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Cloud Computing and Extensive Margins of Exports – An Update using data for 2025

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Cloud Computing and Extensive Margins of Exports – An Update using data for 2025*

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Abstract

In a paper published in the *Journal of Information Economics* in 2024 I reported evidence that firms which use cloud computing do more often export, do more often export to various destinations all over the world, and do export to more different destinations. Results are based on data for manufacturing firms from the 27 member countries of the European Union taken from the Flash Eurobarometer 486 survey conducted in 2020. This note uses strictly comparable data from the Flash Eurobarometer 559 conducted in 2025 and the identical empirical strategy to document that the big picture found for 2020 did not change over the last five years. Extensive margins of exports and the use of cloud computing are still positively related.

JEL classification: D22, F14

Keywords: Cloud computing, exports, firm level data, Flash Eurobarometer 559, kernel-regularized least squares (KRLS)

* The firm level data used in this study are taken from the Flash Eurobarometer 559 and can be downloaded free of charge after registration at http://www.gesis/eurobarometer. Stata code used to generate the empirical results reported in this note is available from the author.

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1. Motivation

In a paper published in the *Journal of Information Economics* Wagner (2024) reported evidence that firms which use cloud computing do more often export, do more often export to various destinations all over the world, and do export to more different destinations. Results are based on data for manufacturing firms from the 27 member countries of the European Union taken from the Flash Eurobarometer 486 survey conducted at the beginning of 2020 – before the Corona pandemic hit the world and before artificial intelligence models were easily available on our laptops.

Do these results still hold five years later after all this progress in advanced technologies? This short note uses strictly comparable data from the Flash Eurobarometer 559 conducted in 2025 and applies the identical empirical strategy that is used in Wagner (2024) to investigate this question. Given that this note is an update of the earlier study, neither the related literature nor the econometric methods applied are discussed in any detail here; readers are referred to the original study. Furthermoe, note that the data from the two surveys conducted in 2020 and 2025 are not panel data, so firms (and any estimated coefficients) cannot be compared over time.

To anticipate the most important result, this note reports that the big picture did not change over time. Extensive margins of exports and the use of cloud computing are still positively related in 2025.

The rest of this note 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 559 survey conducted between February and April 2025. Note that information on export activities relates to the year 2024. We use data for firms from the 27 member states of the European Union in 2025. The sample covers 1,539 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 Q14_2 whether they introduced cloud computing, i.e. the use of remote servers via the internet for storage of files or processing of data. Firms that answered in the affirmative are classified as users of cloud computing. Descriptive evidence is reported in Table 1, showing a share of 48.9 percent of firms using cloud computing. Compared to the sample from the survey conducted in 2020 used in Wagner (2024) this share of users increased by five percentage points.

In the empirical study we look at various measures of export activity of firms:[1]

First, firms were asked in question Q8_1 whether they exported any goods (or not) in 2024. Firms are classified as exporters or non-exporters based thereon. Descriptive evidence is reported in Table 1, showing a share of 58 percent of exporters.

[Table 1 near here]

Second, firms were asked in questions Q8_2 to Q8_8 whether they exported goods in 2024 to the following destinations: Other EU countries; other European countries outside the EU (including Russia); North America; Latin America; China;

[1] 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.

other countries from Asia and the Pacific; countries from the Middle East and Africa. Descriptive evidence is reported in Table 1, showing that 54.7 percent of firms exported to countries from the EU, while 25.7 percent exported to other European countries. The other destinations follow with shares between some eight percent and about 13 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 destinations.

[Table 2 near here]

In the empirical investigation of the link between the use of cloud computing 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 DX2a), firm size (measured as the number of employees – excluding the owners - at the time of the survey; see question DX3a), and whether the firm has introduced an innovation over the last twelve months for which it received a patent or has a patent application pending (see question Q12_7). Descriptive statistics are again reported in Table 1.

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

3. Testing for cloud computing premium 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 cloud computing, and to document the size of these differences, the following empirical approach is applied:

. 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 in (1) is estimated by Probit.

$$(1)\ \text{Indicator}_i = a + ß\ \text{Cloud computing}_i + c\ \text{Control}_i + e_i$$

where i is the index of the firm, Indicator is a dummy variable for the use or not of a type of export activity, Cloud computing is a dummy variable for the use of cloud computing 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 cloud computing premium is computed as the estimated average marginal effects of the cloud computing dummy variable.

For the number of export destinations, (1) becomes (2)

$$(2)\ \text{Number}_i = a + ß\ \text{Cloud computing}_i + c\ \text{Control}_i + e_i$$

where i is the index of the firm, number is the number of export destinations, Cloud computing is a dummy variable for the use of cloud computing 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 model (2) is estimated by OLS. The cloud computing premium is the estimated coefficient ß; it shows the average difference between firms that use and do not use cloud computing, controlling for firm age, firm size, patents, and country of origin of the firm.

3.1 Results from standard parametric models

In a first step, the empirical models outlined above are estimated using standard parametric econometric models with Probit or OLS. Results are reported in the first columns of tables 3 - 5.

The big picture that is shown is crystal clear: Firms that use cloud computing are more often exporters. Furthermore, firms with cloud computing do more often export to all different destinations looked at here except Latin America, and do export to a larger number of destinations. Each estimated cloud computing premium is statistically significant ceteris paribus after controlling for firm age, firm size, patents, and country of origin of the firms.[2]

[Tables 3 – 5 near here]

3.2 Results from Kernel-Regularized Lest Squares (KRLS) models

In the standard parametric models used in section 3.1 the firm characteristics that explain the export margins enter the empirical model in linear form. This functional form which is used in hundreds of empirical studies for margins of exports, however, is rather restrictive. If any non-linear relationships (like quadratic terms or higher order polynomials, or interaction terms) do matter and if they are ignored in the specification of the empirical model this leads to biased results. Researchers, however, can never be sure that all possible relevant non-linear relationships are

[2] Results for the control variables are not reported to economize on space; they are available on request.

taken care of in their chosen specifications. In a robustness check of the results from the standard parametric models, therefore, this note uses the Kernel-Regularized Least Squares (KRLS) estimator to deal with this issue. KRLS is a machine learning method that learns the functional form from the data. It has been introduced in Hainmueller and Hazlett (2014) and Ferwerda, Hainmueller and Hazlett (2017), and used to estimate empirical models for margins of trade for the first time in Wagner (2026). A discussion of the Kernel-Regularized Least Squares (KRLS) estimator is far beyond the scope of this applied note; for a short outline of some of the important features and characteristics might help to understand why this estimator can be considered as an extremely helpful addition to the box of tools of empirical trade economists see Wagner (2024).

KRLS works well both with continuous outcomes and with binary outcomes. It is easy to apply in Stata using the `krls` program provided in Ferwerda, Hainmueller and Hazlett (2017). Instead of doing a tedious specification search that does not guarantee a successful result, users simply pass the outcome variable and the matrix of covariates to the KRLS estimator which then learns the target function from the data. As shown in Hainmueller and Hazlett (2014), the KRLS estimator has desirable statistical properties, including unbiasedness, consistency, and asymptotic normality under mild regularity conditions. An additional advantage of KRLS is that it provides closed-form estimates of the pointwise derivatives that characterize the marginal effect of each covariate at each data point in the covariate space (see Ferwerda, Hainmueller and Hazlett (2017), p. 11). These estimates can be used to examine the heterogeneity of the marginal effects.

Therefore, KRLS is suitable to estimate empirical models when the correct functional form is not known for sure – which is usually the case because we do not know which polynomials or interaction terms matter for correctly modelling the relation between the covariates and the outcome variable.

Results for an application of KRLS to the models for margins of exports are reported in the second to fifth columns of tables 3 - 5.

The big picture that is shown is again crystal clear, and it is identical to the one shown by the standard parametric models: Firms that use cloud computing are more often exporters, do more often export to any of the different destinations except for Latin America, and do export to a larger number of destinations. Each estimated premium is statistically significant ceteris paribus after controlling for firm age, firm size, patents, and country of origin of the firms. Note that the estimated average marginal effects tend to be somewhat smaller here than in the standard parametric models. The difference in the size of the average marginal effects can be explained by the fact that the parametric model in column 1 imposes a restrictive functional form in the shape of the estimated relationships, while KRLS estimated this relationship without imposing a functional form.

An additional advantage of KRLS compared to the parametric models is that it provides closed-form estimates of the pointwise derivatives that characterize the marginal effect of each covariate at each data point in the covariate space (see Ferwerda, Hainmueller and Hazlett (2017), p. 11). The last three columns of tables 3 - 5 report the marginal effects estimated by KRLS at the 1st quartile, at the median, and at the 3rd quartile. We can clearly see the heterogeneity in the marginal effects. The estimated marginal effects differ widely over the quartiles.This shows the nonlinearity and heterogeneity of the relationship between the covariates and the extensive margins of exports.

4. Concluding remarks

This study finds that manufacturing firms from 27 EU member countries that use cloud computing are more often exporters than firms that do not use cloud computing. Furthermore, firms with cloud computing do more often export to different destinations, and do export to a larger number of destinations.

Does this study imply that in order to be successful in export markets, firms should use cloud computing? Or that using cloud computing will help the firms to be successful as an exporter? This is an open question because we do not know whether this premium is due to self-selection of exporting firms into the use of cloud computing, or whether it is the effect of using cloud computing. 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 cloud or not over time (in both directions). The jury is still out to find a generally accepted answer.

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Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Cloud computing (Dummy; 1 = yes)	0.4886	0.5000	0	1
Exporter (Dummy; 1 = yes)	0.5796	0.4938	0	1
Export Destination (Dummy-Variables; 1 = yes)				
- EU-countries	0.5471	0.4979	0	1
- Other Europe	0.2573	0.4373	0	1
- North America	0.1313	0.3378	0	1
- Latin America	0.0760	0.2651	0	1
- China	0.0858	0.2801	0	1
- Other Asia	0.1189	0.3238	0	1
- Middle East, Africa	0.1046	0.3062	0	1
Number of Export Destinations	1.32	1.62	0	7
Firm Age (years)	33.47	32.19	1	325
No. of Employees	138.14	167.13	1	11457
Patent (Dummy; 1 = yes)	0.0572	0.2322	0	1
No. of Firms in Sample	1,539			

Source: Own calculation based on data from Flash Eurobarometer 559

Table 2: Share of Firms by Number of Export Destinations

Number of Export Destinations	Number of Firms	Percent
0	647	42.04
1	352	22.87
2	268	17.41
3	114	7.41
4	68	4.42
5	37	2.40
6	25	1.62
7	28	1.82
Total	1,539	100.0

Source: Own calculation based of data from Flash Eurobarometer 559

Table 3: Empirical results, Part I: Export participation

Method	Probit Average marginal effects	KRLS Average marginal effect	P25	P50	P75
Cloud computing (Dummy; 1 = yes)	0.1195 (0.000)	0.0902 (0.001)	0.0511	0.0818	0.1215
Control variables	included	included			
26 country dummies	included	included			
Number of cases	1,539				

Note: Probit reports average marginal effects from a model estimated by ML Probit. KRLS reports average marginal effects and marginal effects at the 25th, 50th and 75th percentile estimated by kernel-based regularized least squares. P-values are reported in parentheses. For details, see text.

Table 4: Empirical results, Part II: Exporter by destination

Method	Probit Average marginal effects	KRLS Average marginal effect	P25	P50	P75
EU countries					
Cloud computing (Dummy; 1 = yes)	0.1224 (0.000)	0.0870 (0.004)	0.0607	0.0807	0.1180
Other Europe					
Cloud computing (Dummy; 1 = yes)	0.0912 (0.000)	0.0690 (0.007)	0.0211	0.0630	0.1109
North America					
Cloud computing (Dummy; 1 = yes)	0.0476 (0.005)	0.0391 (0.057)	0.0076	0.0407	0.0716
Latin America					
Cloud computing (Dummy; 1 = yes)	0.0126 (0.381)	0.0075 (0.589)	-0.0107	0.0125	0.0218
China					
Cloud computing (Dummy; 1 = yes)	0.0462 (0.003)	0.0297 (0.075)	0.0091	0.0264	0.0610

Other Asia					
Cloud computing	0.0564	0.0451	0.0062	0.0467	0.0739
(Dummy; 1 = yes)	(0.001)	(0.018)			
Middle East, Africa					
Cloud computing	0.0533	0.0334	0.0196	0.0305	0.0469
(Dummy; 1 = yes)	(0.001)	(0.021)			
Number of cases	1,539				

Note: Probit reports average marginal effects from a model estimated by ML Probit. KRLS reports average marginal effects and marginal effects at the 25th, 50th and 75th percentile estimated by kernel-based regularized least squares. P-values are reported in parentheses. All models include control variables (firm size, firm age, patent) and a set of country dummies. For details, see text.

Table 5: Empirical results, Part III: Number of export destinations

Method	OLS Regression coefficient	KRLS Average marginal effect	P25	P50	P75
Cloud computing (Dummy; 1 = yes)	0.2873 (0.003)	0.2305 (0,036)	0.0211	0.2876	0.3989
Control variables	included	included			
26 country dummies	included	included			
Number of cases	992				

Note: OLS reports the estimated regression coefficients from a linear model. KRLS reports average marginal effects and marginal effects at the 25th, 50th and 75th percentile estimated by kernel-based regularized least squares. P-values are reported in parentheses. For details, see text.

Appendix: Number of Firms by Country

Country	Number of Firms	Percent
Austria	45	2.92
Belgium	53	3.44
Bulgaria	48	3.12
Cyprus	26	1.69
Czech Republic	60	1.90
Germany	77	5.00
Denmark	109	7.08
Estonia	67	4.35
Spain	59	3.83
Finland	83	5.39
France	59	3.83
Greece	62	4.03
Croatia	62	4.03
Hungary	57	3.70
Ireland	49	3.18
Italy	66	4.29
Lithuania	46	2.99
Luxembourg	24	1.56
Latvia	60	3.90
Malta	26	1.69
Netherlands	53	3.44
Poland	56	3.64
Portugal	50	3.25
Romania	56	3.64
Sweden	69	4.48
Slovenia	48	3.12
Slovakia	69	4.48
Total	1,539	100.0

Source: Own calculations based on data from Flash Eurobarometer 559

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