# Digitalization and international competitiveness: a cross-country exploration of the relation between firm-level ICT use, productivity and export?

Mark VANCAUTEREN (Hasselt University, Statistics Netherlands)
Kevin Randy CHEMO DZUKOU (INRAE)
Michael POLDER (Statistics Netherlands)
Pierre MOHNEN (Maastricht University)
Javier MIRANDA (Halle Institute for Economic Research, Friedrich-Schiller University Jena)

October 2, 2024

# Context

- Digitalization and other ICT types of adoption, though different from general technological progress, have revived the debate about the 'productivity paradox', and has triggered a new round of upgrading (e.g., AI, Robots) enabling firms to improve their productivity through efficiency gains.
- ICT is largely determined by complementary organizational changes in business processes. In general, information about which type of ICT are used in combination with the availability of specific human capital appears to be very essential in understanding its relationship to productivity.
- Recent research shows that ICT reduces communication costs and trade barriers, which has resulted in an increase of international activities such as trade, the outsourcing of support activities and further integration of global value chains.

# Context

Two hypotheses - non-mutual exclusive:

- **ICT investments** $\longrightarrow$ **export**: trade flows are driven primarily by the utilization of technological innovations including ICT.
- **export** $\longrightarrow$ **ICT investments**: firms profit, e.g., in terms of their technological endowment, from their export.

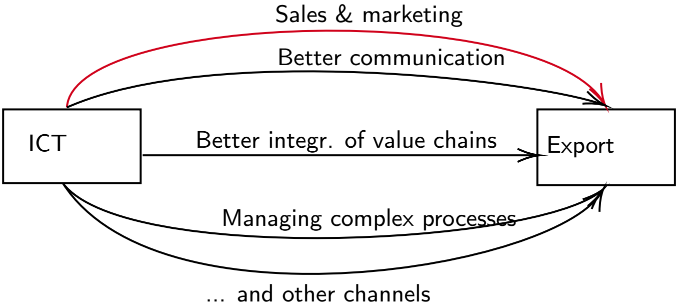
## Two explaining mechanisms

- **Market size effect**: ICT create competitive advantages when entering foreign markets which lead to larger sales volumes (Bloom, Sadun, and Van Reenen 2012).

## Two explaining mechanisms

- **Market size effect**: ICT create competitive advantages when entering foreign markets which lead to larger sales volumes (Bloom, Sadun, and Van Reenen 2012).
- **Competition effect**: ICT active firms acquire new knowledge and expertise that enable them to improve their productivity levels which in turn lead to higher exports (Melitz 2003).

Empirical studies like (Fernandes et al. 2019, Koch, Manuylov, and Smolka 2021, Goldfarb and Tucker 2019 or Kneller and Timmis 2016) demonstrate the importance of ICT on firm exports...**However, none of these studies reach conclusions about the mechanism(s)**.




Within this context, the purpose of the study: to emphasize the "productivity" mechanism

## Objectives

Our objectives can be summarized in three parts

- **First** to estimate cross-country (BE, FR, NL) firm-level TFP in Manufacturing and services which we let to vary by type of firm in terms of ICT technology and (goods) trade behavior.

## Objectives

Our objectives can be summarized in three parts

- **First** to estimate cross-country (BE, FR, NL) firm-level TFP in Manufacturing and services which we let to vary by type of firm in terms of ICT technology and (goods) trade behavior.
- **Second** to explore the determinants of ICT adoption and to relate heterogeneity of ICT to export and TFP. Literature states that the ability to successfully use a technology depends on the technical skills and ICT interrelated types.

## Objectives

Our objectives can be summarized in three parts

- **First** to estimate cross-country (BE, FR, NL) firm-level TFP in Manufacturing and services which we let to vary by type of firm in terms of ICT technology and (goods) trade behavior.
- **Second** to explore the determinants of ICT adoption and to relate heterogeneity of ICT to export and TFP. Literature states that the ability to successfully use a technology depends on the technical skills and ICT interrelated types.
- **Third** objective is to examine the direct and indirect impact of ICT on export through TFP growth at the firm level. Empirical challenge is to disentangle treatment effects of ICT from self-selection and learning by exporting. Are the findings compatible with differences in terms of the trade and ICT environment in the three countries?

# Preview of the main findings

- First, we find that ICT increases export (both at the intensive and extensive margin) everywhere, but the transmission mechanism differs across the three countries.

# Preview of the main findings

- First, we find that ICT increases export (both at the intensive and extensive margin) everywhere, but the transmission mechanism differs across the three countries.
- Second, when we replace TFP by markups in the system of equations, we find that the indirect effect of ICT on export is not significant.

# Preview of the main findings

- First, we find that ICT increases export (both at the intensive and extensive margin) everywhere, but the transmission mechanism differs across the three countries.
- Second, when we replace TFP by markups in the system of equations, we find that the indirect effect of ICT on export is not significant.
- Third, we obtain results that may be indicative of heterogeneous effects among specific ICT technologies.

# Preview of the main findings

- Fourth, we show that human skills are an important determinant affecting ICT, TFP and export jointly, thereby confirming the importance of key workers within innovative and trade-oriented firms.

# Preview of the main findings

- Fourth, we show that human skills are an important determinant affecting ICT, TFP and export jointly, thereby confirming the importance of key workers within innovative and trade-oriented firms.
- Fifth, ICT use is negatively correlated to past TFP in Belgium, positively in France and not significantly in the Netherlands. This suggests different dynamic effects across the three countries.

## Preview of the main findings

- Fourth, we show that human skills are an important determinant affecting ICT, TFP and export jointly, thereby confirming the importance of key workers within innovative and trade-oriented firms.
- Fifth, ICT use is negatively correlated to past TFP in Belgium, positively in France and not significantly in the Netherlands. This suggests different dynamic effects across the three countries.
- Sixth, the correlations between random effects are generally insignificant while the correlations of the idiosyncratic effects are significant suggesting that the simultaneous process of ICT, export and TFP is important.

# Policy relevance

From a policy perspective, our study contributes to an understanding of policies aimed at promoting digitalization and exporting

- Investigating channels through which export, ICT and productivity can be promoted
- How do trade and ICT related country-specificities influence these channels?

Identification issues:

$$[\epsilon_E, \epsilon_\Omega] \perp\!\!\!\perp \epsilon_{ICT} | X_i = x \qquad \text{SI.1}$$

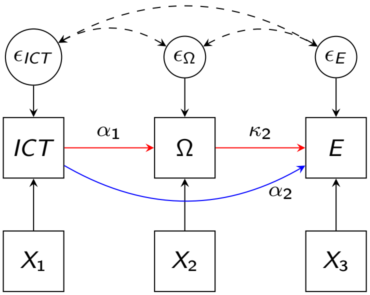
$$[\epsilon_E \perp\!\!\!\perp \epsilon_\Omega | ICT_i = ict, X_i = x \qquad \text{SI.2}$$

where $0 < \Pr(ICT_i = ict | X_i = x) < 1$.

SI.1 rules out the possible existence of unmeasured confounders between ICT, export and productivity. (simultaneity)

SI.2 rules the possible correlation between productivity and export once we control for the ICT status. (anticipation)

Table 1: The direct and indirect role of productivity in the relationship between ICT and export




**The causal model**

$$\begin{aligned} ICT &= f_{ICT}(X_1, \epsilon_{ICT}) \\ \Omega &= f_\Omega(X_2, ICT, \epsilon_\Omega) \\ E &= f_E(X_3, ICT, \Omega, \epsilon_E) \end{aligned} \tag{1}$$

The left panel gives the graphical representation of the mediating role of productivity ($\Omega$) on the relationship between ICT ($ICT$) and exports ($E$). The right panel presents the structural equations of the relationship. $\rightarrow$, *red*, denote indirect mechanism. $\rightarrow$, *blue*, all the other (non-TFP) direct possible causal mechanisms. $\dashrightarrow$ reflect the correlation between (1) random effects and (2) remaining idiosyncratic errors $\epsilon_\Omega$, $\epsilon_{ICT}$, $\epsilon_E$.

## Empirical issues

- A total effect of ICT is decomposed in an indirect effect: $\alpha_1\kappa_2$ and direct effect $\alpha_2$
- We use a multi-equations model in the case of endogenous treatment on diverse types of outcomes using FIML estimator (robustness check: 3SLS)
- The system allows for unobserved heterogeneity by considering an error-component specification allowing for independence between errors and unobserved heterogeneity
- for better identification, we include exogenous control variables: initial conditions, dynamics
- TFP is measured using the control function approach [De Loecker 2013; Ackerberg, Caves, and Frazer 2015] allowing for policy variables of interest, price bias control and markup measurement.

1. Context
2. Empirical framework
3. Data
4. Results
5. Conclusion

## Three important sources of international data

- Balance sheet data (2014-2021, manufacturing industries and trade) from `Insee-DGFiP`, `Statistics Netherlands`, `NBB` and `STATBEL` on the productivity and finances of firms operating in France (37,235 obs.), the Netherlands (9,125 obs.) and Belgium(7,365 obs.) We only select firm having at least 3 consecutive observations.
- The Customs database (FR/BE), which reports the annual export flows of companies per destination (we will also consider export starters).
- `ICT harmonized survey data`, detailed information about ICT usage. We use an ICT innovator on the basis of a `Digitalization Index`. Data on `ICT STEM related capital` is available from the educational databases for Belgium and the Netherlands; France has unique detailed data on `STEM professions` where we consider the same data definition as in Harrigan, Reshef, and Farid 2023.

Table 2: Digital intensity Index, 2021

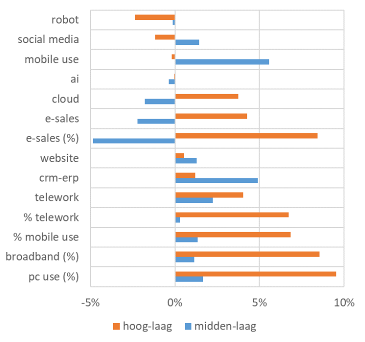
| | |
|---|---|
| 1 | Enterprises where more than 50% of the persons employed have access to the internet for business purposes |
| 2 | Have ERP software package to share information between different functional areas |
| 3 | The maximum contracted download speed of the fastest fixed line internet connection is at least 30 Mb/s but less than 100 Mb/s |
| 4 | Enterprises where web sales were more than 1% of the total turnover and B2C web sales more than 10% of the web sales |
| 5 | Enterprises use interconnected devices or systems that can be monitored or remotely controlled via the Internet (Internet of Things) |
| 6 | Use any social media |
| 7 | Have CRM |
| 8 | Buy sophisticated or intermediate CC services (2021) |
| 9 | Enterprises use artificial intelligence |
| 10 | Buy CC services used over the internet |
| 11 | Used any computer networks for sales (at least 1%) – continuation with previous years |
| 12 | Use two or more social media |

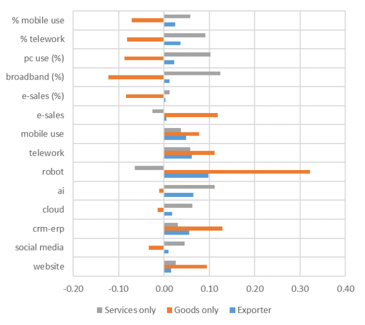
*Source:* Eurostat, Community survey on ICT usage.

- ICT types are interrelated versus specific ICT types
- digital infrastructure (ICT hardware, high-speed broadband connections), digital technologies (CRM, AI), digital skills ICT workforce, skilled personnel)

1. Context
2. Empirical framework
3. Data
4. **Results**
5. Conclusion

# Productivity and export differences according to ICT type




Note: This Table presents descriptive statistics on heterogeneous ICT usage according to high/middle versus low productivity differences (left table) and export versus non-exporters (right table) for the Netherlands. These values are the average over the whole period 2012-2021.

Table 3: The direct and indirect impact of ICT index on firm exports, Belgium

| Variables | ICT use (1) | | Total factor Productivity (2) | | Export output (3) | |
|---|---|---|---|---|---|---|
| *Panel A. Parameters of interest* | | | | | | |
| $ICT_{itML}$ | | | 0.040*** | (0.010) | -0.095 | (0.227) |
| $ICT_{itMH}$ | | | 0.082*** | (0.026) | 0.040 | (0.290) |
| $ICT_{itH}$ | | | 0.120*** | (0.035) | 0.205 | (0.405) |
| $\omega_{it}$ | | | | | 0.580*** | (0.125) |
| *Panel B. Exclusion variables* | | | | | | |
| $ICT_{i,\mathbf{0}}$ | 0.640*** | (0.100) | | | | |
| $ICT_{i,t-\mathbf{1}ML}$ | 1.010*** | (0.115) | | | | |
| $ICT_{i,t-\mathbf{1}MH}$ | 1.950*** | (0.160) | | | | |
| $ICT_{i,t-\mathbf{1}H}$ | 2.770*** | (0.250) | | | | |
| $SKILL_{i,t-\mathbf{1}}$ | 0.957*** | (0.240) | 0.084*** | (0.023) | 0.112* | (0.065) |
| $Capint_{i,t-\mathbf{1}}$ | -0.065*** | (0.017) | | | -0.012 | (0.039) |
| $Emp_{i,t-\mathbf{1}}$ | 0.230*** | (0.030) | | | 0.313*** | (0.083) |
| $\omega_{i,t-\mathbf{1}}$ | -0.340*** | (0.050) | 0.945*** | (0.007) | | |
| $\omega_{i,\mathbf{0}}$ | | | 0.345*** | (0.044) | | |
| $EXP_{i,\mathbf{0}}$ | | | | | 2.431*** | (0.542) |
| $EXP_{i,t-\mathbf{1}}$ | 0.845*** | (0.272) | 0.084 | (0.201) | 0.245*** | (0.075) |

*Notes:* The coefficients on $ICT_{i,\mathbf{0}}$ by ICT category (medium-low, medium-high and high) are reported as an average coefficient for space saving. All equations includes year and sector dummies and an intercept. We report the estimated coefficients rather than the average partial effects. For the export decision equation, we report average partial effects instead of coefficients. Standard Error are in parenthesis. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 4: The direct and indirect impact of ICT index on firm exports, the Netherlands

| | ICT use | | Total factor Productivity | | Export output | |
|---|---|---|---|---|---|---|
| Variables | (1) | | (2) | | (3) | |
| *Panel A. Parameters of interest* | | | | | | |
| $ICT_{itML}$ | | | 0.044 | (0.040) | -0.469 | (0.627) |
| $ICT_{itMH}$ | | | $0.103^{**}$ | (0.055) | -0.645 | (0.765) |
| $ICT_{itH}$ | | | $0.125^{*}$ | (0.075) | -0.434 | (1.112) |
| $\omega_{it}$ | | | | | $0.334^{**}$ | (0.122) |
| *Panel B. Exclusion variables* | | | | | | |
| $ICT_{i,\mathbf{0}}$ | $0.635^{***}$ | (0.058) | | | | |
| $ICT_{i,t-\mathbf{1}ML}$ | $0.915^{***}$ | (0.162) | | | | |
| $ICT_{i,t-\mathbf{1}MH}$ | $1.295^{***}$ | (0.176) | | | | |
| $ICT_{i,t-\mathbf{1}H}$ | $1.955^{***}$ | (0.215) | | | | |
| $SKILL_{i,t-\mathbf{1}}$ | $1.300^{***}$ | (0.252) | $1.007^{***}$ | (0.192) | 0.122 | (0.301) |
| $Capint_{i,t-\mathbf{1}}$ | 0.035 | (0.028) | | | $0.201^{**}$ | (0.071) |
| $Emp_{i,t-\mathbf{1}}$ | 0.100 | (0.075) | | | 0.009 | (0.085) |
| $\omega_{i,t-\mathbf{1}}$ | -0.019 | (0.010) | $0.760^{*}$ | (0.431) | | |
| $\omega_{i,\mathbf{0}}$ | | | $0.295^{***}$ | (0.022) | | |
| $EXP_{i,\mathbf{0}}$ | | | | | $1.377^{***}$ | (0.229) |
| $EXP_{i,t-\mathbf{1}}$ | $1.600^{***}$ | (0.215) | $0.057^{***}$ | (0.019) | $0.940^{*}$ | (0.561) |

*Notes:* The coefficients on $ICT_{i,\mathbf{0}}$ by ICT category (medium-low, medium-high and high) are reported as an average coefficient for space saving. All equations includes year and sector dummies and an intercept. We report the estimated coefficients rather than the average partial effects. For the export decision equation, we report average partial effects instead of coefficients. Standard Error are in parenthesis. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 5: The direct and indirect impact of ICT index on firm exports, France

| | ICT use | Total factor Productivity | Export decision |
|---|---|---|---|
| Variables | (1) | (2) | (3) |
| *Panel A. Parameters of interest* | | | |
| $ICT_{itML}$ | | 0.023*** (0.005) | 0.028*** (0.008) |
| $ICT_{itMH}$ | | 0.037*** (0.006) | 0.062*** (0.012) |
| $ICT_{itH}$ | | 0.058*** (0.010) | 0.120*** (0.019) |
| $\omega_{it}$ | | | 0.050*** (0.007) |
| *Panel B. Other variables* | | | |
| $ICT_{i,0}$ | 0.637*** (0.009) | | |
| $ICT_{i,t-1ML}$ | 0.542*** (0.048) | | |
| $ICT_{i,t-1MH}$ | 0.947*** (0.057) | | |
| $ICT_{i,t-1H}$ | 1.248*** (0.075) | | |
| $SKILL_{i,t-1}$ | 0.914*** (0.090) | 0.050*** (0.010) | 0.037*** (0.013) |
| $Capint_{i,t-1}$ | 0.026*** (0.009) | | 0.002 (0.001) |
| $Emp_{i,t-1}$ | 0.246*** (0.009) | | 0.005*** (0.001) |
| $\omega_{i,t-1}$ | 0.130*** (0.048) | 0.637*** (0.004) | |
| $\omega_{i,0}$ | | 0.289*** (0.005) | |
| $EXP_{i,0}$ | | | 0.159*** (0.006) |
| $EXP_{i,t-1}$ | 0.344*** (0.028) | -0.002 (0.004) | 0.087*** (0.012) |

*Notes:* The coefficients on $ICT_{i,0}$ by ICT category (medium-low, medium-high and high) are reported as an average coefficient for space saving. All equations includes year and sector dummies and an intercept. We report the estimated coefficients rather than the average partial effects. For the export decision equation, we report average partial effects instead of coefficients. Standard Error are

Table 6: Robustness. Using export shares

| | Total factor Productivity | | Export output | |
|---|---|---|---|---|
| Variables | (1) | | (2) | |
| *A. Main parameters of the model, Belgium* | | | | |
| $ICT_{itML}$ | $0.064^{***}$ | (0.018) | 0.012 | (0.010) |
| $ICT_{itMH}$ | $0.106^{***}$ | (0.026) | 0.015 | (0.016) |
| $ICT_{itH}$ | $0.157^{***}$ | (0.036) | 0.019 | (0.024) |
| $\omega_{it}$ | | | $0.015^{**}$ | (0.007) |
| *B. Main parameters of the model, the Netherlands* | | | | |
| $ICT_{itML}$ | 0.281 | (0.312) | 0.532 | (0.497) |
| $ICT_{itMH}$ | $0.108^{**}$ | (0.049) | 0.775 | (0.612) |
| $ICT_{itH}$ | $0.154^{**}$ | (0.066) | 0.784 | (0.776) |
| $\omega_{it}$ | | | $0.185^{**}$ | (0.101) |
| *C. Main parameters of the model, France* | | | | |
| $ICT_{itML}$ | $0.023^{***}$ | (0.005) | $0.011^{***}$ | (0.002) |
| $ICT_{itMH}$ | $0.037^{***}$ | (0.006) | $0.021^{***}$ | (0.002) |
| $ICT_{itH}$ | $0.050^{***}$ | (0.010) | $0.031^{***}$ | (0.003) |
| $\omega_{it}$ | | | $0.023^{***}$ | (0.004) |

*Notes:* To obtain results in columns (1) and (2), we regress equations ?? using a random-effects mixed model (ordered logit for the ICT (not reported) and linear models for TFP and export). All the estimated equations include variables in the vector $x_{it}$ as observed confounders. We also include variables used as excluded instruments in their respective equation. The values reported in the Table are the estimated coefficients and values in parentheses are the standard error. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

# Table 7: Robustness. Using markups

| | Log of markups | | Export output | |
|---|---|---|---|---|
| Variables | (1) | | (2) | |
| *A. Main parameters of the model, Belgium* | | | | |
| $ICT_{itML}$ | 0.019 | (0.028) | 0.947*** | (0.213) |
| $ICT_{itMH}$ | 0.053 | (0.026) | 1.361*** | (0.345) |
| $ICT_{itH}$ | 0.102* | (0.058) | 1.185*** | (0.024) |
| $\mu_{it}$ | | | 0.861 | (1.3001) |
| *B. Main parameters of the model, the Netherlands* | | | | |
| $ICT_{itML}$ | 0.281 | (0.312) | 0.119 | (0.144) |
| $ICT_{itMH}$ | 0.177 | (0.190) | 0.775 | (0.612) |
| $ICT_{itH}$ | 0.112 | (0.260) | 1.049 | (1.082) |
| $\mu_{it}$ | | | 0.861 | (1.300) |
| *C. Main parameters of the model, France* | | | | |
| $ICT_{itML}$ | 0.024 | (0.082) | 0.028*** | (0.008) |
| $ICT_{itMH}$ | 0.033 | (0.073) | 0.063*** | (0.012) |
| $ICT_{itH}$ | 0.047 | (0.123) | 0.120*** | (0.019) |
| $\mu_{it}$ | | | 0.021** | (0.011) |

*Notes:* To obtain results in columns (1) and (2), we regress equations ?? using a random-effects mixed model (ordered logit for the ICT (not reported) and linear models for markups and export). All the estimated equations include variables in the vector $x_{it}$ as observed confounders. We also include variables used as excluded instruments in their respective equation. The values reported in the Table are the estimated coefficients and values in parentheses are the standard error. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 8: Robustness. Using e-commerce shares

| | Total factor productivity | Export output |
|---|---|---|
| Variables | (1) | (2) |
| *A. Main parameters of the model, Belgium* | | |
| $ECom_{it}$ | $0.276^{***}$ (0.045) | -0.081 (0.349) |
| $\omega_{it}$ | | $0.260^{***}$ (0.088) |
| *B. Main parameters of the model, the Netherlands* | | |
| $ECom_{it}$ | $-0.044^{***}$ (0.011) | 0.004 (0.255) |
| $\omega_{it}$ | | $0.875^{***}$ (0.083) |
| *C. Main parameters of the model, France* | | |
| $ECom_{it}$ | $0.011^{***}$ (0.003) | $0.191^{***}$ (0.060) |
| $\omega_{it}$ | | $0.752^{***}$ (0.101) |

*Notes:* To obtain results in columns (1) and (2), we regress equations ?? using arandom-effects mixed model (ordered logit and linear models). All the estimated equations include variables in the vector $x_{it}$ as observed confounders. We also include variables used as excluded instruments in their respective equation. The values reported in the Table are the estimated coefficients and values in parentheses are the standard error. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

Table 9: Robustness. Using CRM-ERP

| Variables | Total factor productivity (1) | | Export output (2) | |
|---|---|---|---|---|
| *A. Main parameters of the model, Belgium* | | | | |
| $CrmErp_{it}$ | 0.204*** | (0.050) | 0.723** | (0.346) |
| $\omega_{it}$ | | | 0.317* | (0.186) |
| *B. Main parameters of the model, the Netherlands* | | | | |
| $CrmErp_{it}$ | 0.089*** | (0.023) | 1.060 | (0.686) |
| $\omega_{it}$ | | | 0.611** | (0.248) |
| *C. Main parameters of the model, France* | | | | |
| $CrmErp_{it}$ | 0.019*** | (0.002) | 0.089** | (0.042) |
| $\omega_{it}$ | | | 0.739*** | (0.101) |

*Notes:* To obtain results in columns (1) and (2), we regress equations ?? using a random-effects mixed model (ordered logit for the ICT (not reported) and linear models for TFP and export). All the estimated equations include variables in the vector $x_{it}$ as observed confounders. We also include variables used as excluded instruments in their respective equation. The values reported in the Table are the estimated coefficients and values in parentheses are the standard error. $^{***}p < 0.01$, $^{**}p < 0.05$ and $^{*}p < 0.1$.

1 Context

2 Empirical framework

3 Data

4 Results

5 Conclusion

## Conclusion & Policy implications

- ICT increases export (both at the intensive and extensive margin) everywhere, but the transmission mechanism differs across the three countries.
    - In Belgium and in the Netherlands it is to a large extent due to ICT-driven improved productivity whereas in France, although there also exists the indirect effect, ICT affects exporting mainly through other unidentified (non-TFP related) channels.
- In France, part of the productivity effect runs though profitability rather than efficiency; in Belgium and France, we do not find any productivity effect explained by markups

Combining firm and country-level perspectives with a focus on three EU countries, this paper allows to disentangle various economic policy drivers within a contextual framework

- if exporting (at the intensive or extensive margin) is a policy goal, export performance is positively related to increased productivity. Hence any policy boosting productivity should on average promote exports.
- A potential policy lever to promote productivity is to provide incentives for a greater use of ICT. Our results clearly show that a higher use of ICT increases productivity.

- Small open economies heavily involved in international trade, like Belgium and the Netherlands, probably have a lead when it comes to ICT investments necessary to increase their export performance. Firms in economies with a larger domestic market and less dependent on international trade, like France, may still have to make progress in exporting through the adoption of ICT.
- The lower effect of ICT on export in France could be due to the structure of France's economy, with a higher share of activities in low digital-intensive industries and a lower share of activities in high digital-intensive industries than in Belgium and in the Netherlands
    - in 2018 the proportion of low-intensive activities was 31.85% in France, 26.18% in Belgium and 25.62% in the Netherlands, whereas the proportion of high-intensive activities was 24.92% in France, 27.64% in Belgium and 28.06% in the Netherlands; source: OECD, STAN Database for Structural Analysis.

# Références bibliographique I

Bloom, Nicholas, Raffaella Sadun, and John Van Reenen (2012). "Americans Do IT Better: US Multinationals and the Productivity Miracle". In: *American Economic Review* 102.1, 167–201. DOI: 10.1257/aer.102.1.167. URL: https://www.aeaweb.org/articles?id=10.1257/aer.102.1.167.

Melitz, Marc (2003). "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity". In: *Econometrica* 71.6, pp. 1695–1725. DOI: 10.1111/1468-0262.00467.

Fernandes, Ana M. et al. (2019). "The internet and Chinese exports in the pre-ali baba era". In: *Journal of Development Economics* 138, pp. 57–76. ISSN: 0304-3878. DOI: https://doi.org/10.1016/j.jdeveco.2018.11.003. URL: https://www.sciencedirect.com/science/article/pii/S0304387818304942.

# Références bibliographique II


Koch, Michael, Ilya Manuylov, and Marcel Smolka (2021). "Robots and Firms". In: *The Economic Journal* 131.638, pp. 2553–2584. URL: https://ideas.repec.org/a/oup/econjl/v131y2021i638p2553-2584..html.

Goldfarb, Avi and Catherine Tucker (2019). "Digital Economics". In: *Journal of Economic Literature* 57.1, 3–43. DOI: 10.1257/jel.20171452. URL: https://www.aeaweb.org/articles?id=10.1257/jel.20171452.

Kneller, Richard and Jonathan Timmis (2016). "ICT and Exporting: The Effects of Broadband on the Extensive Margin of Business Service Exports". In: *Review of International Economics* 24.4, pp. 757–796. DOI: https://doi.org/10.1111/roie.12237. eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/roie.12237. URL: https://onlinelibrary.wiley.com/doi/abs/10.1111/roie.12237.

De Loecker, Jan (2013). "Detecting Learning by Exporting". In: *American Economic Journal: Microeconomics* 5.3, pp. 1–21. ISSN: 19457669.

Ackerberg, Daniel A., Kevin Caves, and Garth Frazer (2015). "Identification Properties of Recent Production Function Estimators". In: *Econometrica* 83.6, pp. 2411–2451. ISSN: 0012-9682.

# Références bibliographique IV

Harrigan, James, Ariel Reshef, and Toubal Farid (2023). "Techies and firm level productivity".