The Dynamics of Exporting and Innovation: Evidence from the Tunisian Manufacturing Sector

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Abstract

We analyse the dynamics of internationalisation and innovation decisions using firm-level data on Tunisian manufacturing firms from 2004 to 2006. We examine whether there are complementarities between exporting and innovation investments, and whether and how these complementarities affect the firm’s performance. The analysis has been conducted on two clusters of firms. The first cluster distinguishes exporters from non-exporters, and the second distinguishes fully exporting firms from others. The results are consistent with complementarities between the exporting and innovation. The results also indicate that these complementarities positively affect the firm’s performance for fully exporting firms.

Key words: manufacturing industry, learning by exporting, self-selection, R&D investment, complementary effect, Tunisia

JEL classification: F140, L63, L67, O55

1. Introduction

We explore the dynamics of exporting and R&D investments, and their connections with firm performance, in Tunisian manufacturing. We test for the validity of two hypotheses: (a) self-selection which results from the direct effect of the firm’s productivity on the profitability of investing in exporting or R&D and (b) the learning-by-exporting hypothesis which states that exporting is an important source of “external” knowledge accumulation for improving firm capabilities. Unlike most previous work in this area, we explicitly recognise that R&D and exporting are interdependent. We investigate whether the two decisions exhibit complementarity or substitutability effects, and whether and how this interdependence affects the firm performance. The empirical analysis is based on three firm-level data...
sets using accounting, industrial and exporting flow surveys conducted on 1323 Tunisian manufacturing firms from 2004 to 2006.

This article is structured as follows. In Section 2, we describe the data set and present descriptive statistics. In Section 3 we describe the methodology for investigating the dynamics of exporting and innovation, the interdependence between the two decisions, and the links with productivity. Estimation results are presented in Section 4, and Section 5 concludes.

2. Data and summary statistics

Three firm-level data sets, collected by the Institut National de la Statistique in Tunisia over the period 2004–06, are used in this article. These data are drawn from the annual accounting, industrial and export flow surveys, which, while not complete censuses of all firms, do have a wide coverage of all sectors. After dropping a small number of firms due to missing data on variables of interest, our balanced panel data set covers 1323 firms. Our data contain information about the status of exporting and R&D activities, as well as the number of employees and the number of years in operation. We also have information about firms’ financial resources and whether there is a direct or indirect foreign ownership. The data also include information about sales.

We use information on R&D expenditures to define the firm’s status as an innovator. That is, the R&D variable takes 1 if a firm reports positive R&D expenditures and 0 otherwise. Even though expenditure in R&D is a very common measurement of firms’ technological activities, it does have limitations. Firms may well expend on R&D, although they may not in fact be innovating. That is, expenditures may or may not lead to innovation.

In our analysis, we use two clusters of firms. In the first cluster, we distinguish exporters (including partially and fully exporting firms) from non-exporters. In the second cluster, we distinguish firms devoting their entire production to exports from others (partially exporting firms and non-exporters). The rationale for this distinction is driven by a peculiarity of the Tunisian manufacturing sector: almost 70% of exports come from the offshore sector in which firms are mainly subcontractors (Jacobson and Lindberg, 2005) benefiting from several advantages including technological advances and export guarantees. Moreover, pooling partially and fully exporting firms may well mask more than real features of fully exporting firms.

Table 1 presents variable definitions and summary statistics for our main variables in the empirical analysis. About 47% of the firms in our sample are exporters, and 31% of the firms export 100% of their output. Eleven per cent of the firms carry out R&D.

Table 2 reports proportions of firms that undertake each combination of the activities and the transition rates between pairs of activities over time. Several patterns are clear. First, there is significant persistence for some activities. Of the firms that did neither activity in 2004 (resp. 2008), 0.795 (resp. 0.802) are in the same category in 2005 (resp. 2006). Similarly, between 77% and 81% of the firms that export but do not innovate remain in that category in the following year. Hence, there is strong persistence in exporting.

Second, a relatively large share of the firms engaged in R&D activity but not exports would move to the category “no exporting and no R&D” in the following year; only between 8% and 17% of the firms belonging to this group would stay in the same category.
| Variable       | Description                                | Observations | Mean       | Standard deviation | Minimum | Maximum |
|---------------|--------------------------------------------|--------------|------------|--------------------|---------|---------|
| **Firm characteristics** |                                            |              |            |                    |         |         |
| SIZE_1        | Number of employees (lagged)               | 2735         | 191.25     | 540.28             | 0       | 9950    |
| AGE_1         | Years in operation (lagged)                | 2735         | 20.165     | 14.454             | 1       | 142     |
| SALES         | Total sales, in constant (2004) US dollars | 2735         | 1.65e + 07 | 9.24e+07           | 1       | 2.30e + 09 |
| CAPITAL_1     | Financial resources, in constant (2004) US dollars (lagged) | 2734 | 2.92e + 07 | 1.92e+08           | 0       | 3.81e + 09 |
| PRODUCTIVITY_1| Value-added per employee, in constant (2004) US dollars (lagged) | 2719 | 104,212.9  | 319,527.2          | 0       | 7.5e + 07 |
| FOREIGN_1     | Dummy (lagged): 1 if any foreign ownership; 0 otherwise | 2736 | 0.190      |                    |         |         |
| **Exporting** |                                            |              |            |                    |         |         |
| ANYEXP        | Dummy: 1 if firm is an exporter; 0 otherwise | 2736 | 0.474      |                    |         |         |
| TOTEXP        | Dummy: 1 if firm exports 100% of its output; 0 otherwise | 2701 | 0.306      |                    |         |         |
| RD            | Dummy: 1 if firm has positive R&D expenditures; 0 otherwise | 2736 | 0.107      |                    |         |         |
| **Exporting and R&D combined** |                                            |              |            |                    |         |         |
| ANYEXPONLY_1  | Dummy (lagged): 1 if ANYEXP = 1 and RD = 0; 0 otherwise | 2735 | 0.416      |                    |         |         |
| RDAYEXP_1     | Dummy (lagged): 1 if ANYEXP = 1 and RD = 1; 0 otherwise | 2735 | 0.05704    |                    |         |         |
| RDONLY_1      | Dummy (lagged): 1 if ANYEXP = 0 and RD = 1; 0 otherwise | 2735 | 0.0501     |                    |         |         |
| RDTOTEXP_1    | Dummy (lagged): 1 if TOTEXP = 1 and RD = 1; 0 otherwise | 2735 | 0.0325     |                    |         |         |
| TOTEXPONLY_1  | Dummy (lagged): 1 if TOTEXP = 1 and RD = 0; 0 otherwise | 2735 | 0.296      |                    |         |         |
| **Sector**    |                                            |              |            |                    |         |         |
| ELECT         | Dummy: 1 if electricity sector; 0 otherwise | 2736 | 0.0351     |                    |         |         |
| TEXILE        | Dummy: 1 if textile sector; 0 otherwise    | 2736 | 0.239      |                    |         |         |
| ENER_MIN_MISCEL| Dummy: 1 if other sector; 0 otherwise      | 2736 | 0.661      |                    |         |         |
| AGROFOOD      | Dummy: 1 if agrofood sector; 0 otherwise   | 2736 | 0.0636     |                    |         |         |

*Source: Compilation of variables and calculations made by the authors.*
in the subsequent year. These statistics indicate weak persistence in R&D. This can reflect the specificity of innovation activity in Tunisia (and may be other developing countries), for which innovation seems to be rather an adoption of foreign technologies that require more adaptation effort to the domestic context. Moreover, exporting firms involved in R&D activities in 2004 (resp. 2005) will continue to export but abandon R&D in 2005 (resp. 2006) with a probability 0.845 (resp. 0.756). These findings reinforce previous conclusions about the persistence of exporting and the weak persistence of R&D.

Third, exporting firms have a 0.155 (resp. 0.159) probability of adding R&D investment as a second activity in 2005 (resp. 2006). Firms performing R&D and exporting activities in 2005 will continue with a probability of 0.205 in 2006. These statistics suggest that there are complementarities between exporting and R&D decisions, suggesting that R&D and exporting should be modelled jointly.

### 3. Exporting, innovation and firm performance: conceptual framework

#### 3.1 Modelling R&D and exporting

The empirical model for exporting relates the probability of firm $i$ exporting in period $t$ to lagged exporting, lagged R&D and firm characteristics, including the firm’s age, size, labour productivity, capital intensity and foreign capital-owning status. The probit models for the first and second clusters of firms are given by equations (1) and (2), respectively:

$$\text{Prob}(\text{ANYEXP}_{i,t} = 1) = \Phi(\text{ANYEXP}_{i,t-1}, \text{RD}_{i,t-1}, Z_{i,t-1})$$

and

$$\text{Prob}(\text{TOTEXP}_{i,t} = 1) = \Phi(\text{TOTEXP}_{i,t-1}, \text{RD}_{i,t-1}, Z_{i,t-1})$$

Table 2: Transition Patterns for R&D and Exporting$^a$

| Status year $t-1$ | Status year $t$ | Year | No exporting and no R&D | Exporting but no R&D | R&D but no exporting | Exporting and R&D |
|-------------------|-----------------|------|--------------------------|----------------------|---------------------|------------------|
|                   |                 | 2005 | 0.795                    | 0.053                | 0.139               | 0.012            |
|                   |                 | 2005 | 0.802                    | 0.041                | 0.145               | 0.012            |
| No exporting and no R&D | 2004 | 0.026 | 0.805                    | 0.014                | 0.155               | 0.155            |
|                   |                 | 2005 | 0.063                    | 0.773                | 0.0047              | 0.159            |
| Exporting but no R&D | 2004 | 0.77    | 0.046                    | 0.172                | 0.0115              | 0.0115           |
|                   |                 | 2005 | 0.875                    | 0.0375               | 0.075               | 0.0125           |
| R&D but no exporting | 2004 | 0.056 | 0.845                    | 0.014                | 0.0845              | 0.205            |
|                   |                 | 2005 | 0.038                    | 0.756                | 0.00                | 0.205            |

Source: Authors’ calculations.

$^a$Any exporting, including partially and fully exporting firms.
where $\text{ANYEXP}_{i,t-1}$ and $\text{TOTEXP}_{i,t-1}$ are the lagged export status for any exporting firms (including partially and fully exporting firms) and fully exporting ones, respectively; $\text{RD}_{i,t-1}$ is the lagged investment in R&D activities; $Z_{i,t-1}$ is a vector of lagged control variables capturing firm characteristics; and $i$ and $t$ are firm and time indices, respectively. In order to estimate the degree of persistence and cross-persistence of exports and R&D, we include lagged variables for both in the regression. The coefficient on lagged R&D captures whether innovating firms are more or less likely to be exporters. Following the literature, the model allows for dynamics in the form of a lagged dependent variable (for instance, see Bigsten et al., 2004; Damijan and Kostevc, 2006; Keiko and Lechevalier, 2010; Nickell, 1996) to capture state dependence and also to make serial correlation of the error term less likely. Previous export participation accounts for fixed and sunk costs associated with entering the export market (see Roberts and Tybout, 1997). For example, the costs of collecting information on foreign markets and creating sales channels in foreign countries are likely lower for exporters than for non-exporters. These costs represent a barrier for entry and, as consequence, can induce state dependence.

We also assume that export participation depends on lagged productivity, firm size and capital intensity. Firm size, measured as the number of employees, has a fixed-cost interpretation as exporting is typically associated with fixed costs that are too high for small firms to incur (Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013). For instance, it may be necessary for the exporting firm to set up a marketing department to investigate marketing channels, meet export orders, etc. Firm size might also indicate the size of the scale of production, which may affect exports positively (Golovko and Valentini, 2011; Esteve-Pérez and Rodríguez, 2013). Lagged labour productivity is included in the model as a proxy of firms’ efficiency, in order to capture a potential self-selection process by which certain firms choose to export because they are relatively efficient. Foreign participation in firms’ capital is an important control variable as foreign firms may have better access to financial resources, knowledge and technology—factors that are expected to affect exporting positively. The effect on exports of firm age, measured as the number of years in operation, is ambiguous. On the one hand, older firms are more likely to have the required resources (financial and knowledge) to export; on the other hand, if younger firms are more flexible, aggressive and proactive, there could be a negative relationship between age and exporting (Esteve-Pérez and Rodríguez, 2013). We also include a set of sector and year dummies to control for the industry heterogeneity and macroeconomic conditions common to all firms.

Investment in R&D is modelled in line with Aw et al. (2008) and Girma et al. (2008) who ascribe similar determinants to R&D and exporting status. The innovation equation is thus modelled as a probit regression of firm $i$ investing in R&D activity in period $t$ on lagged investment in R&D, exporting and other firm characteristics (similar to those used in the exporting equation). The estimation procedures for the first and second clusters of firms are given by equations (3) and (4), respectively:

$$\text{Prob}(\text{RD}_{i,t} = 1) = \Phi(\text{ANYEXP}_{i,t-1}, \text{RD}_{i,t-1}, Z_{i,t-1})$$

(3)

and

$$\text{Prob}(\text{RD}_{i,t} = 1) = \Phi(\text{TOTEXP}_{i,t-1}, \text{RD}_{i,t-1}, Z_{i,t-1})$$

(4)
where \(Z_{i,t-1}\) is the same vector of control variables used for the exporting equation. The key variable in this equation is the lagged exports, whose coefficient captures whether exporting firms are more or less likely than non-exporters to be innovators. The lagged exports' variable captures the learning-by-exporting effect, i.e. the potential positive impact of the stock of knowledge accumulated externally through exporting on new R&D expenditure (Girma et al., 2008). Is state dependence expected for innovation? Peters (2009) emphasises a kind of “success breeds success” effect to explain why state dependence is expected for innovation, suggesting that successful innovations would stimulate subsequent innovations resulting from increasing market power or/broader technological opportunities. Another potential reason for this state dependence may result from fixed and sunk costs associated with R&D activities. Such costs could include costs of researching promising technologies, creating R&D divisions and searching for people who could conduct these activities. Costs like these are probably lower for those firms that had previously conducted these activities. Productivity is included to capture a selection effect that results from the direct effect of productivity on the profitability of investing in R&D. Size is a potentially important determinant of R&D activities, but its impact in stimulating subsequent innovation is ambiguous. On average, larger firms may have more financial capabilities to invest in R&D (Golovko and Valentini, 2011), as they are likely to have a better access to credit markets and may enjoy a larger set of non-financial resources (managerial, scale economies). Nevertheless, small firms may have an advantage in innovation. For example, they may have more flexibility in coping with the evolution of competitive environments and may enjoy more flexible management structures (Esteve-Pérez and Rodríguez, 2013). Similarly AGE is a potentially important determinant of R&D activities, but its effect on subsequent innovation is ambiguous. On the one hand, older firms may have more financial resources and may be more experienced in conducting these activities. On the other hand, older individuals may be more rooted in traditional practices and therefore be less receptive to innovative techniques, in which case there will be a negative relationship between age and R&D. Foreign participation has an unclear effect on R&D investment, as innovative activities may take place in the parent firm, allowing the subsidiary firm to benefit from this available stock of knowledge and financial resources to carry its own R&D activities (Esteve-Pérez and Rodríguez, 2013).

The next step in the analysis involves investigating whether there is complementarity between investment in R&D and exports. Following Aw et al. (2008), Girma et al. (2008), Golovko and Valentini (2011) and Esteve-Pérez and Rodríguez (2013), we model joint decisions to export and to invest in R&D using a bivariate probit regression. The bivariate probit allows for correlation between the error terms (Esteve-Pérez and Rodríguez, 2013), which may arise given the high serial correlation and the inter-dependence between exports and R&D. In this model, the simple export and R&D dummies are replaced by a vector of mutually exclusive dummy variables \(D\) capturing the combination of the export and R&D activities in the previous year (Golovko and Valentini, 2011):

\[
D = \{\text{RDONLY}_{i,t-1}, \text{ANYEXPONLY}_{i,t-1}, \text{TOTEXPONLY}_{i,t-1}, \text{RDANYEXP}_{i,t-1}, \\
\text{RDTOTEXP}_{i,t-1}\}.
\]
The empirical model given by equations (5) and (6) and equations (7) and (8) for the first and second cluster of firms, respectively, relates probabilities of firm \( i \) exporting and innovating in period \( t \) to lagged firm characteristics:

\[
\text{Prob}(R\&D_{i,t} = 1) = \Phi(\text{ANYEXPONLY}_{i,t-1}, R\text{DONLY}_{i,t-1}, R\text{DANYEXP}_{i,t-1}, Z_{i,t-1})
\]  

\( (5) \)

\[
\text{Prob}(\text{ANYEXP}_{i,t} = 1) = \Phi(\text{ANYEXPONLY}_{i,t-1}, R\text{DONLY}_{i,t-1}, R\text{DANYEXP}_{i,t-1}, Z_{i,t-1})
\]  

\( (6) \)

and

\[
\text{Prob}(R\&D_{i,t} = 1) = \Phi(T\text{OTEXPONLY}_{i,t-1}, R\text{TOTEXP}_{i,t-1}, Z_{i,t-1})
\]  

\( (7) \)

\[
\text{Prob}(\text{TOTEXP}_{i,t} = 1) = \Phi(T\text{OTEXPONLY}_{i,t-1}, R\text{TOTEXP}_{i,t-1}, Z_{i,t-1})
\]  

\( (8) \)

The coefficients on the dummies in the vector \( D \) show whether previous R&...with R&D in the current period are more likely to become an exporter in the next period than firms that are engaged in neither activity. Similarly, firms not engaged in R&D but exporting in the current period are more likely to conduct R&D in the next period than firms that are engaged in neither activity. We can also expect that firms engaged in R&D and exporting are more likely to continue R&D or exporting than firms doing R&D (exporting) only.

3.2 The impact of exports and R&D on firm performance

Next, we investigate the impact of exporting and R&D on firm performance. Following Golovko and Valentini (2011) and other studies, we use the firm’s sales growth as a measure of performance. We replace the simple export and R&D dummies by the vector of mutually exclusive dummy variables \( D \). In order to account for possible endogeneity of export and innovation decisions, we estimate the model using a fixed effects approach. To correct for serial correlation, we use firm-level clustered standard errors. The models for the first and second clusters are given by equations (9) and (10), respectively:

\[
\text{Salesgrowth}_{i,t} = f\left(\text{ANYEXPONLY}_{i,t-1}, R\text{DONLY}_{i,t-1}, R\text{DANYEXP}_{i,t-1}, Z_{i,t-1}\right)
\]  

\( (9) \)

and

\[
\text{Salesgrowth}_{i,t} = f\left(\text{TOTEXPONLY}_{i,t-1}, R\text{TOTEXP}_{i,t-1}, Z_{i,t-1}\right)
\]  

\( (10) \)

where \( Z_{i,t-1} \) is the same vector of control variables used in the previous section.
In this model, previous export participation (\(ANYEXPONLY_{i,t-1}\) and \(TOTEXPONLY_{i,t-1}\)) is included to capture efficiency gains (learning) from exporting. There is evidence of the learning-by-exporting effect whenever coefficients of these variables are positive and statistically significant. Complementarities between exporting and R&D decisions are expected to positively affect sales growth, possibly because the innovative exporting firms are likely to increase their sales by supplying higher quality products on export markets. Whenever R&D and export involvement have complementary effects on the firm’s performance, the parameters’ estimates of \(RDANYEXP_{i,t-1}\) (for the first cluster of firms) and \(RDTOTEXP_{i,t-1}\) (for the second cluster) are positive and statistically significant.

4. Empirical results

In this section, we consider the independent and joint decisions to export and to innovate and thus report results of the univariate and bivariate models. We then report the results concerning the connections between exports and R&D investment and the firm’s performance. All empirical results should be interpreted as indicating partial correlations and not necessarily causation.

Table 3 shows average marginal effects (based on probit regressions) for the exporting and innovation equations. All the underlying specifications allow for a quadratic effect of productivity (which is taken into account in the computation of the marginal effect).

4.1 Estimates of exporting activity (exporting equation)

4.1.1 Exporters versus non-exporters

Lagged exporting is associated with a relatively high probability of current exporting. The average marginal effect is 0.28, implying that if we compare two otherwise identical firms, the one that exported in the previous period is 28% points more likely to export in the current period than the firm that did not. This result is consistent with the sunk-cost line of reasoning. Productivity has a small positive, and marginally significant, effect on the likelihood of exporting. Thus, there is some evidence of self-selection into exporting, consistent with the findings of Bernard and Jensen (1999b) and Greenaway and Kneller (2007). The likelihood of becoming an exporter further increases with firm size. This may be because large firms produce and sell on a large scale or because they enjoy lower fixed exporting costs than small firms. This is in line with the findings of Helpman et al. (2004). The positive and significant coefficient of \(FOREIGN_1\) is also along expected lines.

The coefficients of sector dummies \(ELECT\) and \(TEXTILE\) are positive and significant, with the coefficient of \(TEXTILE\) more than two times larger than that of \(ELECT\). This indicates that these two sectors are the most involved in foreign markets as compared to the remaining sectors, with a higher involvement of the textile sector, although fully exporting firms in both sectors are mainly subcontractors benefiting from similar advantages. While the textile sector has benefited from subcontracting regime since the beginning of the 1970’s, the electronics sector has only emerged recently, meaning that textile firms have longer previous exporting experience that may allow them to produce at a larger scale and satisfy higher demand trends. Finally, the coefficient of the year dummy, \(YEAR 2004\), is positive. The point estimate indicates that the underlying likelihood of exporting was 0.037% points higher in 2004 than in 2005.
4.1.2 Fully exporting firms versus others

The positive and significant effect of lagged exporting is along expected lines. Moreover, the marginal effect increases considerably (0.28–0.69) as compared to the previous setting that may be associated with a larger scale of production of these firms. This argument is strengthened by the positive and highly significant coefficient of SIZE_1, implying that large firms have large fixed costs associated with production and are very likely to engage in large-scale production. Besides, the marginal effect of lagged size decreases from 0.087 to 0.05 as compared to previous setting, suggesting that fixed costs associated with exporting are somewhat less important for fully exporting firms. The results imply little support for self-selection into exporting, since the productivity effect is statistically insignificant. This finding does not imply that fully exporting firms do not exhibit high productivity to self-select into export markets, but it rather arises from the peculiarity of Tunisian manufacturing firms that might mainly be subcontractors. For such firms to benefit from this (subcontracting) regime, they should enjoy ex ante efficiency advantages. Hence, they are likely to be the most competitive and also the most technologically advanced. The coefficient of FOREIGN_1 is positive and highly significant as expected. The coefficient of AGE_1 is still negative but now statistically

Table 3: Exporting and Innovation Equations—Marginal Effects (Univariate Probit Estimation)

| Independent variable | Exporting equation | Innovation equation |
|----------------------|--------------------|---------------------|
|                      | Exporters versus non-exporters | Fully exporting firms versus others |
|                      | Exporters versus non-exporters | Fully exporting firms versus others |
| ANYEXP_1/TOTEXP_1    | 0.278***          | 0.69***           | -0.0046 | 0.0213 |
|                      | (0.022)           | (0.05)            | (0.011) | (0.019) |
| R&D_1                | 0.0157            | 0.02              | -0.003  | -0.004 |
|                      | (0.039)           | (0.04)            | (0.016) | (0.016) |
| SIZE_1               | 0.087***          | 0.05***           | -0.032*** | -0.033*** |
|                      | (0.0203)          | (0.019)           | (0.008) | (0.008) |
| AGE_1                | -0.011            | -0.06***          | -0.024*** | -0.022*** |
|                      | (0.0186)          | (0.017)           | (0.006) | (0.007) |
| CAPITAL_1            | -0.034**          | 0.034***          | 0.013**  | 0.014** |
|                      | (0.016)           | (0.015)           | (0.006) | (0.006) |
| PRODUCTIVITY_1       | 0.031†            | 0.025             | -0.027*** | -0.028*** |
|                      | (0.016)           | (0.02)            | (0.006) | (0.006) |
| FOREIGN_1             | 0.426***          | 0.22***           | 0.01     | 0.002 |
|                      | (0.049)           | (0.042)           | (0.015) | (0.016) |
| TEXTILE              | 0.429***          | 0.144**           | -0.024   | -0.035 |
|                      | (0.07)            | (0.05)            | (0.025) | (0.027) |
| ELECT                | 0.17**            | -0.012            | 0.075    | 0.066 |
|                      | (0.066)           | (0.066)           | (0.033) | (0.033) |
| ENER_MIN_MISCEL      | -0.22***          | -0.111**          | -0.019   | -0.02 |
|                      | (0.05)            | (0.047)           | (0.022) | (0.022) |
| YEAR 2004            | 0.037**           | -0.03             | -0.013   | -0.013 |
|                      | (0.018)           | (0.028)           | (0.010) | (0.010) |
| No. of observations  | 2678              | 2667              | 2678     | 2678 |

Source: Authors’ calculations.
Note: Heteroskedasticity-robust standard errors (clustered within a firm) are in parentheses.
*, ** and *** denote variables significant at 10%, 5% and 1%, respectively.
significant. Hence, young firms are more likely to be fully exporting than old firms. The estimated coefficient of the TEXTILE dummy is positive and significant, although the marginal effect is somewhat smaller than the previous one.

4.2 Estimates of innovation activity (innovation equation)

4.2.1 Exporters versus non-exporters

The coefficients of lagged exporting and investment in R&D activities are negative but statistically insignificant. Firm size negatively affects the R&D decision (its coefficient is significant at less than 1%). This is in line with the findings of Esteve-Pérez and Rodríguez (2013) in that smaller firms may be more innovative as they are more flexible in coping with the evolution of competitive environments and may also enjoy more flexible management structures.

As noted in the previous sections, older firms may be less innovative than young firms. This conjecture is supported by the negative coefficient of AGE_1. The coefficients of the linear and quadratic terms of labour productivity are negative and positive, respectively, and they are both statistically significant at less than 5% (results not shown). This suggests that a positive effect of PRODUCTIVITY_1 only emerges after a certain threshold, possibly because R&D activity may require some learning phase for labour to take its full effect in increasing the incentives to perform the corresponding activity. The estimated marginal effect of productivity, evaluated at sample means and with both the linear and the quadratic terms taken into account, is actually negative and significant at the 5% level. The coefficient of CAPITAL_1 is positive and significant. The coefficient of the sector dummy ELECT is positive and strongly significant. Firms in this sector are heavily dependent on technological advancement, increasing their incentives to innovate. The coefficients of the remaining control variables are insignificant.

4.2.2 Fully exporting firms versus others

The coefficient of lagged R&D remains negative as in the first cluster, but the coefficient on lagged exporting becomes positive, although both coefficients remain statistically insignificant. Firm size reduces the incentives to conduct R&D, and older firms are less prone to engage in innovation activities and the marginal effect increases slightly (from −0.024 to −0.022). After a certain threshold, labour productivity has a positive effect on the R&D decision, but on average the marginal effect of labour productivity is negative. Capital has a positive and significant effect on innovation. Similar to the results above, the estimated coefficient of the sector dummy ELECT is positive and statistically significant. The year dummy for 2004 is insignificant.

4.3 Estimates of complementarities between exporting and R&D activities

Table 4 summarises the estimates of complementarities between exporting and R&D activities for the two clusters of firms.

4.3.1 Exporters versus non-exporters

Compared to firms not engaged in exporting or innovation, firms that innovate but do not export are more likely to export in subsequent periods. This result implies there are complementarities between R&D and exporting. As for firms doing both activities, they are likely
to continue exporting, although the coefficient of \textit{RDANYEXP\_I} is smaller than that of \textit{ANYEXPONLY\_I}.

The results for the remaining control variables are similar to those shown in Table 3. \textit{AGE\_I} reduces the incentives to investment in R&D activities (but has no impact on exporting); the sector dummy \textit{TEXTILE} increases exporting (but has no impact on R&D); the sector dummy \textit{ELECT} positively affects both decisions; Size affects exporting positively and R&D decision negatively; the year dummy increases the incentives to export (but no impact on R&D) and the sector dummy \textit{ENER_MIN_MISCEL} negatively affects

\begin{table}[h]
\centering
\begin{tabular}{lcccc}
\hline
Independent variable & Exporters versus non-exporters & Fully exporting firms versus others \\
& Exporting decision & R&D decision & Exporting decision & R&D decision \\
\hline
\textit{RDONLY\_I} & 0.3075\textsuperscript{**} & -0.09426 & & \\
& (0.123) & (0.157) & & \\
\textit{ANYEXPONLY\_I} & 0.754\textsuperscript{***} & -0.0457 & 0.781\textsuperscript{***} & -0.1438 \\
/\textit{TOTEXPONLY\_I} & (0.0617) & (0.0778) & (0.0875) & (0.088) \\
\textit{RDANYEXP\_I} & 0.525\textsuperscript{***} & 0.00049 & 0.7055\textsuperscript{***} & -0.0343 \\
/R\textit{DOTEXP\_I} & (0.1316) & (0.144) & (0.1879) & (0.173) \\
\textit{SIZE\_I} & 0.217\textsuperscript{***} & -0.2126\textsuperscript{***} & 0.3257\textsuperscript{***} & -0.232\textsuperscript{***} \\
& (0.051) & (0.05) & (0.07227) & (0.0512) \\
\textit{AGE\_I} & -0.03 & -0.1547\textsuperscript{***} & -0.28\textsuperscript{***} & -0.17\textsuperscript{***} \\
& (0.046) & (0.046) & (0.0573) & (0.0459) \\
\textit{CAPITAL\_I} & -0.0826\textsuperscript{**} & 0.0852\textsuperscript{**} & -0.30148\textsuperscript{***} & 0.1\textsuperscript{**} \\
& (0.0396) & (0.04) & (0.0547) & (0.04) \\
\textit{PRODUCTIVITY\_I} & 0.2508 & -0.567\textsuperscript{***} & -0.1704 & -0.6507\textsuperscript{***} \\
& (0.237) & (0.182) & (0.279) & (0.2) \\
\textit{PRODUCTIVITY\_I} squared & -0.00826 & 0.0185\textsuperscript{**} & 0.0136 & 0.02156\textsuperscript{**} \\
& (0.011) & (0.01) & (0.0136) & (0.01) \\
\textit{FOREIGN\_I} & 1.0643\textsuperscript{***} & 0.0675 & 1.519\textsuperscript{***} & 0.098 \\
& (0.124) & (0.0967) & (0.137) & (0.0987) \\
\textit{TEXTILE} & 1.0815\textsuperscript{***} & -0.1557 & 1.633\textsuperscript{***} & -0.157 \\
& (0.167) & (0.166) & (0.232) & (0.167) \\
\textit{ELECT} & 0.4252\textsuperscript{*} & 477\textsuperscript{**} & 0.7179\textsuperscript{**} & 0.472\textsuperscript{**} \\
& (0.238) & (0.2138) & (0.285) & (0.2137) \\
\textit{ENER\_MIN\_MISCEL} & -0.561\textsuperscript{***} & -0.1246 & -0.3 & -0.14 \\
& (0.1287) & (0.1417) & (0.22) & (0.142) \\
\textit{YEAR 2004} & 0.0935\textsuperscript{**} & -0.084 & 0.1 & -0.093 \\
& (0.0451) & (0.0676) & (0.0625) & (0.068) \\
\textit{CONSTANT} & -1.823 & 0.745\textsuperscript{***} & 2.465 & 3.213\textsuperscript{***} \\
& (1.301) & (1.028) & (1.6) & (1.1056) \\
\hline
\text{Wald }\chi^2 (p\text{-value} > \chi^2) & 1.077 (0.299) & 0.2938 (0.5878) & \\
\text{No. of observations} & 2678 & 2678 & 2667 & 2667 \\
\hline
\end{tabular}
\caption{Estimates of Complementarities Between Exporting and R&D Decisions—Bivariate Probit Estimation}
\end{table}

Source: Authors’ calculations.

Note: Heteroskedasticity-robust standard errors (clustered within a firm) are in parentheses.

*, ** and *** denote variables significant at 10%, 5% and 1%, respectively.
4.3.2 Fully exporting firms versus others
In this cluster, firms involved in both R&D and exporting tend to continue to export in the current period. The coefficient of $RDTOTEXP_1$ is somewhat smaller compared to the coefficient of $TOTEXPOONLY_1$, providing little evidence about complementarities between R&D and exporting decisions. The exporting behaviour of fully exporting firms (these are mainly subcontractors) appears to be shaped more by export arrangements rather than by the interaction between R&D and exports activities. Previous innovation or exporting activity does not appear to impact current R&D.

The results for the remaining control variables are similar to those shown in Table 3. Still, some differences arise in the bivariate model compared to the univariate models, particularly for the sector dummy $ENER_MIN_MISCEL$ whose coefficient reduces to insignificance in the bivariate model (although it was significant in the exporting equation). In addition the sector dummy $ELECT$ positively affects both activities in the bivariate model, although it had no impact on exporting in the univariate equation.

4.4 Estimates of the influence of exports and R&D on the firm performance
Table 5 summarises the estimates of the independent and joint impact of exporting and R&D decisions on sales growth.

4.4.1 Exporters versus non-exporters
There is little evidence of complementarities between exporting and R&D decisions on the firm’s performance. There is also weak evidence of learning by exporting: partially exporting firms seem to acquire no efficiency gains from exporting. However, this may arise from the peculiarity of the Tunisian manufacturing sector (where 70% of exports come from the offshore sector) and from the structure of our data sets characterised by a large percentage of fully exporting firms that might be mainly subcontractors enjoying export guarantees. This may well mask most of the efficiency gains from exporting. Larger firms tend to have lower sales growth rates than smaller firms. Labour productivity has a non-linear effect on growth and increases sales growth only after a certain threshold. Sales growth was 5.5% lower in 2004 compared to 2005, conditional on the other explanatory variables.

4.4.2 Fully exporting firms versus others
The positive and significant coefficient of $RDTOTEXP_1$ indicates that firms involved in both exporting and R&D activities have a higher average sales growth rate than firms that do not export and innovate. This result suggests that R&D and export involvement have complementary effects on the firm’s performance. The coefficient of $TOTEXPOONLY_1$ is negative and insignificant. This finding does not imply that fully exporting firms do not have efficiency gains from exporting, but it rather arises from the peculiarity of Tunisian manufacturing firms that might be mainly subcontractors with relatively long exporting experience. Hence, they are likely to experience a gradual decline in the scope for learning. After a certain threshold, $PRODUCTIVITY_1$ increases sales growth. Moreover, coefficients of the linear and quadratic terms of $PRODUCTIVITY_1$ are slightly larger in absolute value as
compared to the previous cluster, probably because fully exporting firms that are known to be larger on average may produce and sell at a larger scale.

5. Conclusions

This study has investigated the interdependence between exporting and R&D, and whether and how this interdependence affects sales growth. The empirical analysis was based on the data on 1323 Tunisian manufacturing firms for the period 2004–06. These data were obtained in accounting, industrial, and exporting flow surveys. We distinguished between

### Table 5: Predictors of Sales Growth—Fixed Effects Estimation

| Independent variable          | Exporters versus non-exporters | Fully exporting firms versus others |
|------------------------------|--------------------------------|-----------------------------------|
| **RDONLY_1**                 | −0.01547                       |                                   |
|                              | (0.0757)                       |                                   |
| **RDANYEXP_1/ RDTOTEXP_1**   | 0.0972                         | 0.102*                            |
|                              | (0.064)                        | (0.06)                            |
| **ANYEXPONLY_1/TOTEXPONLY_1**| −0.0027                        | −0.0135                           |
|                              | (0.0186)                       | (0.0258)                          |
| **SIZE_1**                   | −1.0237***                     | −1.022***                         |
|                              | (0.1)                          | (0.096)                           |
| **AGE_1**                    | 0.0206                         | 0.0243                            |
|                              | (0.04)                         | (0.04)                            |
| **CAPITAL_1**                | −0.252*                        | −0.255*                           |
|                              | (0.1436)                       | (0.1445)                          |
| **FOREIGN_1**                | −0.002                         | −0.00517                          |
|                              | (0.0908)                       | (0.09)                            |
| **PRODUCTIVITY_1**           | −1.957***                      | −1.968***                         |
|                              | (0.3868)                       | (0.383)                           |
| **PRODUCTIVITY_1 squared**   | 0.0388**                       | 0.04**                            |
|                              | (0.0172)                       | (0.0173)                          |
| **TEXTILE**                  | 0.036                          | 0.03                               |
|                              | (0.127)                        | (0.124)                           |
| **ELECT**                    | −0.733**                       | −0.753***                         |
|                              | (0.2)                          | (0.2)                             |
| **ENER_MIN_MISCEL**          | −0.022                         | −0.0353                           |
|                              | (0.032)                        | (0.04)                            |
| **YEAR 2004**                | −0.0553***                     | −0.0548***                        |
|                              | (0.017)                        | (0.0168)                          |
| **CONSTANT**                 | 24.46***                       | 24.547***                         |
|                              | (3.586)                        | (3.532)                           |
| R² within                    | 0.6441                         | 0.6437                            |
| No. of observations          | 2667                           | 2667                              |

*Source*: Authors’ calculations.

*Note*: Heteroskedasticity-robust standard errors (clustered within a firm) are in parentheses.

*, ** and *** denote variables significant at 10%, 5% and 1%, respectively.
two clusters of firms: (a) exporters (including partially and fully exporting firms) versus non-exporters and (b) fully exporting firms versus others. The analysis brought evidence of self-selection in exports for the first cluster of firms. However, there is little or no support for learning-by-exporting effects. Results were consistent with complementarities between exporting and R&D decisions for the exporting activity for the first clusters of firms. Moreover, the R&D and export involvement have complementary effects on the firm’s sales growth for fully exporting firms only.

We believe our research has some implications for understanding the dynamics of exporting and innovation in developing countries with features similar to the Tunisian economy. First, our results suggest that the subcontracting regime characterising most of the fully exporting firms in our sample might either mask or impede the interaction between R&D and exporting, as exporting behaviour is shaped by strict export arrangements. Second, the results show that even in economies characterised by R&D activities whose main purpose is to enhance the firm’s absorptive capacity, rather than to innovate, there is some evidence of a complementary effect between R&D and exporting on future exporting and firm performance. This highlights the benefits of combining R&D and exporting. One could then expect greater benefits whenever R&D investments aim to innovate.

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