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Big Data Analytics and Exports -Evidence for Manufacturing Firms from 27 EU Countries

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Abstract: The use of big data analytics (including data mining and predictive analytics) by firms can be expected to increase productivity and reduce trade costs, which should be positively related to export activities. This paper uses firm level data from the Flash Eurobarometer 486 survey conducted in February – May 2020 to investigate the link between the use of big data analytics and export activities in manufacturing enterprises from the 27 member countries of the European Union. We find that firms which use big data analytics do more often export, do more often export to various destinations all over the world, and do export to more different destinations. The estimated big data analytics premia for exports are statistically highly significant after controlling for firm size, firm age, patents, and country. Furthermore, the size of these premia can be considered to be large. Successful exporters tend to use big data analytics.

Keywords: Big data analytics, exports, firm level data, Flash Eurobarometer 486

JEL Classification: D22, F14



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Acknowledgement: The firm level data used in this study are taken from the Flash Eurobarometer 486 and can be downloaded free of charge after registration at <u>http://www.gesis/eurobarometer</u>. Stata code used to generate the empirical results reported in this note is available from the author.

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1 Motivation

Digital technologies like artificial intelligence, cloud computing, the use of robots to automate processes, or big data analytics, are more and more widely applied by innovative firms. However, comprehensive empirical evidence on the links between the use of digital technologies and various dimensions of firm performance seems to be lacking. A case in point is the role of big data analytics (e.g., data mining and predictive analytics) for export activities of firms. In their comprehensive discussion of artificial intelligence (AI) and international trade Goldfarb and Trefler (2018, p. 1) state that "even to the extent that progress has been made in understanding the impact of AI, we remain largely uninformed about its international dimensions. This is to our great loss." ¹

This note contributes to the literature by looking at differences in exports between manufacturing enterprises from 27 member countries of the European Union that use or do not use big data analytics. We expect these differences to be positive for firms that use big data analytics for two reasons:

First, the use of big data analytics (including data mining and predictive analytics) by firms can be expected to increase productivity. According to a large empirical literature that uses firm level data from many different countries productivity and export activities in firms are positively related (Ferencz, López-González and García 2022, p. 12; see Wagner 2007 for a survey of the empirical literature).

Second, big data analytics can be expected to reduce trade costs (Ferencz, López-González and García 2022, p. 12). The use of data mining and predictive analytics allows firms to do comprehensive research on competitors and customers on foreign markets faster and at lower costs. Furthermore, it can help to improve predictions in future changes in consumer demand there (Meltzer 2018, p. 2).

To anticipate the most important result we find that firms which use big data analytics do more often export, do more often export to various destinations all over the world, and do export to more different destinations. The estimated big data analytics premia for exports are statistically highly significant after controlling for firm size, firm age, patents, and country. Furthermore, the size of these premia can be considered to be large. The take-home message, therefore, is that successful exporters tend to use big data analytics.

The rest of the paper is organized as follows. Section 2 introduces the data used and discusses the export activities that are looked at. Section 3 reports results from the econometric investigation. Section 4 concludes.

2 Data and discussion of variables

The firm level data used in this study are taken from the Flash Eurobarometer 486 survey conducted in February – May 2020. Note that while the data were collected at the start of the COVID-19 pandemic, the data on export activities relate to the year 2019, the year before the pandemic. We use data for firms from the 27 member states of the European Union in 2020 (i.e., firms from the UK are

¹ See Ferencz, López-González and García (2022), Goldfarb and Trefler (2018) and Meltzer (2018) for a discussion of various aspects of the relations between artificial intelligence and international trade.



are no longer included in the sample). The sample covers 2,355 firms from manufacturing industries (included in NACE section C); the numbers of firms by country are reported in the appendix table.

In the survey firms were asked in question Q23_5 whether they introduced *Big Data Analytics* (e.g., *Data Mining* and *Predictive Analytics*). Firms that answered in the affirmative are classified as users of big data analytics. Descriptive evidence is reported in Table 1, showing a share of 13.8 percent of firms with big data analytics.

In the empirical study we look at various measures of export activity of firms:²

First, firms were asked in question Q11_1 whether they exported any goods (or not) in 2019. Firms are classified as exporters or non-exporters based thereon. Descriptive evidence is reported in Table 1, showing a share of 64.5 percent of exporters.

[Table 1 near here]

Second, firms were asked in questions Q11_2 to Q11_8 whether they exported goods in 2019 to the following destinations: Other EU countries; other European countries outside the EU (including Russia); North America; Latin America; China; other countries from Asia and the Pacific; countries from the Middle East and Africa. Descriptive evidence is reported in Table 1, showing that 61.8 percent of firms exported to countries from the EU, while 29.2 percent exported to other European countries. The other destinations follow with shares between some 10 percent and about 16 percent. Exporters to each destination are investigated separately.

Third, from the evidence reported for exports to the seven destinations mentioned for each exporting firm the number of different destinations exported to is calculated. The share of firms by number of export destinations is reported in Table 2. Not surprisingly, most exporters serve one or two destinations only, but there are quite some firms that export to more (or even all) destinations.

[Table 2 near here]

In the empirical investigation of the link between the use of big data analytics and exports we control for three firm characteristics that are known to be positively linked with exports: firm age (measured in years, based on the answer given to question Q1), firm size (measured as the number of employees – excluding the owners - at the time of the survey; see question Q2A), and whether the firms has a patent or a patent application pending (see question Q9_6).³ Descriptive statistics are again reported in Table 1.

² To the best of my knowledge (based on a Google Scholar search for "Flash Eurobarometer 486" performed on September 17, 2023) the data used in this note have not been used to investigate the links between exports and the use of bog data analytics before. Note that all measures looked at here refer to extensive margins of exports; information on intensive margins (share of exports in total sales) are not available in the data used.

³ Given that these variables are included as control variables only, we do not discuss them in detail here. Suffice it to say that numerous empirical studies show a positive link between these firm characteristics and export performance.



Furthermore, in the empirical investigations the country of origin of the firms is controlled for by including a full set of country dummy variables.

3 Testing for big data analytics premia in export activities

To test for the difference in the types of export activities listed in section 2 between firms that do and do not use big data analytics, and to document the size of these differences, an empirical approach is applied that modifies a standard approach used in hundreds of empirical investigations on the differences between exporters and non-exporters that has been introduced by Bernard and Jensen (1995, 1999). Studies of this type use data for firms to compute so-called exporter premia, defined as the ceteris paribus percentage difference of a firm characteristic - e.g. labour productivity - between exporters and non-exporters. These premia are computed from a regression of log labour productivity on the current export status dummy and a set of control variables:

(1) In LP_i = a + β Export_i + c Control_i + e_i

where i is the index of the firm, LP is labour productivity, Export is a dummy variable for current export status (1 if the firm exports, 0 else), Control is a vector of control variables, and e is an error term. The exporter premium, computed from the estimated coefficient ß as 100(exp(ß)-1), shows the average percentage difference between exporters and non-exporters controlling for the characteristics included in the vector Control (see Wagner (2007) for a more complete exposition of this method).

Here we look at differences between firms that do and that do not use big data analytics (instead of differences between exporters and non-exporters) and are interested in the existence and size of big data analytics premia in export activities (instead of exporter premia in various forms of firm performance like productivity). For export activities that are measured by dummy variables (the decision to export or not, and the decision to export to one of the seven export destinations listed in section 2) the empirical model is estimated by Probit instead. Therefore, (1) becomes (2)

(2) Indicator_i = a + ß Big Data Analytics_i + c Control_i + e_i

where i is the index of the firm, Indicator is a dummy variable for the use or not of a type of export activity, Big Data Analytics is a dummy variable for the use of big data analytics by the firm (1 if the firm uses it, 0 else), Control is a vector of control variables (that consists of measures of firm age, firm size, and patents, and dummy variables for countries), and e is an error term. The big data analytics premium is computed as the estimated average marginal effects of the big data analytics dummy variable.

For the number of export destinations, (1) becomes (3)

(3) number_i = $a + \beta$ Big Data Analytics_i + c Control_i + e_i



where i is the index of the firm, number is the number of export destinations, Big Data Analytics is a dummy variable for the use of big data analytics by the firm (1 if the firm uses it, 0 else), Control is a vector of control variables (that consists of measures of firm age, firm size, and patents, and dummy variables for countries), and e is an error term. The big data analytics premium is the estimated coefficient ß; it shows the average difference between firms that use and do not use big data analytics, controlling for firm age, firm size, patents, and country of origin of the firm.

Results are reported in Tables 3 - 5. The big picture that is shown is crystal clear: Firms that use big data analytics are more often exporters, do more often export to any of the different destinations, and do export to a larger number of destinations. All estimated big data analytics premia are statistically highly significant ceteris paribus after controlling for firm age, firm size, patents, and country of origin of the firms.⁴ Furthermore, the size of these premia can be considered to be large – the estimated marginal effects reported in Table 3 and Table 4 are in the order of magnitude of ten percent, and from Table 5 we see that the average difference in the number of destinations exported to is +0.701 in favour of firms that use big data analytics (with an average value of 1.544 destinations for all firms).

[Tables 3 – 5 near here]

However, it is an open question (that is asked the same way when exporter premia are discussed; see Wagner 2007) whether these premia are due to self-selection of more export active firms into the use of big data analytics or whether these premia are the effect of using big data analytics.

4 Concluding remarks

This paper demonstrates that the use of big data analytics is positively related to export activities of firms from manufacturing industries. Big data analytics premia are large for all types of export activities looked at here. Does this study imply that in order to be successful in export markets, firms should use big data analytics? Or that using big data analytics will help the firms to be successful as an exporter? This is an open question (that is asked the same way when exporter premia are discussed) because we do not know whether these premia are due to self-selection of exporting firms into the use of big data analytics, or whether they are the effect of using big data analytics. This issue cannot be investigated with the cross-section data at hand. To answer this important question longitudinal data for firms are needed that cover several years and that include a sufficiently large number of firms that switch the status between using big data analytics or not over time (in both directions). To the best of my knowledge such data are not available as of today. Let's collect it!

⁴ Note that all control variables have the expected positive sign and all are highly significant statistically.



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| - | | | | |
|-------------------------------|-------|-----------|-----|------|
| Variable | Mean | Std. Dev. | Min | Max |
| Big Data Analytics | 0.138 | 0.345 | 0 | 1 |
| (Dummy; 1 = yes) | | | | |
| Exporter | 0.645 | 0.478 | 0 | 1 |
| (Dummy; 1 = yes) | | | | |
| Export Destination | | | | |
| (Dummy-Variables; 1 = yes) | | | | |
| - EU-countries | 0.618 | 0.486 | 0 | 1 |
| - Other Europe | 0.292 | 0.455 | 0 | 1 |
| - North America | 0.157 | 0.364 | 0 | 1 |
| - Latin America | 0.099 | 0.298 | 0 | 1 |
| - China | 0.109 | 0.311 | 0 | 1 |
| - Other Asia | 0.138 | 0.345 | 0 | 1 |
| - Middle East, Africa | 0.132 | 0.339 | 0 | 1 |
| Number of Export Destinations | 1.544 | 1.857 | 0 | 7 |
| Firm Age (years) | 29.03 | 23.43 | 0 | 170 |
| No. of Employees | 91.63 | 269.11 | 1 | 5000 |
| Patent | 0.120 | 0.325 | 0 | 1 |
| (Dummy; 1 = yes) | | | | |
| No. of Firms in Sample | 2,355 | | | |

Table 1: Descriptive statistics

Source: Own calculation based on data from Flash Eurobarometer 486.



| Number of Export Destinations | Number of Firms | Percent |
|-------------------------------|-----------------|---------|
| 0 | 835 | 35.46 |
| 1 | 700 | 29.72 |
| 2 | 338 | 14.35 |
| 3 | 150 | 6.37 |
| 4 | 100 | 4.25 |
| 5 | 73 | 3.1 |
| 6 | 68 | 2.89 |
| 7 | 91 | 3.86 |
| Total | 2,355 | 100 |

Table 2: Share of Firms by Number of Export Destinations

Source: Own calculation based on data from Flash Eurobarometer 486

Table 3: Estimation results, Part I: Exporter vs. Non-Exporter

Dependent variable: Exporter (Dummy; 1 = yes)

Method: Probit

| Variable | Coefficient | p-value | Marginal effect | p-value |
|----------------------|-------------|---------|-----------------|---------|
| Big Data Analytics | 0.386 | 0.000 | 0.122 | 0.000 |
| (Dummy; 1 = yes) | | | | |
| Firm Age (years) | 0.0045 | 0.001 | | |
| No. of employees | 0.0010 | 0.000 | | |
| Patent | 0.720 | 0.000 | | |
| (Dummy; 1 = yes) | | | | |
| Country | included | | | |
| (26 Dummy variables) | | | | |
| Constant | included | | | |
| No. of firms | 2,355 | | | |

Source: Own calculation based on data from Flash Eurobarometer 486



Table 4: Estimation results, Part II: Exporter by Destination

Dependent variable: Exporter (Dummy; 1 = yes)

| Variable | Coefficient | p-value | Marginal effect | p-value |
|---------------------|-------------|---------|-----------------|---------|
| EU countries | | | | |
| Big Data Analytics | 0.395 | 0.000 | 0.129 | 0.000 |
| Firm Age | 0.005 | 0.001 | | |
| No. of employees | 0.001 | 0.000 | | |
| Patent | 0.730 | 0.000 | | |
| Other Europe | | | | |
| Big Data Analytics | 0.511 | 0.000 | 0.163 | 0.000 |
| Firm Age | 0.007 | 0.000 | | |
| No. of employees | 0.0006 | 0.000 | | |
| Patent | 0.705 | 0.000 | | |
| North America | | | | |
| Big Data Analytics | 0.409 | 0.000 | 0.095 | 0.000 |
| Firm Age | 0.006 | 0.000 | | |
| No. of employees | 0.0004 | 0.000 | | |
| Patent | 0.751 | 0.000 | | |
| Latin America | | | | |
| Big Data Analytics | 0.523 | 0.000 | 0.097 | 0.000 |
| Firm Age | 0.005 | 0.001 | | |
| No. of employees | 0.0005 | 0.000 | | |
| Patent | 0.596 | 0.000 | | |
| China | | | | |
| Big Data Analytics | 0.532 | 0.000 | 0.100 | 0.000 |
| Firm Age | 0.007 | 0.000 | | |
| No. of employees | 0.0005 | 0.000 | | |
| Patent | 0.615 | 0.000 | | |
| Other Asia | | | | |
| Big Data Analytics | 0.501 | 0.000 | 0.109 | 0.000 |
| Firm Age | 0.006 | 0.000 | | |
| No. of employees | 0.0006 | 0.000 | | |
| Patent | 0.654 | 0.000 | | |
| Middle East, Africa | | | | |
| Big Data Analytics | 0.529 | 0.000 | 0.113 | 0.000 |
| Firm Age | 0.007 | 0.000 | | |
| No. of employees | 0.0005 | 0.000 | | |
| Patent | 0.664 | 0.000 | | |
| No. of firms | 2,355 | | | |

Note: All empirical models include 26 country dummy variables plus a constant

Source: Own calculations based on data from Flash Eurobarometer 486



Table 5: Estimation results, Part III: Number of Export Destinations

Dependent variable: Number of export destinations for exporters

| M | let | hod | l: 0 | LS |
|---|-----|-----|------|----|
| | | | | |

| Variable | Coefficient | p-value |
|----------------------|-------------|---------|
| Big Data Analytics | 0.717 | 0.000 |
| (Dummy; 1 = yes) | | |
| Firm Age (years) | 0.011 | 0.000 |
| No. of employees | 0.0007 | 0.000 |
| Patent | 0.956 | 0.000 |
| (Dummy; 1 = yes) | | |
| Country | included | |
| (26 Dummy variables) | | |
| Constant | included | |
| R-squared | 0.278 | |
| No. of firms | 2,355 | |

Note: Estimated standard errors are clustered at the level of the 27 countries

Source: Own calculations based on data from Flash Eurobarometer 486



Appendix

Appendix: Number of Firms by Country

| Country | Number of Firms | Percent |
|----------------|-----------------|---------|
| Austria | 86 | 3.65 |
| Belgium | 81 | 3.44 |
| Bulgaria | 97 | 4.12 |
| Cyprus | 33 | 1.40 |
| Czech Republic | 94 | 3.99 |
| Germany | 74 | 3.14 |
| Denmark | 75 | 3.18 |
| Estonia | 99 | 4.20 |
| Spain | 137 | 5.82 |
| Finland | 88 | 3.74 |
| France | 101 | 4.29 |
| Greece | 111 | 4.71 |
| Croatia | 136 | 5.77 |
| Hungary | 117 | 4.97 |
| Ireland | 30 | 1.27 |
| Italy | 149 | 6.33 |
| Lithuania | 64 | 2.72 |
| Luxembourg | 25 | 1.06 |
| Latvia | 75 | 3.18 |
| Malta | 21 | 0.89 |
| Netherlands | 55 | 2.34 |
| Poland | 101 | 4.29 |
| Portugal | 93 | 3.95 |
| Romania | 102 | 4.33 |
| Sweden | 75 | 3.18 |
| Slovenia | 130 | 5.52 |
| Slovakia | 106 | 4.50 |
| Total | 2,355 | 100.00 |

Source: Own calculations based on data from Flash Eurobarometer 486