Fiscal Stabilization and Productive Investment: Evidence from Advanced Economies*

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September 2017

Abstract

We use a difference-in-difference approach to 25 industries for 18 advanced economies over the period 1985-2012 to examine the effect of fiscal stabilization on productive investment: i) Research and Development (R&D), and ii) Information and Communications Technology (ICT). The results show that fiscal stabilization increases R&D expenditure and the share of ICT capital in industries that are more financially constrained. Moreover, the effect is larger during recessions—when financing constraints are more likely to be binding—than during economic expansions. Our statistical method mitigates concerns about omitted variable bias and reverse causality. In addition, the results are robust to different measures of fiscal stabilization and to the inclusion of several controls.

Keywords: E62; H50; H60.

JEL codes: industry-level data, fiscal stabilization; time varying coefficients; financial dependence; recessions vs expansions.

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[*] The usual disclaimer applies. The views expressed are those of the authors and do not necessarily represent those of the IMF or its policy.

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I. INTRODUCTION

Several years after the Global Financial Crisis, growth in many advanced economies remains well below pre-crisis rates. Medium-term growth expectations have been steadily revised downward since 2011, highlighting uncertainties surrounding medium-term growth prospects (IMF, 2015). At the same time, public debt-to-GDP ratios have increased, reaching historical high levels in some countries. Against this background, how can fiscal policy contribute to higher medium-term growth?

While the effects of fiscal policy on aggregate demand have been widely analyzed in the literature, much less is known about the effect of fiscal policy on medium-term growth. One important channel through which fiscal policy can contribute to boost supply over the medium term is by reducing aggregate volatility (Van den Noord, 2000; Kumhof and Laxton, 2009; Debrun and Kapoor, 2011; Fatas and Mihov, 2012; Furceri and Jalles, 2016), which has been typically found to be negatively related with medium-term growth (Ramey and Ramey, 1995; Imbs, 2007).

Aghion et al. (2010) suggest a specific channel through which fiscal stabilization affects medium-term growth. In their theoretical framework, firms can invest either in short-run projects, or in productivity-enhancing long-term projects. Short-term projects face an aggregate productivity shock while the completion of long-term innovative projects is subject to a liquidity risk. If credit market imperfections bind only during periods of bad economic conditions, reducing the volatility of aggregate shocks increases the likelihood that long-term projects survive liquidity shocks in bad states without affecting what happens in the good state where credit constraints do not bind. Moreover, the higher the fraction of credit constrained firms, the larger the positive effect from reducing aggregate volatility on the fraction of long-term projects that survive liquidity shocks. This mechanism suggests that a countercyclical fiscal policy that reduces aggregate volatility would have larger effects on high-productive investment in more credit-constrained industries, particularly in bad times—when financing constraints are more likely to be binding.

Aghion et al. (2004) test these predictions using the Rajan and Zingales' (1998) difference-in-difference methodology to examine whether in countries with a higher degree of fiscal stabilization, TFP growth is larger in industries that are more credit constrained. This paper builds on Aghion et al. (2014) but it extends it in three important ways. First, we let the degree of fiscal stabilization in each country to vary over time. In previous studies, the cyclicality of fiscal policy is typically captured by a unique time-invariant parameter, making difficult to discern the effects of fiscal stabilization from unobserved cross-country heterogeneity. In contrast, our empirical framework allows us to consider a three-dimensional (country-sector-year) panel. Second, we examine the direct channels through which fiscal stabilization can affect industry growth by looking at the effect on high-productive investment such as Research and Development (R&D) and the share of Information and Communications Technology (ICT) investment in total investment. Third, we assess whether the effect of fiscal stabilization on R&D expenditure and ICT capital is larger during periods of recessions—that is, when financing constraints are more binding.

Specifically, we apply Rajan and Zingales' (1998) difference-in-difference methodology to a panel of 25 industries for 18 advanced economies over the period 1985-2012 to assess the effect of fiscal stabilization on R&D expenditure and ICT capital through sectoral dependence on external finance. The advantages of having a three-dimensional (j industries, i countries and t time periods) dataset are twofold:

- First, it allows to control for aggregate and country-sector shocks by including country-time (*i, t*) and industry-country (*j, i*) fixed effects. The former are particularly important as they allow us to control for any unobserved cross-country heterogeneity in the macroeconomic shocks that affect productivity growth in countries. In a pure cross-country analysis, this would not be possible, leaving open the possibility that the impact attributed to fiscal stabilization is due to other unobserved macro shocks.

- Second, it mitigates concerns about reverse causality. While it is typically difficult to identify causal effects using aggregate data, it is much more likely that fiscal stabilization affects industry-level outcomes than the other way around. This because when controlling for country-time fixed effects—and therefore aggregate productivity and investment—reverse causality implies that differences in R&D expenditure (ICT capital) across sectors influence fiscal stabilization at the aggregate level. Moreover, our main independent variable is the interaction between fiscal stabilization and the industry's dependence on external finance; this makes it even less plausible that causality runs from industry-level R&D expenditure (ICT capital) to this composite variable.

A limitation of this approach is that our analysis captures the impact of fiscal stabilization on industry-level R&D expenditure (ICT capital), rather than the aggregate effect. Inferring the impact of fiscal stabilization from this micro estimate would require some additional assumptions regarding, for example, the effect of fiscal stabilization in industries with low external finance dependence.

Our main finding is that fiscal stabilization increases R&D expenditure (ICT capital) in industries that rely more on external finance. Moreover, the effect is larger during recessions—when financing constraints are more likely to be binding—than during times of economic expansions. The effect is robust to different checks, including the use of alternative measures of fiscal stabilization and when controlling for different interaction effects.

Our work contributes to three main strands of the literature. The first strand is on the relationship between volatility and long-run economic growth. There have been extensive efforts to identify the channels through which volatility interacts with growth (King and Levine, 1993; Ramey and Ramey, 1995; Martin and Rogers, 2000; Acemoglu et al., 2003; Imbs, 2007). However, Imbs (2007) emphasize that the sign of the relationship between volatility and growth at the aggregate level cannot be used to draw inferences on what mechanisms are supported by the data. By addressing this concern using the disaggregated data, we confirm the finding of Ramey and Ramey (1995) that the negative effect of volatility on growth mainly works through technology adoption rather than capital accumulation.

The second strand of the literature is on the role of financial frictions in amplifying the effect of volatility by raising borrowing costs and reducing micro and macro growth within a general equilibrium framework (Arellano et al., 2010; Christiano et al., 2014; Gilchrist et al., 2014). We contribute to this strand of the literature by providing novel empirical evidence of the interaction between fiscal stabilization and financial frictions, and how this interaction affects productivity-enhancing investment.

The third strand of the literature is on the relation between fiscal policy and medium-term growth. An extended literature looked at the short-run response of investment and productivity growth to exogenous changes in fiscal policy. We complement this literature by looking at the long-term effects of counter-cyclical fiscal policy on productivity-enhancing investment.

The remainder of the paper is organized as follows. Section II presents the approach used to measure fiscal stabilization in each country and describes the data and the empirical framework to test the effects of fiscal stabilization on productivity-enhancing investment. Section III discusses the results. The last section concludes and outlines some policy implications.

II. Data and Methodology

This section provides a description of the main variables used in the empirical analysis and of the empirical framework.

A. Data

Fiscal Stabilization

Measuring the stabilizing effect of fiscal policy requires assessing how fiscal policy affects aggregate demand. As discussed by Blanchard (1993), in a static setting, the budget balance-to-GDP ratio is an appropriate proxy for the aggregate demand's effect of fiscal policy in each year. This implies that the response of the budget balance to changes in economic activity gives a good approximation of the stabilizing effects of fiscal policy: (i) the more countercyclical government spending is, the higher the effect of fiscal stabilization—a relatively high level of government spending when private demand is low will stabilize aggregate demand; (ii) the more progressive taxes are, the higher fiscal stabilization will be—if taxes fall more than output, when output falls, then taxes contribute to stabilize household's disposable income.[1]

[1] In principle, one should adjust the budget balance and taxes by the marginal propensity to consume out of disposable income, which is typically less than one. Moreover, in a dynamic setting, measuring the impact of

(continued)

Within this conceptual framework, assessing the degree of fiscal stabilization in a given country *i* implies estimating the following regression:

$$b_i = \alpha_i + FS_i \Delta y_i + \varepsilon_i \quad (1)$$

where *b* is the budget balance-to-GDP ratio, *Δy* is GDP growth (or a measure of the output gap) and FS measures the degree of fiscal stabilization or fiscal counter-cyclicality, with larger values of the coefficient denoting higher stabilization.

We generalize equation (1) by introducing the assumption that the regression coefficients (FS) may vary over time. Time-varying measures of fiscal stabilization (FS_{it}) are then estimated as:

$$b_{it} = \alpha_{it} + FS_{it} \Delta y_{it} + \varepsilon_{it} \quad (2)$$

The coefficient FS is assumed to change slowly and unsystematically over time, with its expected being equal to its past value. The change of the coefficient is denoted by $v_{i,t}$, which is assumed to be normally distributed with expectation zero and variance σ_i^2:

$$FS_{it} = FS_{it-1} + v_{it} \quad (3)$$

Equation (2) and (3) are jointly estimated using the Varying-Coefficient model proposed by Schlicht (1985, 1988). In this approach the variances σ_i^2 are calculated by a method-of-moments estimator that coincides with the maximum-likelihood estimator for large

fiscal policy on aggregate demand requires looking not only at current budget balance but also at future anticipated deficits and at the level of the stock of public debt (Blanchard and Summers, 1984 and Blanchard, 1985). Therefore, to assess the overall fiscal stabilization, requires examining how future anticipated deficits respond to changes in economic activity today.

samples (see Schlicht, 1985, 1988 for more details). The model described in equation (2) and (3) generalizes equation (1), which is obtained as a special case when the variance of the disturbances in the coefficients approaches to zero.

As discussed by Aghion and Marinescu (2008), this method has several advantages compared to other methods to compute time-varying coefficients such as rolling windows and Gaussian methods. First, it allows using all observations in the sample to estimate the degree of fiscal stabilization in each year—which by construction it is not possible in the rolling windows approach. Second, changes in the degree of fiscal stabilization in each year come from innovations in the same year, rather than from shocks occurring in neighboring years. Third, the methodology accounts for the fact that changes in policy are slows and depends on the immediate past. Fourth, it reduces reverse causality problems when fiscal stabilization is used as explanatory variable as the degree of fiscal stabilization depends on the past.

Figure 1 reports the average level and the time path of the *FS* coefficient estimated in equations (2) and (3) for a sample of 18 advanced economies, for which for which we have estimates of fiscal stabilization for at least 34 years.

[insert Figure 1 here]

As a first observation, it is worth nothing that the time-average fiscal stabilization coefficient is positive (about 0.25-0.3), which is consistent with the fact that the budget balance is generally counter-cyclical (Lane, 2003; Aghion and Marinescu, 2008). Second, the degree of fiscal stabilization has increased over time (mostly during the 80s and the 90s), with the pattern holding for many advanced economies (Figure 2)—as evident by the evolution of the interquartile range of the stabilization coefficient.

[insert Figure 2 here]

External dependence

Data to construct measures of dependence on external finance are taken from Compustat, which compiles balance sheets and income statements for US-listed firms. Following Rajan and Zingales (1998), dependence on external finance in each industry is measured as the median across all US firms in each industry of the ratio of total capital expenditures minus current cash flow to total capital expenditures.[2] Figure 3 shows how industries vary based on their reliance on external finance. Transport Equipment and Food Products, Beverages and Tobacco are among those sectors characterized by a lower dependence on external finance, while Construction and Mining and Quarrying are among those sectors with the highest dependence.

[insert Figure 3 here]

RD expenditure and ICT-capital

Data on sectoral R&D private expenditure are taken from the OECD Research and Development Industry database. The dataset includes comparable time-series on industrial R&D expenditures broken for OECD countries from 1987 to 2012.

Data on ICT-capital are taken from the KLEMS database. Compared to other sectoral datasets, such as the OECD Structural Analysis Database (STAN) or Industrial Statistics

[2] Data have been kindly provided by Hui Tong. For details, see Hui Tong and Shang-Jin Wei, 2011."The Composition Matters: Capital Inflows and Liquidity Crunch During a Global Economic Crisis," Review of Financial Studies 24(6), pages 2023-2052."

Database by United Nations Industrial Development Organization (UNIDO), the KLEMS is the only one that provides harmonized data on TFP growth as well on investment broken downy by information technology and communications (ICT) investment and non-ICT investment (for details, see O'Mahony and Timmer, 2009).

Our data sample covers an unbalanced panel of 25 industries for 18 advanced economies (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hungary, Korea, Ireland, Italy, Japan, the Netherlands, Spain, Sweden, the United Kingdom and the United States) over the period 1985-2012. The sample is dictated by the availability of the main variable of interest (R&D expenditure and ICT-capital).[3]

B. Methodology

The methodology used to assess the effect of fiscal stabilization follows the approach originally proposed by Rajan and Zingales (1998). The following specification is estimated for an unbalanced panel of 18 advanced economies and 25 industries over the period 1985-2012:

$$G_{i,j,t} = \alpha_{i,t} + \gamma_{i,j} + \beta f d_j FS_{i,t} + \varepsilon_{i,j,t}, \quad (4)$$

where *i* denotes countries, *j* industries, and *t* years. *G* is alternatively the (log of the) level of R&D expenditure or the share of ICT-capital in the total capital stock; *fd* is a measure of dependence on external finance for each industry *j*; *FS* is our time-varying measure of fiscal stabilization for each country *i*; $\alpha_{i,t}$ and $\gamma_{i,j}$ are country-time and country-industry fixed effects, respectively.

[3] All the results are robust to the exclusion of Hungary from the sample.

The inclusion of these two types of fixed effects provides two important advantages compared to the cross-country analysis: (i) country-year fixed effects allow to control for any variation that is common to all sectors of a country's economy, including aggregate macroeconomic shocks; (ii) country-industry fixed effects allow to control for industry-specific factors including, for instance, cross-country differences in the R&D expenditure (or the share of ICT-capital) of certain sectors.

As discussed in the previous section, industry dependence on external finance is measured using only US firm-level data. One potential problem with this approach is that US industry dependence on external finance may not be representative for the whole sample—that is, US measures of dependence on external finance may be affected by US-specific regulations or sectoral patterns. However, this issue is unlikely to be important when restricting the analysis to other advanced economies for two main reasons. First, differences in financial dependence are likely to mostly reflect differences in industry-specific factors common across counties, rather than difference across countries' institutional characteristics. For example, if the electrical machinery sector relies more on external finance than the tobacco sector in the United States, the same pattern is likely to hold also in other advanced economies. Second, given the slow growth convergence process in advanced economies, cross-country differences are likely to persist in our sample.

Equation (4) is estimated using OLS—and standard errors are clustered at the country-industry level—as the inclusion of country-time and industry-country fixed effects is likely to largely address endogeneity concerns related to omitted variable bias. In addition, reverse causality issues are unlikely in this setting. First, and related to the measure of external dependence, it is hard to conceive that sectoral R&D expenditure (ICT-capital) can influence the degree to which industries rely on external finance in the United States. Second, it is very implausible that R&D expenditure (ICT-capital) at the sectoral level can influence aggregate measures of fiscal stabilization While, in principle, this could be the case if R&D expenditure (ICT-capital) co-moves across all sectors, we address this concern when we include country-industry fixed effects.

However, a remaining possible concern in estimating equation (5) with OLS is that other macroeconomic variables could affect sector R&D expenditure (ICT-capital) when interacted with industry' dependence on external finance. This could be the case for the credit-to-GDP ratio—the original variable assessed by Rajan and Zingales (1998), but also for inflation as well as for uncertainty (Choi et al., 2016). This issue is addressed in the sub-section on robustness checks.

III. Results

A. Baseline

We start by extending the findings of Aghion et al. (2014) by assessing the impact of fiscal stabilization on output growth. Our results presented in column I of Table 1 confirm that the interaction between fiscal stabilization and external financial dependence is positively correlated with industry growth. In particular, the results suggest that the differential growth gain from an increase in fiscal stabilization from the 25^{th} to the 75^{th} percentile of fiscal stabilization—that is, an increase in the degree of fiscal stabilization from the level in Sweden to the level in Portugal—for an industry with relatively low external financial dependence (at the 25^{th} percentile of the distribution of external financial dependence) compared to an industry that has relatively high external financial dependence (at the 75^{th} percentile) is about 0.5 percentage point.

The magnitude of the results is economically significant, but smaller than the one found by Aghion et al. (2014) using country-sectoral data—that is, not allowing for time variation in fiscal stabilization and in sectoral growth. At the same, it must be acknowledged that while the effect is economically significant, increasing fiscal stabilization from the 25th to the 75th percentile of the distribution corresponds to a dramatic change in the design of fiscal policy over the cycle, and—as illustrated in Figure 1 and 2—changes in fiscal stabilization within countries are typically smaller and occur only gradually over time. [4]

[insert Table 1 here]

Having confirmed the effect of fiscal stabilization on sectoral growth, we now move to directly test the different transmission channels. Table 1 presents the results obtained by estimating equation (1) alternatively using the level of private R&D expenditure and the share of ICT-capital in the total capital stock as dependent variables. The results suggest that an increase in fiscal stabilization increases R&D expenditure and the share of ICT-capital in industries that relies more on external finance.[5]

Our results are robust when considering the lag of the interaction term between fiscal stabilization and sectoral external finance (Table 1, column IV-V), as well as when using a categorical measure of external finance—which takes value 1 for the sector with the lowest degree of external finance, and 25 for the sector with the largest degree of external finance (Table 1, column VI-VII).

[4] See Furceri and Jalles (2016) for further evidence on the drivers of fiscal stabilization.

[5] The results in Table A1 in appendix shows that fiscal stabilization increases both non-ICT and ICT-capital, but the effect on the latter is larger.

In terms of magnitude, the results suggest that the differential gains in R&D expenditure (share of ICT-capital) from an increase in fiscal stabilization from the 25th to the 75th percentile of distribution of fiscal stabilization for an industry with relatively low external financial dependence (at the 25th percentile of the distribution of external financial dependence) compared to an industry that has relatively high external financial dependence (at the 75th percentile) range between 5 and 21 percent (1 and 3 percentage points).

Different samples of industries

The theoretical predictions of the effect of fiscal stabilization on R&D expenditure (ICT-capital) and the role of credit constrained are likely to be more relevant for manufacturing industries, as these are those characterized by a higher share of R&D investment and are typically more involved in innovation-related activities. To check whether this is the case, and to control at the same time for possible measurement errors due to the fact that capital is typically poorly measured in non-manufacturing sectors, equation (4) is estimated separately for manufacturing and non-manufacturing industries. The results presented in Table 2 shows that the effect of fiscal stabilization is, indeed, typically larger in manufacturing sectors.

[insert Table 2 here]

Asset tangibility

As a robustness check, we also examine whether the results are robust to replace the RZ index of external financial dependence with a measure of asset tangibility—computed as the median fraction of assets represented by net property, plant and equipment for US firms in the same industry for the period 1980–1989 (Braun and Larrain, 2005). The estimates presented in Table 3 confirms the validity of our results. We find that the differential increase in R&D expenditure

(ICT capital) from an increase in fiscal stabilization from 25th to the 75th percentile of the distribution of fiscal stabilization from an industry with relatively high asset tangibility (at the 75th percentile of the distribution) compared to an industry with relatively low asset tangibility (at the 25th percentile of the distribution) is about 9 percent (2 percentage points). These results are statistically significant and very similar to those obtained using the RZ index.

[insert Table 3]

Uncertainty in fiscal stabilization estimates

A possible limitation of the analysis is that fiscal stabilization is estimated and not directly observable. This implies that the above findings could simply reflect that the standard errors around the fiscal stabilization estimates are not properly considered. To address this limitation, we re-estimate equation (4) using Weighted Least Squares (WLS), with weights given by the inverse of the standard deviation of the fiscal stabilization estimated coefficient.

The results of this exercise are reported in Table 4. The interaction between fiscal stabilization and industry financial constraints still has a statistically significant effect on R&D expenditure (ICT-capital). The estimated parameters are similar and not statistically different from those obtained using OLS, suggesting that baseline results appear to not be biased using a generated regressor.

[insert Table 4]

Alternative fiscal stabilization estimates

To check the robustness of the results to different measure of fiscal stabilization, we have re-estimated equation (2) and (3) using the primary balance-to-GPD ratio. The results obtained by estimating equation (4) with this alternative measure of fiscal stabilization are reported in the first two columns of Table 6. They confirm a statistically significant impact of fiscal stabilization on R&D expenditure (ICT-capital) through industry financial constraints. At the same time, the magnitude of the effect is smaller, even though not statistically significantly different from those reported using the baseline specification.

A possible important limitation of the analysis is that the estimated measure of fiscal stabilization is biased downward. This because an increase in the budget balance tends to reduce GDP growth, therefore biasing the coefficients estimated in equation (2) and (3). As a robustness check, we have re-estimated equation (2) and (3) using an Instrument Variable (IV) approach. Specifically, we use as instrument for GDP growth in each country the corresponding GDP growth in main trading partners. The results reported in column III and IV of Table 5 confirm that an increase in fiscal stabilization increases R&D expenditure (ICT-capital) for industries that rely more on external finance. In addition, the magnitude of the effect is similar and not statistically different from the one obtained using OLS, suggesting that the bias of in estimating equation (2) and (3) with OLS is not a great concern.

[insert Table 5]

Different factors and omitted variable bias

As discussed before, a possible concern in estimating equation (4) is that the results are biased due to the omission of macroeconomic variables affecting R&D (the ICT-capital share) through the dependence on external finance and that are at the same time correlated with our measure of fiscal stabilization.

The first obvious candidate is the level of financial development, the variable originally used by Rajan and Zingales (1998) in their approach. Financial development has been found to increase growth in industries that rely more on external dependence (Rajan and Zingales, 1998), and to be strongly correlated with the degree of fiscal stabilization (Furceri and Jalles, 2016). To check whether the inclusion of this variable alters our results, we augment equation

(5) by interacting the ratio of bank credit-to-GDP (the main variable used in Rajan and Zingales, 1998) with the degree of dependence on external finance. The results presented in the first column of Tables 6 and 7 (for R&D and ICT capital, respectively) show that the effect of fiscal stabilization remains of the sign and also statistically significant, even though the point estimates are smaller. In addition, we find that financial deepening has a positive effect on R&D expenditure but a negative one on the share of ICT capital.

Another potential variable that may affect R&D expenditure (ICT capital) through external financial dependence is inflation. Inflation may lead to capital misallocation and—to the extent that more financially dependent sectors are those that suffer more from capital misallocation—may have larger negative effects on industries that rely more heavily on external sources of financing. Moreover, inflation may affect sectoral growth by increasing price level uncertainty. To further check the robustness of our results, we include an interaction term between inflation and external financial dependence as a control. The results reported in the second column of Table 6 and 7 show that effect of fiscal stabilization on R&D expenditure and ICT capital is unchanged, while inflation does not have statistically significant effects.

Another potential variable that may affect R&D and ICT capital is uncertainty. As discussed by Choi et al. (2017), an increase in uncertainty may lead financially constrained firms to switch the composition of investment away from long-term productive one—which is typically more subject to liquidity risks. To check whether the effect of fiscal stabilization remains statistically significant when uncertainty is included, we re-estimate equation (4) including an interaction term between uncertainty and external financial dependence as a control. The results reported in the third column of Tables 6 and 7 suggest that the effect of fiscal stabilization remains statistically significant, and the differential effect on R&D expenditure (ICT capital) is larger than the one presented in the baseline.[6]

Finally, our results are also robust when controlling for these interaction terms simultaneously (Tables 6 and 7, column IV).

[insert Table 6 and 7 here]

B. Nonlinearities

Degree of external finance

An interesting question is whether the effect of fiscal stabilization is larger in industries that are more financially constrained. To test for this hypothesis, the following equation is estimated:

$$G_{i,j,t} = \alpha_{i,t} + \gamma_{i,j} + \beta fd_j FS_{i,t} + \delta D_j FS_{i,t} + \varepsilon_{i,j,t}, \quad (5)$$

where *D* is a dummy variable which takes value 1 for industries that rely relatively more heavily on external finance—that is, with a degree of external finance above the 75th percentile of distribution—and zero otherwise.[7]

The results presented in Table 8 suggest that the effect of fiscal stabilization on R&D tends to be larger in industries with higher external financial dependence—even though the difference is not statistically significantly different from zero. In contrast, the effect of fiscal stabilization on the share of ICT capital is statistically significantly larger in industries that rely

[6] The difference in the differential effect is mostly due to different estimation samples.

[7] Qualitatively similar results are obtained when considering different thresholds, such as the median or the 66th percentile of the distribution of external finance. These are available from the authors upon request.

(continued)

more on external finance.[8] This result is consistent with the evidence presented in Ghosal and Loungani (2000) on the greater effect of volatility for small firms which are typically more financially constrained.

[insert Table 8]

C. Recessions vs. expansions

The argument that fiscal stabilization has larger effects on R&D expenditure (the share of ICT capital) in industries that rely more on external finance builds on the assumption that firms face credit constraints that prevent them to borrow to finance not only short- but also long-term investment. Based on this assumption, we should therefore expect that the effect of fiscal stabilization varies over time and is stronger when overall credit conditions are more binding, such as in periods of recession. To test for this hypothesis, we expand equation (4) to interact fiscal stabilization with a smooth transition function of the state of economy.[9] Specifically, we estimate the following regression:

$$TFP_{j,i,t} = \alpha_{i,t} + \gamma_{i,j} + \beta^L fd_j F(z_{i,t})FS_{i,t} + \beta^H fd_j (1 - F(z_{i,t}))FS_{i,t} + \vartheta X_{i,j,t} + \varepsilon_{i,j,t} \qquad (6)$$

with $F(z_{it}) = \frac{\exp(-\delta z_{it})}{1+\exp(-\delta z_{it})}, \quad \delta > 0,$

[8] The overall effect of fiscal stabilization is given by $\beta + \delta$. The F-test suggests that this effect is statistically significant at 1 percent for both R&D expenditure and the share of ICT capital.

[9] The approach follows the one proposed by Auerbach and Gorodnichenko (2012) to assess the magnitude of fiscal multipliers in expansions and recessions.

where z is an indicator of the state of the economy normalized to have zero mean and unit variance and $F(z_{it})$ is the corresponding smooth transition function between states—our analysis uses contemporaneous GDP growth as a measure of the state of the economy. Following Auerbach and Gorodnichenko (2012), the value of δ is set to be equal to 1.5 to mimic the business cycle properties of many advanced economies—that is, we assume that each economy spends about 80 percent of the time in expansion and 20 percent in recession; $\boldsymbol{X}$ is the interaction between the smooth transition function and the degree of dependence on external finance.[10] Controlling for this interaction term is important since changes in volatility and fiscal stabilization may coincide with downturns, which may directly affect investment in industries that are more financial constrained (Abiad et al., 2011).

The results presented in Table 9 suggest that the effects of fiscal stabilization on R&D expenditure and the share of ICT capital are very different across economic regimes.[11] During periods of relatively low growth, an increase in fiscal stabilization increases R&D expenditure (the share of ICT capital) growth in those industries that rely more on external finance, but during periods of relatively high growth the effect is not statistically significantly different from zero. In addition, the results also show that private R&D expenditure is pro-cyclical, particularly in industries that are more financially constrained.

[insert Table 9]

[10] Similar results are obtained, using lagged output growth or the IMF WEO measure of output gap. Following Auerbach and Gorodnichenko (2012), we use $\gamma = 1.5$ for the analysis of recessions and expansions.

[11] Similar are results are also obtained when the sample period is restricted to 2007, suggesting that they are not driven mainly by the Great Recession.

IV. Conclusions

By reducing aggregate volatility, fiscal policy can stimulate medium-term growth by boosting R&D and ICT investment. This paper empirically tests whether this theoretical prediction is borne out in the data by making use of industry-level data and approaches. More specifically, by means of the Rajan and Zingales' (1998) difference-in-difference methodology applied to an unbalanced panel of 25 industries for 18 advanced economies over the period 1985-2012, we assessed the effect of fiscal stabilization on R&D expenditure and ICT capital through sectoral dependence on external finance.

Our estimates suggest that private R&D expenditure (ICT capital) is significantly and positively correlated with the degree of fiscal policy counter-cyclicality. Higher fiscal stabilization increases industry R&D expenditure (ICT capital) the more so for industries with higher external financial dependence. Moreover, this effect tends to be larger in recessions—that is, when financial conditions are likely to be more binding—than in times of economic expansion. Our results are robust to different robustness checks, including the use of alternative measures of fiscal stabilization as well as the inclusion of other macroeconomic control variables affecting industry productivity-enhancing investment through financial external dependence.

Identifying policies that could lift productivity growth by promoting innovation is crucial at this juncture. The results of the paper suggest that fiscal policy can play an important role not only by carefully designing targeted tax incentives and research subsidies, but also by strengthening the role of automatic stabilizers. An important avenue for further research is therefore to investigate what are the determinants of fiscal counter-cyclicality and which components of fiscal policy can deliver higher stabilization.

Another avenue for future research is to extend the analysis to emerging and developing economies. Recent research (e.g., Frankel et al., 2013) has shown that changes in market access and domestic financial institutions have enabled fiscal policy in many developing countries over the last 15 years to switch from being procyclical to acyclical or even countercyclical.

Finally, it is interesting to analyze other industry-specific channels through fiscal stabilization can affect productivity growth. The credit constraint (or external finance dependence) channel is not necessarily the only one through fiscal stabilization can affect growth. To the extent to which certain industry-level technological characteristics—such as, for example, R&D and labor intensity, asset fixity and investment lumpiness—interact with the degree of output volatility, fiscal stabilization may affect growth via the same channel.[12]

[12] For example, Samaniego and Sun (2016) run a horse race of mechanisms suggested in the theoretical literature through which volatility can affect growth.

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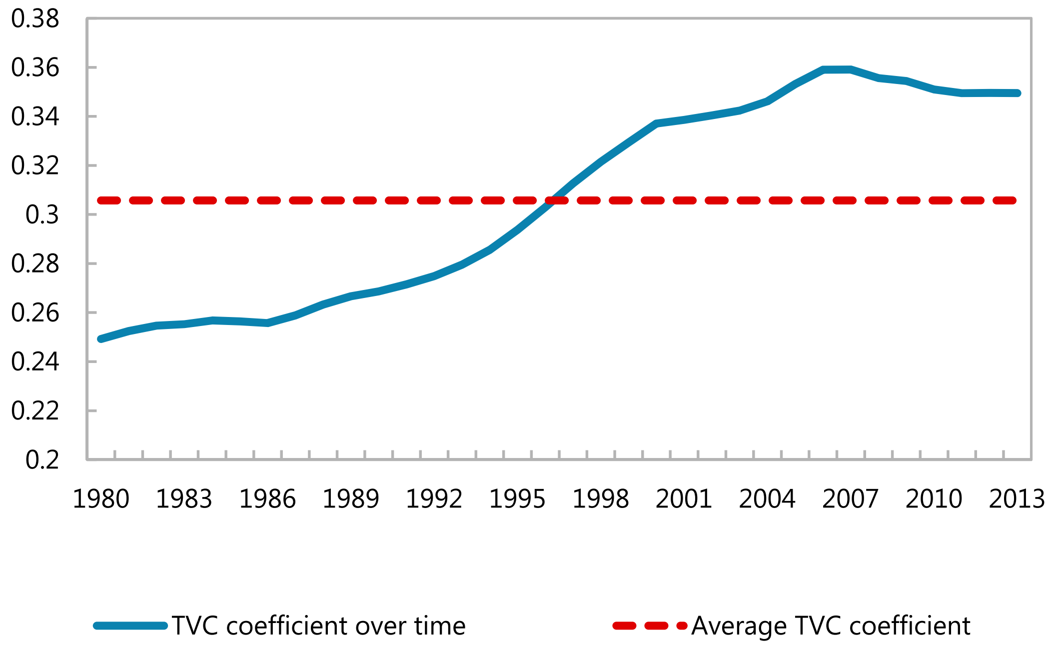
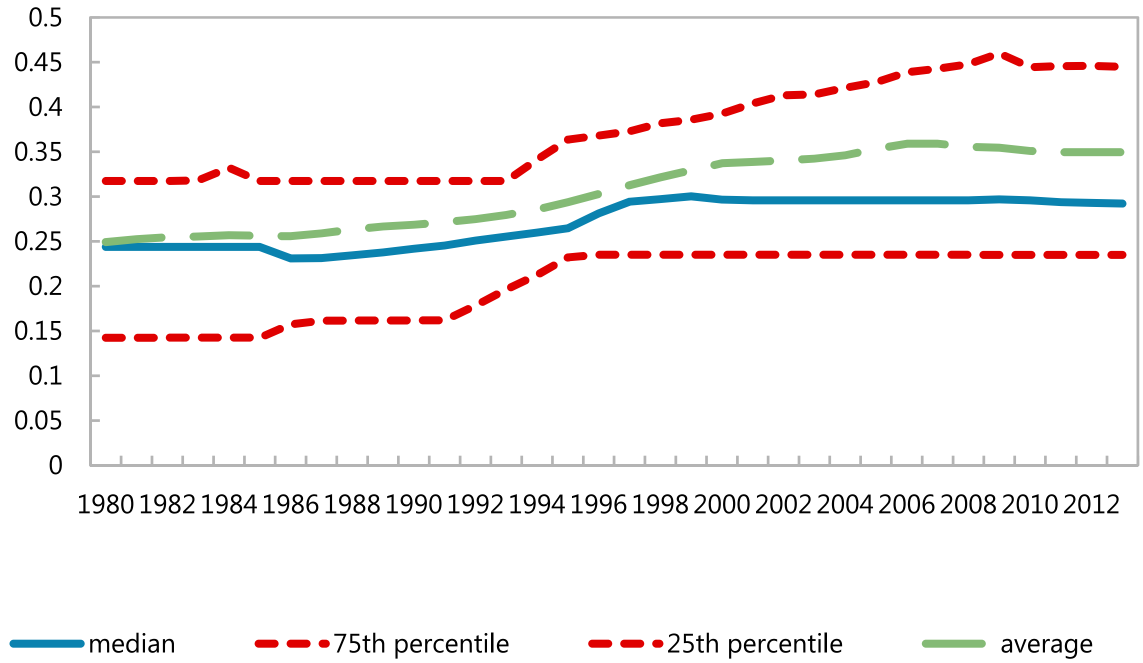
Figure 1. Fiscal stabilization over time in Advanced Economies, 1980-2013



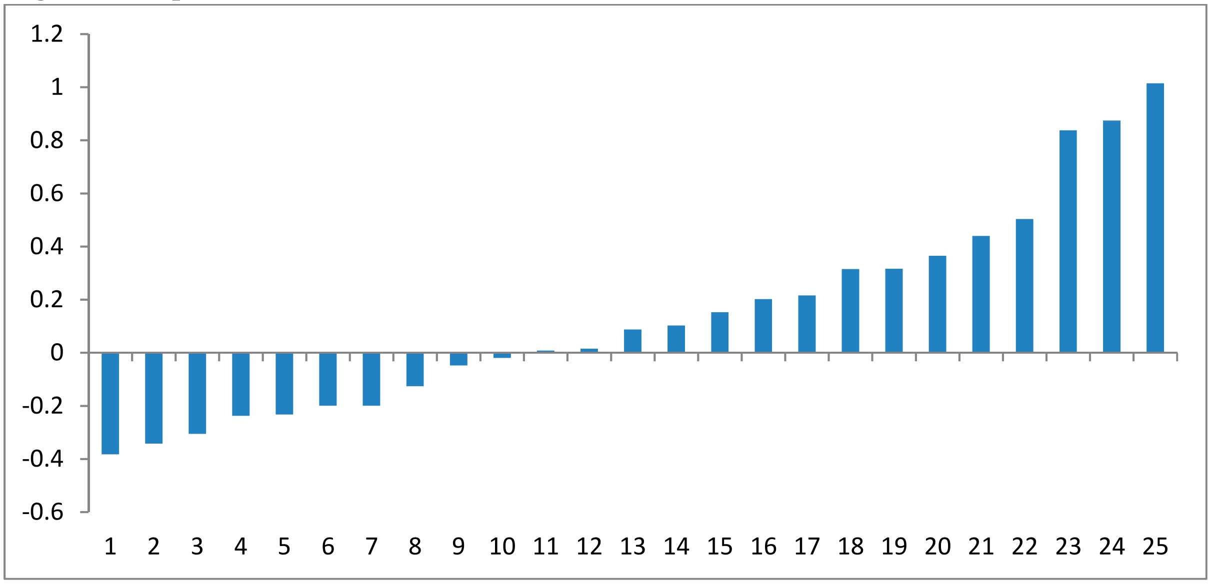
Note: Figure displays the time profile of the TVC coefficient estimates for Advanced Economies. It includes 18 countries with at least 34 observations.

Figure 2. Fiscal stabilization over time in Advanced Economies-within sample, 1980-2013



Note: Figure displays the interquartile and mean evolution of the TVC coefficient estimates for Advanced Economies. It includes 18 countries with at least 34 observations.

Figure 3. Dependence on external finance



Notes: 1= Transport Equipment; 2= Food Products, Beverages and Tobacco; 3= Chemicals and chemical Products; 4= Textiles, Wearing Apparel, Leather and Related Products; 5= Wood and Paper Products; Printing and Reproduction of Recorded Media; 6=Education; 7= Financial and Insurance Activities; 8= Rubber and Plastics Products, and Mineral Products; 9= Basic Metals and Fabricated Metal Products, Except Machinery and Equipment; 10= Electrical and Optical Equipment; 11= Agriculture, Forestry and Fishing; 12= Machinery and Equipment N.E.C.; 13= Electricity, Gas and Water Supply; 14= Accommodation and Food Service Activities; 15= Professional, Scientific, Technical, Administrative and Support Service Activities; 16= Transport and Storage; 17= Retail Trade, Except Of Motor Vehicles and Motorcycles; 18= Arts, Entertainment, Recreation and Other Service Activities; 19= Wholesale and Retail Trade and Repair of Motor Vehicles and Motorcycles; 20= Wholesale Trade, Except Of Motor Vehicles and Motorcycles; 21= Health and Social Work; 22= Real Estate Activities; 23= Construction; 24= Mining and Quarrying; 25= Postal and Courier Activities.

Table 1. The effect of fiscal stabilization on growth, R&D expenditure and the share of IT-capital in the total capital stock

Explanatory variable	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)
	Growth	R&D	ICT-capital share	R&D	ICT-capital share	R&D	ICT-capital share
Fiscal stabilization* financial dependence	4.364** (1.93)	0.914*** (2.90)	0.162*** (3.72)				
Lag of fiscal stabilization* financial dependence				0.456** (2.08)	0.103*** (3.54)		
Fiscal stabilization * financial dependence (ordinal)						0.354*** (3.49)	0.043*** (3.06)
Differential effect (%)	0.5	10.1	1.8	5.1	1.1	22.0	2.7
Country*time fe	yes	yes	yes	yes	yes	yes	Yes
Country*sector fe	yes	yes	yes	yes	yes	yes	Yes
Observations	12,734	4,759	9,944	4,705	9,765	4,759	9,944
R^2	0.35	0.97	0.77	0.97	0.78	0.97	0.77

Note: estimates based on equation (5). T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effects computed for an industry whose external financial dependence would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 2. The effect of fiscal stabilization: manufacturing versus non-manufacturing

Explanatory variable	(I)	(II)	(III)	(IV)
	All sectors		Manufacturing	
	R&D	ICT-capital share	R&D	ICT-capital share
Fiscal stabilization* financial dependence	0.914*** (2.90)	0.162*** (3.72)	1.206*** (4.02)	0.173*** (3.72)
Differential effect (%)	10.1	1.8	13.3	1.9
Observations	4,759	9,944	3,952	6,165
R^2	0.97	0.77	0.98	0.81

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry whose external financial dependence would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 3. The effect of fiscal stabilization: asset tangibility

Explanatory variable	(I)	(II)
	R&D	ICT-capital share
Fiscal stabilization* asset tangibility	-2.754***	-0.558***
	(-3.81)	(-4.19)
Differential effect (%)	-9.2	-1.9
Observations	4,547	7,608
R^2	0.98	0.79

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry asset tangibility would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 4. The effect of fiscal stabilization—WLS

Explanatory variable	(I)	(II)
	R&D	ICT-capital share
Fiscal stabilization*financial dependence	1.224*** (2.78)	0.138*** (2.57)
Differential effect (%)	13.5	1.5
Observations	4,759	9,944
R^2	0.97	0.77

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry asset tangibility would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 5. The effect of fiscal stabilization—alternative measures of fiscal stabilization

Explanatory variable	(I)	(II)	(I)	(II)
	R&D	ICT-capital share	R&D	ICT-capital share
Fiscal stabilization (primary balance)* financial dependence	0.479*** (3.05)	0.029** (2.02)		0.029** (2.02)
Fiscal stabilization (IV)* financial dependence			1.118*** (4.20)	0.037*** (2.58)
Differential effect (%)	5.5	0.3	15.3	0.5
Observations	2,960	6,727	3,480	5,230
R^2	0.97	0.81	0.97	0.78

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry asset tangibility would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 6. The effect of fiscal stabilization on R&D expenditure: controlling for other effects.

Explanatory variable	(I)	(II)	(III)	(IV)
Fiscal stabilization* financial dependence	0.627*	0.810**	2.254***	1.912***
	(1.94)	(2.49)	(5.94)	(4.60)
Credit to GDP * financial dependence	0.004***			0.003***
	(4.07)			(2.87)
Inflation* financial dependence		-0.012		-0.006
		(-1.36)		(-0.48)
Uncertainty * financial dependence			0.102*	0.097
			(1.85)	(1.63)
Differential effect (%)	6.9	9.0	24.9	21.2
Observations	4,690	4,759	3,676	3,617
R^2	0.97	0.97	0.97	0.97

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry whose external financial dependence would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 7. The effect of fiscal stabilization on ICT-capital: controlling for other effects.

Explanatory variable	(I)	(II)	(III)	(IV)
Fiscal stabilization* financial dependence	0.232*** (4.59)	0.181*** (4.10)	0.242*** (5.03)	0.365*** (6.55)
Credit to GDP * financial dependence	-0.001*** (-2.72)			-0.001*** (3.82)
Inflation* financial dependence		0.001 (1.18)		0.001 (0.50)
Uncertainty * financial dependence			-0.013*** (-2.70)	-0.012*** (-2.63)
Differential effect (%)	2.6	2.0	2.7	4.0
Observations	9,841	9,728	8,835	8,516
R^2	0.78	0.79	0.77	0.80

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry whose external financial dependence would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.

Table 8. The effect of Fiscal stabilization: high financial dependence

Explanatory variable	(II)	(III)
	R&D expenditure	Share of ICT-capital
Fiscal stabilization* financial dependence	0.293 (0.43)	0.013 (0.18)
Fiscal stabilization * high financial dependence	0.652 (1.03)	0.168*** (2.62)
Observations	4,759	3,676
R^2	0.97	0.97

Note: estimates based on equation (8). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Table 9. The effect of fiscal stabilization: recessions vs. expansions

Explanatory variable	(I)	(II)
	R&D expenditure	Share of ICT-capital
Fiscal stabilization* financial dependence *recessions	1.221***	0.243***
	(3.02)	(4.80)
Fiscal stabilization * financial dependence*expansions	-0.006	0.131**
	(-0.01)	(2.30)
Expansion* financial dependence	0.552***	-0.014
	(2.78)	(-0.84)
Observations	4,745	9,867
R^2	0.77	0.78

Note: estimates based on equation (9). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively.

Appendix

Table A1. The effect of fiscal stabilization on ICT and non-ICT capital (percent)

Explanatory variable	(I)	(II)
	ICT-capital	Non-ICT capital
Fiscal stabilization* financial dependence	0.599** (2.86)	0.241** (2.10)
Observations	9,961	9,963
R^2	0.95	0.85

Note: estimates based on equation (5). Country*time and country*sector fixed effects included. T-statistics based on clustered standard errors at the country-industry level are reported in parenthesis. *, **, *** denote significance at 10, 5 and 1 percent, respectively. Differential effect computed for an industry whose external financial dependence would increase from the 25th percentile to the 75th percentile of the financial dependence distribution when fiscal stabilization would increase from the 25th to the 75th percentile.