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Summary *– A semi-parametric approach is used to estimate firm propensity to exit. The unobserved individual productivity of a firm is first estimated using the Ackerberg* et al. *(2006) approach and then introduced as a determinant of firm exit in conjunction with other variables that may serve as barriers to exit, including the firm's level of sunk costs and the industry concentration. Using an unbalanced panel of data for 5,849 firms in French food industries from 1996 to 2002, we find a significantly negative relationship between a firm's probability to exit and its individual efficiency and age. In addition to validating these well-known results, we also show that the level of sunk costs may be an important barrier to exit. Ultimately, the relationship between the propensity to exit and the industry level of concentration contains a turning point: the relationship is at first increasing but then becomes decreasing.*

Keywords*: firm, productivity, sunk costs, exit, concentration, food industries*

Productivité, coûts irrécupérables et sortie d'activité : le cas des firmes agro-alimentaires françaises

Résumé – Nous étudions les facteurs qui déterminent la propension des firmes à cesser leur activité. La productivité individuelle de la firme n'est pas directement observée mais estimée selon l'approche proposée par Ackerberg *et al.* (2006). Elle est ensuite introduite dans une équation de sortie à côté d'autres variables. On utilise un panel non cylindré de 5 849 firmes des industries agro-alimentaires françaises observées entre 1996 et 2002. La probabilité de cesser l'activité est négativement reliée à la productivité individuelle et l'âge de la firme. Au-delà de ces premiers résultats bien connus, nous montrons aussi que le niveau des coûts irrécupérables peut constituer une barrière importante à la sortie. La relation entre la propension à la sortie de la firme et le degré de concentration de l'industrie est marquée par la présence d'un seuil de retournement : d'abord croissante, la relation devient décroissante une fois ce point dépassé.

Mots-clés : firme, productivité, coûts irrécupérables, sortie, concentration, industries agro-alimentaires

JEL Classification: C33, D24, L25, L66

Acknowledgments
We gratefully thank two anonymous referees for helpful comments and suggestions. Usual caveats apply.
This article was produced within MICRO-DYN (*www.micro-dyn.eu*), funded by the EU Sixth Framework Programme. It reflects only the authors' views, the European Community is not liable for any use that may be made of the information contained therein.

1. Introduction

Firm demography (including both firm entry and firm 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 for the period 1989-1994) varies from 16% in the Netherlands to 23% in the United States. Despite the apparent inertia of stock (the number of units at a given date), such flows deeply modify the distribution of firms in terms of industry, size, location and performance. The food industry is particularly affected by such demographic processes for several reasons (Dimara *et al.*, 2008). On the demand side, changes in consumer tastes or in the regulatory environment may affect the industry dynamics. On the supply side, firms (which are often small in this industry) may be affected by both the volatility of agricultural prices and the pressure of retailers. For these reasons, turnover is high in the food industry overall, and substantial heterogeneity exists among firms in terms of their propensity to exit. Identifying the reasons for such heterogeneity can help to provide empirical evidence related to the firm exit process.

As shown by Caves (1998), there is a large body of empirical literature devoted to firm exit. Until recently, most studies have highlighted the influence of a particular set of determinants (e.g., firm characteristics, industry, and period) on this phenomenon. However, the theoretical contributions of Jovanovic (1982), Hoppenhayn (1992) and Ericson and Pakes (1995) (EP95 hereafter) consider exit within the more general framework of industry dynamics. These researchers assume that exit among incumbent firms occurs generally for the firms at the lowest productive level. In other words, if exit is the result of a market selection process, then the less efficient the firm, the higher its probability of exiting.

This prediction is widely confirmed by empirical studies. In a study that was directly based on the EP95 theoretical framework, Olley and Pakes (1996) (OP96 hereafter) estimate firm level unobserved individual efficiency (TFP hereafter) and introduce it as a determinant of the firm's probability of exit. Using different approaches and estimation methods, other researchers produce similar 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) analyse the post-entry and pre-exit performance of French manufacturing firms and show, again that exiters are less efficient than firms that are still in activity. Frazer (2005) and Shiferaw (2009) find similar results for developing countries (namely, Ghana and Ethiopia): only the more efficient firms, it seems, can survive. Griliches and Regev (1995) and Almus (2004) suggest that this relationship between efficiency and exit may reflect what they call the "Shadow of Death" effect: lower (and decreasing) efficiency may signal the imminent exit of the firm.

Extending these researches, our study analyses the exit process for firms in the French food industries using a large unbalanced panel dataset of 5,849 firms from 1996 to 2002. We start from the EP95 theoretical model to explain why the lower-performing firms exit. In our analysis, we estimate the TFP using a Cobb-Douglas production function and the semi-parametric method proposed by Ackerberg *et al.* (2006) (ACF06 hereafter), which is an extension of the OP96 method. We also add a stage that corrects for potential selection bias due to firm exit. Hence, this augmented

ACF06 method allows us to correct for both endogeneity and selection bias when estimating the production function. Thus we obtain a consistent estimation of firm-level TFP. This variable is then used as a determinant of the probability of exit in conjunction with the usual state variables such as firm age. Furthermore, we introduce two additional variables: sunk costs and industry concentration.

Sunk costs play an important role in theoretical models of industry dynamics because they constitute a barrier to entry for new firms but also act as barriers to exit for incumbents (see, for example, Dixit, 1989; Lambson, 1991; Sutton, 1991; Hopenhayn, 1992; Cabral, 1995). Such predictions have been confirmed by numerous empirical tests (Kessides, 1990; Dunne and Roberts, 1991; Farinas and Ruano, 2005; Hölzl, 2005; Gschwandtner and Lambson, 2002; Fotopoulos and Spence, 1998) whose results indicate that capital requirements are a barrier to exit. In this study, we propose an original measurement of these costs that is mainly based on the firm's level of investment and capital but is weighted by parameters that reflect industry characteristics, taking into account leasing, capital depreciation and the resale of second-hand equipment. Thus, the measure reflects that not all of the capital used by firms is systematically sunk.

In addition, it is generally assumed that in highly concentrated industries, firms may be protected from competition. As a consequence, the exit rate may be small. However, following previous studies (*e.g.*, Gopinath *et al*., 2003; Aghion *et al*., 2005), we can consider that in markets that display a high degree of concentration, firms are ill-equipped to react to changes in their environment. We therefore prefer to use a flexible form that includes both first- and second-order measures for industry concentration and that will thereby allow us to detect a possible turning point for the relationship between concentration and exit.

Our main findings are as follows. First, our summary statistics confirm the results presented in the previous literature and mimic the expected patterns. From 1996 to 2002 the average annual exit rates equalled 6.5% for the entire food industry. However, this rate greatly varies from one industry to the next. Whereas this value is between 4 and 5% for many industries (*e.g.*, *Oils and Fats*, *Dairy Products*, *Grain Products* or *Beverages*), it is more than 8.0% for *Other Food Products* and is greater than 10% in sub-industries such as *Sugar Manufacturing*; indeed, the corresponding figure is 16% for *bread and pastry goods and cake shops*.

The goal of our estimation is primarily to explain such differences in exit rates both between and within industries. Thus, we first provide consistent estimates of the production function using the augmented ACF06 approach. These estimates are different from the estimates obtained via the usual methods, as is consistent with the literature devoted to simultaneity and selection bias in production function estimations (Ackerberg *et al.*, 2007). However, our more important findings concern the exit function: the exit probability of firms is negatively and significantly correlated with individual firm productivity (TFP) and firm age. These results are consistent with the predictions associated with the theoretical model and with the results of previous studies that have been conducted using similar methods. Additionally, the present study has yielded two original findings. The first concerns the relationship between firms' propensity to exit and industry concentration. There appears to be a critical concentration level below which a higher concentration will mean a higher propensity to exit; beyond this level, in contrast, a higher concentration will mean a lower propensity to exit. This level, which is actually attained and exceeded in several sectors, may correspond to the end of what is called the "*shakeout*" process (Klepper and Miller, 1995; Klepper and Simons, 2005). The second finding is that after we control for individual firm productivity, age and concentration, sunk costs play a significant and negative role; when the level of sunk costs is high, the firm's propensity to exit will be lower. The low magnitude of this effect, which is associated with the large variability in this value between firms, suggests that this effect is generally weak but may become quite strong in industries with high sunk costs amounts, for example, in the *Grain products* sector as opposed to the *Meat* sector.

In summary, concentration and sunk costs may explain the differences between the exit rates of particular industries – *e.g.,* between "*inert*" versus "*turbulent*" industries – whereas age and TFP explain an important part of the variability observed between firms within a particular industry.

The rest of this paper is organised as follows. Section 2 introduces the economic model, and section 3 presents the econometric methods. The data and summary statistics are introduced in section 4, whereas in section 5, the estimation results are provided and analysed. Section 6 concludes the paper.

2. The economic model

Ericson and Pakes (1995) provide the theoretical model underlying the Olley and Pakes (1996) approach. Their aim is to explain the great variability empirically observed between firms in terms of their performance level, including the entry and exit processes. Toward this end, in addition to using the usual firm-level state variables (i.e., capital, labour and age), these authors incorporate a new variable, $\omega_{it} \cdot \omega_{it}$ is defined as the individual productivity (TFP) of firm i observed at period t, and it captures all of the unobserved heterogeneity between firms.

In this type of model, entry and exit processes are natural components of industry dynamics. Entrants must invest to explore and then exploit the opportunities offered by the industry. At the same time, at the beginning of any period t, an incumbent firm must make two decisions. First, it must decide to continue within or to 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 of remaining active (the sell-off value), and the *EDP*, which is the expected present discount value of the activity profit assuming optimal future investment decisions. The Bellman equation is:

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

with

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

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

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

Thus, the current capital stock is determined at time $t-1$. The exit rule is based on the comparison between the sell-off value ϕ and the optimal expected discounted profits EDP_{it}, which depend on the value of $V_{it}(\omega_{it}, K_{it})$. 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 (remain in) the market. Then, the exit rule can be written as

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

Second, if the firm decides to stay in the industry, it has to choose the level of investment I_{it} that will maximise EDP_{it} in relation to the usual state variables, capital and age, but also in relation to the TFP:

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

Our study is based on this model, but it also introduces two additional variables: sunk costs and industry concentration.

Sunk costs are invoked in Ericson and Pakes (1995, p. 55), though they are not explicitly included in the model. Sunk costs first occur when the firm enters the industry and begins to explore the opportunities offered by that industry. They also accrue as part of the investment cost during each period t. Sunk costs act as entry barriers for potential new entrants and as exit barriers for incumbents. Whereas the first point is well known (Gilbert, 1989), there are several theoretical arguments that may explain the second. First, sunk costs may be barriers to exit because they induce (nearly) irrecoverable losses for the incumbents when the latter decide to close down or to leave the market (Sutton, 1991). This may explain why there is a positive correlation between entry and exit rates (Lay, 2003). When sunk costs are high, incumbents are less often threatened by the entry of new competitors, and thus, both exit rates as well as entry rates are low. Furthermore, sunk costs may increase the firm's future profits as past costs can generate future earnings by increasing firm efficiency (Hopenhayn, 1992) and then modifying the value of the second term in the Bellman equation. Second, the first term in the Bellman equation (*i.e.*, the sell-off value of the firm) may also be affected by sunk costs, particularly "endogenous" sunk costs (Sutton, 1991) such as advertising or R&D expenses, because a potential buyer may be interested in acquiring brands or technological know-how. In such a case, both the sell-off value and the expected profits may be affected by the level of these costs. Finally, although the concept of *fallacy* [1] effects is sometimes invoked in this discussion (Friedman *et al.*, 2007), real option theory suggests that by increasing the cost of entry, sunk costs create a zone of uncertainty in which inaction in terms of entry (Dixit, 1989) or exit (O'Brien and Folta, 2009) may be a rational choice.

Regarding the second variable, concentration, studies of industry life cycles (Klepper and Miller, 1995; Klepper and Simons, 2005) have indicated that both entry rates and exit rates greatly depend on the development stage of the industry. There are several such stages, each of which corresponds to a different level of propensity toward firm exit. As in many processes involving concentration, the relationship between firm exit and the industry concentration may not be linear. Aghion *et al.* (2005) find a non-linear relationship between concentration and innovation and Gopinath *et al.* (2003, 2004) find a U-inverted between concentration and productivity. Thus, it seems useful to allow for the potential existence of a critical level of concentration that generates a U- or inverted U-shaped relationship between firm exit and concentration. Consequently, the concentration variable is introduced within the exit model as a second-degree polynomial.

The above arguments suggest that the probability that firm i observed during period t will exit can be written as follows:

$$\Pr(Exit_{it}) = p(\omega_{it}, a_{it}, Conc_{it}, Conc_{it}^2, SC_{it}, X_{it}) \tag{6}$$

3. The econometric method

Based on the previous model, we assume that the probability of firm exit depends on the firm's TFP and age, the industry concentration, the amount of the firm's sunk costs, and several control variables denoted as X_{it}, which represent industry, time and region dummies. However, ω_{it} cannot be directly observed; instead, it must first be estimated using a production function, as in the case of a Cobb-Douglas technology:

$$\log Y_{it} = \beta_0 + \beta_l \log L_{it} + \beta_k \log K_{it} + \omega_{it} + \varepsilon_{it} \tag{7}$$

Y_{it} is the output of firm i observed at period t, L_{it} is the labour input, K_{it} is the capital input, and ω_{it} is the individual efficiency (TFP), a state variable for the firm's decisions that is known by the firm but not observed by the econometrician. In contrast, ε_{it} is the usual error term associated with a non-predictable productivity shock.

It is well known that standard econometric methods, such as the OLS, provide biased and inconsistent estimates of the previous production function for at least two

[1] A so-called *fallacy* effect occurs when people "throwing good money after bad" continue investing in a non-profitable project simply because of their past investments (O'Brien and Folta, *op. cit.*).

reasons: simultaneity between outputs and inputs and selection bias resulting from the exit process. There are several methods of addressing these problems, including the use of current panel data estimators such as the Within, Instrumental Variables and Generalized Moments Method estimators and the use of semi-parametric methods (Ackerberg *et al.*, 2007).

In this study, we use a semi-parametric method with reference to the theoretical model presented in section 2. Precisely, we apply the ACF06 method and include a correction for sample selection bias due to the possibility of firm exit. Toward this end, we first estimate a reduced [2] form of the exit equation:

$$\Pr(Exit_{it}) = p(K_{it}, a_{it}, X_{it}) \tag{8}$$

This provides $\widehat{p_{it}}$, which is the predicted exit probability of firm i during period t and will be used in the upcoming stages to estimate the production function and the TFP.

When using the ACF06 method to estimate the production function, one assumes that labour is not a perfectly variable input (*i.e.* fixed at t, just before production takes place), as assumed in Olley and Pakes (1996) but is a quasi-flexible factor (fixed somewhere between t and $(t-1)$). This assumption makes it possible to avoid co-linearity between the labour inputs and ω_{it}, which is expressed as a non-parametric part of the function to estimate [3]. Thus, the first goal is to properly separate ω_{it} from ε_{it} within the production function. Once this step has been completed, in the next step, we conduct the estimation for labour and capital. Then, we obtain the estimate for ω_{it} by subtracting the estimated value of the output to its observed value.

The final step in our econometric procedure involves the probit estimation of the exit model from equation (6), including the estimated value of the TFP and the other variables: firm age, sunk costs level, industry concentration and industry and time dummies. As previously indicated, concentration will be included in both the first- and second-order forms.

$$\Pr(Exit_{it}) = p(\widehat{\omega_{it}}, a_{it}, SC_{it}, Conc_{it}, Conc_{it}^2, Ind_{it}, Year_{it}) \tag{9}$$

4. Data and summary statistics

Our database contains 26,452 observations. This database is an unbalanced panel of 5,849 firms from the French food industry that were observed during the period

[2] In using the word "reduced", we simply mean that the unobserved efficiency is not included at this stage because it has not yet been estimated. X is a set of control variables, including industry and year dummies.

[3] This non-parametric component is obtained by inverting (5) with respect to I. Investment becomes a "proxy" variable for ω. However, the proxy variable must be strictly positive, which is not necessarily the case for investment. Consequently, as in Levinsohn and Petrin (2003), we use intermediate consumption instead of investment as a proxy for ω.

1996-2002. The data are obtained from annual surveys about firms' activities that were published in the "*Enquête annuelle d'entreprise*" (EAE hereafter), which is the official French business-level data collected by the French Office of National Statistics (INSEE), and for the food industry, by the Statistical Department of the French Agriculture Ministry. This survey only includes firms that employ at least 20 employees.

4.1. The construction of the variables

According to the standard definition of exit, an incumbent at period t is a firm that is present both during the current year t and the next year $t+1$, whereas a firm that exits at period t is in the market during year t but not during $t+1$ [4]. The EAE survey is limited in measuring exit because it does not introduce any distinction about the firms' reasons for exiting. A firm may exit from the survey for several reasons, including closure, a merger or acquisition; because of the sample selection rules (*e.g.*, size, industry), it may also be excluded from the survey.

We deflate the value added for firm i operating in sector j at time t by the annual price index of value-added. As a measure of the capital used by firm i, we sum of the value of the fixed assets at the end of the year and the leased capital. This sum is deflated by the annual price index for capital. Intermediate consumption is deflated by the annual price index for intermediate consumption. The labour input for firm i at time t is the number of firm 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.

The concentration in the industry is measured using the Herfindahl-Hirschman concentration index calculated from the initial database for each industry s observed at period t:

$$Conc_{st} = \sum_{i=1}^{i=N_{st}} \left(\frac{VA_{it}}{\sum_{i=1}^{i=N_{st}} VA_{it}} \right)^2 \tag{10}$$

with N_{st} being the number of firms present in industry s at period t. As previously mentioned in the theoretical section, due to the non-linear effect of concentration on firm exit, both $Conc_{st}$ and $Conc_{st}^2$ are introduced in the exit equation.

Sunk costs are not easy to measure. Hence, many studies use proxies such as the lagged value of the dependent variable in the case of exports, which are assumed to generate sunk costs (Roberts and Tybout, 1997). Other proxies include capital stock, as used by Lambson and Jensen (1998), and capital intensity, as used by O'Brien and Folta (2009) and Roberts and Thompson (2003). Hölzl (2005), on the other hand, used

[4] Our database ends in 2002 but information about the presence of each firm in an industry is available until 2003.

"endogenous sunk cost" variables such as advertising expenditure, whereas Kessides and Tang (2010) used investment. Following Gschwandtner and Lambson (2002), we could consider the sunk costs of a firm to be a function of the current period investment I_{it} and the lagged value of physical capital K_{it-1}. However, not all investment and capital must be viewed as sunk (Kessides, 1990); the deciding factors include the degree of capital depreciation, whether firms lease or buy their equipment and whether there exists a second-hand market for the equipment. Consequently, we propose the following variable for sunk costs:

$$Sunk_{it} = \left(1-\rho_{st}\right)\left[cI_{it} + c\left(1-\delta_{st}\right)(1-\alpha_{st}\frac{s_{st}}{c})K_{it-1}\right] \quad (11)$$

As previously mentioned, several underlying assumptions must be made to provide a realistic measure of sunk costs. First, we must assume that the firm may not buy all of its equipment but rather may lease a fraction ρ_{st} of it. In our database, ρ_{st} is approximated at the industry level s by the rental payments divided by the capital. Thus, only the fraction $1-\rho_{st}$ is related to sunk costs. Second, physical capital is affected at the industry level by a depreciation rate of δ_{st} per cent during each period. As a result, δ_{st} is the ratio of the destructed capital for the current period to the capital stock that is available at the beginning of the current period K_{it-1}. Third, a firm may sell α_{st} per cent of its physical capital on the second-hand market at the end of each period at a price S_{st}, where c is the (current) unit cost of capital. $\alpha_{st}\frac{s_{st}}{c}$ is approximated at the industry level by the ratio of the capital sold on the second-hand market to the value of the capital. These three variables are assumed to vary over time but are fixed at the industry level because no data are available at the firm level. In summary, sunk costs will differ between industries; they will be low in industries where the assets used can be easily leased, where the depreciation rate of capital is high and/or where the capital can be resold on a large second-hand market. Accordingly, the more industry-specific are the assets, the higher are the sunk costs. Next, these industry coefficients are applied to firm-level variables (investment and capital), in which case the outcome is partly firm-specific because the sunk costs will differ between firms within a given industry.

4.2. Summary statistics

The food industry is a field of particular interest for at least two reasons. First, it represents a significant part of manufacturing in France and in many other countries. Second, the food industry should not be considered a homogeneous sector. Instead, it should be considered a large and heterogeneous set of industries, with nine industries at the NACE [5] (rev. 1) 3-digit level and forty-five at the NACE 4-digit level, embodying a large variety of activities. As shown in table 1 and table 2, significant heterogeneity exists among industries and may even persist within some industries, partly because of their large size.

[5] Statistical classification of economic activities used in Europe.

Table 1. **Summary statistics by industry, French food industry, 1996-2002. NACE (rev. 1), 3-digit level**

Industry code and name	Number (Firms)	Number (Obs.)	Exit Rate (%)	Size (Number of Employees)	Age (Years)	Sunk Cost (€ millions)	Herfindahl (*100)
15 Total	5,849	26,452	6.50	102	11.03	10.03	2.48
15.1 Meat	1,846	8,504	6.27	101	10.77	4.74	5.31
15.2 Fish	243	1,092	5.40	87	9.54	4.91	3.26
15.3 Fruits, vegetables	232	1,058	6.14	140	11.21	13.19	2.55
15.4 Oils and fats	34	169	4.14	140	13.44	21.78	21.98
15.5 Dairy products	368	1,931	4.19	179	13.62	18.27	3.43
15.6 Grain products	157	841	4.76	96	12.52	23.53	13.67
15.7 Prepared animal feed	299	1,523	6.11	74	12.85	7.48	4.58
15.8 Other food products	2,201	8,632	8.39	90	9.97	9.75	1.92
15.9 Beverages	538	2,702	4.33	99	12.72	19.05	3.51

The global average exit rate for firms is 6.5% per year in the French food industry for the 1996 to 2002 period. Further, the turnover rate is higher in the food industry than in other manufacturing industries (approximately 13% for the food industry and 10% for other manufacturing industries), although it is lower than that of services (where turnover is 15%). These findings are consistent with those in the literature on firm demography (Bartelsman *et al.*, 2005) for manufacturing firms excluding very small firms (those with fewer than 20 employees). Bellone *et al*. (2006) find an exit rate of 10% when considering fourteen French manufacturing industries during the period 1990 to 2002, with lower values at the end of the period.

Furthermore, a great variability in terms of exit rates exists between the sectors in the food industry. This rate varies between 4.14% and 8.39% at the NACE 3-digit level and between 2.30 and 16.02% at the NACE 4-digit level. A distinction can be made between:

– the industries with a low exit rate (smaller than 5%): *Oils and fats*, *Dairy Products, Grain Products* and *Beverages*;
– the industries with a medium exit rate (between 5 and 6%): *Meat*, *Fruit and vegetable products* and *Animal feed*; and
– the only industry with a very high exit rate (over 8%): *Other food products*.

However, this last 3-digit level industry is formed by very different 4-digit level industries. The high value of the exit rate is mainly due to only three 4-digit level sectors. Two (*Cooking and Bakery products* and *Bread and pastry goods and cake shops*) are

Table 2. **Summary statistics by industry, French food industry, 1996-2002. NACE, (rev. 1), 4-digit levels**

Industry code and name	Number (Firms)	Number (Obs.)	Exit Rate (%)	Size (Number of Employees)	Age (Years)	Sunk Cost (€ millions)	Herfindahl (*100)
15.1.A Meat	620	3,106	5.83	104.29	10.97	4.38	1.73
15.1.C Poultry	246	1,249	5.04	156.65	11.51	5.01	3.44
15.1.E Ind. Meat	633	3,044	6.08	98.62	12.00	5.89	1.04
15.1.F Delicatessen	382	1,105	9.41	32.81	8.66	2.24	3.51
15.2Z Fish	243	1,092	5.41	86.86	9.54	4.91	3.26
15.3A Potatoes	17	77	6.50	253.34	11.79	33.54	22.19
15.3C Fruit Juice	26	115	6.09	122.16	9.68	14.43	14.50
15.3E Vegetables	116	533	6.00	150.84	11.43	13.53	4.84
15.3F Fruits	77	333	6.31	102.08	11.26	7.52	11.54
15.4A Crude Oil	16	87	2.30	106.71	13.46	23.39	32.68
15.4C Ref. Oil	17	71	5.63	191.39	12.92	22.05	37.67
15.4E Margarine	3	11	9.09	71.64	16.64	7.32	77.50
15.5A Milk	69	337	3.86	303.24	13.30	36.16	16.94
15.5B Butter	14	75	4.00	167.24	13.55	11.34	22.53
15.5C Cheeses	224	1,182	4.23	150.00	12.82	13.82	5.11
15.5D Oth. dairy	51	197	3.05	96.20	14.17	12.60	9.44
15.5F Ice cream	29	140	6.43	241.12	12.07	24.55	22.35
15.6A Grains	114	613	4.24	53.35	12.74	6.66	4.87
15.6B Starch Products	34	162	6.79	102.01	12.17	14.84	12.91
15.6D Starches	12	66	4.55	482.10	11.32	201.51	57.35
15.7A Farm feed	272	1,374	6.19	59.30	13.03	5.43	1.39
15.7C Pet food	29	149	5.37	212.46	11.21	26.36	27.43

Table 2. **Summary statistics by industry, French food industry, 1996-2002. NACE, (rev. 1), 4-digit levels *(continuing)***

Industry code and name	Number (Firms)	Number (Obs.)	Exit Rate (%)	Size (Number of Employees)	Age (Years)	Sunk Cost (€ millions)	Herfindahl (*100)
15.8A Ind. Bakeries	424	1,932	6.94	89.62	10.09	5.08	1.98
15.8B Cook. Bakery Prod.	202	487	16.02	35.86	6.32	2.51	9.90
15.8C Bakeries	504	1,311	14.57	48.90	7.78	2.96	11.27
15.8D Pastry Shops	577	1,637	7.57	48.42	9.35	10.61	3.74
15.8F Rusk Biscuits	163	776	6.57	131.38	11.72	10.97	16.09
15.8H Sugar	32	140	10.71	295.49	15.54	95.20	15.56
15.8K Cocoa	160	810	6.67	151.95	12.58	15.17	13.89
15.8M Noodles, etc.	42	210	6.19	108.08	11.79	13.90	22.75
15.8P Tea/Coffee	65	325	6.46	142.53	12.49	10.58	27.99
15.8R Condiments	32	169	2.37	106.52	13.01	9.66	27.55
15.8T Food Dietetics	49	199	5.53	157.72	9.93	17.70	28.77
15.8V Other n.e.c.	143	636	4.40	88.51	9.17	9.75	18.19
15.9A Dist. alcohol	62	328	4.27	80.03	14.03	15.75	23.56
15.9B Spirituous	36	178	3.93	163.18	14.65	13.94	23.71
15.9D Ethyl. alcohol	24	128	4.69	41.47	14.58	7.91	8.76
15.9F Champagne	122	624	4.81	69.09	12.70	14.19	10.17
15.9G Wine	171	775	4.13	34.70	11.75	7.51	2.18
15.9J Cider	8	36	2.78	93.33	13.16	5.56	44.12
15.9N Beer	42	162	6.79	244.56	13.62	65.89	30.79
15.9Q Malt	8	39	2.56	58.72	13.87	17.21	28.18
15.9S Mineral w.	48	275	3.27	227.39	10.90	43.86	21.46
15.9T Soft drinks	33	157	3.82	186.82	13.04	28.87	29.69

more similar to service activities than to manufacturing in terms of both the products offered and firm size. The third industry is *Sugar manufacturing*, a declining activity in France and in which the exit rate largely exceeds entry rates.

A negative correlation exists at the industry level between the exit rate and the variables *size* and *age,* which are commonly used in the empirical literature as determinants of firm survival (Caves, 1998). However this is also clearly the case with the two variables that we introduce: *concentration* and *sunk costs*. Again, significant heterogeneity exists within the food industry between the different 3-digit level sectors in terms of concentration and sunk costs [6]. The last point of interest concerns the variable concentration according to the NACE level, which is used for computation. We consider the 3- and 4-digit levels in succession. To be consistent with the notion of relevant markets in the French food industry, we use the 4-digit level to define the concentration index used in the estimations. This level is also used for the industry dummies in the different regressions.

5. The estimation results

Table 3 presents the results obtained by estimating the production function using the different estimators. It must be kept in mind that the OLS estimator (Col. 1) does not control for both simultaneity and selection bias. The within-estimator (Col. 2) does not correct for selection bias but corrects for simultaneity bias using a time-invariant individual effect. The interest of the estimator proposed by Ackerberg *et al.* (2006) (Col. 3) is to provide a better correction for simultaneity bias using a time-varying measure of individual efficiency. We also correct for selection bias (Col. 4) when using the original ACF06 method. Based on these estimates, two preliminary comments are in order. First, there are differences between the OLS and ACF estimates. Second, the sign of these differences is consistent with the corresponding literature (Levinsohn and Petrin, 2003; Ackerberg *et al*., 2007). Simultaneity leads to an upward-biased estimation of the labour coefficient.

The corrected ACF06 estimation is used to properly estimate individual firm productivity $\hat{\omega}_{it}$, which is included as a regressor in the exit equation estimated using a probit model. It should be noted that we perform both pooled and panel random-effect probit models. The results were very close, and a likelihood ratio test confirms the absence of random effects. The findings indicate that our model, especially when the estimated TFP, time and industry dummies are included, makes it possible to control for a significant degree of unobserved heterogeneity across firms. The results of these estimations are presented in table 4, which provides coefficient estimates and indicates marginal effects, allowing for a direct comparison of the impact of the different variables on the probability of exit. Two different specifications are tested. The first includes only year and industry dummies in addition to the variables of

[6] An examination of the firm-level results shows that there is also a great heterogeneity between firms within a given sector. For example, within the *Starches* industry, the level of sunk costs varies from 0.06 to 1,732 € million.

Table 3. **Production function estimates. Food Industry, 1996-2002**

Variables	OLS	Within	ACF06 (Without controlling for selection bias)	ACF06 (When controlling for selection bias)
L	0.738 (0.0047)	0.475 (0.0096)	0.684 (0.0203)	0.681 (0.0223)
K	0.237 (0.0029)	0.233 (0.0056)	0.231 (0.0110)	0.233 (0.0121)
N	26,452	26,452	26,452	26,452
R^2	0.8132	0.2465		

Standard errors are in parentheses and computed using 100 bootstrap replications (ACF06).
Time and industry (NACE 4-digit level) dummies are included (OLS, Within).

Table 4. **Estimates of the exit probit model (marginal effects), pooled regression. Food Industry, 1996-2002**

Variables	Pooled Probit (*Estimates*)	Panel Probit (RE) (*Estimates*)	Pooled Probit (*Marginal effects*)	Pooled Probit (with region dummies) (*Estimates*)	Panel Probit (RE) (with region dummies) (*Estimates*)	Pooled Probit (with region dummies) (*Marginal effects*)
$\hat{\omega}_{it}$	– 0.171 (0.0193)	– 0.172 (0.0195)	– 0.0197 (0.00221)	– 0.176 (0.0194)	– 0.176 (0.0194)	– 0.0202 (0.00222)
Age	– 0.0168 (0.0021)	– 0.0168 (0.0021)	– 0.0019 (0.00024)	– 0.0171 (0.0021)	– 0.0171 (0.0021)	– 0.0020 (0.00024)
Concentration	4.677 (0.990)	4.681 (0.992)	0.539 (0.1136)	4.661 (0.993)	4.661 (0.993)	0.534 (0.1135)
Concentration^2	– 13.045 (2.622)	– 13.058 (2.627)	– 1.503 (0.3007)	– 13.013 (2.631)	– 13.015 (2.630)	– 1.4916 (0.3002)
Sunk Costs	– 0.0638 (0.0086)	– 0.0639 (0.0088)	– 0.0073 (0.00099)	– 0.0633 (0.0087)	– 0.0634 (0.0087)	– 0.0073 (0.00099)
Region Dummies	No	No	No	Yes	Yes	Yes
N	26,452	26,452		26,452	26,452	
Log Likelihood	– 6,060.14	– 6060.14 LR test: $p = 0.484$		– 6,046.26	– 6,046.26 LR test: $p = 0.482$	

Standard errors are in parentheses.
Time and industry (NACE 4-digit level) dummies are included in each regression.
RE: random effects.

interest. In the second, regional dummies are added to test the potential impact of the firm's location on its propensity to exit [7].

First, the coefficients of TFP, age and sunk costs are significant and negative. This result suggests that these three variables act as barriers to exit. However, to determine the effect of concentration on exit probability, further examination is required. According to our results, concentration first favours exit propensity, but once a critical point has been reached, concentration has a negative effect on propensity to exit. Some years and industry dummies are significant, as are some French region dummies [8].

The coefficient of $\hat{\omega}_{it}$ is significantly negative and close to -0.17. The more efficient firms are better protected against the risk of exit when all else is equal. This result is consistent with the theoretical predictions. Because the exit process is the result of market selection, the least efficient producers are the first to be eliminated. Similar results were found in previous empirical studies. Olley and Pakes (1996) obtain a significant value of -0.16 for the American telecommunications equipment industry, as observed during the 1980s. Considering the survival rate in the food industry in the Greek case using another approach (data envelopment analysis), Dimara *et al*. (2008) obtain positive estimates for both technical and scale efficiency. Farinas and Ruanos (2005) obtain a similar result by studying the productivity distribution for exiting and continuing Spanish manufacturing firms during the 1991 to 1997 period: the latter are significantly more productive than the former. Exploring a very different context – manufacturing in Africa – some studies also confirm the negative impact of TFP on the probability of firm exit in the case of Ghana (Frazer, 2005) and Ethiopia (Shiferaw, 2009), whereas the results of Söderbom *et al.* (2006) for Ghana, Kenya and Tanzania are less conclusive. As previously mentioned, our database is limited because there is no distinction made between failure on one hand and a merger or acquisition on the other hand within our definition of potential causes of firm exit. In the case of a merger or acquisition, it is likely to expect a positive effect of firm productivity on exit probability: the more efficient the firm, the more attractive the firm will be to a potential buyer. Ultimately, our resulting apparent result is the sum of two components with opposite signs. It suggests that the effect of TFP on exit probability will be even stronger if only exit due to failure is considered.

Our results also show that the probability of exit is negatively and significantly correlated with the age of the firm. This result is consistent with theoretical models that suggest that an experience effect occurs due to an "active" learning process by firms (Ericson and Packes, 1995). Such a result has been empirically validated (Caves, 1998) with special attention to the low survival rate of entrants. However, it is interesting to compare the marginal effects of TFP and age. A 1% increase in TFP leads to a 2 percentage point decrease in exit probability, which is 10 times the effect of one additional year of existence for a firm. Age appears to be an imperfect proxy of firm experience of the firm. "Real" experience, which is a function of knowledge inputs

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[7] We gratefully acknowledge an anonymous referee for suggesting this improvement.

[8] The coefficients of the time, industry and region dummies are not reported in table 4 due to space limitations.

and absorption capacity (as defined by Cohen and Levinthal, 1989, for R&D) would be more precisely captured by the firm's TFP.

When considering the effect of industry concentration on firm propensity to exit, one obtains a positive and significant estimated coefficient for *Conc* and a negative and significant estimated coefficient for $Conc^2$. As a result, the relationship between exit and concentration is an inverted U-shape with a critical value of 0.18 for *Conc* [9]. The higher the concentration, the higher the propensity to exit if the industry Herfindahl index is below 0.18; in contrast, after this turning point, a higher concentration will be correlated with a lower propensity to exit. This result is consistent with the so-called "shakeout" literature (Klepper and Miller, 1995; Klepper and Simons, 2005). A shakeout is the stage within the industry life cycle during which the number of firms dramatically decreases. In this scenario, the critical point within the inverted-U relationship is the end of the shakeout stage. Once the latter ends, the industry concentration continues to increase, but the exit rate decreases. From an empirical point of view, it could be noted that some industries have actually passed the turning point. These include all of the sub-sectors of *Oils and Fats* and some of the sub-sectors of *Dairy* or *Beverages*. In contrast, other sub-sectors such as *Delicatessens* or *Bakeries* do not seem to have still attained the shakeout step.

The effect of sunk costs on exit probability is clearly significant and negative. The intensity of this effect seems to be significantly lower than the effect of concentration, as shown by the marginal effect. However, there are very great differences between the sunk cost levels of different industries, even without speaking of the differences between firms (which extend from 10^{-4} to 10^{4} € millions). One may conclude from this that sunk costs have a small impact on the decision to exit for most firms and in most industries, but they may act as very important barriers to exit in particular cases. This result is consistent with the previous empirical literature. Gschwandtner and Lambson (2002) examine data for 36 countries and observe a negative relationship between sunk cost and exit rates as well as significant variation in sunk costs. Hölzl (2005) finds a robust negative relationship between sunk costs and both exit and entry rates in Austrian manufacturing between 1981 and 1994.

Time industry and spatial dummies are included in our exit model. The estimates for some year dummies are significant, which confirms the well-known relationship between the exit process and the business cycle, as shown by Caves (1998). Industry dummies also play a role, even once we have controlled for certain characteristics of the market structure by means of concentration. Such variables are used (perhaps imperfectly) to control for numerous unobserved factors such as specific-industry technology (Audretsch, 1991). Ultimately, spatial dummies are introduced in one of our two specifications. We use the region-based NUTS2 level (with 22 regions in France). With the Paris region (*Ile de France*) as the reference region, we obtain several significant and negative estimates. These results suggest that some firm locations have

[9] The value of *Conc* at this critical point equals $Conc_{CP}$ = (Marginal effect of *Conc*)/2(Marginal effect of $Conc^2$).

a negative impact on propensity to exit. Although the regions in question [10] are all less urbanised than the reference region, these results validate the findings presented by Huiban (2011) that indicate that urbanised areas exhibit greater turbulence (higher exit but also entry rates) than do rural areas.

In summary, industry concentration and sunk costs act as exit barriers. These variables may explain most of the differences observed between industries. It is important to recall that *concentration* is measured at the industry level. The variable *sunk costs* is observed and measured at the firm level but is defined (as exogenous sunk costs) in a way that tends to favour inter-industry dispersion rather than intra-industry dispersion. Together with the variable *age*, TFP may explain most of the differences observed between the firms within a given industry in terms of their propensity to exit.

6. Conclusions

This study estimates the effects of several determinants of a firm's probability of exit. One of these potential determinants, the individual firm efficiency, is not directly observable but must instead be estimated. The method developed by Ackerberg *et al.* (2006) is used but is completed with a correction for the selection bias due to entry and exit. The data cover 5,849 individual firms within the French food industries between 1996 and 2002. The main finding is that the firm's probability of exit is negatively and significantly correlated with its individual productivity, age, and level of sunk costs. The relationship between the concentration level of the firm's industry and the firm's propensity to exit is a U-inverted one. After an initial stage in which concentration increases the propensity to exit, there exists a turning point after which the relationship is inverted, suggesting the existence of a shakeout process.

The present study could be extended and improved in several ways. Some concern the measurement of exit rates. For instance, it would be useful to introduce a distinction between exits that occur due to failure (*i.e.*, bankruptcy) and those that may signify firm success (*i.e.*, a sale, a merger or acquisition). In fact, one may posit that both the determinants and the effects of exit differ based on the situation. We could also potentially improve our definition of sunk costs. We currently only consider exogenous sunk costs. However, data on R&D expenditures would allow us to take into account the endogenous components of sunk costs.

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