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R&D tax credits, innovative activity and the targeting approach

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Abstract

The aim of this study is to investigate whether the French R&D tax credit targeted at small and medium-sized enterprises (SMEs) has a positive impact on innovative activity. The French institutional setting provides a unique research framework as the R&D tax credit targeted at SMEs only applies to expenditures incurred during the development phase of R&D projects instead of all eligible R&D expenditures. In order to explore the effectiveness of the French R&D tax credit, a regression discontinuity design (RDD) is applied by comparing targeted SMEs with larger firms not subject to the tax credit over the period 2014–2018. In general, we find that the French R&D tax credit has a positive impact on innovative activity. Moreover, SMEs react more strongly to this incentive in their growth stage. The findings suggest, however, that this effectiveness in increasing SMEs' innovation does not persist over time.

Keywords

- R&D tax credit
- innovation
- targeted tax incentive
- SMEs
- firm life cycle

JEL codes: H25, H32, O31, O32

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Introduction

Governments have many measures at their disposal in order to stimulate private R&D, among which subsidies and R&D tax credits are the most commonly used (Chen & Yang, 2019; Montmartin et al., 2018). The governments of most Western nations have introduced tax incentives designed to complement subsidies (Mulkay & Mairesse, 2013). However, the complementarity between direct support, in the form of subsidies, and indirect support, in the form of various tax incentives, has only been considered in a limited number of studies (Dumont, 2017; Montmartin et al., 2018). Whereas countries such as Belgium, France and the Netherlands increasingly favour tax incentives, others such as Germany, Sweden and Switzerland up until recently only provided direct support (Appelt et al., 2019; Dumont, 2017).

While tax incentives are essentially a generic policy instrument, targeting specific groups of firms is quite common and many European countries target small and medium-sized enterprises (hereinafter, SMEs) and young firms (European Commission, 2014). The level of R&D performed by SMEs is crucial to a country's technological progress and economic growth: as Kobayashi (2014) points out, dormant R&D by Japanese SMEs contributed to the slowdown of Japan's economic growth and its lost decade. The effects of tax incentives on R&D vary across subgroups of firms, with most studies focusing on whether the impact of tax incentives is related to firm size (e.g., Baghana & Mohnen, 2009; Foreman-Peck, 2013; Kobayashi, 2014; Koga, 2003; Lokshin & Mohnen, 2012).

R&D tax credits are a major public policy instrument geared towards increasing private firms' incentives to invest in R&D activities. The growth in the literature is partly due to the increasing popularity of tax credits, which are adopted in more than 20 OECD countries (Castellacci & Lie, 2015). According to the meta-regression analysis of Castellacci and Lie (2015), the additionality effect of R&D tax credits, i.e. the rate at which R&D investments increase due to the introduction of tax incentives is on average stronger for SMEs. Moreover, the empirical literature investigates the effects of R&D tax credits targeted at SMEs in France, the United Kingdom and Japan (e.g., Bunel & Hadjibeyli, 2021; Dechezleprêtre et al., 2023; Foreman-Peck, 2013; Kobayashi, 2014).

The French R&D tax credit targeted at SMEs, also referred to as the innovation tax credit, offers interesting research opportunities for several reasons. Firstly, in France, SMEs account for 86% of R&D tax relief recipients, while the share of R&D tax support accounted for by SMEs only amounts to 30%. This indicates that larger firms, which represent the remaining 14% of R&D tax relief recipients, account for 70% of R&D tax support (Appelt et al., 2019). Secondly, France offers a policy mix of public support to business R&D, providing R&D tax relief through its R&D tax credits and its regime for young innovative companies, which was introduced back in 2004. This makes France one of the most generous OECD countries in terms of R&D tax incentives (Appelt et al., 2019). Thirdly, the French institutional setting offers a unique research framework as the French R&D tax credit targeted at SMEs only applies to expenditures incurred during the development phase of R&D projects. The R&D tax credits targeted at SMEs in the United Kingdom, Canada and Japan do not share this characteristic. Providing additional tax advantages may be an effective tool to induce SMEs to conduct more R&D, as existing studies find that many SMEs face financial constraints and have limited access to external funding, which in turn hinders their R&D (Kobayashi, 2014).

The aim of our research is to investigate whether the French R&D tax credit targeted at SMEs was successful at promoting R&D for French SMEs. We explore this by comparing French SMEs with larger companies which do not have access to this specific R&D tax credit. We contribute to literature by being, to the best of our knowledge, the first to conduct an in-depth study of the impact of the French R&D tax credit targeted at SMEs on innovation. On behalf of the French Institute of Statistics and Economic Studies, the National Bank of France and the French tax authorities, Bunel and Hadjibeyli (2021) also evaluated this French R&D credit, although they did so in terms of employment and turnover instead of R&D development as measured by the firms' investments in intangible fixed assets. Although the empirical literature has investigated the impact of targeted tax incentives for R&D in the United Kingdom, Canada and Japan, as yet no independent study exists of the French R&D tax credit targeted at SMEs. We also investigate if this impact is more pronounced for SMEs in their growth stage and in high-tech industries. Moreover, we contribute to the research methodology by applying a fuzzy regression discontinuity design and taking into account all SME criteria for determining eligibility for this specific R&D tax credit. By doing so, we reduce the likelihood that SMEs are incorrectly assigned to the control group or large firms to the treatment group. With this study, we provide further evidence regarding the effectiveness of targeted tax incentives, an aspect that might have important policy implications. In general, we find that the French R&D tax credit has a positive impact on innovative activity. Moreover, SMEs react more strongly to this incentive in their growth stage.

The remainder of our paper is structured as follows: Section 1 discusses the French R&D tax credit targeted at SMEs in greater detail. Section 2 gives an overview of the existing literature on the impact of R&D tax credits on corporate innovation and develops our hypotheses. Section 3 delves deeper into our data, research design and econometric model. Section 4 presents the results of our regression analyses and robustness tests. Finally, we state our conclusions.

1. Institutional setting: The French R&D tax credits

In late 2013, a new R&D tax credit targeted at French SMEs was introduced. Called the innovation tax credit (*Crédit d'Impôt Innovation*, CII), this would come into effect on 1 January 2014. The CII allows SMEs an extra reduction of 20% of incurred expenditures, with a ceiling of 400,000 EUR per year, thus resulting in a maximum tax credit of 80,000 EUR per year (Bozio et al., 2014). According to Art. 244 quarter B of the French Tax Code, only the expenditures incurred during the development phase of R&D projects can be taken into account for the CII. The expenditures incurred during the research phase of R&D projects can still be taken into account for the CIR (*Crédit d'Impôt Recherche*), since this R&D tax credit is applicable to all French firms. The CII can be combined with the CIR in order to offer a very generous tax treatment to French SMEs for expenditures incurred during the development phase of R&D projects.

The design and implementation of tax incentive schemes can have an important impact on the capacity of SMEs to benefit from them (Mitchell et al., 2020). In this regard, an immediate refund, which is available in the CII, is beneficial for SMEs, as they might be faced with liquidity constraints. Internal funding is important for making investments in activities with uncertain outcomes, such as R&D. If liquidity-constrained firms have any difficulty raising capital externally, R&D credits might be especially important (Kobayashi, 2014). Table 1 provides an overview of the main characteristics of the CIR and CII during the period 2008–2018.

Whereas all French firms are eligible for the CIR, only French SMEs are eligible for the CII. The definition of an SME in France is based on three firm-specific criteria: the number of employees, the total assets and the turnover. As is the case in most European countries, this definition takes into account the above-mentioned criteria from the last two accounting years. A French firm is considered to be an SME if, during the last two accounting years, its number of employees was less than 250. Moreover, its total assets or its turnover could not exceed 43,000,000 EUR or 50,000,000 EUR, respectively, during the last two accounting years.

Table 1. Overview of the French R&D tax credits (2008–2018)

Characteristics	CIR (2008–2018)	CII (2014–2018)
Target	all	only SMEs
Credit tax rate	30% for R&D exp. <= 100 mln EUR 5% for R&D exp. > 100 mln EUR	20%
Eligible expenditures	all R&D expenditures (fundamental, applied and experimental research)	only the expenditures incurred during the development phase of R&D projects
Ceiling	–	400,000 EUR
Refund	after 3 years (for large firms) or immediately (for SMEs)	immediately

Source: on the basis of (Bozio et al., 2014; Liu, 2013; Mulkay & Mairesse, 2013).

2. Literature and hypotheses

Tax incentives for R&D are one of the most popular innovation policy tools (European Commission, 2014). Over the last two decades, substantial research has been done on the effects of R&D tax credits and their impact on corporate innovation (e.g., Chen & Yang, 2019; Kobayashi, 2014; Koga, 2003; Lokshin & Mohnen, 2012). These studies' findings converge, as they find that R&D tax credits increase firms' innovative activities.

The effects of tax incentives for R&D vary across subgroups of firms, with most studies focusing on firm size (European Commission, 2014). In some countries, SMEs and liquidity constrained firms respond more positively to tax incentives (e.g., Baghana & Mohnen, 2009; Lokshin & Mohnen, 2012). In other countries, however, the opposite conclusion can be drawn (e.g., Koga, 2003). Thus, when investigating how the impact of tax incentives relates to firm size, the results differ across countries (European Commission, 2014). Nonetheless, the meta-regression analysis conducted by Castellacci and Lie (2015) indicates that the additionality effect of R&D tax credits, i.e. the rate at which R&D investments increase due to the introduction of tax incentives, is on average stronger for SMEs.

However, the studies so far mentioned in this section focused on untargeted tax incentives applicable to all firms. When considering targeted tax incentives which offer preferential regimes to any specific subgroup of firms, the results converge. R&D tax credits targeted at SMEs, which offer preferential regimes to SMEs relative to large firms, impact positively on SMEs' decisions to conduct more R&D (e.g., Agrawal et al., 2020; Dechezleprêtre et al., 2023; Kobayashi, 2014). Moreover, recent studies advocate for a more targeted approach of tax incentives for R&D in order to make them more effective (Chen & Yang, 2019; Montmartin et al., 2018).

Montmartin et al. (2018) found evidence of a neutral impact of the French tax credit system prior to the introduction of the CII, and concluded that this result was principally due to the French tax credit policy being untargeted. Furthermore, Chen & Yang (2019) recommend that governments should restrict the scope of industries and mainly allocate tax credits to innovation-driven enterprises, as their results indicate that the Chinese R&D tax credit only facilitated innovative activities in large firms. This result seems in line with the study for Japan conducted by Koga (2003). Hence, evidence suggests that tax incentives which do not target any specific subgroup of firms tend to support the larger incumbent R&D firms. Rao (2016) adds that larger firms have a weaker immediate response to tax incentives for R&D but do not go on to reduce their research spending in future years like smaller firms do.

In terms of a cost-benefit rationale, a key question in our research setting is whether additional tax advantages offered to French SMEs can offset mechanisms such as compliance burdens or liquidity constraints (Mitze & Kreutzer, 2023). As these authors point out in their research, policy enforcement and monitoring cost rise with strategic importance. Moreover, hidden implementation costs that stem from unpredicted task complexities may be associated with the disruption to the cohesion and consistency of a firm's internal (innovative) activity configuration. We therefore formulate our first hypothesis as follows:

H1: The introduction of the CII in France leads to an increase in innovative activity among SMEs.

The most widely studied firm characteristic in the context of heterogeneity of tax incentives is firm size. However, few studies contain evidence on whether the impact of tax incentives on innovative activity is related to firm age and to firm life cycle. Studies that consider whether the impact of tax incentives is related to firm age are still rare, although contributions exist, Coad et al. (2016) and Rao (2016), in particular. Their results indicate that younger firms react more strongly to tax incentives, especially in the short run.

Anthony and Ramesh (1992) pioneered the empirical measures for sorting firms in different life cycle stages by using classification variables such as dividend payout ratio, sales growth rate, capital expenditures and firm age. Economic theory suggests that firms make early investments in their growth stage to gain a competitive edge and early entry into the market. As the firm matures, it will cut new investments, reducing risky and innovative investments (Shahzad et al., 2022). This is in line with the results of Chang et al.

(2017), which indicate that managers of firms in their growth stage tend to increase R&D expenditures. As R&D expenditures possess uncertain benefits as compared to capital expenditures, it is necessary for managers to understand how and when to maximise the benefits from R&D (Chang et al., 2017). We therefore formulate our second hypothesis as follows:

H2: The positive effect of CII on innovation activities is more pronounced for SMEs in their growth stage.

In order to increase the effectiveness of R&D tax credits, Montmartin et al. (2018) conclude that the tax credit scheme should introduce a more targeted approach by implementing different levels of tax credits by regions and industries. Moreover, Castellacci and Lie (2015) argue that tax incentive schemes should be concentrated in industries with high technological opportunities in sectors that lead to strong spillover effects to the rest of the economy.

The OECD has drawn up a series of technology-themed classifications of economic activities. In the study by Hatzichronoglou (1997), the technology classification was created by clustering industries based on a measure of internal R&D intensity. A similar approach was used in Galindo-Rueda and Verger (2016), whose study represents an update and reframing of previous OECD taxonomies that were based on earlier versions of the International Standard Industrial Classification (ISIC). According to Castellacci and Lie (2015), R&D tax incentive schemes should be restructured to better incorporate sector-specific innovation drivers and to allocate a greater proportion of fiscal support to sectors with high opportunities and strong technological dynamism. We therefore formulate our third hypothesis as follows:

H3: The positive effect of CII on innovation activities is more pronounced for SMEs in high-tech industries.

3. Research methodology

3.1. Sample and data

We gather firm-specific information from the Bureau Van Dijk's Orbis Europe database, which contains financial statement, ownership and intellectual property data on European firms. We collect financial statement data from a sample of French SMEs and large firms. We obtain financial statement information of French firms' intangible fixed assets, number of employees, total assets, turnover, number of patents, year of establishment, paid dividends, sales, capital expenditures and industry classification.

These intangible fixed assets are needed as the expenditures incurred during the development phase of R&D projects will be recorded on this item of the balance sheet.[4] According to the generally accepted French accounting principles, firms have the option to capitalise expenditures incurred during the development phase of R&D projects if the following conditions are met: (1) the R&D project has a high probability of being successful, (2) the firm will be able to complete the R&D project, (3) the R&D project will generate future economic benefits. Furthermore, according to Art. 244 quarter B of the French Tax Code, it is only such expenditures that can be taken into account for the CII. The number of employees, total assets and turnover are the criteria that are used in order to determine whether a French firm is an SME. We collect data on the number of patents a firm has registered during its lifetime in order to determine whether the firm has engaged in innovative activities. The year of establishment is needed in order to determine a firm's age. The paid dividends, sales and capital expenditures are the criteria that are used in order to determine a firm's life cycle stage.

Our sample period covers the five-year period 2014–2018, thus going beyond the sample period 2013–2016 previously studied in Bunel and Hadjibeyli (2021). Although the CII was introduced in late 2013, it only came into effect on 1 January 2014. We do not extend the sample period beyond 31 December 2018, since the French definition of an SME was revised in 2019 with the PACTE law. With this law, two separate definitions were introduced for small firms and medium-sized firms. We select French firms whose book value of intangible fixed assets was greater than or equal to 1 euro during the entire sample period, whose registered number of patents during its lifetime was at least equal to one, and whose number of employees in 2012 was not missing. This approach resulted in an unbalanced panel data set of 2,023 firms over 5 years, which, due to 231 missing values for the variable turnover, led to 9,884 firm-year observations.

Table 2 presents the descriptive statistics of our full sample. Due to the distributions of our outcome variable and the criteria for the SME definition being highly skewed, we decided to take their natural logarithms, as working with the natural logarithm of a variable often helps to deal with outliers and heteroskedasticity (Verbeek, 2017).

It can be seen from Table 2 that after the logarithmic transformations, these variables appear to be symmetrically distributed. The criteria for determining a firm's life cycle, i.e. the dividend payout ratio, sales growth ratio and capital expenditures, all in percentages, are highly skewed. The median firm age is 31 years, and its distribution is skewed to the right.

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[4] Intangible fixed assets include more than the development costs incurred during R&D projects. While all firms in our sample are innovative in nature, i.e. they have registered at least one patent application during their lifetime, we lack the data isolating these development costs from the rest of the intangible fixed assets.

Table 2. Descriptive statistics

Panel A: Full sample, all firms Number of observations: 9,884					
	Mean	**Standard deviation**	**Q1**	**Median**	**Q3**
Outcome variable (after logarithmic transformation)					
IFA	13.2854	3.3544	11.0696	12.9244	15.1543
Criteria for the SME definition (after logarithmic transformations)					
Total assets	17.2936	2.2981	15.7520	16.9459	18.5123
Turnover	17.3844	2.1630	16.0178	17.1504	18.5157
Number of employees	4.7901	2.0654	3.4657	4.5109	5.8319
Criteria for the firm life cycle (in %, except for firm age)					
Dividend/ EBIT	0.1082	4.4523	0.0000	0.0000	0.0000
Sales growth	44.8012	1318.9754	–4.5478	2.1181	9.8365
Capex/Assets	50.3541	239.3572	12.2884	30.0424	56.7311
Firm age	36.58	23.83	21.00	31.00	48.00
Panel B: Firms in their growth stage Number of observations: 2,793					
	Mean	**Standard deviation**	**Q1**	**Median**	**Q3**
Outcome variable (after logarithmic transformation)					
IFA	13.0691	2.83617	11.1138	13.0077	14.8637
Criteria for the SME definition (after logarithmic transformations)					
Total assets	16.8200	1.9520	15.5180	16.7126	17.9554
Turnover	16.8501	1.8297	15.6367	16.7076	17.9287
Number of employees	4.4951	1.6727	3.4012	4.3631	5.5175
Criteria for the firm life cycle (in %, except for firm age)					
Dividend/ EBIT	0.0000	0.0000	0.0000	0.0000	0.0000
Sales growth	90.1923	1800.7956	3.9425	8.3674	16.4255
Capex/Assets	86.6764	109.9802	40.9582	58.1018	88.1124
Firm age	20.70	6.84	15.00	21.00	27.00

Table 2 continued

Panel C: Firms in high-tech industries Number of observations: 3,373					
	Mean	**Standard deviation**	**Q1**	**Median**	**Q3**
Outcome variable (after logarithmic transformation)					
IFA	13.6688	3.3344	11.3840	13.2615	15.5581
Criteria for the SME definition (after logarithmic transformations)					
Total assets	17.5733	2.2217	16.0367	17.1442	18.8076
Turnover	17.6319	2.1348	16.1854	17.3057	18.8162
Number of employees	5.2195	1.9873	3.8712	4.9200	6.2634
Criteria for the firm life cycle (in %, except for firm age)					
Dividend/ EBIT	0.2979	2.2233	0.0000	0.0000	0.0000
Sales growth	31.1328	487.0278	–3.4361	3.0965	10.6174
Capex/Assets	56.8648	176.4442	16.5019	34.1455	61.4719
Firm age	36.35	22.54	21.00	31.00	47.00

Note: IFA: intangible fixed assets, EBIT: Earnings before interest and taxes, Capex: Capital expenditures.

Source: own calculations on the basis of Orbis Europe.

3.2. Research design

We test our hypotheses by using a regression discontinuity design (hereinafter, RDD) and by comparing the level of innovative activity of French SMEs and large French firms after the introduction of the CII in late 2013. The RDD has become one of the leading quasi-experimental strategies in economics and many other social and behavioural sciences (Lee & Lemieux, 2010). In RDD, the research units are assigned to the treatment group based on the value of the running variable, i.e. the variable which determines treatment, with the probability of treatment assignment jumping discontinuously at a known cut-off (Angrist & Pischke, 2014). Since the number of employees is the most binding criterion in determining whether a French firm is an SME or not, it becomes our running variable of choice for our RDD.[5]

[5] Sensitivity checks based on totals assets or turnover can be found in the Appendix. See also the robustness checks section.

We test the validity of the running variable by performing the McCrary test, which estimates the discontinuity of the running variable at the cut-off (Dechezleprêtre et al., 2023). Figure 1 shows that the distribution of firms' number of employees in 2012 appears to be continuous around the threshold equal to the natural logarithm of 250.

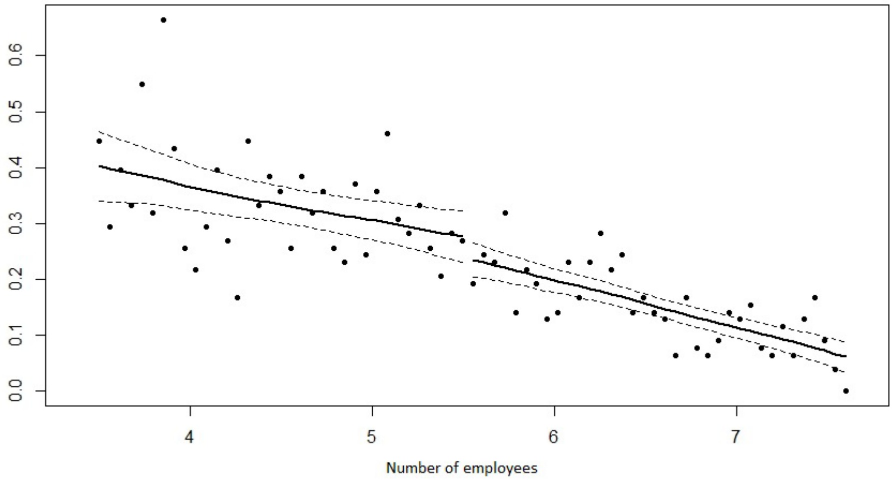


Figure 1. McCrary test at the SME threshold (number of employees) in 2012

Note: The density of number of employees is displayed on the vertical axis. The number of employees is displayed on the horizontal axis, in a natural logarithmic scale.

Source: own calculations on the basis of Orbis Europe.

The McCrary test gives a discontinuity estimate of –0.1511, which is statistically insignificantly different from zero (p-value = 0.2009). We thus cannot reject the null hypothesis of no discontinuity in the density of the running variable at the cut-off and conclude that the firms in our sample did not precisely manipulate their number of employees in the year 2012.

3.3. Econometric model

For our RDD, we estimate the following log-linear model:

$$\ln(IFA_{i,t}) = \alpha_0 + \beta_1 \ln(a_{i,2012}) + \beta_2 SME_{i,t} + \gamma_1 \overline{\ln(IFA_{i,past})} + \varepsilon_{i,t} \quad (1)$$

The left-hand side of equation (1) contains the outcome variable, which measures innovative activity. In line with previous studies (e.g., Alstadsaeter et al., 2018; Ernst & Spengel, 2011; Karkinsky & Riedel, 2012), the amount of the intangible fixed assets of firm i in year t will be our measure for innovative activity. The intangible fixed assets displayed on the balance sheet contain the expenditures incurred during the development phase of R&D projects and, according to Art. 244 quarter B of the French Tax Code, these expenditures can be taken into account for the CII. We measure the amount of the intangible fixed assets of firm i both in levels and in first differences.

The right-hand side of equation (1) includes a treatment dummy *SME*, which will be equal to 1 if firm i is considered to be an SME in year t and 0 otherwise. The right-hand side of equation (1) also includes the running variable *a*, which is equal to the number of employees firm i had in 2012, i.e. the year prior to the reform. Because of the two-year rule, a firm's SME status in 2014 was partly based on its financial information in 2012 and 2013. Using the number of employees in 2012 as our running variable of choice mitigates the concern that there might have been endogenous sorting of firms across the SME threshold (Dechezleprêtre et al., 2023). Finally, the right-hand side of equation (1) also includes the average value of a firm's intangible fixed assets during the pre-treatment period 2008–2012, as we control for past innovative activity.

As mentioned earlier, a firm's number of employees is not the only criterion for determining whether a French firm is an SME or not. The firm's total assets and turnover also play an important role, albeit a less binding one. In this setting, a *fuzzy* RDD, which is based on an instrumental variable approach, might be a remedy (Stock & Watson, 2015). For our first-stage regression, we estimate the following linear probability model:

$$SME_{i,t} = \alpha_1 + \beta_3 \ln(a_{i,2012}) + \beta_4 D_{i,2012} + \gamma_2 \overline{\ln(IFA_{i,past})} + \mu_{i,t} \tag{2}$$

The right-hand side of equation (2) contains a new dummy variable, D_i, which will be equal to 1 if firm i had less than 250 employees in 2012, i.e. the year prior to the reform. Due to the CII being introduced in late 2013, French firms were unable to precisely manipulate the value of the running variable around the cut-off in 2012. Under this assumption, D_i is as good as randomly assigned at the cut-off (Dechezleprêtre et al., 2023; Lee & Lemieux, 2010). As the number of employees in 2012 does not determine post-reform SME status perfectly, equation (2) represents the reduced form of a fuzzy RDD, in which D_i is the instrument for firm's i actual SME status and its eligibility to the CII. For our second-stage regression, we estimate the following log-linear model:

$$\ln(IFA_{i,t}) = \alpha_2 + \beta_5 \ln(a_{i,2012}) + \beta_6 \widehat{SME}_{i,t} + \gamma_3 \overline{\ln(IFA_{i,past})} + \omega_{i,t} \tag{3}$$

The right-hand side of equation (3) includes a new variable, $\widehat{SME}$, which contains the fitted values of the first-stage regression. In a two-stage least squares (2SLS), the consistency of the second-stage estimates is not based on getting the first-stage functional form right. This means that using a linear regression for the first-stage estimates generates consistent second-stage estimates even with a dummy endogenous variable (Angrist & Pischke, 2014).

4. Results

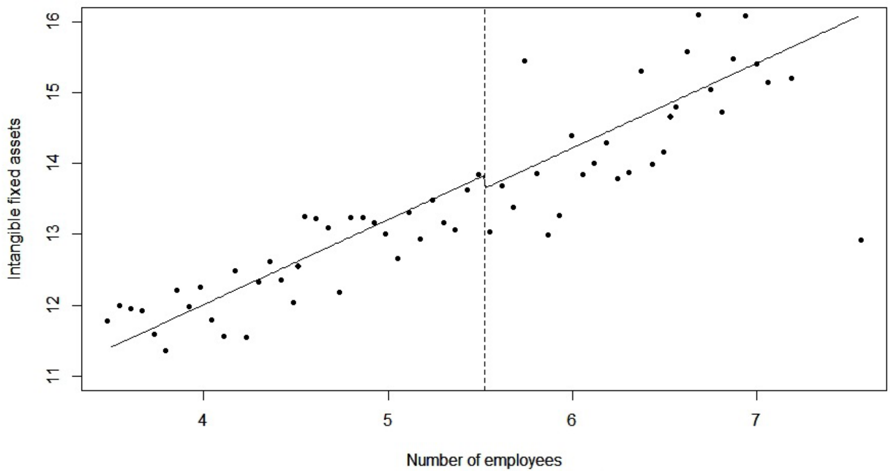
4.1. Main regression analyses

In Figure 2, we present two graphs that show the relationship between the outcome and the running variable, during the post-treatment period (Panel A) and the pre-treatment period (Panel B). In both graphs, our outcome variable is a firm's intangible fixed assets, which is our measure for innovative activity. Our running variable is a firm's number of employees, which is the most binding criterion in determining whether a French firm is an SME or not. A natural logarithmic scale is used for both variables. The cut-off value represented by the dashed line is equal to the natural logarithm of 250, which approximates the value of 5.52.

In Panel A, we observe a jump in the outcome variable during the post-treatment period, i.e. from 1 January 2014 to 31 December 2018. In Panel B, we do not observe a jump in the outcome variable during the pre-treatment period 2008–2012 prior to the introduction of the CII. Thus, only Panel A shows a jump in a firm's intangible fixed assets at the threshold of 250 employees, suggesting that firms below the threshold increase their innovative activity as a result of the treatment and not due to other factors in the pre-treatment period.

When introducing our econometric model in the previous section, we assumed a linear relationship between our running variable and the outcome variable. In general, as in any other setting, there is no particular reason to believe that the true model is linear (Lee & Lemieux, 2010). Angrist and Pischke (2014) point out that the problem of distinguishing jumps from non-linear trends diminishes as we concentrate on observations close to the cut-off, which in our case is the number of employees being equal to 250. This suggests an approach that compares averages in a narrow bandwidth just to the left and just to the right of the cut-off. We balance the reduction in bias near the cut-off against the increased variance suffered by fewer observations, generating an optimal bandwidth. We calculate this optimal bandwidth following the procedure in Imbens and Kalyanaraman (2012) and are left with a sample containing 6,685 firm-year observations.

Panel A: Post-treatment period (2014–2018)



Panel B: Pre-treatment period (2008–2012)

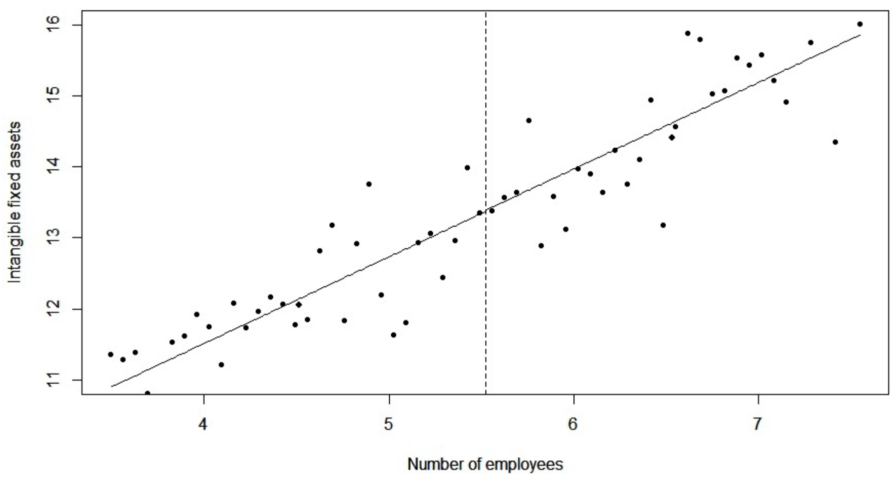


Figure 2. Graphical presentation of the regression discontinuity design

Note: A natural logarithmic scale is used for number of employees and intangible assets. The dashed line represents the cut-off value, which is equal to ln(250).

Source: own calculations on the basis of Orbis Europe.

The first column of Table 3, Panel A contains the results of our main regression analyses for all firms whose number of employees lies within the optimal bandwidth. A firm's intangible fixed assets, measured in levels, is the outcome variable. We regress our outcome variable on the running variable employees, our variable of interest, namely *SME*, and on the average amount of a firm's intangible fixed assets during the five years preceding the reform, i.e. the period 2008–2012.

Table 3. Main regression results

Panel A

Outcome variable: ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	2.7994*** (0.4296)	2.9435*** (0.8625)	2.5889*** (0.7306)
ln(Employees)	0.5872*** (0.0592)	0.6501*** (0.1169)	0.7346*** (0.1011)
SME	0.4211** (0.1662)	0.6119* (0.3306)	0.5000* (0.2747)
ln(Past IFA)	0.5636*** (0.0084)	0.5398*** (0.0171)	0.5139*** (0.0137)
Observations	6,685	1,795	2,475

Panel B

Outcome variable: First difference of ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	0.1344 (0.1693)	0.3182 (0.2867)	0.5279* (0.2764)
ln(Employees)	0.0123 (0.0232)	–0.0017 (0.0387)	–0.0428 (0.0382)
SME	0.0146 (0.0661)	–0.0735 (0.1108)	–0.1052 (0.1051)
ln(Past IFA)	–0.0151*** (0.0032)	–0.0174*** (0.0056)	–0.0185*** (0.0049)
Observations	5,348	1,436	1,980

Note: IFA: intangible fixed assets. We report heteroskedasticity-and-autocorrelation-consistent standard errors in parentheses. ***, **, and * denote a significant difference at the 1%, 5% and 10% levels, respectively.

Source: own calculations on the basis of Orbis Europe.

Our variable of interest, the treatment dummy *SME*, has a statistically significant positive effect at the 5% level on a firm's intangible fixed assets during the post-treatment period. Looking at the economic order of magnitude, it is evident that SMEs invested on average 42% more in intangible fixed assets than large firms in our sample during the post-treatment period. Employees and the average amount of a firm's intangible fixed assets prior to the reform also have a statistically significant positive effect on the outcome variable. These results do support hypothesis 1, stating that the introduction of the CII in France would lead to an increase in innovative activity among SMEs. Although measured in number of patents, Dechezleprêtre et al. (2023) find a comparable large innovation increase (58%) in the UK as a response to changing SME thresholds for R&D tax incentives.

Next, we identify a firm's life cycle stage (Anthony & Ramesh, 1992; Chang et al., 2017). Firms in their growth stage are young and usually exhibit lower dividend payout ratios, higher sales growth rates and have more capital expenditures. We perform similar regression analyses with a subsample containing the firms in their growth stage. We identify firms in their growth stage as firms with below median age, below median dividend payout ratio, above median sales growth rate, and above median capital expenditures using five-year historical data. All four criteria must be fulfilled in order for a firm to be classified as being in the growth stage. Once more, we calculate the optimal bandwidth following the procedure in Imbens and Kalyanaraman (2012) and are left with a subsample containing 1,795 firm-year observations.

The second column of Table 3, Panel A contains the results for the firms in their growth stage whose number of employees lies within the optimal bandwidth. The treatment dummy *SME* has a statistically significant positive effect on the level of a firm's intangible fixed assets during the post-treatment period, albeit at the 10% significance level. Looking at the economic order of magnitude, we can see that SMEs in their growth stage invested on average 61% more in intangible fixed assets than large firms in their growth stage during the post-treatment period. This coefficient is greater than the one reported in the first column of Table 3, Panel A, when looking at all SMEs in our sample (42%), irrespective of their life cycle stage. This result does support hypothesis 2, assuming that the positive effect of the CII in France on innovation activities is more pronounced for SMEs in their growth stage.

Next, we identify firms in high-tech industries based on the OECD's technology-themed classifications of economic activities, as can be found in the study of Hatzichronoglou (1997). Hatzichronoglou (1997) created these technology-themed classifications by clustering industries into four clusters—high-tech, medium-high-tech, medium-low-tech and low-tech—based on a measure of internal R&D intensity.

An updated version of the OECD's technology-themed classifications of economic activities can be found in Galindo-Rueda and Verger (2016). Once more, these technology-themed classifications were created by clustering industries based on a measure of internal R&D intensity. The above study classified industries into five clusters: high-tech, medium-high-tech, medium, medium-low-tech and low-tech.

We perform similar regression analyses with a subsample containing the firms in high-tech industries. We identify firms in high-tech industries as firms in high-tech and medium-high-tech industries, according to the updated OECD's classification. Once more, we calculate the optimal bandwidth following the procedure described in Imbens and Kalyanaraman (2012), and are left with a subsample containing 2,475 firm-year observations.

The third column of Table 3, Panel A contains the results for firms in high-tech industries whose number of employees lies within the optimal bandwidth. In the post-treatment period, *SMEs* show a statistically significant positive effect at the 10% level on a firm's intangible fixed assets. In terms of economic magnitude, we can see that SMEs in high-tech industries invested on average 50% more in intangible fixed assets than large firms in high-tech industries during the post-treatment period. This coefficient is greater than the one reported in the first column (42%), when looking at all SMEs in our sample, irrespective of their industry. This result does support hypothesis 3 that the positive effect of the CII on innovation activities is more pronounced for SMEs in high-tech industries.

In Table 3, Panel B, the outcome variable firm's intangible assets is now measured in first differences. In line with Panel A, the columns contain the results within the optimal bandwidth for all firms, firms in their growth stage, and firms in high-tech industries, respectively. Again, we regress our outcome variable on the running variable employees, our variable of interest *SME*, and on the average amount of a firm's intangible fixed assets during the five years preceding the reform, i.e. the period 2008–2012. When a firm's intangible fixed assets are measured in first differences, however, the treatment dummy *SME* no longer has a statistically significant effect. The factor 'employees' also has no statistically significant effect, while the average amount of a firm's intangible fixed assets prior to the reform now has a statistically significant negative effect on the outcome variable.

In brief, when the outcome variable is measured in levels, the results in Table 3 support hypothesis 1, 2 and 3. However, when intangible fixed assets are measured in first differences, the results indicate that this positive effect for SMEs is a one-time level shift, as it has no effect in terms of growth rates. This is in accordance with the study by Rao (2016), who noted that SMEs have a stronger immediate response to R&D tax incentives but go on to reduce their research spending in future years, unlike larger firms.

4.2. Robustness tests

RDD does not guarantee to produce reliable causal estimates, since one cannot be certain of a linear relationship between the running variable and the outcome variable. There is also the risk of confusing nonlinearities with discontinuities (Angrist & Pischke, 2014). It is therefore essential to explore how RDD estimates are robust to the inclusion of higher-order polynomial terms and to changes in the bandwidth around the cut-off (Lee & Lemieux, 2010). In accordance with the study by Lee and Lemieux (2010), we perform two additional robustness tests by including a smaller bandwidth as well as the squared value of the running variable to account for nonlinearity. The smaller bandwidth increases the comparability between the treatment group and the control group, but reduces the initial sample to 5,705 firm-year observations.

Table 4 presents the findings within the smaller optimal bandwidth, including squared values for our running variable employees. In line with our main analyses, results are reported for all firms, firms in their growth stage, and firms in high-tech industries.

When intangible assets are measured in levels (Panel A), the treatment dummy *SME* has a statistically significant positive effect at the 1% level on this outcome variable during the post-treatment period. Thus, in line with the main analyses, hypothesis 1 is supported. Moreover, hypothesis 2 is supported, as SMEs in their growth stage show a significant positive effect at the 5% level and invest on average 80% more in intangible fixed assets than large firms during the post-treatment period. This coefficient is greater than the one reported for all SMEs in our sample (70%), irrespective of their life cycle stage. The robustness tests for high-tech firms are somewhat weaker compared to our main analyses. The treatment dummy *SME* has a statistically significant positive effect on a firm's intangible fixed assets during the post-treatment period at the 10% level. However, SMEs in high-tech industries invested on average 54% more in intangible fixed assets than large firms in high-tech industries. This economic effect is smaller compared to SMEs active in all kinds of industries (70%). Therefore, when applying robustness tests, the empirical findings do not support hypothesis 3.

In Table 4, Panel B, the outcome variable firm's intangible assets is now measured in first differences. We find similar results as for our main analyses considering the first differences. *SME* no longer has a statistically significant effect.

In brief, after having performed these robustness tests, our conclusion does not change as regards hypotheses 1 and 2. Following the introduction of the CII in France, innovative activity increases for SMEs, relative to large firms. Moreover, the positive effect is more pronounced for SMEs in their growth stage. However, when intangible fixed assets are measured in first differences, the results indicate that this positive effect for SMEs does not persist over time.[6]

[6] We furthermore perform sensitivity checks based on total assets and turnover, which can be found in the Appendix. The results are not in line with our main regression analyses and robustness tests. These divergent results can be explained by the fact that a fuzzy RDD, being underpinned by an instrumental variable approach, requires a strong instrument. In the French setting, a firm's total assets and turnover are weak instruments to predict for a firm's SME status compared to the number of employees.

Table 4. Robustness tests

Panel A

Outcome variable: ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	2.3126*** (0.8968)	4.0745*** (1.2185)	3.5134** (1.4958)
ln(Employees)	0.3759 (0.2887)	0.0688 (0.4197)	0.2842 (0.4879)
ln(Employees)^2	0.0272 (0.0263)	0.0617 (0.0413)	0.0373 (0.0448)
SME	0.7010*** (0.1824)	0.8013** (0.3373)	0.5419* (0.3002)
ln(Past IFA)	0.6080*** (0.0094)	0.5435*** (0.0171)	0.5362*** (0.0148)
Observations	5,705	1,515	2,155

Panel B

Outcome variable: First difference of ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	0.2993 (0.3492)	0.1988 (0.5661)	0.3369 (0.5642)
ln(Employees)	–0.0848 (0.1102)	–0.0604 (0.1948)	0.0089 (0.1789)
ln(Employees)^2	0.0113 (0.0099)	0.0113 (0.0189)	–0.0029 (0.0162)
SME	0.0655 (0.0742)	0.0489 (0.1293)	–0.0715 (0.1187)
ln(Past IFA)	–0.0159*** (0.0036)	–0.0146** (0.0062)	–0.0202*** (0.0054)
Observations	4,564	1,212	1,724

Note: IFA: intangible fixed assets. We report heteroskedasticity-and-autocorrelation-consistent standard errors in parentheses. ***, **, and * denote a significant difference at the 1%, 5% and 10% levels, respectively.

Source: own calculations on the basis of Orbis Europe.

Our findings are in line with previous studies which suggest that R&D tax credits targeted at SMEs or offering preferential regimes to SMEs, relative to large firms, positively influence SMEs' decisions to conduct more R&D (Agrawal et al., 2020; Dechezleprêtre et al., 2023; Kobayashi, 2014). Bunel and Hadjibeyli (2021) find an increase in employment in the short term, along with an increase in turnover in the medium term for the French CII, and our results complement theirs. In particular, our results show an immediate, though not sustained, increase in the amount of intangible fixed assets. Also, our findings are in line with previous studies suggesting that firms innovate more in their growth stage (Chang et al., 2017; Shahzad et al., 2022). Hence, this study demonstrates that, despite being only applicable to expenditures incurred during the development phase of R&D projects, the French targeted tax credit is still effective, at least in the short run. The effect might have been bolstered by the immediate refund available to liquidity-constrained SMEs.

Conclusions

In order to stimulate private R&D, the governments of most Western nations have introduced tax incentives designed to complement subsidies. While tax incentives are essentially a generic policy instrument, targeting specific groups of firms is quite common, and many European countries target SMEs and young firms. The empirical literature has investigated the effects of some tax incentives targeted at SMEs in the United Kingdom, Canada and Japan, as the level of R&D performed by SMEs is crucial to a country's technological progress and economic growth. Introduced in late 2013, the CII serves as an extension to the already existing R&D tax credit available to all French firms. One notable characteristic of the CII that distinguishes it from other R&D tax credits is that it only applies to expenditures incurred during the development phase of R&D projects.

The aim of our research was to investigate whether the CII was successful at promoting R&D for French SMEs. We explored this by implementing a fuzzy regression discontinuity design and by comparing the innovative activity of SMEs with the innovative activity of larger firms in France over the period 2014–2018. We also investigated whether SMEs reacted more strongly to this targeted tax incentive in their growth stage and in high-tech industries.

In general, our results demonstrate that the CII has a positive impact on their level of innovative activity. In particular, SMEs invested on average 42% more in intangible fixed assets than large firms during the post-treatment period. Our results also demonstrate that this impact is more pronounced for SMEs in their growth stage. However, we do not find evidence that this impact is more pronounced for SMEs in high-tech industries. Furthermore, our analysis indicate that the positive increase for SMEs is a one-time level shift. We do not find any effect on growth rates, thus CII does not lead to accumulating effects over time.

The findings might be of interest to policy makers assessing the design and implementation of R&D tax incentives and their capacity to benefit certain target groups. The French R&D tax credit, with its unique features, seems successful at promoting the level of innovative activity of SMEs, albeit only in the short term. Our study has its limitations, as we were unable to exclude the non-R&D items (e.g., goodwill) from the intangible fixed assets. Moreover, we solely focused on investigating French firms. A study of recently introduced targeted R&D tax incentives in other countries might be an important avenue for further research.

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Appendix

Table A1. Sensitivity analyses (total assets)

Panel A

Outcome variable: ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	–2.3289*** (0.7121)	4.4315** (1.7834)	–4.4900*** (1.5408)
ln(Employees)	0.5234*** (0.0357)	0.2600*** (0.0886)	0.6711*** (0.0783)
SME	0.1173 (0.1494)	–1.5037*** (0.3907)	0.3918 (0.3000)
ln(Past IFA)	0.4999*** (0.0081)	0.4328*** (0.0161)	0.4619*** (0.0132)
Observations	6,685	1,795	2,475

Panel B

Outcome variable: First difference of ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	0.0685 (0.2828)	1.2039** (0.6389)	0.4207 (0.5880)
ln(Employees)	0.0092 (0.0142)	–0.0431 (0.0319)	–0.0091 (0.0299)
SME	–0.0026 (0.0595)	–0.2758* (0.1399)	–0.0379 (0.1148)
ln(Past IFA)	–0.0167*** (0.0032)	–0.0192*** (0.0055)	–0.0182*** (0.0048)
Observations	5,348	1,436	1,980

Note: IFA: intangible fixed assets. We report heteroskedasticity-and-autocorrelation-consistent standard errors in parentheses. ***, **, and * denote a significant difference at the 1%, 5% and 10% levels, respectively.

Source: own calculations on the basis of Orbis Europe.

Table A2. Sensitivity analyses (turnover)

Panel A

Outcome variable: ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	3.0586*** (0.8149)	10.3271*** (1.6446)	1.6932 (1.3115)
ln(Employees)	0.2011*** (0.0412)	–0.1389* (0.0839)	0.3025*** (0.0672)
SME	–0.5774*** (0.1437)	–1.6314*** (0.3026)	–0.3370 (0.2259)
ln(Past IFA)	0.5453*** (0.0083)	0.5128*** (0.0167)	0.5064*** (0.0136)
Observations	6,685	1,795	2,475

Panel B

Outcome variable: First difference of ln(Intangible fixed assets)			
Estimator: Two-stage least squares (2SLS)			
Firms	**All firms (within bandwidth)**	**Growth stage (within bandwidth)**	**High-tech (within bandwidth)**
Intercept	0.3719 (0.3107)	0.6082 (0.5474)	1.2368*** (0.4706)
ln(Employees)	–0.0090 (0.0157)	–0.0159 (0.0279)	–0.0512** (0.0241)
SME	–0.0295 (0.0550)	–0.1172 (0.1013)	–0.1647** (0.0815)
ln(Past IFA)	–0.0143*** (0.0031)	–0.0171*** (0.0054)	–0.0186*** (0.0048)
Observations	5,348	1,436	1,980

Note: IFA: intangible fixed assets. We report heteroskedasticity-and-autocorrelation-consistent standard errors in parentheses. ***, **, and * denote a significant difference at the 1%, 5% and 10% levels, respectively.

Source: own calculations on the basis of Orbis Europe.

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