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THE DYNAMICS OF FRENCH FOOD INDUSTRIES: PRODUCTIVITY, SUNK COSTS AND FIRM EXIT*

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Abstract:

A semi-parametric approach is used to estimate the unobserved individual productivity of firms. This productivity is then introduced in a model of firm exit. We also introduce the firm's level of sunk costs as an expected barrier to exit. By using an unbalanced panel of 4818 firms in French food industries from 1999 to 2002, we find a significantly negative relationship between the probability of exit of the firm and its individual efficiency, age and sunk costs level. At the opposite, the intensity of competition in an industry increases the propensity to exit for firms in that industry.

Key-Words: FIRM PRODUCTIVITY, SUNK COSTS, EXIT, FOOD INDUSTRIES

JEL Classification: C23, D24, L25

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1. Introduction

In France, 63,024 firms failed between August 2008 and August 2009, 19,1% more than the number of failed firms during the same period the previous year (Banque de France, 2009). However, regardless of the period under consideration, firm demography (including both firm entry and exit) is a major component of industry dynamics. Bartelsman *et al.* (2005) show that the firm turnover rate (calculated as the national average rate of entry plus exit, over the period 1989-1994) varies from 16% in the Netherlands to 23% in the United States. Behind the apparent inertia of the stock (the number of existing units at a given date), these important flows deeply modify the distribution of industries by size, location and performance.

There is a large body of empirical literature devoted to firm exit, as shown by Caves (1998). Until recently, most studies have highlighted the influence of a particular set of determinants (such as firm characteristics, industry, and period), but without replacing exit as a structural component within a theoretical model of industry dynamics. However, following the theoretical contributions of Jovanovic (1982), Hoppenhayn (1992) and Ericson and Pakes (1995) (EP95 hereafter), among others, some empirical methods have proposed to assess the contribution of firm exits to the industry dynamics. The one by Olley and Pakes (1996) (OP96 hereafter) is one of the most widely used. The study of productivity growth is often the first and main goal of such studies. But, it also permits to implement more complete exit models, where the unobserved individual efficiency of the firm is introduced as a determinant of the firm's probability of exit. Clearly, if exit is the expression of a market selection process, the less efficient the firm, the higher its probability of exiting. Such a prediction is widely confirmed by empirical results. Farinas and Ruano (2005) focus on Spain and find that exiting firms exhibit significantly lower productivity levels than other firms. Bellone *et al.* (2006) analyze post-entry and pre-exit performances of French manufacturing firms and also show that exiters are less efficient than firms still in activity. Frazer (2005) and Shiferaw (2009) find similar results in the case of developing countries (namely Ghana and Ethiopia): only the more efficient firms can survive. Griliches and Regev (1995) and Almus (2004) suggest that this relationship between efficiency and exit may reflect what is called the "Shadow of Death" effect: a lower (and lowering) efficiency would be a symptom of the imminent exit of the firm.

Following this line of research, the aim of this study is to analyse the exit process of the firms in French food industries, by using a large unbalanced panel data set of 4,818 French firms over the period 1999-2002. We start with the EP95 model and use the semi-parametric method initially developed by OP96 to estimate unobserved individual firm efficiency. Then, this measurement of efficiency is used as a determinant of the probability of exit, in addition to the usual state variables, such as age. But, the major interest of the study is the introduction of two new variables, the level of sunk costs and the intensity of industry competition.

Sunk costs play an important role in the theoretical models of industry dynamics (as EP95), but are rarely introduced in empirical tests, presumably because of the difficulty of measurement. Being non recoverable in the case of exit, sunk costs have an engagement value for incumbents and consequently create barriers to entry for new firms but also barriers to exit for incumbents (see for example Dixit, 1989; Lambson, 1992; Sutton, 1991; Hopenhayn, 1992; Cabral, 1995). The corresponding empirical tests of this claim are less conclusive. Some authors (Kessides, 1990; Dunne and Roberts, 1991; Fotopoulos and Spence, 1998) find that capital requirements are barriers to exit, while others (Rosenbaum, 1993; Roberts and Thompson, 2003) find no evidence of this. Two complementary reasons may explain such mixed findings, namely definition and measurement. Following Sutton (1991), a distinction must be made between exogenous (*passive*) and endogenous (*active*) sunk costs. Exogenous sunk costs (as the cost of "acquiring a single plant of minimum efficient scale" (Sutton, 1991, p.28) mainly depend on the industry and affect the capital variable. Such costs represent both entry and exit barriers. Endogenous sunk costs (R&D or advertising expenses, for instance) are linked to firm's own strategy. This certainly represents entry and exit barriers, but in a more complex way, as it may increase the individual efficiency of the firm. In this way, endogenous sunk costs reduce the probability of exit even without being directly observed. In this study, we exclusively use exogenous sunk costs, for which an original measure is proposed. This measure is mainly based on the amount of investment and capital, but weighted with several coefficients. Such coefficients take into account leasing, capital depreciation and the resale of second hand equipment.

Our main findings are the following. First, our summary statistics are consistent both with the literature results and with expected patterns. When considering the all food industry, the annual entry and exit rates vary between 5.6% and 8.0% depending on the year, providing a turnover rate between 11.5% and 15.5%. Such a value is close to, but slightly lower than those obtained previously in the literature (Bartelsman *et al.*, 2005), which are around 20%. The difference may be explained by several reasons linked to our population, which is composed of manufacturing firms, and excludes very small units of less than 20 employees. First, firm turnover is lower in manufacturing (including food industries) than in services. Second, very small firms, which are not included in our sample exhibit generally high turnover rate. Third, turnover is lower when it is measured at the firm level than at the plant level, because of multi-plant firms. When comparing the different component of the food industry, we find that both entry and exit rates vary greatly across industries. For example, exit rate is very low in the Oils and fats industry at around 2% and very high in the Bread and pastry goods and cakes shops industry at more than 16%. Some interesting correlations may be found between variables when they are observed at both 3 and 4-digit mean levels. A well-known positive correlation in firm demography is between entry and exit rates, as shown among others by Fotopoulos and Spence (1998). But some other patterns are more directly related to our model, such as the apparent negative correlation between the level of sunk costs and the competition intensity on the one hand, and the intensity of flows (both entry and exit) on the other hand.

The estimation results first provide some presumably unbiased estimates of the production function. Compared to the OLS results, the estimates obtained by using the OP96 method are significantly different: the estimated capital elasticity is higher (0.317 versus 0.251), while the labor elasticity is lower (0.579 versus 0.704). The OP96 values of estimates lie between the OLS and the Within values, clearly suggesting that simultaneity bias, which is corrected by the OP96 and Within estimators, and selection bias, corrected only by the OP96 estimator, exhibit opposite signs. But our more important findings concern the exit function; the exit probability of firms is negatively and significantly correlated with the individual firm productivity, the firm age and positively correlated with the intensity of competition in the industry. These results are consistent with the predictions of the theoretical model and, more generally with previous studies using similar methods. The specific result offered by this study is that sunk costs also play a significant and negative role: the higher the sunk costs level, the lower the exit rate. The low magnitude of this effect, which is associated with the large dispersion of the variable value between firms, suggest that this effect is generally light but may become very strong in some particular industry cases. In summary, competition intensity and sunk costs may explain differences in exit rates between industries, opposing "inert" versus "turbulent" industries, while age and individual efficiency may explain the variability observed between firms within an industry.

The rest of this paper is organized as follows: Section 2 introduces the economic model, and Section 3 presents the econometric methods. Data and some summary statistics are introduced in Section 4, while in Section 5, estimation results are provided and analyzed. Section 6 concludes.

2. The economic model

EP95 provide the theoretical model underlying the OP96 approach. Their aim is to explain the great variability observed between firms in terms of their performance level, including entry and exit processes. To do so, these authors first incorporate "idiosyncratic or firm-specific sources of uncertainty (that) can generate the variability in the fortunes of firms observed in (...) data" (p. 53). In addition to the usual state variables (i.e. capital, labour and age) they use a new variable: ω_{it}. This variable is defined as follows. A firm (or an entrepreneur) exploits "an opportunity (technology) provided by the industry, which is open to all, so that the only distinction among firms is their achieved state of "success" (index of efficiency), $\omega_t \in Z$, in exploiting it."(p. 55). As defined, ω_{it}, the individual efficiency of the firm *i* observed at the period *t*, explains all the unobserved heterogeneity between firms.

In such a model, entry and exit processes are a natural component of industry dynamics. Entrants must invest, in order to explore and then exploit an opportunity offered by the industry. At the same time, at the beginning of any period *t*, the incumbent firm must make two decisions. First, it must decide to continue or exit the industry. Second, if it decides to stay, it must decide how much to invest.

To make the first decision, the firm compares ϕ, which is the cost to remain in activity (the sell-off value) and *(EDP)*, which is the expected present discount value of activity profit, according to optimal future decisions concerning investment. The Bellman equation is:

$$V_{it}(\omega_{it}, K_{it}, a_{it}) = \max\{\phi_{it}, EDP_{it}\}, \tag{1}$$

with:

$$EDP_{it} = \max_{I_{it}} \pi(\omega_{it}, K_{it}, a_{it}) - c(I_{it}) + rE\left[V_{it+1}(\omega_{it+1,} K_{it+1}, a_{it+1}) \middle| J_{it}\right], \tag{2}$$

where $\pi(.)$ is the profit of the current period, gross of the investment cost $c(I_{it})$, K_{it} is the capital, a_{it} is the age of the firm and ω_{it} its individual unobserved efficiency. $E(.)$ is the expectation operator, r is a discount factor and J_{it} is the information set available at time t. $V_{it+1}(\omega_{it+1}, K_{it+1})$ is the discounted value at time $t+1$ of the future cash flows of the firm.[4] K_{it} the current capital stock, follows the accumulation equation which includes the rate of capital depreciation δ:

$$K_{it+1} = (1-\delta)K_{it} + I_{it}, \tag{3}$$

The exit rule is based on the comparison between the sell-off value ϕ and the optimal expected discounted profits EDP_{it}, depending on the value of $V_{it}(\omega_{it}, K_{it}, a_{it})$. If the first term is greater than the second, the firm leaves the industry otherwise it stays in. Let z be a decision variable such that $z = 1$ $(z = 0)$ if the firm decides to exit (stay on) the market. Then, the exit rule can be written as,

$$z = \begin{cases} 1 & if \quad \phi_{it} > EDP_{it} \\ 0 & \text{otherwise} \end{cases}, \tag{4}$$

Second, if the firm decides to stay in the industry, it has to choose the level of its investment I_{it} that maximizes EDP_{it}, in relation to the usual state variables capital and age, but also to the unobserved individual efficiency:

$$I_{it} = I(K_{it}, \omega_{it}, a_{it}), \tag{5}$$

Our specific contribution consists of introducing two new variables in this well known model, namely sunk costs and competition intensity. Concerning the first variable, EP95 assume: "Investment to enter is a sunk cost, perhaps partially recoverable if there is some scrap value realizable on exit" (p. 55). Such costs are present first when the firm enters to explore the opportunities that are offered in the industry and second as a part of the investment cost for each period *t*:

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[4] Note that this last function can be expressed as the following Bellman equation:
$V_{it+1}(\omega_{it+1,} K_{it+1}) = \sup\{\phi_{it+1}, EDP_{it+1}\}$

$$SC_{it} = \left[\alpha_I I_{it} + \alpha_K K_{t-1}\right] \quad , \qquad (6)$$
$$\alpha_I, \alpha_K \in [0,1]$$

This definition which is further developed when presenting our empirical measurement of this variable is consistent with the definition of sunk costs, more precisely of what J. Sutton (1991) calls "exogenous" sunk costs: "We identify the set-up cost incurred by firms on entering (…) with the cost of acquiring a single plant of minimum efficient scale, net of any resale value" (p. 28). We introduce it in the exit equation which then becomes:

$$V_t(\omega_t, K_t, a_t) = \max\left\{\phi - SC_{it}, EDP_t\right\}, \qquad (7)$$

This exit rule suggests that the higher the sunk costs, the lower the propensity to exit. Sunk costs appear then to be barriers to exit as well as barriers to entry.[5]

The intensity of competition in the industry should also be included in the model. In the Bellman equation, the expected profit *EDP* is a function of ω_{it} which is the individual efficiency of the firm. The level of ω_{it} should be compared with $\underline{\varpi_{st}}$ which is the efficiency level cutoff in the industry during the same period. This average efficiency is a function of competition intensity in the industry. It seems consistent to assume that the more intense the competition, the higher the value of $\underline{\varpi_{st}}$, and the higher the probability of exit, for firm *i*. Thus, we obtain:

$$V_{it}(\omega_{it}, K_{it}, a_{it}) = \max\left\{\phi_{it} - SC_{it}, EDP_{it}\right\} = f(\omega_{it}, K_{it}, a_{it}, Comp_{it}, SC_{it}), \qquad (8)$$

The inclusion of sunk costs and competition intensity completes the theoretical model and allows a more precise identification of resulting firm heterogeneity through the non-observable individual efficiency ω_{it}. One may consider this efficiency to further depend on many non-measurable arguments, such as manager's ability, skill level of the labour force, the agglomeration effect due to location or the other kind of sunk costs, namely *endogenous* costs such as advertising or R&D expenses.

3. The econometric model

Our goal is to estimate the exit model of firm *i* observed during period *t*:

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[5] Interestingly, one may note point may be that a potential buyer should implicitly include such costs in the value accorded to the firm. Unfortunately the structure of the data does not allow us to test this assumption.

$$\Pr(Exit_{it}) = f(\varpi_{it}, a_{it}, Comp_{it}, SC_{it}, X_{it}), \tag{9}$$

The probability of a firm's exit depends on the individual firm's efficiency, age, level of sunk costs, the intensity of industry competition and some control variables, such as industry and time dummies. But ϖ_{it}, which is individual efficiency, cannot be directly observed but has to be estimated by using a production function. Such a function has the following form, in the case of a Cobb-Douglas technology:

$$\log Y_{it} = \beta_0 + \beta_l \log L_{it} + \beta_k \log K_{it} + \beta_a a_{it} + \varpi_{it} + \varepsilon_{it}, \tag{10}$$

where Y_{it} is the output of firm i observed at period t, L_{it} is the labor input, K_{it} is the capital input, a_{it} is the age of the firm, and ϖ_{it} is the individual efficiency. ϖ_{it} is a state variable for the firm's decision, which is known by the firm even if it is non observed by the econometrician, while ε_{it} is the usual error-term, associated for instance with a non-predictable productivity shock.

It is well known that standard econometric methods, such as OLS, provide biased and inconsistent estimates of the previous production function for (at least) two reasons: simultaneity between output and inputs and selection bias resulting from the exit process.[6] Several methods exist to address these problems, (or at least one), including current panel data estimators, such as within estimator, IV and GMM estimators, and semi-parametric methods, such as the OP96 method, or some extensions of it (Levinsohn and Petrin, 2003; Ackerberg *et al.*, 2006).[7] In this study we use the OP96 approach, modified as suggested by Levinsohn and Petrin (2003). Their argument is as follows. In the standard OP96 method, the investment is a proxy for unobserved efficiency:

$$I_{it} = I(\omega_{it}, K_{it}, a_{it}), \tag{11}$$

Under the assumption that I_{it} is strictly positive, one can write the inverse function of the unobserved shock, and obtain:

$$\omega_{it} = I^{-1}(I_{it}, K_{it}, a_{it}), \tag{12}$$

However, especially from the perspective of a coming exit, a firm may stop to invest while it always requires intermediate consumptions to produce. Consequently, we follow Levinsohn and Petrin (2003)

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[6] Some other reasons may exist, that are not taken into account in this study. As one example, Katayama *et al.* (2009) claim that severe measurement errors of both output and inputs occur, when applying to differentiated products industries.

[7] Many surveys have been proposed regarding the way to estimate total factor productivity. Van Beveren (2007) proposes an empirical application to the case of Belgian food industries.

and substitute intermediate consumption M_{it} to investment I_{it}. Under the assumption that M_{it} is strictly positive the inverse function of the unobserved shock is now:

$$\omega_{it} = M^{-1}(M_{it}, K_{it}, a_{it}) = h(M_{it}, K_{it}, a_{it}) \ , \tag{13}$$

Following this and taking into account the introduction of two new variables (namely sunk costs and competition intensity) the OP96 method may be implemented as follows. At the first step, one estimates a reduced exit equation (that, of course, does not include firm efficiency at this cannot be yet be estimated):

$$\Pr(Exit_{it}) = f(K_{it}, a_{it}, Comp_{it}, SC_{it}, X_{it}) \, , \tag{14}$$

This provides $\widehat{p_{it}}$ which is the predicted exit probability of firm *i* during period *t*. The second step consists of the estimation of the labor coefficient β_l, which is the only flexible input. The third step consists in writing:

$$\log Y_{it} = \widehat{\beta_l} \log L_{it} + g(Comp_{it}, SC_{it}, \log M_{it}, a_{it}, \log K_{it}, \widehat{p_{it}}) + \eta_{it} \, , \tag{15}$$

Being non-parametric, *g* is estimated using a second-order polynomial series. At this step $\beta_k, \beta_a, \beta_{comp}$ and β_{SC} are estimated and the difference between output and its fitted value from the second and third steps yields an estimate of the individual firm's efficiency, $\widehat{\varpi_{it}}$. The fourth and final step is the estimation of the exit model from the equation 9, including the estimated value of the individual firm's efficiency:

$$\Pr(Exit_{it}) = f(\widehat{\varpi_{it}}, a_{it}, Comp_{it}, SC_{it}, X_{it}) \, , \tag{16}$$

4. Data and summary statistics

Our database contains 15,110 observations. This is an unbalanced panel of 4,818 firms from the French food industry, observed during the period 1999-2002. The data are obtained from annual surveys about firms' activity ("*Enquête annuelle d'entreprises*", *EAE* thereafter) which is the official French business-level data collected by the French Office of National Statistics (INSEE), and, in the case of the food industry, by the Statistical Department of the French Agriculture Ministry. This survey only includes firms that employ at least 20 employees. The affiliation of firms with an industry depends on their activity in terms of product turnover by products.

4.1. The construction of the variables

Using the standard definitions of exit, an incumbent at period t is a firm that is present both during the current year t and the next year $t+1$, while the exit firm at period t is in the market in year t but not in $t+1$.[8] The EAE survey suffers from several limits with respect to this measurement, because of its own selection rules. According to these rules, a firm may exit for three reasons, two "good" reasons, according to this paper's topic, and one "bad" reason. The first reason is closure, which occurs when a firm is liquidated, which is a first kind of exit. Merging or acquisition may also happen. In this case, the firm identity has changed, and the initial unit is considered as exiting, even if the concrete firm is still active. Those two cases, the "failure" and the "successful closure", to use Bates' (2005) term, are both consistent with the theoretical model. They simply correspond to a different sell-off value ϕ, which is about 0 for the first case, and largely positive in the second case. But, in addition a firm may be unfortunately excluded from the data set without exiting, because its number of employees has fallen under the threshold or because its main activity has changed. This last reason should lead to an upward bias for our measurement of exit.

Concerning the other variables, we deflate the value-added by firm i operating in sector j at time t by the annual price index of value-added. As a measure of capital used by firm i, we compute the sum of the value of fixed assets at the end of the year and the leased capital. This sum is deflated by the annual price index of capital. Intermediate consumption is deflated by the annual price index of intermediate consumption. Labour input in firm i at time t is the number of its employees at the end of the year. The investment deflated by the annual price index of gross fixed capital formation is used to build the capital series when the value of fixed assets is only available either at the beginning or at the end of the period.

To measure the intensity of competition, we first compute the Herfindhal index ($Herfindhal$) calculated from the initial database for each industry s (at the NACE 2 3-digit level) observed at period t:

$$Herf_{st} = \sum_{i=1}^{i=N_{st}} \left(\frac{VA_{it}}{\sum_{i=1}^{i=N_{st}} VA_{it}}\right)^2, \tag{17}$$

We then use the following indicator:

$$LCOMP_{st} = \ln\left(\frac{1}{Herf_{st}}\right), \tag{18}$$

Given this, the higher is the indicator value and the more intense is the competition within the industry.

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[8] Our database ends in the year 2002 but information about the presence of a firm in an industry is available for 2003.

We pay particular attention to the sunk costs variable. We come back to equation (6) and propose the following indicator:

$$Sunk_{it} = \left(1-\rho_{st}\right)\left[cI_{it} + c\left(1-\delta_{st}\right)(1-\alpha_{st}\frac{s_{st}}{c})K_{t-1}\right], \tag{19}$$

During the current period, the sunk cost of a firm is a linear function of its current investment I_{it} and the lagged value of physical capital K_{it-1}, with several underlying assumptions. First, the firm may lease ρ_{st} percent of its current physical capital K_{it}, such that only the fraction $1-\rho_{st}$ is related to sunk costs. Second, physical capital is affected by a depreciation rate of δ_{st} percent each period. Third, a firm may sell α_{st} percent of its physical capital on the second-hand market at the end of each period at a price of s_{st}. From the information available in our database, we can build some proxies for δ_{st}, ρ_{st} and $\alpha_{st}\frac{s_{st}}{c}$. Thus, δ_{st} is built as the ratio between the destructed capital during the current period over the capital stock available at the beginning of the period K_{t-1}. ρ_{st} is approximated by the rental payments divided by the capital in value while $\alpha_{st}\frac{s_{st}}{c}$ is the ratio of the value of used capital sold on the second-hand market over the value of capital. These three variables are assumed to vary over time but not within a given industry. To sum up, sunk costs will be low for firms (and industries) using assets that can be easily leased, have depreciation rate and are present on a large second-hand market. Such measurement suggests that the more specific the assets, the higher the sunk costs.

4.2. Summary statistics

As shown in Table 1, the exit rate in French food industry varies between 5.66% and 7.56%, between 1999 and 2002, depending on the year. These values are in accordance with findings in the literature of firm demography, though they lie in the lowest part of the range. Studying France, Bartelsman *et al.* (2005) report an exit rate of 11% per year between 1989 and 1994, which is one of the highest values among OECD countries. This difference relative to our results may be explained by the absence of very small firms in our sample, where there is a well known negative relationship between the size of firms and both entry and exit rates. The industry is another reason: firm's turnover is traditionally higher in services than it is in manufacturing (including food industries). The observation level is the last reason. Exit rates would be higher at the plant level because of the high number of multi-plant firms as a plant may be closed while the firm itself is still active. The same analysis may also be applied to the entry rate, which ranges between 5.67% and 7.97%, and to the resulting turnover rate, which ranges between 11.44% and 15.53%.

[*Table 1*]

Table 1 suggests the existence of a positive correlation between entry and exit rates. Such a result is strongly confirmed when considering food industry at a disaggregated level. Food industry corresponds to class 15 of the NACE 2-digit level but also to 45 different industries at the NACE 4-digit level and to 9 positions at an intermediate 3-digits level that we have built specifically for this study. Table 2 provides a list of industries, the corresponding number of firms in our sample and, finally, entry and exit rates.

[*Table 2*]

As shown in Table 2, a great variability in terms of the entry and exit rates exists between the sectors composing the food industry. This is even true, first with respect to the NACE 3-digit level. While the average exit rate between 1999 and 2002 equals 6.62% for the all population, this rate varies between 2.02% and 8.56%, with the upper bound being more than four times the lower bound. A brief distinction can be made between:

- The set of industries with a low exit rate (smaller than 5 %): Oils and fats, Fish, Dairies and Beverages;
- The set of industries with a medium exit rate (between 5 and 7 %): Grain products, Meat, Fruits and vegetables products and Animal feeds;
- An industry with a very high exit rate: Other food products.

However, this last 3-digit level class Other food products is a very heterogeneous one, composed of very different 4-digit level industries such as Manufacture of Sugar and Bakeries or Pastry shops. For this reason, Table 2 presents some results that are computed at the infra-level that is the NACE 4-digit level. When observing the results of the industries composing the *15.8* class (Manufacture of other food products) at the 3-digit level, we find that only three 4-digit sectors exhibit high entry rates, among which two (Cooking and Bakeries products and Bread and pastry goods and cakes shops) are closer to service activities than to manufacturing both in terms of products and firm's size. In such industries, the exit rate is very high (16.11% and 14.80% respectively). To a lesser extent, this is also the case for the exit rate observed in Sugar manufacturing, which equals 10.14%. When considering the other 3-digit level classes, one may observe that within heterogeneity, as revealed by the 4-digit level, is more limited. Therefore, most heterogeneity is captured at the 3-digit level of the NACE, with the exception of the class Manufacture of other food products that has to be disaggregated.

[*Table 3*]
[*Table 4*]
[*Table 5*]

Table 3 reports the average value of the different variables by 3-digit level industry. Table 4 (and Table 5) shows the correlation matrix at the 3-digit NACE level (and 4-digit NACE level), respectively.

The main result is the positive correlation between exit and entry rates, which equals 0.707 at the 3-digit level of the NACE, and 0.582 at the 4-digit level of the NACE, with both coefficients being significant at the 5% level. This positive correlation confirms a well-established result (Caves, 1998): the relevant distinction is not (or not first) between creative and destructive industries but rather between turbulent and inert ones. Another interesting result is the apparent negative correlation between, on the one hand, both exit and entry rates, and, on the other hand, *sunk costs* and *competition*. These results are consistent with the expected results of estimations. One may note that the two variables that we introduce *competition* and *sunk costs* are more strongly correlated to exit rate than *size* and *age* which are commonly in the literature.

5. The estimation results

5.1. Estimation of the production function

A primary interest of the OP96 approach is to provide unbiased estimates for input coefficients in the production function, in contrasts to OLS estimates which suffers from both endogeneity and selection biases, as well as to the Within estimator, which corrects the simultaneity bias but not the selection one. Accordingly, Table 6 proposes estimation results using the OLS, Within , and OP96 estimators.

[*Table 6*]

The first point is that significant differences appear between the results obtained with the different estimators.[9] If we first consider simultaneity bias, one may consider that biased estimates (such as the OLS) capture both the real effect of the variable and that of the omitted variable, which is the unobserved individual productivity in this case. Because productivity is expected to be positively linked with labor and age, when comparing the OLS to Within or OP96 estimates[10], one should find upward-biased values. This is the case with our results: the estimate of labor equals 0.704 using the OLS and 0.376 using the Within estimators, while the estimate for *age* is not significant with the OLS estimator and equals -0.033 when using the Within estimator. In the case of capital, Levinsohn and Petrin (2003) suggest that, if there is a positive correlation between the two inputs, then the simultaneity bias will lead to underestimate the coefficient β_k. This seems to be the case, as the value when this bias is corrected is 0.278 (Within) versus 0.213 (OLS).

When considering selection bias, the exit decision is not taken into account in OLS or Within estimators, while the OP96 estimator includes the estimated probability of exit at the next period as an

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[9] Such differences are consistent, in value and sign, with those found in Olley and Pakes (1996) in the case of the Telecommunications Equipment Industry.

[10] One should also note that Within and OP96 corrections of simultaneity differ (time-invariant versus time-varying individual effects).

argument. Once again, the biased estimates add to the "true" unbiased value of the correlation between the variable and the omitted variable, which is this time the probability of exit. As this probability is negatively related to age, capital and labour, selection biases are expected to be negative. The direct comparison of OLS to OP96 results is uneasy because of the opposite signs of the biases. However, when comparing Within to OP96 results, one should obtain higher values in the second case. In the case of labor, we obtain 0.579 when using the OP96 estimator against 0.376 when using the Within estimator, 0.317 against 0.278 for capital and, for *age*, a non significant estimate when using the OP96 estimator against -0.033 when using the Within estimator.

5.2. Estimation of the exit equation

Individual firm productivity $\hat{\omega}_{it}$, as estimated in the previous step, is now included as a regressor in the exit equation. The results of this estimation are presented in Table 7, which provides both coefficient estimates and marginal effects, allowing for a direct (but cautious) comparison of the impact of the different variables on the probability of exit.

[*Table 7*]

First, the coefficient of $\hat{\omega}_{it}$ is significantly negative and equal to about -0.12: the more efficient the firm, the more protected against the risk of exit. This result is consistent with theoretical predictions. As exit process is the result of market selection, the least efficient producers are the first to be eliminated. Similar results may be found in previous empirical studies. OP96 obtain a significant value of -0.16 in the case of the American telecommunications equipment industry, observed during the 1980s. Exploring a very different context, namely the Ghana, Kenya and Tanzania manufacturing firms, Söderbom *et al.* (2006) obtain a negative estimate equal to -0.239. Using the hazard survival rate, Shiferaw (2009) finds a positive estimate for the productivity variable in the case of the private manufacturing sector in Ethiopia, during 1996-2002. Our results also show that the probability of exit is negatively and significantly correlated to the age of the firm. Such a result is consistent both with numerous empirical results and with theoretical models based on the effect of "learning by doing" (Jovanovic, 1982). However it is interesting to compare the marginal effects of individual efficiency and age. The effect of the former is clearly stronger; a 1% increase in efficiency leads to a 1.47% decrease in exit probability, which is about 10 times more than the effect of one additional year of existence of the firm. One may conclude that most of this experience effect is captured by unobserved individual efficiency, with age being a poor proxy. As in R&D models, the absorption capacity of the firm which is largely based upon unobserved characteristics, would greatly improve the effect of experience and then represent a component of unobserved firm efficiency.

One now must consider the effect of industry variables, namely competition intensity. A positive estimate is obtained, as a higher intensity of competition leads to a higher probability of exit. This result is consistent with findings about industry life cycles, and more precisely with the so-called "Shakeout" literature (Klepper and Miller, 1995; Klepper and Simons, 2005). When competition is the more intense in an industry, a great number of exits occur, as in Production and processing of meat industry. Once this Shakeout period ends, the industry is more concentrated, as in Manufacture of oils and fats, and the exit rate decreases. Using a different approach based on spatial patterns, Huiban (2009) empirically obtains the same result: a negative relationship between a firm's *survival* probability and the intensity of local competition.

The effect of sunk costs on exit probability is clearly significant and negative. Sunk costs are barriers to exit for French firms because they limit the mobility of incumbents outside the market, other things being equal. The intensity of this effect seems lower than the effect of competition, as shown by the marginal effect. However, at the same time, one has to recall that there is a huge dispersion of sunk cost levels between industries, even if not speaking of the firm level. One may conclude from this that sunk costs play a poor role for most firms and in most industries, but may serve as very important barrier to exit in particular cases.

In summary, competition increases the probability of exit, while sunk costs act as exit barriers. These variables may mostly explain the differences between industries. Recall that *competition* is measured at the industry level. *Sunk costs* is observed and measured at the firm level but defined in a way (as exogenous sunk costs) that tends to favour inter-industry dispersion and reduce intra-industry dispersion. Together with the variable *age*, the individual efficiency explains most part of the differences observed between firms of a given industry, in terms of propensity to exit.

6. Conclusions

This study uses the OP96 method to estimate the effects of several determinants of a firm's probability of exit. As in previous works using a similar approach, some robust estimates are obtained for the production function arguments. Capital and labor estimates are both different from those obtained when using methods that do not correct for simultaneity and selection biases. Once the unobserved individual efficiency has been estimated for each firm, it is introduced as a regressor in the exit model. As a result, the firm's probability of exit is negatively and significantly correlated with the individual firm' productivity, its age and positively correlated with the intensity of competition that exists in the firm's industry. However, this study also provides an original measurement of sunk costs at the firm level which is then introduced in the empirical model. Thus, sunk costs appear to play a significant and negative role: the higher the level of sunk costs, the lower the exit rate. The low value of the marginal effect and the large dispersion of the variable value suggest that this determinant effect is generally light but may become very strong in some particular industries. In summary, competition intensity and sunk costs may explain differences in exit rates between industries, while age and individual efficiency may explain the variability observed between firms within an industry.

Several extensions and improvements can be made with respect to the present study. Some concern the measurement of exit rates. It would be useful to introduce a distinction between exits that correspond to a failure situation (i.e. closure) and that signify a success (i.e. selling, merging and acquisition). Actually, one may posit that both the determinants and effects of exit differ between these two kinds of situations. The present classification of food industries is a second problem. The complete 4-digit level classification is not a very tractable one, as some classes of the 3-digit level classification are too heterogeneous. A specific classification should be developed to provide a more efficient measurement of both the intensity of competition and sunk costs.

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Table 1: Exit and entry rates by year

Year	*Number of Observations*	*Entry Rate*	*Exit Rate*	*Turnover*
1999	3725	5.80	5.66	11.46
2000	3822	7.64	7.22	14.86
2001	3738	5.67	5.99	11.66
2002	3825	7.97	7.56	15.53
Average Rate	15110	6.78	6.62	13.40

Table 2: Exit by industry, average annual rate, from 1999 to 2002
Nace, 2,3 and 4-digit levels

Industry code and name	*Number of Firms*	*Number of Observations*	*Entry Rate (%)*	*Exit Rate (%)*
15 Manufacture of food products and beverages	**4818**	**15110**	**6.78**	**6.62**
15.1 Production and preserving of meat and meat products	**1524**	**4822**	**6.43**	**6.64**
15.1A Production, processing and preserving of meat	509	1740	4.89	5.63
15.1C Production of poultry meat	207	707	5.23	4.67
15.1E Production of meat and poultry meat products	520	1702	6.46	6.23
15.1F Cooked pork meats	288	673	11.59	12.33
15.2 Processing and preserving of fish and fish products	**198**	**637**	**5.97**	**4.55**
15.2Z Processing and preserving of fish and fish products	198	637	5.97	4.55
15.3 Processing and preserving of fruits and vegetables	**186**	**608**	**6.58**	**5.26**
15.3A Processing and preserving of potatoes	12	41	2.44	4.88
15.3C Manufacture of fruit and vegetable juice	21	63	6.35	7.94
15.3E Processing and preserving of vegetables	92	302	7.62	4.64
15.3F Processing and preserving of fruit	61	202	5.94	5.45
15.4 Manufacture of vegetable and animal oils and fats	**27**	**99**	**4.04**	**2.02**
15.4A Manufacture of crude oils and fats	15	53	1.89	1.89
15.4C Manufacture of refined oils and fats	10	39	7.69	2.56
15.4E Manufacture of margarine and similar edible fats	2	7	0	0
15.5 Manufacture of dairy products	**318**	**1082**	**3.70**	**3.70**
15.5A Operation of dairies and cheese making	54	192	4.17	3.65
15.5B Production of butter	13	40	0	7.50
15.5C Production of cheeses	188	665	3.61	3.31
15.5D Production of other dairy products	39	108	2.78	2.78
15.5F Manufacture of ice	24	77	6.49	6.49

cream				
15.6 Manufacture of grain mill products, starches and starch products	**138**	**485**	**4.74**	**5.36**
15.6A Manufacture of grain mill products	100	355	4.79	4.51
15.6B Other manufacture of grain products	27	91	4.40	8.79
15.6D Manufacture of starches and starch products	11	39	5.13	5.13
15.7 Manufacture of prepared animal feeds	**251**	**857**	**5.02**	**6.88**
15.7A Manufacture of prepared feeds for farm animals	225	768	5.08	6.77
15.7C Manufacture of prepared pet foods	26	89	4.49	7.87
15.8 Manufacture of other food products	**1700**	**4919**	**8.52**	**8.56**
15.8A Manufacture of bread; manufacture of fresh pastry goods and cakes	329	1116	6.72	6.72
15.8B Cooking and bakery products	130	277	21.30	14.80
15.8C Bread and pastry goods and cakes shops	295	776	14.56	16.11
15.8D pastry goods and cakes shops	393	928	5.82	8.19
15.8F Manufacture of rusks and biscuits; manufacture of preserved pastry goods	126	421	7.13	5.23
15.8H Manufacture of sugar	23	69	4.35	10.14
15.8K Manufacture of cocoa; chocolate and sugar confectionery	138	456	5.26	7.89
15.8M Manufacture of macaroni, noodles, couscous and similar farinaceous products	35	116	3.45	7.76
15.8P Processing of tea and coffee	51	176	5.11	5.11
15.8R Manufacture of condiments and seasonings	29	100	5.00	3.00
15.8T Manufacture of homogenized food preparations and dietetic food	38	114	14.04	4.39
15.8V Manufacture of other food products n.e.c.	113	370	7.30	3.51
15.9 Manufacture of beverages	**476**	**1601**	**6.75**	**4.43**
15.9A Manufacture of distilled potable alcoholic beverages	53	188	4.79	3.72
15.9B Production of ethyl alcohol from fermented materials	29	101	2.97	2.97
15.9D Production of ethyl	22	73	4.11	8.22

alcohol from fermented materials				
15.9F Manufacture of champagne	104	363	6.06	5.51
15.9G Manufacture of wine	154	483	11.59	3.73
15.9J Manufacture of cider and other fruit wines	6	22	9.09	4.55
15.9L Manufacture of other non-distilled fermented beverages	2	8	0	0
15.9N Manufacture of beer	31	91	4.40	7.69
15.9Q Manufacture of malt	7	21	0	4.76
15.9S Production of mineral waters	43	159	3.14	2.52
15.9T Production of soft drinks	25	92	4.35	4.35

Table 3: Average annual values by industry, (1999-2002)
Nace, 3-digit level

Industry code and name	*Size (Number of Employees)*	*Age (Years)*	*Sunk Cost (€ millions)*	*Herfindahl*
15.1 Production and preserving of meat	106.95	11.50	5.05	0.54
15.2 Processing and preserving of fish and fish products	94.38	10.21	5.77	3.80
15.3 Processing and preserving of fruits and vegetables	144.52	11.88	14.52	2.34
15.4 Manufacture of vegetable and animal oils and fats	126.59	13.77	20.49	24.43
15.5 Manufacture of dairy products	183.99	14.02	20.09	3.58
15.6 Manufacture of grain mill products, starches and starch products	95.91	13.24	26.03	13.46
15.7 Manufacture of prepared animal feeds	76.64	13.38	7.99	4.34
15.8 Manufacture of other food products	94.25	10.71	9.09	1.73
15.9 Manufacture of beverages	96.77	13.21	19.23	3.58

Table 4: A correlation table at the industry level (1999-2002)
Nace, 3-digit level (9 industries)

Variable	*Size*	*Entry rate*	*Exit rate*	*Sunk costs*	*Herfindahl*	*Age*
Size	1	-0.43286	-0.50693	0.37953	0.04297	0.35715
		(0.2445)	(0.1637)	(0.3137)	(0.9126)	(0.3454)
Entry rate	-0.43286	1	0.70672	-0.51151	-0.57954	-0.74389
	(0.2445)		(0.0333)	(0.1593)	(0.1019)	(0.0216)
Exit rate	-0.50693	0.70672	1	-0.56788	-0.64167	-0.52457
	(0.1637)	(0.0333)		(0.1107)	(0.0107625)	(0.1471)
Sunk costs	0.37953	-0.51151	-0.56788	1	-0.52457	0.72457
	(0.3137)	(0.1593)	(0.1107)		(0.1471)	0.47070272
Herfindahl	0.04297	-0.57954	-0.64167	-0.52457	1	0.49744
	(0.9126)	(0.1019)	(0.0107625)	(0.1471)		(0.1730)
Age	0.35715	-0.74389	-0.52457	0.72457	0.49744	1
	(0.3454)	(0.0216)	(0.1471)	0.47070272	(0.1730)	

Table 5: A correlation table at the industry level (1999-2002)
Nace, 4-digit level (45 industries)

Variable	*Size*	*Entry rate*	*Exit rate*	*Sunk costs*	*Age*
Size	1	-0.2470	-0.13457	0.81210	0.18154
		(0.106)	(0.3782)	(0.0001)	(0.2327)
Entry rate	-0.2470	1	0.58179	-0.15282	-0.78027
	(0.106)		(0.0001)	(0.3162)	(0.0001)
Exit rate	-0.13457	0.58179	1	-0.01643	-0.53618
	(0.3782)	(0.0001)		(0.9147)	(0.0001)
Sunk costs	0.81210	-0.15282	-0.01643	1	0.11031
	(0.0001)	(0.3162)	(0.9147)		0.4707
Age	0.18154	-0.78027	-0.53618	0.11031	1
	(0.2327)	(0.0001)	(0.0001)	0.4707	

Table 6: Estimates of the production function
Food Industry, 1999-2002

Variables	OLS	Within	Olley-Pakes 96
L	0.704 (0.0063)	0.376 (0.0014)	0.579 (0.0068)
K	0.251 (0.0041)	0.278 (0.0081)	0.317 (0.0367)
Age	Ns	-0.033 (0.0023)	Ns
N	15110	4818	15110
R^2	0.8040	0.2038	0.5801

Standard errors are in parentheses and computed using 50 bootstrap replications (OP96).
Time and industry (Nace3 level) dummies are included in each regression but are not reported.

Table 7: Estimates of the exit probit model (marginal effects)
Food Industry, 1999-2002
(Including *Lcomp3* and *Lcomp4*)

Variables	(1) Estimates	(2)Marginal Effects
$\hat{\omega}_{it}$	-0.1233	-0.0146
	(0.0238)	(0.0028)
Age	-0.0146	-0.0017
	(0.0026)	(0.0003)
Competition	0.7387	0.0877
	(0.1734)	(0.0205)
Sunk Costs	-0.0586	-0.0070
	(0.0116)	(0.0014)
Intercept	-5.5061	
	(0.9108)	
N	15110	15110
Log Likelihood	-3539	

Standard errors are in parentheses.
Time and industry (Nace3 level) dummies are included in each regression but are not reported.

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