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RÉPUBLIQUE FRANÇAISE

No. 50
January 2009

TRÉSOR-ECONOMICS

The economic impact of the 2008 research tax credit reform *(Crédit d'Impôt Recherche)*

This study was prepared under the authority of the Treasury and Economic Policy General Directorate and does not necessarily reflect the position of the Ministry for the Economy, Industry and Employment.

- In so-called knowledge-based economies, both research and development (R&D) and innovation are essential to growth and competitiveness. In this respect, France does not appear to be investing enough in R&D activity. With R&D spending at 2.1% of GDP, France ranks in the middle of the league table, above the European average but well below Germany, the Scandinavian countries, the United States and Japan.

- The gap between France and its main partners in terms of R&D intensity can be entirely attributed to the volume of private-sector R&D. Although France ranks among the leading countries in terms of publicly-funded R&D, private-sector domestic R&D spending (DIRDE) amounts to only 1.1% of GDP, versus 1.7% in Germany and the United States, and 2.5% in Japan.

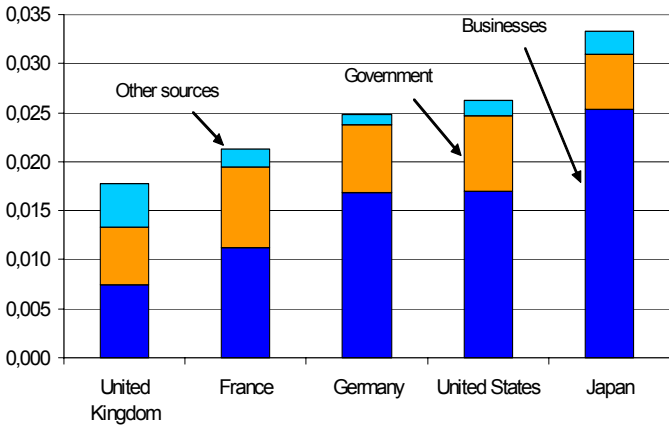
- France has taken steps to address this situation by seeking to stimulate private sector investment in R&D. In particular, the 2008 Budget Bill reformed the research tax credit (CIR - Crédit Impôt Recherche).

- The previous CIR was based on a mixed system that proved to be too complex without providing sufficient incentives. The 2008 reform of the CIR seeks to boost the mechanism's effectiveness in two ways: first by discarding the tax break applied to increased R&D spending by companies, and second by increasing the CIR applied to the level of R&D spending.

- This reform constitutes a significant effort to boost private sector R&D, with public support rising from €1.6 billion for R&D spending in 2007 to €4.1 billion in 2008. As a result, the intensity of R&D spending is expected to rise by 0.33 percentage point of GDP over the next 10 years, and it is estimated that companies will require 25,000 researchers between now and 2022 (or 25% of the current total).

- The reform is expected to have a major impact, adding 0.6 percentage point to GDP at the end of 15 years, or nearly 0.05% of GDP on average per year over 15 years. This means that each euro spent by the government in the form of the research tax credit should add €4.50 to GDP.

Breakdown of domestic R&D spending (DIRD) by source of funding in 2005, as a % of GDP



Source: OECD (MSTI 2007-1).

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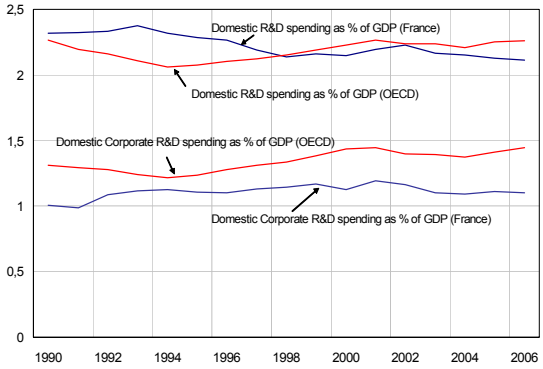
1. CIR reform is taking place in a context of declining R&D spending by business since 1993, now below the average for OECD countries

1.1 A downward trend in French R&D intensity since 1993

R&D spending in France is frequently decried as insufficient, especially regarding the portion funded by business. With R&D spending accounting for 2.1% of GDP in 2006, France's R&D intensity is well below that of Germany (2.5%), the Scandinavian countries (3.7% in Sweden and 3.4% in Finland), the United States (2.6%) and Japan (3.4%). Moreover, French domestic R&D spending has been trending downwards since 1993, declining from 2.37% of GDP in 1993 to 2.1% in 2006[1]. What is particularly striking about this negative trend is that it comes after a period of rapid growth in R&D as a share of GDP -from 1.9% in 1981 to 2.37% in 1993[2] - and that during the same period the OECD countries have on average stepped up their R&D efforts (+0.15 percentage point of GDP between 1993 and 2006).

The level of public funding of domestic R&D spending in France is relatively high, amounting to 0.82% of GDP in 2005, versus 0.7%, 0.77% and 0.56% of GDP in Germany, the United States and Japan, respectively. On the other hand, private-sector spending in France is particularly low, representing 1.1% of GDP, compared with 1.7% in Germany and the United States and 2.5% in Japan. Since 1993 it has been flat, whereas the OECD average rose slightly (by 0.2 percentage point of GDP between 1993 and 2006).

Chart 1: Trends in R&D spending, total and private-sector, in France and in the OECD countries



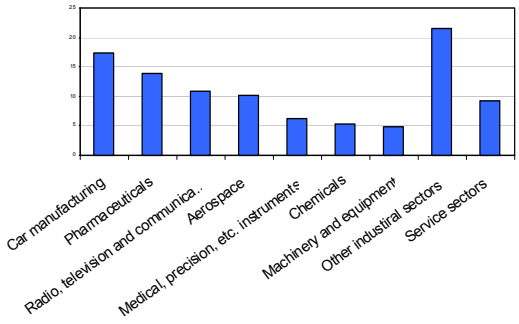
Source: OECD (MSTI 2007-1).

1.2 Large industrial corporations account for the vast majority of private-sector R&D spending in France

In the developed economies, large corporations account for the vast majority of private-sector R&D spending. In Germany and Japan, for example, companies with more than 250 employees are responsible for over 90% of such expenditures. The proportion is around 86% for the United States and 84% for France, which therefore does not appear to suffer from any lack of effort on the part of its SMEs.

Moreover, like Japan and Germany, industry accounts for the vast bulk (90%) of corporate R&D spending in France. In France, the car manufacturing, pharmaceuticals, capital goods and aerospace sectors are responsible for practically half of all private-sector R&D spending.

Chart 2: Breakdown of corporate R&D spending in France by main sectors in 2006 (%)



Source: French Ministry of Education, Ministry of Higher Education and Research DEPP-C2 and INSEE.

One outcome of the low level of corporate R&D spending in France is that researchers account for only a small percentage of industrial employees, which can in turn act as a brake on innovation.

The incentive for a firm to embark on innovative projects depends to a large extent on its "absorptive capacity"-i.e. its ability to exploit the knowledge produced by its competitors or by publicly-funded research centres[3]. While above the European average, researchers account for only a small percentage of industrial employment in France compared with figures from countries that spend heavily on research: with 6.2 researchers per 1,000 jobs in industry in France in 2006, there are only half as many as in Sweden or Finland (13 researchers per 1,000 jobs), and significantly fewer than in Japan or the United States (11 per 1,000)[4].

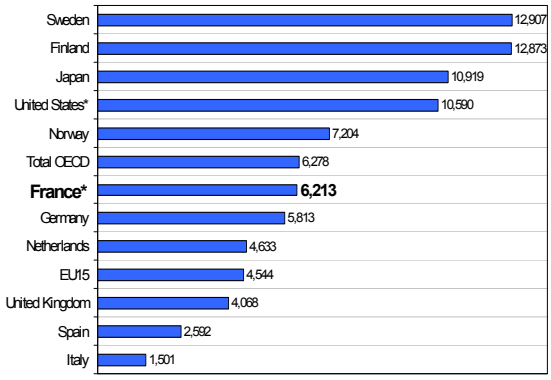
(1) The last available year for data supplied by the Ministry of Higher Education and Research.

(2) The rise of around 0.47 percentage point in R&D spending as a percentage of GDP over the period is chiefly attributable to additional investment by businesses and foreign residents. Domestic R&D funded by the private sector rose from 0.78% to 1.12% of GDP between 1981 and 1993 (representing a rise of 0.34 percentage point of GDP) and that funded by foreign residents rose from 0.1% to 0.19% of GDP (a rise of practically 0.1 percentage point of GDP).

(3) Cohen and Levinthal define "absorptive capacity" as "the ability [of a firm] to recognize the value of new, external information, assimilate it, and apply it to commercial ends. The number of researchers in the private sector can therefore be seen as a relevant measure of this phenomenon.

(4) Source: OECD, Main Scientific and Technical Indicators (MSTI).

Chart 3: Number of researchers in the private sector per 1,000 employment in industry



*Source: OECD (MSTI 2007-1), (*2005).*

The average performance of French firms in terms of their R&D spending could compromise the future position of France among the knowledge-based economies. Greater public support was therefore deemed necessary in order to stimulate corporate R&D spending, boost firms' capacity to absorb technologies and, more generally, to create conditions conducive to sustained medium and long-term growth.

2. The reform of the research tax credit has streamlined an overly-complex mechanism and is aimed at encouraging firms to boost their medium-term R&D spending

2.1 Positive externalities derived from research activities justify the provision of public support

Public support for private-sector research is justified economically by the fact that a company's R&D effort also benefits other firms and society as a whole (through positive externalities). Government therefore has a role to play in compensating for the share of value added that the firm cannot appropriate to itself (and which could lead it to refrain from undertaking certain projects). Without public intervention, market mechanisms are not sufficient to achieve the socially optimal level of investment in R&D.

The research tax credit to which each company is entitled is for the most part calculated on the basis of R&D spending that gives rise to externalities as defined by the Frascati[5] manual, namely R&D personnel costs, related operating costs, and subcontracted R&D work[6]. It is available in the form of a deduction from corporation tax to all industrial or agricultural firms that incur R&D expenditures, on application. The credit is therefore transversal in character (i.e. all kinds of enterprise qualify, regardless of category), on the grounds that any R&D effort (irrespective of its scale or sector of activity) should entail positive externalities.

This mechanism was originally instituted in 1983 and has since been modified on several occasions to make it more effective (see Box 1).

It should further be pointed out that prior to the research tax credit reform of 2008, the French mechanism was not especially favourable by comparison with those in other OECD countries, with one of the lowest rates, in volume terms (10%), versus an average of between 15% and 20%. It also appears to have been the only one to impose a cap on the tax credit (see Table 1).

Box 1: **The evolution of the research tax credit and its cost**

The research tax credit was instituted in 1983.

Until 2003, the tax deduction applied only to an increase in R&D spending, in fact to 50% of any increase in R&D in one year relative to average spending of the same type for the previous two years. In addition, the amount of the annual research tax credit was capped at €6.1 million per company. The annual research tax credit claim thus ranged between €400 and 500 million.

The research tax credit has grown in importance since 2004, when part of the tax credit was based on the volume of R&D spending. Consequently, the research tax credit was based on a combination of the volume of R&D spending incurred by the firm and the increase in its spending. The research tax credit underwent a series of changes between 2004 and 2007[a]:

- the deductibility from corporation tax applied to the volume of R&D spending incurred in the year was increased from 5% (in 2004) to 10% (in 2006);
- the share of research tax credit applied to the increase in R&D spending was reduced from 45% (in 2004) to 40% (in 2006);
- the annual cap on the research tax credit has been raised successively to €8 million per firm in 2004, €10 million in 2006, and then to €16 million in 2007;
- costs relating to young PhDs and expenses incurred in work contracted to public-sector research bodies count double for research tax credit purposes

The research tax credit reform provided for in the 2008 Budget Act abolishes the portion of research tax credit calculated on the increase in R&D spending.

The research tax credit now functions by tranches, namely:

- the tax credit rate has been increased to 30% of the volume of R&D spending up to €100 million (versus 10% initially).
- beyond that level, firms receive a 5% tax credit, with no ceiling.
- the rate for the first tranche is raised by 50% for the first year in which firms join the mechanism and by 40% for the second year.

To improve the cash flow of innovative firms in an economic crisis, the Additional Budget Act for 2009 has modified the conditions of reimbursement of the research tax credit, guaranteeing reimbursement in full in 2009 of the tax claim in respect of the 2008 research tax credit and residual claims in respect of research tax credits for 2007, 2006 and 2005[b].

a. Source: Document issued by the Ministry of Higher Education and Research. "Bilan du CIR au titre de l'année 2006" (Assessment of the research tax credit for 2006).

b. Until now, it was possible to deduct the research tax credit from tax due in respect of the four years following the expense. Only companies less than five years old, innovative start-ups and firms qualifying for the tax reduction in virtue of their status as "Growth SMEs" qualified for immediate payment of this claim.

(5) The international methodological reference for statistical surveys concerning R&D, published by the OECD.

(6) Other spending categories less directly connected with research, but part of the technological innovation process, are also taken into account, such as technology watch, and the filing, maintenance and defence of patents.

Table 1: International comparison between the French research tax credit mechanisms (pre-2008 reform) and those in other OECD countries (in 2005)[a]

Country	Rate (applicable to spending volume)	Rate (applicable to spending increase)	Rate reserved for SMEs (applicable to spending volume)	Ceiling
Autria	8%			No
Canada	20%		35%	
Spain	30%	50%		35%-45% of company's tax liability
United States		20%		No
France (pre-reform)	10%	40%		€16 million
Ireland		20%		No
Italy			30%	20% of av. taxable profit over past 3 years
Japan	10-15%			20% of company's tax liability
Norway	18%		20%	
Netherlands	14%		42%	No

a. Some countries, such as Germany, have no tax mechanism to support private sector R&D. In other countries such as the UK, a company can deduct up to 125% (150% for an SME) of its R&D spending.

NB: For detailed comparisons see J. Warda (2006) "Tax treatment of business investments in intellectual assets: an international comparison", STI Working paper 2006/4, OECD, and IFBD (2004), "Tax treatment of research & development expenses".

2.2 Before the 2008 reform, the research tax credit to which a firm was entitled depended partly on the year-on-year increase in its R&D spending, and not merely on the level of that spending, which led to certain adverse side effects

Until 2007, the rate of the research tax credit to which a firm was entitled partly depended (and entirely so between 1983 and 2003) on the increase in R&D spending. The chief virtue of this mechanism is that the rate applies solely to a firm's additional effort, which restricts its windfall impact. The support for new projects and hence its marginal incentive effect on firms are thus maximal, in principle. Nevertheless, this mechanism can also produce a variety of adverse side effects.

- A tax credit calculated on an increase in spending provides no incentive to a firm to keep up its R&D efforts in subsequent years. Rather it acts as an incentive to revert to the initial level of R&D in order to requalify for the mechanism in the following year. Companies can thus seek to maximise the amount of the research tax credit over time by varying their R&D spending.
- Moreover, a "negative" tax credit mechanism applied to firms reducing their R&D effort. This "negative" tax credit was applicable over five years to the research tax credit earned by the resumption of growth in R&D spending. Consequently, a company had to wait five years before the tax credit's increased spending mechanism became an incentive to boost its R&D investment again.
- A company can seek to take advantage of mechanisms favouring increased spending in more than one country and so be encouraged to move its R&D around in order to benefit alternately from a range of different mechanisms or opt for the most attractive of them.
- Fast-growing firms are favoured at the expense of firms with more stable (and potentially greater) R&D activity, which may encourage the latter to fragment their R&D among small subcontractors, even though this may not be desirable from society's point of view.

To avoid this kind of tax-optimisation strategy and its adverse side effects, various safeguards have been put in place, such as calculating the increase in R&D spending on the average for the previous two years. But the complexity of this mechanism has led some firms to withdraw from it: between 1993 and 2003, the number companies applying for the research tax credit fell by 33% from 8,720 to 5,833.

2.3 To encourage firms to step up their R&D effort in the medium term, the new system abolishes the previous share of the research tax credit calculated on the increase in spending and the ceiling

The research tax credit reform is structured around two main pillars (see Box 2), namely a significant streamlining of the mechanism, with the elimination of the share of the tax linked to the increase in spending, and its progressive application, via a substantial greater tax credit applicable to the volume of R&D spending.

In addition to limiting the aforementioned adverse side effects associated with the method of calculation based on the increase in spending, the system now in force offers the following advantages:

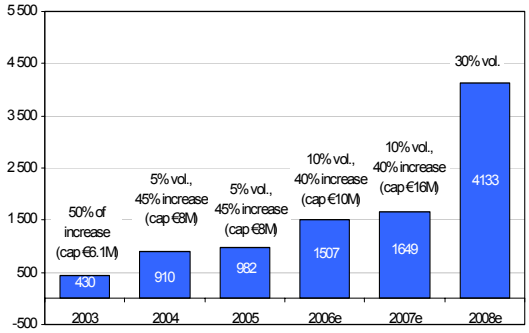
- With a research tax credit based on R&D volume only, the Government's contribution to a firm's research effort will always be proportional to the spending it incurs. The mechanism acts as an incentive both to boost R&D spending and not to reduce it, which ought to stimulate corporate R&D spending over the medium to long term.
- A significantly streamlined method of calculation makes the system more readily comprehensible and hence more efficient. This ought to provide a greater incentive to small businesses (for which administrative costs are more burdensome) to take advantage of it.
- The removal of the ceiling will enable large firms to avail themselves of the mechanism for all of their spending (since each euro of R&D is entitled to public support). This is economically sensible since it is the total volume of R&D, not merely its increase, which generates positive externalities. The 30% rate adopted helps to limit short-term windfall effects which rapidly ramping up corporate R&D spending in France[7].

(7) According to D. Guellec and B. Van Pottelsberghe ("The Impact of Public R&D Expenditures on Business R&D", OECD, 2000), the relationship between the elasticity of private spending / public funding of R&D and the rate of the government's contribution to corporate research is non-linear, in the shape of an inverted U. On this view, there is a rate of public support of between 12% and 15% at which the leverage effect of public support for private R&D investment is maximal in the short term (on average). On the other hand, a substitution effect between private and public spending on research is deemed to intervene when public support for private R&D exceeds 30%.

- Moreover, the application of a lower tax credit rate for large firms (the tax credit rate is reduced from 30% to 5% for spending above €100 million) is justified by the fact that it is relatively easier for large firms to internalise the positive spinoff (externalities) from their innovations. Small and medium-sized firms have greater difficulty reaping the benefits of their innovations, due to their weaker market power and because they lack the financial resources to defend their patents and exploit them rapidly on a large scale.

The 2008 research tax credit reform represents a substantial effort in favour of private R&D on the part of the government, with public support rising from €1.6 billion for R&D spending incurred in 2007 to €4.1 billion in 2008.

Chart 4: Change in research tax credit tax claims (in current euros millions)



Source: DGTPE.

3. Increased public support should enable firms to step up their R&D activity and so boost potential future economic growth

3.1 The increase in corporate R&D spending resulting from the research tax credit reform ought to help France move closer to the goal of 3% of GDP for R&D spending as adopted in the Lisbon Strategy

The impact of the research tax credit reform on corporate R&D spending has been evaluated bearing in mind the structural rise in private R&D spending and the reform's spillover into firms' investment behaviour and reported spending (see Box 2).

An econometric estimate of the past impact of the research tax credit (over the period 1993-2003) and a survey of firms has allowed us to assess these leverage effects on private R&D spending in the short and medium term.

The results of the econometric evaluation[8] suggest that the additional aid should add (and not subtract) to private research spending in the short run (over two years), representing a stimulus of slightly over €1 of additional R&D spending per euro of research tax credit. On this assumption, the increase in corporate R&D spending in France has been estimated at 0.13 percentage point of GDP in the medium term, which would push domestic R&D spending to 2.26% of GDP (as from 2013) versus 2.13% in 2005.

Certain studies suggest that the research tax credit has a greater leverage effect on private R&D spending over a longer time frame[9]. In that case, the reform's impact in the medium term (5 years) would be that €1 additional of research tax credit generates an additional €2 of R&D, of which €1 is financed by firms. The increase in R&D intensity could be greater in that case, representing +0.33 percentage point of GDP looking to 2018, culminating in an R&D intensity of 2.46%[10].

Box 2: The dynamic effects of the research tax credit on R&D spending

1. Excluding the research tax credit reform (but taking into account all of the pre-existing aids in favour of private R&D, including the pre-reform research tax credit), **domestic R&D spending financed by firms is trending upwards.** The simulations assume that corporate domestic R&D spending in volume terms has grown at an annual rate of 2% since 2006[a].
2. For a given level of actual spending, it is likely that the **reform will boost the share of corporate domestic R&D spending reported within the framework of the research tax credit (72% in 2005)** under the triple impact of the mechanism's simplification and enhanced attractiveness, and the elimination of the ceiling. The simulations assume that the share of corporate domestic R&D spending reported within the framework of the reformed research tax credit rises to 90% in 2010 (72% in 2005, 75% in 2006 and 2007, 85% in 2008, and 88% in 2009) and then stabilises at this leve[b].
3. **Increased public support for private R&D spending should spill over in private research spending.** The two main assumptions underlying results of the scenarios presented here are consistent with the available empirical literature, namely that of a pure short-term addition effect (the supplementary aid is added to private research spending, i.e. an additional €1 of R&D spending per € of research tax credit), and that of a 2x spillover effect in the medium term (€1 of research tax credit generates €2 of additional R&D, with the firm financing €1 of that additional spending).

a. Most recent available year for R&D and research tax credit data.
b. By way of comparison, the corporate reporting rate increased from 63% to 72% between 2004 and 2005 following introduction of the doubling of the "volume share" in the method of calculating the research tax credit.

(8) Study carried out by E. Duguet (University of Évry) for the Ministry for Higher Education and Research.

(9) Mulkay and Mairesse (2004) identify a more substantial spillover effect in the longer term, with €1 of the research tax credit generating between €3 and €4.6 of additional R&D spending, of which an additional €2 - €3.6 are financed by the firms. "Une évaluation du crédit d'impôt recherche en France (1980-1997)" (An evaluation of the research tax credit in France), *Revue d'Économie Politique, no. 114(6)*

(10) Which means that the impact is twice as large as under the previous assumption of a pure addition of credits. This flows from a cumulative phenomenon: an additional research tax credit entails a rise in R&D in subsequent years, which leads to an additional rise in the research tax credit (due to the rules used to calculate it), and hence to further R&D as a result of the stimulus provided.

3.2 The research tax credit reform is expected to lead to a significant rise in corporate recruitment of researchers

Translating corporate R&D spending into innovations depends on France's resources in terms of researchers. In a tight labour market, increased R&D spending can lead to a very high price effect (pushing up wages) at the expense of a volume effect (in the sense of an increase in the number of researchers). The additional long-term future need for researchers is therefore estimated by determining the growth path for corporate R&D spending and by factoring in the structural growth in researchers' wages resulting both from their rising productivity and tensions arising as the supply and demand for labour adjust (see Box 3).

In the scenario considered, the additional corporate R&D effort is expected to occur mainly between 2008 and 2013, as corporate R&D spending implemented[11] in France rises from 1.35% to 1.7% of GDP over this period, reaching 1.75% in 2020.

Taking rising wages into account, the net requirement for new researchers resulting from the reinforced mechanism is estimated, all other things being equal, at 25,000 researchers over the period 2008-2020, representing an additional 5,300 researchers annually at the beginning of the period (2009-2010), and 200 new researchers at the end of the period (2019-2020)[12].

Table 2: The impact of the research tax credit reform on domestic R&D spending, the number of researchers and their wages

	Corporate domestic R&D spending (€M 2004)	Corporate domestic R&D spending/GDP*	Domestic R&D spending/GDP	Number of researchers	Annual change in wages (2009-2020)
Initial situation	24 041	1.34%	2.17%	106 500	2%
Situation in 2020 post- research tax credit reform	39 000	1.74%	2.55%	134 000	3.2%–2.1%

Sources: OECD, Main Science and Technology Indicators (2005) and DGTPE simulations.

NB: Corporate domestic R&D spending refers to R&D spending implemented by the private sector. The reported rate of growth in wages is annual and increases by 3.17% at the beginning of the period (2009) to 2.04% at the end of the period. Estimates do not take account of researchers leaving their occupations.

When compared with current annual inflows into the labour market (10,000 new PhDs per year), this looks like a substantial stimulus to the demand for researchers (representing around 50% of the present annual supply of new researchers, initially, and progressively falling to 2% of this supply at the end of the period, according to estimates). If the private sector mainly requires scientific researchers, and knowing that the annual supply of these amounts to 6,000 new PhDs, then France will need practically to double its output of new PhDs over the period 2009-2013 or else attract foreign-trained PhDs.

The impact of rising spending and wages on France's attractiveness is nevertheless uncertain. In all likelihood, however, in the absence of an increase in supply, the gradual rise in the research tax credit will lead to a higher increase in researchers' wages, although this would be a major factor in boosting the attraction of France to foreign researchers and would serve to ease short-term tension in the labour market.

3.3 Thanks to a potentially high fiscal multiplier[13], the boost to R&D activity should provide a strong stimulus to long-term economic activity

Past investment in R&D helps to raise the level of knowledge and technology in an economy, which has a positive impact on its growth rate. The macroeconomic effects of the research tax credit reform have been evaluated by estimating the consequent rise in the overall level of knowledge and technology. The stock of knowledge is constructed by analogy with the stock of physical capital. Each year, the volume of R&D spending is added to the previous year's stock of knowledge, after depreciating a constant portion of this stock[14]. The research tax credit has a powerful impact on the stock of knowledge, but this is slow to make itself felt. The leverage effects of R&D resulting from the dissemination of knowledge among sectors of activity are felt only progressively.

Table 3: Effects of the reform on the stock of knowledge (relative to the stock of knowledge in the absence of reform)

Hypothesis considered	2008	2009	2010	2012	2015	2020	2025
Pure addition effect	0.0%	0.3%	0.8%	1.9%	3.3%	4.7%	5.4%
Multiplier leverage effect	0.0%	0.4%	1.2%	3.2%	6.5%	10.6%	13.0%

Interpretation: assuming a research tax credit multiplier effect of 2, the stock of knowledge in 2012 would be 3.2% higher as a result of the research tax credit reform..

(11) Which corresponds to an increase in corporate-financed R&D of 0.28 percentage point of GDP, rising from 1.11% to 1.39% of GDP over the period.

(12) An alternative approach based on the elasticity of labour supply to wages produces a similar outcome. This evaluation was based on the estimates of Ryoo and Rosen (2004) according to which the elasticity of labour supply to expected earnings is between 2.5 and 4,5. Ryoo Jaewoo and Rosen Sherwin (2004), "The Engineering Labor Market", *Journal of Political Economy*.

(13) The fiscal spending multiplier, or fiscal multiplier, is defined as the relationship between the additional GDP generated by the measure and the ex ante cost of the measure to the public finances.

(14) The depreciation rate here is equal to 10%. Cf. Charles Ian Mead, R&D Depreciation Rates in the 2007 R&D Satellite Account - BEA US Departement of Commerce - www.bea.org.

Box 3: **How the research tax credit stimulates corporate demand for researchers**

1. **The main determinant of the net demand for researchers is the change in R&D intensity** (and its distribution by sector of implementation looking to 2020). The growth path for R&D spending implemented by firms (corporate domestic R&D spending) is arrived at by assuming that public funding for corporate domestic R&D spending is constant, and by taking account of the stimulus effects of the research tax credit reform (including a 2x leverage effect) on corporate spending (see Box 2).
2. **The price effects (rising wages[a]) and volume effects (rising number of researchers) of labour market pressures resulting from an increased corporate R&D effort are evaluated on the basis of available data in the literature on the elasticity of wages to R&D intensity**[b]. The mechanism that is explicitly estimated is the effect (a)+(b)+(c) in the chart below, i.e. the effect of labour demand on wages given that the labour supply responds imperfectly (which means that the effect (d) is indirectly taken into account[c]). The elasticity value used is 0.2[d], which means that a 10% increase in R&D spending intensity leads to a 2% rise in wages (w_t).
3. Wages too rise structurally: **a 2% annual increase (equivalent to the economic growth rate) has been assumed in order to capture the effect of productivity on wages** (w_p).

   The model resolved in each period is therefore as follows:

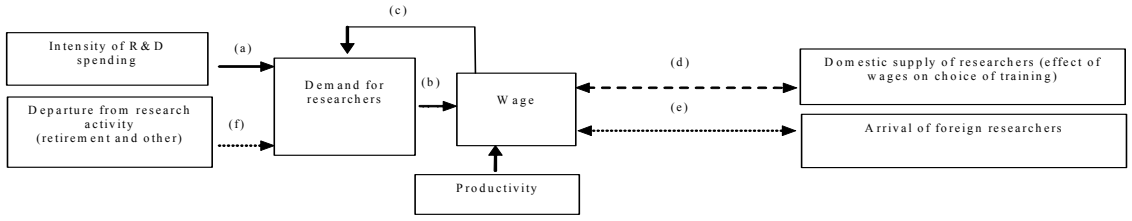
   Assuming that the share of wages paid to researchers *(w.N)* in the volume of R&D investment (I) is constant over the period, the dynamic relation between wages, number of researchers and R&D investment (variables in lower case indicate growth rates) can be written:

   $$(1+i) = (1+w)*(1+n)$$

   The change in wages being defined by the following relations[e] :

   $$w=wt + wp$$
   $$wt = 0,2*(i-gdp)$$
4. The impact of migrations and departures from research activity (effects e and f) on future demand is not taken into account, which implies that **the model chiefly evaluates net demand for researchers arising out of the research tax credit reform**.

   The main mechanisms at work in the labour market liable to affect private sector demand for researchers are synthesised as follows:



a. Leaving aside the general rise in prices, which is assumed, moreover, to be controlled by the Central Bank.
b. The elasticities of wages to R&D spending are taken from the work of Austan Goolsbee (1998), "Does government R&D policy mainly benefit scientists and engineers?" *American Economic Review, Papers and Proceedings.*
c. The tension in the labour market measured by the elasticity of wages to the intensity of R&D takes into account the imperfect response by labour supply to the demand for labour on the part of firms that spend on R&D.
d. Goolsbee (1998) estimates elasticities of between 0.3 in the short term and 0.171 in the medium term. The supply of labour is more sensitive to variations in real wages in the long term, and David and Hall (2000) consider, within this framework, that these elasticities ought to be on the order of 0.1. The fact that France is less attractive to researchers (relative to the United States) ought to lead to higher elasticities.
e. With a fixed rate of spending growth and intensity (see Box 2), we obtain a simple 3-equation model with three unknowns (*n; wt* et *n*).

The growth in the stock of knowledge has a progressive impact on productivity. It takes time for new knowledge to boost productivity. This time lag is necessary to allow firms to develop new products or improve their processes, on the one hand, and to launch these innovations onto the market, on the other. The findings of economic studies have been used to estimate the impact of the growth in the stock of knowledge on GDP (see Box 4).

Depending on the extent of the leverage effect applied to the fiscal spending (which determines the direction of the change in R&D investment), the research tax credit reform ought to boost the level of economic activity in France by between 0.3% and 0.6% over the long term, and still more so over the longer run relative to what it would have been without the reform.

Table 4: The effects of the reform on activity (relative to GDP in the absence of reform)

Assumption considered	Additional GDP in 2022 (as a percentage point of GDP)
Pure addition effect	+ 0.3
2x multiplier leverage effect	+ 0.6

Interpretation: assuming the research tax credit has a 2x multiplier leverage effect, a rise in R&D spending in France could boost GDP by 0.6 percentage point of GDP looking to 2022.

The long term multiplier of fiscal spending thus appears to be very high, on the order of 4.5 after 15 years for a multiplier leverage effect of 2. The annual budgetary effort here is on the order of 0.13 percentage point of GDP, whereas the impact on GDP looking to 2022 is 0.6 percentage point of GDP.

Paul CAHU, Lilas DEMMOU, Emmanuel MASSÉ

Box 4: **The macroeconomic effects of the research tax credit reform**

R&D activity serves to build up a stock of R&D that represents a factor of production in the economy, alongside labour and physical capital. GDP is then assumed to be a Cobb-Douglas function of the stock of R&D, R.

$$PIB = R_{t-D}^{\beta} AF(K, L) \quad (1)$$

In firms, there is a minimum lead time of three years between an increase in the stock of R&D and the appearance of its first effects on GDP. At the macroeconomic level, added value is strongly correlated with the stock of knowledge with a 3-5 year time lag. This lag reflects the time it takes to innovate and exploit innovations. This is why the stock of R&D enters the production function with a time lag D.

Estimating the macroeconomic impact of an increase in R&D spending therefore depends on assumptions relating to the stock of R&D and on this stock's elasticity to GDP, written β.

1. **To evaluate the level of the stock of R&D, R, it should be augmented in each period by the volume of investment flows I and diminished by the depreciation rate** δ. The values for this depreciation rate are between 10% and 15% depending on which study one considers[a]. In our calculations we have opted for 10%, this being the most recent value and the one best-suited to the context of Europe. The stock is thus evaluated at € 340 billion[b] in 2007.

$$R_{t+1} = (1-\delta)R_t + I_t \quad (2)$$

2. **The elasticity of GDP to the stock of R&D depends on the dissemination of the effects of R&D**, which is considerable, between sectors and between countries. The complexity of the interactions explains[c] why estimates for this elasticity vary[d] between 0.06 and 0.2. More recent studies give a narrower range in cases where European countries simultaneously boost their R&D effort[e].

3. **The elasticity of GDP to the stock of R&D could be lower if France alone were to step up its R&D effort**. There is no econometric estimate of this effect for France, although recent work by In't Veld[f] isuggests that due to reduced spillover effects the impact of an increase in R&D would be 25% less if this policy were pursued in a single country rather than across the whole of the Union. In the case of a unilateral policy, any favourable relative competitiveness effects always turn out to be dominated by spillover effects. Consequently, the value of 0.075[g] has been selected for the elasticity of GDP to the stock of R&D[h].

4. **Elasticity is estimated by simulating the general equilibrium of multi-sectoral and multi-country models that model spillover effects:** a sector's R&D intensity tends to rise with the size of its stock of knowledge.

a. Carson et al., 1994, A satellite account for Research and Development, *Survey of Current Business, vol. 74, no.11, pp. 37-71*, ERASME selects 10%, the PCB, 11%. Griliches, 1992, The search for R&D spillovers, *NBER Working Paper 3768*.
b. A 15% depreciation rate leads us to estimate the stock at €240 billion in 2007. The "initial" value of the stock of R&D (here in 1959) plays a negligible role in the evaluation. The Ministry of Research supplies R&D spending figures since 1959, *Repères et références statistiques*, 2007.
c. Jacobs, 2002, Sectoral productivity growth and R&D spillovers in the Netherlands, *De Economist, vol. 150, pp. 181-210*.
d. For the PCB, this elasticity is 0.18 (PCB Document 91); it is 0.12 in ERASME, 0.20 for Griliches (1992), between 0.06 and 0.20 for Canton et al. (2005, Human capital, R&D and competition in macroeconomic analysis), and 0.10 for Griffith et al. (2000, Mapping the two faces of R&D: productivity growth in a panel of OECD industries, *CEPR Discussion Paper 2457)*.
e. The PCB and ERASME respectively evaluate this elasticity at 0.13 and 0.09.
f. In't Veld, Jan, 2007, International Spillovers of Structural Reforms, working paper presented at DG ECFIN, European Commission, Lime Workgroup.
g. Representing 75% of the effect of a given increase in R&D Europewide.
h. . Cahu, Paul, 2003, Effets de l'investissement en éducation supérieure sur la productivité française (Effects on French productivity of investment in higher education), *mimeo*, estimates at a given moment in time a total elasticity of the stock of GDP to the stock of knowledge of 0.1 for France. This parameter theoretically measures cross-border externalities.

Publisher:

Ministère de l'Économie, de l'Industrie et de l'Emploi

Direction Générale du Trésor et de la Politique économique

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Version anglaise :

Centre de traduction des ministères économique et financier

Layout:

Maryse Dos Santos

ISSN 1777-8050

Recent Issues in English