

Macroeconomic Policy, Product Market Competition, and Growth: The Intangible Investment Channel

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Abstract

While there is growing evidence of persistent or even permanent output losses from financial crises, the causes remain unclear. One candidate is intangible capital—a rising driver of economic growth that, being non-pledgeable as collateral, is also vulnerable to financial frictions. By sheltering intangible investment from financial shocks, counter-cyclical macroeconomic policy could thus strengthen longer-term growth, particularly so where strong product market competition prevents firms from self-financing their investments through rents. Using a rich cross-country firm-level dataset and exploiting heterogeneity in firm-level exposure to the sharp and unforeseen tightening of credit conditions around September 2008, we find strong support for these theoretical predictions. The quantitative implications are large, highlighting a powerful stabilizing role for macroeconomic policy through the intangible investment channel, and its complementarity with pro-competition product market deregulation.

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I. INTRODUCTION

There is growing evidence that recessions accompanied by financial crises are associated with large permanent output losses, although the magnitude of these is still being debated (Cerra and Saxena, 2008; Jorda, Schularick and Taylor, 2013; Reinhart and Rogoff, 2009; Romer and Romer, 2017). Even more puzzling, some have argued that even “plain vanilla” recessions are followed by permanently lower output (Blanchard, Cerutti and Summers, 2015). The causes of such large and persistent output losses remain to be determined, but the potential implications for economic theory and policy are daunting—in particular, this gives rise to the possibility that counter-cyclical macroeconomic policy persistently or even permanently affects growth. This paper focuses on the role of intangible investment as a transmission channel. Using cross-country firm-level data and focusing on the 2008-2009 global financial crisis, we show that counter-cyclical macroeconomic policy alleviates intangible investment cuts by credit-constrained firms when financial conditions tighten. We also find that product market competition has the opposite effect, pointing to a complementarity between market deregulation and counter-cyclical macroeconomic policy for growth.

Intangible asset investment is an increasingly important driver of economic growth in advanced economies (Corrado et al., 2005; Corrado et al., 2009).¹ Even focusing only on those intangible assets currently captured in national accounts, and leaving aside other possible sources of under-measurement—such as inaccurate deflators—simple growth accounting suggests that intangible capital accumulation contributed about a third to overall labor productivity growth in the European Union and the United States over the 2000-2013 period (Corrado et al., 2016).²

However, intangible investment is also a potentially vulnerable growth driver. Because—unlike tangible investment—it cannot generally be pledged against collateral or liquidated quickly, it is likely to be particularly vulnerable to continued availability of external or internal sources of finance. Moreover, the inherent uncertainty regarding the outcome of intangible investment magnifies asymmetric information and moral hazard problems would prevail (Hall and Lerner, 2010). For example, building on the work of Holmstrom and Tirole (1997), Aghion et al. (2010) show theoretically that credit constraints can lead firms to cut R&D spending—and long-term illiquid investments more broadly—during recessions. In turn, more

¹ At the firm level, structural estimation of various dynamic models of R&D also point to a significant role of R&D in determining the evolution of productivity over time (e.g., Aw et al., 2011; Doraszelski and Jaumandreu, 2013).

² Only a few intangible assets are currently capitalized in national accounts (SNA 2008), namely R&D, mineral exploration, computer software and databases, as well as entertainment, literary and artistic originals. Expenditures for design, branding, new financial products, organizational capital and firm-provided training are instead currently treated as intermediate costs.

volatile R&D spending can undermine long-term growth if research projects need continuity to bear fruit.

Macroeconomic policy and product market competition and monetary policy should have a bearing on the availability and/or cost of internal and external finance, and thereby on the resilience of intangible investment to sudden shifts in credit conditions. Monetary and fiscal policies have an indirect impact on firms' credit constraints through their effect on output, while monetary policy also influences the cost and availability of bank and non-bank credit (Aghion et al., 2010; Aghion, Hemous and Kharroubi, 2014; Correa-Caro et al., 2018). Likewise, product market competition drives down product market rents and, thereby, the amount of internal funds available for investment projects. For these reasons, there should also be some complementarity between product market reforms and active counter-cyclical monetary policy. The argument runs as follows. Product market deregulation can boost growth,³ and as such features high on the policy agenda in many advanced economies,⁴ but it also reduces product market rents. As a result, monetary policy—and, more broadly, counter-cyclical macroeconomic policy—can be more powerful in stabilizing intangible asset investment and fostering longer-term growth in a more deregulated economy. Aghion, Farhi and Kharroubi (2018) build up a model that delivers these predictions, and provide supportive evidence using industry- and firm-level data. In particular, using data for over 2000 listed firms in selected European economies, they find that the European Central Bank's Outright Monetary Transactions Program announced in 2012 had a larger positive impact on firms' sales and employment growth in industries where market concentration measures (Herfindahl indices) were low than in more concentrated industries.

In this paper, we use a large cross-country firm-level dataset of several millions firm-year observations (ORBIS) to test directly for the impact of the counter-cyclicity of monetary (and fiscal) policy on intangible asset investment, and investigate how this impact varies depending on direct measures of product market competition.

Our empirical approach is a differences-in-differences strategy that exploits the sharp and unforeseen tightening of credit conditions that took place in the immediate aftermath of the collapse of Lehman Brothers on September 15th 2008. Using an extensive cross-country firm-

³ The existence of gains from easing barriers to entry in product markets has gradually become consensual since at least Blanchard and Giavazzi (2003) (e.g. Ebell and Haefke, 2009; Fang and Rogerson, 2011; Felbermayr and Prat, 2011). A strand of studies using country-time or country-time-industry panel data documents a significant positive effect of product market reform on productivity, investment, employment and/or output (e.g. Aghion et al., 2009a; Alesina et al., 2005; Bassanini and Duval, 2009; Bourles et al., 2013; Bouis, Duval and Eugster, 2016; Conway et al., 2006; Fiori et al., 2012; Inklaar et al., 2008; Nicoletti and Scarpetta, 2003). A related firm-level literature provides evidence on the impact of competitive pressures on innovation, technology adoption and productivity (e.g. Aghion et al., 2004, 2005; 2009b; Arnold et al., 2016; Gal and Hijzen, 2016).

⁴ See, for example, Draghi (2015), IMF (2015, 2016), or OECD (2016).

level dataset put together by merging different waves of ORBIS, we start by showing, in line with Duval, Hong and Timmer (2017), that firms with greater pre-crisis balance sheet vulnerabilities—higher leverage or, alternatively and as a robustness check, a higher interest expense burden—reduced their intangible investment rate more than their less vulnerable counterparts in the aftermath of the crisis. This holds within narrowly defined country-industry cells—that is, controlling for any country-industry (supply or demand) shocks, and then comparing firms with strong vs. weak balance sheet vulnerabilities within each cell. This finding is not driven by more vulnerable firms having experienced slower intangible investment growth already before the crisis—more and less vulnerable firms do not differ significantly along these or other relevant dimensions. Instead, the results are consistent with the view that when credit markets froze after September 15th 2008, more exposed firms were forced to reduce expenditure, particularly on items, such as intangible investment, that could not be pledged as collateral or translate quickly into sales. Indeed, we also find that the investment drop associated with balance sheet vulnerability was larger for intangible assets than for tangible ones.

Having established that financial frictions mattered for firm-level intangible investment after the crisis, we then explore the role of monetary (and fiscal) policy in mitigating their impact. Using various measures of the response of monetary (and fiscal) policy to the Lehman shock, we find a strong and statistically significant interaction with our measures of firm-level balance sheet vulnerabilities; monetary policy easing dampened the adverse impact of financial frictions on firms' intangible asset investment.

Finally, using various measures of product market competition at the country- or country-industry-level, including Lerner indices and markups, we find that monetary policy was more powerful at stabilizing intangible investment after the collapse of Lehman Brothers where product market competition was stronger, that is, where product market rents were lower. This key finding highlights the complementarity between product market reforms and monetary policy. Product market deregulation should come hand in hand with aggressive counter-cyclical monetary policy—and macroeconomic policy more broadly—to shelter intangible asset investment from macroeconomic shocks. Otherwise, there is a risk that the well-documented growth benefits from deregulation might be undermined by their side effect on intangible investment stability.

This paper relates to the existing studies on the permanent output costs of financial crises we mentioned above, but also to a related literature on macroeconomic volatility and long-term growth. Ramey and Ramey (1995) point to a negative cross-country correlation between volatility and growth. Aghion et al. (2010) focus on intangible investment as one channel through which such link may arise. They show theoretically that in the presence of credit constraints, adverse macroeconomic shocks will lead firms to cut spending on intangible and other forms of long-term, illiquid, but high-return forms of investment. Focusing on R&D

spending, Aghion et al. (2012) provide supportive empirical evidence on French firm-level data. Using cross-country-industry panel data, Aghion, Hemous and Kharroubi (2014) find that counter-cyclical fiscal policy mitigates the impact of credit constraints on country-industry-level output growth. Aghion, Farhi and Kharroubi (2018) focus instead on monetary policy, introduce the interaction between monetary policy and product market competition, and use both industry- and (listed) firm-level data. Both papers focus on output growth without investigating the possible channel(s) at play. Also, competition is measured indirectly through broad indices of market concentration among a small set of listed firms, with well-known practical and conceptual limitations; in particular, competing non-listed domestic firms and— even more importantly in the case of highly open European economies—foreign firms are ignored in the calculations, while market contestability cannot be accounted for (Baumol, 1982). In this paper, we address both issues. We explore how intangible investment at the firm level is affected by monetary (and fiscal) policy and its interplay with direct measures of product market competition at the 4-digit industry level, including (firm-level based) Lerner indices and markups a la De Loecker and Warzynski (2012).

Also related to this paper is the recent literature on how the 2008-2009 global financial crisis (GFC) affected firms. Using firm-level data for the U.S., several papers find that financial frictions amplified the adverse impact of the GFC on employment; those firms with weaker corporate balance sheets (Giroud and Mueller, 2017; Dinlersoz et al., 2018), that had a relationship with weak banks (Chodorow-Reich, 2014), faced greater refinancing risk (Benmelech, Bergman and Seru, 2011) or were smaller and younger (Siemer, 2016) experienced greater job losses, all else equal. Other papers focus on the productivity losses from such financial frictions, such as De Ridder (2016) for U.S. firms, Huber (2017) for German firms and counties, or Duval, Hong and Timmer (2017) for a cross-country panel of firms. The latter paper also explores the effect of financial frictions on the response of firm-level intangible investment to the GFC. We extend their analysis to the role of counter-cyclical monetary (and fiscal) policy and its interplay with product market competition.

The remainder of this paper is structured as follows. Section II outlines our empirical strategy and the dataset employed in this study. Section III presents our econometric results. Section IV concludes.

II. EMPIRICAL STRATEGY AND DATA

A. Empirical strategy

The baseline empirical strategy is set on a differences-in-differences framework, thereby comparing the difference in investment in intangible assets between firms with different levels of financial vulnerabilities, before and after the drastic unforeseen credit tightening that followed the collapse of Lehman Brothers.

Our methodology bears similarities with Giroud and Mueller (2017), who investigate the impact of this credit supply shock on firm-level employment in the U.S. by regressing the change in firm-level employment around the global financial crisis on the pre-crisis leverage ratio which is the measure of firm-level credit constraint. A similar approach is employed in Kalemli-Özcan et al. (2018) to study the effect of financial factors on the slowdown in tangible investment in European countries. Duval et al. (2017) apply this methodology to investigate the role of firm-level financial constraints in the productivity slowdown in advanced countries following the GFC. In a first stage, in line with them, we begin by estimating:

$$\Delta Intangible Investment_{isc} = \beta_1 Financial Vulnerability_{isc} + \delta_{sc} + \gamma X_{isc} + \epsilon_{isc}, \quad (1)$$

where $\Delta Intangible Investment_{isc}$ is the difference in the average investment in intangible assets (scaled by total assets) of firm i , in industry s and country c between the pre-crisis (2002-2007) and post-crisis (2008-2013) periods. $Financial Vulnerability_{isc}$ is a measure of pre-crisis balance sheet vulnerability, details of which are discussed below. δ_{sc} denotes country-sector fixed effects, absorbing all the country-sector level characteristics that might commonly affect firm-level changes in intangible investment between the two periods in a given country-sector where sectors are highly disaggregated at 4digit NACE level.⁵ In effect, this implies that we will be comparing the impact of the Lehman shock on intangible investment between strong- and weak-balance-sheet firms *within* a given country-sector. Finally, X_{isc} is a set of firm-level controls including age, total assets and cash flows (ratio of cash flows to assets) in the pre-crisis period. Our rich set of country-sector fixed effects and firm-level controls addresses key sources of omitted variable bias, while reverse causality is not a concern in our set-up since firm-level development within each 4-digit country-sector are highly unlikely to influence monetary policy.

In a second stage, once β_1 is tested to be negative, implying that firm-level financial vulnerabilities had an adverse effect on intangible investment, we turn to the counteracting effect of counter-cyclical macroeconomic policy. To do so, we exploit the cross-country heterogeneity in the response of monetary conditions to the GFC and estimate:

$$\Delta Intangible Investment_{isc} = \beta_1 Financial Vulnerability_{isc} + \beta_2 Financial Vulnerability_{isc} \times Expansionary Conditions_c + \delta_{sc} + \gamma X_{isc} + \epsilon_{isc}, \quad (2)$$

where $Expansionary Conditions_c$ is a measure—discussed in detail further below—of the extent to which monetary conditions eased after the GFC owing to counter-cyclical

⁵ For instance, intangible investment in some sectors relying more heavily on external finance than others may have been on average more affected by the GFC. Similarly, export-intensive industries in a more export-oriented country may have been affected differently following the great trade collapse. All such potential channels that are specific at the country-industry level but common across firms in that specific country-industry will be controlled by country-sector fixed effects.

macroeconomic policies. In this specification, together with $\beta_1 < 0$, $\beta_2 > 0$ would imply that expansionary monetary conditions dampen and—depending on its magnitude and the estimated values of β_1 and β_2 —even possibly offset the negative impact of financial vulnerabilities on the response of intangible investment to the credit supply shock.

In a third and final stage, we explore the complementarities between counter-cyclical macroeconomic policies and product market deregulation. The theoretical underpinnings are laid out in Aghion, Farhi and Kharroubi (2018). They develop a model in which firms decide on the amount of investment in a growth-enhancing form of capital in the presence of profitability and liquidity shocks. In their set-up, strong product market competition reduces profits, the ability of firms to weather liquidity shocks and, thereby, investment. They also show that by mitigating the impact of liquidity shocks, counter-cyclical monetary policy incentivizes firms to invest more, particularly so where strong product market competition depresses profits.

In our empirical set-up, these considerations yield two testable implications that can be checked by estimating the following specification:

$$\begin{aligned} \Delta \text{Intangible Investment}_{isc} = & \beta_1 \text{Financial Vulnerability}_{isc} + \\ & \beta_2 \text{Financial Vulnerability}_{isc} \times \text{Expansionary Conditions}_c + \\ & \beta_3 \text{Financial Vulnerability}_{isc} \times \text{Weak Competition}_{sc} + \\ & \beta_4 \text{Financial Vulnerability}_{isc} \times \text{Expansionary Conditions}_c \times \text{Weak Competition}_{sc} + \\ & \delta_{sc} + \gamma X_{isc} + \epsilon_{isc} \end{aligned} \quad (3)$$

where *Weak Competition*_{sc} is a proxy measure for the degree of product market competition, which will be discussed in detail below. First, the adverse effect of corporate balance sheet weakness on intangible investment in the aftermath of the Lehman collapse should be greater for firms facing higher competition; this implies $\beta_3 > 0$. Second, the beneficial impact of expansionary monetary conditions should be greater for firms facing higher competition, that is, β_4 should be negative. Standard errors will be clustered at the country-sector level.

B. Data

Firm-level variables

Our firm-level variables are constructed using ORBIS, a cross-country longitudinal dataset of both listed and unlisted firms provided by Bureau van Dijk. The dataset features rich information on firms' activities and financial variables based on balance sheets and income statements. We refer the reader to Diez et al. (forthcoming) for a more detailed description of

the dataset and the approach taken to clean the data, which essentially follows similar steps as in Kalemli-Özcan et al. (2015) and Gopinath et al. (2017).⁶

We focus on 17 OECD countries for which we have data on both firm-level and country-level macroeconomic variables over this period, namely Austria, Belgium, Czech Republic, Germany, Finland, France, Greece, Hungary, Ireland, Italy, Korea, Norway, Poland, Portugal, Slovakia, Spain, UK. We study firms in the non-farm, non-financial business sector, which corresponds to the two-digit industry codes 5-82 in NACE Revision 2., covering both manufacturing and a number of service sectors (e.g. real estate and profession/scientific/technical activities). Basic firm-level summary statistics are provided in Table [1].

Our main dependent variable of interest is the change in intangible investment, defined as difference in average investment in intangibles as a share of total assets between pre- and post-crisis periods. We measure investment in intangibles on a net basis—that is, net of depreciation (or amortization), computing it as the change in real intangible assets. One potential concern regarding this measure stems from the highly complex nature of international standards for intangible assets accounting.⁷ In practice, the intangible assets reported on firms' balance sheets tend to be mostly acquired assets—with a clear transaction price, such as patents or software—or internally-generated ones at the development phase—and thereby with estimable future economic benefits. This leaves out other types of internally-generated intangibles, most notably R&D projects at the research stage. Therefore, intangible assets are likely to be both imperfectly reported and under-reported. As a result, our econometric analysis is likely to be subject to classical measurement error in the dependent variable, leading to attenuation bias and overly conservative results—against finding any statistically significant relationship. We will also check the robustness of our results to alternative measures of the dependent variable.

To explore the role of firm-level financial vulnerabilities for intangible investment and their interplay with policies, we consider two variables that capture potential financial constraints faced by firms. The baseline measure is the pre-crisis average of leverage ratio to capture the

⁶ To ensure consistency and comparability of monetary variables across countries and over time, time-industry varying value-added or gross output deflators are applied to convert nominal monetary variables to real variables in 2010 constant USD for non-capital variables, while the country-level investment deflators from the World Development Indicators database are applied for capital variables. Importantly, any heterogenous changes in country-industry-level capital price deflators will be absorbed by the country-sector fixed effects included in specifications (1)-(3). In addition, observations with likely reporting errors due to concerns related to the reliability of the data as well as the consistency of variables over time are excluded.

⁷ In principle, intangible assets include, but are not limited to, scientific or technical knowledge, design and implementation of new processes or systems, licenses, intellectual property, market knowledge and trademarks such as brand names and publishing titles. According to International Accounting Standard (IAS) 38, however, only those that meet three criteria—identifiability, controllability, and estimability—should be recorded on the balance sheet.

degree of debt overhang risk. Giroud and Mueller (2017) discuss that U.S firms with a higher pre-crisis leverage ratio faced more acute financial constraints when credit conditions tightened afterwards. This is calculated as the ratio of the sum of current liabilities and long-term debt to total assets for corresponding periods. As a robustness check, we also consider the interest coverage ratio prior to the crisis, defined as total interest paid by the firm over its earnings before taxes, depreciation and amortization of capital (EBITDA). This is supposed to capture the degree of drags on financing that stem from debt payments (Kalemli-Özcan et al., 2018). Since the Lehman shock to credit conditions was unforeseen, firms' debt structure prior to this event is unlikely to be correlated with other unobserved firm-level characteristics that may be correlated with the change in intangible investment after the crisis.

Macroeconomic policy conditions

Post-crisis monetary conditions in a given country are measured in four alternative ways. The baseline measure is the average forecast error of long-term (10 year) government bond yields in the post-crisis period, relative to OECD forecasts for the year considered, as published in the Fall issue of the *OECD Economic Outlook* in the previous year. This is intended to capture the surprise component of monetary conditions, that is, the extent to which they were more expansionary than expected post-crisis. One advantage of this measure, beyond its simplicity, is to capture relevant monetary conditions for firms better than short-term policy rates do, and to encompass the impact of both conventional and unconventional monetary policy measures that were implemented by major central banks after the crisis.

Alternatively, we consider more direct measures of monetary policy shocks. One is the deviation of the policy rate from its simple Taylor-rule-implied value in the post-crisis period, using standard Taylor rule parameters and following extensive previous literature (e.g. Bordo and Landon-Lane, 2013; Bruno and Shin, 2015; Coibion et al., 2017; Dell'Ariccia, Laeven, and Suarez, 2017). Another monetary policy shock measure is the forecast error of the short-term policy rate that is orthogonal to unexpected changes in output growth and inflation.⁸ This is computed in two steps. In a first step, the difference between the actual and forecast short-term rate is calculated, along with similar differences for inflation and GDP growth, where the forecasts of short-term policy rates, inflation, and output growth are taken from *Consensus Economics* in October of the same year. In a second step, forecast errors for the short-term rate are regressed on forecast errors for inflation and GDP growth; residuals from this panel regression are then taken as the exogenous monetary policy shock in a given country and year.

Finally, since fiscal policy can ease firms' credit constraints by raising aggregate demand and output (Aghion et al., 2012), we also consider a fiscal policy shock measure in an extension of our analysis. We use the forecast error of the ratio of government consumption to GDP,

⁸ See for example Duval and Furceri (2018).

following Auerbach and Gorodnichenko (2012). The forecasts are taken from the Fall issue of the *OECD Economic Outlook* in the same year.

Product market competition measures

The degree of competition faced by firms is measured in three ways, two of which are derived from firm-level market power measures. The baseline measure is the (median value of the) Lerner index for each country-sector in the pre-crisis period. It is calculated as $(EBITDA - Depreciation\ and\ Amortization) / (Operating\ Revenue)$ and represents an inverse measure of country-sector-level competition. Alternatively, we use firm-level markups. These are computed following the approach proposed by De Loecker and Warzynski (2012) and applied by De Loecker and Eeckhout (2017) or Diez et al. (forthcoming) to document rising corporate market power in advanced economies. We take the median of firm markups in each country-sector as a measure of (weak) competition.⁹

While firm-level-based measures are our preferred indicators because they aim to measure directly the strength of market competition and can be computed for each country-industry, we also confirm the robustness of our results to using instead the economy-wide product market regulation (PMR) indicators published by the OECD. These are based on responses by national governments to extensive questionnaires covering a wide range of anti-competitive product market regulations (for details, see Koske et al., 2015). In our analysis, we consider the overall PMR indicator but also, given our focus on the role of incumbent firms' product market rents, two specific sub-indicators on barriers to entry and regulatory protection of incumbents.

C. Stylized Facts

For our differences-in-differences strategy to be valid, two conditions should be met. First, the 2008 GFC shock should be exogenous, and second, firms with different levels of financial vulnerabilities should have had a parallel trend in intangible investment growth prior to the crisis, with any divergence materializing only after the crisis. Regarding the first condition, there is broad consensus that the GFC was unforeseen by individual firms; for example, Cheng et al. (2014) show that even managers in the securitized finance industry failed to identify the housing bubble. The second condition requires a careful look at the data to ensure that our estimates will not be driven by more vulnerable firms having experienced slower intangible investment growth already before the crisis.

To this end, we run a regression of firm-level intangible investment growth on year dummies and four-digit country-sector fixed effects separately for high-leverage and low-leverage firms, where the leverage threshold used to split firms in those two groups is, in each country-sector

⁹ We are grateful to Federico Diez, Jiayue Fan and Carolina Villegas-Sanchez for sharing the estimated markup data they calculated on the dataset used in the present paper.

separately, the median across firms of the average leverage ratio over the pre-crisis period. Panel A in Figure [1] reports the evolution of the year dummy variable derived from these regressions—which basically captures average annual growth in intangible investment, expressed as a deviation from its country-sector average over the sample period—across high-leverage (solid blue line) and low-leverage (solid red line) firms, respectively. The figure confirms that the second condition is satisfied: intangible investment by both sets of firms grew at a similar pace until the GFC, after which high-leverage firms started experiencing a greater decline in intangible investment than their low-leverage counterparts. Moreover, a corresponding chart for tangible investment in Panel B indicates that the post-crisis divergence between high- and low-leverage firms was less pronounced for tangible investment, supporting our underlying premise that intangible investment is likely to be more dependent on continuous availability of external or internal sources of finance due, in particular, to its inherently limited pledgeability.

Figure [2] illustrates the relevance of these changes in intangible investment for changes in total factor productivity (TFP) between the pre-crisis and post-crisis periods. The TFP series for each firm is derived here from the estimation of a production function with labor and tangible capital, using the GMM procedure proposed by Wooldridge (2009) to address the simultaneity problem stemming from the input choices and the firm's productivity, and also the critique of Akerberg, Caves and Frazer (2015). For each firm in the sample, the change in the intangible-to-total-assets ratio (in percent) between the pre- and post-crisis periods is calculated, and then ranked. The resulting data are then broken into 100 quantiles, for each of which the median value of the change in the intangible-to-total-assets ratio is calculated. Each dot in the figure represents this quantile-median, as a deviation from a country-sector fixed effect (x-axis). It is plotted against the quantile-median of the deviation of the change in average TFP growth from a country-sector fixed effect (y-axis). The post- and pre-crisis periods includes five years after and before the 2008 crisis, respectively. Overall, the figure shows a strong positive correlation between changes in intangible investment and TFP growth between the pre- and post-crisis periods, consistent with recent literature pointing to a sizeable impact of intangible capital on productivity (e.g., Aw et al., 2011; Doraszelski and Jaumandreu, 2013). Incidentally, Figure 2 also confirms that, although far from fully comprehensive, the intangible assets included in firm balance sheets do contain relevant information for productivity growth, and are therefore worth studying.

Now, we turn to investigating the role of financial frictions for intangible investment and their interplay with policies.

III. EMPIRICAL RESULTS

Baseline estimates

Our starting point, as specified in (1), is to show, as in Duval et al. (2017), that firms with pre-existing balance sheet vulnerabilities tended to reduce intangible investment in the post-crisis period more than their less vulnerable peers within a given country-industry. The results are presented in Table [2]. The estimated coefficient implies that firms with a 10 percentage point higher leverage ratio reduced their intangible investment rate more by around 0.05 percentage point (column 1). To get a better sense of the estimated effect, Figure [3] illustrates the difference in the estimated decline in intangible investment rate (relative to country-sector averages) between the 75th percentile (blue bar) and 25th percentile firms (shaded bar) in terms of the leverage ratio, which amounts to 0.15 percentage point (red bar).

Insofar as firms could still bring their physical assets as collateral or liquidate them to avoid cutting intangible investment expenditure—which cannot be collateralized or liquidated easily—the extent to which firms cut intangible investment might be expected to be greater for firms that have few or no physical assets. To test for this, we further differentiate among firms depending on their asset pledgeability, measured as the share of tangible assets in total assets in the pre-crisis period, by interacting this measure with leverage. The results, which are reported in column (2) of Table [2], lend further support to the hypothesis that financial frictions affected intangible investment after the crisis: as shown by the statistical significance (at the 10% confidence level) of the interaction term, firms with a larger (smaller) share of physical assets turn out to have been less (more) affected by the tightening of credit conditions in 2008.

Turning to the role of expansionary monetary conditions in mitigating the adverse impact of financial constraints on intangible investment, Table [3] reports regression results from the specification (2) in column 1. The positive and statistically significant coefficient estimate on the interaction term implies that more expansionary monetary conditions could dampen, and indeed prevent, a cut in intangible investment by financially-constrained firms. The size of the coefficient estimates is such that a more-than-expected reduction in the long-term external financing cost of some 100 basis points fully negates the adverse impact on intangible investment stemming from debt overhang risk. Figure [4] contrasts the estimated effects for firms with high and low leverage under two different scenarios—more-than-expected expansionary (right bars) and contractionary monetary conditions (left bars) by 50bps—suggesting that adverse effects of financial frictions on intangible investment can be reduced by one-third under the cases considered (red bars in the middle).

These estimates have sizeable implications for output. A back-of-the-envelope calculation of the output effects of weaker post-crisis intangible investment in more leveraged firms requires using an elasticity of output with respect to intangible capital, for which available estimates tend to vary substantially across data samples and methodologies, ranging roughly from 20 to 40 percent (Doraszelski and Jaumandreu 2013; Hall et al., 2010). Based on this range, our estimation results would imply that a 100 basis points negative surprise on monetary conditions could prevent a cumulative output loss of 1 to 2 percent for high-leverage firms (75th percentile

of the leverage distribution) vis-à-vis their low-leverage counterparts over the five years after the crisis.¹⁰

As an intermediate step toward investigating potential complementarity between monetary and competition policies, we first check if competition had any impact on relationship between financial frictions and intangible investment. Our premise is that the adverse effects of financial frictions on intangible investment should have been greater for firms facing high competition because, unlike their low-competition counterparts, they could not use monopoly rents to keep on financing intangible investment after the crisis. Regression results in column 2 of Table [3] support this view: we find that financial constraints have a larger adverse effect on intangible investment when competition is stronger (i.e., when the country-sector median Lerner index is lower).

We then examine potential complementarity between monetary and competition policies by running a regression of the specification (3). To the extent that expansionary monetary conditions could help alleviate the adverse impact of financial constraints on intangible investment (column 1) and that such adverse effects are particularly strong in a more competitive environment (column 2), it should be the case that the role of counter-cyclical macroeconomic policy is more pronounced for firms facing high competition, suggesting potential complementarity—counter-cyclical policy that prevents a slowdown in intangible investment by constrained firms is more effective in a more competitive environment. This is precisely what column 3 in Table [3] reports as illustrated in Figure [4]. Coefficient estimates on the triple interaction term is negative and statistically significant, reinforcing the alleviating role of expansionary conditions when firms face stronger competition. These results provide evidence of a complementarity between pro-competition product market reforms and counter-cyclical macroeconomic policy.

The estimated magnitude of this complementarity between pro-competition product market reforms and counter-cyclical macroeconomic policy is illustrated in Figure [4], which is an extension of Figure [3]. Specifically, when product market competition is stronger (at the 25th percentile of the pre-crisis distribution of Lerner indices), the estimated cut in intangible investment by more-leveraged firms relative to their less-leveraged counterparts can be reduced from 0.25 to 0.08 percentage point when monetary conditions are more rather than less

¹⁰ The 0.15 percentage points difference in the decline in the intangible-investment-to-total-assets ratio in Figure 1 corresponds to about a 1 percentage point difference in the intangible-investment-to-intangible-assets ratio, or about a $1 \times 5 = 5$ percent cumulative loss in intangible capital. Applying a 20 to 40 percent return on this capital implies a 1 to 2 percent output loss in the high-leverage firm vis-à-vis its low-leverage counterpart—which, per the estimates in Table [3], is therefore the output loss prevented by a 100 basis points negative surprise on monetary conditions. Note that this back-of-the-envelope calculation is performed only within each country-sector. We conjecture that the aggregate effects of financial frictions on intangible investment, and thereby on output, are also likely to have played out across country-sectors, with the more leveraged among them being more affected. Any such effects are absorbed by our 4-digit country-sector fixed effects here.

expansionary than expected (green shaded bars on the left). When competition is weaker (at the 75th percentile of the Lerner index distribution), the corresponding numbers are smaller at 0.16 and 0.05 (green shaded bars on the right), and so is the difference between them— $0.25 - 0.08 = 0.17$ versus $0.16 - 0.05 = 0.11$ (red solid and shaded bars in the middle), implying an overall 50% stronger effect of counter-cyclical macroeconomic policies in more competitive environments.

Table [4] checks whether our baseline results reflect the effects on intangible investment only or also capture those relative to tangible investment. We replace the dependent variable with the difference in the average ratio of intangible to tangible assets (column 1) or the difference in the average investment in tangible assets (scaled by total assets; column 2), both between the pre- and post-crisis periods. The estimation results confirm that the identified channel—financial frictions—through which counter-cyclical macroeconomic policies and product market competition shape the response of investment to credit conditions is more pronounced for intangible assets than it is for tangible ones.

Extensions and robustness checks

We perform a wide range of sensitivity analyses on our results. In particular, we show that our findings are robust to alternative measures of expansionary macroeconomic policies, product market competition, and firm balance sheet vulnerability.

Table [5] confirms that the baseline results are robust to alternative measures of expansionary monetary conditions. Keeping the baseline competition measure, we alternate the policy shocks measures: the deviation of the actual policy rate from Taylor-rule implied rate (column 1); the forecast error of the actual short-term rate that is orthogonal to changes in inflation and output growth (column 2); the forecast error of the government consumption expenditure to GDP (column 3). All of them show qualitatively identical results to the baseline results reported in Table [3]. In particular, all double and triple interactions terms featured in column (3) of Table [3] remain statistically significant, with the partial exception of the triple interaction term testing for the complementarity between competition and counter-cyclical monetary policy, which is only borderline significant (at the 10% level) when the forecast error of the short-term rate is used.

Likewise, Table [6] confirms that the baseline results are robust to alternative measures of product market competition. This time, we keep the baseline monetary condition measure, and alternate the competition measures: the country-sector median of estimated markups (column 1); OECD's overall product market regulation (PMR) indicator (column 2); OECD's sub-indicator on regulatory protection of incumbents (column 3); OECD's sub-indicator on administrative burdens on start-ups. All columns indicate qualitatively identical results to the

baseline results, with all relevant effects showing statistical significance at the 1% confidence level.

We conduct three additional sets of robustness checks on the sample, baseline specification and firm-level balance sheet vulnerability variable, whose results are summarized in Table [6]. First, we shorten the time window to 2005-2010 (two years before versus two years after the GFC), which also has the advantage of fully removing the 2010-2012 euro area crisis period. Since the adverse effects of financial frictions are likely to have been more acute right after the crisis, we expect the estimated effects to be at least as big as the baseline results. This is confirmed by slightly larger point estimates in absolute terms compared to those from the baseline estimation (column 1).

Second, we check the robustness of our results to an alternative measure of firm-level financial vulnerability, namely the interest coverage ratio. The higher the ratio is, the greater the debt burden is, and the more vulnerable the firm should be to a tightening of credit conditions. Again, this yields qualitatively identical results to the baseline regression (column 2).

Lastly, given that intangible investment data are potentially noisy, as discussed earlier, we replace the dependent variable with a dummy variable that takes value 1 for non-negative changes in net intangible investment between the pre- and post-crisis periods, and 0 otherwise (negative change). This linear probability model has the advantage of being potentially less prone to measurement error in the dependent variable. Again, results are qualitatively identical to the baseline specification (column 3). In a similar vein, we exclude those firms that have never had any intangible assets throughout the sample period—about 10 percent of the full sample. The estimation results are almost identical to the baseline results, with slightly bigger point estimates (column 4).

IV. CONCLUSION

Investment in intangible assets is an increasingly important driver of economic growth but, being non-pledgeable as collateral and hard to liquidate quickly, it is also potentially vulnerable to financial frictions. This implies that counter-cyclical macroeconomic policy could strengthen longer-term growth by sheltering intangible investment from adverse shocks, particularly so where strong product market competition prevents firms from self-financing their investments through rents. Using a large cross-country firm-level dataset and focusing on the global financial crisis and its aftermath, this paper finds strong support for these theoretical predictions. Our results highlight a complementarity between pro-competition product market deregulation and counter-cyclical monetary (and fiscal) policy in fostering intangible investment and growth.

Our findings thus have strong implications for economic theory and policy that give rise to the possibility that counter-cyclical macroeconomic policy persistently or even permanently affects

growth. Moreover, insofar as product market competition can backfire when credit constraints bite in downturns, our results call for strengthening countercyclical macro policies alongside any market deregulation to foster growth.

REFERENCES

- Akerberg, D., K. Caves, and G. Frazer. 2015. "Identification Properties of Recent Production Function Estimators." *Econometrica* 83 (6): 2411–2451.
- Aghion, P., G. Angeletos, A. Banerjee and K. Manova. 2010. "Volatility and Growth: Credit Constraints and the Composition of Investment." *Journal of Monetary Economics* 57 (3), 246-65.
- Aghion, P., P. Askenazy, R. Bournès, G. Cette, and N. Dromel. 2009a. Education, Market Rigidities and Growth. *Economics Letters*, vol. 102(1), pp. 62-65.
- Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. "Competition and Innovation: an Inverted-U Relationship." *Quarterly Journal of Economics* 120 (2): 701-28.
- Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl. 2009b. The Effects of Entry on Incumbent Innovation and Productivity. *Review of Economics and Statistics*, vol. 91(1), pp. 20-32.
- Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl 2004. Entry and Productivity Growth: Evidence from Microlevel Panel Data. *Journal of the European Economic Association*, vol. 2(2-3), pp. 265-76.
- Aghion, P., R. Burgess, S. Redding and F. Zilibotti. 2008. "The Unequal Effects of Liberalization: Evidence from Dismantling the License Raj in India." *American Economic Review* 98(4): 1397-1412.
- Aghion, P., E. Farhi and E. Kharroubi. 2018. "Monetary Policy, Product Market Competition and Growth." CEPR Discussion No. 13214.
- Aghion, P., D. Hemous and E. Kharroubi. 2014. "Cyclical Fiscal Policy, Credit Constraints, and Industry Growth." *Journal of Monetary Economics* 62(C): 41-58.
- Alesina, A., S. Ardagna, G. Nicoletti, and F. Schiantarelli. 2005. Regulation and Investment. *Journal of the European Economic Association*, vol. 3(4), pp.791-825.
- Almeida, H., M. Campello, B. Laranjeira and S. Weisbenner. 2012. "Corporate Debt Maturity and the Real Effects of the 2007 Credit Crisis." *Critical Finance Review* 1 (1): 3-58.
- Arnold, J., B. Javorcik, M. Lipscomb and A. Mattoo. 2016. Services Reform and Manufacturing Performance: Evidence from India. *Economic Journal*, vol. 126 (590), pp. 1-39.
- Aw, B., M. Roberts, D. Xu. 2011. "R&D Investment, Exporting, and Productivity Dynamics." *American Economic Review*, vol. 101(4), pp. 1312-44.

- Barone, G. and F. Cingano (2011). Service Regulation and Growth: Evidence from OECD Countries. *Economic Journal*, vol. 121(555), pp. 931-957.
- Bassanini, A. and R. Duval. 2009. Unemployment, Institutions, and Reform Complementarities: Reassessing the Aggregate Evidence for OECD Countries. *Oxford Review of Economic Policy* vol. 25, pp. 40-59, Spring.
- Benmelech, E., N. Bergman and A. Seru. 2011. "Financing Labor," *NBER Working Paper* No. 17144.
- Blanchard, O., E. Cerutti and L. Summers. 2015. Inflation and Activity: Two Explorations and their Monetary Policy Implications. *IMF Working Paper* No. 15/230.
- Blanchard, O. and F. Giavazzi. 2003. Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets. *Quarterly Journal of Economics* 118 (3): 879-907.
- Bordo, M., and J. Landon-Lane. 2013. "Does Expansionary Monetary Policy Cause Asset Price Booms: Some Historical and Empirical Evidence", *NBER Working Paper* No. 19585, National Bureau of Economic Research.
- Bouis, R., R. Duval and J. Eugster. 2016. Product Market Deregulation and Growth : New Country-Industry-Level Evidence. *IMF Working Paper* No. 16/114.
- Bourlès, R., G. Clette, J. Lopez, J. Mairesse, and G. Nicoletti. 2013. Do Product Market Regulations in Upstream Sectors Curb Productivity Growth? Panel Data Evidence for OECD Countries. *The Review of Economics and Statistics*, vol. 95(5), pp. 1750-1768.
- Bruno, V., and H. Shin. 2015. "Capital Flows and the Risk-Taking Channel of Monetary Policy." *Journal of Monetary Economics* 71: 119-132.
- Cerra, V. and S. Saxena. 2008. "Growth Dynamics: The Myth of Economic Recovery," *American Economic Review* 98 (1), 439-457.
- Cheng, I.-H., Raina, S., & Xiong, W. (2014). Wall street and the housing bubble. *American Economic Review*, 104 (9), 2797–2829.
- Chodorow-Reich, G. 2014. "The Employment Effects of Credit Market Disruptions: Firm-Level Evidence from the 2008-9 Financial Crisis," *Quarterly Journal of Economics* 129 (1), 1-59.
- Coibion, O., Y. Gorodnichenko, L. Kueng and J. Silvia. 2017. "Innocent Bystanders? Monetary Policy and Inequality." *Journal of Monetary Economics* 88: 70-89.
- Conway, P., D. de Rosa, F. Steiner and G. Nicoletti. 2006. Product Market Regulation and Productivity Convergence. *OECD Economic Studies*, vol. 43, pp. 39-76.

- Corrado, C., J. Haskel, C. Jona-Lasinio and M. Iommi. 2016. “Intangible Investment in the EU and US Before and Since the Great Recession and its Contribution to Productivity Growth.” *EIB Working Paper No. 2016/08*.
- Corrado, C., C. Hulten and D. Sichel, 2009. “Intangible Capital and U.S. Economic Wealth.” *Review of Income and Wealth* 55: 661-685.
- Corrado, C., C. Hulten and D. Sichel, 2005. Measuring Capital and Technology: An Expanded Framework. In J. Haltiwanger, C. Corrado and D. Sichel (eds), *Measuring Capital in New Economy*, Chicago, IL: University of Chicago Press pp. 114-146.
- Correa-Caro, C., L. Medina, M. Poplawski-Ribeiro, B. Sutton. 2018. “Fiscal Stimulus Impact on Firms’ Profitability During the Global Financial Crisis.” *IMF Working Paper No.18/251*.
- Dell’Ariccia, G., L. Laeven, and G. Suarez. 2017. “Bank Leverage and Monetary Policy’s Risk-Taking Channel: Evidence from the United States.” *Journal of Finance* 72(2): 613-654.
- De Loecker, J., and F. Warzynski. 2012. “Markups and Firm-Level Export Status.” *American Economic Review* 102(6): 2437-2471.
- de Ridder, Martin. 2016. “Investment in Productivity and the Long-Run Effect of Financial Crises on Output.” *Cambridge-INET Working Paper Series 2016/18*; Cambridge Working Paper Economics 1659, University of Cambridge, UK.
- Diez, F., J. Fan and C. Villegas-Sanchez. forthcoming. “Global Declining Competition.” *IMF Working Paper*.
- Dinlersoz, E., S. Kalemli-Ozcan, H. Hyatt, and V. Penciakova. 2018. “Leverage over the Life Cycle and Implications for Firm Growth and Shock Responsiveness.” *NBER Working Paper No. 25226*.
- Doraszelski, U., and J. Jaumandreu. 2013. “R&D and Productivity: Estimating Endogenous Productivity.” *Review of Economic Studies*, vol. 80(4), pp. 1338-1383.
- Draghi, M. 2015. Monetary Policy and Structural Reforms in the Euro Area.” Speech, Prometeia40, Bologna, December 14th, available at <https://www.ecb.europa.eu/press/key/date/2015/html/sp151214.en.html>
- Duval, R., G. Hong and Y. Timmer. 2017. “Financial Frictions and the Great Productivity Slowdown.” *IMF Working Paper No. 17/129*.
- Duval, R., D. Furceri. 2018. “The Effects of Labor and Product Market Reforms: The Role of Macroeconomic Conditions and Policies.” *IMF Economic Review*, vol. 66(1), pp. 31-69.
- Ebell, M., and C. Haefke. 2009. Product Market Deregulation and the U.S. Employment Miracle. *Review of Economic Dynamics*, vol. 12(3), pp. 479-504.

- Fang, L., and R. Rogerson. 2011. Product Market Regulation and Market Work: A Benchmark Analysis. *American Economic Journal: Macroeconomics*, vol. 3(2), pp. 163-88.
- Felbermayr, G. and J. Prat. 2011. Product Market Regulation, Firm Selection, and Unemployment. *Journal of the European Economic Association*, vol. 9(2), pp. 278-317.
- Fiori, G., G. Nicoletti, S. Scarpetta, and F. Schiantarelli. 2012. Employment Outcomes and the Interaction between Product and Labor Market Deregulation: Are They Substitutes or Complements?" *Economic Journal*, vol. 122 (558), pp. 79-104.
- Gal, P. 2013. "Measuring Total Factor Productivity at the Firm Level using Orbis," *OECD Economics Department Working Paper No. 1049*.
- Gal, P. and A. Hijzen. 2016. "The Short-Term Impact of Product Market Reforms: A Cross-Country Firm-Level Analysis." *IMF Working Paper Series No. 16/116*.
- Giroud, X., and H. Mueller. 2017. "Firm Leverage, Consumer Demand, and Employment Losses during the Great Recession." *Quarterly Journal of Economics* 132 (1): 271-316.
- Holmstrom, B. and J. Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *The Quarterly Journal of Economics* 112 (3): 663-691.
- Giroud, X. and H. Mueller. 2017. "Firm Leverage, Consumer Demand, and Employment Losses during the Great Recession," *The Quarterly Journal of Economics*, 132 (1), 271-316.
- Hall, B. and J. Lerner. 2010. "The Financing of R&D and Innovation." In *Handbook of the Economics of Innovation*. Vol. 1, edited by Bronwyn H Hall and Nathan Rosenberg. Elsevier, 2010.
- Hall, B., J. Mairesse, and P. Mohnen. 2010. "Measuring the Returns to R&D." In *Handbook of the Economics of Innovation*. Vol. 2, edited by Bronwyn H Hall and Nathan Rosenberg. Elsevier, 2010.
- Huber, K. 2017. "Disentangling the Effects of a Banking Crisis: Evidence from German Firms and Counties," *American Economic Review*, forthcoming.
- Inklaar, R. and M. Timmer, 2014. "The Relative Price of Services" *Review of Income and Wealth* 60 (4): 727-746.
- Inklaar, R., M. Timmer, and B. Van Ark. 2008. "Market Services Productivity Growth across Europe and the US," *Economic Policy* 23 (53): 139-94.
- International Monetary Fund. 2016. Time for a Supply-Side Boost? Macroeconomic Effects of Labor and Product Market Reforms in Advanced Economies. *World Economic Outlook*, Chapter 3, April, Washington.

- International Monetary Fund. 2015. Where Are We Headed? Perspectives on Potential Output. *World Economic Outlook*, Chapter 3, April, Washington.
- Jordà, Ò., M. Schularick and A. Taylor. 2013. “When Credit Bites Back,” *Journal of Money, Credit and Banking* 45 (s2): 3-28.
- Kalemli-Ozcan, S., L. Laeven and D. Moreno. 2018. “Debt Overhang, Rollover Risk, and Corporate Investment: Evidence from the European Crisis,” NBER Working Paper Series 24555, National Bureau of Economic Research.
- Kalemli-Ozcan, S., B. Sorensen, C. Villegas-Sanchez, V. Volosovych and S. Yesiltas, 2015. “How to Construct Nationally Representative Firm Level Data from the Orbis Global Database,” NBER Working Paper Series 21558, National Bureau of Economic Research.
- Koske, I., I. Wanner, R. Bitetti and O. Barbiero. 2015. “The 2013 update of the OECD product market regulation indicators: policy insights for OECD and non-OECD countries”, *OECD Economics Department Working Papers*, No. 1200.
- Nicoletti, G. and S. Scarpetta. 2003. Regulation, Productivity and Growth: OECD Evidence. *Economic Policy*, 18 (36), pp. 9-72.
- Organisation for Economic Cooperation and Development, OECD. 2016. *Economic Policy Reforms: Going for Growth*, Paris.
- Ramey, G. and V. Ramey. 1995. “Cross-Country Evidence on the Link between Volatility and Growth.” *American Economic Review* 85 (5): 1138-51.
- Reinhart, C. and K. Rogoff. 2009. “The Aftermath of Financial Crises,” *American Economic Review* 99 (2): 466-72.
- Romer, C. and D. Romer. 2017. “New Evidence on the Aftermath of Financial Crises in Advanced Countries,” *American Economic Review* 107 (10): 3072-3118.
- Siemer, M. 2016. “Firm Entry and Employment Dynamics in the Great Recession,” *Finance and Economics Discussion Series* 2014-56, Board of Governors of the Federal Reserve System.
- Wooldridge, J. M. 2009. “On Estimating Firm-level Production Functions Using Proxy Variables to Control for Unobservables.” *Economics Letters* 104 (3): 112–114.

Table [1]. Summary Statistics

	Mean	Median	25th percentile	75th percentile	Standard Deviation
Δ Intangible investment	-0.0012	0	-0.0005	0.0023	0.0231
Δ Tangible investment	-0.0140	0	-0.0315	0.0266	0.2080
Intangible/Total assets ratio	0.16	0.02	0.00	0.21	0.25
Leverage ratio	0.67	0.70	0.53	0.84	0.21

Note: Δ Intangible investment is the difference in the average net investment in intangible assets (as a ratio of total assets) between post- and pre-crisis periods. Δ Tangible investment is similarly defined. Intangible/Total assets ratio is the ratio of intangible assets to total (tangible+intangible) assets in the pre-crisis period. Leverage ratio is defined as the average debt-to-assets ratio in the pre-crisis period. Lerner index is computed as the average of (EBITDA-Depreciation and amortization)/Operating revenue in the pre-crisis period. This summary table is based on 664,086 observations of the baseline estimation sample.

Table [2]. Baseline Estimation Results: Intangible Investment and Leverage

	(1)	(2)
<i>Dependent variable: change in intangible investment rate between pre- and post-crisis periods</i>		
(Vulnerability) _i	-0.005*** (0.000)	-0.014*** (0.005)
(Vulnerability) _i X (pre-crisis Physical assets ratio) _i		0.010* (0.006)
Observations	664,086	664,086
R-squared	0.061	0.065
Country-Sector FE	YES	YES

Note: The dependent variable is the difference in the average net investment ratio in intangible assets (ratio of intangible to total assets) between post- and pre-crisis periods. Firm-level vulnerability is the average debt-to-assets ratio in the pre-crisis period. The post-crisis period starts in 2008. Firm-specific controls (included but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with the pre-crisis average ratio of physical assets in total assets. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table [3]. Baseline Estimation Results: Intangible Investment, Leverage and Macro Policies

	(1)	(2)	(3)
<i>Dependent variable: change in intangible investment rate between pre- and post-crisis periods</i>			
(Vulnerability) _i	-0.005*** (0.000)	-0.007*** (0.001)	-0.009*** (0.001)
(Vulnerability) _i X (Expansionary monetary conditions) _c	0.005*** (0.001)		0.009*** (0.001)
(Vulnerability) _i X (Weak competition) _{cs}		0.047*** (0.011)	0.061*** (0.013)
(Vulnerability) _i X (Expansionary monetary conditions) _c X (Weak competition) _{cs}			-0.074*** (0.019)
Observations	664,086	664,086	664,086
R-squared	0.062	0.061	0.062
Country-Sector FE	YES	YES	YES

Note: The dependent variable is the difference in the average net investment in intangible assets (as a ratio of total assets) between post- and pre-crisis periods. Firm-level Vulnerability is measured as the average debt-to-assets ratio in the pre-crisis period. Expansionary monetary conditions is the average OECD forecast error for long term (10-year government bond) interest rate in the post-crisis period as a measure of more-than-expected policy loosening. Weak competition is measured as the median pre-crisis Lerner index value in each country-sector, reflecting the degree of profitability. The post-crisis period starts in 2008. Firm-specific controls (included in regressions but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with Expansionary monetary conditions and/or Weak competition measures. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table [4]. Baseline Estimation Results: Intangible Investment vs Tangible Investment

	(1) <i>intangible-to-total assets ratio</i>	(2) <i>investment in tangible assets</i>
(Vulnerability) _i	-0.022*** (0.004)	-0.017*** (0.003)
(Vulnerability) _i X (Expansionary monetary conditions) _c	0.027*** (0.006)	0.002 (0.005)
(Vulnerability) _i X (Weak competition) _{cs}	0.141*** (0.053)	-0.001 (0.048)
(Vulnerability) _i X (Expansionary monetary conditions) _c X (Weak competition) _{cs}	-0.233*** (0.079)	0.007 (0.075)
Observations	664,084	674,266
R-squared	0.012	0.033
Country-Sector FE	YES	YES

Note: The dependent variable is the difference in the average ratio of intangible assets to total (tangible + intangible) assets between post- and pre-crisis periods in column (1); the difference in the average net investment in tangible assets (as a ratio of total assets) between post- and pre-crisis periods in column (2). Firm-level Vulnerability is measured as the average debt-to-assets ratio in the pre-crisis period. Expansionary monetary conditions is the average OECD forecast error for long term (10-year government bond) interest rate in the post-crisis period as a measure of more-than-expected policy loosening. Weak competition is measured as the median pre-crisis Lerner index value in each country-sector, reflecting the degree of profitability. The post-crisis period starts in 2008. Firm-specific controls (included in regressions but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with Expansionary monetary conditions and/or Weak competition measures. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table [5]. Alternative Measures of Macroeconomic Policy Shocks

	(1)	(2)	(3)
<i>Dependent variable: change in intangible investment rate between pre- and post-crisis periods</i>			
<i>Expansionary policy is:</i>	<i>Deviation from Taylor rule</i>	<i>Forecast errors in short-term policy rate</i>	<i>Forecast errors in gov't consumption</i>
(Vulnerability) _i	-0.005*** (0.001)	-0.011*** (0.001)	-0.015*** (0.001)
(Vulnerability) _i X (Expansionary monetary conditions) _c	0.004*** (0.000)	0.010*** (0.003)	0.014*** (0.001)
(Vulnerability) _i X (Weak competition) _{cs}	0.019** (0.010)	0.062*** (0.015)	0.099*** (0.015)
(Vulnerability) _i X (Expansionary monetary conditions) _c X (Weak competition) _{cs}	-0.016** (0.006)	-0.072* (0.038)	-0.121*** (0.017)
Observations	664,086	571,482	647,836
R-squared	0.063	0.062	0.063
Country-Sector FE	YES	YES	YES

Note: The dependent variable is the difference in the average net investment in intangible assets (as a ratio of total assets) between post- and pre-crisis periods. Firm-level Vulnerability is measured as the average debt-to-assets ratio in the pre-crisis period. Expansionary monetary conditions as a measure of more-than-expected policy loosening is the average deviation of policy rates from the Taylor-rule implied one in the post-crisis period in column 1; the forecast error in monetary policy rates from Duval and Furceri (2018) in column 2; the forecast error of government consumption expenditure to GDP from Duval and Furceri (2018) in column 3. Weak competition is measured as the median pre-crisis Lerner index value in each country-sector, reflecting the degree of profitability. Firm-specific controls (included in regressions but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with Expansionary monetary conditions and/or Weak competition measures. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table [6]. Alternative Measures of Product Market Competition

Competition measure is:	(1) <i>median markup (country-sector)</i>	(2) <i>product market regulation</i>	(3) <i>regulatory protection of incumbents</i>	(4) <i>administrative burdens for startups</i>
(Vulnerability) <i>i</i>	-0.011*** (0.001)	-0.018*** (0.002)	-0.042*** (0.003)	-0.030*** (0.003)
(Vulnerability) <i>i</i> X (Expansionary monetary conditions) <i>c</i>	0.011*** (0.002)	0.041*** (0.003)	0.067*** (0.005)	0.052*** (0.005)
(Vulnerability) <i>i</i> X (Weak competition) <i>cs</i>	0.003*** (0.001)	0.008*** (0.001)	0.030*** (0.003)	0.009*** (0.001)
(Vulnerability) <i>i</i> X (Expansionary monetary conditions) <i>c</i> X (Weak competition) <i>cs</i>	-0.004*** (0.001)	-0.021*** (0.002)	-0.049*** (0.004)	-0.017*** (0.002)
Observations	664,086	664,086	664,086	664,086
R-squared	0.062	0.062	0.062	0.062
Country-Sector FE	YES	YES	YES	YES

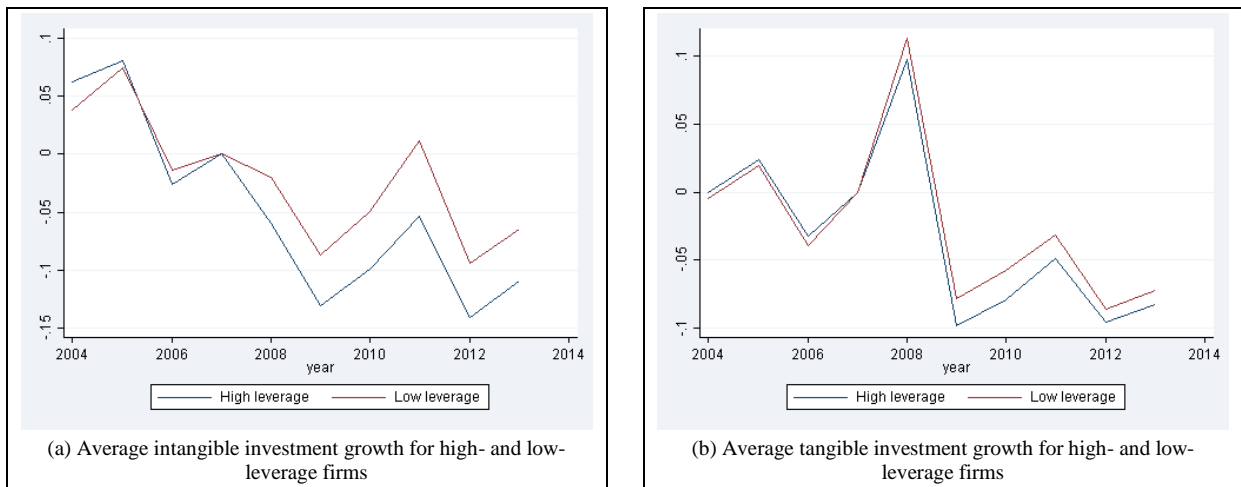
Note: The dependent variable is the difference in the average net investment in intangible assets (as a ratio of total assets) between post- and pre-crisis periods. Firm-level Vulnerability is measured as the average debt-to-assets ratio in the pre-crisis period. Expansionary monetary conditions is the average OECD forecast error for long term (10-year government bond) interest rate in the post-crisis period as a measure of more-than-expected policy loosening. Weak competition is measured as the median markup estimate in each country-sector, reflecting the degree of profitability in column 1; the OECD indicator of Product Market Regulation (PMR) in 2008 in column 2; the OECD indicator of Regulatory Protection of Incumbents (RPI) in 2008; the OECD indicator of Administrative Burdens for Start-ups (ABS) in 2008 in column 4. The post-crisis period starts in 2008. Firm-specific controls (included in regressions but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with Expansionary monetary conditions and/or Weak competition measures. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Table [7]. Further Robustness Checks

	(1) <i>Shorter window (2005-2010)</i>	(2) <i>Alternative vulnerability (Interest coverage)</i>	(3) <i>Binary choice model (Linear probability)</i>	(4) <i>Excluding zeros (no intangible assets)</i>
(Vulnerability) _i	-0.013*** (0.001)	-0.002*** (0.000)	-0.175*** (0.013)	-0.010*** (0.001)
(Vulnerability) _i X (Expansionary monetary conditions) _c	0.011*** (0.002)	0.004*** (0.001)	0.078*** (0.023)	0.011*** (0.002)
(Vulnerability) _i X (Weak competition) _{cs}	0.093*** (0.015)	0.012* (0.007)	0.879*** (0.209)	0.069*** (0.016)
(Vulnerability) _i X (Expansionary monetary conditions) _c X (Weak competition) _{cs}	-0.100*** (0.024)	-0.028*** (0.009)	-0.623* (0.322)	-0.096*** (0.023)
Observations	615,143	664,453	664,086	518,048
R-squared	0.074	0.060	0.087	0.072
Country-Sector FE	YES	YES	YES	YES

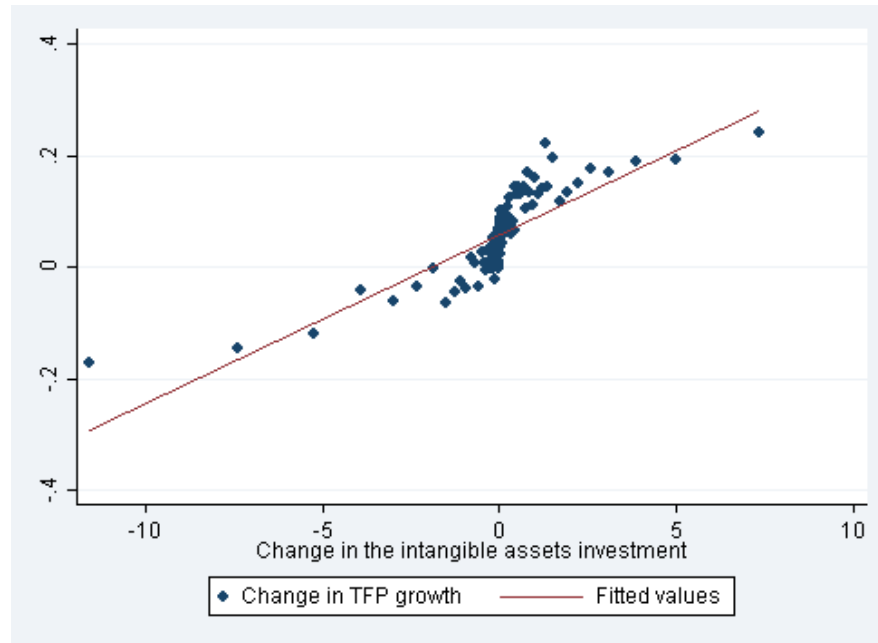
Note: The dependent variable is the difference in the average net investment in intangible assets (as a ratio of total assets) between post- and pre-crisis periods. Firm-level Vulnerability is measured as the average debt-to-assets ratio in the pre-crisis period except for in column 2 where it is measured as the interest coverage ratio (the average ratio of interest payments to earnings (EBITDA)) in the pre-crisis period. Expansionary monetary conditions is the average OECD forecast error for long term (10-year government bond) interest rate in the post-crisis period as a measure of more-than-expected policy loosening. Weak competition is measured as the median pre-crisis Lerner index value in each country-sector, reflecting the degree of profitability. Column 1 considers a shorter window between 2005 and 2010; column 3 corresponds to linear probability model by replacing the non-negative dependent variable with 1 (and 0 otherwise). Column 4 excludes observations without intangible assets in both periods, and hence, no change in intangible investment during the periods. The post-crisis period starts in 2008. Firm-specific controls (included in regressions but not reported) are firm age, total assets, and cash-flow/assets ratio as well as their interaction terms with Expansionary monetary conditions and/or Weak competition measures. All columns include country-sector fixed effects. Standard errors are clustered at the country-sector level. *: significant at 10% level; **: significant at 5% level; ***: significant at 1% level.

Figure [1]. Illustration of the Pre- and Post-GFC Trends in Intangible and Tangible Investment Growth in High-Leverage versus Low-Leverage Firms



Note: This figures illustrate the evolution of average intangible (panel a) and tangible (panel b) investment growth in high-leverage versus low-leverage firms. Each series in the panel represents a coefficient estimate on year dummy variables from a regression of firm-level intangible (panel a) or tangible (panel b) investment growth on year dummies and country-sector fixed effects separately for high-leverage firms (blue solid line) and low-leverage firms (red solid line), where the leverage threshold used to split the data in two groups is, in each country-sector separately, the median across firms of the average leverage ratio over the pre-crisis period.

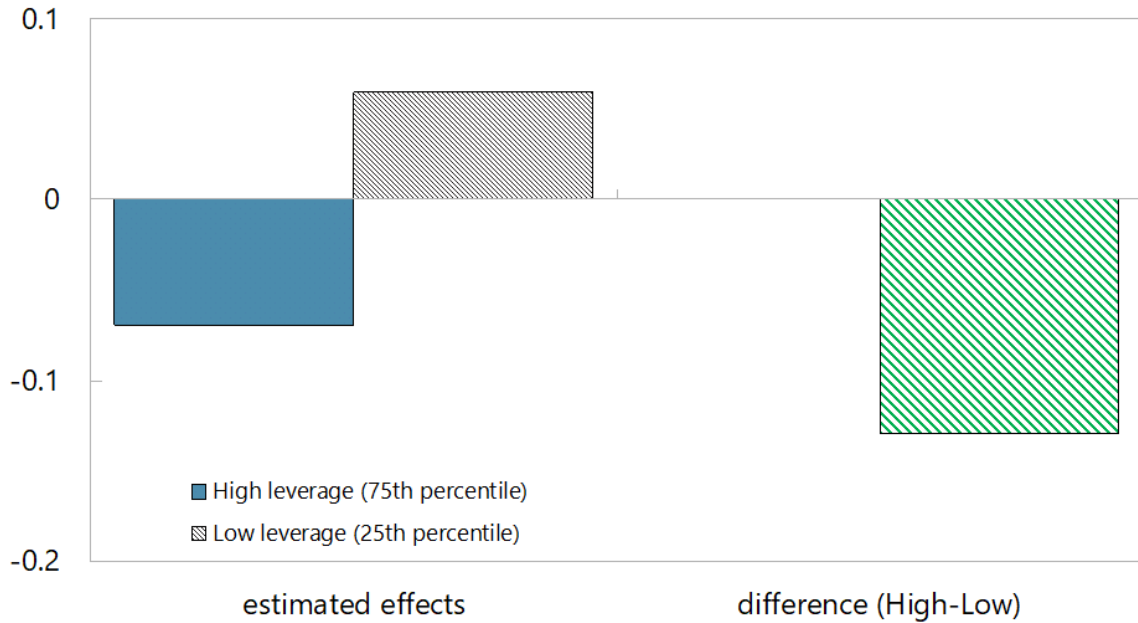
Figure [2]. Illustration of the Link between the Change in Average TFP Growth and Average Intangible Investment Growth between the Pre-GFC and post-GFC periods



Note: For each firm in the sample, the change in the intangible-to-total-assets ratio (in percent) between the pre- and post-crisis periods is calculated, and then ranked. The resulting data are then broken into 100 quantiles, for each of which the median value of the change in the intangible-to-total-assets ratio is calculated. Each dot in the figure represents this quantile-median, as a deviation from a country-sector fixed effect (x-axis). It is plotted against the quantile-median of the deviation of the change in average TFP growth from a country-sector fixed effect (y-axis). The post- and pre-crisis periods includes five years after and before the 2008 crisis, respectively.

Figure [3]. Illustration of the Baseline Estimation Results: Financial Frictions and Intangible Investment

Estimated Decline in Intangible Assets Investment

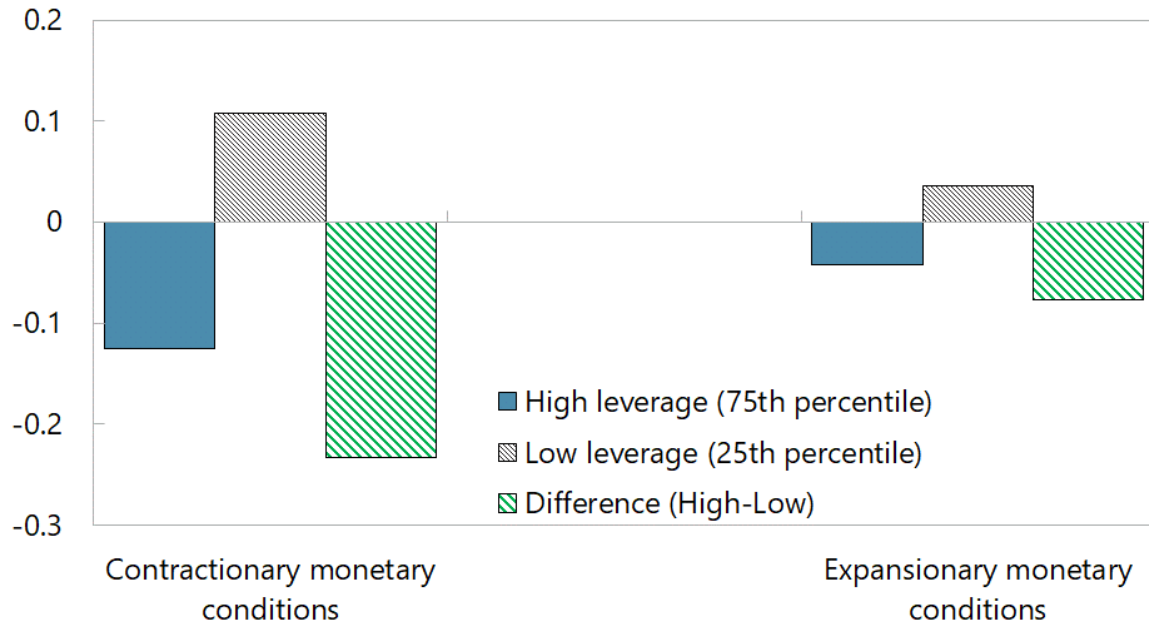


Note: High (low) leverage corresponds to the 75th (25th) percentile of the cross-firm distribution of pre-crisis average leverage ratio. The green shaded bar indicates the difference in estimated effects for high and low leverage firms. Estimated coefficients are from column (1) in the baseline results table.

Figure [4]. Illustration of the Baseline Estimation Results: The Role of Counter-cyclical Policy

Estimated Decline in Intangible Assets Investment

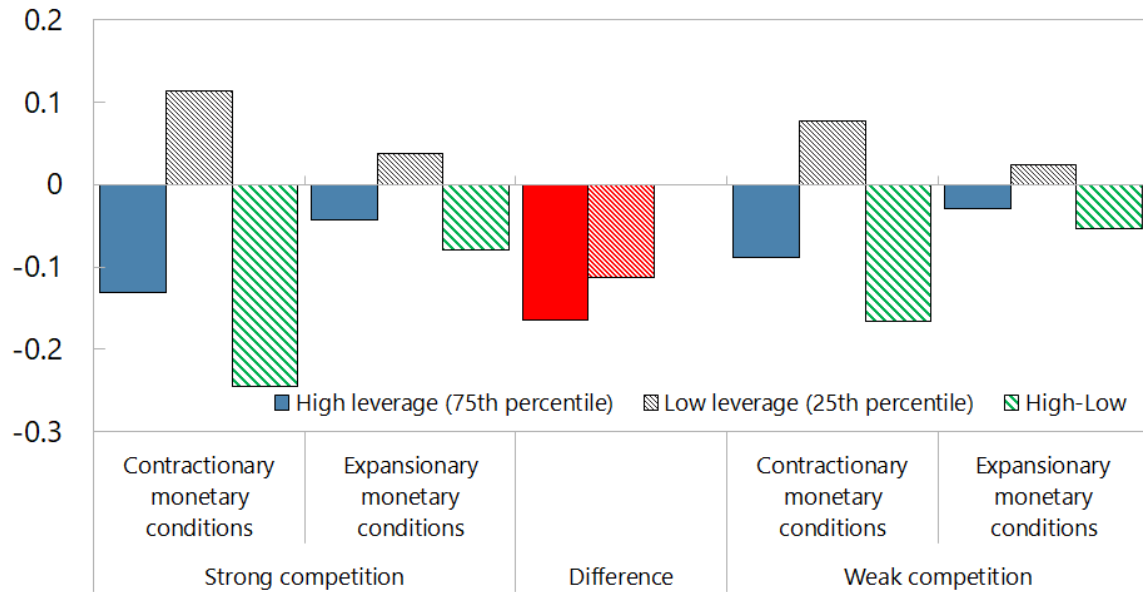
(in percent of total assets)



Note: High (low) leverage corresponds to the 75th (25th) percentile of the cross-firm distribution of pre-crisis average leverage ratio. The green shaded bars indicate the difference in estimated effects for high and low leverage firms, separately for contractionary and expansionary monetary conditions. Estimated coefficients are from column (2) in the baseline results table. Expansionary/contractionary monetary conditions are defined as forecast errors in 10-year gov't bond yields by ± 50 bps.

Figure [5]. Illustration of the Baseline Estimation Results: Complementarity between Product Market Competition and Counter-cyclical Policy

Estimated Deline in Intangible Assets Investment



Note: High (low) leverage corresponds to the 75th (25th) percentile of the cross-firm distribution of pre-crisis average leverage ratios. The green shaded bars indicate the difference in estimated effects for high and low leverage firms in contractionary and expansionary monetary conditions, respectively, while the red bars measure the difference between them, separately for strong and weak competition environments. Estimated coefficients are from column (4) in the baseline results table. Expansionary/contractionary monetary conditions are defined as forecast errors in 10-year gov't bond yields by ± 50 bps. Weak (strong) competition corresponds to the 75th (25th) percentile of the country-sector distribution of pre-crisis average Lerner index values.