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Characteristics of Firms Transmitting Data Across Borders: Evidence from Japanese Firm-level Data

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Characteristics of firms transmitting data across borders: Evidence from Japanese firm-level data*

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Abstract

Cross-border data flows are increasingly critical for our economies in the digital age, but only a limited fraction of firms regularly transfer data across national borders or collect data from overseas. Based on our unique survey on cross-border data transfers linked with firm-level data derived from official statistics in Japan, we find that high-productivity firms tend not only to be active in global activities, such as exporting and foreign direct investment, but also to intensively transmit data across borders. Globalized and productive firms are also more likely to introduce 3D printers.

Keywords: cross-border data transmission; firm-level data; globalization; productivity; 3D printer
JEL Classifications: F14; F23; O33

*This study is conducted as a part of the Project "Empirical Analysis of Corporate Global Activities in the Digital Economy" undertaken at the Research Institute of Economy, Trade and Industry (RIETI). This study utilizes the micro data of the questionnaire information based on "the Basic Survey of Japanese Business Structure and Activities" which is conducted by the Ministry of Economy, Trade and Industry (METI), and the micro data of the "Survey of cross-border data flows of firms," which is conducted by RIETI. The authors are grateful for helpful comments by Makoto Yano and Masayuki Morikawa.
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1. Introduction

As has been frequently mentioned, cross-border data flows are increasing in our digitized economies.[1] We observe the introduction of regulations on data transfers across borders, including European Union's General Data Protection Regulation (GDPR) and cyber security regulations by emerging countries, such as China and Russia, to respond to this trend. To capture useful information for discussing this critical policy issue, we conducted a survey of Japanese firms asking about their cross-border data transfers. From our survey, we find that only a limited fraction of firms are active in data collection overseas even among large- or mid-sized firms in Japan.[2] This paper combines the results of this unique survey with firm-level data derived from official statistics to characterize firms actively engaged in cross-border data transfers in terms of basic firm attributes, especially their productivity.

While it is vital to know the value and content of data flows crossing national borders, it is practically impossible for academic researchers to directly capture these by surveys. Our survey asked about firms' activities regarding the collection of digital data, including the introduction of the Internet of Things (IoT). In our survey, we also asked whether firms are affected by regulations on cross-border data transfers. From these questions, we can indirectly infer whether firms are actively transmitting vast or detailed data across national borders. Our survey results show that the share of firms transmitting data across borders is extremely limited even among our sample excluding small-sized firms. This finding indicates the importance of characterizing these firms. In other words, we will report how they differ from other firms in their basic firm characteristics.

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[1] McKinsey Global Institute (2016), for example, reports the explosion of data flows in terms of bytes.

[2] See Tomiura et al. (2019) for a detailed explanation of the survey.

To document these firm attributes, we derive firm-level data from official statistics conducted annually by the government. All mid- or large-sized firms in manufacturing, wholesale and related service industries are required to respond by law. In this sense, our sample can be regarded as a reliable representation of Japanese firms in Japan. We find that firms actively transmitting data across borders tend to be large, productive, and active in globalization, such as exporting and foreign direct investment (FDI). The productivity of firms collecting data in the home country and overseas tends to be higher than those collecting data only in the home country, which in turn tends to be higher than those not engaged in data collection. The productivity premium is especially evident for firms collecting data overseas and affected by regulations on cross-border data transfers, suggesting non-negligible fixed costs for transmitting data across national borders.

The relation with firm attributes also discussed in this paper is about the introduction of 3D printers. Among various equipment recently introduced to manufacturing, 3D printing is one of the most important in its potential impact on international trade. As 3D printing makes assembly process and jigs almost completely useless, we will witness declined transports of intermediates and materials but activated transactions and speedy local production of more customized products. We focus on 3D printers also as an equipment for active cross-border data flows, as firms need to intensively transmit design data.[3] As firms using 3D printers are still extremely limited, however, it is premature to determine the impact of 3D printers on business performance and economic activities. This paper examines which characteristics of firms are related with the adoption of this new technology. While we expect more intensive use of 3D printers by larger firms, it will be informative to investigate associations especially with firms' global activities.

[3] ING (2017) predicts that 3D printing will eliminate almost one quarter of world trade by 2060.

The rest of this paper is organized as follows. Section 2 explains our two data sources. Section 3 reports our empirical results from summarizing descriptive statistics summary and estimating regressions. Section 4 adds concluding comments.

2. Description of data

This section describes our dataset, which we construct by combining two data sources: a survey of cross-border data transmission, and firm-level data of basic firm characteristics. We obtain unique data of cross-border data transmission by our own survey of Japanese firms. The firm-level data is retrieved from the official statistics conducted annually by the Japan's Ministry of Economy, Trade, and Industry (METI). By merging these two, we can characterize cross-border data transmitters in terms of fundamental firm attributes, such as firm size, productivity and capital intensity.

The information on cross-border data transmission was collected by our survey of firms in Japan. The "Survey of cross-border data flows of firms" was conducted by the Tokyo Shoko Research Co., Ltd. (TSR) for our research project at the Research Institute of Economy, Trade and Industry (RIETI). We sent the questionnaire to all large- and mid-sized firms (50 or more employees and capital of 30 million yen or more) in manufacturing, wholesale, and information-related service industries in Japan.[4] As most small firms concentrate on the domestic market and as they are unlikely to actively transfer data across borders, the omission of small firms will not affect our main results. Hence, our survey can be regarded as a reliable representation of

[4] We sent the questionnaire to all firms covered by the METI's *Basis Survey of Japanese Business Structure and Activities* (*Keizaisangyosho Kigyo katsudo kihon chosa* in Japanese), which METI conducts annually by imposing legal reporting obligation in these industries. Before sending our questionnaire, we drop firms experiencing recent bankruptcy or mergers based on updated information from the TSR. Additionally, TSR found that eight firms were integrated or dissolved among 19,790 firms. These discrepancies are due to the time lag after the most recent survey at the time of this research.

firms in Japan when we discuss cross-border data activities. We distributed our survey questionnaires at the beginning of April 2019, and accepted responses until August.[5] We sent questionnaires to 19,790 firms and collected responses from 4,227 firms with the response rate of 21%, which is relatively high for an academic survey.

Although we are interested mainly in data transfer by manufacturers, we include wholesalers as some manufacturing firms are categorized as wholesalers as a result of offshoring and/or the outsourcing of production tasks.[6] As information-related service industries, we cover the following: software (391), information processing service (392), Internet services (401), academic, research and development institutions (710), and engineering (728) (Japanese Standard Industry Classification numbers in parentheses).

A previous survey closely related to ours is that of the Organisation for Economic Cooperation and Development (OECD), which is briefly referred to in OECD (2018). The sample size of our survey is by far larger than that of the OECD business questionnaire, which covered 259 firms.[7] While the OECD survey concentrates on ICT and business service sectors, we include manufacturers and wholesalers. Although OECD asked firms to reveal how much cross-border data protection affected their costs, we decided not to include this type of question as information-demanding quantitative questions inevitably result in response rejections. Our survey instead focuses on the firms' data collection activities overseas and how their activities are affected by newly introduced regulations on cross-border data transfers, such as EU's GDPR

[5] The firms could choose to respond either by (i) filling in the survey form directly and returning it in the enclosed return envelope, or (ii) accessing the URL provided and answering the questions using the provided ID and password. As a result, 2,628 were via the postal mail and 1,599 via the Internet.

[6] From the wholesale sectors, we omitted the following three industries, as they are likely to be unrelated to cross-border activities or difficult to characterize: wholesalers of construction materials (531), wholesalers of renewable resources (536), and miscellaneous wholesalers (559), with Japanese Standard Industry Classification numbers in parentheses.

[7] The respondent firms in the OECD survey are from over 48 countries with 16 from Japan.

or Cyber Security Act of China and similar regulations of other emerging countries. If a firm recognizes that it has been affected by these regulations, we can interpret it as an indication that the firm has transferred significant amounts of data and/or detailed, sensitive data across borders.

The second data source we use for our research is firm-level data derived from METI's Basic Survey of Japanese Business Structure and Activity (hereinafter BSJBSA for short, or *Keizaisangyosho Kigyo Katsudo Kihon Chosa* in Japanese). METI conducts this survey annually by imposing legal reporting obligation for all mid- or large-sized firms as defined above. Firms are required to report the previous year's financial information on a non-consolidated firm basis. We design the sample of our survey on data transfers in order to exactly match that of the official statistics. Although the industrial coverage of BSJBSA includes retail and other wide-ranging services, we draw firms in manufacturing, wholesale and above-mentioned information-related services. The items collected by BSJBSA include basic firm attributes, such as the firm size (number of employees), sales, capital (tangible fixed assets), R&D and ICT expenditures, exports, imports, and the status of multinational enterprise (MNE, firms investing in foreign related companies). The labor productivity is the value added divided by the number of employees. The total factor productivity (TFP) is defined as residuals of Cobb-Douglas production function, using the value-added as the output, and both the hours worked and fixed tangible assets as the inputs. Unless otherwise noticed, this paper links our survey on cross-border data transfers with the firm characteristics at the year 2017, two years before our survey, to circumvent the possible reverse causality. Although we omit the results with alternative lags, we confirm that our principal findings remain basically intact even if we link with firm attributes at five years ago, ten years ago or the previous year.

3. Empirical results

3.1. Basic firm characteristics

This subsection summarizes characteristics of firms active in data transfers across national borders. Although it is far from perfect, our survey gathers useful information at least indirectly related with cross-border data transfers of firms.

As shown in Table 1, only a limited fraction of firms is actively collecting data. Our survey asks respondents the following question; *For the collection of data in Japan and overseas through business in your company, choose the most appropriate option from the following*.[8] More than half of firms are not collecting data regularly even within the home country. The percentage of the firms introducing IoT in Japan is less than 8%, with the share of those using IoT overseas even lower at 2%.[9] Although firms can collect digital data without IoT, the percentage of firms collecting data overseas with or without IoT is a mere 10% (2.31+8.73). This result suggests that only a handful of firms are engaged in cross-border data transfer, although some of these firms may store and/or process collected data in the foreign country without transferring data across borders. As a stylized fact in international economics, we know that only a limited share of firms exports and invests directly abroad. We will later examine the relationship between the firm's cross-border data transfers and their exporting and FDI.

Table 1 around here

[8] We provided an explicit definition of "data" in our survey in the following note to the question of our survey: "*the 'data' refers to raw data before being processed and/or edited on the format, such as a database*." The main motivation of this definition is to exclude already constructed databases.
[9] In the survey, we give the definition of IoT in the note to the question as follows; "*IoT" refers to various devices connected via networks for collecting digital data*.

Table 2 compares basic firm attributes across different types of firms. We group firms by their engagement in data collection: (1) not collecting data, (2) collecting data in Japan, (3) collecting data overseas and in Japan.[10] We find that firms decisively differ according to their data activities. Firms actively collecting data overseas tend to be substantially larger in size, and more productive than firms collecting data only within the home country, which are in turn larger and more productive than those not engaged in data collection even within Japan. The ordering is not affected whether we measure the firm size in terms of sales, value-added, the number of employees or capital (fixed tangible assets). The productivity ranking is the same between labor productivity and TFP. We observe the same ordering in R&D intensity (R&D expenditure divided by total sales) and in the probability of exporting. ICT intensity (information and communication expense divided by total sales) is related with the firms' engagement in data collection activities in general, but not necessarily with those overseas. The firms' age appears not to be discernibly associated with data collection in our sample.

Table 2 around here

As an additional investigation, we further examine how the productivity premium varies by using another question in our survey. As we asked firms about whether they recognize any impacts of regulations on cross-border data transfers, it is possible to further divide firms collecting data overseas into the following two categories: (3) collecting data overseas but recognizing no impacts of regulations, (4) collecting data overseas and reporting impacts of regulations. As expected, firms that report some impacts tend to be larger, more productive, or

[10] Since there are only two firms that collect data overseas but do not collect data in Japan, we merge them with the firms that collect data both in Japan and overseas. The tabulation of basic firm attributes across the original responses to the question is also available in Appendix Table A1.

globalized than those that did not. This finding can be interpreted as suggesting that firms are likely to be affected by regulations of cross-border data transfers when they transmit vast amount of or sensitive data across borders. The summary results will be shown in Appendix Table A2.

3.2. Productivity premiums of firms transmitting data across borders

While the previous subsection reveals that firms actively collecting data overseas distinctively differs from other firms in many dimensions, this subsection focuses on the productivity premiums, which is the extent of productivity advantage of firms actively collecting data overseas relative to those not collecting data overseas. The motivation of this focus on productivity is the established stylized fact repeatedly reported in international economics. A series of empirical and theoretical studies in the literature of firm heterogeneity and international trade have indicated that more productive firms succeed in entering the international market. Since Bernard and Jensen (1995), the productivity premiums of exporters over non-exporters have been confirmed in many countries. The productivity premiums of FDI firms are formalized by Helpman et al. (2004) relative to exporters and by Antràs and Helpman (2004) over foreign outsourcers. Tomiura (2007) is an early empirical study confirming productivity ordering among firms in these three different globalization modes.

As firms are likely to incur fixed costs not only for exporting and FDI but also for cross-border data transmissions, only highly productive firms can enter into these activities. The fixed costs are expected to be higher for transmitting data across borders than those within the home country. Additional costs for cross-border data transfers include compliance with foreign regulations and installation of required servers and networks. Only a limited number of productive firms are supposed to be able to cover these non-negligible fixed costs. Therefore, it

is predicted that only productive firms are collecting data across borders while less productive firms collect data only within the home country, and the least productive firms do not engage in data collection.

Considering that productivity does not follow the normal distribution, we examine this sorting pattern by using the semiparametric quantile regressions where the normality assumption is relaxed. The quantile regressions allow us to estimate the coefficients of the covariates on any particular percentile of the productivity distribution. The estimated model is expressed as follows:

$$Y_{i,q} = \alpha_q + \beta_{1q} DD_i + \beta_{2q} DO_i + \beta_{3q} EXP_i + \beta_{4q} MNE_i + u_{i,q},$$

where *Y* is labor productivity or TFP in logarithm; *q* indicates *q* th quantile; *i* indexes firm; *DD* is the dummy for firms collecting data domestically; *DO* is the dummy for firms collecting data overseas. *EXP* and *MNE* indicate the status of exporter and that of MNE, respectively. The estimated coefficients of *DD* and *DO* indicate the difference in the log of the productivity indicators at the *q* th conditional quantile compared to firms not engaged in data collection, and thus they are regarded as productivity premiums associated with the data collection activities.

Table 3 displays the results of productivity premiums from the quantile regressions at five quantiles: 0.1, 0.25, 0.5, 0.75, and 0.9 quantiles. Column (1) shows the result from OLS as a reference and (2)-(5) display the results for the quantiles. Panel (a) displays the results for TFP while Panel (b) present those for the labor productivity. The all models include 3-digit industry dummy variables though the estimated coefficients are suppressed. The quantile regression results in this table confirm the previous finding from descriptive statistics. The results show statistically significant and positive productivity premium for firms collecting data, except for

the lowest quantile. The productivity of firms collecting data overseas is consistently the highest in all quartiles except the bottom, followed by that of firms collecting data only within Japan, which is in turn higher than that of firms not collecting data even within Japan. This sorting pattern is consistent with our conjecture based on the literature of firm heterogeneity in international trade. This ordering is observed even if we control for the firms' globalization by adding the dummies for exporters and multinationals.

Table 3 around here

As shown in the previous subsection, firms collecting data overseas can be divided into the two groups depending on whether they are affected by the data transfer regulations. Table 4 reports the results from the model that separately includes *DO* and *DOR*, of which the latter is defined as the dummy for firms collecting data overseas that recognize some impacts of the regulations on cross-border data transfers. Regarding the regulations, we conducted estimations by changing the *DOR* categorization as follows: (a) GDPR of EU, and (b) Cyber Security Law in China and similar regulations by other emerging countries.

Table 4 around here

As a whole, the results in Table 4 show statistically significant and positive productivity premiums for firms collecting data overseas and reporting regulatory impacts compared to firms not involved in data collection, while such productivity premium turns out to be insignificant or negligible for firms collecting data overseas but recognizing no regulatory impacts and for firms collecting data only in Japan. This result indicates that the productivity premiums of the cross-

border transmitters affected by the regulations are substantial. In addition, the comparison of the estimated coefficients between the quantiles shows that the productivity premiums for firms collecting data overseas and reporting regulatory impacts are consistently significant and positive at the all TFP or labor productivity deciles except for the results in the 0.1 quantile in the panel (b). The largest magnitude of the *DOR* is found in the most productive firms as shown in the column of 0.9 quantile, indicating that cross-border data transfer particularly matters at the upper tail of the conditional distribution of TFP or labor productivity. This result suggests that only a handful of extremely high-productivity firms are intensively engaged in cross-border data transfers.

The survey also asked about firms' responses to the data transfer regulations. Table 5 presents the characteristics of firms grouped according to their responses to the regulations. Firms that have taken some countermeasures are on average large in size and all indicators listed in the table are likely to be high both in their responses to EU's GDPR and emerging countries' regulations. For example, the firms that have started to process and store data at own affiliates located in EU (A) have six times greater turnover on average than firms that are not considering any countermeasures (E) in responding to GDPR. In the case of the responses to cyber security regulations in China and other emerging economies, their sales size is more than three times larger.[11]

Table 5 around here

[11] The survey also asked respondents whether firms transfer data to/from their own overseas subsidiaries. Among firms transferring data regularly, more than half of them are intra-firm data transmitters (Tomiura et al., 2019). Thus, we further decompose the category of cross-border data transmitters into the two groups (see Appendix Table A3). Firms engaged in intra-firm cross-border data transfer have higher productivity premiums, consistent with the finding shown in Table 5, even after controlling for the MNE status (whether the firm own a foreign affiliate).

Thus, the firms affected by regulations can be divided into those that have taken actions and those that have not. The differences in productivity premiums with and without measures against regulations are examined in Table 6. As for panel (a) on the measures for GDPR, the results from OLS show that firms that have taken measures tend to be more productive than those that do not, suggesting that regulatory compliance can be costly. On the other hand, the results of quantile regression suggest that the ordering in terms of the responses to regulation is heterogeneous depending on the level of productivity. The highest positive coefficient of the dummy for a firm that has taken measures to regulations is found in the highest TFP quantile while the dummy for a firm that has not taken measures shows a negative sign in the highest TFP quantile and its positive coefficients are found at the lower tail of the conditional distribution of TFP. For high-productivity firms, taking measures is closely related to the productivity premium, while for low-productivity firms, the opposite is more associated with the productivity premium. This contrasting result suggests that measures for GDPR are essential for high-productivity firms, but not necessarily for low-productivity firms.

Table 6 around here

3.3. Introduction of 3D printers

Our survey also inquired about the introduction of 3D-printers, as its use increases cross-border data flows and possibly influences international trade in goods. The question we asked on 3D printers was as follows.

The "3D printer" is a new device that sends design drawings to remote locations and does not require molds or jigs. Its introduction may replace the trade in goods through digital

data transfer, and may facilitate trade. Does your company use 3D printers on a daily basis for routine manufacturing operations (including prototype production, and use in affiliated companies)? Choose the most appropriate as the impact on exports and imports of goods.

1. The introduction of 3D printers has decreased exports and/or imports of goods.

2. The introduction of 3D printers has increased exports and/or imports of goods.

3. Our company has introduced 3D printers, but there is no significant change in exports and/or imports of goods.

4. Our company does not use any 3D printer for routine manufacturing operations (or does not perform manufacturing operations).

Note: "3D printer" refers to a machine that forms a solid object by stacking cross-sectional shapes from three-dimension digital data generated by computers.

Although we omit to show the tables to save space, our survey shows that very few firms have introduced 3D printers.[12] In our sample, 93.3% of firms have not yet introduced 3D printers. Though from such a limited number of users, 6.5% of the firms reported no impact on their international trade in goods, possibly due to the limited use of 3D printers or to their premature stage of 3D printer usage. As the impact of 3D printers on international trade remains to be seen, this paper focuses on the relationship between firm characteristics and the introduction of 3D printers.

Table 7 shows the average value of basic characteristics of firms grouped by their usage of 3D printers. To alleviate the problem of reverse causality, we compare firm attributes not only at the most recent year 2017, but also those at five years ago (2014) and ten years ago (2009) to capture the characteristics prior to the introduction of this new technology. On

[12] See again Tomiura et al. (2019) for the survey result on 3D printers.

average, firms that have introduced 3D printers have about three times more sales and employees than those that have not. This remarkable difference in firm size is confirmed even if we compare the size of firms 5 years ago and 10 years ago. The higher productivity is also associated with the introduction of 3D printers. The proportion of internationalized firms such as exporters and MNEs is also high among firms that have introduced 3D printers.

Table 8 shows the results of adding the dummy variable indicating introduction of 3D printers to the quantile regression model estimated in the previous subsection. Although the results from OLS show insignificant coefficients on average, but quantile regression results show that the productivity premium with the introduction of 3D printers is not uniform. The productivity premium due to the introduction of 3D printers remains for firms at the median level of productivity quantile, even considering cross-border data flows and other internationalization indicators.

Table 7 and 8 around here

With the introduction of 3D printers, firms will be able to manufacture goods by transferring data such as blueprints and designs. Therefore, the introduction of 3D printers is possibly related to data transfer. Cross-tabulations of the data transfer mode and the introduction of 3D printers in our survey are shown in the Appendix Table A4 as descriptive statistical evidence. Although the number of 3D printer users is limited, the percentage of firms engaged in cross-border data transfer is high when comparing the firms that have introduced 3D printers with those that have not.

We also investigate a possible complementary relationship between the introduction of 3D printers and cross-border data transfer for the productivity premium by adding the

interaction term of data transfer mode dummy variables and the dummy variable indicating introduction of 3D printers to the quantile regression model. Although the complementary relationship is partially shown at the bottom of the productivity quantile, the robust relationship is not detected (See Appendix Table A5 for details). There seems to be no additional productivity premium for firms simultaneously transmitting data across borders and introducing 3D printers, except for the lowest productivity firms.

4. Concluding remarks

While cross-border data flows are increasing, firms engaged in cross-border data transmissions remain limited. By merging our unique survey on cross-border data activities of firms with firm-level data drawn from official statistics, we have characterized firms active in cross-border data transfers. Firms actively collecting data overseas tend to be significantly more productive than those only within the home country, which in turn are more productive than those not involved in data collection. The productivity premium is particularly noticeable for firms collecting data overseas and affected by the regulations on cross-border data transfers. This pecking order of productivity is the same as repeatedly confirmed ordering in the firms' globalization; FDI firms are more productive than exporters, which in turn more productive than domestic firms. We also find a similar ordering in the introduction of 3D printers. As we use lagged firm attributes in our regressions, the problem of reverse causality is expected to be mitigated. Although our finding is a useful first step toward our understanding of cross-border data flows at the firm level, there are several issues remain for future work. For example, it will be informative if a new survey enables us to quantify the data crossing borders.

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Appendix

Table A1. Data collection activities and firm attributes

(a) Collecting data in Japan	Collecting data with IoT	Collecting data without IoT	Not collecting data	Not sure	Total
N of firms	325	899	2315	620	4159
Total sales	46041.1	16411.1	7561.0	7172.2	12423.0
Fixed tangible asset	7236.6	3095.0	1356.4	1336.3	2190.3

N of employees (L)	811.6	315.9	176.6	166.8	254.8
Value added (VA)	7720.5	2824.1	1191.8	1033.2	2031.2
VA/L	6.88	6.94	6.42	5.89	6.49
TFP	0.04	0.03	-0.02	-0.12	-0.02
Exporter share	0.34	0.36	0.23	0.19	0.26
MNEs share	0.27	0.23	0.15	0.12	0.17
R&D intensity	0.0156	0.0174	0.0129	0.0097	0.0140
ICT intensity	0.0067	0.0049	0.0038	0.0024	0.0040
Firm age	49.1	47.8	47.7	48.8	48.0

(b) Collecting data overseas	Collecting data with IoT	Collecting data without IoT	Not collecting data	Not sure	Total
N of firms	93	352	2850	736	4031
Total sales	114148.5	28163.7	8702.9	7303.1	12579.5
Fixed tangible asset	16932.0	5901.1	1499.4	1330.9	2211.6
N of employees (L)	2009.5	523.0	189.9	170.9	257.5
Value added (VA)	20182.6	5516.2	1297.5	1064.6	2059.0
VA/L	7.12	7.53	6.49	5.93	6.49
TFP	0.08	0.10	-0.01	-0.12	-0.02
Exporter share	0.67	0.56	0.24	0.19	0.27
MNEs share	0.55	0.40	0.15	0.12	0.18
R&D intensity	0.0230	0.0207	0.0134	0.0097	0.0141
ICT intensity	0.0033	0.0051	0.0044	0.0025	0.0041
Firm age	51.8	50.5	47.5	48.4	48.0

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI

Table A2. Basic firm attributes and regulatory impacts

(a). Impacts of GDPR

Firm type	N of firms	Total sales	Fixed tangible asset	N of employees	Value added	VA/L	TFP	Exporter share	MNEs share	R&D intensity	ICT intensity	Firm age
Not collecting data	2,890	7504.2	1359.6	174.7	1157.9	6.30	1.07	0.22	0.15	0.012	0.003	48.1
Collecting data in Japan	691	12240.7	1904.8	233.0	1632.4	6.67	1.13	0.24	0.13	0.014	0.006	46.2
Collecting data overseas but unaffected by regulations	371	11656.4	2134.2	275.7	2099.9	6.93	1.18	0.55	0.39	0.012	0.004	49.4
Collecting data overseas and affected by regulations	73	221890.2	39148.8	3677.4	41617.0	10.08	1.68	0.71	0.67	0.048	0.006	57.7

(b). Impacts of regulations by emerging countries

Firm type	N of firms	Total sales	Fixed tangible asset	N of employees	Value added	VA/L	TFP	Exporter share	MNEs share	R&D intensity	ICT intensity	Firm age
Not collecting data	2,891	7504.8	1360.3	174.8	1158.7	6.30	1.07	0.22	0.15	0.012	0.003	48.1
Collecting data in Japan	691	12240.7	1904.8	233.0	1632.4	6.67	1.13	0.24	0.13	0.014	0.006	46.2
Collecting data overseas but unaffected by regulations	304	11112.1	2137.6	258.6	1979.7	6.94	1.18	0.52	0.34	0.011	0.004	48.6
Collecting data overseas and affected by regulations	139	123274.1	21557.4	2098.0	23106.3	8.58	1.44	0.70	0.63	0.038	0.005	55.7

(c). Impacts of regulations

Firm type	N of firms	Total sales	Fixed tangible asset	N of employees	Value added	VA/L	TFP	Exporter share	MNEs share	R&D intensity	ICT intensity	Firm age
Not collecting data	2,891	7504.8	1360.3	174.8	1158.7	6.30	1.07	0.22	0.15	0.012	0.003	48.1
Collecting data in Japan	691	12240.7	1904.8	233.0	1632.4	6.67	1.13	0.24	0.13	0.014	0.006	46.2
Collecting data overseas but unaffected by regulations	287	11064.8	2073.4	256.5	1951.5	6.85	1.17	0.51	0.34	0.010	0.004	48.8
Collecting data overseas and affected by regulations	156	111138.2	19559.2	1901.3	20856.0	8.55	1.43	0.71	0.60	0.036	0.005	54.7
Total	*4,025*	*12588.3*	*2212.8*	*257.5*	*2059.9*	*6.49*	*1.10*	*0.27*	*0.18*	*0.014*	*0.004*	*48.0*

Note: See the note in Table 2.

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI

Table A3. Productivity premiums of intra-firm cross-border data transmission

	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a). lnTFP	OLS	q10	q25	q50	q75	q90
Collecting data within Japan	0.042**	0.033	0.044	0.031	0.033	0.065***
	[0.018]	[0.042]	[0.035]	[0.022]	[0.021]	[0.021]
Collecting data from foreign unrelated partners	0.000	-0.122*	0.047	0.048	0.053	0.021
	[0.039]	[0.066]	[0.055]	[0.049]	[0.053]	[0.039]
Collecting data from foreign affiliates	0.120***	0.037	0.130**	0.121***	0.119***	0.166***
	[0.036]	[0.052]	[0.065]	[0.036]	[0.034]	[0.060]
Exporter	0.134***	0.054	0.069**	0.160***	0.188***	0.165***
	[0.021]	[0.036]	[0.029]	[0.026]	[0.022]	[0.032]
MNE	0.065***	0.114***	0.060**	0.023	0.024	0.035
	[0.023]	[0.035]	[0.029]	[0.020]	[0.029]	[0.030]
Panel (b). ln(Y/L)	OLS	q10	q25	q50	q75	q90
Collecting data within Japan	0.052***	0.050***	0.059**	0.043***	0.065***	0.094***
	[0.019]	[0.017]	[0.025]	[0.014]	[0.019]	[0.025]
Collecting data from foreign unrelated partners	0.006	-0.088	0.071**	0.042	0.028	0.015
	[0.040]	[0.077]	[0.030]	[0.029]	[0.046]	[0.061]
Collecting data from foreign affiliates	0.105***	0.004	0.146***	0.134**	0.123***	0.170***
	[0.037]	[0.050]	[0.034]	[0.054]	[0.046]	[0.043]
Exporter	0.145***	0.065**	0.102***	0.169***	0.219***	0.192***
	[0.022]	[0.029]	[0.027]	[0.039]	[0.044]	[0.025]
MNE	0.090***	0.134***	0.082***	0.063*	0.041	0.069*
	[0.023]	[0.026]	[0.030]	[0.032]	[0.034]	[0.038]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and "Survey of cross-border data flows of firms" by RIETI

Table A4. Cross-tabulation of firms engaged in data collection and introduction of 3D printers

	3D printer		
	No	Yes	Total
Not collecting data	2,775	164	2,939
Collecting data in Japan	728	53	781
Collecting data overseas	386	59	445
Total	3,889	276	4,165

Source: Authors calculations based on "Survey of cross-border data flows of firms" by RIETI

Table A5. Productivity premiums and interaction effect of collecting data and 3D printers

	(1)	(2)	(3)	(4)	(5)	(6)
lnTFP	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.033*	0.031*	0.041**	0.027*	0.029	0.061
	[0.019]	[0.019]	[0.018]	[0.015]	[0.023]	[0.041]
Collecting data overseas	0.046	-0.074	0.060*	0.090***	0.063***	0.090***
	[0.030]	[0.059]	[0.032]	[0.031]	[0.016]	[0.032]
3D printer user	-0.008	-0.018	-0.017	0.070*	0.012	-0.013
	[0.038]	[0.027]	[0.034]	[0.036]	[0.054]	[0.064]
Collecting data in Japan	0.136*	0.047	0.097	0.099	0.131	0.12
×3D printer user	[0.073]	[0.088]	[0.140]	[0.065]	[0.095]	[0.142]
Collecting data overseas	0.073	0.165***	0.064	-0.067	0.067	0.07
×3D printer user	[0.071]	[0.051]	[0.105]	[0.072]	[0.094]	[0.128]
Exporter	0.134***	0.051**	0.080***	0.160***	0.189***	0.171***
	[0.021]	[0.024]	[0.027]	[0.024]	[0.021]	[0.037]
MNE	0.082***	0.121***	0.063***	0.049	0.028	0.041
	[0.022]	[0.021]	[0.023]	[0.030]	[0.025]	[0.044]
	(7)	(8)	(9)	(10)	(11)	(12)
ln(VA/L)	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.042**	0.058*	0.056***	0.037**	0.054**	0.089***
	[0.019]	[0.030]	[0.014]	[0.015]	[0.021]	[0.030]
Collecting data overseas	0.036	-0.082*	0.091*	0.082***	0.060*	0.064
	[0.030]	[0.043]	[0.054]	[0.018]	[0.032]	[0.051]
3D printer user	-0.027	-0.039	-0.043	0.029	0.03	0.007
	[0.039]	[0.090]	[0.057]	[0.044]	[0.035]	[0.030]
Collecting data in Japan	0.141*	0.072	0.05	0.128**	0.086*	0.049
×3D printer user	[0.080]	[0.162]	[0.075]	[0.059]	[0.051]	[0.163]
Collecting data overseas	0.108	0.163	0.068	-0.015	0.075	0.14
×3D printer user	[0.074]	[0.137]	[0.126]	[0.088]	[0.121]	[0.102]
Exporter	0.144***	0.073**	0.102***	0.178***	0.204***	0.180***
	[0.021]	[0.035]	[0.026]	[0.028]	[0.030]	[0.043]
MNE	0.104***	0.159***	0.082***	0.083***	0.051**	0.092**
	[0.023]	[0.039]	[0.022]	[0.013]	[0.023]	[0.037]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and "Survey of cross-border data flows of firms" by RIETI

Table 1. Data collection activities of firms (%)

Reponses to the question	*Domestic*	*Overseas*
Our company is continuously collecting digital data through IoT.	7.81	2.31
Although IoT has not been introduced, our company is regularly collecting digital data.	21.62	8.73
Our company is not particularly conscious of data, or not collecting data consciously.	55.66	70.7
I do not know whether IoT is introduced, or do not know IoT.	14.91	18.26
Total	100	100

Source: Tomiura et al. (2019) Table 5 based on "Survey of cross-border data flows of firms" by RIETI.

Table 2. Basic characteristics of firms grouped by data collection activities

Firm type	Not collecting data	Collecting data in Japan	Collecting data overseas	Total
N of firms	2,891	691	443	4,025
Total sales*	7504.4	12240.7	46133.6	12588.3
Fixed tangible asset*	1359.3	1904.8	8206.5	2212.8
N of employees (L)	174.7	233.0	833.7	257.5
Value added (VA)*	1157.7	1632.4	8581.3	2059.9
VA/L	6.30	6.67	7.45	6.49
TFP	0.96	1.01	1.10	0.98
Exporter share	0.22	0.24	0.58	0.27
MNEs share	0.15	0.13	0.43	0.18
R&D intensity	0.0124	0.0140	0.0211	0.0142
ICT intensity	0.0035	0.0061	0.0047	0.0041
Firm age	48.1	46.2	50.8	48.0

Note: The unit of variables with asterisks is one million Japanese yen. R&D intensity and ICT intensity are measured as the ratio of the expenses to sales.

Source: Authors calculations based on BSJBSA by METI and "Survey of cross-border data flows of firms" by RIETI

Table 3. Productivity premiums of firms collecting data

	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a). lnTFP	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.042**	0.041	0.041*	0.027**	0.036*	0.066**
	[0.018]	[0.032]	[0.023]	[0.012]	[0.021]	[0.030]
Collecting data overseas	0.059**	-0.037	0.082*	0.084***	0.071**	0.111***
	[0.027]	[0.048]	[0.046]	[0.031]	[0.036]	[0.041]
Exporter	0.134***	0.049*	0.074***	0.164***	0.190***	0.171***
	[0.021]	[0.026]	[0.027]	[0.035]	[0.027]	[0.037]
MNE	0.078***	0.117***	0.058*	0.03	0.026	0.03
	[0.023]	[0.032]	[0.030]	[0.029]	[0.023]	[0.027]
Panel (b). ln(VA/L)	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.052***	0.050**	0.055***	0.048**	0.065***	0.093***
	[0.019]	[0.024]	[0.015]	[0.019]	[0.022]	[0.026]
Collecting data overseas	0.055*	-0.028	0.106***	0.078**	0.070**	0.095**
	[0.028]	[0.041]	[0.025]	[0.037]	[0.032]	[0.047]
Exporter	0.146***	0.065**	0.103***	0.177***	0.219***	0.190***
	[0.022]	[0.033]	[0.019]	[0.018]	[0.025]	[0.030]
MNE	0.101***	0.134***	0.087***	0.080***	0.052*	0.083**
	[0.023]	[0.041]	[0.022]	[0.024]	[0.026]	[0.037]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and "Survey of cross-border data flows of firms" by RIETI

Table 4. Productivity premiums of firms grouped by regulatory impacts

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnY/L	lnY/L	lnY/L	lnY/L	lnY/L	lnY/L
(a). Impacts of GDPR	OLS	q10	q25	q50	q75	q90	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.041**	0.042	0.042	0.030*	0.026	0.065**	0.052***	0.043	0.060**	0.044*	0.065**	0.098**
	[0.018]	[0.038]	[0.031]	[0.017]	[0.024]	[0.030]	[0.019]	[0.042]	[0.027]	[0.026]	[0.031]	[0.048]
Collecting data overseas but unaffected by regulations	0.011	-0.1	0.044	0.047**	0.032	0.073*	0.004	-0.098**	0.038	0.033	0.011	0.049
	[0.029]	[0.066]	[0.045]	[0.024]	[0.030]	[0.041]	[0.030]	[0.039]	[0.046]	[0.024]	[0.016]	[0.039]
Collecting data overseas and affected by regulations	0.309***	0.385***	0.334***	0.272***	0.201***	0.489***	0.326***	0.315***	0.314***	0.325***	0.276***	0.395***
	[0.054]	[0.085]	[0.056]	[0.031]	[0.062]	[0.143]	[0.055]	[0.116]	[0.078]	[0.049]	[0.069]	[0.124]
Exporter	0.134***	0.054	0.081**	0.156***	0.189***	0.166***	0.145***	0.09	0.098***	0.167***	0.205***	0.194***
	[0.021]	[0.037]	[0.032]	[0.025]	[0.030]	[0.042]	[0.022]	[0.062]	[0.033]	[0.031]	[0.041]	[0.029]
MNE	0.069***	0.117***	0.059***	0.027	0.01	0.03	0.091***	0.119***	0.084***	0.063***	0.049*	0.064
	[0.023]	[0.024]	[0.021]	[0.023]	[0.019]	[0.041]	[0.023]	[0.033]	[0.029]	[0.019]	[0.029]	[0.050]
(b). Impacts of regulations in emerging countries	OLS	q10	q25	q50	q75	q90	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.042**	0.036**	0.049***	0.03	0.03	0.065	0.052***	0.050**	0.057***	0.046***	0.066***	0.097***
	[0.018]	[0.016]	[0.018]	[0.019]	[0.031]	[0.044]	[0.019]	[0.025]	[0.014]	[0.014]	[0.020]	[0.032]
Collecting data overseas but unaffected by regulations	0.014	-0.096**	0.056	0.046	0.052**	0.056*	0.006	-0.080*	0.066	0.033	0.024	0.035
	[0.032]	[0.041]	[0.043]	[0.034]	[0.026]	[0.033]	[0.032]	[0.046]	[0.067]	[0.029]	[0.039]	[0.054]
Collecting data overseas and affected by regulations	0.158***	0.058	0.160***	0.161***	0.175**	0.220***	0.165***	0.074	0.154*	0.205***	0.170***	0.268***
	[0.044]	[0.081]	[0.057]	[0.036]	[0.076]	[0.079]	[0.045]	[0.051]	[0.085]	[0.054]	[0.060]	[0.080]
Exporter	0.134***	0.064*	0.074**	0.160***	0.189***	0.180***	0.145***	0.070**	0.107***	0.169***	0.212***	0.183***
	[0.021]	[0.038]	[0.030]	[0.015]	[0.030]	[0.030]	[0.022]	[0.030]	[0.022]	[0.026]	[0.017]	[0.038]
MNE	0.072***	0.108***	0.063***	0.027	0.019	0.031	0.094***	0.130***	0.085***	0.063**	0.045	0.078**
	[0.022]	[0.021]	[0.021]	[0.021]	[0.018]	[0.037]	[0.023]	[0.019]	[0.010]	[0.025]	[0.029]	[0.036]
(c). Impacts of regulations		q10	q25	q50	q75	q90		q10	q25	q50	q75	q90
Collecting data in Japan		0.036	0.047**	0.027	0.031	0.065*		0.050*	0.059***	0.045*	0.065**	0.113***
		[0.026]	[0.023]	[0.017]	[0.022]	[0.034]		[0.030]	[0.016]	[0.023]	[0.031]	[0.036]
Collecting data overseas but unaffected by regulations		-0.109	0.048	0.037	0.037	0.056		-0.092	0.05	0.024	0.011	0.033
		[0.075]	[0.049]	[0.031]	[0.045]	[0.070]		[0.065]	[0.065]	[0.026]	[0.038]	[0.047]
Collecting data overseas and affected by regulations		0.056	0.154**	0.164***	0.179***	0.213**		0.086	0.147***	0.194***	0.174***	0.253***
		[0.074]	[0.062]	[0.039]	[0.059]	[0.093]		[0.064]	[0.048]	[0.057]	[0.051]	[0.070]
Exporter		0.063	0.069**	0.163***	0.189***	0.180***		0.077***	0.100***	0.168***	0.212***	0.177***
		[0.061]	[0.034]	[0.029]	[0.019]	[0.037]		[0.025]	[0.017]	[0.021]	[0.027]	[0.031]
MNE		0.109***	0.063***	0.023	0.019	0.029		0.125***	0.091***	0.064**	0.044***	0.070*
		[0.037]	[0.021]	[0.025]	[0.018]	[0.028]		[0.021]	[0.028]	[0.032]	[0.016]	[0.036]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI.

Table 5. Characteristics of firms grouped by their responses to regulations

Panel (a). Responses to GDPR	A	B	C	D	E	Total
N of firms	36	5	1	77	32	151
Total sales	90798.0	15873.0	9170.0	198134.2	14333.8	121145.8
Fixed tangible asset	12033.3	3308.6	1423.0	33672.9	2249.1	19498.2
N of employee (L)	945.0	299.4	1214.0	3291.5	379.4	2062.5
Value added (VA)	13522.4	4087.1	3995.0	35999.1	3049.1	21146.8
VA/L	10.48	12.78	-3.29	9.96	7.11	9.46
lnTFP	0.41	0.75	0.43	0.44	0.16	0.39
Exporter	0.68	0.80	0.00	0.61	0.63	0.61
MNEs	0.59	0.60	0.00	0.52	0.53	0.51
R&D intensity	0.0395	0.0288	0.0648	0.0543	0.0179	0.0403
IT intensity	0.0026	0.0018	0.0185	0.0057	0.0042	0.0052
Firm age	44.3	48.2	16.0	54.5	51.5	49.5
Panel (b). Responses to regulations in China/other emerging countries	A	B	C	D	E	Total
N of firms	83	28	16	n/a	195	322
Total sales	107057.6	149012.4	54853.6	n/a	28782.5	70046.4
Fixed tangible asset	17622.8	21995.1	13027.6	n/a	5652.4	11505.0
N of employee (L)	1786.9	2281.7	1080.3	n/a	557.7	1219.0
Value added (VA)	19864.4	22801.9	8473.6	n/a	5540.1	11883.8
VA/L	8.28	8.65	6.24	n/a	7.65	8.00
lnTFP	0.25	0.27	-0.04	n/a	0.16	0.20
Exporter	0.71	0.54	0.50	n/a	0.57	0.61
MNEs	0.64	0.39	0.31	n/a	0.47	0.50
R&D intensity	0.0353	0.0223	0.0292	n/a	0.0297	0.0310
IT intensity	0.0035	0.0130	0.0050	n/a	0.0045	0.0051
Firm age	48.7	46.2	44.3	n/a	51.3	50.0

Note. The responses A-E correspond to the following answers. A: “Our company now processes and stores data at our affiliate in the relevant country.” B: “Our company now outsources data processing and storage to local companies in the relevant country.” C: “Our company has converted, shrunk, or stopped business in the relevant countries.” D: “Our company manages personal data as strictly as the EU.” (not applicable for the panel (b)) E: “4. Our company has not considered any specific measures.”

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI.

Table 6. Productivity of firm collecting data and affected by cross-border data transfer regulations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnTFP	lnY/L	lnY/L	lnY/L	lnY/L	lnY/L	lnY/L
(a). Impacts of GDPR	OLS	q10	q25	q50	q75	q90	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.040**	0.04	0.042**	0.031*	0.025	0.067***	0.051***	0.045**	0.057***	0.041***	0.065***	0.098***
	[0.018]	[0.026]	[0.021]	[0.017]	[0.018]	[0.023]	[0.019]	[0.021]	[0.016]	[0.015]	[0.015]	[0.025]
Collecting data overseas but unaffected by regulations	0.01	-0.098*	0.043	0.044*	0.031	0.068	0.002	-0.098**	0.033	0.033	0.012	0.048
	[0.029]	[0.052]	[0.035]	[0.025]	[0.032]	[0.049]	[0.030]	[0.050]	[0.036]	[0.024]	[0.034]	[0.051]
Collecting data overseas and affected by regulations but taking no measures	0.192***	0.541***	0.491***	0.241***	0.027	-0.176**	0.173***	0.555***	0.376**	0.132	-0.017	-0.193***
	[0.044]	[0.071]	[0.107]	[0.047]	[0.054]	[0.070]	[0.057]	[0.198]	[0.169]	[0.093]	[0.052]	[0.051]
Collecting data overseas, affected by regulations, and taking some measures	0.318***	0.378***	0.334***	0.272***	0.208*	0.514**	0.334***	0.296**	0.311**	0.349***	0.279**	0.393**
	[0.062]	[0.102]	[0.080]	[0.032]	[0.122]	[0.232]	[0.062]	[0.146]	[0.124]	[0.064]	[0.139]	[0.156]
Exporter	0.135***	0.058**	0.081***	0.159***	0.188***	0.187***	0.147***	0.089***	0.102***	0.169***	0.210***	0.197***
	[0.021]	[0.026]	[0.029]	[0.023]	[0.030]	[0.040]	[0.022]	[0.018]	[0.031]	[0.015]	[0.013]	[0.034]
MNE	0.070***	0.114***	0.059***	0.028	0.011	0.014	0.092***	0.123***	0.080***	0.063*	0.046	0.066**
	[0.023]	[0.024]	[0.017]	[0.020]	[0.028]	[0.053]	[0.023]	[0.036]	[0.030]	[0.033]	[0.030]	[0.030]
(b). Impacts of regulations in emerging countries	OLS	q10	q25	q50	q75	q90	OLS	q10	q25	q50	q75	q90
Collecting data in Japan	0.040**	0.036	0.046**	0.026	0.03	0.061	0.051***	0.047***	0.059**	0.045	0.059***	0.097***
	[0.018]	[0.030]	[0.018]	[0.021]	[0.023]	[0.039]	[0.019]	[0.018]	[0.024]	[0.028]	[0.022]	[0.030]
Collecting data overseas but unaffected by regulations	0.012	-0.095	0.055	0.042	0.05	0.053*	0.003	-0.08	0.063	0.026	0.018	0.033
	[0.032]	[0.059]	[0.045]	[0.038]	[0.034]	[0.031]	[0.032]	[0.055]	[0.040]	[0.022]	[0.018]	[0.030]
Collecting data overseas and affected by regulations but taking no measures	0.093	-0.049	0.048	0.110**	0.097	0.132*	0.081	0.006	-0.012	0.139***	0.096	0.216
	[0.065]	[0.125]	[0.086]	[0.055]	[0.067]	[0.075]	[0.068]	[0.109]	[0.093]	[0.049]	[0.078]	[0.133]
Collecting data overseas, affected by regulations, and taking some measures	0.178***	0.112	0.227**	0.174***	0.189*	0.103	0.200***	0.092	0.220***	0.225***	0.242***	0.155**
	[0.057]	[0.123]	[0.103]	[0.063]	[0.103]	[0.148]	[0.059]	[0.161]	[0.074]	[0.080]	[0.072]	[0.073]
Exporter	0.136***	0.051	0.077***	0.163***	0.191***	0.177***	0.147***	0.068**	0.106***	0.171***	0.221***	0.183***
	[0.021]	[0.036]	[0.028]	[0.018]	[0.029]	[0.037]	[0.022]	[0.031]	[0.023]	[0.026]	[0.029]	[0.043]
MNE	0.074***	0.119**	0.064**	0.031	0.021	0.042	0.096***	0.132***	0.087***	0.064**	0.048**	0.096***
	[0.022]	[0.047]	[0.029]	[0.025]	[0.023]	[0.042]	[0.023]	[0.029]	[0.020]	[0.027]	[0.022]	[0.026]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI

Table 7. Basic firm attributes of 3D printer users

	3D printers		
(a) Current	No	Yes	Total
Total sales	11,234.6	32,772.8	12,677.7
Fixed tangible asset	1,985.2	5,730.3	,2236.9
N of employee (L)	233.2	653.1	261.3
Value added (VA)	1,810.4	5,875.1	2,082.7
VA/L	6.45	7.06	6.49
TFP	1.09	1.16	1.10
Exporter	0.24	0.52	0.26
MNEs	0.16	0.36	0.17
R&D intensity	0.0044	0.0154	0.0051
IT intensity	0.0041	0.0028	0.0040
Firm age	47.7	51.1	48.0

(b) 5 year ago	No	Yes	Total
Total sales	1,1762.4	2,9891.3	13,021.5
Fixed tangible asset	2,049.5	5,961.1	2,322.2
N of employee (L)	235.8	628.5	263.1
Value added (VA)	1,758.4	5,405.7	2,011.7
VA/L	6.30	6.90	6.34
TFP	1.06	1.12	1.07
Exporter	0.23	0.52	0.25
MNEs	0.15	0.33	0.17
R&D intensity	0.0042	0.0137	0.0048
IT intensity	0.0037	0.0069	0.0039
Firm age	44.8	46.8	44.9

(c) 10 years ago	No	Yes	Total
Total sales	13,827.3	39,005.1	15,675.4
Fixed tangible asset	2,493.8	6,720.6	2,805.0
N of employee (L)	261.4	689.7	292.9
Value added (VA)	2,157.6	6,547.3	2,479.8
VA/L	6.77	7.51	6.82
TFP	1.12	1.21	1.12
Exporter	0.23	0.51	0.25
MNEs	0.16	0.36	0.17
R&D intensity	0.0049	0.0118	0.0054
IT intensity	0.0043	0.0031	0.0042
Firm age	42.5	43.6	42.6

Note: See the note in Table 3. Column of "Yes" indicates that the firm has introduced 3D printers. The number of observations is 4,179 in the latest year (2017), 3,542 five years ago, and 2,861 ten years ago.

Source: Authors calculations based on BSJBSA by METI and "Survey of cross-border data flows of firms" by RIETI

Table 8. Productivity premium of 3D printer users

	(1)	(2)	(3)	(4)	(5)
lnTFP	q10	q25	q50	q75	q90
Collecting data in Japan	0.043	0.043*	0.028	0.031*	0.085***
	[0.026]	[0.026]	[0.027]	[0.017]	[0.023]
Collecting data overseas	-0.038	0.084***	0.075***	0.069***	0.097**
	[0.043]	[0.030]	[0.029]	[0.022]	[0.048]
3D printer user	0.018	-0.008	0.077***	0.065**	0.036
	[0.034]	[0.035]	[0.020]	[0.027]	[0.045]
Exporter	0.051	0.073***	0.154***	0.187***	0.185***
	[0.032]	[0.020]	[0.016]	[0.020]	[0.036]
MNE	0.108***	0.060***	0.046*	0.021	0.027
	[0.035]	[0.021]	[0.025]	[0.027]	[0.046]
	(6)	(7)	(8)	(9)	(10)
ln(VA/L)	q10	q25	q50	q75	q90
Collecting data in Japan	0.050***	0.056***	0.048***	0.058**	0.093**
	[0.018]	[0.020]	[0.016]	[0.027]	[0.040]
Collecting data overseas	-0.028	0.094***	0.075**	0.069*	0.088
	[0.047]	[0.034]	[0.035]	[0.040]	[0.062]
3D printer user	-0.001	-0.027	0.067***	0.048	0.023
	[0.066]	[0.050]	[0.025]	[0.029]	[0.049]
Exporter	0.067**	0.103***	0.174***	0.221***	0.191***
	[0.033]	[0.021]	[0.023]	[0.028]	[0.041]
MNE	0.132***	0.080***	0.068**	0.049	0.078
	[0.042]	[0.020]	[0.033]	[0.034]	[0.071]

Note: Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1.

Source: Authors calculations based on BSJBSA by METI and “Survey of cross-border data flows of firms” by RIETI