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# Determinants of sector competitiveness and implications for the EU food & drink manufacturing industries


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Focus Area: Effective Food Chain Management

## Determinants of sector competitiveness and implications for the EU food & drink manufacturing industries

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### Executive Summary

Possible determinants of the competitiveness of the food and drink (F&D) manufacturing sector (NACE 15.x, 10 industries) in 13 EU countries are analyzed empirically, using 1995-2002 Eurostat data, which is divided in two sub-periods. Apart from the identification of possible competitiveness-influencing factors, the analysis aims at quantifying the strength and direction of their impact and at exploring the interrelationships between the different competitiveness indicators. The used indicators include available measures for industry-level productivity, profitability and output growth. Due to data-quality concerns, only a limited set of meso-level determinants is used: investment intensity, industry specialization, average company size and export orientation, in addition to country, industry and period memberships as additional explaining categorical variables. Given the particular data structure, parameters are estimated by unbalanced panel fixed-effects regression.

Overall, the estimation results suggest that investments and average company size have a positive impact on manufacturing productivity. Sector profitability is mainly explained by productivity, in addition to company size and specialisation, which have negative impacts. The main determinant for output growth is profitability, while export orientation is determined by output growth (positively), productivity (positively) and company size (negatively). In all regressions, the country and industry control factors come out as highly significant, implying that the used determinants are not sufficient to explain the whole picture and more variables need to be included once reliable data on them becomes available. The period factor is only significant in the productivity regression, which may be interpreted as technical progress since in period two (1999-2002) real productivity levels are significantly higher than in period one (1995-1998).

The main implication arising from the analysis is that, in fact, competitiveness is complex in nature and characterised by important interrelationships between determinants and indicators. Both business leaders and policy makers need to be aware that, given these interrelationships, improving competitiveness in practice is not easy. The very heart of sector competitiveness is productivity – all other performance dimensions seem to depend on it, directly and indirectly. Enhancing productivity should therefore be at the top of agribusiness managers' priorities. Nonetheless, it is obvious that competitiveness is not solely about efficiency ("doing things right") but also about effectiveness ("doing the right things"), and only the combined effect of both will result in superior profitability. Effective strategic decisions on investments (including R&D), the extent to which a company should specialise or diversify, the right size of a company, etc. are all crucial and directly affect productivity as well as the other investigated performance dimensions, such as profitability and output growth. Another important finding of our analysis is that export orientation may result directly and indirectly from superior productivity, rather than being an input factor for it. This clearly implies that agribusiness managers should only consider internationalisation activities when they have reached superior productivity levels. Otherwise, the international expansion activities may not be economically sustainable.

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## Abstract

Possible determinants of the competitiveness of the food and drink (F&D) manufacturing sector (NACE 15.x, 10 industries) in 13 EU countries are analyzed empirically, using 1995-2002 Eurostat data, which is divided in two sub-periods. The analysis aims at quantifying the strength and direction of competitiveness-influencing factors and the interrelationships between different competitiveness indicators. Given the particular data structure, parameters are estimated by unbalanced panel fixed-effects regression. The results confirm that most findings from previous, non-F&D industry studies also apply to the EU agribusiness situation. The main implication arising from the analysis is that, the very heart of sector competitiveness is productivity – all other performance dimensions seem to depend on it, directly and indirectly. Enhancing productivity should therefore be at the top of agribusiness managers' priorities. Our findings also support the conclusion that agribusiness managers should only consider internationalisation activities when they have reached superior productivity levels.

## Keywords:

European Union, competitiveness, determinants, food and drink manufacturing industry

## Introduction: problem statement and objectives

The food and drink manufacturing (F&D) industry is Europe's second largest manufacturing sector, as measured by value added (Lienhardt, 2004). It is a relatively fragmented industry with many small and medium-sized companies, as compared to the US food processing industry and most other EU manufacturing sectors. Under its economic significance, it is important for the EU F&D sectors to maintain or to achieve their competitiveness in both EU and third country markets. However, at present, the European food industry faces several structural changes (e.g., competition from emerging countries, multi-lateral trade negotiations and a demanding regulatory environment increasing production costs).

While in the literature there is much agreement on the economic and social importance of competitiveness, it is less clear what exactly competitiveness is and what its most important determinants are (Martin, 2003). While not being an economic subject category per se, the topic is in particular popular in the fields of international business/strategy, international economics, economic geography and applied economics (e.g., agribusiness). Recent collections of common competitiveness definitions can be found in Aiginger (2006), and Fischer and Schornberg (2007). In an attempt to find a unifying, 'meta' definition, Aiginger (2006) refers to competitiveness as "the ability of a country or location to create welfare", while Fischer and Schornberg (2007) see competitiveness as a construct (i.e., a composite concept), covering relative and multidimensional economic performance as indicated by profitability, productivity as well as output growth. In both cases, the importance of distinguishing between competitiveness indicators (which describe the economic result or "outcome") and competitiveness determinants (or "process"; i.e., the inputs necessary to achieve the result), is stressed when dealing with competitiveness. While different definitions of competitiveness exist, most of them aim at taking productivity, profitability and growth as measurable indicators into account. However, the ability to compete in terms of those three competitiveness indicators depends on a number of factors and is determined by the entire food chain.

Having reliable knowledge about competitiveness determinants is important for both business strategy generation and policy making. Business leaders need to know what affect their corporate success and policy makers must understand how they effectively can provide support for underperforming industry in order to secure jobs and value creation in the long run.

The purpose of this study is to analyze possible determinants of the competitiveness situation of the EU food and drink (F&D) manufacturing sectors (following the Eurostat NACE classification DA15.x, 10 industries). Thirteen EU countries are analyzed empirically, using 1995-2003 Eurostat data, which is divided in two sub-periods. Apart from the identification of possible competitiveness-influencing factors, the analysis aims at quantifying the strength of their impact and the interaction between some of the competitiveness determinants, too. In this study, we focus on meso level determinants such as investment intensity, research and development efforts, industry specialization, average company size and the extent of foreign market penetration via exports. The paper's structure is as follows. After this introduction, section two briefly reviews previous work on the topic of competitiveness determinants. In the third section, data issues and the estimation method are described. The fourth section discusses the obtained results. The analysis concludes with section five, emphasizing in particular some implications for food industry managers.

## Theory: competitiveness determinants in previous studies

Several determinants potentially having an impact on competitiveness exist. We differentiate between meta-, macro-, meso- and micro-level determinants. Following UNCTAD (2003, p. 13) and for the special case of agricultural export performance of developing countries, meta-level determinants may be grouped into socio-cultural factors and political and economic global framework conditions. Socio-cultural factors are religion, language, values and attitudes as well as general political and economic conditions such as international trade rules set by the WTO. However, since the aim of this analysis is to look at factors that could theoretically be influenced by economic actors (e.g., company leaders in the food industry), and because it seems difficult to influence most of the meta-level factors, those factors will not play any role in our further analysis.

Elements of the macroeconomic, political and legal framework are proposed as being macro-level determinants of competitiveness. Mainly the governance system with its policies is meant here (UNCTAD 2003, p. 13). At the macro level, some well-received studies which use a whole range of different competitiveness determinants are the Global Competitiveness Report by the World Economic Forum (WEF) and the World Competitiveness Yearbook compiled by the Swiss-based International Institute for Management Development (IMD).

As for the analysis of sector competitiveness with 'The Competitive Advantage of Nations' Michael Porter's ambition was to find the reasons 'why nations succeed in particular industries' (Porter 1990, p. 71). As a result, he suggested six determinants serving to enhance a country's competitiveness: factor conditions (e.g., skilled labor, infrastructure), demand conditions (e.g., nature of home demand), related and supporting industries (e.g., presence of internationally competitive supplier industries), firm strategy, structure, and rivalry (e.g., conditions of company creation, organization and management) and government and chance (Porter 1990, p. 71). UNCTAD (2003, p. 13) proposes targeted policies and institutional changes as drivers for strengthening the competitiveness of a(n) (agricultural) sector in a country. Agricultural policy, education policy and environmental policy can be seen as examples for sector policies. Institutional changes can be made by standards organizations, testing and certification bodies, suppliers of inputs and services, and state trading enterprises. "Education and training, marketing support, physical infrastructure, financing, small and medium-scale enterprises support and technology cooperation, integration into technological and institutional networks are further relevant factors" (UNCTAD 2003, p. 13) at the meso level.

Finally, there is quite a large body of literature on success factors of firm performance. One strand of the literature exists in the resource-based view which places emphasis on the internal resources and competencies of the firm. Following this theory, a firm can gain competitiveness if its resources are valuable, rare, hard to imitate and difficult to find substitutes for (Barney 1991, p. 111). UNCTAD (2003, p. 13) states that microeconomic factors refer to the behavior and strategies of individual enterprises, their managerial competence and logistics.

In this study, focus is given to one particular economic sector – EU F&D manufacturing – which makes an adapted competitiveness framework necessary. The structure-conduct-performance (SCP; Bain 1968) approach serves as a basis. This conceptual model is used to link elements of market structure (or more generally: "structure of environment") to business conduct and performance. The structure of the environment is made up by factors on the before mentioned meta-, macro and meso-levels. The conduct of the (sub-)sector refers to its competitive strategy. The performance of an industry or sub-sector is influenced by both, structure and conduct. Numerous previous studies have analyzed the different SCP links. For example, the connections between market share and profitability (Goddard et al. 2005), R&D and profitability (Czarnitzki and Kraft 2004), investment and growth (Grossman and Helpman 1991), firm size and productivity (Goddard et al. 2005) and industry concentration and profitability (Schmalensee 1989). A range of empirical studies have also shown that within the different stages of the SCP-approach – especially inside the performance measures – interdependences exist, too. For example, McKinsey (2002) confirmed a positive relationships between productivity and profitability, Koerner and Weiss (2001) the one between growth and profitability and Bernard and Jensen (1999) investigated the causal links between exports and productivity. Figure 1 summarises the different sector-competitiveness determinants and indicators discussed in the literature und displays the links between them.

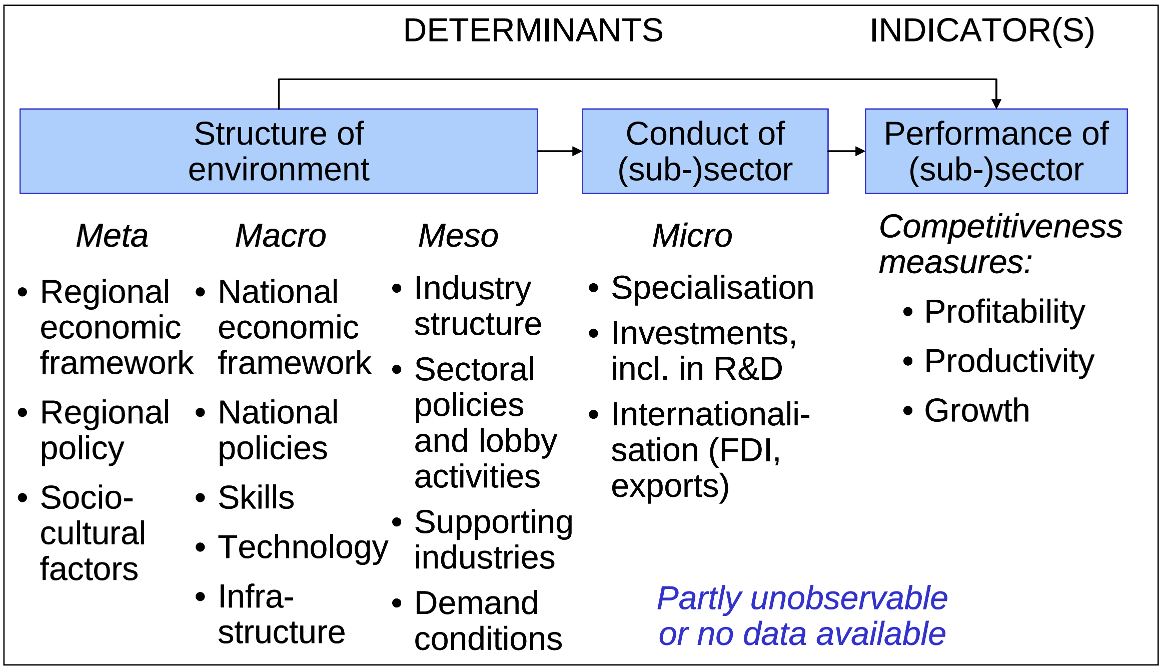



**Figure 1. Sector-competitiveness framework**

*Source*: author's draft.

## Empirical investigation: data issues and analysis method

The raw data for the empirical analysis were taken from Eurostat databases covering structural business statistics (including parts of the former New Cronos database), and external trade (Comext database). In the annual enterprise statistics, economic sectors are classified according to the statistical classification of economic activities in the European Community ("Nomenclature statistique des Activités économiques dans la Communauté Européenne", NACE) (Eurostat, 2004). For the food and drink manufacturing sector (NACE 15), the 10 most important sub-sectors (or 'industries', NACE 15x) for 13 EU countries were selected, as measured by these industries' share in sector value-added (see Table 1).

**Table 1. Covered food and drink manufacturing industries and their importance**

| NACE code | Product | Detailed description | 2001** share in EU-13 food and drink manufacturing sector (NACE 15) value added (%) |
|---|---|---|---|
| 151 | Meat | Production, processing, preserving of meat, meat products | 17.7 |
| 152 | Fish | Processing and preserving of fish and fish products | 2.1 |
| 153 | Fruit & veg. | Processing and preserving of fruit and vegetables | 5.7 |
| 154 | Oils & fats | Manufacture of vegetable and animal oils and fats | 2.3 |
| 155 | Dairy products | Manufacture of dairy products | 10.0 |
| 156 | Mill products | Manufacture of grain mill products, starches and starch products | 3.3 |
| 157 | Animal feeds | Manufacture of prepared animal feeds | 3.8 |
| 1581 | Bakery products | Manufacture of bread; manufacture of fresh pastry goods and cakes | 15.3 |
| 1584 | Confectionery | Manufacture of cocoa; chocolate and sugar confectionery | 6.1 |
| 159 | Beverages | Manufacture of beverages | 17.6 |

Note*:* ** 152: value for France for 2000, value for Austria for 1999; 153: value for Ireland for 2000; 154: missing value for Denmark, value for Ireland for 2000, value for Austria for 2000; 155: value for Denmark for 1999; 157: value for Sweden for 1999; 159: value for the Netherlands for 1997.

*Source*: authors' compilations/calculations from Eurostat data.

The selection of relevant variables occurred on the basis of theoretical reasons and practical data availability issues. While the New Cronos database contains more than 70 "economic indicators for structural business statistics", unfortunately, only a few of these proved to be useful for the empirical investigation. In an early stage of this analysis, a few more determinants such as R&D activity and measures for employee qualification were used. However, data quality (in particular after removing outliers and calculating logarithms of the original series), proved to be as not acceptable and the variables needed to be excluded from the regression analysis. Thus, in the end, only seven variables could be used in the empirical investigation. These were:

- As a *productivity* measure, value added per employee. Value added-based labour productivity is the single most frequently computed productivity statistic and is often called "apparent labour productivity" (OECD, 2003). This expression points out that labour productivity is clearly influenced by changes in capital, as well as technical, organisational and efficiency change (within as well as between firms), the influence of economies of scale, varying degrees of capacity utilisation and measurement errors. Thus, the ratio of value added to employees depends largely on the concomitance of other inputs. Nevertheless, measuring value added-based labour productivity is useful: with the costs of intermediate inputs already excluded, it relates to the single most important factor of production (OECD, 2001). Before calculating the ratio, value added was deflated using Eurostat's national Harmonised Indices of Consumer Prices for food and beverages.

- As a *profitability* measure, gross operating surplus (GOS; in €) as a share of turnover. This indicator may also be called gross operating profit margin or gross operating rate[1]. GOS is the balance that is generated by operating activities after the labour factor input has been recompensed and it is calculated from the value added at factor cost less expenses for personnel. Thus, GOS is the surplus available which allows for the compensation of the providers of own funds and debt, to pay taxes and eventually to finance all or part of its investment.[2]
- As an output *growth* measure, the annual change of production value. Production value instead of turnover is used because the former comprises total operating activities including changes in stocks and capitalised production and thus reflects real output within a given period. Turnover corresponds to market sales only (Eurostat, 2004) and thus appears to be less useful as an output indicator. (In practice, the difference between production value and turnover is small.)
- As a measure for *export* activities, the share of export value in production value. This variable is often also called 'export ratio' or 'export orientation' (OECD, 1999). In order to calculate this ratio, Comext export data needed to be matched with the New Cronos production data, using correspondence tables for external trade data (8-digit level), obtained from Eurostat. While in theory export ratios cannot be in excess of one, in some cases the calculated numbers where considerably higher. Given that no Eurostat data on re-exports are available to adjust reported export values, these cases were excluded from the empirical analysis.
- As a measure for the degree of *specialisation*, the average share of the principal activity in turnover of the companies operating in an industry is used. The principal activity is identified as the activity which contributes most to the total value added of the entity under consideration. The principal activity so identified does not necessarily account for 50% or more of the entity's total value added (Eurostat, 2006).
- As a measure for *investments*, the investment rate. The investment rate is defined as investments/value added at factor cost. Investments are expenditures for the acquisition of goods, services or information expected to develop company activities for more than one reference period, to the direct or indirect benefit of that company (Eurostat, 2006).
- As a measure for average company *size*, the industry turnover divided by the number of enterprises within the industry. Turnover comprises the totals invoiced

[1] Another option would be to employ a capital-based measure such as the return on investment (ROI). Unfortunately, Eurostat's databases contain only data on capital flows but not on capital stocks (see European Commission 2005, p. 20). Since investment flows are usually volatile, an indicator with flows in the denominator may be considerably biased (even if average values of four years are taken).

[2] Income and expenditure classified as financial or extra-ordinary in company accounts is excluded from gross operating surplus (Eurostat, 2004).

by an enterprise during the reference period, and this corresponds to market sales of goods or services supplied to third parties.[3]

**Table 2. Descriptive statistics of the employed variables**

| | N | Mean | Std dev | Min | Max |
|---|---|---|---|---|---|
| Value added per employee (€ '000) (productivity) | 241 | 49.9 | 21.3 | 7.40 | 114.9 |
| Gross operating surplus per turnover (profitability) | 242 | 0.88 | 0.43 | 0.01 | 0.23 |
| Output growth (growth) | 239 | 1.01 | 0.06 | 0.80 | 1.26 |
| Export value per production value (exports) | 234 | 0.25 | 0.21 | 0.00 | 0.94 |
| Share of main activity in total turnover (specialisation) | 163 | 0.79 | 0.16 | 0.37 | 0.99 |
| Investments per employee (€ '000) (investments) | 232 | 10.1 | 5.76 | 0.40 | 30.0 |
| Average turnover per enterprise (€ million) (size) | 235 | 13.8 | 28.0 | 0.15 | 301.6 |

*Source*: authors' calculations from Eurostat data.

The overall data availability and period of investigation was determined by the temporal coverage of New Cronos data: 1995 to 2003 only. In order to limit the effect of the inherent year-to-year volatility in the obtained data and thus to base the parameter estimations on a more 'structural' situation, two four-years averages (arithmetic means) for all variables were calculated, the first for 1995-1998 and the second for 1999-2003. Another reason for using four-year averages was the significant share of missing values (e.g., due to confidentiality in small countries) in the raw data. In addition, all variables needed thorough checking for outliers. By looking at the density functions and boxplots of the individual variables, outliers could be detected and removed in multiple cases. Overall, by averaging the observations of several years, the impact of missing values could be minimised. Nevertheless, from a total theoretical number of 260 observations (13 countries x 10 industries x 2 observation periods), the effective number of data points available for estimation was lower for each variable. Table 2 reports these numbers and other relevant descriptive statistics for the just described variables.

In the empirical analysis and given the special nature of the data (i.e., a short unbalanced panel, or, more accurately, a nested cross-section with one repeated measurement), a general linear model (GLM) was fitted for estimating the impact of

[3] According to Eurostat (2006), turnover includes all duties and taxes on the goods or services invoiced by the unit with the exception of the VAT invoiced vis-a-vis its customer and other similar deductible taxes directly linked to turnover. Turnover also includes all other charges (transport, packaging, etc.) passed on to the customer, even if these charges are listed separately in the invoice. Reduction in prices, rebates and discounts as well as the value of returned packing must be deducted. Price reductions, rebates and bonuses conceded later to clients, for example at the end of the year, are not taken into account. Income classified as other operating income, financial income and extraordinary income in company accounts is excluded from turnover. Subsidies received from public authorities or the institutions of the European Union are also excluded.

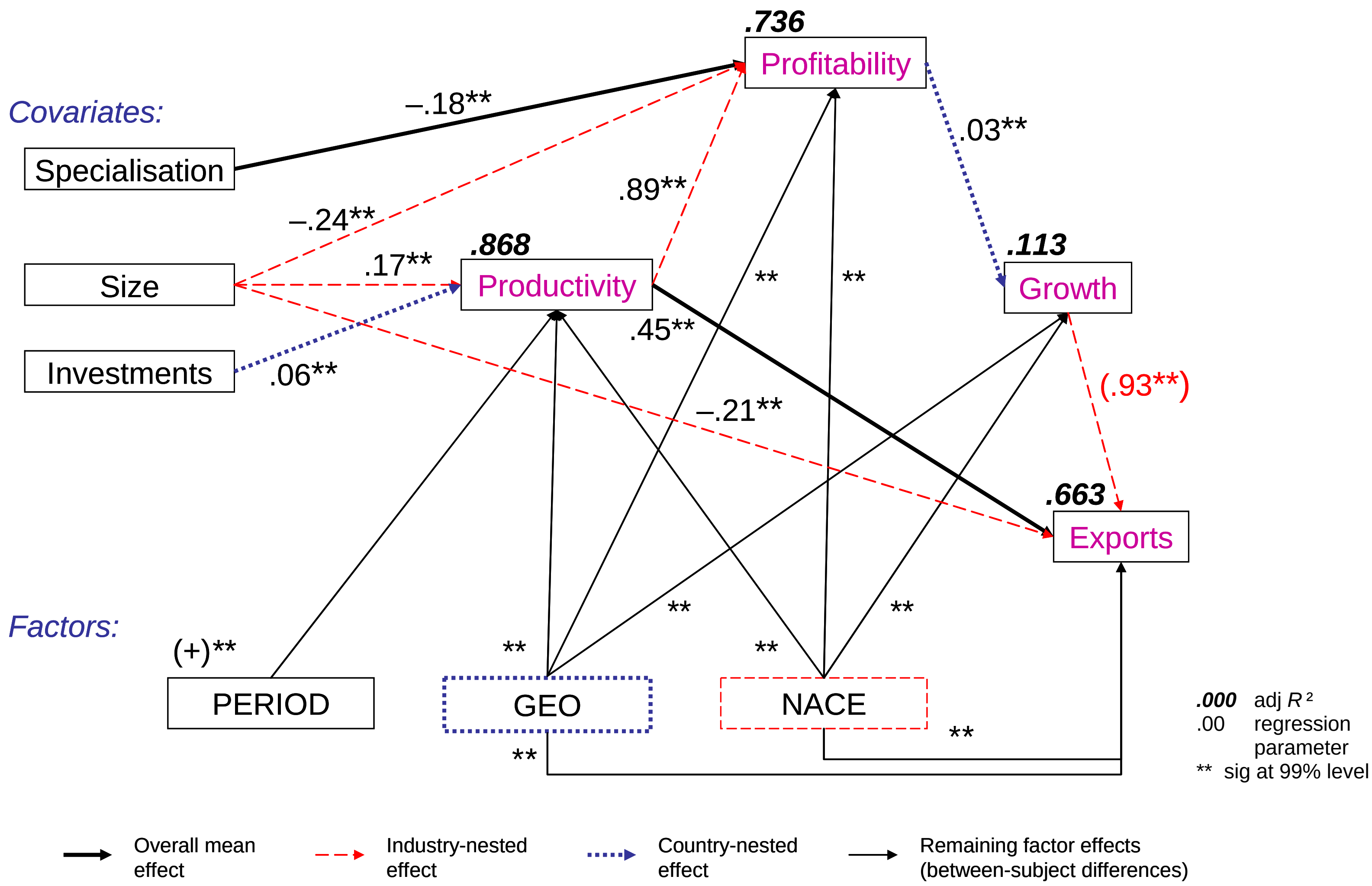
different determinants on several competitiveness indicators and for investigating the interrelationships among these. The fixed effects of a number of determinants (specialization, investments and average company size) on sector productivity, profitability, output growth and export orientation (i.e., exports as a percentage of output) are computed, controlling for several factors (industry membership, country membership and period). We also considered interaction effects in our regressions. We account for potential endogenity of our independent variables by including them as regressors. Appendix A describes the technical details of the used estimation method.

## Estimation results and discussion

Figure 1 summarizes the obtained results. It depicts all included variables and the relationships among them, using unidirectional arrows which show the found direction of causality. Different arrow types indicate whether the revealed effects are significant across all analysed countries, industries and periods, or whether they are country- or industry-specific. However, all given elasticities are the overall mean ones (except for the one in parentheses between growth and exports which is only significant for one industry, the manufacture of beverages). Remaining differences between factor categories are also depicted which in all cases are statistically significant at the 99% confidence level (**). The numbers on top of the dependent variable boxes represent adjusted $R^2$ values.

The estimation results reveal that the selected determinants have different effects on the individual competitiveness indicators. *Specialisation* only (negatively) affects *profitability*, but neither *productivity*, output *growth* nor *exports*. Investments just have a (positive) influence on *productivity*. Only average company *size* simultaneously influences *profitability* and *exports* (negatively), and *productivity* (positively). Except for the investment effect (elasticity of 0.06%), a one per cent change in a determinant results in about a 0.2% change in a competitiveness indicator, implying that the isolated impact of an individual determinants is small. Given that only a few relevant determinants have been included in the regressions, unexplained and highly significant differences in the country, industry and, in one case, period means remain. This clearly indicates that more relevant explanatory variables need to be included in order to fully explain sector competitiveness. In the case of *productivity*, an estimated larger marginal mean for the second period (not reported) than for the first period may be interpreted as evidence of technical progress. Since all data have been deflated, productivity levels have increased in real terms over time, a result which may only be explained by improved technical efficiency.

**Figure 2. The overall picture: determinants of and interrelationships within EU food & drink manufacturing competitiveness, 1995-2003**




*Source*: authors' draft

A second overall finding is that interrelationships between the different competitiveness indicators do exist. In particular, *productivity*, *profitability* and output *growth* seem to be (at least partly) endogenous variables, in the sense that they serve as dependent and independent variables at the same time. While *productivity*, *profitability* and *exports* are also partly explained by (assumed as being completely exogenous) competitiveness determinants, output *growth* appears to be fully endogenous. *Productivity* is the most central competitiveness indicator which positively and strongly (elasticity of 0.89) affects *profitability* and *exports* (0.45). Profitability has a small (0.03) positive effect on output *growth*, while *growth* seems to have (at least in one country and industry, see below) a strong positive impact (0.93) on *exports*.

The advantage of our employed method is the investigation of detailed results related to country- and industry-specific differences (where data availability permits). The detailed estimation results are provided in Appendix B. In particular, the following findings emerge from our detailed estimations:

*Productivity-related results*

- In seven countries (Austria, Belgium, Finland, France, Italy, Spain and Sweden), specific domestic conditions contribute to significantly higher productivity levels than the EU average across all F&D industries. In Belgium, aggregate F&D industry productivity turns out to be especially high.
- At the individual industry level, NACE 156 and 159 (mill products, beverages), are found to be extra productive.
- A significant period effect (period 2 contributes positively to productivity) may be interpreted as technical progress, since all financial variables were deflated before the estimations. Thus, productivity increased in real terms over time.
- Company size contributes positively to productivity, highlighting the effect of economies of scale. This is true overall, and for all sub-industries except for NACE 152 (fish) and 155 (dairy products).
- Investments contribute overall positively to productivity but in Ireland, Portugal and the UK the effect seems to be particularly high.

*Profitability-related results*

- Specialisation as a non-nested regressor has a small but significantly negative impact on profitability in F&D manufacturing (across all countries, sub-sectors and periods).
- In all countries, except for Ireland, Finland and Portugal, profitability turns out to be significantly lower than that of the UK.
- Industry-specific effects reveal that productivity has a significant impact on profitability. This is true for every single F&D sub-sector.
- In NACE categories 153 (fruit & veg.), 157 (animal feeds) and 159 (beverages) only, our results generate no causal link between average company size and profitability. In all other F&D sub-industries, a significantly negative impact of average company size on profitability exists.

*Output growth-related results*

- In all ten countries, there is a weak but significant positive connection between profitability and growth. Thus, output growth is partly determined by profits, which are one source for capital needed for expansion activities.
- Industry-specific positive effects are found in sub-industries NACE 1584 (confectionery), 152 (fish), 153 (fruit & veg.) and 154 (oils & fat).

*Export-related results*

- As a non-nested variable, *productivity* affects *export* (orientation) positively.
- Country-specific effects are mixed: positive for Belgium, Denmark, Ireland and the Netherlands, and negative for Finland.
- Output *growth* and *size* are relevant in NACE 159 (beverages) only. With respect to those two variables, they affect sector exports in different directions. While – as one would expect – *growth* leads to more *exports*, average company *size* seems to reduce it.

Our results largely confirm what has been found by other studies involving different countries, industry aggregates or time periods. For example, the positive link between productivity and exports has already been widely acknowledged as discussed before. However, our results also reveal that *exports* may not only directly be caused by (higher levels of) *productivity*. *Exports* may additionally be stimulated when *productivity* is translated into higher *profitabilty* which can result in output *growth* and part of this growth may occur via exports. Thus, productivity plays a direct and an indirect role in increasing the export orientation of F&D manufacturing companies. More generally speaking, our finding about the central role of productivity in F&D manufacturing competitiveness is also confirmed by Porter's (2004) claim, based on the analysis on many different manufacturing and service industries and a multitude of countries, that competitiveness essentially means productivity. Thus, productivity may be a *sine qua non* for profitability (McKinsey 2002).

## Conclusions

This analysis has investigated theoretically and empirically the importance of several determinants on different indicators of EU F&D manufacturing industry competitiveness and existing interrelationships among them.

Overall, the estimation results suggest that investments and average company *size* have a positive impact on manufacturing *productivity*. Sector *profitability* is mainly explained by *productivity*, in addition to company *size* and *specialisation*, which have negative impacts. The main determinant for output *growth* is *profitability*, while *export* orientation is determined by output *growth* (positively), *productivity* (positively) and company *size* (negatively). In all regressions, the country and industry control factors come out as highly significant, implying that the used determinants are not sufficient to explain the whole picture and more variables need to be included once reliable data on them becomes available. The period factor is only significant in the *productivity* regression, which may be interpreted as technical progress since in period two (1999-2002) real productivity levels are significantly higher than in period one (1995-1998).

The main implication arising from our analysis is that, in fact, competitiveness is complex in nature and characterised by important interrelationships between determinants and indicators. Both business leaders and policy makers need to be aware that, given these interrelationships, improving competitiveness in practice is not easy. The very heart of sector competitiveness is productivity – all other performance dimensions seem to depend on it, directly and indirectly. Enhancing productivity should therefore be at the top of agribusiness managers' priorities. Nonetheless, it is obvious that competitiveness is not solely about efficiency ("doing things right") but also about effectiveness ("doing the right things"), and only the combined effect of both will result in superior profitability. Effective strategic decisions on investments (including R&D), the extent to which a company should specialise or diversify, the right size of a company, etc. are all crucial and directly affect productivity as well as the other investigated performance dimensions, such as profitability and output growth. Another important finding of our analysis is that export orientation may result directly and indirectly from superior productivity, rather than being an input factor for it. This clearly implies that agribusiness managers should only consider internationalisation activities when they have reached superior productivity levels. Otherwise, the international expansion activities may not be economically sustainable.

Future research should evolve in two directions. First, more variables covering relevant competitiveness determinants need to be included into the empirical analysis as they become available. Eurostat's databases actually contain many potentially useful measures. However, at the time of our analysis, only a few of them were sufficiently complete and reliable in order to be used in the estimation process. Second, from a methodological point of view, given the endogenous nature of some of our analysed competitiveness indicators, system estimation methods should be applied in order to test the simultaneous validity of the specification suggested in Figure 1. Structural equation modelling may be one such estimation method. Often endogeneity bias is found to be small (e.g., Falk, 2006). However, by properly accounting for endogeneity, estimation results may nevertheless be improved.

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## Appendix A – technical description of estimation method

Given the special nature of the data (i.e., a short unbalanced panel, or, more accurately, a nested cross-section with one repeated measurement), a general linear model (GLM) was fitted for estimating the impact of different determinants on several competitiveness indicators and for investigating the interrelationships among these. Formally, the GLM (i.e., a fixed-effects specification which is assumed to be linear in parameters; Verbeke and Molenberghs, 1997) can be specified as

$$y_{cit}^{k} = \mu^{k} + \phi_{c}^{k} + \phi_{i}^{k} + \phi_{t}^{k} + \sum_{l} \left( \gamma_{(c,i,t)}^{kl} \cdot x_{cit}^{kl} \right) + \varepsilon_{cit}^{k} . \qquad (1)$$

For a respective $y^{k}$ (k = 1,…, $K$), $\mu^{k}$ is the overall (grand) mean (a fixed parameter, equivalent to the usual intercept); $\phi_{..}^{k}$ the fixed main-effect parameter for the three categorical predictors (i.e., 'factors') country ($c$ = 1, …, $C$), industry ($i$ = 1,…, $I$) and time period ($t$ = 1,…, $T_{ci}$); $\gamma_{(c,i,t)}^{kl}$ the fixed parameters of $l$ included (non-stochastic) covariates $x_{cit}^{kl}$ ($l$ = 1,…, $L$); and $\varepsilon_{cit}^{k}$ the random error (disturbance) of $y_{cit}^{k}$. (In our case, $C$ = 12, $I$ = 10 and $T_{ci} \in$ [0, 1, 2], depending on the chosen $y^{k}$, with $K$ = 4; and $L$ can be potentially quite high, since interaction effects between covariates were considered.) In the given specification, industries (level one) are nested in countries (level two), and covariate parameters $\gamma_{(c,i,t)}^{kl}$ are allowed to vary by included factor, i.e., across countries, industries or periods. (If the parameter is estimated and presented as not factor-specific, then it represents the overall mean effect across all countries, industries and periods, i.e., $\gamma^{kl}$.) In this way, eq. (1) can also be seen as a two-level hierarchical linear model (HLM) (Cameron and Trivedi, 2005).

Equation (1) can be simplified to $y_{cit}^{k} = \mathbf{x}'^{k}_{cit} \boldsymbol{\beta}_{(c,i,t)}^{k} + \varepsilon_{cit}^{k}$, where $\mathbf{x}'^{k}_{cit}$ denotes a (row) vector of $m$ inputs (factors, covariates and interactions) and $\boldsymbol{\beta}_{(c,i,t)}^{k}$ the (column) vector of corresponding parameters (including the $\phi_{..}^{k}$). Rewritten in full matrix notation, eq. (1) becomes

$$\mathbf{y}^{k} = \mathbf{X}^{k} \boldsymbol{\beta}_{(c,i,t)}^{k} + \boldsymbol{\varepsilon}^{k} , \qquad (2)$$

where $\mathbf{y}^{k}$ is $\sum_{c=1}^{C} I_c T_c \times 1$ response vector, $\mathbf{X}^{k}$ is a $\sum_{c=1}^{C} I_c T_c \times m$ input matrix, $\boldsymbol{\beta}^{k}$ is a $m \times 1$ parameter vector, and $\boldsymbol{\varepsilon}^{k}$ is $\sum_{c=1}^{C} I_c T_c \times 1$ disturbance vector.

Given the panel structure of our data, where the different sub-industries (NACE codes) are treated as subjects, $\mathrm{E}(\mathbf{y}^{k}) = \mathbf{X}^{k} \boldsymbol{\beta}_{(c,i,t)}^{k}$, and $\mathrm{Var}(\mathbf{y}^{k}) = \mathrm{Var}(\boldsymbol{\varepsilon}^{k})$ is assumed to be i.i.d. $N(0, \sigma_t^2)$, thus observations in the two panels may be contemporaneously correlated and potentially heteroscedastic (i.e., displaying non-constant variance). As a consequence, $\boldsymbol{\beta}_{(c,i,t)}^{k}$ in eq. (2) cannot efficiently be estimated by pooled ordinary least squares (OLS) regression. Instead, a method that takes into account autocorrelated and non-constant residual errors needs to be used. One such method is feasible generalised least squares (FGLS), where (for each $k$):

$$\hat{\boldsymbol{\beta}}_{\text{FGLS}} = \left[\mathbf{X}'\hat{\mathbf{V}}^{-1}\mathbf{X}\right]^{-1}\mathbf{X}'\hat{\mathbf{V}}^{-1}\mathbf{y} \qquad (3)$$

(see Cameron and Trivedi, 2005), and where implementation requires the consistent estimation of **V**, the variance-covariance matrix of disturbances $\boldsymbol{\varepsilon}^k$. In order to consistently estimate **V**, one usually needs to make explicit assumptions about the underlying structure of its variance components, but it is possible (and was done in our case) to treat **V** as being completely unstructured, i.e., $\begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix}$.

The estimation of variance components can be done in different ways. Under the i.i.d. multivariate normal assumption for $\boldsymbol{\varepsilon}^k$, maximum likelihood estimation methods are usually employed, with two possible options: maximum likelihood (ML) or restricted maximum likelihood (REML). A weakness of the ML method is that the estimates are biased in small samples (Cameron and Trivedi, 2005). Moreover, since REML does explicitly take into account the loss of the degrees of freedom involved in estimating the fixed effects, it is the recommended option in models containing many fixed-effect parameters (Verbeke and Molenberghs, 1997). The –2 times log-likelihood of REML is (Cameron and Trivedi, 2005)

$$-2\ell_{\text{REML}}(\mathbf{V}) = \ln|\mathbf{V}| + (NT-p)\ln\left(\mathbf{r}'\mathbf{V}^{-1}\mathbf{r}\right) + (NT-p)\left[1+\ln\left(\frac{2\pi}{NT-p}\right)\right] + \ln\left|\mathbf{X}'\mathbf{V}^{-1}\mathbf{X}\right| \qquad (4)$$

where $\mathbf{r} = \mathbf{y} - \mathbf{X}\left[\mathbf{X}'\mathbf{V}^{-1}\mathbf{X}\right]^{-1}\mathbf{X}'\mathbf{V}^{-1}\mathbf{y}$, $|\mathbf{V}|$ denotes the determinant of **V**, $N$ the number of subjects, and $p$ is the rank of **X**. The variance components of **V** can be computed by maximising eq. (4), however in general, there are no closed-form solutions. Therefore, Newton and scoring algorithms are usually used to find the solution numerically, starting with some initial value for residual error variance $\sigma^2$. Assuming i.i.d. $N(0, \sigma^2)$, residual sum of squares from OLS regression usually yields $\hat{\sigma}^2$ to be used as starting value.

Once **V** has been estimated (for each $k$), original data $\mathbf{X}^k$ and $\mathbf{y}^k$ are then accordingly transformed and OLS regressions are run on the adjusted data, yielding autocorrelation and heteroscedasticity-adjusted $\hat{\boldsymbol{\beta}}^k_{(c,i,t)}$ and respective panel-robust standard errors. For the significance tests of the included factors, ANOVA (methods of moments-type) estimators, which equate quadratic sums of squares to their expectations and solve the resulting equations for the unknowns, are used. Baltagi et al. (2001) have shown that ANOVA methods perform well in estimating the regression coefficients in unbalanced nested error-component regression models. Given that our data is unbalanced, and that we are interested in the significance of the remaining differences in the factor category (or marginal) means, Type III sums of squares are used (Hill and

Lewicki, 2006). Remaining significantly different marginal means indicate that more explanatory variables (covariates) are needed to fully explain the analysed $y^k$.

In maximum likelihood-based FGLS regressions, conventionally only the final value of the (restricted) –2 times log-likelihood function and derived information criteria (such as the Akaike information criteria, AIC, and the Bayesian information criteria, BIC) are calculated (see Cameron and Trivedi, 2005 for a discussion), on the basis of which appropriate (nested) models are selected. However, for assessing the overall fit of a model to the underlying data, theses statistics are less useful, since they cannot be compared across different non-nested models. In order to obtain some measure of overall goodness of fit, we report adjusted $R^2$ (coefficient of multiple determination) statistics from pooled OLS regressions of identically specified models.

## Appendix B – detailed estimation results

**Table 3. Summary regression results (feasible GLS estimates) for a two-level hierarchical linear model with one repeated measurement; best estimation results reported only**

| | Dependent variable | | | |
|---|---|---|---|---|
| | Productivity | Profitability | Output growth | Exports |
| Regressors | Fixed effect parameters | | | |
| Intercept | 3.55** | 0.45 | 4.53** | –2.97** |
| *Covariates* | | | | |
| Productivity | | 0.89** | | 0.45** |
| Profitability | | | 0.03** | |
| Specialisation | | –0.18** | | |
| Investments | 0.06** | | | |
| Size | 0.17** | –0.24** | | –0.21** |
| *Factors* | | | | |
| GEO | ** | ** | ** | ** |
| NACE | ** | ** | ** | ** |
| PERIOD | ** | | | |
| | Variance/covariance matrix components[†] | | | |
| $\sigma_1^2$ | 0.03** | 0.08** | 0.00** | 0.52** |
| $\sigma_2^2$ | 0.03** | 0.06** | 0.00** | 0.50** |
| $\sigma_{12}$ | 0.03** | 0.06** | –0.00* | 0.47** |
| | Model statistics | | | |
| Max. # of obs.[a] | 260 | 260 | 260 | 260 |
| Restr. –2 log lik. | –167.0 | 13.7 | –583.6 | 295.7 |
| AIC | –161.0 | 19.7 | –576.6 | 301.7 |
| BIC | –151.0 | 28.4 | –566.5 | 311.4 |
| Adj $R^2$ [‡] | 0.86 | 0.74 | 0.11 | 0.63 |

Notes: All covariates expressed in their (natural) logarithms.
** statistically significant at least at 99% confidence level;
* statistically significant at least at 95% confidence level.
Significant levels are based on panel-robust standard errors.
[†]Restricted maximum likelihood estimate.
[a]In theory, 13 (countries) x 10 (industries) x 2 (periods) observations, but the effective no. differs depending on variables included in the estimation specification (see Table 2).
[‡]Computed from pooled OLS.

*Source*: authors' calculations from Eurostat data.

**Table 4. Productivity-related country and industry-specific regression results (feasible GLS estimates) for a two-level hierarchical linear model with one repeated measurement; best estimated model and significant parameters (95% confidence level) reported only**

| | Productivity | | | |
|---|---|---|---|---|
| Regressors | Fixed effect parameter | Standard error | *t* statistic | Significance |
| Intercept | 2.83 | 0.22 | 12.6 | 0.00 |
| *Country-specific* | | | | |
| UK | 0 | 0 | – | – |
| AUS | 0.53 | 0.26 | 1.99 | 0.05 |
| BEL | 1.01 | 0.34 | 3.00 | 0.00 |
| FIN | 0.74 | 0.26 | 2.89 | 0.00 |
| FRA | 0.59 | 0.30 | 2.01 | 0.05 |
| ITA | 0.85 | 0.29 | 2.95 | 0.00 |
| SPA | 0.57 | 0.21 | 2.74 | 0.01 |
| SWE | 0.85 | 0.27 | 3.09 | 0.00 |
| *Level-two nested* | | | | |
| Investments (IRE) | 0.46 | 0.11 | 4.25 | 0.00 |
| Investments (POR) | 0.17 | 0.06 | 3.02 | 0.00 |
| Investments (UK) | 0.39 | 0.09 | 4.28 | 0.00 |
| *Industry-specific* | | | | |
| NACE 1584 | 0 | 0 | – | – |
| NACE 156 | 0.38 | 0.13 | 2.85 | 0.01 |
| NACE 159 | 0.62 | 0.17 | 3.63 | 0.00 |
| *Level-one nested* | | | | |
| Size (NACE 151) | 0.14 | 0.06 | 2.63 | 0.01 |
| Size (NACE 153) | 0.20 | 0.07 | 2.78 | 0.01 |
| Size (NACE 154) | 0.17 | 0.03 | 5.94 | 0.00 |
| Size (NACE 156) | 0.11 | 0.05 | 2.21 | 0.03 |
| Size (NACE 157) | 0.18 | 0.07 | 2.60 | 0.01 |
| Size (NACE 1581) | 0.22 | 0.06 | 3.81 | 0.00 |
| Size (NACE 1584) | 0.19 | 0.04 | 4.29 | 0.00 |
| Variance/covariance matrix components[†] | Parameters | Standard error | Wald Z | Significance |
| $\sigma_1^2$ | 0.03 | 0.00 | 6.27 | 0.00 |
| $\sigma_2^2$ | 0.03 | 0.00 | 6.36 | 0.00 |
| $\sigma_{12}$ | 0.02 | 0.00 | 5.69 | 0.00 |
| *Model statistics* | Max. # of obs.[a] | Restr. –2 log lik. | AIC | BIC |
| | 260 | –142.0 | –136.0 | –126.4 |

Notes: All covariates expressed in their (natural) logarithms. Significant levels are based on panel-robust standard errors. [†]Restricted maximum likelihood estimate. [a]In theory, 13 (countries) x 10 (industries) x 2 (periods) observations, but the effective no. differs depending on variables included in the specification (see Table 2).

*Source*: authors' calculations from Eurostat data.

**Table 5. Profitability-related country and industry-specific regression results (feasible GLS estimates) for a two-level hierarchical linear model with one repeated measurement; best estimated model and significant parameters (95% confidence level) reported only**

| | Profitability | | | |
|---|---|---|---|---|
| Regressors | Fixed effect parameter | Standard error | *t* statistic | Significance |
| *Non-nested* | | | | |
| Specialisation | –0.19 | 0.06 | –3.27 | 0.00 |
| *Country-specific* | | | | |
| UK | 0 | 0 | – | – |
| AUS | –0.45 | 0.12 | –3.69 | 0.00 |
| BEL | –0.74 | 0.12 | –6.25 | 0.00 |
| DEN | –0.33 | 0.13 | –2.60 | 0.01 |
| FRA | –0.85 | 0.12 | –6.86 | 0.00 |
| GER | –0.40 | 0.12 | –3.43 | 0.00 |
| ITA | –0.50 | 0.13 | –3.85 | 0.00 |
| NLD | –0.53 | 0.12 | –4.51 | 0.00 |
| SPA | –0.31 | 0.13 | –2.33 | 0.02 |
| SWE | –0.63 | 0.13 | –4.89 | 0.00 |
| *Industry-specific* | | | | |
| *Level-one nested* | | | | |
| Prod. (NACE 151) | 0.86 | 0.13 | 6.67 | 0.00 |
| Prod. (NACE 152) | 1.01 | 0.14 | 7.23 | 0.00 |
| Prod. (NACE 153) | 0.91 | 0.14 | 6.61 | 0.00 |
| Prod. (NACE 154) | 0.78 | 0.11 | 6.90 | 0.00 |
| Prod. (NACE 155) | 0.86 | 0.12 | 7.07 | 0.00 |
| Prod. (NACE 156) | 0.85 | 0.11 | 7.91 | 0.00 |
| Prod. (NACE 157) | 0.78 | 0.14 | 5.47 | 0.00 |
| Prod. (NACE 159) | 0.85 | 0.11 | 8.12 | 0.00 |
| Prod. (NACE 1581) | 1.03 | 0.13 | 8.04 | 0.00 |
| Prod. (NACE 1584) | 0.92 | 0.12 | 7.53 | 0.00 |
| Size (NACE 151) | –0.23 | 0.92 | –2.46 | 0.02 |
| Size (NACE 152) | –0.43 | 0.17 | –2.62 | 0.01 |
| Size (NACE 154) | –0.22 | 0.05 | –4.45 | 0.00 |
| Size (NACE 155) | –0.27 | 0.08 | –3.22 | 0.00 |
| Size (NACE 156) | –0.18 | 0.076 | –2.46 | 0.02 |
| Size (NACE 1581) | –0.44 | 0.08 | –5.80 | 0.00 |
| Size (NACE 1584) | –0.17 | 0.08 | –2.16 | 0.03 |
| Variance/covariance matrix components[†] | Parameters | Standard error | Wald Z | Significance |
| $\sigma_1^2$ | 0.08 | 0.02 | 5.12 | 0.00 |
| $\sigma_2^2$ | 0.05 | 0.01 | 5.93 | 0.00 |
| $\sigma_{12}$ | 0.05 | 0.01 | 5.16 | 0.00 |
| *Model statistics* | Max. # of obs.[a] | Restr. –2 log lik. | AIC | BIC |
| | 260 | 44.5 | 50.5 | 59.1 |

Notes: See Table 4.

*Source*: authors' calculations from Eurostat data.

**Table 6. Output growth-related country and industry-specific regression results (feasible GLS estimates) for a two-level hierarchical linear model with one repeated measurement; best estimated model and significant parameters (95% confidence level) reported only**

| | Output growth | | | |
|---|---|---|---|---|
| Regressors | Fixed effect parameter | Standard error | *t* statistic | Significance |
| Intercept | 4.54 | 0.03 | 173.5 | 0.00 |
| *Country-specific* | | | | |
| *Level-two nested* | | | | |
| Profit. (AUS) | 0.03 | 0.01 | 2.36 | 0.02 |
| Profit. (BEL) | 0.03 | 0.01 | 2.55 | 0.01 |
| Profit. (DEN) | 0.04 | 0.01 | 3.09 | 0.00 |
| Profit. (FRA) | 0.04 | 0.01 | 3.16 | 0.00 |
| Profit. (IRE) | 0.03 | 0.01 | 2.42 | 0.02 |
| Profit. (ITA) | 0.03 | 0.01 | 3.11 | 0.00 |
| Profit. (NLD) | 0.02 | 0.01 | 1.99 | 0.05 |
| Profit. (SPA) | 0.04 | 0.01 | 3.12 | 0.00 |
| Profit. (SWE) | 0.05 | 0.01 | 3.75 | 0.00 |
| Profit. (UK) | 0.03 | 0.01 | 3.32 | 0.00 |
| *Industry-specific* | | | | |
| NACE 1584 | 0 | 0 | – | – |
| NACE 152 | 0.04 | 0.02 | 2.62 | 0.01 |
| NACE 153 | 0.04 | 0.01 | 2.75 | 0.01 |
| NACE 154 | 0.04 | 0.02 | 2.38 | 0.02 |
| Variance/covariance matrix components[†] | Parameters | Standard error | Wald Z | Significance |
| $\sigma_1^2$ | 0.00 | 0.00 | 6.40 | 0.00 |
| $\sigma_2^2$ | 0.00 | 0.00 | 6.55 | 0.00 |
| $\sigma_{12}$ | –0.00 | 0.00 | –2.04 | 0.04 |
| *Model statistics* | Max. # of obs.[a] | Restr. –2 log lik. | AIC | BIC |
| | 260 | –564.1 | –558.1 | –548.0 |

Notes: See Table 4.

*Source*: authors' calculations from Eurostat data.

**Table 7. Exports-related country and industry-specific regression results (feasible GLS estimates) for a two-level hierarchical linear model with one repeated measurement; best estimated model and significant parameters (95% confidence level) reported only**

| | Exports (export orientation) | | | |
|---|---|---|---|---|
| Regressors | Fixed effect parameter | Standard error | *t* statistic | Significance |
| Intercept | –5.34 | 1.85 | -2.89 | 0.05 |
| *Non-nested* | | | | |
| Productivity | 0.39 | 0.17 | 2.30 | 0.02 |
| *Country-specific* | | | | |
| UK | 0 | 0 | – | – |
| BEL | 1.09 | 0.34 | 3.25 | 0.00 |
| DEN | 1.21 | 0.32 | 3.83 | 0.00 |
| FIN | –0.79 | 0.32 | –2.19 | 0.02 |
| IRE | 1.01 | 0.32 | 3.13 | 0.02 |
| NLD | 1.72 | 0.32 | 5.45 | 0.00 |
| *Industry-specific* | | | | |
| *Level-one nested* | | | | |
| Growth (NACE 159) | 0.93 | 0.41 | 2.25 | 0.03 |
| Size (NACE 159) | –1.14 | 0.26 | –4.36 | 0.00 |
| Variance/covariance matrix components[†] | Parameters | Standard error | Wald Z | Significance |
| $\sigma_1^2$ | 0.46 | 0.07 | 6.34 | 0.00 |
| $\sigma_2^2$ | 0.47 | 0.07 | 6.38 | 0.00 |
| $\sigma_{12}$ | 0.42 | 0.07 | 6.13 | 0.00 |
| *Model statistics* | Max. # of obs.[a] | Restr. –2 log lik. | AIC | BIC |
| | 260 | 312.3 | 318.3 | 327.9 |

Notes: See Table 4.

*Source*: authors' calculations from Eurostat data.