Innovation height, spillovers and TFP growth at the firm level: Evidence from French manufacturing

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Innovation height, spillovers and TFP growth at the firm level: Evidence from French manufacturing

We examine the contribution of incremental and radical innovations to total factor productivity (TFP) growth at the firm level. The first part of our analysis is dedicated to the determinants of innovation and reveals two different innovation regimes. On the one hand, radical innovations rely strongly on firm-level spillovers, including property rights, and formal internal research while, on the other hand, incremental innovations rely mostly on the adoption of equipment goods accompanied by informal research. We find that radical innovations are the only significant contributors to TFP growth so that innovation height matters. We also find evidence that TFP growth is better represented by an upward shift of the production function than by a continuous innovation measure. Overall, the growth gains that we find are comparable to the ones of the previous studies.

Keywords: growth, innovation, total factor productivity, Solow residual, spillovers.

JEL: C34, D24, O31, O33, O47.

Hauteur des innovations, externalités et croissance de la productivité globale des facteurs: Une analyse micro-économétrique sur l'industrie manufacturière française.

Nous examinons la contribution des innovations incrémentales et radicales à croissance de la productivité globale des facteurs (PGF) sur données d'entreprises. La première partie de notre analyse est dédiée aux déterminants de l'innovation et révèle deux régimes différents. D'une part, les innovations radicales reposent fortement sur les externalités, y compris les droits de propriété, et sur la recherche formelle interne. D'autre part, les innovations incrémentales reposent principalement sur l'adoption de biens d'équipements accompagnée d'une recherche informelle. Nous trouvons que seule l'innovation radicale contribue significativement à la croissance de la PGF, de sorte que la hauteur de l'innovation est une donnée importante. Nous trouvons également que la croissance de la PGF est mieux expliquée par un modèle avec saut que par une mesure continue d'innovation. Globalement, les gains de croissance que nous trouvons sont comparables à ceux des autres études.

Mots-clef : Croissance, innovation, productivité globale des facteurs, résidu de Solow, externalités.

1. Introduction

In this famous paper of 1957, R. Solow found that the share of GNP attributable to capital and labor was rather small. He proposed an interpretation of the residual as a measure of technical progress. Even though the author remained cautious about the interpretation of this residual, the methodology involved by this contribution is now widespread in macroeconomics. The Solow residual is, most of the time, still interpreted as a measure of technical progress. However, its main drawback is well known: it evaluates the rate of technical progress without using any information on innovation itself. The point is important since, in econometrics, a residual includes anything we cannot explain and is therefore considered by most researchers, to quote Abramovitz (1956), as “a measure of our ignorance”.[2] For this reason, many researchers have preferred to use other methods in order to evaluate the contribution of innovation to growth. These methods rely on firm-level measures of innovation (Minasian, 1962; Griliches, 1964; Mansfield, 1965). The analysis presented in this paper is in accordance with this line of work and aims to answer the following question: is the Solow residual linked to technical progress, and if so, how much? The answer to this question is obtained by examining the relationship between the Solow residual and measures of innovation implemented at the firm level. Our approach is based on the three following elements.

First, the growth gains may depend on innovation height. A small modification to the product or to the process will generally be recorded as an innovation in the surveys. But it is possible that small modifications do not have large effects on total factor productivity (henceforth, TFP) growth. On the contrary, a process breakthrough could lower the unit cost and generate a strong growth, or the introduction of a product that is new for the market can create a demand and have a similar effect. Data on such innovation types are available and we use it in this paper to see whether there is an innovation threshold leading to a better growth. We distinguish incremental innovation, that refer to a small change of product or process, and radical innovation that refer to products that are new for the market and to technological breakthroughs. To our knowledge, this paper is the first attempt to introduce innovation height in a firm-level growth analysis.

Second, the determinants of incremental and radical innovations need not be the same and we take a special care distinguishing them. Intuitively, incremental innovations are more likely to rely on informal research sources or on the adoption of a technology

[2] See Griliches (1979, 1996) on this topic.

developed in other firms, while radical innovations are more likely to originate from a more sophisticated knowledge accompanied by a formal organization of research and development activities. We examine this issue by using eight innovation inputs, including formal and informal research, and internal and external knowledge sources.

Third, innovation implementations are made contemporaneously with production decisions, which creates a doubt about the causality running from innovation to TFP growth. We solve this problem by using a structural model and instrumental variable methods.

The main results we find are the following. First, radical innovations depend much more on spillovers than incremental innovation. One the one hand, incremental innovation relies on the adoption of new equipment goods accompanied by informal research and development. These determinants suggest that incremental innovation are closely linked to adoption or to the modernization of the production process rather than to a genuine innovation process. On the other hand, radical innovation make a strong use of both informal and formal R&D but use much more external sources of knowledge, both inside and outside the group, as well as the knowledge codified in patents and licenses. These innovation sources are used to achieve new products for the market and process breakthroughs.

Our second finding is that only radical innovation would significantly contribute to TFP growth. This result is robust to the definition of incremental innovation, differences in estimation methods and to the introduction of variable returns to scale. We also find that the return on radical innovation is increasing with the degree of technological opportunities. These results suggest that the radical innovators would succeed in capturing the rents from innovation from the incremental innovators, and that the latter would simply make a gain of the same size as what they buy and would not enjoy extra profits from adoption. Since the incremental innovators do not strongly innovate, this result means that only genuine innovators make extra profits from innovation.

Our last result is that radical innovation is better modeled by a discontinuity in the production process rather than a continuous investment model. The non nested tests that we have performed show that representing radical innovations as shifts in the production function results in a better statistical fit of the TFP growth at the firm level.

The paper is organized as follows. The first section presents the main properties of the data. Section 2 presents the model and the third section the econometric application. The fourth section summarizes our main findings and the last section presents the conclusions of this study.

2. The data

This section summarizes the main properties of the data, while the details about the sources and the sample construction have been relegated in appendix 1.The innovation data come from the first innovation survey in France, that was conducted in 1991. It was presented as an appendix to the industry census, compulsory over 20 employees. This survey has been used to perform the Community Innovation Surveys (henceforth, CIS) that have followed. We choose this survey for two reasons. First, it includes information on innovation height that has been neglected in the CIS surveys.[3] Second, it includes five times more firms than the CIS so that we will be able to evaluate the contribution of innovation to growth separately for three different technological classes.

The information provided by the French innovation survey (henceforth, FIS) is made up of retrospective answers over the period 1986-1990. This survey provides information on eight innovation types that firms can have implemented, including five types about products and processes, as well as information about eight knowledge sources used as the determinant of these innovations. Finally, it also provides information about the motivation of firms' activities (market pull, technology push) and the innovative opportunities of their line of business.

The product or process innovation included in the survey can be regrouped according to their height. We define incremental innovation as one of the three following innovation types:

- Significant improvement of an already existing product;
- Launching a product that is new for the firm but that is not new for the market;
- Significant improvement of an already existing process.

These three innovation types are incremental since the first one refers to an already existing product, the second one implicitly refers to product imitation of competitors and the third one applies to an already existing process. All these innovation types suggest a rather continuous management of innovation. It is not the case of radical innovation that involves some kind of discontinuity in the production process. Radical innovations can take two forms:

- Launching a product that is new both for the firm and for the market;
- Implementation of a process breakthrough.

[3] CIS1 does not include innovation height and CIS2 includes it for product innovations only.

These two innovation types are much stronger than the incremental ones. The first one involves a discontinuity of the product line of the firms, both because it does not refer to previously existing products and because no competitor produces it. Therefore it can be interpreted either as creating a new market or as the result of a significant vertical differentiation.[4] The second type of radical innovation refers to process and is defined as a way of producing that did not exist before. Here, we could interpret it a shift in the production function (or the cost function). It may grant the innovative firm a strong competitive advantage over its competitors. The radical innovations also share an additional property in common: they are more likely to generate important spillovers than the other innovations and to generate innovative sales. The latter result, on innovative sales, was clearly found by Barlet et al. (1998) mostly in the lines of business with strong technological opportunities (with the same definition as in this study).[5]

Table 1 presents the percentage of innovators by industry. Out of the 4085 respondents, 64% have made an incremental innovation over 1985-90 and 37% a radical innovation. These high figures come from the fact that the survey spans a 5 years period instead of the standard 3 years periods used in the CIS. A simple rule of thumb would give 38% for incremental innovation on a three-year period.[6] Here we should distinguish the firms that have performed incremental innovations only from the ones that have performed both incremental and radical innovations. The reason is that radical innovators are almost always incremental innovators as well. We find that only 29% of the firms have done incremental innovations alone. This point is interesting because these firms are the basis for identifying the separate performances of incremental and radical innovations. Moreover, the percentage of incremental “alone” innovators is fairly stable across industries (except in glass and paper and board), always close to the mean of the sample, around 30%. This is an interesting result because it implies that one cannot identify an industry by the percentage of firms that perform incremental innovation alone. On the contrary, radical innovation presents much more variance across industries, from 17% in printing and publishing to 71% in houseware.

The previous results suggest that the industry growth differences that one can see between industries would not be correlated to incremental innovation because it nearly does not vary across industries. The growth differences would be correlated mostly to radical

[4] Horizontal differentiation is closer to incremental innovation since it can be interpreted both as a product that is new for the firm and not for the market or as an improvement of an already existing product.

[5] Notice that radical innovation is less efficient under weak technological opportunities (Barlet et al., 1998).

[6] That is $3/5 \times 64\% = 38\%$.

innovations, since the industries with the highest scientific basis have the highest percentages of radical innovators. This fact about the percentages of innovators may help understanding our firm-level results on radical innovation.

The sources of innovation are presented in Table 2. On average radical innovators make a stronger use of all innovative inputs, except two of them: informal research and equipment goods. Since the radical innovators are much more innovative, this result suggest that these two determinants will play an especially important role for incremental-only innovators. Also notice that the strongest difference in innovative inputs is found for patents and licenses, so that we expect that these two inputs will play an important role for the radical innovators. Therefore, the determinants of incremental and radical innovations may be different. This will be confirmed by the firm-level econometric analysis.

The other data sources provide accounting data. The first one is the EAE[7] that provides information on value added, employment and capital and that we use to compute the Solow residual. The second one is the line-of-business EAE that provides information about diversification, market shares and concentration. We use these data in the list of innovation determinants.

The growth data covers the 1985-1991 period. The reason of this choice is that one the one hand, the FIS refers to innovations introduced between January 1st 1986 and December 31st 1990. Since the accounting data is always taken at the end of the year, the data of 1985 refer in fact to December 31st 1985, which is the same as January 1st 1986. It is therefore the good starting point for our growth rate. The two reasons why we selected 1991 (December 31st) for the terminal year are the following. The FIS refers to innovation that have been *implemented* so that we do not expect a long delay between innovation and its performance, one year is a reasonable choice. The second reason why we took 1991 is that the more distant the terminal year the less there are firms in the sample. A six years presence allows keeping a large number of firms in our analysis. All these data are merged according the compulsory firm national identification number (the SIREN number), so that there is no loss of information due to matching.

In order to compute the TFP, we use the following definitions, where all the variables are taken in logarithm at the end of the year. Q denotes value added, L the number of hours worked, C physical capital and W the wage rate. We use the following variables:

Value added per employee hour: $q = \ln(Q / L)$

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[7] "Enquête Annuelle d'Entreprises" (yearly industry census) that is compulsory for all firms above 20 employees.

Capital per employee hour: $c = \ln(C / L)$

Labor cost share: $s = WL/Q$

Total factor productivity: $a = q - (1 - s)c$

The Solow residual is the growth rate of TFP denoted Δa. By convention, all our growth rates are computed on inflation corrected quantities (at the 1985 prices), and are annualized in order to easier comparisons with other works.

Table 3 presents the production function variables and gives both the sample statistics per employee and per employee hour. Notice that we use the hourly data only for the econometric study.[8] Our sample is representative of the standard structure of a large sample in French manufacturing. In 1985, 75% of the firms in our sample have between 34 and 144 employees, so that our study includes many small and medium-sized firms. The average size is 257 employees because of the large firms.[9] On average, a firm hold 28 thousands Euros per employee in physical capital and produce with it a value added of 30 thousands Euros per employee. The labor cost share is close to 75%, a standard value in French manufacturing. The growth rates per capita are closed to their hourly counterparts. Over the period, value added per employee rose on average by 6% a year while physical capital rose on average at 10% a year.[10] The TFP growth was on average 2.4%. Hence, there remains a significant part of the growth to be explained. One of these explanations, innovation height, is the motivation of this paper.

[8] Previous studies of French manufacturing use per capital statistics, so that we provide it to show that our sample does not differ from a standard sample of French manufacturing firms.

[9] Our sample has been cleaned for outliers as explained in appendix 1.

[10] These high figures are typical of non-weighted averages over samples that include many small firms.

3. The model

We propose two models of innovation and growth based on two ways to represent innovation. We call them the simultaneous innovation model and the ordered innovation model. In the simultaneous innovations model, both incremental and radical innovations are included in the TFP growth equations, including for the firms that performed both types of innovation. This model allows disentangling the effects of incremental and radical innovations. In particular, it allows for a return on incremental innovation among radical innovators. For the radical innovator, this model implies that the return on their innovation is the *sum* of the two innovation coefficients since the radical innovators are also incremental innovators. In practice, we observe two innovation dummies, one for incremental innovation and one for radical innovation.

In the ordered innovations model, one assumes that only innovation height matter. The innovative level of the firm is defined as the *maximum* innovation level achieved over the period. Here we observe only one categorical variable that can take three ordered values: no innovation, incremental innovation and radical innovation. In this model, the firms that performed both incremental innovation and radical innovations are considered as radical innovators.

The two models are equivalent in one case: when incremental innovation is not significant in the growth equation. In that case, the correct specification reduces to radical innovation in the growth equation, with only one dummy variable, since radical innovation is defined the same way in both the simultaneous and in the ordered innovation models.

3.1. The growth equation

The basic idea of the model is similar to Crépon, Duguet and Mairesse (1998). A first relationship explains a performance by innovations outputs and the traditional inputs of the production process and the other relationships explain innovation outputs by innovation inputs (the “innovation functions”). We write the production function as:

$$Q = A\,F(K, L)$$

Where A is total factor productivity, that depends on the innovations *implemented* by the firms. From this relationship, we derive the Solow residual and estimate the following relationship:

$$\Delta a_{i,t} = \alpha\, a_{i,t-1} + I_{i,t}\,\beta + S_{i,t}\,\gamma\,, \quad \alpha < 0\,.$$

where a_{-1} is the lagged value of TFP, I_t the innovation vector and S_t the industry dummies vector. In our case there is only one long-difference available and we use the annualized growth rate.[11] This model has the interesting following interpretation: it explains TFP by the *innovation effective capital*. To see this, develop the previous equation from the starting date (0 by convention), we get:

$$a_t = (1+\alpha)^t a_0 + \left(\sum_{s=1}^{t} (1+\alpha)^{s-1} I_{i,s} \right) \beta + \left(\sum_{s=1}^{t} (1+\alpha)^{s-1} S_{i,s} \right) \gamma$$

Now consider the definition of knowledge capital. Let $I_{i,t}$ denote innovation achievement by firm *i* in year *t*, its innovation capital, denoted K_{it} (K for "knowledge"), is defined as:

$$K_{i,t} = (1-\delta)^t K_{i,0} + \sum_{s=1}^{t} (1-\delta)^{s-1} I_{i,s}$$

where δ is the annual depreciation rate of knowledge capital. When the current date is far from the starting date, we can neglect the initial conditions and the two previous equations becomes:

$$a_t = \left(\sum_{s=1}^{t} (1+\alpha)^{s-1} I_{i,s} \right) \beta + \left(\sum_{s=1}^{t} (1+\alpha)^{s-1} S_{i,s} \right) \gamma \quad \text{and} \quad K_{i,t} = \sum_{s=1}^{t} (1-\delta)^{s-1} I_{i,s} ,$$

so that we can write:

$$\alpha = -\delta$$

and

$$a_t = K_{i,t}\, \beta + Z_{i,t}\, \gamma$$

This simple relationship means that the total factor productivity achieved by a firm depends on two determinants. The first determinant is its knowledge capital $K_{i,t}$, the higher it is the higher is TFP. Its growth rate is equal to the difference between the innovation achievements that are an addition to prior knowledge and the depreciation of knowledge that is measured by the opposite of coefficient α. The second determinant $Z_{i,t}$ is the industry trend. Notice that this variable does not represent the knowledge spillovers since they are already accounted for in the determinants of innovation and therefore of $K_{i,t}$.

[11] We cannot build a sample with several long differences since the CIS1 does not account for innovation height and CIS2 accounts only for the products that are new for the market.

This model simplifies the interpretation of the coefficients: α is the opposite of the depreciation rate of knowledge capital and β is the TFP return on knowledge capital.

3.2. The innovation functions

The second part of the model is made of the "innovation functions" that relate the innovation inputs to the innovative outputs. We use two sets of variables. The first set of variables includes the innovation inputs from the FIS survey: formal R&D, group R&D, informal R&D, external R&D, patents, licenses, equipment goods, materials and components. The interpretation of their coefficients is straightforward: they give the contribution of each innovation source to the innovative output once controlled for the other determinants. The second set of variables summarizes the determinants identified in the reduced-form literature. It includes size, diversification, market share, industry concentration, a market pull indicator and a technology push indicator. However, these variables do not have the same interpretation in our model and in reduced-form models. This is because the Schumpeterian determinants of innovation explain the innovation inputs rather than the innovative outputs directly. Since we already account for the innovative inputs, they represent potential additional effects to the ones that they already have on the innovative inputs. We expect most of these variables to be insignificant, since they are already highly significant in the inputs explanation.[12]

3.2.1. The simultaneous innovations model

The innovation output variables are both binary (Yes/No) and endogenous so that we need to estimate a system of limited dependent variables. There are two basic ways of estimating this system: either by considering that the output decision matter so that the output dummy enters directly in the TFP growth equation, or by considering that a linear index enters the model. These two models have different theoretical implications on the nature of the innovation process.

More precisely, the innovation output can be considered as coming from the following latent innovation variable model:

$$INC_i{}^* = X_i b_1 + u_{1,i}$$
$$RAD_i{}^* = X_i b_2 + u_{2,i}$$

[12] For a study of the relationship between the Schumpeterian variables and innovative input and output with a reduced form approach, see Crépon, Duguet and Kabla (1996).

where X is the vector of the innovation inputs, u_1 and u_2 are the disturbances of the model and where $INC_i{}^*$ and $RAD_i{}^*$ represent continuous measures of the innovation potential available to the firm. We observe an effective innovation when these latent variables (or linear indexes) cross a threshold, set to zero without loss of generality.[13] We have:

$$INC_i = \begin{cases} 1 & \text{if } INC_i{}^* > 0 \\ 0 & \text{if } INC_i{}^* \leq 0 \end{cases} \quad \text{and} \quad RAD_i = \begin{cases} 1 & \text{if } RAD_i{}^* > 0 \\ 0 & \text{if } RAD_i{}^* \leq 0 \end{cases}$$

Therefore two representations of the relationship between growth and innovation are possible. In the first model, innovation output creates a shift in the production function, we have:

$$\begin{aligned} &\Delta a_{i,t} = \alpha\, a_{i,t-1} + \beta_1 INC_i + \beta_2 RAD_i + S_{i,t}\, \gamma + v_{i,t} \\ &INC_i = \mathbf{1}\left(INC_i{}^* > 0\right) \\ &RAD_i = \mathbf{1}\left(RAD_i{}^* > 0\right) \\ &INC_i{}^* = X_i b_1 + u_{1,i} \\ &RAD_i{}^* = X_i b_2 + u_{2,i} \end{aligned}$$

In the second model, innovation output is represented by a continuous process:

$$\begin{aligned} &\Delta a_{i,t} = \alpha\, a_{i,t-1} + \beta_1 INC_i{}^* + \beta_2 RAD_i{}^* + S_{i,t}\, \gamma + v_{i,t} \\ &INC_i{}^* = X_i b_1 + u_{1,i} \\ &RAD_i{}^* = X_i b_2 + u_{2,i} \end{aligned}$$

These two models involve different visions of the innovation process. According to the first one, only practical implementations matter for improving on TFP growth. Innovation is therefore described as a *discontinuity* of the production process.[14] Two firms with the same innovation inputs will not be predicted the same TFP growth if the first one succeeded in implementing its innovation and the other firm did not. According to the second model, innovation is described as a continuous process at the firm level since the only element that matters for growth is the innovative potential of the firm summarized by the linear index of its innovative inputs.

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[13] In general, this threshold is included in the intercept of the model. In our application, there are industry dummies in the regression so that the threshold in fact depends on each industry, which is equivalent to 17 different thresholds. The thresholds are also specific to each innovation type.

[14] This discontinuity at the firm level is compatible with continuity by aggregation at the macroeconomic level.

Which model is the right one is basically an empirical issue and we have performed a non-nested test presented in appendix 3. The conclusion is that modeling growth as shifts in the production function is better. We will therefore focus on the innovation dummy model.

These models can be estimated by the two-step method. This method first estimates dichotomous models for innovative outputs. We assume that the disturbances of the innovation equations are logistic and therefore estimate two logit models. In a second step, we estimate the TFP growth equation with the predicted innovation probabilities in place of the inputs. One can interpret this method as a non-linear equivalent of the two-stage least squares method. Indeed, the natural instruments of the model are the innovative inputs since, one the one hand, they are correlated with the innovative outputs and, on the other hand, that they are not correlated to TFP growth once controlled for innovative output. This is because an innovative input can influence TFP growth only when a modification is done to the product or the process.

The only econometric issue comes from the fact that the predicted probabilities are estimated. On the one hand, it creates heteroskedasticity in the growth equation and, on the other hand, it creates a correlation between the predicted probabilities of the firms since the predicted probabilities are computed from the same estimated parameters for all the firms. The OLS standard errors of the growth equation are therefore not consistent (see Lee, 1981; Pagan, 1994). The only straightforward solution to this problem is to estimate the standard errors of the two-step estimator by the *bootstrap* method. There remains to choose the number of drawings. Since we know that the two-step estimator is asymptotically normal, we just need to estimate standard errors.[15] Therefore we can follow Efron and Tibshirani (1993) and use 100 drawings. The logit model is re-estimated at each draw.

3.2.2. The ordered innovations model

Here we model innovation height directly, where height is defined as the highest innovation level achieved by a firm. We defined a categorical variable taking 3 possible ordered values:

$$H = \begin{cases} 0 & \text{if the firm has not innovated} \\ 1 & \text{if the firm has performed incremental innovations only} \\ 2 & \text{if the firm has performed at least one radical innovation} \end{cases}$$

The latent linear model defining innovation height is given by:

[15] This is because a normal distribution is fully defined by its two first moments.

$$H_i{}^* = X_i d + w_i$$

where X_i includes the innovation inputs and w_i is a disturbance. Innovation height is then obtained as:

$$H_i = \begin{cases} 0 & \text{if } H_i{}^* < a_1 \\ 1 & \text{if } a_1 \le H_i{}^* < a_2 \\ 2 & \text{if } H_i{}^* \ge a_2 \end{cases}$$

where a_1 is the threshold defining incremental innovation and a_2 the threshold defining radical innovation.[16]

In this model, what matters is the global input investment of the firm. If it is too low, the firm will not innovate and $H = 0$, if the investment is higher but not very strong the firm will achieve incremental innovations only and $H = 1$. On the contrary, if the inputs intensity is strong, the firm will cross the radical innovation threshold a_2. In our application, we assume that the disturbance w_i follows a logistic distribution, so that we estimate one ordered logit model.

The estimation of the growth equation raises the same issue as in the simultaneous innovation model, since we still have both a linear index and two predicted probabilities corresponding to incremental and radical innovations. Therefore, we can apply the two-step method to this model as well, and estimate the standard errors of the growth equation by the bootstrap method on 100 drawings. The ordered logit model is re-estimated at each draw.

The estimations of all models have been done using SAS-IML, SAS macro language, and the *logistic* procedure.

3.3. Validity of the instruments

The two-step method is very useful for testing the innovation dummy model against the linear index model, but it does not provide a direct test for the validity of the instruments. Therefore, we have estimated the innovation dummy model by another method to provide such a statistic.

It is clear that the innovation dummy model can be estimated by the Generalized Method of Moments, that reduces here to the two stage instrumental variable (2SIV) estimator of White (1982).[17]

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[16] The regression includes industry dummies so that the thresholds are allowed to be different in each industry.

The only practical point is that one must not use the same definition of incremental innovation depending on whether one estimates the simultaneous innovations model or the ordered innovations model. In the simultaneous innovations model, the dummy indicates an incremental innovation independently of radical innovation, while in the ordered innovations model the dummy indicates an incremental innovation only when the firm has not performed a radical innovation. In the tables, we will refer to these two cases by “incremental innovation” (simultaneous innovations model) and “incremental innovations only” (ordered innovations model).

We need two ingredients to estimate the innovation dummy model by GMM: first, the conditional expectation of the growth equation and, second, valid instruments. The interest of GMM is that it provides an overidentification statistic (the Sargan test) that allows checking the validity of the instrument set. The innovation inputs instruments may not raise an issue since they are natural determinants of innovation. But the reduced-form determinants are sometimes criticized on the ground that they evolve so slowly over time that their lagged values are strongly correlated to their contemporary values. We performed the Sargan test for each instrument set (innovation inputs, reduced-form and both) and find that the reduced-form instruments are unambiguously rejected while the innovations inputs are always accepted.[18] These tests are presented in appendix 4.

The conclusions of the tests in appendices 3 and 4 have led us to focus on the results of the innovation dummy model and to retain the innovation inputs as the only instrument set. Notice that this set includes the demand-pull indicator, the technology push indicator and a full set of industry dummies.

[17] The 2SIV is the application of GMM to one cross-section. In this application, we only have one long-difference so that we are in this case. Notice that no panel of growth rates can be used because the innovation survey is not annual and provides only retrospective information over a 5-year period.

[18] Notice that previous studies do not always provide tests for the validity of the instruments.

4. Results

4.1. The determinants of innovations

The logistic regressions are presented in Table 4. We compare three logit regressions: radical innovation, incremental innovation only and incremental innovation broadly defined (i.e., with or without radical innovations). The regression on incremental innovation alone is not used in the two-step method and is presented only for the following purpose.[19] Since the radical innovators are almost all incremental innovators, the incremental innovation logit presents results that are an average of incremental-alone and of radical innovators. By performing this additional regression we better see the specificity of incremental innovation. A comparison of the two first columns clearly shows that the determinants of incremental and radical innovations are not the same.

Radical innovations make a strong use of all innovation inputs except equipment goods. The latter result can be explained by two arguments: first, a large number of radical innovators are equipment goods producers and second, introducing an equipment good supplied by another firm into a production process looks more like a technology adoption than like a technology creation.

We also find that the firm-level spillovers play an important role for radical innovation. Spillovers take several forms. First, there is a significant impact of the input spillovers: the research of the group and external research. Second, there is also a strong impact of output spillovers: patents and property rights in general. Patents are defined as owned by the firm and can be interpreted both as the impact of past innovations or as knowledge bought from other firms. In both cases, this indicates a strong codification of the knowledge used for radical innovation. The other property rights are clearly defined as from other firms and we find that the "strong" response only is significant. This means that radical innovation makes a strong use of this codified spillover and that a small use of it is associated to a low probability of finding a radical innovation.

These results about spillovers are interesting because they are related to the debate on the impact of intellectual property rights on innovation incentives. We find that these property rights significantly contribute to the strongest innovation type.[20]

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[19] The regression that is used for the incremental-alone innovations is the ordered logit.

[20] More generally, the influence of property rights on the incentives to innovate depends on whether the knowledge is cumulative. On this topic, see Bessen and Maskin (2000).

The last significant determinant can also be interpreted as an output spillover: the use of materials and components. The fact that they are significant for radical innovation and not for incremental innovation is of interest since it is well known that it is more difficult to change a component of a product than to use a new equipment good. Undoubtedly, changing a material or a component used in a production may lead to change many related characteristic of the product or of the process. We find that such changes are associated with the strongest innovation types only since they increase the probability that the firm launches a product that is new for the market or implements a technological breakthrough.

Overall, radical innovation relies on a strong diversity of the knowledge sources, accompanied by both formal and informal internal R&D but, interestingly, it makes a strong use of all the kinds of spillovers.

This makes a strong difference with incremental innovation alone. First, a strong formal research and development is negatively related to incremental innovation alone, group research and development is not significant, patents strongly reduce the probability to introduce an incremental innovation and the external property rights are not significant as well as materials and components. We clearly deal with an entirely different innovation process. Its main significant input is the adoption of new equipment goods, accompanied by informal research and some external R&D. It is important to notice that the output spillovers like patents, licenses or new materials or components do not contribute to this innovative process.

The third column of Table 4 presents incremental innovation with or without radical innovation. As expected, we find coefficients that are close to a weighted average of the two first columns. But we showed that the positive coefficients that we get in this third regression do not truly reflect the incremental innovations characteristics but also the radical innovators characteristics. However, this cannot influence the growth regressions since they rely on partial correlations.

The last column of Table 4 presents the ordered logit on innovation height. All the inputs are significant but here the ways firms are classified as incremental or radical innovators is different. The firms that are radical innovators are in the highest classes of most variables so that their score will tend to be higher to the ones of the incremental innovators. It is less easy to distinguish incremental from radical innovation with this regression but it is because there is only one variable in this model: innovation height. We just remark that external knowledge sources play an important role on innovation height, and that the other regressions show that this comes mostly from the radical innovators.

This first set of estimates reveals that there are two innovation regimes. On the one hand, incremental innovation is based on the adoption of equipment goods while, on the other hand, radical innovation is closer to the creation of a knowledge standing on other firms or institutions' past achievements.

This suggests that the return on these two innovation types should be different. Clearly, the radical innovators are more likely to get strong gains from their innovations while the incremental-alone innovators mostly implement small changes from a creative viewpoint. Apart from the fact that the less innovative products may give the smaller performance, there is another reason why the gains of incremental innovators could be lower. Since they rely on equipment goods and that the radical innovators produce them, the latter may well have the possibility to extract some monopoly rent from the incremental innovators. Therefore, it is likely that the returns from innovation benefit mostly to the innovators themselves.

4.2. Innovation and growth

The results obtained by the two-step method are presented in table 5 and the results obtained with GMM in table 6. They are similar.

Both the simultaneous innovation model and the ordered innovations models reach the same conclusion about incremental innovation: whatever its definition, incremental innovation has no significant impact on TFP growth. The good model is therefore with radical innovation alone.

Overall, we find that the depreciation rate of the knowledge capital is close to 8% a year, a stronger figure than for the values generally admitted for physical capital (between 2% and 3% a year). Radical innovation generates an average gain of 2% of TFP growth per annum for the innovators.

Another interesting result is that the non-nested test reported in appendix 3 concludes that the good growth modeling is not continuous but discontinuous. Therefore, our finding suggests that the right model generating the data should represent innovation as creating upward shifts in the production function.[21]

All these results are robust to separate regressions by technological opportunities classes (appendix 5) and to the introduction of variable returns to scales (appendix 6). For the separate regressions, we find that the return on radical innovation is increasing with technological opportunities: from 2% in the lowest class to 5% in the highest one.

[21] No similar test seems to have been done in the literature.

Finally, we also find that using innovation inputs as instruments for innovation outputs is very important for getting these results. The (inconsistent) OLS estimates, presented in appendix 2, show a twice to three times lower return on innovation than the instrumental variable methods.

The constant firm-level estimate involves different returns on innovation in each industry since the importance of radical innovators differs among industries. The aggregate growth gain from radical innovation is simply equal to:

$$g = \frac{\sum_i a_{i,t} - \sum_i a_{i,t-1}}{\sum_i a_{i,t-1}} = \sum_i \left(\frac{a_{i,t-1}}{\sum_i a_{i,t-1}} \right) \times \frac{a_{i,t} - a_{i,t-1}}{a_{i,t-1}} ,$$

which is the average of individual TFP growth weighted by the share of TFP in 1985. Since the innovation dummy model is accepted, the growth gain of each industry equals the products of the weight of radical innovators in TFP 1985 by the firm-level constant growth gain (2.1%). The weights of radical innovators are given in Table 7. We find that the global effect of radical innovation on manufacturing TFP growth, once accounted for non-innovators, is 0.8% but that this returns varies strongly from one industry to another. The lowest figures are found for printing and publishing, textile, leather and footwear and wood and furniture. These industries have few radical innovators and therefore benefit the less from their output. On the contrary, the high-tech industries make large gains, like in houseware, pharmaceuticals, glass, basic chemicals, rubber products, aircraft and shipbuilding and equipment.

Recent works conducted with comparable data have been performed so that an international comparison is possible.[22] Nearly all studies report an increasing relationship between different performance measures (including some similar to TFP) and innovation output:[23] Jefferson et al. (2001) for China, Lööf and Hesmati (2001) and Lööf et al. (2001) for Norway and Sweden, Van Leeuwen and Klomp (2001) for the Netherlands. In these studies the innovation output measure is continuous so that the more firms produce an innovative output the more their performance. Our paper uses innovation dummies but includes innovation height so that the interpretation is close to the previous works: firms that have performed radical innovation will have on average a higher innovative output intensity than the other firms. This affirmation is supported by a previous work performed on similar data (Barlet et al., 1998) that shows that the share of innovative sales, used in the other studies, is

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[22] The Community Innovation Surveys played an important role in Europe.

[23] The exceptions are Benavente (2002) for Chile and Lööf et al. (2001) for Finland.

indeed strongly correlated to the radical innovations. Overall, our results go in the same direction than the previous studies on the other countries.

5. Conclusion

This paper proposed a study of innovation and performance, starting from the innovation inputs and going progressively to TFP growth. Our main findings are that the innovation height increases with a more formal organization of research and with all the kinds of spillovers, and that the innovation height matters for explaining the growth gains obtained by innovators. While incremental innovations rely mostly on the adoption of new equipment goods accompanied by informal research, the radical innovation relies on both formal and codified knowledge sources. These radical innovators would be the only significant direct contributors to TFP growth. Our results have several implications both on the interpretation of the innovation-growth relationship and for the future data collections.

First, we find that the spillovers of all types play an especially important role for the making of the radical innovations. This is true of both input spillovers (related to external research) and of output spillovers (related to the research output of others including property rights). The importance of these spillovers is specific to radical innovations. We even find that property rights both reduce the probability to undertake an incremental innovation and increase the probability to undertake a radical innovation. The reason why they decrease the probability of an incremental innovation may be simply be that incremental innovations require less sophisticated knowledge or are more likely to infringe on the property rights of the other firms. Since only radical innovation contributes significantly to TFP growth, the conclusion as to the impact of spillovers on performance is unambiguous: they stimulate TFP growth.

Second, we find that the growth process is better represented by a shift of the production function than with a continuous knowledge investment model. This result clearly recalls the theoretical models of endogenous growth where innovation is represented as a succession of productivity shifts (see Aghion and Howitt, 1998). Moreover, since the innovations that contribute to growth are radical, one should have expected this type of representation to take place.

Last, this paper has some implications for the data collection of the future Community Innovation Surveys. The re-introduction of innovation height would be useful for assessing the impact of innovation on performance as well as the contribution of spillovers to innovative output.[24]

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[24] Radical *product* innovations are sometimes included in the CIS. Notice that radical innovation is also linked to the debate on the intellectual property rights since they refers to products that are new for the market or to process breakthrough, due to the novelty requirements imposed on patenting.

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Table 1: Innovation in industry

Code	Industry	Number of firms	%	Incremental innovation	Incremental innovation alone	Radical innovation
T07	Ferrous ore mining	55	1.4	65.5	25.5	43.6
T08	Non ferrous ore mining	27	0.7	77.8	25.9	55.6
T09	Construction materials	241	5.9	60.2	25.7	38.1
T10	Glass	27	0.7	59.3	7.4	59.3
T11	Basic chemicals	78	1.9	80.8	25.6	59.0
T12	Pharmaceuticals	174	4.3	86.2	24.7	66.1
T13	Foundry and metalworking	663	16.2	63.5	33.3	32.4
T14	Non electrical equipment	597	14.6	72.9	30.5	44.4
T15A	Electrical equipment	240	5.9	77.9	27.5	52.9
T15B	Houseware	21	0.5	90.5	23.8	71.4
T16	Cars and rail equipment	167	4.1	79.6	33.5	48.5
T17	Aircraft and shipbuilding	46	1.1	84.8	30.4	54.3
T18	Textile and wearing apparel	576	14.1	40.6	21.9	20.3
T19	Leather and footwear	97	2.4	49.5	33.0	18.6
T20	Wood and furniture	348	8.5	59.5	30.2	29.9
T21	Paper and board	174	4.3	67.8	39.7	30.5
T22	Printing and publishing	321	7.9	47.7	31.8	17.1
T23	Rubber products	233	5.7	80.7	30.9	52.8
Total	Manufacturing	4085	100.0	64.0	29.3	36.9

Table 2: Innovation inputs and outputs

Percentage of the firms responding that the following innovation inputs have been moderately or strongly important as a determinant of their innovations.

Type of firm	Incremental innovation alone	Radical innovation	All firms
Formal research and development	26.4	49.8	28.1
Group research and development	15.0	44.5	14.5
Technical studies including casual research	49.0	46.7	39.6
External research and development	19.9	41.4	14.1
Patents owned by the firm	6.7	44.7	12.1
Rights and licenses	6.6	31.9	6.2
Equipment goods	57.6	49.9	37.0
Materials and components	32.0	49.6	25.5

Table 3: Production statistics

Sample of 4085 firms in manufacturing.

	25th percentile	Median	75th percentile	Average
Year 1985				
Number of employees	34	50	144	257
Value added per employee (1000's Euros)	22.2	27.4	44.8	30.5
Physical capital per employee (1000's Euros)	7.4	17.2	34.5	28.1
Hours worked (thousands)	55	81	230	411
Value added per employee hour (Euros)	13.8	17.0	21.6	19.0
Physical capital per employee hour (Euros)	4.6	10.6	21.5	17.5
Labor cost/Value added (%)	66.6	76.1	83.4	74.0
Year 1991 (at 1985 prices)				
Number of employees	36	57	151	241
Value added per employee (1000's Euros)	31.2	39.1	50.6	44.2
Physical capital per employee (1000's Euros)	15.2	28.6	54.3	43.0
Hours worked (thousands)	58	93	244	387
Value added per employee hour (Euros)	19.2	24.1	31.4	27.4
Physical capital per employee hour (Euros)	9.4	17.7	33.5	26.7
Labor cost/Value added (%)	63.5	74.2	82.9	72.4
Average annual real growth rate 1985-1991 (%)				
Employment	-2.1	0.4	3.3	0.6
Value added per employee	3.7	5.8	8.2	6.0
Physical capital per employee	3.6	7.9	14.2	10.1
Total factor productivity	-0.6	2.7	5.5	2.4
Hours worked	-2.0	0.5	3.4	0.6
Value added per employee hour	3.6	5.7	8.1	5.9
Physical capital per employee hour	3.5	7.8	14.1	10.0
Total factor productivity	-0.2	2.8	5.3	2.4

Table 4: The determinants of innovations

Maximum likelihood estimations of logit models. Standard errors between parentheses. Industry dummies are included in all the regressions. Innovation height is defined as: "no innovation", "incremental innovation alone" or "radical innovation".

Estimation methods	Separate logits			Ordered logit
Innovation	Radical	Incremental alone	Incremental	height
Intercepts:				
- incremental alone	×	×	×	-5.96 (0.68)*
- radical	×	×	×	-3.68 (0.68)*
- global	-4.89 (0.79)*	-0.45 (0.72)	-3.12 (1.04)*	×
Ln(sales 1985)	0.20 (0.05)*	-0.15 (0.05)*	0.04 (0.07)	0.17 (0.05)*
Ln(market share 1985)	-0.02 (0.05)	-0.01 (0.04)	-0.03 (0.06)	-0.05 (0.04)
Ln(diversification 1985)	0.23 (0.15)	-0.16 (0.14)	0.06 (0.20)	0.19 (0.13)
Ln(concentration 1985)	0.03 (0.05)	0.03 (0.05)	0.03 (0.07)	-0.04 (0.04)
Demand pull	0.52 (0.20)*	0.38 (0.19)*	1.34 (0.28)*	0.84 (0.18)*
Technology push	0.15 (0.26)	-0.20 (0.25)	-0.86 (0.38)*	-0.06 (0.23)*
Formal research and development				
- moderate	0.86 (0.13)*	-0.10 (0.13)	2.70 (0.37)*	1.14 (0.13)*
- strong	1.12 (0.12)*	-0.66 (0.12)*	1.69 (0.27)*	1.27 (0.12)*
Group research and development				
- moderate	0.20 (0.16)	0.21 (0.16)	1.23 (0.38)*	0.41 (0.16)*
- strong	0.35 (0.16)*	-0.18 (0.16)	1.01 (0.36)*	0.50 (0.16)*
Technical studies including casual research				
- moderate	0.90 (0.11)*	0.48 (0.11)*	2.35 (0.22)*	1.29 (0.10)*
- strong	1.25 (0.11)*	0.15 (0.11)	2.51 (0.23)*	1.58 (0.10)*
External research and development				
- moderate	0.29 (0.13)*	0.44 (0.12)*	1.58 (0.30)*	0.62 (0.13)*
- strong	0.66 (0.20)*	0.33 (0.18)	1.64 (0.37)*	1.06 (0.19)*
Patents owned by the firm				
- moderate	1.16 (0.18)*	-1.04 (0.18)*	0.73 (0.41)*	1.24 (0.19)*
- strong	1.51 (0.22)*	-1.25 (0.22)*	0.14 (0.39)	1.65 (0.23)*
Rights and licenses				
- moderate	0.05 (0.20)	0.07 (0.19)	1.55 (0.59)*	0.17 (0.20)
- strong	1.04 (0.31)*	-0.42 (0.29)	1.54 (0.64)*	1.17 (0.32)*
Equipment goods				
- moderate	0.18 (0.11)	1.33 (0.10)*	3.02 (0.25)*	1.08 (0.10)*
- strong	0.13 (0.12)	1.37 (0.11)*	3.16 (0.26)*	1.06 (0.10)*
Materials and components				
- moderate	0.51 (0.11)*	0.07 (0.11)	1.72 (0.28)*	0.71 (0.11)*
- strong	0.58 (0.14)*	0.06 (0.13)	0.98 (0.30)*	0.77 (0.13)*
% of concordant predictions	85.6	73.4	94.1	87.4

* Significant at the 5% level.

Table 5: TFP growth and innovation height (two-step method)

Left-hand variable: annualized TFP growth.

Two-step estimation. The standard errors, given between parentheses, are computed by the bootstrap method on 100 drawings. The logit models are re-estimated for each draw. The instruments include the innovation inputs, the demand pull and technology push indicators and a full set of industry dummies.

Model	**Simultaneous innovations**	**Ordered innovations**	**Radical innovation**
Method used in the first step	Two separate logits	Ordered logit	Single logit
Intercept	-0095 (0.006)*	-0.092 (0.007)*	-0.095 (0.006)*
Incremental innovation alone	×	-0.003 (0.010)	×
Incremental innovation	-0.001 (0.005)	×	×
Radical innovation	0.022 (0.006)*	0.015 (0.004)*	0.021 (0.004)*
Ln(TFP 1985)	-0.077 (0.002)*	-0.077 (0.003)*	-0.077 (0.002)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.029 (0.011)*	0.031 (0.010)*	0.029 (0.011)*
Non ferrous ore mining	0.037 (0.010)*	0.039 (0.009)*	0.037 (0.010)*
Construction materials	0.022 (0.006)*	0.022 (0.005)*	0.022 (0.006)*
Glass	-0.001 (0.013)	0.003 (0.011)	-0.001 (0.013)
Basic chemicals	0.041 (0.008)*	0.044 (0.007)*	0.041 (0.008)*
Pharmaceuticals	0.039 (0.007)*	0.042 (0.006)*	0.039 (0.007)*
Foundry and metalworking	0.003 (0.005)	0.004 (0.004)	0.003 (0.005)
Non electrical equipment	0.009 (0.005)	0.010 (0.004)*	0.009 (0.005)
Electrical equipment	0.014 (0.006)*	0.014 (0.006)*	0.014 (0.006)*
Houseware	0.039 (0.017)*	0.042 (0.015)*	0.039 (0.017)*
Cars and rail equipment	0.009 (0.008)	0.008 (0.006)	0.009 (0.008)
Aircraft and shipbuilding	0.004 (0.010)	0.006 (0.009)	0.004 (0.010)
Leather and footwear	-0.020 (0.008)*	-0.023 (0.009)*	-0.020 (0.008)*
Wood and furniture	0.007 (0.006)	0.008 (0.005)	0.007 (0.006)
Paper and board	0.029 (0.005)*	0.029 (0.005)*	0.029 (0.005)*
Printing and publishing	0.005 (0.006)	0.005 (0.005)	0.005 (0.006)
Rubber products	0.008 (0.006)	0.009 (0.005)	0.008 (0.006)
R-squared (average over the drawings)	0.303	0.302	0.302

* Significant at the 5% level.

Table 6: TFP growth and innovation height (GMM)

Left-hand variable: annualized TFP growth.

GMM estimation. The instruments include the innovation inputs, the demand pull and technology push indicators, a full set of industry dummies and the logarithm of TFP in 1985.

Model	Simultaneous innovations	Ordered innovations	Radical innovation
Intercept	-0.097 (0.006)*	-0.096 (0.006)*	-0.098 (0.006)*
Incremental innovation alone	×	-0.010 (0.007)	×
Incremental innovation	-0.009 (0.006)	×	×
Radical innovation	0.031 (0.008)*	0.022 (0.004)*	0.022 (0.004)*
Ln(TFP 1985)	-0.078 (0.003)*	-0.078 (0.003)*	-0.078 (0.003)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.028 (0.010)*	0.028 (0.010)*	0.027 (0.010)*
Non ferrous ore mining	0.040 (0.009)*	0.040 (0.009)*	0.040 (0.009)*
Construction materials	0.022 (0.005)*	0.023 (0.005)*	0.022 (0.005)*
Glass	0.001 (0.012)	0.001 (0.012)	0.003 (0.012)
Basic chemicals	0.042 (0.007)*	0.042 (0.007)*	0.042 (0.007)*
Pharmaceuticals	0.041 (0.007)*	0.041 (0.007)*	0.041 (0.007)*
Foundry and metalworking	0.004 (0.004)	0.005 (0.004)	0.004 (0.004)
Non electrical equipment	0.011 (0.005)*	0.011 (0.005)*	0.010 (0.004)*
Electrical equipment	0.015 (0.006)*	0.015 (0.006)*	0.015 (0.006)*
Houseware	0.039 (0.016)*	0.039 (0.016)*	0.039 (0.015)*
Cars and rail equipment	0.008 (0.007)	0.008 (0.007)	0.007 (0.007)
Aircraft and shipbuilding	0.006 (0.009)	0.006 (0.009)	0.005 (0.009)
Leather and footwear	-0.017 (0.008)*	-0.017 (0.008)*	-0.018 (0.008)*
Wood and furniture	0.009 (0.005)	0.009 (0.005)	0.008 (0.005)
Paper and board	0.032 (0.005)*	0.032 (0.005)*	0.030 (0.005)*
Printing and publishing	0.007 (0.005)	0.007 (0.005)	0.006 (0.005)
Rubber products	0.010 (0.006)	0.010 (0.006)	0.009 (0.005)
Overidentification statistic p-value	0.162	0.180	0.121

* Significant at the 5% level.

Table 7: Aggregate TFP growth gains from radical innovations

The industries are ranked according to their return on radical innovation. All figures are in %.

Industry	Weight of radical innovators in TFP 1985	Growth gain from radical innovation
Manufacturing	40.2	0.84
Houseware	75.6	1.59
Pharmaceuticals	68.4	1.44
Glass	66.0	1.39
Basic chemicals	60.5	1.27
Rubber products	60.3	1.27
Aircraft and shipbuilding	55.3	1.16
Electrical equipment	55.2	1.16
Non electrical equipment	53.3	1.12
Cars and rail equipment	51.2	1.08
Non ferrous ore mining	47.6	1.00
Ferrous ore mining	45.6	0.96
Construction materials	39.9	0.84
Paper and board	35.6	0.75
Foundry and metalworking	34.8	0.73
Wood and furniture	33.6	0.71
Leather and footwear	18.0	0.38
Textile and wearing apparel	17.6	0.37
Printing and publishing	15.0	0.31

Appendix 1: Sources and sample construction

We used two types of sources: EAE (Enquête Annuelle d'Entreprise) for the accounting data and the Innovation Survey of 1991 for innovation ("L'innovation technologique dans l'industrie"). Both data sources are collected by SESSI (Service des Statistiques Industrielles, Ministry of Industry). EAE is made of two data sets: a firm-level data set that provides information about value added, employment, labor cost, investment, capital etc. and a second data set, called the "fractions" that provides information about sales and employment for each line of business. The lines of business are defined at the finest level available according to the NAP industrial classification (NAP: Nomenclature d'Activités et de Produits). This level decomposes manufacturing into 255 lines-of-business (and all economic activities into 600 activities).[25]

The accounting data

The firm-level EAE provides the following information: value added, employment and labor cost.[26] For capital, the book value is available for firms above 50 employees only so that we had to reconstruct series of capital from the original investment data. The reason why we do not restrict our sample to firms above 50 employees is that we would lose a half of our sample. In order to perform this operation we had access to all EAE since 1978.[27] We have followed the following rules, that have been applied to all the firms (below and above 50 employees).

First, we have discarded the firms that had an accounting duration different from 12 months. By definition these firms do not have accounting quantities computed over one full year, so that their data is not comparable to the one of the other firms. Second, we have excluded the firms that had a modification of their capital structure like a merger or the sale of a part of the firm. Only firms with no modification of structure are included in this study. This data is provided explicitly in the EAE through the structure modification codes, which also include information about entry and exit. Finally, we kept the firms with a continuous presence in the data set in order to compute their capital correctly. The reason why we cannot keep firms with, say, one year missing, is that investment at the firm level often has a

[25] NAP has been replaced by NAF (Nomenclature d'Activités Françaises) in 1992 in order to easier international comparisons. Since our data stop in 1991, we have to use NAP instead of NAF.

[26] The full EAE includes dozens of variables. We only present the ones we use in this study.

[27] The national identification code (SIREN) that allows matching firms was progressively introduced between 1975 and 1977. This is why most data sets begin in 1978.

profile with several year with nearly no investment followed by a year of strong investment. Therefore, we need the complete investment series to construct the capital series. Notice that this is *not* a balanced sample since firms can enter the sample at any date.

All the computations that follow have been made with deflated values of investment. We use the deflators provided by the national accounts at the level 40 of the NAP, that breaks manufacturing into 21 industries. We also use, at the same level of aggregation, the economic depreciation rate of physical capital (between 2% and 4% per annum depending on the industry). These depreciation rates over 21 industries vary over time and allow us to improve on the current fixed rate method.[28] For the year 1978, we use the average age of capital at the same level of aggregation to compute the starting value of capital.

The starting value is different depending on the firm was present in 1978 or not. If it was created after 1978, we have the full series of investments so that the initial value of capital is equal to:

$K_{i,t_0} = I_{i,t_0} / p_{s,t_0}$, where K_{i,t_0} is initial capital, I_{i,t_0} the investment of the first year and p_{s,t_0} the price index of investment in industry *s*. The date t_0 refers to the first apparition of the firm whatever the date is, so that this date is specific to each firm. The remaining values of capital are computed according to the perpetual inventory formula:

$K_{i,t} = (1 - \delta_{s,t}) K_{i,t-1} + I_{i,t} / p_{s,t}$, where $\delta_{s,t}$ is the time-varying economic depreciation rate of capital in the industry the firm belongs to.

When the firm was present in 1978, we needed to make a correction on the starting value of capital. Here we use the average age of capital for each industry in 1978, which are provided by the national accounts. Assuming a constant investment prior to that date, we have:[29]

$K_{i,78} = I_{i,78} / p_{s,78} \times \left(1 + (1 - \delta_{s,78}) + \ldots + (1 - \delta_{s,78})^{a_{s,78}}\right)$, where $a_{s,78}$ is the age of capital in industry *s*. This formula simplifies to:

$$K_{i,78} = I_{i,78} / p_{s,78} \times \frac{1 - (1 - \delta_{s,78})^{1 + a_{s,78}}}{\delta_{s,78}} ,$$

[28] This method, that we do not follow, assumes that capital depreciation is constant across industries and over time.

[29] The weight of this assumption decreases as times passes by. Since the first value of capital that we use is that of 1985, it should have a weak influence on our estimates.

and the remaining values are computed according to the perpetual inventory formula. These computations give us a value of real capital at the 1985 prices for all firms above 20 employees (instead of 50 employees in the original file).

The number of hours worked is not available in the EAE so that we have assigned the industry average number of hours worked to all the firms in the same industry. This correction simply accounts for the industry and time variations of the number of hours worked in French manufacturing. The number of hours worked that we use is thus the product of the firm-level number of employees by the average number of hours worked per employee at the industry level. The share of labor cost in value added can be computed directly from the data and does not need to be corrected since it is a ratio. Finally, value added is divided by its deflator, so that all the values we use in this study are at 1985 prices. The line-of-business EAE is used to compute the market shares, diversification index, and the industry Herfindahl index of concentration. These computations are described in detail in Crépon, Duguet and Kabla (1996).

Finally, we cleaned the data for outliers, by checking graphically that no truncation occurred due to this operation. In order to clean outliers on a variable we first sort this variable by ascending order. Then we compute the difference between the value of a firm and the one of its nearest neighbor. If the difference it too large the neighbor and all the points located after it are discarded. In practice, we do it in two-step by starting from the median in ascending order and in descending order. This method is useful for cleaning asymmetric distributions. A graphical analysis is done before and after each cleaning to make sure that only outliers have been discarded.

The cleaning has been done on the following variables:

- Logarithm of the market share in 1985
- Logarithm of real value added per employee hour in 1985 and 1991
- Logarithm of real capital per employee hour in 1985 and 1991
- Logarithm of total factor productivity in 1985 and 1991
- Logarithm of the ratio of labor cost on value added in 1985 and 1991
- Growth rates of: the real value added per employee hour, the real capital per employee hour, the ratio of labor cost on value added, the total factor productivity.

Starting from a sample of 4128 firms with complete data (including innovation), all these cleaning operation led us to keep 4085 firms, that is about 99% of the total. The reason of this high figure is that we had already cleaned the data with the EAE codes in the first place, eliminated firms with a discontinuous investment series, kept firms that answered the innovation survey, that were present both in 1985 and 1991 etc.

The innovation survey

The innovation survey was included as an appendix to the industry census over 20 employees (the EAE) and has therefore the same response rate (85%, as usual for the census in France).[30] The data is collected by SESSI. The basic organization is as follows: each person at SESSI manages the same group of firms for all the surveys in order to improve on the quality of data collection. The questionnaire is followed by phone if needed. Each questionnaire includes the name of the usual SESSI correspondent of the firm and his (her) phone number so that the respondents can ask questions on how to answer the questionnaire.

This questionnaire had to be fulfilled by “a person responsible of innovation issues, of development, of strategy of by the boss himself”. Then follows the definitions of innovation.

“A product is considered a technologically innovative if it creates a new market of if it can be substantially distinguished from products fabricated in the past, from a technological perspective or by the services it provides to customers. This excludes the purely esthetic innovations (design); on the contrary, it includes, in a separate question, the packaging innovations”.

“A process is considered as technologically innovative when it implements new techniques in the production of innovative products but also in the production of already existing products in the firms products line.”

The introduction to the questionnaire concludes by “The products concerned by this survey are the ones fabricated by the firm itself, the products that do not involve a production intervention are excluded.”

The first part of the questionnaire is about innovation output from January 1st 1986 to December 31st 1990. All the answers are yes or no:

1. Substantial improvements of already existing products;
2. Products that are new for the firm and for the market;
3. Products that are new for the firm but not for the market;
4. Technological breakthroughs (“premières” in French);

[30] The reasons why it is not 100% are mainly entry and exit.

5. Substantial improvement on production processes;
6. Creation or substantial improvement on packaging methods;
7. Substantial organizational innovations linked to technological innovation;
8. Substantial marketing innovations.

The incremental innovations are defined by the types 1, 3 and 5. The radical innovations are defined as the types 2 and 4. If the firm answered yes to any of the eight types of innovation, it answers to the whole questionnaire. Otherwise, it only answers the questions on the degree of innovation of its line-of-business and on its innovation perspective for the next 5 years (see below).

The second part of the questionnaire is used to compute the demand-pull and technology push indicators.

"For your firm, do you consider that innovation is determined by:

1. The impulse of the market (relationship with customers, competition)
2. The own dynamics of the technology"

The answers are on a four point scale: no (0), weakly (1), moderately (2) and strongly (3). Our demand-pull and technology push indicators are simply the average of these answers at the finest level of the industry classification (255 industries).

The third part of the questionnaires gives the innovation inputs. The answers are also on a four point scale: no, weakly, moderately and strongly.

"Sources of innovations: in your firm, does the introduction of technological innovation results from:"

1. A permanent and organized activity of research and development (at least one scientific or researcher/engineer in equivalent full time) *internal to the firm*.
2. A permanent and organized activity of research and development (at least one scientific or researcher/engineer in equivalent full time) *internal to the group* the firm possibly belongs to.
3. An activity of technical studies and methods inside the firm (including casual research).
4. A research and development acquired from outside the firm (public institutions, professional or private organizations, customers etc.).
5. The patents the firm holds.

6. The rights and licenses of industrialization dealing with patents, inventions, technical know-how, from outside of the firm.
7. The innovative use of equipment goods (installation, process, machines).
8. The implementation of materials and components those are new for the firm.

In this study we use firm-level dummies indicating the responses moderately and strongly (2 dummies per innovation source and per firm). Since only innovative firms answered that part of the questionnaire, a discussion of possible selection biases is needed.

We do not have the response to the innovative inputs for the firms that have not innovated over the period. However, there are two differences between this survey and the CIS survey. On the one hand, we have the answers for the firm that did not change their product or process but that did change their packaging, their organization or their marketing method. On the other hand, the survey spans 5 years instead of 3 so that the definition of "non-innovators" is stronger.

There are two ways to deal with this problem. The first one, applied in Duguet (2000) is to use the data on the respondents only and to test for selection. The principle of the test is as follows. If we use the data on respondents only, the conditional expectations of the relationships that we estimate will be changed by including a function of the variables determining the selection process (similar to a Heckman correction). If we do not account for it, this function will go in the disturbance and could possibly create a correlation between the disturbance and the explanative variables of the growth equation. The simpler way to test for selection is therefore to perform the Sargan test derived from the GMM estimation. Indeed, since the innovation inputs are both the variables determining the selection process and the natural instruments of innovation in the growth equation, a significant selection bias would invalidate these instruments since they would be correlated with the disturbance. We found, in the previous study, that the innovation inputs instruments are accepted so that no significant selection bias may exist.[31] Moreover, this method gives estimates that are similar to the ones of this study that uses another method.

The second method, used in this paper, is based on the fact that non-innovative firms are defined as firms that, during five years, have not changed their products, their process, their packaging, their organization and their marketing methods. It is likely that such firms have innovation inputs that are close to zero. Instead of setting their inputs to zero, we

[31] This result is comforted by the fact that Crépon, Duguet and Mairesse (1998) did not find significant differences in productivity level estimates between the respondents' sample and the sample including all the firms.

classify these firms as having a “none” or a “weak” answer to all innovative inputs in order to reduce the possibility of a misclassification. This is equivalent as using two dummies only (“moderate” and “strong”) for each innovative input. We also perform the Sargan test in this case. We find similar results, but on a larger sample.

The last part of the questionnaire that we use is an indicator of technological opportunities defined at the firm level that is described in detail in appendix 5. All the firms, including the ones that did not innovate, had to answer to the following question: “Do you consider that your activity is: not innovative, weakly innovative, moderately innovative or strongly innovative”. A separate question was included as to the innovative level of the firm (the answers to these two questions are different for a significant part of the respondents). There is no selection among respondents on this indicator so that we used it, in appendix 5, to classify firms in three groups: the “weak technological opportunities” regroup the “non” and “weakly” innovative activities, and the two other groups are defined directly with the “moderately” and “strongly” answers.

Other information available in the survey is not used in this study. It includes the share of innovation in total sales and in exports and the innovation perspective of the firms for the next five years. See Barlet et al. (1998) on the innovative sales and export data.

Appendix 2: OLS regressions

The ordinary least square estimator is inconsistent in presence of endogenous regressors. However, it remains interesting to look at what results we would have had if we had used it. There is clearly a downward bias on innovation return, since we find a twice to three times lower growth contribution of radical innovation.

Table A.1: OLS estimation of the TFP growth equation

Left-hand variable: annualized TFP growth.

Model	Simultaneous innovations	Ordered innovations	Radical innovation
Intercept	-0.093 (0.004)	-0.093 (0.004)*	-0.092 (0.004)*
Incremental innovation alone	0.003 (0.003)	×	×
Incremental innovation	×	0.003 (0.003)	×
Radical innovation	0.010 (0.003)*	0.007 (0.003)*	0.009 (0.002)*
Ln(TFP 1985)	-0.076 (0.002)	-0.076 (0.002)*	-0.076 (0.002)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.030 (0.010)*	0.030 (0.010)*	0.030 (0.010)*
Non ferrous ore mining	0.042 (0.014)*	0.042 (0.014)*	0.042 (0.014)*
Construction materials	0.023 (0.005)*	0.023 (0.005)*	0.023 (0.005)*
Glass	0.005 (0.014)	0.005 (0.014)*	0.005 (0.014)
Basic chemicals	0.045 (0.008)*	0.045 (0.008)*	0.046 (0.008)*
Pharmaceuticals	0.044 (0.006)*	0.044 (0.006)*	0.045 (0.006)*
Foundry and metalworking	0.004 (0.004)	0.004 (0.004)	0.004 (0.004)
Non electrical equipment	0.011 (0.004)*	0.011 (0.004)*	0.012 (0.004)*
Electrical equipment	0.016 (0.005)*	0.016 (0.005)*	0.017 (0.005)*
Houseware	0.046 (0.015)*	0.046 (0.015)*	0.047 (0.015)*
Cars and rail equipment	0.010 (0.006)	0.010 (0.006)	0.011 (0.006)
Aircraft and shipbuilding	0.008 (0.011)	0.007 (0.011)	0.008 (0.011)
Leather and footwear	-0.022 (0.008)*	-0.022 (0.008)*	-0.022 (0.008)*
Wood and furniture	0.008 (0.005)	0.008 (0.005)	0.008 (0.005)
Paper and board	0.029 (0.006)*	0.029 (0.006)*	0.030 (0.006)*
Printing and publishing	0.005 (0.005)	0.004 (0.005)	0.005 (0.005)
Rubber products	0.011 (0.005)*	0.011 (0.005)*	0.012 (0.005)*
R-squared	0.297	0.297	0.297

* Significant at the 5% level.

Appendix 3: non-nested test

We use the simple procedure developed by Davidson and Mac Kinnon (1981) and Godfrey (1983). We first estimate the innovation dummy model and the linear index model separately in order to obtain two growth predictions. Then we estimate each growth model by adding the prediction from its competing model into the regressors. If the prediction is significant, the model is rejected. The intuition is the following. Suppose that the prediction of the innovation dummy model is significant in the linear index model. This means that the innovation dummy model can explain growth differences that the linear model cannot explain. Therefore, the linear index model is not the right one. We also performed the test the over way round. Four results are possible: both models can be accepted (prediction equivalence), one of the two models is accepted and the other one rejected, or both models can be rejected.

In order to evaluate the t statistic of the competing prediction, we used the bootstrap method performed on 100 drawings. The logit models are re-estimated for each draw as well as the predictions of the growth equation.

This non-nested test has been applied to radical innovation. The results are that the linear index model is rejected at the 5% level with a student of 2.12 while the innovation dummy model is accepted at the same level with a student of 1.24. Therefore, the innovation dummy model can explain growth differences that the linear model cannot account for.

Appendix 4: Different instrument sets

There are two sets of instruments available for estimation and their combination that gives a third instrument set. The first instrument set is used in the main text of this paper and includes the eight innovation inputs identified in the survey, the demand pull indicator, the technology push indicator and a full set of industry dummies (17 industries).

The second set of instruments is related to the reduced-form literature on innovation. It includes the following variables taken in 1985: sales, market share, diversification, industry concentration at the finest level available (255 lines of business in manufacturing), the demand pull indicator, the technology push indicator and a full set of industry dummies (17 industries). The third instrument set combines the two previous ones.

The overidentification test unambiguously rejects the reduced-form instruments. The reason may be that variables like size, market share, diversification and concentration move slowly over time so that their value in 1985 may be strongly correlated to the values of 1991.

Table A.2: TFP growth equation with radical innovation and different instruments

Left-hand variable: annualized TFP growth. The table reports the radical innovation coefficient. Standard errors between parentheses.

Instrument set	Innovation inputs	Reduced form	Both
Two-step method	0.021 (0.004)	0.036 (0.008)	0.022 (0.004)
R-squared (average over simulations)	0.320	0.299	0.300
GMM	0.022 (0.004)	0.043 (0.008)	0.024 (0.004)
Overidentification statistic p-value	0.121	0.001	0.001

Appendix 5: Return on innovation and technological opportunities

The innovation survey includes an indicator of « technological opportunities », telling whether the firm considers itself to belong to a weakly, a moderately or a strongly innovative activity. This activity is not identical to the industry. Since the firm answers directly to the question, the activity is closer to the relevant market definition than the industry classification to which the firm belongs. A previous study, by Barlet et al. (1998) showed that the commercial success of innovative products are strongly increasing with their degree of technological opportunities and, especially, with radical innovation. Therefore, we expect that it could be the case for the impact that innovations have on growth.

Figure A.1: percentage of firms reporting moderate or strong technological opportunities

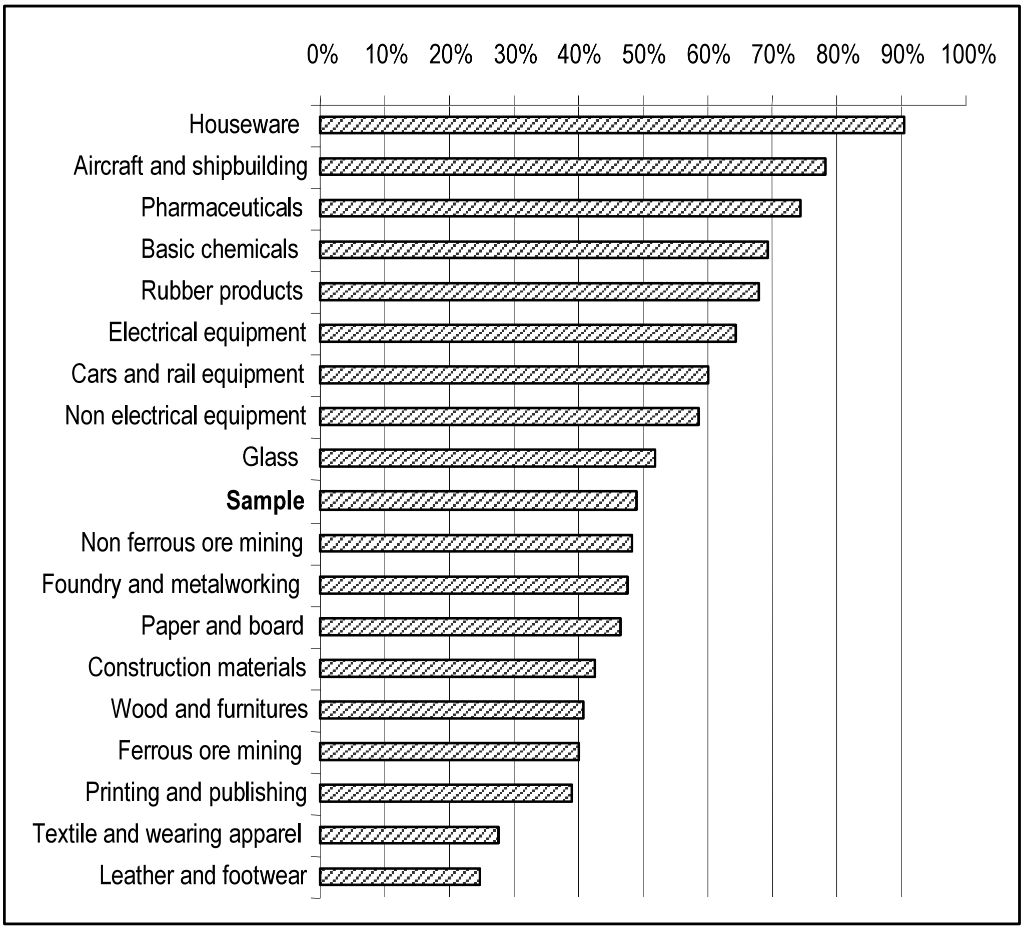
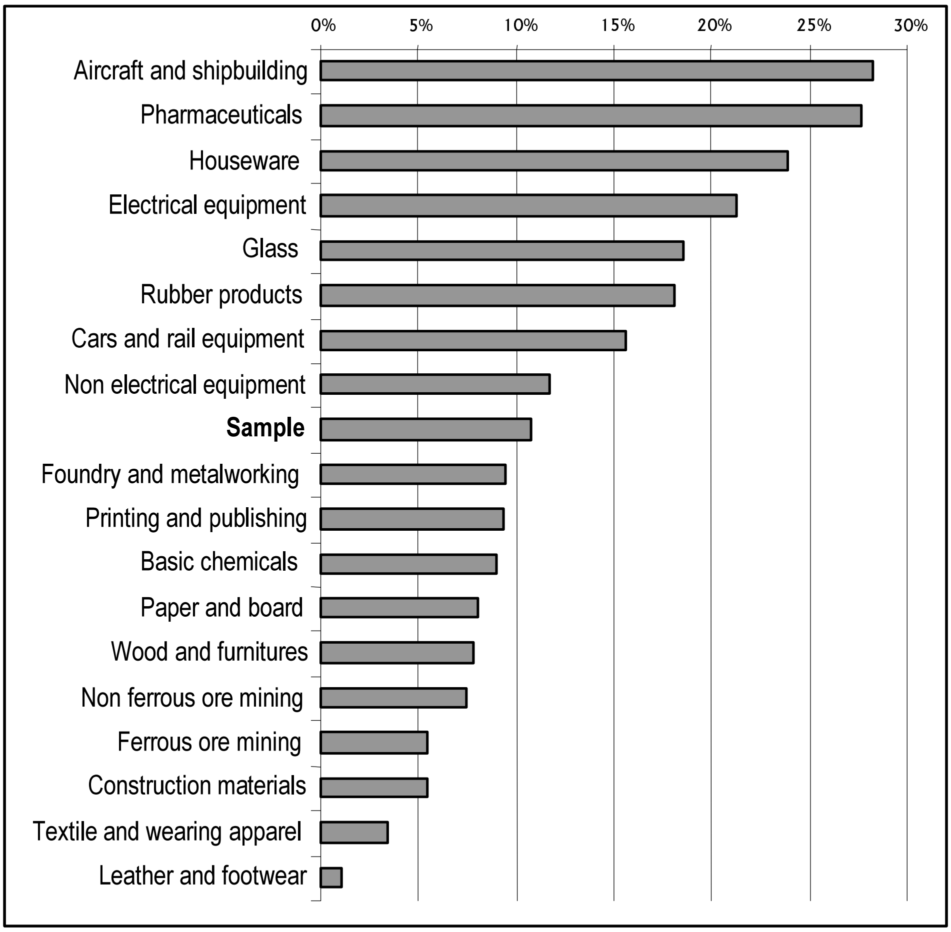


Figure 1 shows how the survey technological opportunities vary across industry. It reveals two interesting facts. First, it gives a ranking that is close to the standard technology level classification and, second, it shows that there remains a strong heterogeneity inside the usual industry classifications. The ranking would define the most innovative industries as houseware, aircraft and shipbuilding, pharmaceuticals, chemicals, rubber products and electrical equipment. This is in line with previous works. But, more important to this study is the fact that there remains a strong proportion of firms that are classified into the previous industry and that consider that their line of business is not or weakly innovative.

It is the case, for example, of more than 20% of the firms in aircraft and shipbuilding, pharmaceuticals or chemicals. The explanation of this result is that in any industry classification there remain firms that produce old products. For instance, some basic chemical products are known since decades. The firms that are specialized in these lines of business may well not consider themselves as operating under strong technological opportunities. This point is well illustrated by Figure 2, that indicates the percentage of firms that consider that they operate in a line of business with strong technological opportunities.

Figure 2: percentage of firms reporting strong technological opportunities



The most striking difference between the figures 1 and 2 is that the ranking of basic chemicals falls from the fourth place to the eleventh place when we pass from moderate or strong technological opportunities to strong technological opportunities. This result suggests that many chemical products have certainly attained maturity so that few opportunities remain open. This heterogeneity of technological opportunities inside industries is at the origin of the following variant of this paper: we have performed separate estimations for each technological opportunity class, since the return on innovation may well depend on the routes let open by the scientific basis. Since incremental innovation is never significant in all classes, we present the results for radical innovation in tables A.3 and A.4.

Table A.3: TFP growth and radical innovation under different technological opportunities (two-step method)

Left-hand variable: annualized TFP growth. Bootstrapped standard errors between parentheses.

Technological opportunities	Weak	Moderate	Strong
Number of firms	2090	1555	440
Intercept	-0.088* (0.008)	-0.111 (0.013)*	-0.125 (0.022)*
Radical innovation	0.022 (0.008)*	0.028 (0.009)*	0.048 (0.019)*
Ln(TFP 1985)	-0.073 (0.004)*	-0.083 (0.004)*	-0.076 (0.007)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.031 (0.013)*	0.028 (0.016)	×
Non ferrous ore mining	0.032 (0.013)*	0.042 (0.018)*	×
Construction materials	0.018 (0.007)*	0.026 (0.010)*	×
Glass	-0.023 (0.016)	0.040 (0.023)	×
Basic chemicals	0.057 (0.017)*	0.034 (0.011)*	×
Pharmaceuticals	0.032 (0.013)*	0.034 (0.012)*	0.068 (0.020)*
Foundry and metalworking	0.003 (0.006)	0.004 (0.009)	0.009 (0.017)
Non electrical equipment	0.003 (0.006)	0.013 (0.009)	0.022 (0.018)
Electrical equipment	0.033 (0.009)*	0.007 (0.010)	0.004 (0.016)
Houseware	0.024 (0.023)	0.050 (0.020)*	×
Cars and rail equipment	-0.003 (0.010)	0.009 (0.011)	0.043 (0.020)*
Aircraft and shipbuilding	0.019 (0.020)	-0.003 (0.015)	0.017 (0.020)
Leather and footwear	-0.021 (0.010)*	-0.032 (0.018)	×
Wood and furniture	0.013 (0.007)	-0.002 (0.009)	0.008 (0.018)
Paper and board	0.031 (0.008)*	0.032 (0.009)*	×
Printing and publishing	0.007 (0.007)	0.003 (0.009)	0.022 (0.018)
Rubber products	0.004 (0.008)	0.009 (0.012)	0.022 (0.016)
Other industries (for strong opportunities)			0.021 (0.016)
R-squared (average over the drawings)	0.293	0.351	0.316

* Significant at the 5% level.

We find that the return on radical innovation increases with the degree of technological opportunities: 2% in the lowest class, 3% in the moderate class and 5% under strong technological opportunities. This result extends the previous findings of Barlet et al. (1998) to TFP growth.

Table A.4: TFP growth and radical innovation under different technological opportunities (GMM)

Left-hand variable: annualized TFP growth. Bootstrapped standard errors between parentheses.

Technological opportunities	Weak	Moderate	Strong
Number of firms	2090	1555	440
Intercept	-0.088 (0.008)*	-0.118 (0.011)*	-0.0133 (0.021)*
Radical innovation	0.020 (0.008)*	0.030 (0.009)*	0.054 (0.019)*
Ln(TFP 1985)	-0.073 (0.004)*	-0.085 (0.004)*	-0.080 (0.007)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.025 (0.014)	0.032 (0.015)*	×
Non ferrous ore mining	0.034 (0.012)*	0.044 (0.016)*	×
Construction materials	0.018 (0.007)*	0.028 (0.009)*	×
Glass	-0.018 (0.015)	0.044 (0.020)*	×
Basic chemicals	0.056 (0.014)*	0.037 (0.010)*	×
Pharmaceuticals	0.030 (0.011)*	0.037 (0.011)*	0.062 (0.016)*
Foundry and metalworking	0.003 (0.005)	0.006 (0.008)	0.009 (0.014)
Non electrical equipment	0.003 (0.006)	0.016 (0.007)*	0.018 (0.014)
Electrical equipment	0.034 (0.008)*	0.009 (0.009)	0.004 (0.015)
Houseware	0.030 (0.020)	0.054 (0.020)*	×
Cars and rail equipment	-0.003 (0.010)	0.007 (0.011)	0.047 (0.018)*
Aircraft and shipbuilding	0.021 (0.020)	0.001 (0.013)	0.015 (0.017)
Leather and footwear	-0.018 (0.009)*	-0.024 (0.017)	×
Wood and furniture	0.013 (0.006)*	0.002 (0.008)	0.006 (0.015)
Paper and board	0.030 (0.007)*	0.035 (0.009)*	×
Printing and publishing	0.006 (0.007)	0.006 (0.008)	0.020 (0.018)
Rubber products	0.006 (0.008)	0.013 (0.009)	0.020 (0.014)
Other industries (for strong opportunities)			0.017 (0.014)
Overidentification statistic p-value	0.436	0.097	0.454

* Significant at the 5% level.

Appendix 6: Constancy of returns to scale

This last variant examines whether allowing for variable returns to scale affect our results. We find that the returns to scale are slightly decreasing (0.95) but that none of our result is changed.

Table A.5: TFP growth and innovation height under variable returns to scale

Left-hand variable: annualized TFP growth. The endogenous regressors include capital growth and innovations. GMM estimation. The instrument set includes the innovation inputs, the demand pull and technology push indicators, a full set of industry dummies, the logarithm of TFP in 1985 and the logarithm of capital in 1985.

Model	Simultaneous innovations	Ordered innovations	Radical innovation
Intercept	-0.087 (0.007)*	-0.087 (0.007)*	-0.088 (0.007)*
Capital growth (returns to scale minus 1)	-0.052 (0.020)*	-0.051 (0.020)*	-0.057 (0.020)*
Incremental innovation alone	×	-0.009 (0.007)	×
Incremental innovation	-0.008 (0.007)	×	×
Radical innovation	0.030 (0.008)*	0.022 (0.004)*	0.021 (0.004)*
Ln(TFP 1985)	-0.075 (0.003)*	-0.075 (0.003)*	-0.074 (0.003)*
Industry			
Textile and wearing apparel (reference)			
Ferrous ore mining	0.029 (0.010)*	0.029 (0.010)*	0.029 (0.010)*
Non ferrous ore mining	0.038 (0.009)*	0.038 (0.009)*	0.038 (0.009)*
Construction materials	0.022 (0.005)*	0.022 (0.005)*	0.022 (0.005)*
Glass	0.003 (0.012)	0.003 (0.012)	0.004 (0.012)
Basic chemicals	0.042 (0.007)*	0.042 (0.007)*	0.042 (0.007)*
Pharmaceuticals	0.040 (0.007)*	0.041 (0.007)*	0.041 (0.007)*
Foundry and metalworking	0.006 (0.004)	0.006 (0.004)	0.005 (0.004)
Non electrical equipment	0.012 (0.005)*	0.012 (0.005)*	0.012 (0.005)*
Electrical equipment	0.016 (0.006)*	0.016 (0.006)*	0.016 (0.006)*
Houseware	0.039 (0.016)*	0.039 (0.016)*	0.039 (0.016)*
Cars and rail equipment	0.009 (0.007)	0.009 (0.007)	0.009 (0.007)
Aircraft and shipbuilding	0.006 (0.009)	0.006 (0.009)	0.006 (0.009)
Leather and footwear	-0.017 (0.008)*	-0.017 (0.008)*	-0.018 (0.008)*
Wood and furniture	0.011 (0.005)*	0.010 (0.005)*	0.010 (0.005)*
Paper and board	0.033 (0.005)*	0.033 (0.005)*	0.032 (0.005)*
Printing and publishing	0.007 (0.005)	0.008 (0.005)	0.006 (0.005)
Rubber products	0.011 (0.006)	0.011 (0.006)	0.011 (0.006)
Overidentification statistic p-value	0.162	0.177	0.142

* Significant at the 5% level.