Internationalization of the Rural Nonfarm Economy and the Cloud:

Evidence from US Firm-level Export Data

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ABSTRACT: The move toward universal broadband availability envisioned in the Broadband Equity, Access, and Deployment Program presents a double-edged sword for many rural communities: increasing the leakage of local spending to more internet sales countered by better opportunities for tapping remote markets. This paper uses confidential data to examine how export intensity is affected by subscription to cloud computer services—a technology that requires very high-speed broadband. Earlier research identified an enabling effect of the cloud on various types of firm-level innovation, effectively reducing the cost of experimentation by replacing large fixed IT investments with a pay-as-you-go service. To the extent that exporting places new demands on IT-enabled functions such as order fufillment and tracking, marketing, or document control, cloud subscriptions could substantially reduce the cost of entering, and excelling in, export markets.

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Introduction

The voluminous literature on exporting from rural areas in the U.S. has a notable lacuna: exports from the nonfarm sector.[1] One reason why agricultural exports eclipse other rural exports in research and policy interest is the sector's consistent trade surplus. In contrast, manufacturing has historically registered large trade deficits and accepted wisdom that rural manufacturers were at a competitive disadvantage relative to their metro peers meant that research on nonfarm exports was unlikely to inform trade policy or rural development policy. However, the largest impediment to research in the area has been the availability of data. Confidential microdata are the only means of assessing the nonfarm contribution to exports across a broad array of goods producing and some service providing industries. Despite extensive use by other researchers of the Longitudinal Firm Trade Transaction Database to study exporting by U.S. firms, we were unable to identify any studies explicitly examining export propensity or intensity from nonmetropolitan firms.

The move toward universal broadband availability envisioned in the Broadband Equity, Access, and Deployment Program presents new challenges and opportunities for rural areas with inadequate digital infrastructure. Cloud subscription services – that can be used effectively only with very high-speed broadband – open new opportunities and encourage new IT-enabled ways of doing business by replacing large IT investment with a pay-as-you-go service (Han, et al. forthcoming). One potential benefit of the cloud is to substantially enhance the ability of remote rural businesses to tap international markets. Cloud-based coordination functions that are critical to successful exporting would no longer require large, fixed IT investment as is the case in underserved locations. Alternatively, rural residents with high-speed broadband may be better able to utilize a wide variety of remote services, potentially reducing demand for local service provision. A greater ability to sell tradeable products to non-local buyers could ameliorate possible adverse consequences. And while this ability would pertain to both non-local domestic and international customers, export data provide a highly reliable means of tracking the volume of non-local sales.

In this paper we use confidential data to investigate if the availability of broadband makes firms more likely to export, and if subscriptions to cloud computing services increase export intensity. The research question has relevance for rural economic development in two important respects. First, cloud computing provides a more stringent threshold for examining the potential benefits of broadband to economic performance identified in previous work by Kolko (2012), and Tranos and Mack (2016). Deller et al. (2022) provide evidence that broadband speed matters – faster speed broadband may have a stronger economic impact on business start-up rates – that is extended in this analysis to the ability to adopt data-intensive business strategies at lower cost.

[1] Two papers on the rural manufacturing export gap, which was first identified by Elf and Livingston (2007) and updated by Wojan (2019), provide the only explicit comparisons of metro and nonmetro export intensity that we are aware of. Most rural development research examining exports is concerned with non-local sales of tradeable goods informing export base theory, but not specifically addressing international exports (Kilkenny and Partridge 2009).

Second, evidence from the National Science Foundation suggests that cloud computing has a large impact on the probability of reporting marketing innovation (Wojan 2022), which in turn is critical to the decision to export (Lee and Falahat 2019; Simmonds and Smith 1968). The role that cloud computing and very high-speed internet play in facilitating nonfarm exports in rural areas is of particular relevance at this time given the large Federal investment in bridging the digital divide.

Literature Review

The limited work on nonfarm exports from nonmetro areas does point to an untapped potential for reducing the nation's large, perennial trade deficits. Elf and Livingston (2007) used a manufacturers directory from 7 southeastern states to examine possible reasons for a lower propensity to export among rural firms. Their Blinder-Oaxaca decomposition finds no evidence that rural manufacturers are less likely to export due to their "ruralness;" i.e., some behavioral predisposition to avoid international markets. Rather, the two differences in urban and rural endowments that explain the majority of the rural export gap are human capital (educational attainment) and informational externalities (availability of professional and educational services).

Wojan (2019) used a special tabulation from the Census Bureau's International Trade Evaluations Branch to extend the rural export gap analysis from export propensity to export intensity. The tabulation included exports from the metro and nonmetro portion of each state for the 21 3-digit NAICS code manufacturing industries and agriculture. Exports per metro manufacturing worker were on average 2.4 times higher than their nonmetro peer, ranging from near parity for Primary Metal (NAICS 331) and Computer and Electronics (NAICS 334) Manufacturing to 3 times higher in Leather and Allied Products (NAICS 316).[2] A comparison of nonmetro agricultural exports ($7.5 billion in 2018) to nonmetro manufacturing exports ($98 billion in 2018) confirms a difference of more than an order of magnitude. If rural manufacturing firms exported at the same rate and intensity of their urban peers, the trade deficit would have been reduced by close to $140 billion in 2018, or about 22 percent. The analysis examined the contributions of patents, STEM and other occupations associated with patenting (Dotzel and Wojan 2022), and region/industry estimates of firm innovation to export intensity. A nonmetro region/industry made up of substantive innovators—firms demonstrating behaviors associated with more far ranging innovation such as producing intellectual property, implementing continuous improvement protocols, and being innovation capital constrained—would halve the rural export gap.

Digitalization of firm processes may accelerate both innovation and the propensity to export. The literature on these topics is much richer in Europe, Africa, and Asia than it is in the U.S. This is especially the case with respect to the cloud as an enabler of digitalization strategies for small- and medium-sized enterprises (SMEs). The difference in government focus in comparative perspective is clearly demonstrated in the recent OECD report examining the digitalization of SMEs in response to the Covid-19 pandemic (OECD 2021). Table 1 (p. 43) summarizes the focus of Covid recovery packages and digitalization to move more business to e-commerce and

[2] Petroleum and Coal Products (NAICS 324) demonstrated a metro export advantage per worker 10 times that of nonmetro workers. The very large difference may be due in part to discrepancies in where exports are produced and where they are reported.

e-exporting. While EU countries devoted 27% of their aid packages to digitalization on average, the focus of the US packages (American Families Plan and American Jobs Plan) was overwhelmingly on income support and infrastructure. And while the EU has set a target of 75% of SMEs using the cloud by 2030 (up from a current 18%), no cloud penetration targets have been set in the U.S.

The policy focus on digitalization and the cloud in the EU is also reflected in academic research. Boccia, et al. (2022), examine longitudinal provincial data from Italy to assess the impact of the cloud on export propensity and export intensity. Their results suggest that the cloud is significantly associated with exports at the provincial level but their results on the export intensity of individual firms are inconclusive. Cassetta, et al (2020), also using Italian data, identify a significant effect of cloud computing on innovation in a short (parsimonious) regression, but the result is inconclusive in a long regression including whether a firm had a website or engaged in online sales. Quarato, et al. (2020) investigate the association between digitalization and internationalization in Italian family-owned firms, which provides insight on enabling effects in a type of business that has historically been much less likely to export. Cloud computing is not investigated independently but is incorporated in a ranked index where the most common digitalization strategies rank lower and the least common highest (cloud was used by 2% of firms). Although family firms were less likely to export, the interaction of the digitalization index and family firms was positive and significant. All of these results should be regarded as preliminary given the relatively small sample size (N from 307 for the longitudinal provincial analysis to 2,516 for the firm-level analysis), but the findings suggest an internationalization effect of the cloud.

Research on business use of the cloud in the U.S. is more limited, and no analyses examine the connection between the cloud and exporting. Questions on cloud computing services use were included in the inaugural 2018 Annual Business Survey (reference year 2017) that sampled roughly 850,000 firms. Working papers by the Center for Economic Studies (Zolas, et al., 2021) and the National Center Science and Engineering Statistics (Wojan 2022) examined the prevalence of cloud computing services and its association with other economic phenomena such as innovation and the adoption of other advanced technologies. Going beyond descriptive analysis, Han, et al. (forthcoming) examined whether cloud computing enabled innovation or was merely a reliable indicator of an extant innovation orientation using propensity score matching and endogenous treatment effect models. The findings support cloud computer services enabling innovation, with the largest effects on marketing and business practice innovation. A Blinder-Oaxaca decomposition suggests that up to half of the difference in marketing innovation rates between firms in the largest metros compared to firms in totally rural counties is explained by differences in broadband availability.

Certain Federal programs have explicitly targeted rural nonfarm exports but at such a modest scale they have not attracted research or policy evaluation attention. The U.S. Rural Export Initiative, administered by the Commerce Department's Commercial Service, briefly mentioned in Elf and Livingston (2007), is otherwise absent in the literature. The Obama Administration recycled the name that it included in the 2014 Farm Bill, and proposed a collaboration of several Federal agencies to increase exports through informational activities and technical assistance delivered through USDA Rural Development offices. The current program to boost rural nonfarm exports is the Rural Export Center, launched in 2020 and once again located in the Commercial Service within the International Trade Administration. The Center provides specialized research to help rural firms identify the most promising international markets, and then drills down to find the best partners or companies within those markets. The service is demand driven and the last available annual report (2022) had total annual expenditures at $466,000.

Data and Method

We merge two confidential firm-level datasets for the main analysis in this Federal Statistical Research Data Center (FSRDC) approved project. The cloud adoption and other firm-level variables are from the 2018 Annual Business Survey (ABS), and the firm international trade data are from the Longitudinal Firm Trade Transactions Database (LFTTD). Specifically, the ABS data report whether a firm subscribes to cloud computing services, which range from billing and accounting, security and firewall, servers, data storage, collaboration and file synchronization, data analysis, customer relationship management, or if the cloud is used for all IT functions. We generate a dummy variable for any cloud adoption that equals one if any of these services are used along with use of specific cloud services that may inform the possible mechanisms that facilitate exporting.[3] The original ABS questionnaire on cloud services is reported in the Appendix. The ABS replaced the Survey of Business Owners, so we are able to control for owner characteristics along with firm characteristics associated with the propensity to export. The LFTTD data are administrative data ranging from 1990-2020 and reflect the export and import transactions collected by the Customs Bureau during the importation or exportation process. Data on the export values allow us to measure firm-level export in a given year accurately. We focus on the trade data in or after 2017 due to data availability from the ABS. Using each firm's unique identifier, we merge a large number of firms in the ABS with the LFTTD trade data. To consider the influences of the location of firms and infrastructure that may affect exporting behavior, we also merge in the county-level Rural-Urban Continuum Codes (RUCC) to control for the rurality of a county and the county level broadband availability in 2017. The RUCC information is from the United States Department of Agriculture (USDA) and the broadband data are from the Federal Communications Commission (FCC).[4]

We start with a linear regression model, where the main treatment variable is cloud adoption, and the main dependent is the international trade values. A naïve linear regression may not capture potential causal effects due to endogeneity issues. For example, a large number of firms do not export and thus are not included in the LFTTD; this causes our dependent export value variable to be truncated at zero. The reason why firms choose not to export may be very different from an exporting firm choosing how much to export. We use a two-stage Cragg hurdle regression model to address the endogeneity caused by a bounded dependent variable due to non-exporting firms. The model combines a selection model that determines the boundary points of the dependent variable (zero in our case) with an outcome model that determines its nonbounded values (export value). The ABS data provide a rich set of firm and firm-owner characteristics that allow us to build a two-stage hurdle model. Particularly, in the first-stage selection equation, we use firm-

[3] In 2018 ABS, firms were asked "Considering the amount spent on each of these IT functions, how much was spent on cloud services?". They can answer "None", "Up to 50%", "More than 50%", "All", "Don't know", and "Don't use IT function". The cloud dummy is one if firms answer, "Up to 50%", "More than 50%", or "All".

[4] We use the "residential fixed high-speed connections of at least 10 Mbps downstream and at least 1 Mbps upstream per 1000 households" in 2017 to measure broadband availability.

owner variables, including a foreign-born owner dummy as foreign-born owners are more likely to export to their home countries due to home ties; the highest education of the firm owners, as more-educated owners are both more likely to implement technological advancements and may have better knowledge of international opportunities. We also include other firm-level variables to control for inherent exporting propensity, including NAICS industry dummies. The location of a firm may also play a role in determining whether a firm exports or not. We currently include a county-level broadband availability variable as well as RUCC dummies.[5] After estimating the first stage model concerned with the boundary point of export value (zero), we run an outcome model that examines export intensity as a continuous variable. To utilize most years of the available export value data, we construct the dependent variable as the sum of 2017-2020 exports for each firm in logarithmic form. As a robustness check, we also fit a Tobit regression model for the continuous outcome variable that is censored at zero.

Findings

As the ABS and LFTTD data are confidential and only can be accessed in an FSRDC with an approved research proposal, our results need to go through a disclosure process, including rounding of coefficients, standard errors, and observations according to disclosure avoidance rules. Table 1 presents summary statistics of all the variables used in the regression. The upper panel is for the metro sample and the lower panel is for the nonmetro sample. We have more firms in the metro than the nonmetro sample and the mean log exporting value in the metro sample (2.9) is larger than that in the non-metro sample (2.1). Overall, for all the cloud services variables, the adoption rate is higher in the metro firms than in nonmetro firms. This is also supported by the lower county-level broadband adoption rate in nonmetro areas.

Table 2 is our main regression table that examines how different characteristics affect firm-level exports. As we discussed in the Data and Methodology section, our exporting values are truncated at zero and this may cause endogeneity issues if we treat non-exporting firms the same as exporting firms. A two-stage Cragg model addresses this issue. The first-stage results that estimate the likelihood of a non-bounded dependent variable (e.g., non-zero export values) are reported in Panel B. We find firms that have any foreign born owners, any STEM degree holders, any bachelor degree or above owners, multiple owners, or are located in counties with higher broadband adoption are more likely to export.[6] Our findings also suggest firms with minority owners or owners who had past military experiences are less likely to export. In Panel A, we report the second-stage output regression results. We detect significant effects on export values with cloud services that are used for all IT functions, servers, and data storage. Significant effects on export values were not detected with respect to cloud services used for customer feedback.

As the coefficient estimates for our Cragg model are not directly interpretable, we report the marginal effects at the mean in the bottom panel C. This confirms that some types of cloud

[5] Broadband availability refers to FCC county-level data that measures "residential fixed high-speed connections of at least 10 Mbps downstream and at least 1 Mbps upstream per 1000 households". We plan to add variables that inform physical infrastructure endowments that may affect the propensity or intensity of exporting but were unable to do so by the paper submission deadline.

[6] STEM is science, technology, engineering, and mathematics.

services have statistically significant effects on exporting values and that metro firms are likely to export more than their nonmetro peers. Firms with foreign born owners or owners with STEM degrees also tend to export more. The most striking result regarding the marginal effects is the large magnitude of foreign-born status. STEM training of at least one of the business owners also has a large effect. These findings suggest that human capital, in the form of general educational preparation, specific (STEM) degree, or lived experience, has a large impact on exports.

To test whether the impact of the cloud on exporting is larger for nonmetro firms we use two approaches. For the full sample, we include a metro*cloud interaction variable. The coefficient estimates are negative in all equations, and statistically significant and larger in magnitude than the corresponding direct cloud coefficient estimate in the cloud servers (4) and storage (5) equations. However, these coefficient estimates are not directly interpretable and the marginal effect on the interaction term is not defined. To provide more interpretable results we also report subsample estimation by metro and nonmetro firms separately in Tables 3 and 4, respectively. Comparing Table 3 with Table 4, we see that the cloud export effect is overwhelmingly a nonmetro phenomenon. Comparing the marginal effects for the other variables in the outcome equation is also instructive. The marginal effect of foreign-born status is nearly identical for metro and nonmetro firms while the marginal effect of STEM preparation in nonmetro firms is half that of their metro peers.

We fit the outcome model using a linear form in Tables 2-4. As a robustness check, we use an exponential form in the Cragg model estimation, and the results are reported in Table A1. The main results remain similar. Finally, our one-stage Tobit model reported in Table A2 also confirms our main findings in Table 2.

Discussions

The findings may inform three important rural economic development issues. First, the national prioritization of universal high-speed broadband raises concerns of possible double-edged effects. Exports from nonfarm businesses may counter the possible increase in internet purchases of goods and services that displace local purchases. Second, the increasing concentration of manufacturing in rural areas and commensurate decline in urban areas has raised concerns regarding the international competitiveness of the dominant export sector, with implications for the balance-of-trade going forward. Evidence that rural nonfarm exports are impacted by the availability of high-speed broadband does suggest a possible policy lever, and one that has already received large government investment. Finally, despite nonfarm rural exports being more than an order of magnitude larger than rural agricultural exports, the topic has generated little academic or policy interest. The current analysis provides a framework for examining economic impacts of the Broadband Equity, Access, and Deployment Program, providing concrete evidence of the costs of the digital divide and allowing nonfarm exports to emerge from agriculture's shadow.

More generally, our findings are important in the context of the current administration's goal of re-locating manufacturing activity to the U.S., including especially to rural areas. They also underscore the critical importance of business owners' and entrepreneurs' human capital, whether general, or specific to fields of science (STEM) or countries (foreign-born). The finding of a negative effect for minority business owners suggests specific targeting of educational materials and outreach by the Rural Export Center may be needed if the benefits of cloud computing are to be made more universally available.

In addition to exploring other key interactions, such as between foreign-born and STEM degrees, an important direction for further research includes the incorporation of physical infrastructure variables such as distance to ports, railways, and highways into the analysis of export intensity. This would allow comparing the relative importance of digital and physical infrastructure to exporting. The study by Elf and Livingston (2007) did not identify physical infrastructure as a barrier to the propensity to export among rural manufacturers, but the effect on rural export intensity is still uninvestigated.

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T1 Descriptive Statistics

Metro Sample:	N	Mean	Std. Err
lg value all	395000	2.931	0.0166
any_cloud	395000	0.5019	0.0008
all_IT_cloud	395000	0.3057	0.0007
customer_cloud	395000	0.2453	0.0007
server_cloud	395000	0.2823	0.0007
storage_cloud	395000	0.2958	0.0007
synch_cloud	395000	0.3247	0.0007
foreignborn	395000	0.1945	0.0006
stem degree	395000	0.2323	0.0007
female	395000	0.4145	0.0008
hisp	395000	0.0693	0.0004
bachelor above	395000	0.5598	0.0008
non white	395000	0.147	0.0006
military	395000	0.1151	0.0005
owner age lower 45	395000	0.2405	0.0007
multi owner	395000	0.4553	0.0008
bb adoption	395000	4.093	0.0009
Non-Metro Sample:			
	N	Mean	Std. Err
lg value all	71000	2.06	0.0329
any_cloud	71000	0.3991	0.0018
all_IT_cloud	71000	0.2046	0.0015
customer_cloud	71000	0.159	0.0014
server_cloud	71000	0.2045	0.0015
storage_cloud	71000	0.2076	0.0015
synch_cloud	71000	0.2113	0.0015
foreignborn	71000	0.0633	0.0009
stem degree	71000	0.1911	0.0015
female	71000	0.4728	0.0019
hisp	71000	0.0316	0.0007
bachelor above	71000	0.4338	0.0019
non white	71000	0.0656	0.0009
military	71000	0.1402	0.0013
owner age lower 45	71000	0.2349	0.0016
multi owner	71000	0.4979	0.0019
bb adoption	71000	2.848	0.0032

Note: Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband data. The lg value all refers exporting value in USD in log-transformed form. The bb_adoption refers to residential fixed high-speed connections of at least 10 Mbps downstream and at least 1 Mbps upstream per 1000 households and is measured in 0-5 scale where larger value means higher share of broadband connections.

T2: Cragg Cloud on LFTTD total export value 2017-2020 with metro dummy interaction using linear model

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Output regression						
any_cloud	0.9594					
	(0.670)					
all_IT_cloud		1.399**				
		(0.709)				
customer_cloud			0.6939			
			(0.781)			
server_cloud				1.453**		
				(0.714)		
storage_cloud					1.878***	
					(0.718)	
synch_cloud						1.261*
						(0.711)
metro	2.045***	2.085***	1.860***	2.271***	2.367***	1.986***
	(0.529)	(0.442)	(0.414)	(0.438)	(0.437)	(0.441)
metro cloud interaction	-0.5612	-1.027	-0.452	-1.560**	-1.906**	-0.7797
	(0.711)	(0.747)	(0.821)	(0.754)	(0.757)	(0.749)
foreignborn	3.884***	3.885***	3.877***	3.883***	3.880***	3.875***
	(0.284)	(0.284)	(0.285)	(0.285)	(0.284)	(0.284)
stem_degree	3.149***	3.149***	3.168***	3.170***	3.167***	3.139***
	(0.259)	(0.259)	(0.259)	(0.259)	(0.259)	(0.260)
Panel B: Selection Regression						
foreignborn	0.1629***	0.1629***	0.1629***	0.1629***	0.1629***	0.1629***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
stem_degree	0.0659***	0.0659***	0.0659***	0.0659***	0.0659***	0.0659***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
female	-0.2730***	-0.2730***	-0.2730***	-0.2730***	-0.2730***	-0.2730***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
hisp	-0.0964***	-0.0964***	-0.0964***	-0.0964***	-0.0964***	-0.0964***
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
bachelor_above	0.0377***	0.0377***	0.0377***	0.0377***	0.0377***	0.0377***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
non_white	-0.1367***	-0.1367***	-0.1367***	-0.1367***	-0.1367***	-0.1367***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
military	-0.0170**	-0.0170**	-0.0170**	-0.0170**	-0.0170**	-0.0170**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
owner_age_lower_45	-0.1457***	-0.1457***	-0.1457***	-0.1457***	-0.1457***	-0.1457***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
multi_owner	0.4298***	0.4298***	0.4298***	0.4298***	0.4298***	0.4298***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)

bb_adoption	0.0811***	0.0811***	0.0811***	0.0811***	0.0811***	0.0811***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Panel C: Marginal Effects						
Cloud variable	0.0233**	0.0248**	0.0148	0.004	0.0101	0.0288**
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
metro	0.0861***	0.0858***	0.0859***	0.0880***	0.0865***	0.0845***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)	(0.018)
foreignborn	0.7712***	0.7713***	0.7710***	0.7715***	0.7712***	0.7706***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
stem_degree	0.3909***	0.3909***	0.3920***	0.3921***	0.3919***	0.3904***
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Observations	466000	466000	466000	466000	466000	466000
NAICS 2 FE	Yes	Yes	Yes	Yes	Yes	Yes
RUCC FE	No	No	No	No	No	No
Nine emp cate dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband data.

T3: Cragg Cloud on LFTTD total export value 2017-2020 using linear model for metro sample

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Output regression						
any_cloud	0.4042					
	(0.246)					
all_IT_cloud		0.3749				
		(0.248)				
customer_cloud			0.2361			
			(0.259)			
server_cloud				-0.1136		
				(0.250)		
storage_cloud					-0.0293	
					(0.249)	
synch_cloud						0.4757*
						(0.246)
foreignborn	3.684***	3.684***	3.676***	3.683***	3.682***	3.677***
	(0.297)	(0.297)	(0.297)	(0.297)	(0.297)	(0.297)
stem_degree	3.254***	3.257***	3.268***	3.279***	3.277***	3.246***
	(0.276)	(0.276)	(0.276)	(0.276)	(0.276)	(0.276)
Panel B: Selection Regression						
foreignborn	0.1554***	0.1554***	0.1554***	0.1554***	0.1554***	0.1554***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
stem_degree	0.0689***	0.0689***	0.0689***	0.0689***	0.0689***	0.0689***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
female	-0.2712***	-0.2712***	-0.2712***	-0.2712***	-0.2712***	-0.2712***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
hisp	-0.1022***	-0.1022***	-0.1022***	-0.1022***	-0.1022***	-0.1022***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
bachelor_above	0.0300***	0.0300***	0.0300***	0.0300***	0.0300***	0.0300***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
non_white	-0.1280***	-0.1280***	-0.1280***	-0.1280***	-0.1280***	-0.1280***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
military	-0.0141*	-0.0141*	-0.0141*	-0.0141*	-0.0141*	-0.0141*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
owner_age_lower_45	-0.1518***	-0.1518***	-0.1518***	-0.1518***	-0.1518***	-0.1518***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
multi_owner	0.4328***	0.4328***	0.4328***	0.4328***	0.4328***	0.4328***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
bb_adoption	0.0672***	0.0672***	0.0672***	0.0672***	0.0672***	0.0672***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Panel C: Marginal Effects						
Cloud variable	0.0212	0.0196	0.0124	-0.006	-0.0015	0.0249*
	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)
foreignborn	0.7651***	0.7652***	0.7649***	0.7654***	0.7653***	0.7647***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
stem_degree	0.4242***	0.4244***	0.4250***	0.4257***	0.4256***	0.4237***

	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Observations	395000	395000	395000	395000	395000	395000
NAICS 2 FE	Yes	Yes	Yes	Yes	Yes	Yes
RUCC FE	Yes	Yes	Yes	Yes	Yes	Yes
Nine emp cate dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband data.

T4: Cragg Cloud on LFTTD total export value 2017-2020 using linear model for non-metro sample

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Output regression						
any_cloud	0.5921					
	(0.647)					
all_IT_cloud		1				
		(0.688)				
customer_cloud			0.348			
			(0.747)			
server_cloud				1.173*		
				(0.688)		
storage_cloud					1.426**	
					(0.696)	
synch_cloud						0.9503
						(0.684)
foreignborn	3.678***	3.710***	3.674***	3.680***	3.673***	3.648***
	(1.135)	(1.135)	(1.135)	(1.135)	(1.134)	(1.135)
stem_degree	2.608***	2.582***	2.650***	2.587***	2.580***	2.578***
	(0.756)	(0.756)	(0.755)	(0.755)	(0.754)	(0.756)
Panel B: Selection Regression						
foreignborn	0.2311***	0.2311***	0.2311***	0.2311***	0.2311***	0.2311***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
stem_degree	0.0447**	0.0447**	0.0447**	0.0447**	0.0447**	0.0447**
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
female	-0.2679***	-0.2679***	-0.2679***	-0.2679***	-0.2679***	-0.2679***
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
hisp	-0.0679	-0.0679	-0.0679	-0.0679	-0.0679	-0.0679
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
bachelor_above	0.0750***	0.0750***	0.0750***	0.0750***	0.0750***	0.0750***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
non_white	-0.2945***	-0.2945***	-0.2945***	-0.2945***	-0.2945***	-0.2945***
	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)	(0.035)
military	-0.0296	-0.0296	-0.0296	-0.0296	-0.0296	-0.0296
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
owner_age_lower_45	-0.1006***	-0.1006***	-0.1006***	-0.1006***	-0.1006***	-0.1006***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
multi_owner	0.4082***	0.4082***	0.4082***	0.4082***	0.4082***	0.4082***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
bb_adoption	0.0294***	0.0294***	0.0294***	0.0294***	0.0294***	0.0294***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Panel C: Marginal Effects						
Cloud variable	0.022	0.0372	0.0129	0.0436*	0.0531**	0.0353

	(0.024)	(0.026)	(0.028)	(0.026)	(0.026)	(0.025)
foreignborn	0.7668***	0.7679***	0.7670***	0.7669***	0.7665***	0.7655***
	(0.095)	(0.094)	(0.095)	(0.095)	(0.094)	(0.094)
stem_degree	0.2190***	0.2180***	0.2207***	0.2182***	0.2180***	0.2178***
	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)
Observations	71000	71000	71000	71000	71000	71000
NAICS 2 FE	Yes	Yes	Yes	Yes	Yes	Yes
RUCC FE	Yes	Yes	Yes	Yes	Yes	Yes
Nine emp cate dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband data.

TA1: Cragg Cloud on LFTTD total export value 2017-2020 with metro dummy interaction using exponential model

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Output regression						
any_cloud	0.0215					
	(0.0179)					
all_IT_cloud		0.0363*				
		(0.0193)				
customer_cloud			0.0166			
			(0.0213)			
server_cloud				0.0323*		
				(0.0195)		
storage_cloud					0.0553***	
					(0.0197)	
synch_cloud						0.0362*
						(0.0193)
metro	0.0392***	0.0422***	0.0374***	0.0448***	0.0514***	0.0407***
	(0.0139)	(0.0116)	(0.0110)	(0.0115)	(0.0115)	(0.0116)
metro cloud interaction	-0.0072	-0.022	-0.0073	-0.029	-0.0519**	-0.0185
	(0.0190)	(0.0204)	(0.0224)	(0.0206)	(0.0207)	(0.0204)
foreignborn	0.1008***	0.1008***	0.1005***	0.1007***	0.1006***	0.1005***
	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0078)
stem_degree	0.0820***	0.0819***	0.0826***	0.0827***	0.0825***	0.0816***
	(0.0072)	(0.0072)	(0.0072)	(0.0072)	(0.0072)	(0.0072)
Panel B: Selection Regression						
foreignborn	0.1629***	0.1629***	0.1629***	0.1629***	0.1629***	0.1629***
	(0.0076)	(0.0076)	(0.0076)	(0.0076)	(0.0076)	(0.0076)
stem_degree	0.0659***	0.0659***	0.0659***	0.0659***	0.0659***	0.0659***
	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)	(0.0069)
female	-0.2730***	-0.2730***	-0.2730***	-0.2730***	-0.2730***	-0.2730***
	(0.0057)	(0.0057)	(0.0057)	(0.0057)	(0.0057)	(0.0057)
hisp	-0.0964***	-0.0964***	-0.0964***	-0.0964***	-0.0964***	-0.0964***
	(0.0111)	(0.0111)	(0.0111)	(0.0111)	(0.0111)	(0.0111)
bachelor_above	0.0377***	0.0377***	0.0377***	0.0377***	0.0377***	0.0377***
	(0.0060)	(0.0060)	(0.0060)	(0.0060)	(0.0060)	(0.0060)
non_white	-0.1367***	-0.1367***	-0.1367***	-0.1367***	-0.1367***	-0.1367***
	(0.0087)	(0.0087)	(0.0087)	(0.0087)	(0.0087)	(0.0087)
military	-0.0170**	-0.0170**	-0.0170**	-0.0170**	-0.0170**	-0.0170**
	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0078)	(0.0078)
owner_age_lower_45	-0.1457***	-0.1457***	-0.1457***	-0.1457***	-0.1457***	-0.1457***
	(0.0063)	(0.0063)	(0.0063)	(0.0063)	(0.0063)	(0.0063)
multi_owner	0.4298***	0.4298***	0.4298***	0.4298***	0.4298***	0.4298***
	(0.0057)	(0.0057)	(0.0057)	(0.0057)	(0.0057)	(0.0057)

bb_adoption	0.0811***	0.0811***	0.0811***	0.0811***	0.0811***	0.0811***
	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)	(0.0036)
Panel C: Marginal Effects						
Cloud variable	0.0319**	0.0358***	0.0214	0.0144	0.0205	0.0419***
	(0.0131)	(0.0136)	(0.0143)	(0.0136)	(0.0136)	(0.0134)
metro	0.0736***	0.0725***	0.0738***	0.0745***	0.0721***	0.0713***
	(0.0198)	(0.0198)	(0.0198)	(0.0198)	(0.0199)	(0.0199)
foreignborn	0.7956***	0.7956***	0.7952***	0.7955***	0.7953***	0.7946***
	(0.0321)	(0.0321)	(0.0322)	(0.0322)	(0.0322)	(0.0321)
stem_degree	0.4085***	0.4084***	0.4099***	0.4100***	0.4096***	0.4075***
	(0.0292)	(0.0292)	(0.0292)	(0.0292)	(0.0292)	(0.0292)
Observations	466000	466000	466000	466000	466000	466000
NAICS 2 FE	Yes	Yes	Yes	Yes	Yes	Yes
RUCC FE	No	No	No	No	No	No
Nine emp cate dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband data.

TA2: Tobit Cloud on LFTTD total export value 2017-2020 with metro dummy interaction

	(1)	(2)	(3)	(4)	(5)	(6)
metro	5.859***	5.731***	5.597***	5.489***	5.302***	5.478***
	(1.389)	(1.366)	(1.362)	(1.365)	(1.363)	(1.366)
any_cloud	5.346***					
	(0.645)					
any_cloud*metro	-1.300*					
	(0.688)					
all_IT_cloud		6.116***				
		(0.729)				
all_IT_cloud*metro		-2.033***				
		(0.769)				
customer_cloud			5.323***			
			(0.804)			
customer_cloud*metro			-1.678**			
			(0.847)			
server_cloud				4.425***		
				(0.733)		
server_cloud*metro				-0.852		
				(0.774)		
storage_cloud					4.403***	
					(0.735)	
storage_cloud*metro					-0.289	
					(0.776)	
synch_cloud						5.982***
						-0.725
synch_cloud*metro						(1.219)
						-0.765
female	-5.644***	-5.567***	-5.609***	-5.564***	-5.570***	-5.609***
	(0.257)	(0.257)	(0.257)	(0.257)	(0.257)	(0.257)
hisp	-1.425***	-1.345***	-1.379***	-1.378***	-1.360***	-1.400***
	(0.492)	(0.492)	(0.492)	(0.492)	(0.492)	(0.492)
bachelor_above	-0.187	-0.19	-0.05	-0.033	-0.104	-0.235
	(0.278)	(0.278)	(0.278)	(0.278)	(0.278)	(0.278)
non_white	-1.803***	-1.826***	-1.888***	-1.866***	-1.825***	-1.835***
	(0.386)	(0.386)	(0.386)	(0.386)	(0.386)	(0.386)
military	-1.360***	-1.347***	-1.354***	-1.371***	-1.346***	-1.264***
	(0.351)	(0.351)	(0.351)	(0.351)	(0.351)	(0.351)
stem_degree	6.623***	6.644***	6.693***	6.675***	6.656***	6.621***
	(0.317)	(0.317)	(0.317)	(0.317)	(0.317)	(0.317)
owner_age_lower_45	-2.874***	-2.890***	-2.912***	-2.762***	-2.878***	-3.088***
	(0.281)	(0.281)	(0.281)	(0.281)	(0.281)	(0.281)
foreignborn	8.430***	8.413***	8.335***	8.344***	8.376***	8.404***
	(0.340)	(0.340)	(0.340)	(0.340)	(0.340)	(0.340)
multi_owner	5.401***	5.380***	5.443***	5.390***	5.399***	5.397***
	(0.263)	(0.263)	(0.263)	(0.263)	(0.263)	(0.263)

bb_adoption	2.805***	2.818***	2.819***	2.854***	2.833***	2.784***
	(0.217)	(0.217)	(0.217)	(0.217)	(0.217)	(0.217)
Observations	466000	466000	466000	466000	466000	466000
NAICS 2 FE	Yes	Yes	Yes	Yes	Yes	Yes
RUCC FE	Yes	Yes	Yes	Yes	Yes	Yes
Nine emp cate dummy	Yes	Yes	Yes	Yes	Yes	Yes

Notes: *** p<0.01, ** p<0.05, * p<0.1. Data is from the LFTTD 2012-2020, ABS 2018, and FCC broadband.

Appendix for cloud variables:

CLOUD SERVICE PURCHASES

Considering the amount spent on each of these IT functions, how much was spent on cloud services? *(Cloud services are services provided by a third party that this business accesses on-demand via the internet.)* ***Select one for each row.***

	None	Up to 50%	More than 50%	All	Don't know	Don't use IT function
a. All IT functions	☐	☐	☐	☐	☐	☐
b. Security or firewall	☐	☐	☐	☐	☐	☐
c. Servers	☐	☐	☐	☐	☐	☐
d. Data storage and management (Examples: Amazon Web Services, IBM Bluemix, Microsoft Azure)	☐	☐	☐	☐	☐	☐
e. Collaboration and file synchronization (Examples: Dropbox, OneDrive, Google Drive)	☐	☐	☐	☐	☐	☐
f. Data Analysis	☐	☐	☐	☐	☐	☐
g. Billing and account management	☐	☐	☐	☐	☐	☐
h. Customer relationship management	☐	☐	☐	☐	☐	☐
i. Other (specify) ↙	☐	☐	☐	☐	☐	☐

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