ATLANTIS PRESS
Advances in Social Science, Education and Humanities Research, volume 357
2nd International Conference on Education, Economics and Social Science (ICEESS 2019)

Exploring Granger Non-causality of the Japanese Employment Rate and the Trade in Services

Yu Hong
College of International Trade & Economics
Jilin University of Finance & Economics
Changchun, China
acjlhong@jlufe.edu.cn

Yumeng Yang
College of International Trade & Economics
Jilin University of Finance & Economics
Changchun, China
yymyym6@126.com

Aijing Hu*
College of Humanities & Sciences
Northeast Normal University
Changchun, China
2465569272@qq.com

Hongwei Su*
School of Accounting
Jilin University of Finance & Economics
Changchun, China
suhongwei@jlufe.edu.cn

Abstract—**This paper uses annual data of the Japanese in services for the period of 1980-2018 to explore the causal relationship between the imports and the exports. We find that: 1) in the short-run, there exist no Granger causal relationship among the employment rate and the Japanese trade in services; 2) in the long-run, both of the Japanese positions in the exports and the imports in the world are Granger causality of the employment rate, but that of the exports has negative effect while that of the imports exerts positive effect on the employment rates, and 3) neither employment rates nor export position in the world trade in services can significantly Granger cause the Japanese import position in the world service trade.**

Keywords—Granger causal relationship; exports; imports; trade in services; Japan

I. INTRODUCTION

The relationship of the imports and the exports has been under the caught scrutiny of scholars all around the world [1-6]. Trade in services has make considerable development in most countries and contributed to the individual economy and to the world economy [7-9]. This fact, however, unnecessarily means that a country's trade position or the proportions of its imports and exports in the world total services trade keep growing. A number of countries have exhibited other features that the changes in their employment rates, as well as the economic growth, seem to be unsynchronized with the development of their trade in services, leaving puzzling questions to answer.

One of these puzzling questions is how a specific country's positions of imports and exports link with the national economy, especially their effects on the employment rates. We chose Japan as the research object because:

- Japan has comparatively high employment rates, partially because of its unique cultural traditions;
- Japan has undergone economic depression for decades since the 1990s; and the positions of the Japanese exports and imports in services have deteriorated.

Even a casual glance may lead up to an impression that the Japanese employment rates are positively associated to the Japanese positions in the world trade in services. This may be, however, unnecessarily true, unless the empirical tests can confirm this. This study aims to test for the intrinsic nexus among the Japanese employment and the Japanese export as well as import position using time series analysis, to be more specifically, using Granger causality approach for time series.

II. DATA AND METHODOLOGY

A. Data Sources and Processing

We collected the data of the employment rate (E) from Statistics Bureau of Japan (http://www.stat.go.jp/data/roudou/longtime/zuhyou/lt01-b61.xlsx).

The Japanese total exports and imports in services were from UNTCAD database (https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx). UNTCAD statistics provide annual trade data BPM5 for 1980-2013 and BPM6 for 2005-2018 We compared the two for 2005-2013 and found that the difference is minimal for the year of 2010. Employing BPM5 classification for 1980-2009 and BPM6 classification for the period of 2010-2018, we obtained the Japanese trade data in services. The world exports and imports are treated as the sum of all individual countries. This procedure enabled us to obtain the Japanese exports and imports in relation to the world trade in services (X and M).

Under the assumption of non-linear relationship, we took natural logarithm on the proportions to get "x" and "m". To

This work was financially supported by Jilin Provincial Department of Education Humanities & Social Sciences Research Project (JJKH20190734S); Jilin Provincial Social Science Fund (2018BS20; 2019B19; 2019B199; 2019C23), Jilin Province Education Science Planning Project (2018292).

avoid negative values, we multiplied *X* and *M* by 100 before taking natural logarithm. For the employment rates, "*e*" is in the form of natural logarithm because the data for "*E*" had been already multiplied by 100 as per the data from Statistics Bureau of Japan. Figure 1 and Figure 2 shows the above mentioned three time series in natural logarithm form.

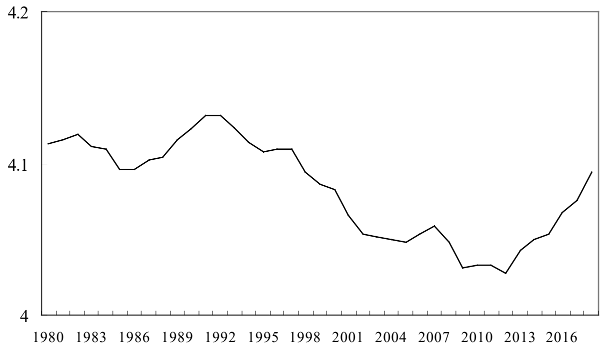

Fig. 1. The Japanese employment rates in natural logarithm

As shown in Figure 1, the Japanese employment rate hit the peak in the year of 1991and had declined until 2012, after which it has risen again.

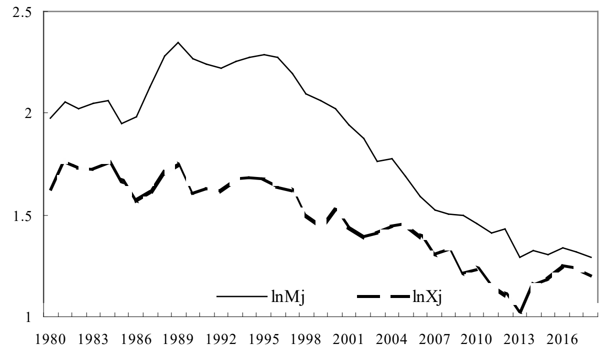

Fig. 2. The Japanese export and import Position in the world trade in services

Figure 2 illustrates that both the Japanese import and export positions in relation to the world trade in services peaked in 1989, and has hence dropped drastically.

B. Stationarity Test of the Time Series

The time series are co-integrated implies that the residual of the optimal equation should be stationary. In order to prevent pseudo-regression problems in the regression of non-stationary sequences, unit root tests of e, m and x are required before regression to verify whether the data is stationary or not. The econometric software that we used is Eviews 11.0.

Table I shows the results of ADF unit root test. For the "test type" column, the first letter stands for linear trend, the existence of linear trend is marked "1" and otherwise "N"; the second letter stands for whether there is a constant (1) or not (N); the third number indicates the lag length selected by Schwarz information criterion with a maximum of 9 lags.

The results reveal that all the three level variables are non-stationary time series. After taking first order difference, they become stationary series at 0.001 confidence levels, implying that we can build vector error correction models (VECM) to test for the Granger non-causality among these three time series.

TABLE I. ADF UNIT ROOT TEST RESULTS

	Test type	ADF t-stats	Prob.		Test type	ADF t-stats	Prob.
e	N, N, 1	-0.0904	(0.6459)	Δ e	N, N, 0	-3.3021	(0.0016)
x	N, N, 0	-1.1340	(0.2291)	Δ x	N, 1, 0	-6.6126	(0.0000)
m	N, N, 0	-1.5554	(0.1113)	Δ m	N, N, 0	-4.4908	(0.0010)

a. Note: ① Prob. is for MacKinnon (1996) one-sided p-values of ADF t-statistics [10]; ② Δ refers to the first difference of each variable.

C. Co-integration Test

This study conducted Johansen co-integration approach to test for the existence of a long-run equilibrium co-integrating relation among the three variables. We built a vector auto-regression model (VAR) [11-12]:

$$e_t = \sum_{n=1}^{N} a_n + \sum_{n=1}^{N} b_{1n} e_{t-n} + \sum_{n=1}^{N} b_{2n} x_{t-n} + \sum_{n=1}^{N} b_{3n} m_{t-n} + \sum_{n=1}^{N} \mu_n \qquad (1)$$

where n stands for the lag order, N denotes the optimal lag order, a_n represent the intercepts, b_{1n}, b_{2n} and b_{3n} are the coefficients for the lagged variables of "e", "x" and "m".

Table II presents the lag order selection results. As shown, three of the five VAR lag order selection criteria select 1-4 as the optimal, which implies that of the VECM model is 1-3.

TABLE II. VAR LAG ORDER SELECTION RESULTS

Lag	LogL	LR	FPE	AIC	SC	HQ
0	120.1744	NA	2.04e-07	-6.8926	-6.7579	-6.8467
1	219.1936	174.7398	1.03e-09	-12.1879	-11.649*	-12.0041*
2	229.3985	16.2077	9.69e-10	-12.2587	-11.3160	-11.9373
3	236.2884	9.7269	1.14e-09	-12.1346	-10.7878	-11.6753
4	252.7328	20.3137*	7.87e-1*	-12.5725*	-10.8217	-11.9754
5	258.6994	6.3176	1.06e-09	-12.3941	-10.2392	-11.6592

b. Note: ① LR: sequential modified LR test statistic (each test at 5% level); ②FPE: Final prediction error; ③AIC: Akaike information criterion; ④SC: Schwarz information criterion; ⑤HQ: Hannan-Quinn information criterion; ⑥ * indicates lag order selected by the criterion

The second crucial step is to determine the optimal model specification. Table III gives the summary of co-integration results for all the five possible model specifications, with lag intervals of 1-3, which is consistent to that of the VEC models.

TABLE III. SUMMARY OF CO-INTEGRATION TEST RESULTS

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	2	1	1	2	1
Max-Eig	2	1	1	0	0

c. Note: Critical values based on MacKinnon-Haug-Michelis (1999).

Trace statistics indicate that there exists co-integration relationship for each of all the five possible specification, while max-eigen values indicate two of them. We therefore conclude that the three time series in this research are co-integrated.

D. Error Correction Models

The VECM(s) in this study reads as:

$$\Delta y_t = \sum_{n=1}^{N} c_n + \sum_{n=1}^{N} ECT_{t-1,n} + \sum_{n=1}^{p} \beta_{1n} \Delta e_{t-p} + \sum_{n=1}^{p} \beta_{2n} \Delta x_{t-p} + \sum_{n=1}^{p} \beta_{3n} \Delta m_{t-p} + \sum_{n=1}^{N} \varepsilon_n \quad (2)$$

where y stands for the three variables of e, x and m, c refers to the individual intercepts of each VECM equation, and ECT_{t-1} is the lagged error correction term which is the residual of the co-integration equation and ε represents the residual terms of the VECM equations. The optimal co-integration equation is:

$$e_t = \alpha_1 x_t + \alpha_2 m_t + ECT_t \quad (3)$$

and the error correction term is therefore

$$ECT_t = e_t - \alpha_1 x_t - \alpha_2 m_t \quad (4)$$

for each of the VECM equation. Because the time series are co-integrated, ECT_t are stationary series. The fact that all variables are first-order integrated ensures that the VEC models can avoid the common problem pseudo-regression.

TABLE IV. VEC MODEL SPECIFICATION SELECTION RESULTS

Model specification	I	II	III	IV	V
Co-integration Equation	No Intercept	Intercept	Intercept	Intercept	Intercept
VAR	No Trend	No Trend	No Trend	Trend	Trend
Determinant residual covariance (dof adj.)	1.20E-10	1.16E-10	8.97E-11	7.35E-11	7.59E-11
Determinant residual covariance	1.87E-11	1.81E-11	1.16E-11	9.52E-12*	8.10E-12
Log likelihood	233.626	234.2326	241.9665	245.4528	248.291
Akaike information criterion	-10.1501	-10.1276	-10.3981	-10.5402*	-10.5309
Schwarz criterion	-7.6615	-7.59458	-7.7318	-7.82941*	-7.6869

d. Note: ① VEC models are composed of two parts: the co-integration equation and the VARs. The model specifications of I to V list all the five possible combinations; ② the asterisks indicate the selection results by the selection criteria.

Two of the crucial indicators, AIC (Akaike information criterion) and SC (Schwarz criterion), make the same selection, implying that the model specification IV to be the optimal. We therefore built the VEC models in specification IV with the lag interval of 1-3. This enables us to conduct further short-run and long-run Granger non-causality tests among the three time series of e, x and m in order to explore the intrinsic causal relationship among them.

III. GRANGER NON-CAUSALITY TESTS

We estimated the VEC models in the optimal specification with a lag interval of 1-1. The intrinsic causal relationship, however, depends on the empirical results of Granger non-causality tests instead of the mere analysis of the co-integration equation, which can only reflect the associating relation among the time series. We performed both short-run and long-run Granger non-causality tests to empirically investigate the dynamic relationship among the sample series.

A. Short-run Granger Non-causality Test

Short-run Granger non-causality tests focus on the direct effect between independent and dependent factors. In this paper investigated whether the short-run △m (imports) has direct significant effect on the employment rate "△e" or not.

We used Wald tests on the null hypothesis of non-causality between any pairs of variables based on VEC models. The rejection of the null hypothesis indicates that the lagged differences of the dependent variable will significantly help improve the explanatory power of the model. According to the definition of Granger non-causality, if the lag term of independent variable is added to improve the explanatory power of the model, the independent variable is the Granger cause of the dependent variable. Since this effect does not involve the long-term equilibrium co-integration relationship, the above test focuses on the short-term effect or short-term Granger non-causality [13-14].

Knowledge of Granger non-causality, however, is far less enough to explore the relation among the variables even in the short-run. We add up the coefficients of each independent variable to check the positive or negative sign of the short-run effects upon the separate dependent variable.

TABLE V. SHORT-RUN GRANGER NON-CAUSALITY TEST RESULTS

Dependent / Independent	Δe		Δx		Δm	
	Chi-sq	SE	Chi-sq	SE	Chi-sq	SE
Δe_{t-1}, Δe_{t-2}, Δe_{t-3}	——	——	0.4932 (0.7814)	——	0.7983 (0.6709)	——
Δx_{t-1}, Δx_{t-2}, Δx_{t-3}	3.2754 (0.1994)	——	——	——	0.3712 (0.8306)	——
Δm_{t-1}, Δm_{t-2}, Δm_{t-3}	4.3264 (0.1120)	——	1.8816 (0.3903)	——	——	——

e. Note: ① Chi-sq refers to Chi-square statistics; ② in the brackets are the probabilities ; ③ SE stands for short-run effect, which is the sum up of the coefficients of the lagged differences.

As shown in Table V, there is no significant causal relation between any pair of variables, for any direction in the short-run. However, this unnecessarily implies the non-existence of long-run Granger non-causality.

B. Long-run Granger non-causality test

We used Wald test to explore the long-run Granger causal relationship between each pair of dependent and independent factors of time series. Note again that this study allows each of the variables to play the role of dependent. We conduct joint-test on each coefficient together with that of the error correction term (ε_{t-1}). The long-run effect is judged by the convergence value of the generalized impulse response function based on the VEC models [15]. In this study the values show convergence after 40 periods after the shock, we hence take the values at the 40th period as the long-run effects.

TABLE VI. LONG-RUN GRANGER NON-CAUSALITY TEST RESULTS

Independent \ Dependent	Δe		Δx		Δm	
	F-stats	LE	F-stats	LE	F-stats	LE
ε_{t-1}	3.8335* (0.0625)	——	17.007*** (0.000)	——	0.1638 (0.3912)	——
ε_{t-1}, Δe_{t-1}, Δe_{t-2}, Δe_{t-3}	——	——	6.6473** (0.0010)	0.0206	1.2443 (0.3201)	——
ε_{t-1}, Δx_{t-1}, Δx_{t-2}, Δx_{t-3}	2.9747** (0.0407)	-0.0018	——	——	1.2597 (0.3143)	——
ε_{t-1}, Δm_{t-1}, Δm_{t-2}, Δm_{t-3}	3.2091** (0.0312)	0.0158	6.6778** (0.0010)	0.0346	——	——

f. Note: ① F-stats are F-statistics for Wald restriction test with degree of freedom of (1, 23) for the coefficient of error correction term (εBt-1B), and (4, 23) for the lagged differences of each individual independent variable combined with the error correction term; ② in the brackets are the joint-probabilities of F-statistics; ③ LE stands for the long-run effect.

- The long-run equilibrium co-integrated relation or εBt-1B in this study is the long-run Granger causality of both the Japanese employment rate (*e*) and the Japanese position in the world exports in services (*x*).
- The Japanese position in both the exports and the imports in the world services (*x* and *m*) are long-run Granger causality of the Japanese employment rate (*e*) at 0.05 confidence level. The difference lies in long-run effect of position in the world exports (*x*) on the employment rate is negative, while the Japanese position in the world imports of services (*m*), however, has positive effect upon the employment rate (*e*).
- There are significant long-run causal relationship running from the Japanese employment rate (*e*) and the Japanese position in the world imports of services (*m*) to the Japanese export position in the world trade in services (*x*) at 0.05 confidence level, both with positive long-run effects.
- None of the employment rate (*e*) or the export position in the world trade in services (*x*) has significant Granger effect upon the Japanese import position at usual confidence level. Considering the short-run Granger non-causality test results, our results imply that the Japanese import position (*m*) seems to be exogenous to our VEC models in both the short-run and long-run. In other words, there may be other factors determining the Japanese import position in the world trade in services.

IV. Conclusion

This study conducted time series analysis for the Japanese employment rates (*e*), the Japanese export position in the world exports in services (*x*), and the import position in the world imports in services (*m*).

- Firstly, unit root test results reveal that all the three time series are first order integrated.
- Johansen co-integration tests reveal that the three variables of *e*, *x* and *e* are co-integrated. In other words, there exists a long-run equilibrium co-integrating relationship among the variables in natural logarithm.
- Short-run Granger non-causality tests show that there is no Granger causal relationship in any pair of the three time series. This implies that the Granger causal relationship, if there is, does not embody in the short-run in our econometric model system.
- In the long-run, Granger non-causality tests indicate that there is Granger causality running form *x* to *e* with negative effects, and *m* Granger causes e with positive effects. These results are somewhat contradictory and confusing according to the common economic knowledge that an increasing in exports may often improve the domestic economy as well as employment. A possible explanation may be the import restriction will not encourage the employment or economy of a country (or countries), especially for that of Japan.
- Also in the long-run, neither employment rate nor the export position in world trade in services can explain the Japanese import position in world imports in services, suggesting that the Japanese import position is rather exogenous to the Japanese employment rate as well as the export position.

Acknowledgment

This work was financially supported by Jilin Provincial Department of Education Humanities & Social Sciences Research Project (JJKH20190734S); Jilin Provincial Social Science Fund (2018BS20; 2019B19; 2019B199; 2019C23), Jilin Province Education Science Planning Project (2018292).

We also owe thanks to the support of other projects including “the strategy and implementation of Changjitu pilot area” from Jilin Provincial Social Science Fund; “Research and practice of international business talent training under the background of the Belt and Road” from Education and Teaching Reform Project in High Education of Jilin Province; “Employment-oriented training model of international business talent in provincial undergraduate colleges and universities” from Educational Science Planning Project of Jilin Province.

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