Dynamics of Financing Frictions for Investment in R&D

Irem Guceri & Ahmed Tohamy

Abstract. *We analyze the role of financing frictions for investment in R&D and innovation by building and estimating a structural investment model for privately-held, R&D-intensive companies – a group for which reliable estimates of financing frictions have not been available in earlier papers. We use confidential administrative data from the UK to study the effect of a special policy that aims to address financing frictions and stimulate innovation. Profitable firms are offered tax super-deductions for R&D, while loss-makers are given a choice between taking a cash injection from the government immediately or when they become profitable in the future. Claiming the cash immediately comes at a cost; the rate at which the government pays cash to loss-making firms is significantly lower than a future deduction. Firms' choices reveal financing frictions and unobserved productivity. Using a structural model, we find that privately-held innovative firms face much higher costs of external finance than public firms and there are vast heterogeneities across different sub-groups of firms in their exposure and responses.*

Companies may forego potentially profitable investment opportunities because of financing frictions. It is often difficult to separately identify the effect of financing frictions from the effect of adverse shocks in determining the cause of changes in investment – both at the company- and aggregate-levels. In this paper, we distinguish between the impact of financing frictions and negative shocks in the way they affect firm-level investment in research and development (R&D). The existing literature on quantifying the impact of financing frictions on investment inevitably focuses on large, listed companies, because there is simply not enough data on external financing and investment choices of unlisted enterprises. We use confidential tax returns data from the UK, matched with company accounts to address some of the data challenges.

Reduced form evidence points towards a strong link between the availability of external financing for investment in innovation and growth (Brown, Fazzari and Petersen, 2009; Dechezlepretre et al., 2016; Guceri and Liu, 2019; Chen et al., 2017). High-tech firms increasingly remain private. In this paper, we develop a framework to quantify the extent of financing frictions for private companies using the variation in firms' responses to different tax policy instruments. We flexibly model the dynamic choice of optimizing firms that face costs of external financing. In the model, firms adapt their choice of R&D investment according to technology shocks and external financing costs that they face in each period. We model the tax system surrounding the firms' decision-making process by incorporating R&D tax incentives available to the firms, and their ability to carry their losses forward to offset future taxable profit.

The UK policy has features that are particularly useful for the empirical strategy of this paper. R&D-performing companies in a tax loss position have the option of taking a small amount of cash from the government immediately, or waiting and taking a larger amount (as a tax deductible) in the future. The R&D tax relief allows firms to deduct more than 100 percent of their qualifying R&D spending from taxable income. Because the value of the immediate cash refund is lower, a firm that chooses this option must either be facing a high cost of external

finance, or it must not be expecting to move to profitable position in the near future. We model the choices of these firms, allowing for differences across firms in permanent unobserved productivity and shocks experienced over time. Firms' choices include the amount of investment in R&D, and if the firm is in a tax loss position, whether to take the immediate cashback or to carry forward and claim the cash against future profit. Fluctuations in profit, output and inputs are informative about the nature of shocks and the production function parameters, while the choices of cash-now versus cash-later by firms and other information on financing reveal the cost of external finance. Figure 3 summarises the changes in R&D deduction rates and availability of cash across different groups of firms over time. Such policy variation is not required for identification of the financing friction but it is a useful feature of the setting for examining patterns of R&D investment, productivity and innovative output (i.e. patents) in a rich dataset.

Table 1 provides our preliminary estimates. The financing constraint parameter, λ, is much higher in our sample of privately-held SMEs than previously reported in the literature. Based on the estimated model, we study the impact of the provision of the immediate cash option for cash constrained firms. Figure 5 presents the simulated counterfactual of removing the cash option for R&D investment and knowledge capital accumulation based on our model. We find that for constrained firms, R&D investment almost doubles.

The findings of this paper relate to three strands of literature. First, the available policy setting in this paper allows for a novel approach for the measurement and effects of financing frictions. There is little publicly-available data on firms that are particularly prone to experiencing a high cost of external finance. The limited data availability then creates problems for applying even the standard reduced-form regression analyses of the effect of cash flows on investment rates, controlling for a firm's market-to-book ratio as proposed by Fazzari, Hubbard and Petersen (1988). Even for publicly-traded firms for which more data is available relative to unlisted firms, there is evidence that such reduced-form approaches do not accurately reflect the heterogeneities across firms and therefore misrepresent the extent of financing constraints (Hennessy and Whited, 2007; Farre-Mensa and Ljungqvist, 2016). There is some evidence that smaller firms are more financially constrained than larger firms, but again, within a sample of listed companies, the extent of financing frictions for smaller and privately-held companies is often overlooked (Nikolov, Schmid and Steri, 2019). Both theoretically and empirically, there is evidence that financing frictions explain a large part of firm responses to investment incentives, but the causal link is difficult to establish (Cooper and Ejarque, 2003; Hennessy and Whited, 2007; Edgerton, 2010; Strebulaev and Whited, 2012; Devereux and Liu, 2016).

Second, recently the literature on the effectiveness of investment tax incentives has developed rapidly thanks to the broader availability of micro-level administrative data. Recent estimates based on quasi-experiments have guided our understanding of the impact of tax incentives on firms' investment in both physical capital and R&D, as well as other outcomes such as patent counts and total factor productivity (Rao, 2016; Guceri, 2017; Agrawal, Rosell and Simcoe, 2020; Guceri and Liu, 2019; Dechezlepretre et al., 2016; Chen et al., 2017). Some of these studies found stronger responses to tax incentives by younger firms and interpreted this finding as indicative of the importance of cash flow constraints, but the precise nature and extent of financing frictions for innovative firms have largely remained unexplored. This fundamental question is fundamentally linked to optimal R&D policy design, as explored theoretically in Akcigit, Hanley and Stantcheva (2016).

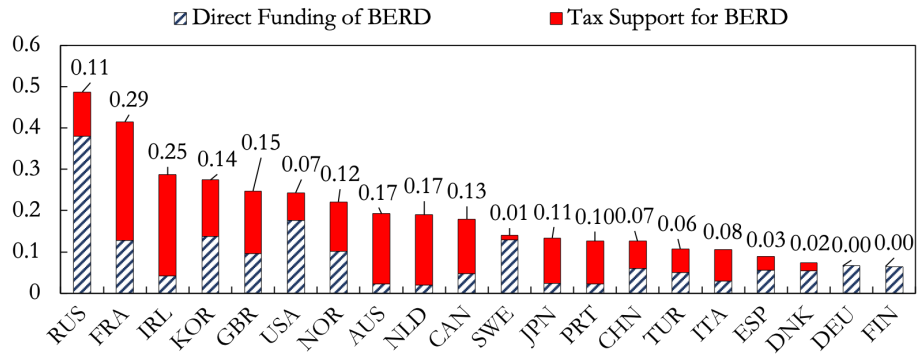
Finally, loss-making companies constitute a large share of businesses in developed economies (Altshuler et al., 2009). Governments that choose to offer special tax incentives to stimulate investment have to consider the implications on firms with tax losses. Theoretically, asymmetries in the tax system result in different investment outcomes for firms with different profit-or-loss statuses (Devereux, Keen and Schiantarelli, 1994; Bond and Devereux, 1995; Edgerton, 2010),

as asymmetric treatment of losses within the tax system renders investment incentives less effective (Auerbach, 1986; Mayer, 1986; Devereux, Keen and Schiantarelli, 1994; Edgerton, 2010; Zwick and Mahon, 2017; Altshuler and Auerbach, 1990; Auerbach and Poterba, 1987). Is a refund option a viable policy alternative to a system that is limited to carrying the losses back or forward in time? The present paper finds that a well-administered cash refund is likely to alleviate some complications arising from financing frictions, at least for innovative companies.

In this paper, we make two novel contributions. First, we quantify the extent of financing constraints for privately-held, innovative companies. This is made possible thanks to the detailed administrative population data and a useful quasi-experiment based on the UK's R&D policy framework. Second, we propose a fiscal policy-focused framework to estimate the dynamics of financing constraints for the population of firms in a large and innovative economy. The use of this framework is not confined to the availability of the specific policy setting in the UK. Alternative policy settings which allow similar approaches include any investment tax credits and net operating loss carryforwards and carrybacks.

Figures & Tables

Figure 1. Share of government support for business R&D, direct and tax support



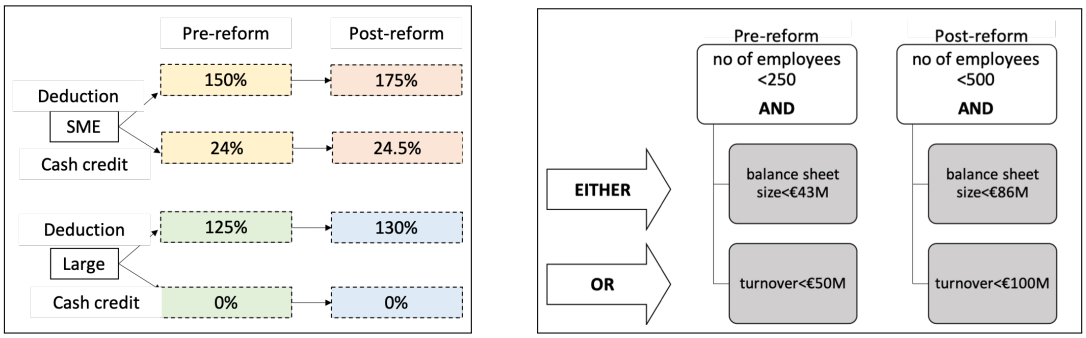
Note: This figure shows government funding of business R&D through: (1) the tax system, and (2) direct subsidies. Vertical axis values are represented as percent of GDP for each of the countries listed on the horizontal axis. The blue-and-white dashed diagonal patterns represent direct support, and the red solid section of the bars represent tax system support. Source: OECD R&D Tax Incentive Database.

Figure 2. Illustrating the cash flow benefit under different policy options

Gain from cash today (2006)	Gain from carry forward to claim against tax in 2007
£24	150 × 0.3 = 45 for main rate taxpayers 150 × 0.2 = 30 for taxpayers at the lower rate
Gain from cash today (2010)	**Gain from carry forward to claim against tax in 2010**
£24.5	175 × 0.26 = 45.5 for main rate taxpayers 175 × 0.21 = 36.75 for taxpayers at the lower rate

Note: Absent discounting, the benefit to firms of each of the cash-now and cash-later options are demonstrated in this figure. In 2006, firms with large profits (above £1.5 million) faced a 30 percent marginal tax rate, while the firms with smaller profits (below £ 300,000) faced a 20 percent marginal tax rate. There were also intermediary marginal tax rate brackets for amounts that fell between these two thresholds.

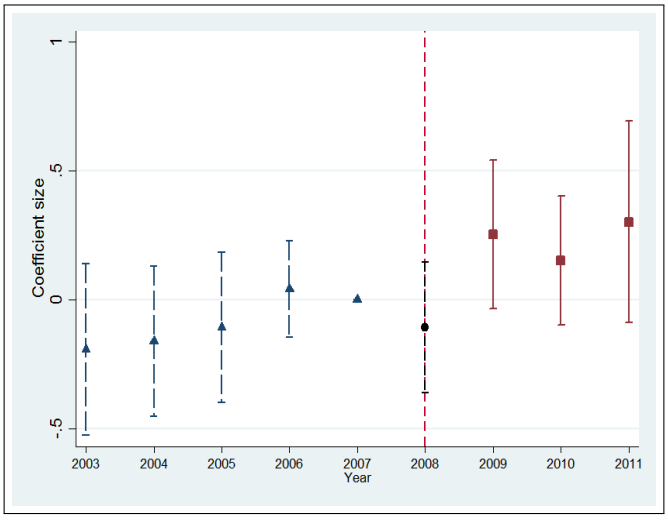
Figure 3. Institutional changes during the data period



(a) Changes in deduction rates (b) Change in the SME definition

Note: The left panel of this figure shows the four main policy regimes that are available in our data period. In both the pre-reform and the post-reform periods, the SME scheme has higher deduction rates than the large company scheme, but the available deduction increases more for SMEs than for large companies in the post-reform period. The large company scheme does not have a cash refund component for loss-making companies.[1] The legislation provides cash refund rates in terms of the way in which they multiply the super-deducted R&D. In the pre-reform period, this means that the cash refund rate, as quoted in the policy, is 16 percent: For a company that invests £1 and is in loss position in the pre-reform period, the gain from claiming cash immediately is $(1 + d) \times c$, which is $1.5 \times 0.16 = 0.24$ in 2006.

Figure 4. Policy effect on medium-sized companies

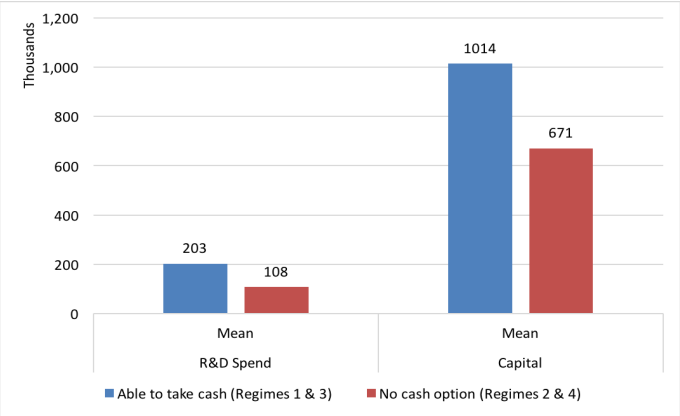


Note: Source: Guceri and Liu (2019). This figure estimates the R&D investment impact of the expansion of R&D tax credit and the 50% pt. increase in the superdeduction rate on medium-sized firms who were suddenly eligible to the higher superdeduction rate and the cash option.

Table 1. Summary of model results: policy, assumed and estimated parameters

Policy Parameters		
d:	Deduction Rate	$d0 = 0$; $d1 = 0.5$; $d2 = 0.25$; $d3 = 0.75$; $d4 = 0.3$
τ:	Tax Rate	0.2 (for small profits)
ϕ:	Cash refund Rate	$\phi_0 = 0$; $\phi_1 = 0.24$; $\phi_2 = 0$; $\phi_3 = 0.245$; $\phi_4 = 0$;
Assumed Parameters		
δ:	Depreciation Rate	0.15 (Hall, Mairesse, Mohnen, 2010)
β:	Discount Factor	0.95 (based on $r_f = 0.05$)
Estimated Parameters by GMM		
$\hat{\rho}$:	Persistence of the shock term	0.670***
$\hat{\sigma}$:	Standard deviation of the shock term	0.769***
$\hat{\alpha}$:	Elasticity of output wrt capital	0.694***
$\hat{\mu}_a$:	Average TFP over types	-9.172***
$\hat{\sigma}_a$:	Variance of TFP over types	19.871***
tentative: Estimated Parameters by MSM		
$\hat{\lambda}^{Low}$:	Cost of external finance	0.020
$\hat{\lambda}^{High}$:	Cost of external finance	0.136***

Figure 5. Counterfactuals for the constrained firms



Thank You for Your Consideration!

References

Agrawal, Ajay, Carlos Rosell, and Timothy Simcoe. 2020. "Tax Credits and Small Firm R&D Spending." *American Economic Journal: Economic Policy*, 12(2): 1–21.

Akcigit, Ufuk, Douglas Hanley, and Stefanie Stantcheva. 2016. "Optimal Taxation and RD Policies." National Bureau of Economic Research Working Paper 22908.

Altshuler, Rosanne, Alan Auerbach, Michael Cooper, and Matthew Knittel. 2009. "Understanding U.S. Corporate Tax Losses." In *Tax Policy and the Economy, Volume 23*. 73–122. National Bureau of Economic Research, Inc.

Altshuler, Rosanne, and Alan Auerbach. 1990. "The Significance of Tax Law Asymmetries: An Empirical Investigation." *The Quarterly Journal of Economics*, 105(1): 61–86.

Auerbach, Alan, and James Poterba. 1987. "Tax Loss Carryforwards and Corporate Tax Incentives." In *The Effects of Taxation on Capital Accumulation*. 305–342. National Bureau of Economic Research, Inc.

Auerbach, Alan J. 1986. "The Dynamic Effects of Tax Law Asymmetries." *The Review of Economic Studies*, 53(2): 205–225.

Bond, Stephen R., and Michael P. Devereux. 1995. "On the design of a neutral business tax under uncertainty." *Journal of Public Economics*, 58(1): 57 – 71.

Brown, James, Steven M. Fazzari, and Bruce C. Petersen. 2009. "Financing Innovation and Growth: Cash Flow, External Equity, and the 1990s R&D Boom." *The Journal of Finance*, 64(1): 151–185.

Chen, Zhao, Zhikuo Liu, Juan Carlos Suarez Serrato, and Daniel Xu. 2017. "Notching R&D Investment with Corporate Income Tax Cuts in China." mimeo. Mimeo.

Cooper, Russell, and Joao Ejarque. 2003. "Financial Frictions and Investment: Requiem in Q." *Review of Economic Dynamics*, 6(4): 710–728.

Dechezlepretre, Antoine, Elias Einio, Ralf Martin, Kieu-Trang Nguyen, and John van Reenen. 2016. "Do Tax Incentives for Research Increase Firm Innovation? An RD Design for R&D." Centre for Economic Performance CEP Discussion Paper 1413.

Devereux, Michael, and Li Liu. 2016. "Stimulating investment through incorporation." Oxford University Centre for Business Taxation.

Devereux, Michael P., Michael Keen, and Fabio Schiantarelli. 1994. "Corporation tax asymmetries and investment: Evidence from U.K. panel data." *Journal of Public Economics*, 53(3): 395 – 418.

Edgerton, Jesse. 2010. "Investment Incentives and Corporate Tax Asymmetries." *Journal of Public Economics*, 94(11): 936 – 952.

Farre-Mensa, Joan, and Alexander Ljungqvist. 2016. "Do Measures of Financial Constraints Measure Financial Constraints?" *The Review of Financial Studies*, 29(2): 271.

Fazzari, Steven, R. Glenn Hubbard, and Bruce Petersen. 1988. "Financing Constraints and Corporate Investment." *Brookings Papers on Economic Activity*, 19(1): 141–206.

Guceri, Irem. 2017. "Will the Real R&D Employees Please Stand Up? Effects of Tax Breaks on Firm-Level Outcomes." *International Tax and Public Finance*. Forthcoming.

Guceri, Irem, and Li Liu. 2019. "Effectiveness of Fiscal Incentives for R&D: Quasi-experimental Evidence." *American Economic Journal: Economic Policy*, 11(1): 266–91.

Hennessy, Christopher A., and Toni Whited. 2007. "How Costly Is External Financing? Evidence from a Structural Estimation." *Journal of Finance*, 62(4): 1705–1745.

Mayer, Colin. 1986. "Corporation Tax, Finance and the Cost of Capital." *The Review of Economic Studies*, 53(1): 93–112.

Nikolov, Boris, Lukas Schmid, and Roberto Steri. 2019. "Dynamic corporate liquidity." *Journal of Financial Economics*, 132(1): 76 – 102.

Rao, Nirupama. 2016. "Do Tax Credits Stimulate R&D Spending? The Effect of the R&D Tax Credit in its First Decade." *Journal of Public Economics*.

Strebulaev, Ilya A., and Toni M. Whited. 2012. "Dynamic Models and Structural Estimation in Corporate Finance." *Foundations and Trends(R) in Finance*, 6(1?2): 1–163.

Zwick, Eric, and James Mahon. 2017. "Tax Policy and Heterogeneous Investment Behavior." *American Economic Review*, 107(1): 217–248.