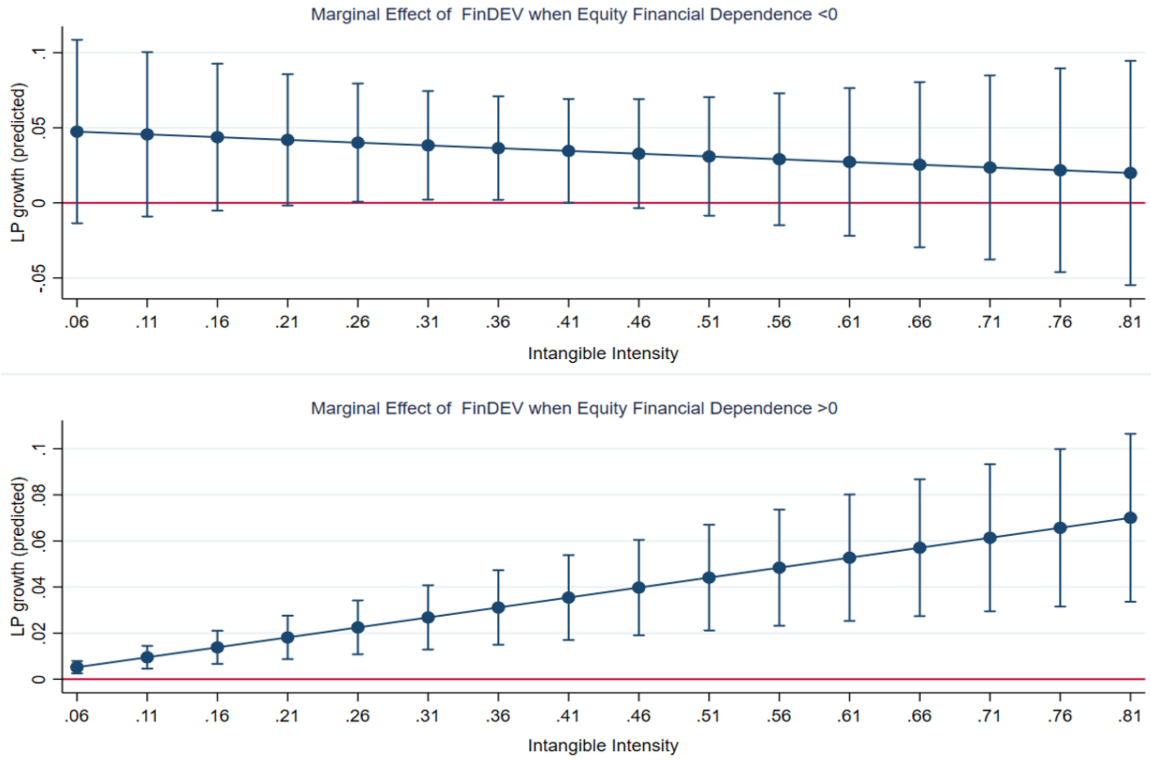


Figure 10: Marginal Effect of Financial Development based on Equity Financial Dependency. The figure shows the marginal effects (equation 3) separately for positive equity financial dependency (on top) and zero equity financial dependency (on bottom). Marginal effects are estimated using the regression presented in Table 4, column 1. Vertical lines report confidence intervals and show non-significant effects when the value zero is within the interval.

Table 1: Intangible Intensity by sector.
The table reports intangible intensity calculated from COMPUSTAT for all U.S. firms from 1990-2006. The mean and the median are calculated at the industry-year level. The knowledge- and organizational-based measures are described in the text. The smooth version is the industry-median intensity calculated at the firm level.

		Intangible Capital Intensity				
Sector	Sector name	Median	Mean	Knowledge based	Organization based	Smooth
D01T03	Agriculture	0.24	0.25	0.00	0.12	0.28
D05T09	Mining	0.04	0.04	0.00	0.03	0.06
D10T12	Food	0.41	0.41	0.00	0.25	0.42
D13	Textiles	0.31	0.31	0.00	0.21	0.31
D14	Wearing apparel	0.63	0.64	0.00	0.52	0.63
D15	Leather	0.69	0.68	0.00	0.58	0.64
D16	Wood	0.21	0.22	0.00	0.14	0.30
D17	Paper	0.18	0.18	0.00	0.09	0.21
D18	Printing	0.41	0.40	0.00	0.25	0.37
D19	Coke and petroleum	0.30	0.30	0.03	0.13	0.31
D21	Pharmaceutical	0.74	0.74	0.60	0.05	0.81
D22	Rubber and plastic	0.37	0.37	0.03	0.22	0.36
D23	Mineral (non-metallic)	0.23	0.23	0.00	0.13	0.24
D24	Basic metals	0.15	0.17	0.00	0.10	0.20
D25	Fabricated metal	0.40	0.40	0.02	0.23	0.42
D26	Computer eq.	0.59	0.60	0.25	0.21	0.63
D27	Electrical eq.	0.59	0.62	0.24	0.25	0.63
D28	Machinery and eq.	0.56	0.55	0.11	0.24	0.54
D29	Motor vehicles	0.37	0.37	0.05	0.17	0.40
D30	Misc transport eq.	0.39	0.39	0.05	0.14	0.46
D31T33	Furniture	0.64	0.63	0.18	0.29	0.67
D41T43	Construction	0.38	0.41	0.00	0.22	0.38
D45T47	Trade	0.55	0.55	0.00	0.45	0.56
D49T53	Transport	0.07	0.07	0.00	0.03	0.10
D55T56	Hotels and rest	0.37	0.36	0.00	0.20	0.39
D58	Publishing	0.63	0.63	0.00	0.26	0.65
D59T60	Broadcasting	0.24	0.26	0.00	0.12	0.23
D61	Telecom	0.27	0.28	0.00	0.07	0.37
D62TD63	Programming / Info	0.75	0.75	0.30	0.31	0.78
D69T82	Prof. serv.	0.57	0.56	0.00	0.24	0.62

Table 2: Financial Dependence measures by sector.
The table reports financial dependence calculated from COMPUSTAT for all U.S. firms from 1990-2006. The mean and the median are calculated at the industry-year level. The knowledge- and organizational-based measures are described in the text. The smooth version is the industry-median at the smoothed intensity calculated at the firm level.

	FinDep (RZ)	FinDep (+ R&D)	Findep (+R&D +Intang)	Equity FinDep	Debt FinDep
Publishing	-1.532	-1.458	-0.024	0.050	0.142
Leather	-0.913	-0.840	0.433	0.294	0.057
Misc transport eq.	-0.828	-0.096	-0.163	0.008	0.071
Printing	-0.674	-0.667	-0.048	0.008	0.018
Wearing apparel	-0.654	-0.647	-0.175	0.107	-0.025
Fabricated metal	-0.531	-0.273	-0.133	0.031	-0.045
Food	-0.504	-0.434	-0.049	0.018	0.154
Coke and petroleum	-0.431	-0.189	-0.159	0.000	0.113
Furniture	-0.360	0.396	-0.203	0.021	-0.022
Machinery and eq.	-0.351	0.239	-0.104	0.000	0.045
Agriculture	-0.326	-0.048	1.288	0.370	0.011
Mineral (non-metallic)	-0.320	-0.232	-0.024	0.000	0.022
Paper	-0.281	-0.197	-0.154	0.000	-0.015
Rubber and plastic	-0.276	-0.038	-0.048	0.069	0.094
Prof. serv.	-0.264	-0.184	-0.125	0.000	0.021
Textiles	-0.210	-0.101	0.406	0.123	0.000
Trade	-0.147	-0.133	0.328	0.125	0.000
Basic metals	-0.127	-0.084	0.110	0.068	-0.009
Wood	-0.107	-0.107	0.135	0.031	0.094
Motor vehicles	-0.095	0.233	-0.070	0.015	0.164
Electrical eq.	-0.075	0.520	0.213	0.106	-0.002
Computer eq.	-0.016	0.566	0.205	0.102	0.264
Transport	0.049	0.094	-0.035	0.027	0.049
Programming / Info	0.057	0.717	0.049	0.068	0.019
Telecom	0.148	0.170	0.073	0.167	0.000
Hotels and rest	0.161	0.163	-0.424	0.000	-0.022
Broadcasting	0.187	0.187	0.156	0.355	0.139
Construction	0.336	0.370	0.130	0.243	0.350
Mining	0.463	0.463	0.447	0.266	-0.004
Pharmaceutical	2.061	1.368	-0.066	0.217	0.001

Table 3: Baseline specification using time-invariant measures for financial development.
The table reports the coefficient estimates for the following linear model: $\Delta logLP_{c,j,t+1} = \beta_0 + \beta_1 IntK_{j,t} + \beta_2(FinDEV_{c,t} \times IntangIntens_{j,t}) + \beta_2 LP_{c,j,t} + \beta_3 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1}$ where the dependent variable is labor productivity growth calculated as value added per employee. Intangible intensity at the sectoral level is computed from U.S. firm-level data: time-varying (filtered using GDP growth rate or non-filtered), or smoothed over the period. Country-level financial development variables are domestic credit (as a % GDP) or market capitalization (as a % GDP) at the beginning of the sample. $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. Country-year and industry level fixed effects are included. Significance levels are denoted by *, **, ***, which correspond to 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FinDEV variable	Domestic credit (initial)	Domestic credit (initial)	Domestic credit (initial)	Domestic credit (initial)	Market cap (initial)	Market cap (initial)	Market cap (initial)	Market cap (initial)
Initial Labour Productivity	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***	-0.025***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change Capital Stock	0.059	0.060*	0.060*	0.061*	0.059	0.060*	0.060*	0.061*
	(0.101)	(0.098)	(0.098)	(0.090)	(0.102)	(0.099)	(0.099)	(0.091)
FinDEV * FinDEP	0.019				-0.038			
	(0.826)				(0.711)			
FinDEV * IntangIntens (smooth)		0.383***				0.465***		
		(0.002)				(0.007)		
FinDEV * Intang ntens (median)			0.371***				0.448***	
			(0.002)				(0.009)	
FinDEV * IntangIntens (lag)				0.364***				0.397**
				(0.001)				(0.037)
IntangIntens (lag)				0.008				0.021
				(0.743)				(0.380)
Observations	10,090	10,090	10,090	10,090	10,090	10,090	10,090	10,090
R-squared	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
Year-Country FE	YES	YES	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 4: Baseline specification using time-variant measures for financial development.
The table reports the coefficient estimates for the following linear model: $\Delta logLP_{c,j,t+1} = \beta_0 + \beta_1 IntK_{j,t} + \beta_2(FinDEV_{c,t} \times IntangIntens_{j,t}) + \beta_2 LP_{c,j,t} + \beta_3 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1}$ where the dependent variable is labor productivity growth calculated as value added per employee. Intangible intensity at the sectoral level is computed from U.S. firm-level data: time-varying (filtered using GDP growth rate or non-filtered), or smoothed over the period. Country-level financial development variables are domestic credit (as a % GDP) or market capitalization (as a % GDP) at the beginning of the sample. $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. Intangible intensity at the sectoral level is computed from U.S. firm-level data. It is further refined, based on the methodology described in Peters and Taylor (2017). The R&D expense is considered an investment into knowledge capital while a fraction of the *Selling, General and Administrative* expense (SG&A) is considered an investment into organization capital. Country-year and industry level fixed effects are included. Country-year and industry level fixed effects are included. Significance levels are denoted by *, **, ***, which correspond to 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) IMF Global Fin Index	(2) IMF Fin Markets Dev Index	(3) IMF Fin Inst Index	(4) Domestic credit (initial)	(5) Market cap (initial)	(6) IMF Global Fin Index
Initial Labour Productivity	-0.021***	-0.022***	-0.021***	-0.025***	-0.025***	-0.022***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change Capital Stock	0.079	0.079	0.078	0.060	0.060*	0.079
	(0.125)	(0.126)	(0.128)	(0.100)	(0.099)	(0.125)
FinDEV * IntangIntens (smooth)	0.076**	0.040**	0.083***			
	(0.012)	(0.038)	(0.006)			
FinDEV * IntangIntens (knowledge)				0.657**	0.541**	0.088***
				(0.042)	(0.018)	(0.003)
FinDEV * IntangIntens (organisation)				0.292*	0.263	0.077
				(0.085)	(0.458)	(0.113)
Observations	7,221	7,221	7,221	10,090	10,090	7,221
R-squared	0.143	0.143	0.144	0.139	0.139	0.143
Year-Country FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES

Table 5: Robustness test: additional country-level variables.

The table reports the coefficient estimates for the following linear model: $\Delta logLP_{c,j,t+1} = \beta_0 + \beta_1 IntK_{j,t} + \beta_2(FinDEV_{c,t} \times IntangIntens_{j,t}) + \beta_2 LP_{c,j,t} + \beta_3 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1}$ where the dependent variable is labor productivity growth calculated as value added per employee. Intangible intensity at the sectoral level is computed from U.S. firm-level data: time-varying (filtered using GDP growth rate or non-filtered), or smoothed over the period. Country-level financial development variables are domestic credit (as a % GDP) or market capitalization (as a % GDP) at the beginning of the sample. $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. Intangible intensity at the sectoral level is computed from U.S. firm-level data. It is further refined, based on the methodology described in Peters and Taylor (2017). The R&D expense is considered an investment into knowledge capital while a fraction of the *Selling, General and Administrative* expense (SG&A) is considered an investment into organization capital. Country-year and industry level fixed effects are included. Country-year and industry level fixed effects are included. Significance levels are denoted by *, **, ***, which correspond to 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Initial Labour Productivity	-0.021***	-0.021***	-0.024***	-0.021***	-0.024***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Change Capital Stock	0.080**	0.080**	0.067	0.080**	0.069
	(0.025)	(0.026)	(0.122)	(0.024)	(0.114)
FinDEV * IntangIntens	0.072**	0.054***	0.117**	0.055***	0.096*
	(0.012)	(0.002)	(0.024)	(0.003)	(0.077)
GDP growth * IntangIntens	-0.002			-0.001	-0.004
	(0.728)			(0.870)	(0.436)
Inflation * IntangIntens		0.001		0.000	0.000
		(0.340)		(0.449)	(0.775)
Labour regulation * IntangIntens			-0.005		-0.008
			(0.445)		(0.141)
Observations	7,221	7,221	6,372	7,221	6,372
R-squared	0.144	0.144	0.147	0.144	0.147
Year-Country FE	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES

Table 6: Extended baseline.

The dependent variable is the labour productivity growth calculated as value added per employee. Country-level financial development variables are domestic credit (as a % GDP) or market capitalization (as a % GDP) at the beginning of the sample or the time-varying IMF global financial index. $IntangIntens$ is intangible asset intensity (smoothed). $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. $dFinDEP1$ is a categorical variable equal to 1 if above across-industry median and 0 otherwise. $dFinDEP2$ is a categorical variable equal to 1 if above zero and 0 otherwise. The presented coefficient on the triple effect is equal to the sum of $\beta_1 + \beta_3$ to highlight the full impact on financially dependent sectors . All regressions include sector and country-year fixed effects. Standard errors are clustered at the industry level and pvalues are presented in parenthesis. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

	(1) Domestic credit (initial)	(2) Market cap (initial)	(3) IMF Global Fin Index	(4) Domestic credit (initial)	(5) Market cap (initial)	(6) IMF Global Fin Index
Initial Labour Productivity	-0.025***	-0.025***	-0.021***	-0.025***	-0.025***	-0.021***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Change Capital Stock	0.060*	0.059	0.079	0.060*	0.060	0.079
	(0.099)	(0.102)	(0.125)	(0.100)	(0.100)	(0.125)
FinDEV * IntangIntens	0.043	0.099	0.032	0.171	0.427	0.048
	(0.726)	(0.736)	(0.564)	(0.254)	(0.237)	(0.253)
FinDEV * IntangIntens * dFinDEP1	0.538***	0.588***	0.092**			
	(0.001)	(0.000)	(0.012)			
FinDEV * IntangIntens * dFinDEP2				0.498***	0.482**	0.088**
				(0.002)	(0.014)	(0.012)
FinDEV*dFinDEP1	-0.231***	-0.327	-0.026			
	(0.007)	(0.104)	(0.490)			
FinDEV*dFinDEP2				-0.131	-0.050	-0.016
				(0.199)	(0.840)	(0.564)
Observations	10,090	10,090	7,221	10,090	10,090	7,221
R-squared	0.139	0.139	0.144	0.139	0.139	0.143
Year-Country FE	YES	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES	YES

Table 7: Extended baseline with low and high equity financial dependence.
The table reports the coefficient estimates for the following linear model: $\Delta logLP_{c,j,t+1} = \beta_0 + \beta_1(FinDEV_{c,t} \times IntangIntens_j \times LowEquity_FinDEP) + (\beta_1 + \beta_2) \times (FinDEV_{c,t} \times IntangIntens_j \times HighEquity_FinDEP) + \beta_3(FinDEV_{c,t} \times FinDEPgroup_j) + \beta_4 LP_{c,j,t} + \beta_5 logK_{c,j,t} + \eta_{c,t} + \mu_j + \epsilon_{c,j,t+1}$ where the dependent variable is labor productivity growth calculated as value added per employee. Intangible intensity is calculated first as the median firm level over the period and then as the median of the industry, and it is time invariant. Country-level financial development variables are domestic credit (as a % GDP) or market capitalization (as a % GDP) at the beginning of the sample or IMF financial development variables. $\Delta logLP$ refers to the change of log labor productivity, K to change of log capital stock. Country-year and industry level fixed effects are included. Significance levels are denoted by *, **, ***, which correspond to 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
FinDEV measures	Domestic credit (initial)	Market cap (initial)	IMF Global Fin Index	IMF Fin Markets Depth Index	IMF Fin Inst Index
Initial Labour Productivity	-0.025***	-0.025***	-0.021***	-0.022***	-0.022***
	(-5.712)	(-5.566)	(-5.361)	(-5.448)	(-5.437)
FinDEV * IntangIntens	0.152	0.432	0.039	0.003	0.077
	(0.674)	(0.931)	(0.730)	(0.090)	(1.026)
FinDEV * IntangIntens * dEquityFinDEP	0.446***	0.475***	0.084***	0.051**	0.085***
	(3.777)	(2.926)	(3.166)	(2.500)	(3.125)
Change Capital Stock	0.060*	0.060*	0.079	0.079	0.078
	(1.702)	(1.707)	(1.581)	(1.582)	(1.570)
FinDEV *dEquityFinDEP	-0.131	0.026	-0.026	-0.030	0.016
	(-1.085)	(0.092)	(-0.907)	(-1.428)	(0.441)
Observations	10,090	10,090	7,221	7,221	7,221
R-squared	0.139	0.139	0.144	0.144	0.144
Year-Country FE	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES

Table 8: **Micro Level: Baseline Regression, Traditional Financial Constraints Indices.**
The dependent variable is the log of total factor productivity, estimated according to the GMM Wooldridge (2009) approach. Financial constraints at firm-level are proxied by a different index in each specification. The indices labelled as WW are based on coefficients extrapolation from Whited and Wu (2006); the num affix indicates the absolute version, while cat (norm) is the relative version based on deciles of the distribution of the deviations from the country sector median (of the distribution of the normalized scores). Similarly, those labelled as SAFE are built on coefficients extrapolation based on the outcome of the SAFE survey, as reported by Ferrando et al (2015); vA stands for the absolute index expressed in deciles, while vB is its relative version. Further details are provided in the text. Intangible Intensity is a categorical binary variable that takes value 1 if sectoral intangible intensity is above the median and 0 if below the median. Intangible intensity is measured as the sum of intangible assets over the sum of total assets over the 1990 to 2006 period for each U.S. listed firm with available data in Compustat; firm level estimates are aggregated at sector level by taking the median-firm intangible intensity ratio of each sector. The remaining explanatory variables are included as controls; while the details about their construction and sources are provided in the text, it is worth noticing that ebitda is divided by 10 mln to adjust the scale of the coefficient. All specifications include firm and country by sector by year fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Dependent Variable: Log TFP					
Intangible Intensity Measure: IntK_cat (0-1)	(1)	(2)	(3)	(4)	(5)
Financial Constraints Indices	WW_num	WW_cat	WW_norm	SAFE_vA	SAFE_vB
Financial Constraints	**-0.915*****	**-0.024*****	**-0.071*****	**-0.012*****	**-0.009*****
	(-99.0)	**(-114.6)**	**(-103.9)**	**(-47.7)**	**(-45.4)**
Financial Constraints * Intangible Intensity	**-0.375*****	**-0.008*****	**-0.028*****	**-0.002*****	**-0.001*****
	(-31.6)	**(-28.9)**	**(-32.0)**	**(-6.2)**	**(-2.9)**
Log of Total Assets	0.121***	0.123***	0.121***	0.148***	0.151***
	(110.3)	(113.7)	(110.4)	(163.9)	(172.2)
Total Assets * Intangible Intensity	-0.035***	-0.030***	-0.035***	-0.016***	-0.015***
	(-24.6)	(-21.5)	(-25.3)	(-14.1)	(-13.8)
Ebitda	0.008***	0.008***	0.011***	0.008***	0.008***
	(5.4)	(5.5)	(4.9)	(6.1)	(6.1)
Ebitda * Intangible Intensity	0.006***	0.006***	0.003	0.008***	0.008***
	(3.2)	(3.4)	(1.2)	(4.6)	(4.6)
Log of Age	0.007***	-0.000	0.007***	-0.004***	-0.004***
	(3.5)	(-0.1)	(3.5)	(-2.9)	(-2.6)
Age * Intangible Intensity	0.021***	0.018***	0.021***	0.016***	0.016***
	(8.0)	(6.9)	(8.1)	(8.6)	(8.7)
Observations	7,459,986	7,459,986	7,459,881	10,008,230	10,008,230
R-squared	0.819	0.818	0.819	0.809	0.809
Country-Sector-Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Table 9: **Micro Level: Baseline Regression, DFS Financial Constraints Indices.**

The dependent variable is the log of total factor productivity, estimated according to the GMM Wooldridge (2009) approach. Financial constraints at firm-level are proxied by a different index in each specification. The DFS indices consist in a revisited version of the financial constraints index developed by Musso and Schiavo (2008); among them, in those labelled as vA (vB), the reference group is a given country-sector-year (country-sector) cell. In vA2 (vB2), the aggregation strategy changes: not the sum of the scores for each component of the index as in vA (vB), but rather the number of variables for which the firm lies in the fifth quintile of the distribution. The PCA version is built from a principal component analysis (first component) on the scores of each variable included in the index. Further details are provided in the text. Intangible Intensity is a categorical binary variable that takes value 1 if sectoral intangible intensity is above the median and 0 if below the median. Intangible intensity is measured as the sum of intangible assets over the sum of total assets over the 1990 to 2006 period for each U.S. listed firm with available data in Compustat; firm level estimates are aggregated at sector level by taking the median-firm intangible intensity ratio of each sector. The remaining explanatory variables are included as controls; while the details about their construction and sources are provided in the text, it is worth noticing that ebitda is divided by 10 mln to adjust the scale of the coefficient. All specifications include firm and country by sector by year fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

	Dependent Variable: Log TFP				
Intangible Intensity Measure: IntK_cat (0-1)	(1)	(2)	(3)	(4)	(5)
Financial Constraints Indices	DFS_vA	DFS_vB	DFS_vA2	DFS_vB2	DFS_PCA
Financial Constraints	**-0.029*** **	**-0.030*** **	**-0.019*** **	**-0.020*** **	**-0.034*** **
	(-111.8)	**(-113.2)**	**(-87.2)**	**(-91.3)**	**(-123.0)**
Financial Constraints * Intangible Intensity	**-0.012*** **	**-0.012*** **	**-0.008*** **	**-0.008*** **	**-0.013*** **
	(-35.8)	**(-36.6)**	**(-27.8)**	**(-27.6)**	**(-37.4)**
Log of Total Assets	0.168***	0.168***	0.156***	0.156***	0.176***
	(179.8)	(179.9)	(195.7)	(195.3)	(187.0)
Total Assets * Intangible Intensity	-0.019***	-0.019***	-0.014***	-0.014***	-0.015***
	(-15.6)	(-15.8)	(-13.9)	(-13.7)	(-12.4)
Ebitda	0.006***	0.006***	0.007***	0.007***	0.006***
	(5.8)	(5.8)	(6.0)	(6.0)	(5.7)
Ebitda * Intangible Intensity	0.005***	0.005***	0.007***	0.007***	0.005***
	(3.7)	(3.7)	(4.1)	(4.2)	(3.5)
Log of Age	-0.017***	-0.019***	-0.020***	-0.029***	-0.013***
	(-10.4)	(-11.5)	(-13.4)	(-19.7)	(-8.0)
Age * Intangible Intensity	0.011***	0.011***	0.009***	0.005***	0.013***
	(5.4)	(5.0)	(4.6)	(2.6)	(6.1)
Observations	8,098,713	8,098,713	8,098,713	8,098,713	8,098,713
R-squared	0.816	0.816	0.807	0.807	0.816
Country-Sector-Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Table 10: Micro Level: Robustness, Alternative Intangible Intensity Measures.

The dependent variable is the log of total factor productivity, estimated according to the GMM Wooldridge (2009) approach. Financial constraints at firm-level are proxied by our baseline index, DFS_vB, which is a revisited version of the financial constraints index developed by Musso and Schiavo (2008). Each specification employs a different measure of intangible intensity. In specification (1), intangible intensity is measured as the sum of intangible assets over the sum of total assets over the period for each U.S. listed firm with available data in Compustat; firm level estimates are aggregated at sector level by taking the median-firm intangible intensity ratio of each sector. In specification (2), we calculate the ratio of intangibles over total assets for each firm-year; then, for each firm, we find the median value over the period and, finally, take the industry median for each sector. Specifications (3) and (4) exploit separately the two sub-components (details in the text) of intangible intensity: the knowledge and the organizational pieces, respectively. The remaining explanatory variables are included as controls; while the details about their construction and sources are provided in the text, it is worth noticing that ebitda is divided by 10 mln to adjust the scale of the coefficient. All specifications include firm and country by sector by year fixed effects *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Dependent Variable: Log TFP				
Financial Constraints Index: DFS_vB	(1)	(2)	(3)	(4)
Intangible Intensity Measures	IntK_cont	IntK_Med	IntK_Know	IntK_Org
Financial Constraints	**-0.029*** **	**-0.028*** **	**-0.037*** **	**-0.023*** **
	(-59.1)	**(-57.8)**	**(-211.8)**	**(-61.4)**
Financial Constraints * Intangible Intensity	**-0.018*** **	**-0.022*** **	**-0.027*** **	**-0.050*** **
	(-18.6)	**(-21.4)**	**(-12.0)**	**(-40.1)**
Log of Total Assets	0.196***	0.190***	0.160***	0.143***
	(111.5)	(110.1)	(257.1)	(104.5)
Total Assets * Intangible Intensity	-0.081***	-0.072***	-0.142***	0.049***
	(-23.1)	(-19.9)	(-17.6)	(10.8)
Ebitda	0.006***	0.006***	0.011***	0.000
	(3.0)	(3.0)	(8.9)	(0.2)
Ebitda * Intangible Intensity	0.006	0.008**	-0.014***	0.048***
	(1.6)	(2.0)	(-4.6)	(6.2)
Log of Age	-0.025***	-0.023***	-0.014***	-0.012***
	(-8.1)	(-7.5)	(-12.8)	(-5.1)
Age * Intangible Intensity	0.027***	0.023***	0.055***	-0.003
	(4.2)	(3.5)	(3.4)	(-0.4)
Observations	8,098,713	8,098,713	8,098,713	8,098,713
R-squared	0.816	0.816	0.816	0.816
Country-Sector-Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES

Table 11: Micro Level: Robustness, Continuous Intangible Intensity and Alternative Financial Constraints.

The dependent variable is the log of total factor productivity, estimated according to the GMM Wooldridge (2009) approach. Financial constraints at firm-level are proxied by a different index in each specification. The DFS indices consist in a revisited version of the financial constraints index developed by Musso and Schiavo (2008); among them, in those labelled as vA (vB), the reference group is a given country-sector-year (country-sector) cell. In vA2 (vB2), the aggregation strategy changes: not the sum of the scores for each component of the index as in vA (vB), but rather the number of variables for which the firm lies in the fifth quintile of the distribution. The PCA version is built from a principal component analysis (first component) on the scores of each variable included in the index. The indices labelled as WW are based on coefficients extrapolation from Whited and Wu (2006); the num affix indicates the absolute version, while cat (norm) is the relative version based on deciles of the distribution of the deviations from the country sector median (of the distribution of the normalized scores). Similarly, those labelled as SAFE are built on coefficients extrapolation based on the outcome of the SAFE survey, as reported by Ferrando et al (2015); vA stands for the absolute index expressed in deciles, while vB is its relative version. Further details are provided in the text. Intangible Intensity is a continuous variable. The remaining explanatory variables are included as controls; while the details about their construction and sources are provided in the text, it is worth noticing that ebitda is divided by 10 mln to adjust the scale of the coefficient. All specifications include firm and country by sector by year fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

	Dependent Variable: Log TFP								
Intangible Intensity Measure: IntK_cont	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Financial Constraints Indices	WW_num	WW_cat	WW_norm	SAFE_vA	SAFE_vB	DFS_vA	DFS_vA2	DFS_vB2	DFS_PCA
Financial Constraints	**-0.937*** **	**-0.024*** **	**-0.070*** **	**-0.010*** **	**-0.007*** **	**-0.029*** **	**-0.019*** **	**-0.020*** **	**-0.033*** **
	(-54.6)	**(-60.7)**	**(-54.8)**	**(-22.6)**	**(-20.1)**	**(-59.3)**	**(-47.5)**	**(-49.0)**	**(-65.5)**
Financial Constraints * Intangible Intensity	**-0.400*** **	**-0.011*** **	**-0.036*** **	**-0.005*** **	**-0.005*** **	**-0.017*** **	**-0.009*** **	**-0.009*** **	**-0.018*** **
	(-11.7)	**(-13.6)**	**(-14.1)**	**(-5.2)**	**(-6.9)**	**(-17.4)**	**(-10.8)**	**(-11.5)**	**(-17.7)**
Log of Total Assets	0.145***	0.148***	0.145***	0.177***	0.181***	0.195***	0.184***	0.184***	0.203***
	(71.3)	(73.6)	(71.6)	(101.7)	(106.7)	(111.4)	(120.4)	(120.3)	(115.2)
Total Assets * Intangible Intensity	-0.092***	-0.090***	-0.095***	-0.081***	-0.081***	-0.080***	-0.075***	-0.076***	-0.076***
	(-22.8)	(-22.4)	(-23.6)	(-23.6)	(-24.2)	(-22.8)	(-25.0)	(-25.0)	(-21.6)
Ebitda	0.008***	0.009***	0.012***	0.008***	0.008***	0.006***	0.007***	0.007***	0.006***
	(3.1)	(3.2)	(3.5)	(3.1)	(3.0)	(3.0)	(3.1)	(3.1)	(3.0)
Ebitda * Intangible Intensity	0.005	0.005	0.002	0.009*	0.009*	0.006	0.007*	0.008*	0.005
	(1.1)	(1.1)	(0.3)	(1.9)	(1.9)	(1.6)	(1.7)	(1.8)	(1.5)
Log of Age	-0.001	-0.008**	-0.001	-0.010***	-0.010***	-0.024***	-0.026***	-0.034***	-0.020***
	(-0.2)	(-2.2)	(-0.3)	(-3.6)	(-3.4)	(-7.7)	(-9.2)	(-11.9)	(-6.5)
Age * Intangible Intensity	0.045***	0.041***	0.045***	0.034***	0.034***	0.029***	0.024***	0.016***	0.032***
	(5.7)	(5.3)	(5.8)	(6.0)	(5.9)	(4.6)	(4.3)	(2.8)	(5.0)
Observations	7,459,986	7,459,986	7,459,881	10,008,230	10,008,230	8,098,713	8,098,713	8,098,713	8,098,713
R-squared	0.818	0.818	0.818	0.809	0.809	0.816	0.807	0.807	0.816
Country-Sector-Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 12: Micro Level: Labor Productivity as Dependent Variable.
The dependent variable is the log of value added based labor productivity, calculated as the ratio of value added over the number of employees. Financial constraints at firm-level are proxied by our baseline index, DFS_vB, which is a revisited version of the financial constraints index developed by Musso and Schiavo (2008). It is constructed as follows: for each of the eight components of the index, we calculate the deviation from the country-sector median; then, we divide into quintiles the resulting distributions of deviations from the median, so that, for each firm-year observation, we have eight scores that range from 1 to 5, in which 1 contains the smallest value; finally, we aggregate information by summing up the eight scores and rescale the index on $0-10$ basis. Each specification employs a different measure of intangible intensity. In specification (1) intangible intensity is a categorical binary variable that takes value 1 if sectoral intangible intensity is above the median and 0 if below the median, while in model (2) it is a continuous variable. In both cases, intangible intensity is measured as the sum of intangible assets over the sum of total assets over the 1990 to 2006 period for each U.S. listed firm with available data in Compustat; firm level estimates are aggregated at sector level by taking the median-firm intangible intensity ratio of each sector. In specification (3), we calculate the ratio of intangibles over total assets for each firm-year; then, for each firm, we find the firm median over the period and, finally, take the industry median for each sector. Specifications (4) and (5) exploits separately the two sub-components (details in the text) of intangible intensity: the knowledge and the organizational pieces, respectively. The remaining explanatory variables are included as controls; while the details about their construction and sources are provided in the text, it is worth noticing that ebitda is divided by 10 mln to adjust the scale of the coefficient. All specifications include firm and country by sector by year fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

Dependent Variable: Log Labor Productivity					
Financial Constraints Index: DFS_vB	(1)	(2)	(3)	(4)	(5)
Intangible Intensity Measures	IntK_cat	IntK_cont	IntK_Med	IntK_Know	IntK_Org
Financial Constraints	**-0.019*** **	**-0.019*** **	**-0.017*** **	**-0.026*** **	**-0.013*** **
	(-68.8)	**(-36.0)**	**(-34.5)**	**(-141.2)**	**(-33.1)**
Financial Constraints * IntangIntens	**-0.012*** **	**-0.017*** **	**-0.020*** **	**-0.027*** **	**-0.047*** **
	(-33.9)	**(-16.5)**	**(-19.0)**	**(-11.4)**	**(-35.6)**
Log of Total Assets	0.117***	0.139***	0.135***	0.109***	0.105***
	(117.7)	(74.5)	(73.7)	(163.6)	(71.9)
Total Assets * IntangIntens	-0.020***	-0.070***	-0.065***	-0.130***	0.001
	(-15.7)	(-18.9)	(-17.0)	(-15.5)	(0.2)
Ebitda	0.006***	0.006***	0.005***	0.009***	0.000
	(5.6)	(3.0)	(2.9)	(8.8)	(0.4)
Ebitda * IntangIntens	0.004***	0.005	0.006*	-0.012***	0.040***
	(3.5)	(1.4)	(1.8)	(-4.5)	(6.0)
Log of Age	-0.051***	-0.060***	-0.058***	-0.051***	-0.049***
	(-27.9)	(-17.6)	(-17.5)	(-42.8)	(-18.8)
Age * IntangIntens	0.002	0.020***	0.018**	0.037**	-0.003
	(0.7)	(3.0)	(2.6)	(2.2)	(-0.4)
Observations	8,153,060	8,153,060	8,153,060	8,153,060	8,153,060
R-squared	0.757	0.757	0.757	0.757	0.757
Country-Sector-Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES

Table 13: Micro Level: Robustness, Labor Productivity as Dependent Variable and Alternative Financial Constraints Indices.

The dependent variable is the log of value added based labor productivity, calculated as the ratio of value added over the number of employees. Financial constraints at firm-level are proxied by a different index in each specification. The DFS indices consist in a revisited version of the financial constraints index developed by Musso and Schiavo (2008); among them, in those labelled as vA (vB), the reference group is a given country-sector-year (country-sector) cell. In vA2 (vB2), the aggregation strategy changes: not the sum of the scores for each component of the index as in vA (vB), but rather the number of variables for which the firm lies in the fifth quintile of the distribution. The PCA version is built from a principal component analysis (first component) on the scores of each variable included in the index. The indices labelled as WW are based on coefficients extrapolation from Whited and Wu (2006); the num affix indicates the absolute version, while cat (norm) is the relative version based on deciles of the distribution of the deviations from the country sector median (of the distribution of the normalized scores). Similarly, those labelled as SAFE are built on coefficients extrapolation based on the outcome of the SAFE survey, as reported by Ferrando et al (2015); vA stands for the absolute index expressed in deciles, while vB is its relative version. All specifications include firm and country by sector by year fixed effects. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

	Dependent Variable: Log Labor Productivity								
Intangible Intensity Measure: IntK_cat (0-1)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Financial Constraints Indices	WW_num	WW_cat	WW_norm	SAFE_vA	SAFE_vB	DFS_vA	DFS_vA2	DFS_vB2	DFS_PCA
Financial Constraints	**-0.720*** **	**-0.019*** **	**-0.056*** **	**-0.010*** **	**-0.008*** **	**-0.019*** **	**-0.011*** **	**-0.012*** **	**-0.023*** **
	(-74.8)	**(-86.2)**	**(-78.7)**	**(-40.0)**	**(-37.0)**	**(-67.6)**	**(-41.5)**	**(-44.9)**	**(-79.3)**
Financial Constraints * Intangible Intensity	**-0.397*** **	**-0.009*** **	**-0.030*** **	**-0.003*** **	**-0.001*** **	**-0.012*** **	**-0.007*** **	**-0.007*** **	**-0.013*** **
	(-32.1)	**(-30.5)**	**(-32.2)**	**(-8.1)**	**(-4.3)**	**(-33.1)**	**(-21.9)**	**(-21.6)**	**(-35.4)**
Log of Total Assets	0.080***	0.082***	0.080***	0.102***	0.105***	0.117***	0.116***	0.115***	0.122***
	(69.6)	(72.0)	(69.5)	(107.8)	(114.4)	(117.7)	(116.0)	(115.7)	(122.3)
Total Assets * Intangible Intensity	-0.036***	-0.031***	-0.036***	-0.017***	-0.016***	-0.020***	-0.019***	-0.019***	-0.016***
	(-24.2)	(-21.5)	(-24.5)	(-14.3)	(-13.6)	(-15.5)	(-15.0)	(-15.0)	(-12.7)
Ebitda	0.007***	0.007***	0.009***	0.007***	0.007***	0.005***	0.006***	0.006***	0.005***
	(5.2)	(5.3)	(4.6)	(5.9)	(5.9)	(5.6)	(5.7)	(5.7)	(5.6)
Ebitda * Intangible Intensity	0.005***	0.005***	0.002	0.007***	0.007***	0.004***	0.005***	0.005***	0.004***
	(2.9)	(3.1)	(1.1)	(4.4)	(4.4)	(3.4)	(3.7)	(3.8)	(3.2)
Log of Age	-0.033***	-0.039***	-0.033***	-0.037***	-0.037***	-0.050***	-0.051***	-0.056***	-0.047***
	(-14.4)	(-17.1)	(-14.4)	(-23.1)	(-22.9)	(-27.2)	(-27.5)	(-30.2)	(-26.1)
Age * Intangible Intensity	0.009***	0.006**	0.010***	0.007***	0.007***	0.002	-0.001	-0.004	0.004*
	(3.3)	(2.3)	(3.4)	(3.7)	(3.7)	(1.1)	(-0.4)	(-1.6)	(1.7)
Observations	7,514,943	7,514,943	7,514,838	10,085,411	10,085,411	8,153,060	8,153,060	8,153,060	8,153,060
R-squared	0.761	0.761	0.761	0.756	0.756	0.757	0.756	0.756	0.757
Country-Sector-Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES	YES	YES	YES

Table 14: Testing channels: R&D and the collateral constraint.
The dependent variable is the growth of R&D expense, defined at country-sector level. *IntangIntens* is defined as the median sector-level value of the ratio between intangible assets and total assets. *dFinDEV* is a categorical variable equal to one if above the IMF Global Fin Index and zero otherwise. *CapitalStock* refers to the total tangible assets (such as plant and equipment). Standard errors are clustered at the industry level and pvalues are presented in parenthesis. *, **, *** denote statistical significance at the 10%, 5% and 1% levels.

	(1)	(2)	(3)
Dependent variable	R&D Growth	R&D Growth	R&D Growth
R&D Growth (lag)	-0.107***	-0.090**	
	(0.031)	(0.041)	
CapitalStock	0.009*	-0.018*	-0.023
	(0.005)	(0.010)	(0.016)
Growth CapitalStock	0.626***	0.577***	1.189*
	(0.162)	(0.173)	(0.605)
IntntangIntens * Growth CapitalStock	0.017**	0.05	0.042
	(0.008)	(0.032)	(0.043)
IntangIntens * CapitalStock * dFinDEV		0.058***	0.060***
		(0.016)	(0.013)
IntangIntens *dFinDEV		-0.412	
		(0.377)	
CapitalStock * dFinDEV		0.027*	0.025
		(0.013)	(0.016)
Observations	4 831	3 345	3 617
R-squared	0.168	0.167	0.157
Country-Year FE	YES	YES	YES
Sector FE	YES	YES	YES

Table 15: Policy: Venture capital and private equity.
The dependent variable is the labor productivity growth. VC is venture capital relative to GDP (a subset of private equity) refers to equity investment made in early, maturity and buyout stage of business developed by enterprises not quoted on the stock market. Data are extracted from EUROSTAT. Due to a collection break in 2006, the different columns refer to different tome periods. Column 1 covers 2007-2014, Columns 2, 3, and 4 cover 1990-2006 and column 5 covers the entire period, from 1990 to 2014. Country-year and industry fixed effects are included.

	VC Total	VC Stage Buyout	VC Early Stage	VC Stage Maturity	Private Equity
IntangIntens*VC	0.471*	0.064***	0.484**	0.124	0.031**
	(0.063)	(0.005)	(0.040)	(0.330)	(0.015)
Initial Labour Productivity	-0.016	-0.028***	-0.028***	-0.028***	-0.022***
	(0.141)	(0.000)	(0.000)	(0.000)	(0.000)
Change Capital Stock	0.214**	0.008	0.003	0.006	0.102*
	(0.030)	(0.937)	(0.977)	(0.956)	(0.056)
Observations	2,947	3,166	3,166	3,166	6,113
R-squared	0.106	0.136	0.137	0.136	0.118
Country - year FE	YES	YES	YES	YES	YES
Sector FE	YES	YES	YES	YES	YES

Table 16: Robustness: country-year and sector-year fixed effects

Main regressions are re-run with year-country and year-sector fixed effects to control for both macroeconomics and sectoral shocks. The dependent variable is the labor productivity growth. Intangible intensity is the smooth measure. Three different measures of financial development are presented: initial credit, initial market capitalization and time-varying IMF global index. For each of them, the first column shows the baseline regression where intangible intensity is interacted with financial development, the second shows the triple interaction with a dummy for high and low financial dependence, and the third shows the triple interaction with a dummy for high and low equity dependence.

FinDEV variable	Domestic credit (initial)	Domestic credit (initial)	Domestic credit (initial)	Market cap (initial)	Market cap (initial)	Market cap (initial)	IMF Global Fin Index	IMF Global Fin Index	IMF Global Fin Index
Initial Labour Productivity	-0.0249***	-0.0249***	-0.0249***	-0.0250***	-0.0252***	-0.0250***	-0.0215***	-0.0214***	-0.0214***
	(0.00441)	(0.00439)	(0.00440)	(0.00458)	(0.00448)	(0.00453)	(0.00432)	(0.00425)	(0.00430)
Change Capital Stock	0.0638	0.0637*	0.0633	0.0633	0.0627	0.0632	0.0668	0.0666	0.0669
	(0.0375)	(0.0374)	(0.0374)	(0.0375)	(0.0375)	(0.0374)	(0.0555)	(0.0553)	(0.0554)
FinDEV		0.233***				0.0645		0.0763	
		(0.0786)				(0.289)		(0.0585)	
FinDEV * IntangIntens		0.0877	0.164		0.00508	0.317		-0.0692	-0.0153
		(0.119)	(0.220)		(0.301)	(0.466)		(0.101)	(0.107)
FinDEV * IntangIntens *dFinDEP2		0.601***			0.604***			0.0911**	
		(0.153)			(0.145)			(0.0367)	
FinDEV * IntangIntens	0.439***			0.447**			0.0530*		
	(0.123)			(0.167)			(0.0295)		
FinDEV * dEquityFinDEP2			-0.144						-0.0268
			(0.119)						(0.0553)
FinDEV * IntangIntens * dEquityFinDEP2			0.512***			0.482***			0.0694**
			(0.128)			(0.172)			(0.0263)
Country-year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Sector-year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster Sector	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	10,080	10,080	10,080	10,080	10,080	10,080	7,146	7,146	7,146
R-squared	0.222	0.222	0.222	0.222	0.222	0.222	0.247	0.247	0.247