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ABSTRACT

This paper investigates impact of e-economic activities on female employment rates in Turkey over 1994–2016. The analysis unveils three major findings. First, 80.74% of variations in female employment are accounted by e-commerce and control variables. Second, Autoregressive Distributed Lag analysis documents that these series (female employment, e-commerce and control variables) are cointegrated, thus, a unit increase in per credit card e-commerce transactions leads the female employment rate to grow by 0.13 units in long-run at 1% significance level, whereas a percentage increase in internet penetration rate in Turkey augments the rates by 0.33%. Third, error-correction model analysis refers that the system quickly corrects its previous period disequilibrium converging at a speed of 75.43%, and also documents that the lags of per credit card e-commerce jointly have short-run impact on female employment rates. Thus, the study concludes that developing e-commerce incentivizing policies might help to empower women in Turkey significantly.

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1. Introduction

Internet technology has incredibly boosted up, after it started to be used as commercially oriented, changing consumption and shopping habits of individuals which, in turn, heated up not only domestic competition, but also global one as many economies became internationalized with the digital revolution.[1] It has spread to such an extent that the global economy today is a digital economy, refuting an initial bias towards success of e-commerce initiatives such as Alibaba, Amazon, Ebay, BestBuy, and Gumtree that today became economically giant firms who manage huge resources. It has changed the structure

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[1] http://www.internetlivestats.com/:

Worldwide Internet activities in 1 second: 1,948 Skype calls; 10,860 tweets; 51,750 google searches; 112,345 youtube video plays; 3,081 Instagram photo uploads; 800 Apple store and 964 Android store app downloads; 312,500 whatsapp messages; 2,446,928 emails (it was just 113,000 emails in 2000); 3 new websites (there was only 1 website in 1991, but today it is about 1 trillion websites); 5 computer and 40 smart phone sales; USD 2,361 Amazon sales; and 31,368 GB of internet traffic.

of economics by reducing transaction, distribution, and marginal production costs, and enhancing accessibility and time efficiency. However, one of the most important impacts of digitalization is influence on the labor markets, both through the creation of new jobs and making labor markets more inclusive, innovative, flexible, and transparent (Nikulin, 2017).

Therefore, the interaction between digitalization and employment is worth to study, as reflected in several researches (El Gawady, 2005; Khosrow-Pour, 2006; MacGregor & Vrazalic, 2007; Maier & Nair-Reichert, 2007; Manyika et al., 2014; Nikulin, 2017; Parnami & Bisawa, 2015; Raja et al., 2013; Vera, 2006). It is widely argued that digitalization enables the inclusion of low-skilled and traditionally marginalized groups, such as women, people with disabilities, and workers at the base of the pyramid into the labor market. Especially in Muslim countries, any endeavors to scale the female labor participation up are frozen due to social and cultural barriers against female interaction with men. The segregation of the sexes in public or social locales as another fence against acceptance of female within working environment, particularly in management positions. Until recent times, the only possibility of enhancing female participation was related with logistical issues such as creating female only working places, special entrances and other separation regulation which make it hard. However, with digitalization an alternative way is emerged. The barriers can be broken down through e-commerce which enables females to work from home in jobs such as customer services over the internet or even start-up self-employed online businesses. A relevant and practical example of such a policy was pursued by British government who successfully increased self-employment of men and women respectively by 4.73% and 19.06% in 2000 after encouraging e-commerce investments.

In this research, we contribute to the relevant literature by examining impacts of digitalization onto female employment over 1994–2016 using the largest data set available for Turkey. Our study distinguishes by being the first study (to our knowledge) in the Turkish literature that examines influences of digitalization of economy on female labor market. We use number of online commerce activities per credit cards and volume of credits attributable to the e-commerce activities per credit cards for a proxy of digitalization, and we get female employment rate by using a ratio of number of female employees in the country to the total female population at working age. As preliminary Augmented Dickey–Fuller (ADF) unit test signals that the series are not integrated at same order – but mixture of $I(0)$ and $I(1)$ – we examine a potential long-run cointegration between them under Autoregressive Distributed Lag (ARDL) cointegration framework (Bound testing) which was introduced by Pesaran, Shin, and Smith (2001).

Our results confirm a significant cointegration between digitalization and female employment in Turkey. More specifically, we detect short-run influences between series as well. By employing error-correction model analysis, we find that the cointegrated series quickly converge to a long-run equilibrium at a speed of 75.43% quarterly. Our results are robust against different control variables and proxies used for e-commerce. The remainder of the paper is as follows. The second section addresses the literature and the role of e-commerce in the labor market and in particular in the process of women's empowerment. The third section is devoted to the description of the data and the methodology. The fourth section covers analysis and reports its findings.

2. E-commerce Literature

Although job creation feature of digitalization is widely accepted, without focused digital-consistent policies that embrace all digital nature of global flows, its impact is very limited. Just after dot-com crisis, enormous economies such as OECD, European Community (hereinafter EC), and US clustered to organize digital flows and develop digital-consistent policies to seize all its opportunities efficiently. In March 2000, EC held an annual summit at Lisbon (Portugal) to discuss and plan how to promote European economic well-being by increasing employment through new job creations of digitalization. They had projected to create 15 million new jobs through e-commerce policies, and thus to increase both male (61%) and female (51%) employment rates to 70% and 60% respectively.[2] According to Muylle and Vijverman (2013), today this aim is excessively accomplished as EC was able to create 3.4 million (1.5 million direct and 3.4 millions indirect) new jobs annually and pull up employment rates to the targeted level.

McKinsey Global Institute published a report where Manyika et al. (2014) examine dynamics of global flows and their impact on GDP growth by covering 195 countries over 1980–2012. They discover two chief driving forces behind acceleration of growth and global flow hike after 2000: (1) an increasing global welfare, and (2) growing diffusion of internet connectivity and digital technologies. Their correlation analysis reveals a significant positive relationship between all types of flows and GDP growth, and they forecast that global flows contribute to global GDP growth annually by $250–450 billion which is equivalent to 15–25% of total global growth. They also state that flows of goods, services, and finance exceeded $26 trillion by 2012 which is 36% of total global GDP, and estimate that it could triple by 2025 continuing to contribute to the economic growth if rising digitalization persists. They highlight that impact of digitalization on economy occurs chiefly through two main macroeconomic dynamics: (1) Price inflation and (2) Employment. First, the reduction in transaction, distribution, and marginal production costs, in turn, contributes in reducing price growth, thus it provides efficient control over inflation (Henry & Dalton, 2000). For instance, in his study El Gawady (2005) finds that e-commerce policies applied by US and UK lead to a reduction in price inflation by 0.5 basis points from 2.3% to 1.8%. Second, Manyika et al. (2014) underlines that the knowledge-intensive portion of global flows progressively dominates (grows faster than) capital- and labor-intensive flows creating digital platforms which enable new players and agents to participate into sectors.

In the eve of digitization era (1980s), governments and multinational firms were the only actors involved in cross-border exchanges, however, today digital technologies enable even the smallest firms or entrepreneurs to be a 'micro multinational' that sell and source products, services, and ideas across borders. In turn, it generates a significant impact on employment, especially self-employment. Although the digitalization might cause a job lose to some extent, it creates many new jobs. For instance, Vera (2006) studies impact of e-commerce on overall employment level through 11 different industries in Philippines, and finds that e-commerce destroys 1202 jobs while it creates 21,298 jobs in economy in the period 2000–2005. Briefly it replaces 17 jobs for every job lost. The author also gives emphasis to the other economic benefits of online stores which is accessible globally and

[2] See Lisbon European Council 23–24 March 2000 Report at http://www.europarl.europa.eu/summits/lis1_en.htm.

Table 1. E-commerce share in globe.

Country	E-commerce/total retail (%)	Internet penetration (%)	Online shopping (%)	Income per capita (USD)	Population (mln)
UK	10.4	87	85	37,000	64
US	7.4	81	72	53,000	316
Germany	6.0	84	79	40,000	81
China	5.6	42	44	10,000	1361
France	5.5	83	75	36,000	64
Poland	5.3	65	30	21,000	39
Japan	4.2	79	77	37,000	127
Brazil	3.1	49	34	12,000	198
Spain	3.1	72	55	30,000	47
Russia	2.8	53	38	18,000	143
Italy	1.8	58	44	30,000	60
Turkey	1.3	49	24	15,000	76
India	0.7	12	23	4000	1243

Source: TUBISAD (2016).

open for 7/24, as well as offers cheap prices due to minimized expenses unlike physical store which has to pay rent for venue and bills.

It is widely accepted that digitalization and e-commerce activities born in US and spread out to other countries starting with EU. Still it has not been highly mobilized yet in Turkey. The Informatics Industry Association (TUBISAD) reports that the volume of e-commerce market of Turkey in 2016 is about 8.5 billion USD (14 billion Turkish Lira) which represents just 1.3% of the country's total retail consumptions (see Table 1). This ratio is remarkably low comparing to advanced economies, and the report addresses it to the fact that one third of Turkish population has never used internet yet, and only 1 out of 10 users has involved, at least once, in e-commerce activities, even though Turkey is ranked ninth in online market attractiveness. In sum, the report highlights that the country has a significant potential which still remains dormant awaiting a spark to stir up, and it could be utilized to vivify the whole economy, especially, through labor markets.

Comparing growth of American and Turkish e-commerce activities in industrial base will show the distinction more clearly. Table 2 displays 2015 e-commerce sales activity in US and Turkey. Notice that almost all product categories experienced two digit year-to-year growth in US, while Turkish sales growth moderately. Also, in US all low ranked categories grew over 20% annually, whereas they grew only 1–4% in Turkey. Indeed, it signifies that these low ranked categories promise aggressive growth in Turkey in coming few years, and notice that these categories (Toy and Hobbies; Flowers, Greetings and Misc. Gifts; Books and Magazines; Sport and Fitness; and Jewelry and Watches) are more likely to be female-attributable than male-attributable in terms of employment.

Ikidilim, Turkish e-commerce consulting company, published a comprehensive report of electronic commerce activities in Turkey in 2016. The report reveals dominance of female-attributable digital stores in Turkish e-market. Table 3 shows that 'Electronic Device' store has the highest penetration rate of e-commerce activities (32%), and it is followed by 'House Decoration' (20%), 'Mothers, Babies, and Toys' (19%), 'Cosmetics, Health, and Home Care' (18%), 'Kitchen & Home Appliances' (15%), and 'Jewelry' (10%) stores. More importantly, notice that majority of e-commerce branches employed females rather than males. The ratio of female employee in the branch is absolutely remarkable in House Decoration, Mothers and Babies, and Cosmetics-Health care industries. This dominance

Table 2. E-commerce in US and Turkey.

	US		Turkey	
Product category	Sales rank	Y/Y growth	Sales rank	Y/Y growth
Apparel and Accessories	1	Very strong	10	Moderate
Computer Hardware	2	Moderate	2	Strong
Consumer Packaged Goods	3	Moderate	6	Moderate
Digital Content and Subscriptions	4	Moderate	13	Strong
Consumer Electronics	5	Moderate	1	Strong
Event Tickets	6	Very strong	14	Strong
Office Supplies	7	Strong	7	Moderate
Furniture, Appliances and Equipment	8	Strong	8	Moderate
Books and Magazines	9	Strong	17	Weak
Home and Garden	10	Strong	12	Moderate
Computer Software	11	Strong	3	Strong
Sport and Fitness	12	Very strong	11	Weak
Jewelry and Watches	13	Very strong	9	Moderate
Flowers, Greetings and Misc. Gifts	14	Very strong	16	Weak
Toy and Hobbies	15	Very strong	15	Weak
Video Games, Consoles and Accessories	16	Very strong	4	Strong
Music, Movies and Videos	17	Very strong	5	Strong

Note: Growth rate → very strong: +20%, strong: 10–19%, moderate: 5–9%, weak: 1–4%.
Source: comScore (2015, p. 16) and Ikidilim (2016).

Table 3. Penetration of e-commerce in Turkey.

	Pen. (%)	Male (%)	Female (%)		Pen. (%)	Male (%)	Female (%)
Branch (Store)				**Departments**			
Electronic Device	32	58	42	Sales	85	25	75
House Decoration	20	12	88	Finance and Accounting	58	55	45
Mothers, Babies, Toys	19	4	96	Administrative Affairs	48	58	42
Cosmetics-Health Care	18	3	97	Logistics and Warehouse	44	55	45
Kitchen and Home Appliances	15	45	55	Marketing and Product Man.	42	30	70
Jewelry	10	40	60	Support and Customer Services	41	45	55
Sports and Outdoor	10	48	52	Human Resources	40	15	85
Fast Food	9	52	48	**Ready for Immediate Employment**			
Apparel and Shoes	9	36	64	1 Employee	81	18	82
Tourism	7	38	62	2–3 Employees	16	36	64
Book, Film, and Music	5	35	65	4–9 Employees	2	42	58
Pet Shop	3	47	53	+10 Employees	1	45	55
Average	**13**	**35**	**65**				

Source: Ikidilim (2016).

promises huge opportunities rising for women in e-commerce, especially, when we consider just averagely 13% penetration of e-commerce in selected branches in Turkey. The report of readiness of immediate employment also supports this statement. Notice that 81% of e-commerce adopted firms are ready to employ one additional employee immediately where 82% of these firms give priority to female employee and just 18% wants to employ males.

Khosrow-Pour (2006) also supports important role of e-commerce developments in female employment. He denotes that social and cultural barriers against female interaction with men freezes any endeavors to scale the female labor participation up, especially, in Muslim countries. He points out the segregation of the sexes in public or social locales as another fence against acceptance of female within working environment, particularly in management positions. He underlines that the only possibility of enhancing female

participation until recent times was related with logistical issues such as creating female only working places, special entrances and other separation regulation which make it hard. However, the author believes that these barriers can be broken down through e-commerce which enables females to work from home in jobs such as customer services over the internet. Equally, MacGregor and Vrazalic (2007) support Khosrow-Pour's assertions, and state that British government had successfully increased self-employment of men and women respectively by 4.73% and 19.06% in 2000 after encouraging e-commerce investments. Similarly, Maier and Nair-Reichert (2007) in his study complies and reports several of successful e-commerce applications that helped to increase female labor participation in India. He talks about 'Computer Facility', 'E-Seva', 'IT-School', and 'India Shop' programs where a group of non-working housewives are taught about utilization of internet technology and techniques of e-commerce through courses and seminars. At the end, the author states that all participants successfully employed either at existing e-commerce companies or they started their own business and became self-employed. Maier denotes that the Indian government launched and encouraged many of these kind programs, thus, eventually volume of Indian e-commerce increased from 3.8 billion USD in 2009 to 9.5 billion USD in 2012, subsequently to 12.6 billion USD in 2013 making 34% annual growth.

On the other hand, current labor share in national income is about 34% in Turkey which is the lowest ratio among any country in OECD, even lower than Mexico. The main cause of this fact is dramatically low level of the country's female labor participation rate which is about 30.8% far below than US (67.2%), EU average (63%), and OECD average (62.6%). Today, Turkey has the lowest female employment rate with 27.1% among OECD where the average is 57.2%.[3] More dramatically October 2016 report[4] of Turkish Statistical Institute (TurkStat) unrolls that this rate is even worse in non-agriculture industries. The report states that 90% of new unemployed in each quarter are formed by females, and 95.55% of this is formed by unemployed females in non-agriculture industries. Thus, overall female unemployment is 12% in the economy, but it scales up to 16.3% in urban areas and to 18% in non-agriculture industries due to a rural exodus that forces less educated women, who used to work in the fields, to stay at home once the family had moved to an urban area, and also due to a prevalent conservative image of gender roles in the labor market. Impact of these causes (chiefly rural exodus) is blatant during 1989–2005 (in Figure 1) where female employment rates drops from 32.70% to 20.7%. On the other hand, Berber and Yilmaz Eser (2008) argue that this longstanding decrease was also partially motivated by the prolongation of time spent in education of young population that cause their delay to participate to labor. They highlight that the tertiary education enrollment has increased comparing to the past years while time spent in education also scaled from 5 years up to 8 years. Subsequently, the female employment rate starts to rally after 2005, and Gursel, Uysal, and Acar (2014) addresses it to the developments in service industry. However, Information and Communication Technologies Authority (ICTA, 2016) emphatically denotes that internet penetration remarkable change the course of both social and economic life after 2005 in Turkey, giving emphasis to its positive correlation with female employment.

[3] See OECD 'Statistics of Female Employment' at http://www.oecd-ilibrary.org/employment/employment-rate-of-women_20752342-table5.

[4] See TurkStat 'Labor Statistics' at https://biruni.tuik.gov.tr/isgucuapp/isgucu.zul.

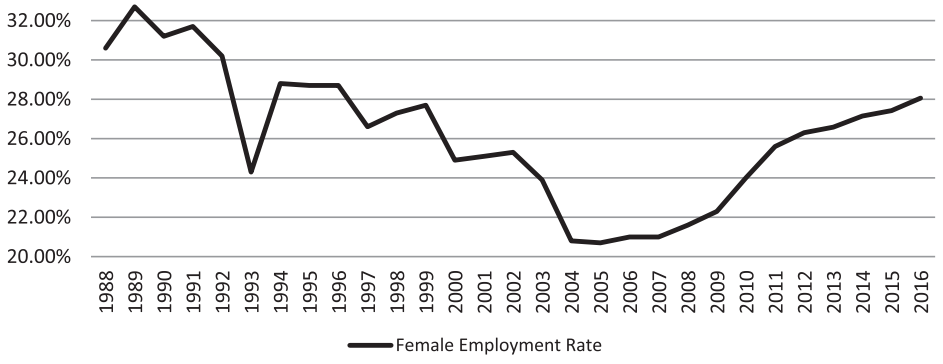

Figure 1. Female employment rate in Turkey. Source: TurkStat (2016).

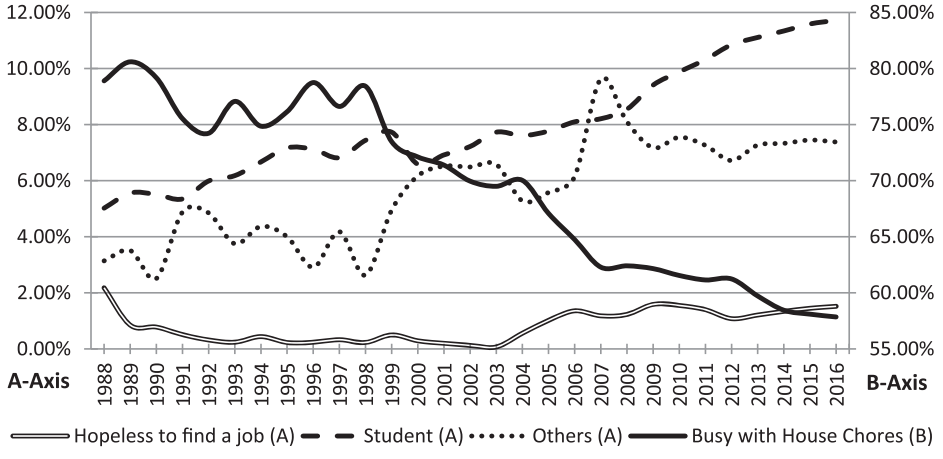

Figure 2. Reasons of non-participation of female to labor. Source: TurkStat (2016).

Notes: 'Hopeless to find a job', 'Student', and 'Others' variables follow the Axis 'A', while 'Busy with House Chores' follows the Axis 'B'. 'Others' variable excludes females who do not want to work and also who are not available to work or cannot work. It also excludes seasonal unemployed and retired females.

The reasons of non-participation of female into labor are essential. The 2016 report of TurkStat shows that fraction of non-participating females who have no hope to find any job gradually increased from 0.78% in 1990 to 1.59% in 2009, as in Figure 2. On contrary, fraction of non-participating females who are busy with housing chores has significantly decreased over time. Particularly, after 1998 with internetalization era, this fraction has experienced sharp declines, i.e. from 78.42% in 1998 to 57.85% in 2016. Moreover, a remarkable increase in fraction of non-participation of females due to their education enrollment can be addressed to assertion of Berber and Yilmaz Eser (2008), however, an increase in 'other' reasons remain unknown.

3. Data and Methodology

The literature about impact of Turkish e-commerce activities on female employment rates is scarce. Sizeable studies investigate the progress of e-commerce and its impact on growth,

however, its impact on female employment is often neglected. This paper aims to fill this room by examining impact of e-commerce activities on female employment rates through quarterly periods over 1994–2016. For analysis, we consider a simple times-series model as below.

$$\mathrm{FE}_t = \beta_0 + \sum_{i=1}^{3} \beta_{it} X_{it} + \sum_{i=4}^{5} \beta_{it} Z_{it} + e_t, \tag{1}$$

where FE_t is a female employment rate of Turkey at time t, and β_0 is an intercept. Due to unavailability of e-commerce data for years before 1994, this 't' is restricted with 1994–2016 periods. The 'X', in the model, represents online commerce activities which are proxied by three variables: number of e-commerce transactions per credit cards (EC), the volume of credit per cards (CC), and the country's internet penetration rate (IP). Data for EC and CC variables are derived from ICTA (2016) and ICC (2016) reports respectively. Likewise the internet penetration rate represents percentage of people with internet access in total population, and its data are gathered from online database of World Bank.

Besides 'Z' stands for two control variables, i.e. real output (GDP) and inflations rate (INF), in order to capture their empirically proven impact on employment rates (Okun, 1962; Phillips, 1958). Controlling these two macroeconomic factors will help us to derive clearer impact of digitalization on female employment rates. Many of other macroeconomic variables might also have relationship with FE, however, majority of them affect FE through GDP channel. Moreover, inclusion of other control variables also might raise potential collinearity problem in the model, which can emerge misleading standard errors and estimates.

The data for female employment rates and control variables are obtained from TurkStat (see footnote 4) and OECD (see footnote 3) databases respectively. We also check for potential collinearity between explanatory variables utilizing cross-variable correlation analysis (see Appendix 1) and confirm robustness of the model. Lastly, we briefly summarize our data at Table 4 providing descriptive statistics.

3.1. Model Specification

In initial step, we check whether the input variables satisfy a stationarity assumption of ordinary least squares (OLS) estimation technique by ADF test with regression equation

Table 4. Descriptive statistics of data.

	Mean	Median	Max.	Min.	Std. dev.	Skewness	Kurtosis	Jarque–Bera prob.	*N*
FE	25.09	26.05	30.00	18.6	2.99	−0.35	−1.25	0.0888	92
EC	34.39	38.13	48.85	6.23	10.58	−1.25	3.62	0.0000	92
CC	2.78	2.32	8.37	0.03	2.51	0.60	2.18	0.0244	92
IP	18.52	13.93	49.00	0.04	17.47	0.44	1.62	0.0089	92
GDP	195.29	161.82	706.20	0.88	179.14	0.84	2.90	0.0043	92
INF	36.06	10.85	100.55	4.30	33.12	0.57	1.64	0.0039	92

Notes: FE is ratio of female employees in the country to female working age population; GDP is quarterly inflation adjusted total output in billions Turkish Lira (TL); INF is a quarterly percentage change in consumer price levels; EC represents the number of online commerce activities per credit cards; CC shows the volume of credits that are attributable to the e-commerce activities per credit cards in thousands of TL; and IP shows percentage of internet penetration among total population in the country.

Table 5. Output of ADF analysis.

	Level			1st Difference		
Variables	ADF	Lag	DW	ADF	Lag	DW
FE	−1.0279	3	1.9218	−12.051***	2	1.9266
EC	−3.8201***	4	1.9678	–	–	–
CC	−0.3830	2	2.0857	−3.9014***	1	2.0827
IP	0.3337	1	1.8219	−3.0804**	0	1.8322
GDP	1.3865	8	2.0038	−3.4712**	7	1.9945
INF	−1.2306	5	2.0165	−3.5974***	4	2.0207

Notes: Numbers in the table are *t*-statistics generated by ADF unit root test with null hypothesis of H_0: the series has a unit root. The lag is automatically selected by SIC with maximum lags of 11. DW represents Durbin–Watson statistics. For abbreviations see Table 4.

as below.

$$\Delta X_t = \alpha_0 + \delta T + \rho X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-i} + v_t, \tag{2}$$

where ΔX_t is the first difference of a variable x; T is trend, and δ is its multiplier; k is a optimal lag length; ΔX_{t-1} is lag differences; and v_t is White Noise residual term. Here, ADF tests whether $\rho = 0$ holds or $\rho < 0$. In case of $\rho = 0$, the variable fails to satisfy the stationarity assumption.

Table 5 displays aftermath of ADF analysis where all series except EC appear non-stationary at level. But they turn out stationary after taking their first differences. Therefore, we conclude that EC is $I(0)$ variables, while others are $I(1)$. Indeed, in this circumstance neither OLS regression (at level) nor Engle and Granger (1987) and Johansen (1988) cointegration model are applicable. Still the interaction of e-commerce and female employment rate can be estimated by utilizing ARDL cointegration framework which is also known as Bound testing approach.

3.2. ARDL Approach

There are three straightforward cases in building a framework with our input series. First, a OLS model that requires all series to be $I(0)$ (stationary). Second, if series are integrated in same order, but not cointegrated, they can be still estimated with OLS by utilizing series in form of their first differences in case they are $I(1)$. Additionally if residuals signalize that input series are cointegrated, and then Engle and Granger (1987) or Johansen (1988) approaches can be pursued to assess long-run relationship, subsequently error-correction model can be built under OLS estimation to measure their short-run relationship. Third, in case some series in the model are $I(0)$ while some are $I(1)$ but none are $I(2)$ as in our case, then Bound testing methodology (ARDL), which was introduced by Pesaran et al. (2001), can be employed. Therefore, we recall our base model (1), and adjust it in accordance to the ARDL approach following Pesaran et al. (2001) as below.

$$\begin{aligned}\Delta \mathrm{FE}_t = \delta_0 + \sum_{i=1}^{p} \delta_i \Delta \mathrm{FE}_{t-i} + \sum_{j=1}^{3} \sum_{i=0}^{q,k,l} \theta_{ji} \Delta X_{jt-i} + \sum_{j=1}^{2} \sum_{i=0}^{m,n} \gamma_{ji} \Delta Z_{jt-i} + \varphi_1 \mathrm{FE}_{t-1} \\ + \sum_{j=1}^{3} \varphi_{2j} X_{jt-1} + \sum_{j=1}^{2} \varphi_{3j} Z_{jt-1} + \omega_t,\end{aligned} \tag{3}$$

where X stands for three e-commerce variables of EC, CC, and IP; and Z stands for two control variables of GDP and INF. The lag of dependent variable starts from 1 to its optimal lag length (p). However, the independent variables begin from lag zero and continue up to their optimal, i.e. q for EC, k for CC, l for IP, m for GDP, and n for INF, which are determined by Schwarz Information Criterion (SIC).

Eventually, the null hypotheses of $\varphi_1 = \varphi_{2j} = \varphi_{3j} = 0$ is tested with Wald analysis where rejection of H_0 under Pesaran et al. (2001) lower and upper bound critical values indicates existence of long-run cointegration between series only if the residual of (1) model (e_t) is stationary. In case of justification of these requirements the Restricted Error-Correction Model (RECM) can be formulated as below.

$$\Delta \mathrm{FE}_t = \delta_0 + \sum_{i=1}^{p} \delta_i \Delta \mathrm{FE}_{t-i} + \sum_{j=1}^{3} \sum_{i=0}^{q,k,l} \theta_{ji} \Delta X_{jt-i} + \sum_{j=1}^{2} \sum_{i=0}^{m,n} \gamma_{ji} \Delta Z_{jt-i} + \lambda_1 \mathrm{ECT}_{t-1} + \omega_t, \tag{4}$$

where ECT_{t-1} is a lag of stationary residual of (1) model (e_{t-1}), and λ_1 is it multiplier which is expected to be significant and negatively signed in bounds of $-1 \leq \lambda \leq 0$, indicating convergence towards equilibrium. This also shows the speed of self-adjustment of RECM model back to equilibrium by correcting its previous period disequilibrium following a shock that disturbs this equilibrium. In case λ derives positive estimate, then it signalizes that the model comprises autocorrelation problem (so model divergences from long-run equilibrium instead of converging), which strictly needs to be fixed. And if $\lambda < -1$, then the model is not stable over time horizon, indicating potential structural breaks to should be corrected (Sovbetov & Saka, 2018).

4. Analysis and Results

4.1. ARDL Model Selection

Initially, we ensure that residual of (1) model (e_t) is stationary at 1% significance level. Subsequently, we determine lags of dependant variable (p) and regressors (q, k, l, m, n) carrying ARDL optimal lag selection test with maximum lag length of 6 under SIC. Evaluating twenty different ARDL models we find out ARDL(1,4,1,2,2,0) model as the most appropriate with the minimum SIC value of 4.0142 (see Figure 3).

Further, we check robustness of this model testing whether its residuals are serially non-correlated and have equal variances or not. Table 6 summarizes the results of these diagnostic tests confirming healthiness of the ARDL model which accounts 80.74% variations in ΔFE at 1% significant level. Plus, we assess stability of the model by employing a cumulative sum of squares of recursive residuals (CUSUM) test that examines changes in CUSUM over time. Consequently, the CUSUM graph in the Figure 4 demonstrates that the model is stable over the analysis period as its CUSUM line does not exceed $\pm$5% significance (two dashed) lines.

Further, we hypothesize $\varphi_1 = \varphi_{21} = \varphi_{22} = \varphi_{23} = \varphi_{31} = \varphi_{32} = 0$ statement utilizing Wald test in order to examine whether these series (female employment, e-commerce and control variables) have long-run interactions. The analysis derives t-statistics of 5.39 (see Table 7) which highly exceeds Pesaran et al. upper bounds' critical value of Case III at 1%

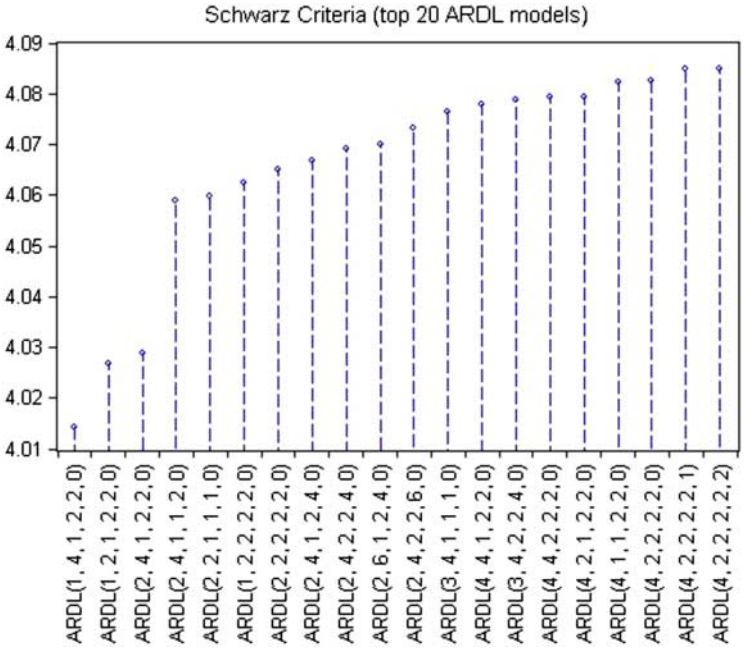

Figure 3. ARDL optimal lag selection test.

Table 6. Estimating coefficients of ARDL model.

Variables	Coefficients		Variables	Coefficients	
$\varphi_1 = \mathrm{FE}_{t-1}$	−1.2785***	(0.1574)	$\theta_{14} = \Delta\mathrm{EC}_{t-4}$	0.3993*	(0.2129)
$\varphi_{21} = \mathrm{EC}_{t-1}$	0.1689***	(0.0491)	$\theta_{20} = \Delta\mathrm{CC}_t$	5.1427	(3.6415)
$\varphi_{22} = \mathrm{CC}_{t-1}$	−0.0316	(0.0522)	$\theta_{21} = \Delta\mathrm{CC}_{t-1}$	6.3324*	(3.7573)
$\varphi_{23} = \mathrm{IP}_{t-1}$	0.4243***	(0.0804)	$\theta_{30} = \Delta\mathrm{IP}_t$	0.3910	(0.3462)
$\varphi_{24} = \mathrm{GDP}_{t-1}$	0.0681*	(0.0355)	$\theta_{31} = \Delta\mathrm{IP}_{t-1}$	−0.1577	(0.4257)
$\varphi_{25} = \mathrm{INF}_{t-1}$	0.0307*	(0.0162)	$\theta_{32} = \Delta\mathrm{IP}_{t-2}$	−0.8348*	(0.4372)
$\delta_1 = \Delta\mathrm{FE}_{t-1}$	0.4519***	(0.1210)	$\gamma_{10} = \Delta\mathrm{GDP}_t$	0.0865**	(0.0428)
$\theta_{10} = \Delta\mathrm{EC}_t$	0.0625	(0.1118)	$\gamma_{11} = \Delta\mathrm{GDP}_{t-1}$	0.0209	(0.0266)
$\theta_{11} = \Delta\mathrm{EC}_{t-1}$	0.3964**	(0.1784)	$\gamma_{12} = \Delta\mathrm{GDP}_{t-2}$	0.0472*	(0.0249)
$\theta_{12} = \Delta\mathrm{EC}_{t-2}$	0.0947*	(0.0483)	$\gamma_{20} = \Delta\mathrm{INF}_t$	0.0215	(0.0296)
$\theta_{13} = \Delta\mathrm{EC}_{t-3}$	−0.3718**	(0.1579)	$\delta_0 =$ Intercept	17.1056***	(3.0878)
R-square	0.8074		BPG test	0.7765	
F-statistics	11.5642		Harvey test	0.0947	
SIC	4.0142		Glejser test	0.3682	
BG Serial LM	0.1296		White test	0.5170	

Notes: The numbers in the table are coefficients estimated by ARDL technique with HAC-robust standard errors. BG is Breusch–Godfrey Serial Correlation test where the residual is regressed on its six lags hypothesizing H_0 (residuals have no serial correlation) against alternative H_1 (residuals are serially correlated). BPG (Breusch–Pagan–Godfrey), Harvey, and Glejser are types of heteroskedasticity tests that regress the squared residuals, the logs of the squared residuals, and the absolute residuals on the original regressors respectively, and White test regresses the squared residuals on the cross product of the original regressors including a constant term. All these tests hypothesize H_0 (Homoskedasticity) against alternative H_1 (Heteroskedasticity). The asterisk denotes statistical significance in following order: *10%, **5%, and ***1%.

significance level, signifying existence of a strong long-run cointegration between series. We dear critical values of Case III that are presented in Pesaran et al. (2001) at table CI as it is specified for models that comprises unrestricted intercept value and no any kind of trends. The reason of excluding the trend factor is due it its statistical insignificance.

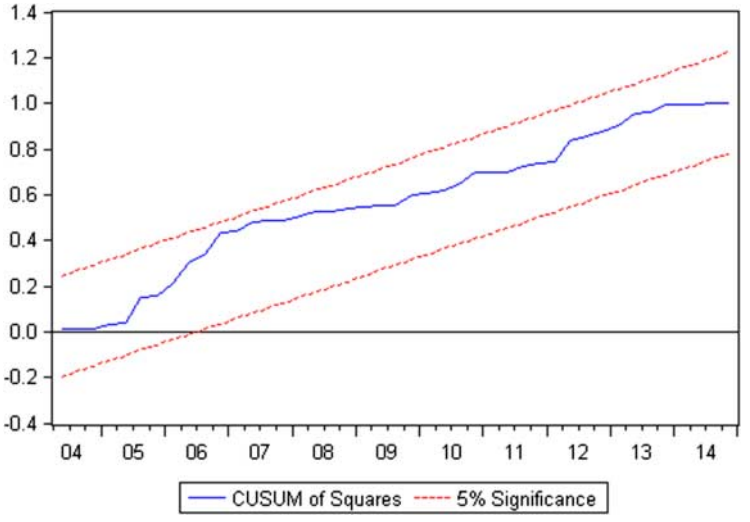

Figure 4. Stability of selected optimal ARDL model.

Table 7. *F*-test with bound critical values.

Bounds	Significance level	Case III ($k = 5$)
Lower Bound [*I*(0)]	1% level	3.41
Upper Bound [*I*(1)]	1% level	4.68
Lower Bound [*I*(0)]	5% level	2.62
Upper Bound [*I*(1)]	5% level	3.79
Lower Bound [*I*(0)]	10% level	2.26
Upper Bound [*I*(1)]	10% level	3.35
Wald test *F*-statistics of ARDL(1,4,1,2,2,0)		5.39***

Notes: The *k* indicates the number original regressors in the model. Therefore, it is 5 for (2.0) model (disregarding FE_{t-1} as it is autoregressor of dependent variable). The asterisk denotes statistical significance in following order: *10%, **5%, and ***1%.

The magnitude of detected cointegration (long-run multiplier) is computed with negative ratio of coefficients of independent variables to dependent one ($-\varphi_i/\varphi_1$). Thus, the ARDL model estimates that 1 unit increase in EC leads to 0.13 units increase in FE in long-run, while a percentage increase in IP, GDP, and INF scale FE up by 0.33%, 0.05%, and 0.02% respectively[5] in long-run. On the other hand, the model fails to detect statistical significant long-run impact running from CC to FE.

Further, we recall the (3) model that was formulated in methodology section in order to examine short-run dynamics of FE using RECM technique. This also provides evidence for how quickly cointegrated series converge to their long-run equilibrium. Table 8 presents results derived by RECM analysis where coefficients of independent variables imply their short-run causality on FE, and coefficient of λ_1 indicates the speed of error correction. As expected λ_1 derives statistically significant negative value that is bonded between -1 and 0. This implies the model does not have serial correlation and instability problems caused by structural breaks in data (Sovbetov & Saka, 2018). Its magnitude of 0.7543 indicates that

[5] Long-run multipliers for EC, IP, GDP, and INF are calculated by formula $-\varphi_i = \varphi_1$ where *i* represents related explanatory variable. In this respect, long-run multiplier for EC is $-0.1689/-1.2785 = 0.1321$; for IP is $-0.4243/-1.2785 = 0.3319$; GDP is $-0.0681/-1.2785 = 0.0532$; and for INF is $-0.0307/-1.2785 = 0.0240$.

Table 8. Estimating of RECM coefficients.

Variables	Coefficients		Variables	Coefficients	
δ_0 = Intercept	−0.8533**	(0.4316)	$\theta_{30} = \Delta IP_t$	−0.0971	(0.1082)
$\delta_1 = \Delta FE_{t-1}$	0.3451***	(0.1165)	$\theta_{31} = \Delta IP_{t-1}$	−0.1295	(0.1245)
$\theta_{10} = \Delta EC_t$	0.0914*	(0.0531)	$\theta_{32} = \Delta IP_{t-2}$	0.1112	(0.0764)
$\theta_{11} = \Delta EC_{t-1}$	0.0819**	(0.0388)	$\gamma_{10} = \Delta GDP_t$	0.0323**	(0.0155)
$\theta_{12} = \Delta EC_{t-2}$	0.1398	(0.1055)	$\gamma_{11} = \Delta GDP_{t-1}$	0.0157**	(0.0079)
$\theta_{13} = \Delta EC_{t-3}$	0.1127*	(0.0582)	$\gamma_{12} = \Delta GDP_{t-2}$	0.0111	(0.0127)
$\theta_{14} = \Delta EC_{t-4}$	0.1375**	(0.0654)	$\gamma_{20} = \Delta INF_t$	0.0209	(0.0318)
$\theta_{20} = \Delta CC_t$	2.0518	(2.8303)	$\lambda_1 = ECT_{t-1}$	−0.7543***	(0.1676)
$\theta_{21} = \Delta CC_{t-1}$	2.4457	(2.0122)			
R-square	0.7526		Hypotheses for jointly short-run impacts		
BG LM	0.1781		H_{01} (EC)	3.0793**	
BPG	0.6798		H_{02} (CC)	0.9784	
Harvey	0.6245		H_{03} (IP)	1.3427	
Glejser	0.8130		H_{04} (GDP)	4.1626***	
CUSUM	Stable		H_{05} (INF)	0.4345	

Notes: The table displays estimates derived by RECM analysis. The asterisk denotes statistical significance in following order: *10%, **5%, and ***1%. The numbers in diagnostics (below) part of the table are probability values of related tests. In the bottom right part of table the Wald analysis of four hypotheses are presented where numbers are *F*-statistics.

the model corrects its previous period's disequilibrium at a speed of 75.43% quarterly. This, indeed, is a quick convergence rate which implies a tight cointegration between series. For robustness, we examine diagnostics of RECM's residual by employing Breusch–Godfrey Lagrange multiplier (BG LM) serial correlation alongside with various heteroscedasticity tests and stability of the model with CUSUM test. As a result, CUSUM test confirms stability of the model, and the results of diagnostics tests suggest not rejecting null hypotheses implying that residuals are homoskedastic and not serially correlated. Moreover, to assess jointly short-run impacts we employ Wald analysis testing below hypotheses:

- $H_{01}: \theta_{10} = \theta_{11} = \theta_{12} = \theta_{13} = \theta_{14} = 0$ against $H_{11}: \exists\theta_{1j} \neq 0$,
- $H_{02}: \theta_{20} = \theta_{21} = \theta_{22} = \theta_{23} = \theta_{24} = \theta_{25} = 0$ against $H_{12}: \exists\theta_{2j} \neq 0$,
- $H_{03}: \theta_{30} = \theta_{31} = \theta_{32} = \theta_{33} = \theta_{34} = \theta_{35} = \theta_{36} = 0$ against $H_{13}: \exists\theta_{3j} \neq 0$,
- $H_{04}: \gamma_{10} = \gamma_{11} = \gamma_{12} = \gamma_{13} = \gamma_{14} = 0$ against $H_{14}: \exists\gamma_{1j} \neq 0$,
- $H_{05}: \gamma_{20} = 0$ against $H_{15}: \exists\gamma_{20} \neq 0$,

The results of Wald tests suggest rejecting H_{01} and H_{04} hypotheses at 5% and 1% significance levels respectively, while tests fails to reject H_{02}, H_{03}, and H_{05} hypotheses. In other words, lags of EC jointly have significant impact on FE in short-run at 5% level, while lags of GDP jointly generate short-run causality on FE at 1% levels. Thus, we conclude that digitalization has significant role in stirring the female employment up both in short- and long-run time horizons, especially through e-commerce transactions per credit cards, while internet penetration rate seems to be significant only in long-run.

5. Conclusion

The paper investigates interaction of e-commerce activities and female employment rates in Turkey through 1994–2016, and finds plausible results. First, stationarity of residual of (1) model signifies a potential long-run cointegrated relationship between variables, and ADF test suggests framing an ARDL model. By accounting 80.74% variations in female

employment rates, the ARDL model estimates a unit increase in e-commerce transactions per credit cards (EC) and internet penetration rate (IP) augment the female employment (FE) rates by 0.13 and 0.33 units respectively in long-run at 1% significance level. Apparently, EC seems to have statistically significant short-run impact on FE as well.

These results suggest that Turkey can empower women by enhancing internet infrastructure investments and incentivizing e-commerce initiatives which, in turn, create a positive impact on online commerce activities in short-run, and thus on female employment rates in long-run. On the other hand, the model fails to detect any causality running from credit volume expansion rates to female employment.

In addition, control variables real output and inflation rates seem to positively related with female employment in long-run as expected due to their empirically proven relationships (Okun's law and Phillips Curve). Moreover, RECM analysis reveals that real output also has deterministic role on female employment in short-run as its lags generate statistically significant joint impact on FE.

The error-correction model also shows that the cointegrated series cannot drift too far apart, and converge to a long-run equilibrium at a speed of 75.43% quarterly. In other words, the model corrects 75.43% of its previous quarter disequilibrium in current quarter.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes on contributor

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Appendix 1

Table A1. Correlation analysis.

	FE	EC	CC	GDP	IP	INF
FE	1	−0.4986	−0.1935	−0.5345	−0.2142	0.5762
EC	−0.4986	1	0.3636	0.3282	0.3347	−0.1682
CC	−0.1935	0.3636	1	0.2462	0.4040	−0.3132
GDP	−0.5345	0.3282	0.2462	1	0.3598	−0.4098
IP	−0.2142	0.3347	0.4040	0.3598	1	−0.2161
INF	0.5762	−0.1682	−0.3132	−0.4098	−0.2161	1