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Korea Institute for International Economic Policy

Ecommerce and Firm Performance: Evidence from Korea

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Executive Summary

Official estimates peg global business-to-business ecommerce at 15 trillion dollars and global business-to-consumer ecommerce at 1.2 trillion dollars in 2013 (UNCTAD 2015). When we turn to official estimates for Korea, it is easy to find that Korea's business-to-consumer ecommerce market is growing at more than twenty percent per year and has emerged as the third largest global ecommerce market in Asia. It is not very much surprising to know the numbers for Korea since Korea is one of the world's most advanced countries in terms of information and communication technology. However, it is somewhat surprising that we know little about how ecommerce firms or establishments are distributed in the economy of Korea. In addition, we know little about how ecommerce establishments perform relative to their counterparts of a similar age and size in the same industry.

The paper aims to characterize and test performance differences between ecommerce and non-ecommerce firms or establishments. Although the number of ecommerce establishments makes up a small fraction of the economy, ecommerce establishments have a heavier weight in sales, employment, and wage. Due to endogeneity of ecommerce variable, the paper reconstructs the 2010 Korea Census dataset by using Propensity Matching Score and shows that in manufacture ecommerce establishments have, on average, larger sales-per-worker and pay higher wage whereas in services ecommerce ones have higher sales-per-worker but pay no larger wage than their counterparts of a similar age and size in the same industry. It also adds quantile estimates showing that sales-per-worker differences between ecommerce and non-ecommerce establishments in manufacture are positive and statistically significant only at lower quantiles of the distribution. In services, sales-per-worker differences between them are positive and significant at most of distribution but turns to be negative, though not significant, at above upper quantile of the distribution.

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Ecommerce and Firm Performance: Evidence from Korea

LEE Kyu Yub [†]

Abstract

This paper describes and tests performance differences between ecommerce and non-ecommerce firms or establishments by using the 2010 Census for Korea. Although the number of ecommerce establishments makes up a small fraction of the economy, ecommerce establishments have a heavier weight in sales, employment, and wage. Due to endogeneity of ecommerce variable, the paper reconstructs the 2010 Korea Census dataset by using Propensity Matching Score. It shows that in manufacture ecommerce establishments have, on average, larger sales-per-worker and pay higher wage whereas in services ecommerce ones have higher sales-per-worker but pay no larger wage than their counterparts of a similar age and size in the same industry. It also adds quantile estimates showing that sales-per-worker differences between ecommerce and non-ecommerce establishments in manufacture are positive and statistically significant only at lower quantiles of the distribution. In services, sales-per-worker differences between them are positive and significant at most of distribution but turns to be negative, though not significant, at above upper quantile of the distribution.

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1. Introduction

Electronic commerce, commerce via internet, is one of the most natural outcomes in the modern digital economy. Official estimates peg global business-to-business ecommerce at 15 trillion dollars and global business-to-consumer ecommerce at 1.2 trillion dollars in 2013 (UNCTAD 2015). When we turn to official estimates for Korea, it is easy to find that Korea's business-to-consumer ecommerce market is growing at more than twenty percent per year and has emerged as the third largest global ecommerce market in Asia. It is not very much surprising to know the numbers for Korea since Korea is one of the world's most advanced countries in terms of information and communication technology. However, it is somewhat surprising that we know little about how ecommerce firms or establishments are distributed in the economy of Korea. In addition, we know little about how ecommerce establishments perform relative to their counterparts of a similar age and size in the same industry. The paper aims to characterize and test performance differences between ecommerce and non-ecommerce firms or establishments.[1]

The main findings of the paper can be summarized as follows. The paper finds that while the number of ecommerce establishments makes up a small fraction of the economy, ecommerce establishments have a heavier weight in sales, employment, and wage. It shows that in manufacture ecommerce establishments have, on average, larger sales-per-worker and pay higher wage[2] whereas in ser-

[1] Fundamentally speaking, if there were no characteristic difference between them, why should we care about ecommerce? It would be meaningless to focus on the effect of ecommerce firms if they were no different from non-ecommerce firms, because that would ultimately mean to deal with just usual firms, regardless of ecommerce activity.

[2] Our findings remind us of performance differences between exporters and non-exporters well documented by Bernard and Jensen (1994) in the international trade literature.

vices ecommerce ones have higher sales-per-worker but pay no larger wage than their counterparts of a similar age and size in the same industry. It also adds quantile estimates showing that sales-per-worker differences between ecommerce and non-ecommerce establishments in manufacture are positive and statistically significant only at lower quantiles of the distribution. In services, sales-per-worker differences between them are positive and significant at most of distribution but turns to be negative, though not significant, at above upper quantile of the distribution.

The contribution of the paper to the ecommerce literature is three folds. First, the paper contributes to the literature by describing performance differences between ecommerce and non-ecommerce establishments using a unique establishment-level dataset that includes all establishments in both manufacturing and services industries. I use the 2010 Census collected by Statistics Korea, the national statistical office of the Republic of Korea. Using the 2010 Korea Census, I report a detailed description of performance differences between ecommerce and non-ecommerce establishments by industry and establishment-size. Based on the statistical description, the paper highlights that the number of ecommerce establishments makes up a small fraction of the economy and that ecommerce activities are concentrated in a few industries in both manufacture and services. Although there are a relatively small fraction of ecommerce establishments in Korea, the paper finds that they play an important role in economic performances and in the labor market. The descriptive statistics provided by the paper can be valuable since existing studies cannot provide such characteristics of ecommerce due to their relying

on a limited number of samples sometimes for manufacture only.

Second, it contributes to the ecommerce literature on productivity. The paper tests performance differences between ecommerce and non-ecommerce establishments and focuses on, at establishment-level, sales-per-worker and wage as dependant variables. In showing regression estimates, it uses the OLS as well as quantile regression analysis. In fact, we can answer main questions of the paper such as "is ecommerce establishment different from non-ecommerce counterparts?" or "do ecommerce establishments pay more than non-ecommerce ones?" based on the OLS regression estimates. The reason why we adopt quantile regeression is that there are outliers in the dataset which lead the OLS regression estimates to be biased and inefficient. Moreover, we can answer additional questions beyond the main questions such as "does ecommerce have a stronger effect at the upper end of sales-per-worker?" or "does ecommerce have a larger effect on the lower end of wage distribution than average?" In this way, we can draw a more comprehensive picture of the effect of ecommerce status on dependent variables such as sales-per-worker and wage.

Third, the paper endeavors to estimate better by relieving the endogeneity problem of ecommerce variable. It is very likely to suffer from self-selection problem in using the 2010 Korea Census. We cannot tell whether large-sized establishments are engaging ecommerce activity because confounding factors that affect both outcome and ecommerce or ecommerce activity affects outcome. Thus, we cannot do impact analysis nor make a causal statement with any results from regression. In other words, estimates do not direct causality between ecommerce activity in

selling goods or services and establishment performance, but show correlation between them. The paper chooses to adopt one of the most natural approaches the so-called propensity score matching given the 2010 Korea Census dataset. The approach predicts outcomes of ecommerce establishment when they were not engaging in ecommerce activity using non-ecommerce establishments which are most close to ecommerce establishments in hand. With a matched sample from the 2010 Korea Census dataset, I run OLS and quantile regression.

Relating to the literature: The scope of existing studies in the ecommerce literature can be very wide if researchers treat the internet and information and communication technology (so-called ICT) as proxies for ecommerce activity. However, note that firms or establishments using the internet and ICT are not necessarily ecommerce users in selling their goods or services. Nevertheless, it is worth to review several papers in the ICT literature since there is no canonical model (or theory) to deal with ecommerce directly. In most cases, earlier studies in the ICT literature treat ICT variable as an additional input of Cobb-Douglas production in an industry or a firm (for example, Marilanta and Rouvinen 2003 and Farooqui 2005). Then the productivity effect of the ICT either in an industry or a firm would depend on complementarity (or substitution) between the variable and other input factors. In general, many authors seem to presume that the ICT variable is likely to be complementary with other input variables such as labor and physical capital. This makes some sense because otherwise an industry or a firm finds no reason to increase ICT investments in their production.

In the same vein, several studies in the ecommerce literature have examined

the effect of ecommerce on firm productivity by using micro-econometric approaches with a limited number of samples.[3] At industry-level, Falk and Hagsten (2015) provide empirical evidence on positive (labor) productivity effects of ecommerce. They use a unique panel of micro-aggregated firm-level for 14 European countries spanning over the years 2002 to 2010.[4] Their empirical approach is based on the usual OLS regression estimation and system GMM to account for endogeneity of ecommerce activity. The main result by Falk and Hagsten (2015) is that an increase in ecommerce sales raises the rate of labor productivity by 0.3 percentage points over a two-year period for the total sample.

At firm-level, Bertschek *et al*. (2006) study the effects of business-to-business ecommerce (B2B) on labor productivity by using a sample of 1,394 German firms from the manufacturing industries and from selected services sectors. To see the productivity effect of B2B ecommerce, they implement an endogenous switching-regression model. One of their main results is that output elasticity with respect to ICT-investment is higher for firms using B2B. They explain this result due to (strategic) complementarity between B2B and the input factors of the firms. OECD (2004) also studies the effect of ecommerce on labor productivity. It combines several ecommerce surveys including the Annual Business Inquiry and the Eurostat ecommerce inquiry. Unlike Bertschek *et al*. (2006), OECD (2004) uses value-added

[3]Aside from the focus on productivity in the ecommerce literature, several other studies use variables of the internet and/or ICT to investigate the effects of the internet and ICT on total productivity (USITC 2013), on trade volume (Xing 2017, Osnago and Tan 2016, Choi 2010, Freunda and Weinhold 2002, 2004), on trade costs (Slum and Glodfarb 2006) and many others. Still other papers including Einav *et al*.(2014), Terzi (2011), Goldmanis *et al*. (2010), Willis (2004), can be included for further readings.

[4]Although they obtained a firm-level dataset, they aggregated firms by industry due to disclosure issues.

per worker and gross output per worker as a measure of productivity. It reports that ecommerce has an overall positive effect on firm performance in both manufacture and services regardless of firm size. However, the size of firm matters in Konings and Roodhooft (2002) who examined the impact of e-business on economic performance. They collect data from Belgian manufacturing firms and find that ecommerce has no effect on total factor productivity in small firms while it has positive effects on performance of e-business in large firms. Their finding implies heterogeneous effect of ecommerce depending on firm size.

Not all studies report that ecommerce activity has a positive impact on firm performance. For example, Quiros Romero and Rodriguez Rodriguez (2010) set up a framework based on the stochastic frontier using Spanish manufacturing firms in 2000-2015. Their results suggest that ecommerce sales have no influence on firm efficiency. Thus, it would be ultimately an empirical question to see if ecommerce activity helps firms increase their (labor) productivity.

All the aforementioned studies rely on a particular dataset with a limited number of samples from ecommerce survey. Thus, it is very difficult to find a paper that describes how ecommerce establishments are distributed in an economy. It is also very difficult to find a paper providing evidence on performance differences between ecommerce and non-ecommerce firms in terms of firm productivity (sales-per-worker in the paper) as well as wage in Korea. The reason for examining wage difference between ecommerce and non-ecommerce establishments is because it is entirely possible that ecommerce activity and sales-per-worker are statistically positively related but ecommerce activity and wage are not related after control-

ling age and size of establishment and detailed industry level. Unlike the previous studies, the estimation strategy that the paper selects is not limited to the OLS regression estimation but also extended to the quantile regression estimation in order to understand better the dataset including ecommerce variables.

The paper is organized as follows. Section 2 explains the 2010 Korea Census data and provides industry and firm-level characteristics of performance differences between ecommerce and non-ecommerce establishments. Section 3 explains how to construct a matched dataset to relieve the self-selection problem in the 2010 Korea Census. Section 4 provides empirical evidence by OLS and quantile regression for performance differences between ecommerce and non-ecommerce establishments. Section 5 concludes the paper.

2. Data and Statistical Description

2.1 Data

This paper uses detailed establishment-level data from the Statistics Korea database to examine the relationship between ecommerce activity and establishment performance. Statistics Korea has released the 2010 Census. The 2010 Korea Census includes all establishments in both manufacturing and services sectors and classifies industries based on the KSIC (Korea Standard Industry Classifications). It collects information on employment, annual compensation for workers, total value of sales, ecommerce activity, etc. These data are available at the 5-digit KSIC.

An ecommerce establishment is an establishment that sells goods or services

through the internet or computer networks. Thus, non-ecommerce establishments in the dataset refer to establishments that sell goods or services offline. The 2010 Korea Census contains ecommerce variables obtained from questions whether the establishment uses ecommerce in selling goods or services, and, if yes, the share of sales conducted by ecommerce. For the sake of simplicity, I use a dummy variable for ecommerce status in our analysis.[5]

The paper focuses on the 2010 Census for Korea because it contains the whole of establishments in all industries. Second, it is the only dataset that includes ecommerce variables of manufacturing industries. Further, data from the 2010 Korea Census is most useful to provide detailed cross-sectional analysis on the characteristics and performance differences between ecommerce and non-ecommerce establishments.

2.2 Statistical Description

Table 1 shows that in 2010 Korea has 3,343,541 establishments in eighteen industries including agriculture, mining, manufacture, and many other services industries. Out of 3,343,541 establishments, only 72,144 establishments engage in ecommerce activity for selling their goods or services, with about 3.2% of these establishments in manufacture and 2.5% in services industries. Among these ecommerce establishments, manufacture takes the largest share, 43.5%, of total ecommerce sales, construction 12.8%, and wholesale and retail trade 20.7%. Note here

[5]Alternatively, we might use the ecommerce share from the establishment as the appropriate establishment-level variable. Due to the complexity required to generate a matched dataset for analysis, we avoid this alternative approach.

Table 1. Industry Characteristics at 1-digit KSIC

Industry (1-digit KSIC)	Number of Est.	Percent Dist. of Est.	Number of EC Est.	EC as Percent of Est.	Percent Dist. of EC Est.
Total	3,343,541	100.0	72,144	2.2	100.00
Agriculture, hunting and forestry	2,354	0.1	139	5.9	0.2
Mining and quarrying	1,770	0.1	78	4.4	0.1
Manufacture	326,813	9.8	10,458	3.2	14.5
Electricity, gas and water supply	1,499	0.0	51	3.4	0.1
Recycling	5,402	0.2	130	2.4	0.2
Construction	96,833	2.9	5,486	5.7	7.6
Wholesale and retail trade	876,654	26.2	31,402	3.6	43.5
Transportation	347,179	10.4	1,209	0.3	1.7
Hotel and restaurants	634,500	19.0	4,061	0.6	5.6
Telecommunication	26,375	0.8	3,219	12.2	4.5
Financial intermediation	39,353	1.2	2,555	6.5	3.5
Real estate, renting	126,081	3.8	2,022	1.6	2.8
Professional, science, and technology	70,601	2.1	2,521	3.6	3.5
Business activities	35,910	1.1	2,177	6.1	3.0
Education	165,964	5.0	2,460	1.5	3.4
Health and social work	107,012	3.2	1,751	1.6	2.4
Art, sports and recreational services	102,948	3.1	791	0.8	1.1
Community social and personal services	376,293	11.3	1,634	0.4	2.3

Notes: Author's calculations at the 1-digit KSIC. EC stands for ecommerce status. Dist. means distribution. Est. stands for establishment, workplace consisting of one or more employees.
Sources: Data are from the 2010 Korea Census collected by Statistics Korea.

that the share of ecommerce sales out of industrial total sales varies from 0.53% (Health and social work) to 8.21% (Construction) at the 1-digit KSIC (see Table A1 in the Appendix).

Table 2 provides industry characteristics in terms of share of total value of sales, total employment (workers), and wage depending on ecommerce status after aggregating up to the 1-digit KSIC in the 2010 Korea Census. EC as percent of Est. in Table 1 is reproduced in the second column of Table 2 as Share of EC Est. for the purpose of comparison with other shares. Although the total number of ecommerce establishment takes only 2.2% in the economy, share of the total sales of ecom-

Table 2. Ecommerce Share at the 1-digit KSIC

Industry (1-digit KSIC)	Share of EC Est.	Share of EC Sales	Share of EC Size	Share of EC Wage
Total	**2.2**	**4.3**	**6.0**	**8.8**
Agriculture, hunting and forestry	5.9	1.1	5.1	3.5
Mining and quarrying	4.4	4.3	5.5	4.8
Manufacture	3.2	5.4	6.3	8.4
Electricity, gas and water supply	3.4	3.6	5.9	6.4
Recycling	2.4	2.4	2.9	2.9
Construction	5.7	8.2	13.2	14.2
Wholesale and retail trade	3.6	5.3	8.4	15.6
Transportation	0.3	3.4	4.7	13.0
Hotel and restaurants	0.6	1.0	2.0	8.3
Telecommunication	12.2	7.9	17.6	18.0
Financial intermediation	6.5	1.7	7.6	10.4
Real estate, renting	1.6	1.2	1.8	1.7
Professional, science, and technology	3.6	2.0	6.7	7.4
Business activities	6.1	3.0	4.9	4.9
Education	1.5	2.3	4.1	4.6
Health and social work	1.6	0.5	1.6	1.4
Art, sports and recreational services	0.8	1.9	4.7	7.9
Community social and personal services	0.4	0.9	1.2	3.2

Notes: Author's calculations at the 1-digit KSIC. EC stands for ecommerce status. Dist. means distribution. Est. stands for establishment, workplace consisting of one or more employees. Size is measured by the number of workers at establishment.
Sources: Data are from the 2010 Korea Census collected by Statistics Korea.

merce establishments takes 4.3%. In addition, the share of the number workers of ecommerce establishments takes 6.0%, and share of the total amount of wage payments by them 8.8%. This implies that, although the number of ecommerce establishments makes up a small fraction of the economy, they play an important role in economic performances in terms of sales, employment, and wage.

More than 70 percent of total sales are concentrated in a few industries, including manufacture (34.71%), wholesale and retail trade (16.89%), financial intermediation (18.43%), and the fourth largest industry, construction (6.73%). The rest of the industries in the economy account for less than 4% of total sales (see Table A1 for more details in Appendix). By decomposing the aggregated variables into

2-digit KSIC, manufacturing and services industries can be characterized by variables including the share of total sales, average establishment size at ecommerce and non-ecommerce establishments, and percentage of total ecommerce sales at ecommerce establishments in two groups of industries (manufacture and services).

Data for manufacturing industries at the 2-digit KSIC level show that the largest industries in terms of above 5% in total sales are Petroleum (8.01%), Chemicals (8.67%), Primary metal (10.24%), Electronic equipment (18.33%), Misc. Manufacture (7.19%), Mobile Manufacture (10.58%), and Misc. Transportation (5.83%). In particular, ecommerce sales are mostly concentrated in Chemicals (8.59%), Primary metal (26.69%), and Electronic equipment (40.95%). It is surprising that the average size of ecommerce establishments is mostly larger than that of non-ecommerce establishments, except for three industries, Beverage, Tobacco, Misc. Transportation. Ecommerce establishments in Petroleum have, on average, about 100 workers more than non-ecommerce establishments in that industry. Similarly, the same patterns can be found in Primary metal, Electronic equipment, Misc transportation industry, all of which are the industries where ecommerce establishments are concentrated (see Table A2 for more details in Appendix).

Services industries at the 2-digit KSIC level show that the largest industries in terms of above 5% in total sales are Construction of buildings (7.14%), Wholesale trade (17.50%), Retail trade (except motor vehicles) (7.81%), Financial services (19.05%), and Insurance (7.19%). Ecommerce establishments' sales are mostly concentrated in Construction of buildings (17.18%), Specialized construction (6.67%), Wholesale trade (18.66%), Resale trade (except motor vehicles) (17.25%), and Fi-

Table 3. Characteristics of Ecommerce Establishments by Industry Group, 2010

(mean values)	Manufacture			Services		
Characteristics	EC	NEC	EC/NEC	EC	NEC	EC/NEC
Total value of sales	12,986	3,988	3.3	4,246	754	5.6
Total employment (workers)	20	10	2.0	13	4	3.3
Sales-per-worker	635	394	**1.6**	329	176	**1.9**
Wage (per worker)	37	27	**1.4**	26	17	**1.5**

Notes: Author's calculations. EC stands for ecommerce status. NEC stands for non-ecommerce. Values represent establishment means either in millions of Korean won or in unit of persons. Wage is measured for annual compensation paid to total employment.
Source: Data are from the 2010 Korea Census.

nancial service (8.18%).[6] As found in manufacturing industries, the average size of ecommerce establishments is mostly larger than that of non-ecommerce establishments. Although exceptions are seen in industries such as Water transport, Broadcasting, Computer programing, Scientific research and development, Office admin. support, and Human health, the size difference between them is not substantial (see Tables A3-A4 for more details in Appendix).

Table 3 reports characteristics of ecommerce and non-ecommerce establishments by two groups, manufacture and services.[7] It provides mean values of total sales, total employment (workers), sales-per-worker, and wage (annual compensation per worker). Values represent establishment means either in millions of Korean won or in unit of persons. In manufacture, the total value of sales that ecommerce establishments yield is on average three times higher than that of non-ecommerce establishments, whereas in services, the total value of sales that ecommerce establishments yield is on average more than five times higher than non-ecommerce

[6]Resale trade classification includes the so-called sub-industry of online-shopping mall business. 5-digit KSIC categorizes the sub-industry as 47911 while 4-digit SIC does so as 4791.

[7]For the sake of simplicity, we focus on manufacturing and services industries. Note that the paper drops agriculture, hunting and forestry and Mining and quarrying in the dataset. The share of total sales from these industries is less than 1 percent in the economy.

Table 4. Characteristics of Establishment by Size Group, 2010

Manufacture	<50		50<, <250	
Characteristics	EC	NEC	EC	NEC
Total value of sales	1,727	1,038	50,268	36,706
Total employment (workers)	9	6	101	97
Sales per worker	194	178	496	379
Wage per worker	19	17	29	30
	250<, <1250			1250<
Characteristics	EC	NEC	EC	NEC
Total value of sales	475,960	347,020	7,309,903	5,001,161
Total employment (workers)	480	434	5,398	4,183
Sales per worker	991	799	1,354	1,195
Wage per worker	45	41	74	82
Services	<50		50<, <250	
Characteristics	EC	NEC	EC	NEC
Total value of sales	1,756	429	24,767	22,281
Total employment (workers)	6	3	98	92
Sales per worker	271	142	253	242
Wage per worker	20	11	26	26
	250<, <1250			1250<
Characteristics	EC	NEC	EC	NEC
Total value of sales	156,069	108,267	2,068,232	826,549
Total employment (workers)	451	468	2,535	2,103
Sales per worker	346	232	816	393
Wage per worker	31	30	52	41

Notes: Author's calculations. This table considers size groups in terms of total employment. Establishment size is divided into four groups, less than 50 (Small), between 50 and 250 (Medium), between 250 and 1250 (Large), and larger than 1250 workers (Very Large). EC stands for ecommerce status. NEC stands for non-ecommerce. Values represent establishment means either in millions of Korean won or in unit of person. Wage is measured for annual compensation paid to workers.
Sources: Data are from the 2010 Korea Census.

establishments. In both manufacture and services, ecommerce establishments hire more workers (total employment) and pay higher wages than non-ecommerce establishments.

Table 4 reports the means for four different size groups from the same dataset used in Table 3. Establishment size is divided into four groups, less than 50 (Small), between 50 and 250 (Medium), between 250 and 1250 (Large), and larger than 1250 workers (Very Large). Depending on the size group, I separately look at

performance differences between ecommerce and non-ecommerce establishments. Of small-and-medium-sized establishments (less than 250) in manufacture, ecommerce establishments are larger than their counterparts of non-ecommerce in terms of sales, employment, and sales-per-worker. It seems that wage is not very different from each other. In services, among small-and-medium-sized establishments, ecommerce establishments also perform better than their non-ecommerce counterparts in many respects such as sales, employment, sales-per-worker, and wage. Similar comparison can be made among establishments with 250 or more workers in both manufacture and services. For example, it is surprising to find that, among large-sized establishments, ecommerce establishments in manufacture are better than non-ecommerce in all performance measures we examined. In particular, large-sized ecommerce establishments sell about 19% more per worker and pay 3 million Korean won per year higher than those in their counterparts in manufacture. While it is more pronounced than the case in manufacture, large-sized ecommerce establishments in services industries hire about 32.9% more workers and pay about 1 million Korean won per year more than those in their counterparts.

3. Estimation

The 2010 Census for Korea is useful in describing how ecommerce establishments are distributed in the economy and characterize performance differences between ecommerce and non-ecommerce establishments. As shown previously in the pa-

per, ecommerce activities vary substantially across industry. Although ecommerce establishments seem to perform better than non-ecommerce ones across industry and size group, there is a possibility that industry and size group may account for most of the differences between ecommerce and non-ecommerce establishments. Thus, it is worth to continue investigations by rigorously estimating performance differences between them after controlling several factors.

In addition, there is a possibility that some outliers in the dataset may lead the OLS regression estimates for measuring performance differences between ecommerce and non-ecommerce establishments to be biased and inefficient. More seriously, it is very likely to suffer from self-selection problem in using the dataset in hand due to endogeneity of ecommerce variable. We cannot tell whether large-sized establishment is engaging ecommerce activity because confounding factors that affect both outcome and ecommerce or ecommerce activity affects outcome. Thus, we cannot do impact analysis nor make a causal statement with any results from regression. In other words, estimates do not direct causality between ecommerce activity in selling goods or services and establishment performance, but show correlation between them. Thus, the paper considers applying propensity score matching (PSM) to construct a matched dataset for ecommerce and non-ecommerce establishments.

3.1 Constructing a Matched Dataset

The PSM is one of the most natural approaches to relieve the self-selection problem given the dataset. This approach predicts the outcomes of ecommerce establish-

ment when they were not engaging in ecommerce activity by using non-ecommerce establishments which are most close to ecommerce establishments in hand.

To construct a matched sample from the 2010 Census dataset, the first step is to estimate propensity score for each establishment by Probit,

$$EC_i = 1[z\pi + u_i > 0] \tag{1}$$

where i indicates an establishment. EC_i is binary. If an establishment does ecommerce in selling its goods or services, it has 1, otherwise 0. 1[.] is an indicator function in which the function is 1 whenever the statement in parenthsis is true, and zero otherwise. π is a vector of parameters and u_i is error term. Lastly, z is a vector of variables including observed characteristics that might determine whether an establishment adopts ecommerce or not. Since it is likely for younger and smaller establishment to adopt ecommerce, this paper selects, for z, age and size of establishment and additionally industry dummies.

The next step is to choose a matching algorithm that use the estimated propensity scores to match ecommerce establishments to non-ecommerce ones. There are several options such as nearest neighbor matching, caliper and radius matching, kernel matching, local linear matching and others (Smith and Todd 2005). This paper chooses to apply nearest neighbor matching because of its simplicity.[8] Using the matching algorithm, I could obtain a best match for each ecommerce establish-

[8]In choosing a matching algorithm among many others, there is no winner for all situations because of trade-offs between bias and efficiency. However, it is known that all PSM estimators should generate the same results asymptotically.

Table 5. Descriptive Statistics of Variables in the Matched Dataset

	Variable	Obs	Mean	Sd	Min	Max
Manufacture	lnsales_per_worker	13,515	4.79	1.08	-1.67	9.66
	Ecommerce	13,515	0.52	0.49	0	1
	lnemp	13,515	2.41	1.06	0	9.81
	Age	13,515	10.23	8.09	1	83
	lnwage	13,442	2.84	0.67	-2.08	4.99
	Ecommerce	13,442	0.53	0.50	0	1
	lnemp	13,442	2.43	1.06	0	9.81
	Age	13,442	10.25	8.09	1	83
Services	lnsales_per_worker	69,738	4.47	1.54	-4.14	10.94
	Ecommerce	69,738	0.63	0.48	0	1
	lnemp	69,738	1.93	1.21	0	9.46
	Age	69,738	9.99	11.39	1	121
	lnwage	57,879	2.81	0.92	-4.55	8.11
	Ecommerce	57,879	0.61	0.49	0	1
	lnemp	57,879	2.19	1.15	0	9.46
	Age	57,879	10.69	12.06	1	149

Sources: Author's calculation based on a matched sample from the 2010 Korea Census.

ment from non-ecommerce establishment. Table 5 shows the descriptive statistics of the variables in manufacture and services in the matched dataset constructed from PMS (see also Tables A5-A6 for more details depending on ecommerce status in Appendix).

3.2 Estimation

With the matched dataset constructed by the PMS approach, I could proceed the OLS and quantile regression. The OLS regression model can be written as[9]

$$lny_i = x_i\theta + e_i \tag{2}$$

[9]So, I solve the following problem: $min_\theta \sum_{i=1}^{n}(y_i - x_i\theta)^2$ where $x_i\theta$ is sample mean. Parametric function $x_i\theta$ is assumed to be linear for the sake of simplicity.

where lny_i is a dependent variable in logarithm. x_i is a vector of regressors, θ is a vector of coefficients and e_i is an error term. y_i is either sales-per-worker or wage and its values are in unit of million Korean won. $x_i\theta$ can be represented as

$$x_i\theta = \alpha + \beta EC_i + \gamma size_i + \delta age_i + \mu industry$$

where α is constant. EC_i is binary, which has 1 if an establishment does ecommerce in selling its goods or services, otherwise 0. Control variables are age as establishment's age, $size$ measured by log of total employment (workers) at establishment, and $industry$ as a vector of 5-digit KSIC dummies.

The equation (2) is used to obtain estimates by OLS regression. I point out two considerations for the OLS regression analysis. First, the coefficient of ecommerce status β is key in every regression result. Second, estimates are obtained by controlling age and size of establishment and industry at the 5-digit KSIC.

Based on the OLS regression estimates, I can answer questions such as "are ecommerce establishments different from their non-ecommerce counterparts?" or "does an ecommerce establishment pay more than non-ecommerce?" If β is positive, then the positive coefficient of β indicates that sales-per-worker at ecommerce establishment is higher than their non-ecommerce counterparts. In general, the OLS regression analysis can provide conditional mean $E(y_i|x_i)$.

Several studies including OECD (2004) and Konings and Roodhooft (2002) in the ecommerce literature attempted to investigate the productivity effect of ecommerce on different size of establishments. In the same vein, I further consider the

following regression model by interacting ecommerce variable with the size of establishment in order to see if the effect of ecommerce varies depending on the size of establishments.

$$lny_i = \alpha + \beta_{base} EC_i + \gamma size_i + \beta_{size} EC_i \times size_i + controls + \epsilon_i \tag{3}$$

where the size of establishment is continuous, $controls$ includes the age of establishment and industry dummies, and lastly, ϵ_i is error term.

However, the OLS estimation makes it difficult to draw a more comprehensive picture of the effect of ecommerce activity on dependent variable. In other words, we do not know the conditional distribution of dependent variable given explanatory variables. Specifically, I fail to answer questions such as "does ecommerce have a larger effect on the lower end of wage distribution than average?" or "does ecommerce have a stronger effect at the upper end of sales-per-worker?"

Quantile regression allows us to consider the impact of ecommerce on the entire distribution of dependent variable, giving richer characteristics from the data.[10] The quantile regression model can be written as

$$lny_i = x_i \theta_\tau + e_{\tau,i} \quad with \quad q_\tau(lny_i | x_i) = x_i \theta_\tau \tag{4}$$

where x_i is a vector of regressors including EC_i, age and size of establishments, a vector of industry dummies at the 5-digit KSIC. A vector of parameters is denoted

[10]Quantile regression is more robust to non-normal errors and outliers. It is invariant to monotone transformations such as logarithm, so the quantiles of a monotone transform of y_i and the inverse transfomation may be used to translate the results back to y_i. This is not possible for the mean (Koenker and Hallock 2001)

as θ_τ. $q_\tau(lny_i|x_i)$ represents the τth conditional quantile of lny_i given x_i. For $\tau \in (0,1)$, q_τ is a τth quantile of distribution of lny_i if $Pr(lny_i \leq q_\tau) \geq \tau$ and $Pr(lny_i \geq q_\tau) \geq 1-\tau$.

The τth regression quantile is defined as a solution to the following problem

$$min_\theta \left\{ \sum_{i:\, lny_i \geq x_i\theta} \tau|lny_i - x_i\theta_\tau| + \sum_{i:\, lny_i \leq x_i\theta} (1-\tau)|lny_i - x_i\theta_\tau| \right\} \tag{5}$$

which is usually written as $min_\theta \sum_{i=1}^{n} c_\tau(lny_i - x_i\theta_\tau)$ where c_τ is called the τ-absolute loss function and defined as $c_\tau(\epsilon) = (\tau - 1[\epsilon < 0])\epsilon$.

The whole point for doing quantile regressions is to see the effects of ecommerce in different quantiles of dependent variable. This paper selects 0.25, 0.5, and 0.75 quantiles in reporting coefficients and standard errors. The first quartile is obtained by setting τ at 0.25. The median is obtained at $\tau = 0.5$. The third quartile is obtained by setting τ at 0.75. In fact, we can traces the entire distribution of dependant variable conditional on independant variables as τ increases from 0 to 1.

4. Results

This section reports estimates by OLS and quantile regression using the matched dataset constructed from the 2010 Korea Census. The OLS regression captures how the mean of dependant variables changes with independent variables. As discussed, conditional quantile function provides a more complete picture of the matched dataset. The paper focuses on the OLS regression and quantile regression estimates of ecommerce variables among independent variables in order to address

relations between sales-per-worker/wage and ecommerce activity.

4.1 Sales-Per-Worker and Ecommerce Activity

Sales-per-worker differences between ecommerce and non-ecommerce establishments are estimated by OLS using (2) and quantile regression using (5). We also examine the sales-per-worker differences between them according to the size of establishments by using OLS (3) and quantile regression (5) with interactions in both manufacture and services.

4.1.1 No interaction with size of establishment

Table 6 reports the results of estimating (2) and (5) using logarithm of sales-per-worker as the dependant variable for both manufacture and services. The second column at the upper part of Table 6 provides the OLS estimates. In both manufacture and services, the coefficient on ecommerce status is positive and very statistically significant for sales-per-worker. In manufacture, sales-per-worker at ecommerce establishment in manufacture is 5.9% higher values on average than at non-ecommerce establishments of a similar age and size in the same industry. In services, it is 3.4% larger on average than their counterparts (the second column at the lower part of Table 6).

Quantile estimates differ depending on whether establishments belong to either manufacture or services. The third to fifth columns in Table 6 provide estimates at quantiles (q = 0.25, 0.50, 0.75) of the sales-per-worker distribution in manufacture. In manufacture, quantile regression shows that sales-per-worker difference

Table 6. Sales-Per-Worker and Ecommerce Activity

Manufacture				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	**0.057**	**0.061**	0.028	0.028
	(0.016)***	(0.021)***	(0.018)	(0.020)
lnemp	0.211	0.260	0.216	0.172
	(0.009)***	(0.011)***	(0.010)***	(0.010)***
Controls	Yes	Yes	Yes	Yes
Obs.	13,515	13,515	13,515	13,515
Services				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	**0.033**	**0.032**	**0.038**	**0.025**
	(0.009)***	(0.011)***	(0.009)***	(0.010)***
lnemp	0.082	0.115	0.084	0.049
	(0.004)***	(0.005)***	(0.004)***	(0.005)***
Controls	Yes	Yes	Yes	Yes
Obs.	69,738	69,738	69,738	69,738

Notes: Author's calculations. Dependent variables are in logarithm of sales-per-worker. EC stands for ecommerce status. Parenthesis represents standard error. $***$, $**$, $*$ stand for significant at the 0.01, 0.05, and 0.1 percent level, respectively. Controls include the age of establishments and industry vector at the 5-digit KSIC.
Sources: Based on a matched sample from the 2010 Korea Census.

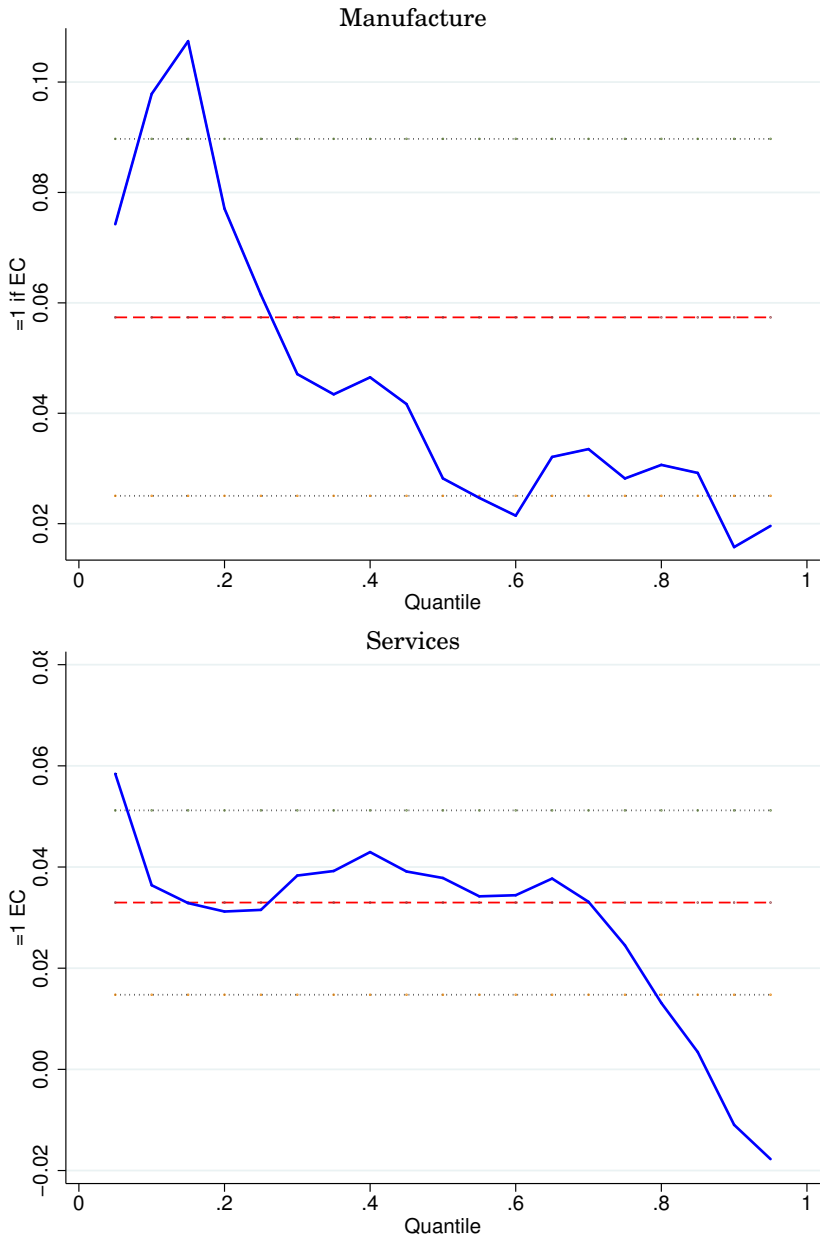
between ecommerce and non-ecommerce establishments is strongest and only statistically significant at the first quartile ($q = 0.25$) of the distribution. The coefficient at the 0.25 quantile is 0.061, implying that ecommerce increases sales-per-worker by 6.3 percent for those with lower sales-per-worker group. The coefficients at the mean and the third quarter of the distribution are positive but not statistically significant.

The third to fifth columns at the lower part of Table 6 provide the results of estimating (3) and (5) using logarithm of sales-per-worker as the dependant variable in services. Unlike the case in manufacture, sales-per-worker differences between ecommerce and non-ecommerce establishments in services are positive and significant at all quantiles ($q = 0.25, 0.50, 0.75$) of the sales-per-worker distribution. In other words, the coefficients on ecommerce at the median and the 0.75 quantile

of the distribution are also statistically significant in contrast to the estimates in manufacture. The coefficient on ecommerce at the 0.25 quantile in services is 0.032, suggesting that ecommerce increases sales-per-worker by 3.3% for those with lower sales-per-worker group. At the median, ecommerce brings an increase by 3.9% for those with top 50 percent proportion in the group. In addition, the effect of ecommerce on the median is slightly stronger than on the mean. At the 0.75 quantile, sales-per-worker at ecommerce is positive and significant, 2.5% higher than their counterparts. It seems that there is no large difference among coefficients on ecommerce variable at the three quantiles in services. Actually, we can test for the equality of the estimated coefficients of ecommerce across various quantiles, in our cases, 0.25, 0.50, and 0.75. To test, I use the bootstrap procedure allowing us to devise F-statistics. The F-test for ecommerce cannot reject the null hypothesis of homogeneous coefficient. It becomes much clearer when we draw a quantile plot for estimates of ecommerce variable.

Figure 1 provides quantile plot with visual presentations of the OLS and the quantile regression estimates of ecommerce variable for both manufacture and services. In both figures in Figure 1, the horizontal axis indicates the quantile and the vertical axis is the value of coefficients on ecommerce variable. The red dashed line represents the coefficients in the OLS model along with the associated 95% confidence interval, and the blue solid line represents the coefficient in the quantile regression. The slope of coefficients does not change for all quantiles in the OLS regression while the slope of coefficients are changing in sales-per-worker in the quantile regression.

Figure 1. Estimates on Sales-Per-Worker as Quantile Varies



Notes: The horizontal axis indicates the quantile and the vertical axis is the value of coefficients on ecommerce variable. The red dashed line represents the coefficients in the OLS model along with the corresponding 95% confidence interval and the blue solid line represents the coefficient in the quantile regression.

The upper figure in Figure 1 shows that in manufacture the ecommerce status enters with a positive coefficient in all parts of the sales-per-worker distribution. Roughly speaking, the coefficient on ecommerce decreases in magnitude as we move along the sales-per-worker distribution while the quantile estimates for ecommerce move mostly within the 95% confidence interval of the OLS estimates. Further, these coefficients are homogeneous despite the movements of the ecommerce coefficients (recall that the null hypothesis is not rejected based on the F-test).[11]

The lower figure in Figure 1 shows that the slope of coefficients on ecommerce is moving as quantile of the sales-per-worker distribution increases in services. Unlike the patterns in manufacture, the ecommerce enters with a positive coefficient up to around 0.85 quantile and with a negative coefficient above 0.85 quantile of the distribution in services. The coefficient on ecommerce moves around the coefficient level at the mean and continues up to the 0.85 quantile of the sales-per-worker distribution. Above the 0.85 quantile, the coefficient on ecommerce decreases with a negative sign, implying that sales-per-worker at ecommerce establishment is lower than that at their counterparts. However, the coefficients at the very upper quantile are not significant at all. For example, at the 0.9 quantile, the coefficient on ecommerce is -0.011 but the corresponding standard error is 0.013. Despite this insignificance, these results might suggest that we need to investigate later price competition effect among ecommerce establishments with high sales-per-worker in

[11]The coefficients on age and size variable in the OLS stay the same across various quantiles as expected. The coefficients on age and size at various quantile are different from the OLS estimates. As we move up to the upper distribution of sales-per-worker, age and size effect of establishment are becoming small in the corresponding quantile plot. For the equality test of the estimated coefficients of age and size, the F-tests for both variables reject the null hypothesis of homogeneous coefficients.

services.

4.1.2 With interaction with size of establishment

A caveat in interpreting the estimates of Table 6 is we cannot say that ecommerce activity increases sales-per-worker of small-and-medium sized establishments particularly in manufacture. This is mainly because establishments with lower sales-per-worker are not necessarily small-and-medium sized ones. To see the effect of ecommerce according to the size of establishments, we need to interact ecommerce variable with the size of establishments.[12]

Table 7 shows the sales-per-worker difference between ecommerce and non-ecommerce establishments after interacting ecommerce variable with the size of establishments. The main regression that I use is (3) and quantile regressions (5) with ecommerce variable interacting with the size of establishments. From the second to fifth column at the upper part of Table 7, it is known that sales-per-worker effects of ecommerce are still positive and significant at the mean and at the lower quantiles of the distribution regardless of the size of establishments in manufacture. The coefficients on the interaction term are negative but not significant. This implies that there is no qualitative difference between no interaction and with interaction models in manufacture. In terms of the effect of ecommerce according to the size of establishments, the result in manufacture reminds us of the empirical paper by Konings and Roodhooft (2002), who studied the effect of ecommerce on firm performance in manufacture. One of their findings is that ecommerce has no

[12]This paper reports no result about the relationship between dependant variable and ecommerce activity according to the age of establishments because coefficients on interaction term are not statistically significant.

Table 7. Sales-Per-Worker Effect of Ecommerce (with interaction)

Manufacture				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	**0.083**	**0.143**	0.037	0.037
	(0.041)**	(0.052)***	(0.045)	(0.049)
lnemp	0.216	0.273	0.218	0.173
	(0.012)***	(0.015)***	(0.006)***	(0.014)***
EC×lnemp	-0.011	-0.032	-0.004	-0.003
	(0.008)	(0.009)	(0.008)	(0.009)
Controls	Yes	Yes	Yes	Yes
Obs.	13,515	13,515	13,515	13,515
Services				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	**0.034**	**0.042**	**0.048**	**0.062**
	(0.018)*	(0.021)**	(0.018)***	(0.019)***
lnemp	0.082	0.117	0.086	0.059
	(0.006)***	(0.007)***	(0.006)***	(0.007)***
EC×lnemp	-0.000	-0.004	-0.004	**-0.015**
	(0.008)	(0.009)	(0.008)	(0.008)*
Controls	Yes	Yes	Yes	Yes
Obs.	69,738	69,738	69,738	69,738

Notes: Author's calculations. Dependent variables are in logarithm of sales-per-worker. EC stands for ecommerce status. Parenthesis represents standard error. ∗ ∗ ∗, ∗∗, ∗ stand for significant at the 0.01, 0.05, and 0.1 percent level, respectively. Controls include the age of establishments and industry vector at the 5-digit KSIC.
Sources: Based on a matched sample from the 2010 Korea Census.

effect on productivity in small firms while it has positive effects on performance of large firms in manufacture. Unlike the paper by Konings and Roodhooft (2002), this study finds that productivity effect of ecommerce activity is valid for low sales-per-worker group regardless of establishment size in manufacture.

The second to fifth column at the lower part of Table 7 shows sales-per-worker difference between ecommerce and non-ecommerce establishments after interacting ecommerce variable with the size of establishments in services. Again, the main regression that I use is (3) and quantile regressions (5) with ecommerce interacting with the corresponding size variables. Under the models having ecommerce interacting with size, sales-per-worker at ecommerce establishments is still

higher on average than their non-ecommerce counterparts, but is statistically significant at the 10 percent level. At all quantiles (0.25, 0.50, 0.75) of the distribution, the coefficients on ecommerce variable are positive and significant, suggesting that ecommerce activity increases sales-per-worker in services. It is interesting to find that the coefficient on the interaction term is statistically significant only at the 0.75 quantile of the sales-per-worker distribution. It turns out to be negative (-0.015), implying that the smaller the size of establishments is, the greater the effect of ecommerce on the 0.75 quantile of the sales-per-worker is. This finding can be considered as one of the advantages in using quantile regression since the OLS is unable to capture the result in its estimation.

4.2 Wage and Ecommerce Activity

This subsection briefly investigates wage differences between ecommerce and non-ecommerce establishments in both manufacture and services. The reason for analyzing the effect of ecommerce on wage is because it is entirely possible that ecommerce activity and sales-per-worker are statistically positively related but ecommerce activity and wage are not related at the mean or a certain quantile of the wage distribution. As in sales-per-worker, wage differences between ecommerce and non-ecommerce establishments are estimated by OLS using (2) and quantile regression using (5). This paper also examines the effect of ecommerce according to the size of establishments by using OLS using (3) and quantile regression (5) with interactions in both manufacture and services. I do not report the results in the paper since the coefficients on the interaction terms are not significant at all.

Table 8. Wage and Ecommerce Activity

Manufacture				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	**0.028**	0.007	0.011	**0.023**
	(0.010)***	(0.014)	(0.010)	(0.010)**
Controls	Yes	Yes	Yes	Yes
Obs.	13,442	13,442	13,442	13,442
Services				
	OLS	$q(0.25)$	Median	$q(0.75)$
EC	0.003	0.016	0.008	-0.004
	(0.007)	(0.010)	(0.007)	(0.006)
Controls	Yes	Yes	Yes	Yes
Obs.	57,879	57,879	57,879	57,879

Notes: Author's calculations. Dependent variables are in logarithm of wage. EC stands for ecommerce status. Parenthesis represents standard error. $***$, $**$, $*$ stand for significant at the 0.01, 0.05, and 0.1 percent level, respectively. Controls indicates controlling age and size of establishments and industry at the 5-digit KSIC.
Sources: Based on a matched sample from the 2010 Korea Census.

Table 8 reports the results using logarithm of wage as the dependant variable in both manufacture and services. The coefficient on ecommerce by the OLS estimation is positive (0.028) and significant for wage in manufacture. Wage at ecommerce establishments in manufacture is 2.8% larger on average than at non-ecommerce establishments of a similar age and size in the same industry. In services, the coefficient on ecommerce by the OLS estimation is close to zero and insignificant.

Quantile regression estimates show different results depending on manufacture and services. In manufacture, all estimates by quantile regression in manufacture are positive, but are not statistically significant except at the 0.75 quantile of the wage distribution. The coefficient on ecommerce at the 0.75 quantile is 0.023, implying that ecommerce increases wage by 2.3% for those with top 25 percent proportion in the group. In services, all estimates from the OLS and quantile regression are not statistically significant. It is interesting that the coefficient on ecommerce at the 0.75 quantile of the wage distribution turns out to be negative although it is

not statistically significant. So, this is not very much surprising because sales-per-worker at ecommerce establishment is lower than that at their counterparts at the upper quantile.

In sum, ecommerce activity and sales-per-worker are on average statistically positively correlated in both manufacture and services based on the OLS regression estimates. However, the effect of ecommerce on sales-per-worker is positive and significant only at the lower quantile ($q = 0.25$) of the distribution in manufacture, whereas it is positive and significant at all quantiles (0.25, 0.50, 0.75) of the distribution in services. Particularly in services, the smaller the size of establishments are, the greater the effect of ecommerce on the 0.75 quantile of the sales-per-worker is. This paper finds no evidence that there is a wage difference between ecommerce and non-ecommerce establishments in services.

5. Conclusion

Many policymakers, researchers, and economists continuously emphasize the opportunity and possible gains by participating in ecommerce market. Many studies have pointed out that ecommerce activity enables firms to approach new markets and new consumers and engage in selling their goods or services with a relatively low transaction cost, leading firms to enhance their performances in both manufacture and services industries. Regarding sales-per-worker, this paper provided evidence based on the 2010 Korea Census that sales-per-worker at ecommerce establishments is higher on average than their counterparts. The paper further showed

that the effect of ecommerce on sales-per-worker is positive and significant only at the lower quantile of the distribution in manufacture whereas it is positive and significant at various quantiles of the distribution in services. However, the paper found no evidence that there is a wage difference between ecommerce and non-ecommerce establishments in services. In addition to the empirical results, the paper also characterized how ecommerce establishments differ from non-ecommerce establishment by total sales, employment, sales-per-worker and wage. The descriptic analysis of the paper would be useful since to date few facts are available to identify performance differences between ecommerce and non-ecommerce establishments.

I close the paper by addressing several limitations that remain in the paper. Although it constructed a matched dataset by implementing propensity score matching due to endogeneity concerns of ecommerce variable, it is still difficult to explain why ecommerce establishments perform better on average than their non-ecommerce counterparts in terms of sales-per-worker in particular. Moreover, it is difficult to understand exactly how ecommerce establishments' performance evolve over time (e.g., birth, growth, and death). Although the cross-sectional differences this paper reports are significant economically, we still cannot conclude whether ecommerce establishments may perform well because well-performing establishments become ecommerce establishments, or because ecommerce activity is good for establishments, or both. Further investigation in this direction was impossible due to the lack of data.

References

Bernard, Andrew and Jensen Bradford. 1994. "Exporters, Jobs, and Wages in U.S. Manufacturing: 1976-1987." *Brookings Paper, Microeconomics*, pp. 67-119.

Bertschek, Irene, Helmut Fryges, and Ulrich Kaiser. 2006. "B2B or Not to Be: Does B2B E-commerce Increase Labor Productivity?" *International Journal of the Economics of Business*, Vol. 13, pp. 387-405.

Choi, Changkyu. 2010. "The Effect of the Internet on Service Trade." *Economics Letters*, Vol. 109, pp. 102-104.

OECD. 2004. "E-Commerce and Firm Performance: An Assessment Using Mutiple Survey Sources and Linked Data." Report to the European Commission.

Einav, Liran, Jonathan Levin, Igor Popov, and Neel Sundaresan. 2014. "Growth, Adoption, and Use of Mobile E-Commerce." *American Economic Review*, Vol. 104, pp. 489-494.

Falk, Martin and Eva Hagsten. 2015. "E-commerce Trends and Impacts Across Europe." United Nations Conference on Trade and Development, Discussion Papers No. 220.

Farooqui, Shikeb. 2005. "Information and Communication Technology Use and Productivity." *Economic Trends*, 625, pp. 65-73.

Freund, Caroline and Diana Weinhold. 2002. "The Internet and International Trade in Services." *American Economic Review*, Vol. 92, pp. 236-240.

Freund, Caroline and Diana Weinhold. 2004. "The Effect of the Internet on International Trade." *Journal of International Economics*, Vol. 62, pp. 171-189.

Goldmanis, Maris, Ali Hortaçsu, Chad Syverson and Önsel Emre. 2010. "E-Commerce and the Market Structure of Retail Industries." *Economic Journal*, Vol. 120, pp. 51-681.

Koenker, Roger and Kevien F. Hallock. 2001. "Quantile Regression." *Journal of Economic Perspectives*, Vol. 15, pp. 143-156.

Konings, Jozef and Filip Roodhooft. 2002. "The Effect of E-business on Corporate

Performance: Firm Level Evidence for Belgium." *De Economist*, Vol. 150, pp. 569-581.

Osnago, Alberto and Shawn W. Tan. 2016. "Disaggregating the Impact of the Internet on International Trade." Policy Research Working Paper 7785. World Bank Group.

Quiros Romero, Cipriano and Diego Rodriguez Rodriguez. 2010. "E-Commerce and Efficiency at the Firm Level." *International Journal of Production Economics*, Vol. 126, pp. 299-305.

Slum, Bernado S. and Avi Goldfarb. 2006. "Does the Internet Defy the Law of Gravity?" *Journal of International Economics*, Vol. 70, pp. 384-405.

Smith, Jeffrey and Petra Todd. 2005. "Does Matching Overcome LaLonde's Critique of Nonexperimental Estimator?" *Journal of Econometrics*, Vol. 125, pp. 305-353.

Terzi, Nuray. 2011. "The Impact of E-commerce on International Trade and Employment." *Procedia-Social and Behavioral Sciences*, Vol. 24, pp. 745-753.

United Nations Conference on Trade and Development. 2015. "Unlocking the Potential of E-commerce for Developing Countries?" *Information Economy Report*, pp. 1-114.

United States International Trade Commission. 2013. "Digital Trade in the US and Global Economies. Part I." USITC Publication 4415.

Willis, Jonathan L. 2004. "What Impact Will E-commerce Have on the U.S. Economy?" *Economic Reviews, Federal Reserve Bank of Kansa City*, Second Quarter.

Xing, Zhongwei. 2017. "The Impacts of Information and Communications Technology (ICT) and E-commerce on Bilateral Trade Flows." *International Economics and Economics Policy*, pp. 1-22.

Appendix

Table A1. Industry Characteristics at 1-digit KSIC

Industry (1-digit KSIC)	Value of Total Sales	Percent Dist. of Total Sales	Value of Total Sales of EC	EC as Percent of Total Sales	Percent Dist. of EC Sales
Total	4,025,013	100.0	173,786	4.32	100.0
Agriculture, hunting and forestry	9,208	0.2	99	1.07	0.1
Mining and quarrying	2,970	0.1	129	4.33	0.1
Manufacture	1,397,254	34.7	75,609	5.41	43.5
Electricity, gas and water supply	120,557	3.0	4,324	3.59	2.5
Recycling	14,474	0.4	342	2.36	0.2
Construction	271,064	6.7	22,252	8.21	12.8
Wholesale and retail trade	679,887	16.9	35,978	5.29	20.7
Transportation	147,571	3.7	5,068	3.43	2.9
Hotel and restaurants	77,683	1.9	788	1.01	0.5
Telecommunication	115,566	2.9	7,145	7.91	4.1
Financial intermediation	741,854	18.4	12,532	1.69	7.2
Real estate, renting	64,306	1.6	784	1.22	0.5
Professional, science, and technology	117,678	2.9	2,346	1.99	1.3
Business activities	36,394	0.9	1,092	3.00	0.6
Education	84,002	2.1	1,912	2.28	1.1
Health and social work	69,553	1.7	372	0.53	0.2
Art, sports and recreational services	34,229	0.9	641	1.87	0.4
Community social and personal services	40,765	1.0	376	0.92	0.2

Notes: Author's calculations at the 1-digit KSIC. EC stands for ecommerce status. Dist. means distribution. Est. stands for establishment, workplace consisting of one or more employees.
Sources: Data are from the 2010 Korea Census collected by Statistics Korea.

Table A2. Industry Characteristics: Manufacturing Industries at 2-digit KSIC

	All		EC				Non-EC
Industry	Number of Est.	Percent of Industrial Sales	Percent of Est.	Average Est. size	Percent of total EC sales	Industrial EC sales (percent)	Average Est. size
All	326,813	100.00	3.20	-	100.00	-	-
Food	53,099	4.44	3.91	13.6	2.16	1.77	4.6
Beverage	1,170	0.56	8.55	11.7	0.31	0.03	13.6
Tobacco	13	0.21	23.08	11.0	0.01	0.00	166.9
Textile	19,528	1.71	2.08	12.2	1.66	0.53	7.1
Apparel	22,470	1.50	1.81	20.8	2.10	0.58	6.0
Leather	4,302	0.40	3.02	13.1	1.39	0.10	7.4
Wood	6,003	0.41	2.42	7.7	1.91	0.15	5.5
Paper	5,442	1.55	5.05	17.1	2.52	0.72	12.0
Printing	16,284	0.44	3.68	7.2	4.27	0.35	4.1
Petrolium	286	8.01	4.55	136.9	1.85	2.73	35.7
Chemicals	7,300	8.67	6.55	20.5	5.36	8.59	17.1
Medicals	847	0.98	6.61	41.9	1.72	0.31	35.5
Rubber	16,863	4.03	3.16	16.9	2.01	1.49	13.6
Non-Metal	9,276	2.56	4.36	15.4	5.88	2.78	10.9
Primary metals	6,451	10.24	2.70	78.3	14.11	26.69	20.7
Fabricated metals	54,592	5.28	1.73	15.5	3.09	3.01	6.9
Electronic equip.	9,623	18.33	4.46	113.2	12.09	40.95	39.0
Medical equip.	7,845	1.20	4.69	16.2	1.69	0.37	10.9
Electricity equip.	16,481	4.71	3.87	16.0	2.22	1.93	11.7
Misc. manu.	32,795	7.19	2.74	16.5	1.74	2.31	11.1
Mobile manu.	7,022	10.58	2.55	63.6	1.70	3.33	40.2
Misc transportation	2,580	5.84	2.48	27.5	0.32	0.35	59.8
Furniture	10,293	0.78	4.31	9.5	4.55	0.65	5.8
Misc.	16,248	0.39	4.26	6.5	3.63	0.26	3.5

Notes: Author's calculations at the 2-digit KSIC. EC stands for ecommerce status. Number of Est. are the number of establishments in all industries. Percent of industrial sales is industrial sales divided by sales by all industries. Percent of Est. is number of ecommerce establishments as a percent. Average Est. size is mean size of employments in each industry. Percent of total ecommerce sales is ecommerce sales in an industry divided by total sales of the industry. Industrial ecommerce sales (percent) is ecommerce sales within industry divided by ecommerce sales from all manufacturing industries.
Sources: Data are from the 2010 Korea Census.

Table A3. Industry Characteristics: Services at 2-digit KSIC

	All		EC					Non-EC
Industry	Number of Est.	Percent of Industrial Sales	Percent of Est.	Average Est. size	Percent of total e-sales	Industrial EC sales (percent)	w/o constr.	Average Est. size
All	3,005,730	100.00	2.04	-	100.00	-	-	-
Construction of buildings	18,942	7.14	8.48	35.4	9.05	17.18	-	20.1
Specialized construction	77,891	3.78	4.98	25.6	6.63	6.67	-	9.1
Sale of motor vehicles and parts	23,865	2.11	5.25	5.9	4.75	2.66	3.49	4.5
Wholesale trade	236,289	17.50	5.14	7.8	4.01	18.66	24.50	4.0
Resale trade, except motor vehicles	616,500	7.81	2.92	6.6	8.31	17.25	22.65	2.3
Land transport	322,527	1.92	0.20	28.7	1.76	0.90	1.18	2.2
Water transport	1,172	1.61	4.52	18.3	0.42	0.18	0.24	19.6
Air transport	139	0.71	18.71	816.7	14.20	2.69	3.53	36.7
Warehousing and support	23,341	1.70	2.10	13.3	3.67	1.66	2.18	9.2
Accomodation	48,203	0.41	4.53	9.0	4.59	0.50	0.65	3.0
Food and beverage service	586,297	2.72	0.32	7.9	0.48	0.35	0.46	2.7
Publishing	11,409	1.25	13.06	25.3	10.29	3.42	4.49	16.2
Sound recording and music publishing	3,532	0.20	7.96	24.2	8.18	0.43	0.57	7.3
Broadcasting	748	0.35	5.35	34.4	1.18	0.11	0.14	37.2
Telecommunications	5,181	1.90	10.29	32.9	6.32	3.19	4.19	18.8
Computer programing	3,841	0.68	11.59	13.7	3.07	0.55	0.73	19.4
Information service	1,664	0.29	25.84	30.4	27.32	2.11	2.76	17.6

Notes: Author's calculations at the 2-digit KSIC. EC stands for ecommerce status. Number of Est. are the number of establishments in all industries. Percent of industrial sales is industrial sales divided by sales by all industries. Percent of Est. is number of ecommerce establishments as a percent. Average Est. size is mean size of employments in each industry. Percent of total ecommerce sales is ecommerce sales in an industry divided by total sales of the industry. Industrial ecommerce sales (percent) is ecommerce sales within industry divided by ecommerce sales from all services industries.
Sources: Data are from the 2010 Korea Census.

Table A4. (Continued from Table A3) Industry Characteristics: Services at 2-digit KSIC

	All		EC					Non-EC
Industry	Number of Est.	Percent of Industrial Sales	Percent of Est.	Average Est. size	Percent of total EC sales	Industrial EC sales (percent)	w/o constr.	Average Est. size
Financial service	21,030	19.05	8.34	17.6	1.61	8.18	10.74	12.9
Insurance, pension	8,261	7.91	3.09	43.6	1.06	2.23	2.93	32.6
Activities auxillary to financial, insur.	10,062	2.95	5.43	21.0	3.86	3.03	3.98	15.1
Real estate activities	113,154	2.40	1.26	3.5	1.04	0.66	0.87	3.5
Leased proporty	12,927	0.20	4.59	4.8	3.45	0.18	0.24	3.4
Scientific research and development	4,082	1.38	3.26	29.8	1.00	0.37	0.48	33.4
Management consultant	32,665	2.17	3.04	29.7	2.24	1.30	1.70	9.3
Architectural, engineering	17,725	1.02	4.39	17.3	2.48	0.67	0.88	13.3
Other professional	16,129	0.18	3.82	5.5	3.87	0.19	0.24	3.1
Services to buildings and landscape	5,605	0.28	2.87	55.9	1.79	0.13	0.18	30.0
Office admin. support	30,305	1.18	6.65	14.7	3.29	1.04	1.36	20.7
Education	165,964	3.39	1.48	23.6	2.28	2.05	2.69	8.3
Human health	61,226	2.32	1.89	9.3	0.51	0.31	0.41	11.2
Residental care	45,786	0.48	1.30	11.5	0.66	0.08	0.11	8.7
Creative, arts and enterainment	9,700	0.16	2.72	20.3	4.63	0.20	0.26	5.9
Sports, amusement, and recreation	93,248	1.22	0.57	18.5	1.51	0.49	0.64	2.7
Activities of membership org.	89,977	0.51	0.25	8.0	0.46	0.06	0.08	2.4
Repair	95,857	0.71	0.94	5.6	1.42	0.27	0.35	2.5
Other personal service	190,459	0.42	0.27	6.8	0.64	0.07	0.09	2.0

Notes: Author's calculations at the 2-digit KSIC. EC stands for ecommerce status. Number of Est. are the number of establishments in all industries. Percent of industrial sales is industrial sales divided by sales by all industries. Percent of Est. is number of ecommerce establishments as a percent. Average Est. size is mean size of employments in each industry. Percent of total ecommerce sales is ecommerce sales in an industry divided by total sales of the industry. Industrial ecommerce sales (percent) is ecommerce sales within industry divided by ecommerce sales from all services industries.
Sources: Data are from the 2010 Korea Census.

Table A5. (Manufacture) Descriptive Statistics of Variables in the Matched Dataset

	Variable	Obs	Mean	Sd	Min	Max
EC	lnsales_per_worker	7,132	4.81	1.09	-1.39	9.33
	Ecommerce	7,132	1	0	1	1
	lnemp	7,132	2.38	1.05	0	9.81
	Age	7,132	10.47	8.29	1	83
NEC	lnsales_per_worker	6,383	4.78	1.09	-1.67	9.67
	Ecommerce	6,383	0	0	0	0
	lnemp	6,383	2.45	1.08	0	9.42
	Age	6,383	9.98	7.87	1	61
	Variable	Obs	Mean	Sd	Min	Max
EC	lnwage	7,087	2.84	0.65	-1.39	4.70
	Ecommerce	7,087	1	0	1	1
	lnemp	7,087	2.39	1.05	0	9.81
	Age	7,087	10.49	8.29	1	83
NEC	lnwage	6,335	2.85	0.68	-2.08	4.99
	Ecommerce	6,335	0	0	0	0
	lnemp	6,335	2.47	1.07	0	9.41
	Age	6,335	10.00	7.86	1	61

Sources: Author's calculations using the matched dataset from the 2010 Korea Census.

Table A6. (Services) Descriptive Statistics of Variables in the Matched Dataset

	Variable	Obs	Mean	Sd	Min	Max
EC	lnsales_per_worker	44,154	4.43	1.55	-3.18	10.94
	Ecommerce	44,154	1	0	1	1
	lnemp	44,154	1.82	1.18	0	9.46
	Age	44,154	9.48	11.25	1	121
NEC	lnsales_per_worker	25,584	4.53	1.51	-4.14	10.40
	Ecommerce	25,584	0	0	0	0
	lnemp	25,584	2.11	1.22	0	9.00
	Age	25,584	10.88	11.57	1	116
	Variable	Obs	Mean	Sd	Min	Max
EC	lnwage	35,052	2.81	0.90	-4.55	6.51
	Ecommerce	35,052	1	0	1	1
	lnemp	35,052	2.12	1.12	0	9.46
	Age	35,052	10.40	12.09	1	121
NEC	lnwage	22,827	2.82	0.95	-4.46	8.11
	Ecommerce	22,827	0	0	0	0
	lnemp	22,827	2.30	1.17	0	9.00
	Age	22,827	11.13	11.99	1	149

Sources: Author's calculations using the matched dataset from the 2010 Korea Census.

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국문요약

2013년 세계 B2B 전자상거래 규모가 15 조 달러를 돌파하였고, 세계 B2C 전자상거래 규모도 1.2 조 달러를 돌파하였다(UNCTAD 2015). 한국의 B2B 시장규모도 증가추세이며, 한국의 B2C 시장규모 역시 연간 20%씩 성장하고 있음을 쉽게 알 수 있다(통계청). 한국의 전자상거래 시장은 아시아에서 세 번째로 크며, 이러한 사실은 한국의 인터넷과 정보통신기술이 세계적인 수준임을 감안할 때 그리 놀라운 것은 아니다. 하지만 놀라운 점은 한국의 전자상거래 시장이 외연적으로 성장하고 있다는 사실 외에 한국의 전자상거래 기업에 대해 알고 있는 바가 많이 없다는 것이다. 한국의 경제 내 전자상거래 기업의 수, 비중, 분포에 대한 정보가 전무하고, 전자상거래 기업과 비전자상거래 기업 간 식별할 수 있는 특징에 대해서도 연구된 바 없다.

본 연구는 전자상거래 기업과 비전자상거래 기업 간 식별할 수 있는 특징에 대해 분석하며 2010년 경제총조사 자료를 바탕으로 실증하였다. 한국경제 전체에서 전자상거래를 활용하는 기업수의 비중은 작으나 전자상거래 기업의 매출액, 고용자 수, 임금의 비중은 상대적으로 큰 편으로 나타났다. 본고에서는 기업의 관찰되지 않는 고유한 특성과 전자상거래 활용여부 사이에 존재하는 상관관계로 인해 추정치의 편의가 발생할 수 있는 점을 감안하여 이러한 내생성을 완화하기 위해 성향점수매칭을 통해 2010 년 경제총조사 자료를 재구축하였다.

재구축된 자료를 바탕으로 선형회귀분석을 통해 제조업에 속한 전자상거래 기업은 같은 산업 내 유사한 규모와 나이를 지닌 비전자상거래 기업보다 평균적으로 더 높은 일인당 매출액을 기록하고 평균적으로 더 높은 임금을 지불하지만, 서비스업에 속한 전자상거래 기업은 비전자상거래 기업에 비해 평균적으로 더 높은 일인당 매출액을 기록하더라도 임금 측면에서는 두 기업 간 큰 차이가 없음을 추정하였다. 추가적으로 분위회귀분석을 통해 제조업에 속한 전자상거래 기업의 높은 일인당 매출액은 낮은 분위에서만 유의미하며, 반대로 서비스업에 속한 전자상거래 기업의 높은 일인당 매출액은 분석 대상 전 분위에서 모두 유의미하다는 결과를 추정하였다.

핵심용어: 전자상거래, 기업활동, 일인당 매출액, 임금

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저서 및 논문

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LEE Kyu Yub

The global ecommerce market is expanding rapidly and dramatically. However we know little about the distribution or performance of ecommerce firms relative to traditional firms in the economy. This paper empirically investigates performance differences between these two types of firms using Korean data.

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