The International Trade Journal

ISSN: 0885-3908 (Print) 1521-0545 (Online) Journal homepage: https://www.tandfonline.com/loi/uitj20

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To cite this article: Fumitaka Furuoka, Hanafiah Harvey & Qaiser Munir (2019) Export diversification, mean-reversion of exports, and stability of export–growth causality, The International Trade Journal, 33:3, 221-238, DOI: 10.1080/08853908.2018.1555497

To link to this article: https://doi.org/10.1080/08853908.2018.1555497

Published online: 24 Dec 2018.

THE INTERNATIONAL TRADE JOURNAL
2019, VOL. 33, NO. 3, 221–238
https://doi.org/10.1080/08853908.2018.1555497

Export diversification, mean-reversion of exports, and stability of export–growth causality

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ABSTRACT

This study proposes a five-step statistical procedure to examine a linkage among export diversification, mean-reversion of exports, and stability of the export–growth causality. This linkage was assessed for France, Norway, and Switzerland between 1980Q1 and 2016Q4. The findings indicated that the mean-reversion tendency of the export sectors in France and Switzerland was stronger than in Norway, which highlighted the important role of export activities for economic growth in France and Switzerland. Also, the causal relationship between exports and economic growth in Norway was found to be more unstable than in France, but more stable than in Switzerland.

KEYWORDS

Export diversification; mean-reversion of exports; stability of export–growth causality

I. Introduction

Exports play an important role in promoting economic growth. Impressive economic performances of several Asian countries have demonstrated multiple beneficial effects of exports on economic growth (Awokuse and Christopoulos 2009; Doraisami 1996; El-Sakka and Al-Mutairi 2000; Lee and Huang 2002; Salim and Hossain 2011; Tang 1998). However, it has been challenging to empirically prove that exports do indeed cause economic growth (Bahmani-Oskooee and Alse 1993; Giles and Williams 2000a, 2000b; Konstantakopoulou 2016; Narayan et al. 2007; Rahman and Mustafa 1997; Salim and Hossain 2011; Tang, Lai, and Ozturk 2015). This could be attributed to notable differences in the research methods adopted by empirical studies on the export–growth nexus.

Several important contributions to the research literature on this topic were made in the 1970s and 1980s, and these studies employed a cross-sectional method (Balassa 1978; Heller and Porter 1978; Michaely 1977; Ram 1985; Tyler 1981). The findings of these studies provided empirical evidence in support of the positive role that exports play in the process of economic growth (Ram 1987). Beginning in the mid-1980s, time-series methods gained popularity

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(Ahmad and Harnhirun 1996; Bahmani-Oskooee and Alse 1993; Dodaro 1993; Doraisami 1996; Dutt and Ghosh 1996; Ekanayake 1999; Fosu 1990; Jung and Marshall 1985; Kwan and Kwok 1995; Rahman and Mustafa 1997; Ram 1987). In the 2000s and 2010s, the time-series methods became more advanced and included the nonlinear causality test and the structural break unit root test (Awokuse 2003; Awokuse and Christopoulos 2009; Bahmani-Oskooee and Economidou 2009; Bahmani-Oskooee, Economidou, and Goswami 2005; Belloumi 2014; Dreger and Herzer 2013; El-Sakka and Al-Mutairi 2000; Konstantakopoulou 2016; Lee and Huang 2002; Lim and Ho 2013; Narayan et al. 2007; Ozturk and Acaravci 2010; Salim and Hossain 2011; Shafiullah and Navaratnam 2016; Shafiullah, Selvanathan, and Naranpanawa 2017; Tang, Lai, and Ozturk 2015; Tekin 2012; Tiwari and Ludwig 2015).

In contrast to the studies of the 1970s and 1980s, more recent scholarly investigations were able to detect instability in the causal relationship between exports and economic growth (Tang, Lai, and Ozturk 2015; Tiwari and Ludwig 2015). A rolling causality test performed in these studies enabled the researchers to detect this instability. However, an important question that remains unanswered is: What causes instability in the export–growth relationship? In order to answer this question, the current study examines possible linkages among export-diversification, mean-reversion of exports, and stability of causal relationships between exports and economic growth. In other words, this study aims to identify the determinants of stability in the export–growth causal relationship by examining the diversification–reversion–stability linkage. To achieve this aim, this study proposes a novel five-step statistical procedure and employs this method to examine the linkage in the context of three European economies—namely, France, Norway, and Switzerland. The period of the study spans from 1980Q1 to 2016Q4.

These three countries all have large volumes of exports (see Figure 1). However, there is a difference in the relative size of their exports. In addition, Norway's exports are dominated by petroleum-related products. France and Switzerland have more diversified exports that include manufacturing goods,

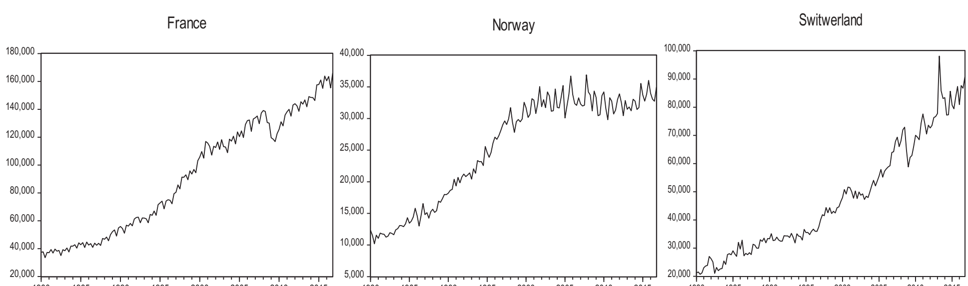

Figure 1. Exports in three European countries (1980 to 2016) in million Euro.
Source: European Commission (2017).

machineries, and pharmaceutical products. Two taxonomies aided the analysis of the diversification–reversion–stability linkage. France, which is the sixth largest exporting country in the world, was classified as a "very large" exporting country with a "very high" export diversification. Norway, which is ranked at number 34 among the world's largest exporters, was deemed as a "moderately large" exporter with a "very low" export diversification. Switzerland, which ranks at number 15 among the world's largest exporters, was classified as a "large" exporting country with a "low" export diversification. An analysis of three countries with different characteristics could yield interesting insights into linkages among export-diversification, mean-reversion of exports, and stability of the export–growth causality. Two assumptions concerning this linkage were made: firstly, there existed a positive correlation between the diversification-reversion tendency and stability of the causality; secondly, there was a positive correlation between the mean-version tendency and export-diversification. The first assumption entails that a higher level of export-diversification would be associated with a greater stability of the export–growth linkage. The second assumption infers that a stronger mean-reversion tendency of exports would be associated with a higher level of export diversification.

Based on these assumptions, two hypotheses were formulated. Hypothesis 1 stemmed from the first assumption regarding a possible relationship between export diversification and stability of the export–growth causality. The export sector in countries with a higher export-diversification level could prove to be more resilient against negative economic shocks. Therefore, the export sector in such countries would contribute to their economic growth in a more consistent way. It can be assumed that there would exist a greater stability in the causal relationship between exports and economic growth in countries with a higher export diversification. Therefore, Hypothesis 1 was formulated as:

H1: The causal relationship between exports and economic growth in countries with a higher export-diversification level will be more stable than in countries with a lower export diversification.

In the current study, this hypothesis was tested by examining whether the export–growth causal relationship in France and Switzerland was more stable than in Norway. The rolling causality test was employed for the analysis.

Hypothesis 2 was based on the second assumption concerning the linkage and possible relationship between the export-diversification level and mean-reversion of exports. The export sector in countries with a higher level of export diversification might recover more swiftly from an economic slowdown. Also, the export sector would revert more smoothly from a negative trend (export decline) to a positive trend (export growth). It can be assumed that in the countries with a higher export diversification, the mean-reversion tendency of exports would be stronger. Therefore, Hypothesis 2 was formulated as:

H2: The mean-reversion of exports in countries with a higher level of export diversification will be stronger than in countries with a lower export diversification.

This hypothesis was tested by examining whether the mean-reversion of exports in France and Switzerland was stronger than the mean-reversion of exports in Norway. Long-memory tests were used for this analysis.

II. Data and methods

A motivation behind this study was to introduce a comprehensive statistical procedure to analyze the linkage among export diversification, mean-reversion of exports, and stability of the export–growth causality. The newly proposed procedure examined this linkage in the context of three European countries (i.e., France, Norway, and Switzerland) for the period of 1980Q1 to 2016Q4. The main source of the time-series data on real exports and real economic growth was the Eurostat database (European Commission 2017). In this database, exports of goods and services (*EXP*) in the chain linked volumes (2010) in million Euro are codified as *P6*; the gross domestic product (*GDP*) at market price in the chain linked volumes (2010) in million Euro is codified as *B1GQ*.

The two hypotheses regarding the diversification–reversion–stability linkage were tested using a five-step procedure that incorporated some innovative methods, such as the Fourier ADF with structural break test (Furuoka 2016), the long memory test (Hurst 1951; Weron 2002), the autoregressive distributed lag analysis (Pesaran, Shin, and Smith 2001), and the rolling Granger causality test (Smith, Brocato, and Rogers 1993; Tang, Lai, and Ozturk 2015; Tiwari and Ludwig 2015). In the first step, the Fourier ADF with structural break (FADF–SB) test (Furuoka 2016) examined a unit root process in the time-series data on exports and income. The FADF–SB test was based on the following equation (Furuoka 2016; Perron and Vogelsang 1992; Zivot and Andrews 1992):

$$\Delta y_t = \alpha_0 + \alpha_1 t + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \theta_1 DU_t + \theta_2 D(TB)_t + \rho y_{t-1} + \sum_{i=1}^{p} \sigma_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

where y is the variable of interest, α_0 is the constant, α_1 is the slope coefficient for trend, ρ is the slope coefficient for the lagged level of the variable, σ is the slope coefficient for the lagged first difference of the variable, ε is the error term, t is the time trend, p is the lag order, Δ is the first difference operator, θ_1 is the slope coefficient for structural break dummy, $DU_t = 1$ if $t > TB$ and $DU_t = 0$

otherwise, TB is the time-series breakpoint when a structural break occurs, θ_2 is the slope coefficient for a one-time break dummy, $D(TB)_t = 1$ if $t = TB$ and $D(TB)_t = 0$ otherwise, k is the frequency for the Fourier approximation function, γ is the slope coefficient for the trigonometric term, and π is 3.141593.

In the second step, two different long memory tests (i.e., the Hurst exponent test and the fractional integration test) examined the mean-reversion tendency of the time series on income and exports. The Hurst exponent statistic (H) was calculated by the rescaled range (R/S) method (Caporale and Gil-Alana 2002; Geweke and Porter-Hudak 1983; Granero, Segovia, and Pérez 2008; Granger and Joyeux 1980; Hurst 1951; Weron 2002). The fractional integration statistic (d) was computed by an estimation procedure suggested by Geweke and Porter-Hudak (1983; see also Hurvich, Deo, and Brodsky 1998). The Hurst exponent statistic was estimated from the linear regression. In this regression, the logarithm base 10 of the adjusted mean value of the rescaled range statistics was regressed on the logarithm base 10 of the number of observations (n) in the sub-sample and the constant (Granero, Segovia, and Pérez 2008; Hurst 1951; Weron 2002). The equation is as follows:

$$Log10[A(R_n/S_n)_m] = \beta_0 + \beta_1 Log10[n] + \varepsilon_t \tag{2}$$

where β_0 is the intercept, β_1 is the slope coefficient that is the Hurst exponent statistic, and ε is the error term. Furthermore, the Geweke–Porter-Hudak (GPH) test was based on the following log-periodogram regression (Geweke and Porter-Hudak 1983; Hurvich, Deo, and Brodsky 1998):

$$\ln\{I(\lambda_j)\} = \beta_0 + \beta_1 \ln\{4\sin^2(\lambda_j/2)\} + \eta_t, \qquad j = 0, \ldots\ldots, T^{1/2} \tag{3}$$

where β_0 is the intercept, β_1 is the slope coefficient, η is the error term, $I(\lambda_j)$ is the periodogram, and λ_j is the harmonic ordinate at ordinate j. The fractional integration coefficient (d) was calculated as $d = -0.5 \times \beta_1$.

In the third step of the statistical analysis, the autoregressive distributed lag (ARDL) cointegration method assessed relationships between exports and economic growth in the three European countries. The bounds test was based on two types of unrestricted error correction models (UECM). The first UECM estimation model with GDP as the dependent variable can be expressed as (Pesaran, Shin, and Smith 2001):

$$\begin{aligned}\Delta GDP_t = \alpha_0 + \sum_{i=1}^{p-1} \gamma_i \Delta GDP_{t-i} + \sum_{i=0}^{p-1} \beta_i \Delta EXP_{t-i} + \rho_1 GDP_{t-1} \\ + \rho_2 EXP_{t-1} + e_t\end{aligned} \tag{4}$$

where γ is the slope coefficient for the lagged first-difference of the dependent variable, β is the slope coefficient for the lagged first difference of the independent variable, ρ_1 is the slope coefficient for the lagged dependent variable, ρ_2 is the slope coefficient for the lagged independent variable, and e is the error term. The maximum lag length was set at four, and the optimal lag length was determined by the Akaike information criterion (Akaike 1974).

In the fourth step, the Granger causality test assessed causal relationships between exports and economic growth. The Granger analysis of a unidirectional causality from *EXP* to *GDP* was based on the equation (Granger 1969):

$$GDP_t = \alpha_0 + \sum_{i=1}^{p} \gamma_i GDP_{t-i} + \sum_{i=1}^{p} \beta_i EXP_{t-i} + e_t \tag{5}$$

where γ is the slope coefficient for the lagged level of the dependent variable, and β is the slope coefficient for the lagged level of the independent variable. The maximum lag length was set at three. The Akaike information criterion (Akaike 1974) determined the optimal lag length.

Finally, a rolling causality test procedure (Smith, Brocato, and Rogers 1993) examined the stability of the causal relationship between exports and economic growth in the three countries. Due to an insufficient number of observations, the size of the rolling window was set at 20. Upon consulting the *F*-statistic distribution table, the 5% critical values were set at 4.49. The rolling causality test procedure was suggested in some previous studies (see Smith, Brocato, and Rogers 1993; Tang, Lai, and Ozturk 2015; Tiwari and Ludwig 2015). In order to enhance the precision of the stability analysis, the current study proposes to set a rejection rate (*RR*). This would enable a more accurate measurement of the relative stability of the causal relationship. The rejection rate is the share of the number of the rolling Granger statistics that is greater than the 5% critical value:

$$RR_i = \frac{RG_i}{TG_i} \tag{5a}$$

where RR_i is the rejection rate in country *i*, *RG* is the number of the rolling Granger statistics in country *i* that is greater than the 5% critical value, and *TG* is the total number of the rolling Granger statistics in country *i*.

III. Empirical findings

This study employed a novel five-step statistical procedure to examine the diversification–reversion–stability linkage in France, Norway, and Switzerland over the period of 1980 to 2016. First of all, three different unit root tests (namely, the ADF test, the ADF–SB, and the FADF–SB test) examined the unit root process in the time series on exports and economic growth. Table 1 reports the findings of the ADF tests. The test could not reject the null hypothesis of a unit root in *GDP* at level, except for Norway. It rejected the null hypothesis of a unit root in *GDP* at the first difference for all

Table 1. Findings from the ADF test.

	GDP		*ΔGDP*		*EXP*		*ΔEXP*	
Countries	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend
France	−0.662	−2.743	−11.750***	−11.732***	0.452	−2.736	−9.298***	−9.302***
Norway	−0.681	−5.564***	−16.283***	−16.226***	−1.349	−2.277	−15.921***	−15.992***
Switzerland	0.674	−2.256	−9.799***	−9.874***	0.246	−2.742	−11.594***	−11.655***

* indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level.

three countries. These findings suggest that the time series on economic growth in France and Switzerland demonstrated a stationary process at the first difference, while the time series on economic growth in Norway demonstrated a stationary process at level. The ADF test failed to reject the null hypothesis of a unit root in *EXP* at level for all three countries. The test rejected the null hypothesis of a unit root in *EXP* at the first difference for these countries. These results suggest that the time series on exports in all three countries demonstrated a stationary process at the first difference. Overall, the ADF test indicated that *GDP* in France and Switzerland was integrated of order one, *I(1)*, while *GDP* in Norway was integrated of order zero, *I(0)*. Also, the test indicated that *EXP* in all three countries was integrated of order one, *I(1)*.

The findings from the unit root tests with structural break (i.e., the ADF–SB test and FADF–SB test) are reported in Table 2. The ADF–SB test rejected the null hypothesis of a unit root in *GDP* at level for all countries. This result was confirmed by the FADF–SB tests: the FADF–SB test rejected the null hypothesis of a unit root in *GDP* at level for all countries. These findings suggest that the time series on economic growth was a stationary process at level. In addition, the ADF–SB test rejected the null hypothesis of a unit root in *EXP* at level for all countries. The FADF–SB test produced identical findings, which confirmed the rejection of the null hypothesis. This means that the time series on exports was a stationary process at level. In other words, the results from the unit root tests with structural break indicated that the *GDP* and *EXP* in the time series for France, Norway, and Switzerland were integrated of order zero, *I(0)*. Overall, the findings from the three types of unit root tests were not consistent regarding the mean-reversion property of exports. On the one hand, the ADF test indicated that the time-series data on exports and economic growth were integrated of order one, which suggested that the time-series data would not have a mean-reversion tendency. On the other hand, the findings from the unit root tests with structural break, the ADF–SB test and the FADF–SB test, indicated that the time

Table 2. Findings from the ADF–SB and the FADF–SB test.

	GDP					*EXP*				
Countries	*TB*	*ADF–SB statistics*	*TB*	*K*	*FADF–SB statistics*	*TB*	*ADF-SB statistics*	*TB*	*K*	*FADF–SB statistics*
France	2008Q4 [0.78]	−4.842***	1984Q1 [0.35]	1	−6.160***	1996Q3 [0.67]	−4.070**	1993Q3 [0.53]	2	−4.722***
Norway	1996Q3 [0.45]	−8.422***	1984Q1 [0.25]	1	−10.410***	2008Q1 [0.76]	−4.853**	2014Q3 [0.93]	1	−10.789***
Switzerland	1991Q3 [0.31]	−3.949*	1990Q3 [0.29]	2	−4.141*	1990Q2 [0.28]	−4.286**	2013Q2 [0.900]	1	−6.587***

Numbers in brackets indicate the break-point (λ); * indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level; *TB* indicates time-series breakpoint; *K* is frequency for the Fourier approximation function. Critical values for the ADF–SB test and the FADF–SB test were obtained from Furuoka (2016).

series on exports and economic growth were integrated of order zero, which indicated that the time-series data on exports would have a mean-reversion tendency.

Next, the Hurst exponent analysis and the fractional integration analysis examined a long-term dependency in the time-series data on exports and economic growth. Table 3 shows the findings. The Hurst exponent statistic for *GDP* in France was 1.024; this indicates that France's *GDP* was a non-stationary process with a mean-reversion tendency. In a similar way, the Hurst exponent statistic for *GDP* in Norway was 1.034, indicating that Norway's *GDP* could be considered as a non-stationary process with a mean-reversion tendency. By contrast, the Hurst exponent statistic for *GDP* in Switzerland was 0.969 (i.e., below 1). This suggests that *GDP* in Switzerland was a stationary process with a mean-reversion tendency. As to the *EXP* variable, the Hurst exponent statistic for France was 1.010, which indicates that France's *EXP* was a non-stationary process with a mean-reversion tendency. Similarly, the Hurst exponent statistic for *EXP* in Norway was 1.034, which suggested that the *EXP* was a non-stationary process with a mean-reversion tendency. In contrast, the Hurst exponent statistic for *EXP* in Switzerland was 0.980 (i.e., below 1). Therefore, *EXP* in Switzerland could be considered as a stationary process with a mean-reversion tendency.

Findings from the fractional integration analysis in Table 4 show that the fractional integration statistic for *GDP* in France was 0.516. This indicates that *GDP* in the country was a non-stationary process with a mean-reversion process. Similarly, the fractional integration statistic for *GDP* in Norway was 0.522, which suggests a mean-reversion tendency. The fractional integration statistic for *GDP* in Switzerland was 0.533 and suggests the presence of a mean-reversion tendency in the export time series. Regarding *EXP*, the fractional integration statistic for this variable in France was 0.505; therefore, the *EXP* was a non-stationary process with a mean-reversion tendency. A similar result was achieved for *EXP* in Norway (0.527) and Switzerland (0.522), which indicated a mean-reversion tendency. Overall, the two long-run memory tests—namely, the Hurst exponent statistic and the fractional integration statistic—provided some interesting insights into the nature of the time-series on exports in the three countries. The long-memory tests suggested that the time-series on exports and economic growth had a mean-reversion tendency. More importantly, the estimated test statistics on exports

Table 3. Findings from the Hurst exponent analysis.

Countries	*GDP*	*EXP*
France	1.024	1.010
Norway	1.034	1.056
Switzerland	0.969	0.980

Table 4. Findings from the fractional integration analysis.

Countries	*GDP*	*EXP*
France	0.516	0.505
Norway	0.522	0.527
Switzerland	0.533	0.522

were higher in the case of Norway than in the cases of France and Switzerland. This result indicates that the mean-reversion tendency in the time-series data on exports for Norway could be weaker than in the time series for France and Switzerland.

In the third step of the statistical procedure, the ARDL cointegration analysis examined the relationships between exports and economic growth in the three European countries. The maximum lag length was set at four, and the Akaike information criterion (Akaike 1974) determined the optimal lag length. Table 5 shows the findings from the ARDL analysis. For the data on France, the bounds *F*-test in the first estimation model with *GDP* as the dependent variable rejected the null hypothesis of no cointegration between *EXP* and *GDP*. This result indicates the presence of a long-run relationship between the country's exports and economic growth. In this first estimation model, the error correction term was statistically significant, which confirmed the presence of a long-run equilibrium relationship between exports and economic growth. In the second estimation model with *EXP* as the dependent variable, the bounds *F*-test failed to reject the null hypothesis of no cointegration. In the second estimation model, the error correction term was statistically significant. As to the findings for Norway, the bounds *F*-test in the first estimation model with *GDP* as the dependent variable failed to reject the null hypothesis of no cointegration between *EXP* and *GDP*. This means that there was no long-run relationship between the country's exports and economic growth. Similarly, the second estimation model with *EXP* as the dependent variable failed to reject the null hypothesis of no cointegration between *EXP* and *GDP*. For the data on Switzerland, the bounds *F*-test in the

Table 5. Findings from the ARDL analysis.

	Dependent variable: GDP				*Dependent variable: EXP*			
Countries	*Lag length*	*Bounds F-statistic*	*Long-run coefficient*	*Error correction term*	*Lag length*	*Bounds F-statistic*	*Long-run coefficient*	*Error correction term*
France	[4,4]	5.484*	0.399	−0.014***	[4,4]	2.336	0.001***	−0.032**
Norway	[4,4]	3.621	2.498***	−0.036***	[4,4]	3.003	0.001	−0.020**
Switzerland	[4,4]	1.830	0.945***	−0.052*	[3,3]	4.599	1.175	−0.227***

* indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level. Critical values for the bounds F-statistics were obtained from Pesaran, Shin, and Smith (2001). Numbers in brackets indicate the optimal lag length. The maximum lag length was set at four, and the Akaike information criterion (Akaike 1974) was used to determine the optimal lag length.

first estimation model with *GDP* as the dependent variable failed to reject the null hypothesis. In the first estimation model, the long-run coefficient and error correction term were statistically significant. The second estimation model with *EXP* as the dependent variable also failed to reject the null hypothesis of no cointegration between *EXP* and *GDP*. In this estimation model, the long-run coefficient and error correction term were statistically significant. Overall, the findings from the ARDL analysis pointed to the existence of a long-run equilibrium relationship between exports and economic growth only for the data on France. No long-run relationship between exports and economic growth was found to exist in the time-series data for Norway and Switzerland.

In the fourth step of the analysis, the Granger causality test assessed causal relationships between exports and economic growth in the three European countries. The maximum lag length was set at three, and the Akaike information criterion (Akaike 1974) determined the optimal lag length. Table 6 shows the findings. In the case of France, the Granger *F*-test rejected the null hypothesis of no causality from *EXP* to *GDP*. Also, the Granger *F*-test rejected the null hypothesis of no reverse causality. These findings suggest that there was a bidirectional causality between exports and economic growth in France. In the case of Norway, the Granger *F*-test failed to reject the null hypothesis of no causality from *EXP* to *GDP*. Similarly, the Granger *F*-test failed to reject the null hypothesis of no reverse causality. These results indicate an independent relationship between exports and economic growth in Norway. As for Switzerland, the Granger *F*-test failed to reject the null hypothesis of no causality from *EXP* to *GDP*. At the same time, the Granger *F*-test rejected the null hypothesis of no causality from *GDP* to *EXP*. These results indicate a unidirectional causality from exports to economic growth in Switzerland. Overall, the Granger causality analysis indicated that there was a statistically significant causality between exports and economic growth in France and Switzerland, which was in line with the results of the ARDL analysis. However, the causality test failed to detect any export–growth causal relationship in Norway.

Table 6. Findings from the Granger test.

Countries	*EXP would cause GDP*	*GDP would cause EXP*
France	17.868[3]**	11.787[3]***
Norway	1.289[3]	4.013[3]
Switzerland	3.051[2]	15.294[3]***

* indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level. Numbers in brackets indicate the optimal lag length. The maximum lag length was set at three, and the Akaike information criterion (Akaike 1974) was used to determine the optimal lag length.

Finally, the rolling Granger causality test examined the stability of the causal relationships between exports and economic growth in the three countries. Figure 2 depicts the findings for France, including the rejection rate. As the figure demonstrates, the rejection rate for France was 0.37, which means that more than one-third of the rolling causality statistics in the whole sample was statistically significant at the 5% level. In addition, the rolling causality statistic served as a basis for separating the whole sample period of 1984Q4 to 2016Q4 into four sub-sample periods; namely, 1984Q4 to 1994Q1, 1994Q2 to 2000Q4, 2001Q1 to 2011Q1, and 2011Q2 to 2016Q4. In the first sub-sample period (1984Q4 to 1994Q1), no causal relationship was detected between exports and economic growth in France. This indicates that the country's exports did not contribute to the economic growth over that time span. In the second sub-sample period (1994Q2 to 2000Q4, except for 2000Q3), there was a significant causal relationship between France's exports and economic growth. The third sub-sample period (2001Q1 to 2011Q1) coincided with a global economic crisis, and France faced a range of economic problems, which could have resulted in the absence of a statistically significant export–growth causal relationship. In the fourth sub-sample period (2011Q2 to 2016Q4), a statistically significant causal relationship was detected between the country's exports and economic growth.

The findings for Norway are depicted in Figure 3. The rejection rate of 0.27 indicated that approximately one-fourth of the rolling causal statistics in the whole sample for Norway was statistically significant at the 5% level. The rolling causality statistics served as a basis to separate the whole sample into five major sub-sample periods. These sub-sample periods were: 1984Q4 to 1986Q3, 1986Q4 to 1990Q3, 1990Q4 to 1998Q3, 1998Q4 to 2012Q3, and 2012Q4 to 2016Q4. In the first sub-sample (1984Q4 to 1986Q3, except for 1984Q4 to 1985Q1), there existed a statistically significant causal relationship between Norway's exports and economic growth. Therefore, during this

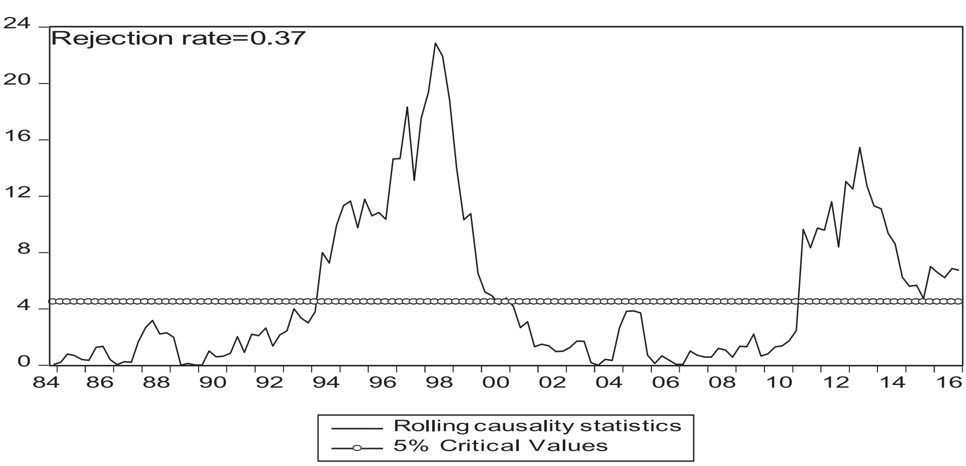

Figure 2. Findings from the rolling causality test for France.

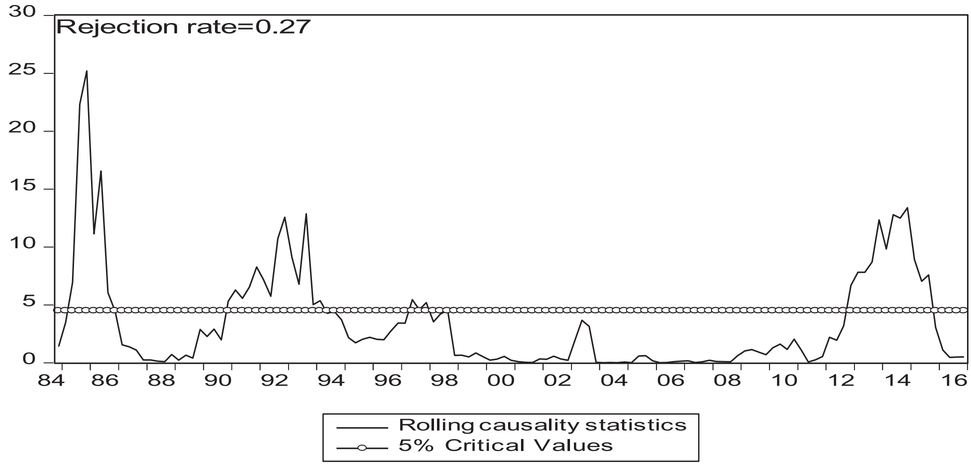

Figure 3. Findings from the rolling causality test for Norway.

particular time span the country's exports contributed to its economic growth. In the second sub-sample (1986Q4 to 1990Q3), no causal relationship between the variables could be found. In the third sub-sample (1990Q4 to 1998Q3, except for two short periods of 1994Q2 to 1997Q1 and 1998Q1 to 1998Q2), there existed a statistically significant causal relationship between Norway's exports and economic growth. In the fourth sub-sample (1998Q4 to 2012Q3), which coincided with the global economic slowdown in the late-2000s when Norway experienced economic problems, no export–growth causal relationship was detected. In the fifth sub-sample (2012Q4 to 2016Q4, except for the 2015Q4 to 2016Q4 period), a significant causal relationship was found to exist between the country's exports and economic growth.

Figure 4 offers a graphical representation of the findings from the rolling causality test for Switzerland. The reject rate of 0.24 indicates that slightly less than one-fourth of the rolling causal statistics in the whole sample were statistically significant at the 5% level. The rolling causality statistics were used to separate the whole sample period into four major sub-samples; namely, 1984Q4 to 1992Q3, 1992Q4 to 1997Q2, 1997Q3 to 2000Q3, and 2000Q4 to 2016Q4. In the first sub-sample (1984Q4 to 1992Q3, except for the brief time spans of 1985Q3 to 1986Q1, 1986Q3, and 1988Q3 to 1988Q4), there existed a significant export–growth causal relationship. This means that the country's exports provided a contribution to economic growth. In contrast, in the second sub-sample (1992Q4 to 1997Q2), no statistically significant causal relationships were detected between the two variables. In the third sub-sample (1997Q3 to 2000Q3, except for the short periods of 1998Q4 to 1991Q1 and 1999Q3 to 2000Q2), there was a statistically significant causal relationship between the country's exports and economic growth. However, no export–growth causal relationships were found to exist in the fourth sub-sample (2000Q4 to 2016Q4).

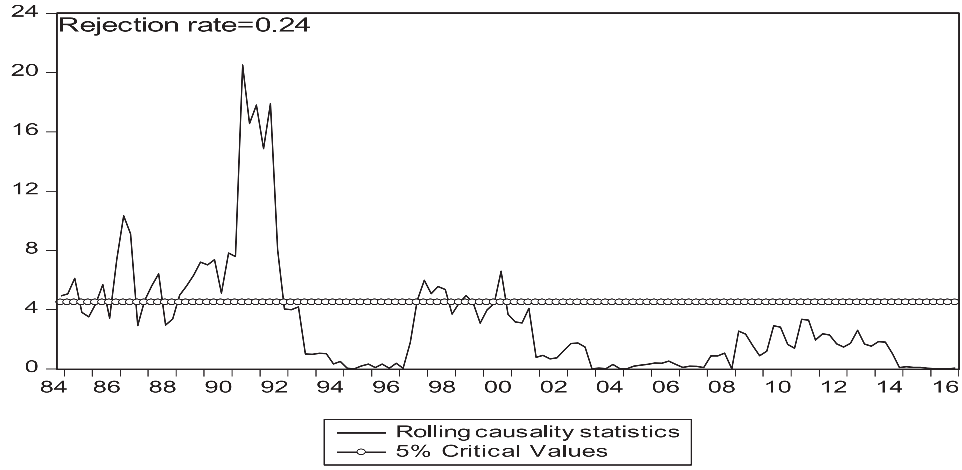

Figure 4. Findings from the rolling causality test for Switzerland.

Overall, the rolling Granger causality test indicated that the export–growth nexus in Norway was more unstable compared to France. This is because the rejection rate for Norway was smaller than the rejection rate for France. At the same time, the causal relationships in the time series for Norway could be described as more stable than in the data for Switzerland. This is because the rejection rate for Norway was slightly higher than the rejection rate for Switzerland. The findings from the five-step newly proposed statistical procedure can be summarized as follows. First of all, the unit root tests indicated that the time-series data on exports and economic growth in the three European countries were a stationary process at level. In addition, they had a mean-reversion tendency when the unit root tests could incorporate an unknown structural break and nonlinearity. Secondly, the long-memory test indicated that the mean-reversion of exports in Norway was weaker than in France and Switzerland. Thirdly, the cointegration test suggested that there existed a cointegrating relationship between exports and economic growth in France and Switzerland. In contrast, no long-run export–growth relationship could be found in the data for Norway. Fourthly, the causality test detected the presence of a causal relationship between exports and economic growth in France and Switzerland. However, no such causal relationship was found in the data for Norway. Fifthly, the rolling causality test indicated that the causal relationship between exports and economic growth in France was more stable than in Norway. At the same time, the export–growth causal relationship in Norway was more stable than in Switzerland.

IV. Concluding remarks

The main objective of this study was to identify determinants of stability in a causal relationship between exports and economic growth. Using a newly proposed five-step statistical procedure, the study examined linkages between export diversification, mean-reversion of exports, and stability in the export–growth causality in three European countries—France, Norway, and Switzerland—over the period of 1980Q1 to 2016Q4. The main findings can be summarized as follows. Firstly, the ARDL test detected a long-run equilibrium relationship between France's exports and economic growth. Secondly, the Granger causality test indicated the presence of a statistically significant causality from exports to economic growth in the cases of France and Switzerland. As to the nature of this causal relationship, the findings from the rolling causality test suggested that the relationship between exports and economic growth in France was more stable than in Norway. Also, the causal relationship was more stable in Norway than in Switzerland.

To conclude, this study has offered empirical evidence in *partial* support of the first hypothesis concerning the relationship between export diversification and stability of the export–growth causal relationship. The findings indicated that the estimated rejection rate in the export–growth causal relationship in Norway was smaller than in France. However, it was also found that the estimated rejection rate in Norway was greater than in Switzerland; this latter result contradicted the first hypothesis. A plausible explanation for these inconsistent findings could be that economic growth in Switzerland was driven not only by the export sector, but also by other sectors, such as the financial and banking sectors. The global financial crisis in the late-2000s produced a strong negative impact on all of these sectors. However, while the export sector was able to eventually recover from the crisis, the other sectors could still be trying to overcome the negative shocks. As a result, no significant causal relationship was found to exist between Switzerland's exports and economic growth over the extended period of 2000Q4 to 2016Q4. At the same time, the findings have given *full* empirical support of the second hypothesis concerning the relationship between export diversification and mean-reversion of exports. In view of this study's findings, measures aimed at enhancing and upgrading the export sector's capacity would be much needed. For example, policymakers may want to devise additional incentives for domestic and foreign companies to stimulate their exports and enhance their research and development activities.

Acknowledgments

The analysis was conducted using the Ox program. The authors are grateful to Professor Jurgen A. Doornik of Oxford University for providing OxEdit free of charge for academic purposes. The current study's data and OxGauss codes are available at Furuoka's webpage: https://sites.google.com/site/fumitakafuruokaswebpage/data-and-oxgauss-codes-ii/paper-27. Also available on this webpage are supplementary files containing more extensive discussions

on the motivation of the study, the merits of the proposed statistical procedure, the selection and classification of the countries, the empirical findings from the panel data analysis, and the policy implications.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This study was conducted as part of a Jean Monnet Center of Excellence project (Project Number: 586907-EPP-1-2017-1-MY-EPPJMO-CoE). This work was supported by the European Commission.

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