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Financial development, economic growth, and income inequality: A Toda-Yamamoto panel causality test

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Abstract

This paper examines the causality between financial development, economic growth, and income inequality using panel data for 23 European Union countries over the period 1987–2017. The empirical study employs a trivariate setting of the Granger non-causality test based on the Toda and Yamamoto approach and uses several proxies of financial development to capture different dimensions of the banking system and stock markets. The findings reveal causal relationships between banking depth, economic growth, and income inequality. However, there are no causal relationships between banking efficiency and stability, stock market development, economic growth, and income inequality. Policymakers should focus primarily on economic growth to raise the demand for financial services in order to increase financial development and alleviate income inequality.

Keywords: economic growth; financial development; inequality; panel causality test
JEL Classification Codes: C53, D63, G20, O11

1. Introduction

The links between financial development and economic growth have been widely investigated; however, it is essential to address how these benefits are spread throughout the population (Aghion et al., 2021). Financial development is a crucial driver of economic growth. The theoretical literature about the relationship between financial development and economic growth has rooted in Schumpeter (1912), who argued that the financial system can provide better services to improve resource allocation to more productive investments, stimulating the innovation activities that eventually promote economic growth. On the contrary, Robinson (1952) considered that as an economy grows, further financial services are demanded, and the financial system increases; thus, financial development follows economic growth. Lucas (1988) mentioned that the role of the financial system is not substantial for economic growth. Establishing a causal relationship directly between inequality and growth is exceptionally

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difficult. The effect of growth on inequality suggests an inverted U curve known as the Kuznets (1955) hypothesis. In other words, inequality increases at the early stages of growth and then decreases as the economy becomes more mature. On the other hand, inequality can affect growth through various channels that can be beneficial or detrimental (Mdingi and Ho, 2021). Inequality can create more incentives through financial constraint relaxation, income mobility, and investment in education and physical capital to enhance economic growth. More recently, the link between financial development and income inequality has attracted more attention among researchers and practitioners. A well-functioning financial system can provide cheaper credit and facilitate access to finance for more segments of society. Consequently, the lower-income segments can acquire more education and job opportunities, the inequality gap is narrowed, and social welfare is improved (Banerjee and Newman, 1993; Galor and Zeira, 1993). Nevertheless, financial constraints could disproportionately aid the high-income segments of society that can be more reliable to repay the loans and gain access to credit, excluding the lower-income segments from borrowing and widening the inequality gap (Rajan and Zingales, 2003; Demirguc-Kunt and Levine, 2009).

Empirical studies have investigated the causality between financial development, economic growth, and income inequality without reaching a universal consensus. Despite the extensive literature about the causality between financial development and economic growth, the findings are inconclusive and can be classified in four ways. The supply-leading hypothesis suggests that financial development can lead to economic growth since a well-developed financial system can improve resource allocation, increase the efficiency of transactions, and lower costs (Christopoulos and Tsionas, 2004; Cavenaile et al., 2014; Pradhan et al., 2020; Küçüksakarya, 2021). The demand-following hypothesis proposes that economic growth can lead to financial system development (Zang and Kim, 2007; Hurlin and Venet, 2008; Al Nasser, 2015). The feedback hypothesis suggests a bidirectional causality between financial development and economic growth (Apergis et al., 2007; Swamy and Dharani, 2019; Nguyen et al., 2022). The neutrality hypothesis proposes no causal relationship between financial development and economic growth (Kar et al., 2011; Mtar and Belazreg, 2021). Most studies that examined the causality between economic growth and income inequality showed contradictory evidence. For example, causality can run from economic growth to inequality (Pérez-Moreno, 2009; Risso et al., 2013; Younsi and Bechtini, 2018; Aremo and Abiodun, 2020), income inequality can lead to economic growth (Risso and Sanchez-Carrera, 2012; Andrade et al., 2014; Amri, 2018) and income inequality and economic growth mutually cause each other (Jihène and Ghazi, 2013; Vo et al., 2019). Empirical research on the causal direction between financial development and income inequality is scarce and mainly denotes a unidirectional causality from financial development to inequality (Gimet and Lagoarde-Segot, 2011; Shahbaz et al., 2015; Sehrawat and Giri, 2016; Azam and Raza, 2018; Younsi et al., 2022).

Previous empirical studies about the causal relationships between financial development, economic growth, and income inequality are based on the bivariate framework. However, the direction of causality between the two variables can potentially change with the inclusion of a third variable (Odhiambo, 2009). In addition, the main findings demonstrate a sensitivity to the measurement of financial development, the econometric techniques, and the data sample (Kar et al., 2011). Most studies mainly use measures of the banking depth and stock market size or a composite financial development index without considering the different characteristics of the financial system. For instance, financial stability can also stimulate economic growth and attain a more equitable income distribution (Baiardi and Morana, 2018). Financial efficiency can foster economic growth (Chu, 2020), but it can also reduce income inequality (Weychert, 2020).

The recent global financial crisis has highlighted the importance of rethinking the links between financial development, economic growth, and income inequality. The causality between financial development, economic growth, and income inequality constitutes a critical issue for policymakers to address. The direction of causality may begin with financial development and lead to economic growth or reverse; meanwhile, the introduction of inequality can affect the direction directly or indirectly. A further understanding of the trivariate relationship can help policymakers plan the appropriate strategy to promote economic growth in the European Union, strengthen the financial system, and alleviate inequality.

This study aims to investigate the causal relationship between financial development, economic growth, and income inequality in 23 European Union countries, covering the period 1987–2017. This study makes several contributions to the existing literature. To the best of our knowledge, this is the first empirical analysis that carries out the Toda-Yamamoto panel causality test to examine the direction of causality between these variables in a trivariate framework. Additionally, financial development is measured separately by measurements of various dimensions of the banking system and stock market development, such as depth, efficiency, and stability.

The remainder of the paper is organized as follows: Sections 2 and 3 focus on the methodology and the data, respectively; Section 4 presents and discusses the results; and Section 5 provides the main conclusions and potential policy implications of the study.

2. Methodology

This study employs a Toda-Yamamoto panel causality test to consider the causality between financial development, economic growth, and income inequality. Andriansyah and Messinis (2019) extend the bivariate Granger non-causality test of heterogeneous panels proposed by Dumitrescu and Hurlin (2012) to a trivariate setting based on the approach of Toda and Yamamoto (1995). This method assumes that the variables can be non-stationary or have different order of integration, and cointegration tests are not required. Thus, an augmented vector autoregressive model (K+m) order is estimated with m additional lags as the maximum order of integration of variables, and K is the optimal lag length taken from the information criteria.

In a trivariate setting, the VAR (K+m) linear model is the following:

$$Y_{i,t} = \alpha_i + \sum_{p=1}^{K+m} \beta_{i,p} Y_{i,t-p} + \sum_{p=1}^{K+m} \gamma_{i,p} X_{1i,t-p} + \sum_{p=1}^{K+m} \delta_{i,p} X_{2i,t-p} + \varepsilon_{i,t} \tag{1}$$

where Y_i, X_{1i}, and X_{2i} are potentially non-stationary variables with a maximum order of integration m. The null hypothesis assumes that X_{1i} Granger does not cause Y_i while the variable X_{2i} is held constant.

Defining the Tlag=K+m, the modified Wald statistics are the following:

$$W_{i,T}^{*} = \frac{\hat{\theta}_i^{*\prime} R^{*\prime} [R^{*} (Z_i^{*\prime} Z_i^{*})^{-1} R^{*\prime}]^{-1} R^{*} \hat{\theta}_i^{*}}{\hat{\varepsilon}_i^{*\prime} \hat{\varepsilon}_i^{*} / (T - 3Tlag - 1)} \tag{2}$$

$$Z_{N,T}^{Hnc*} = \sqrt{\frac{N}{2K}} \left(W_{N,T}^{Hnc*} - K \right) \tag{3}$$

$$\tilde{Z}_{N}^{Hnc*} = \sqrt{\frac{N \times (T - 3Tlag - 5)}{2K \times (T - 2K - 3m - 6)}} \times \left[\frac{(T - 3Tlag - 3)}{(T - 3Tlag - 1)} \times W_{N,T}^{Hnc*} - K \right] \tag{4}$$

A general dynamic model for the causality relationships between financial development, economic growth, and income inequality is specified using the following (K+m) order trivariate panel vector autoregressive (VAR):

$$GDP_{i,t} = \alpha_{1i} + \sum_{p=1}^{K+m} \beta_{1i,p}\, GDP_{i,t-p} + \sum_{p=1}^{K+m} \gamma_{1i,p}\, FINANCE_{i,t-p} + \sum_{p=1}^{K+m} \delta_{1i,p}\, GIN_{i,t-p} + \varepsilon_{1i,t} \tag{5}$$

$$GIN_{i,t} = \alpha_{2i} + \sum_{p=1}^{K+m} \beta_{2i,p}\, GDP_{i,t-p} + \sum_{p=1}^{K+m} \gamma_{2i,p}\, FINANCE_{i,t-p} + \sum_{p=1}^{K+m} \delta_{2i,p}\, GIN_{i,t-p} + \varepsilon_{2i,t} \tag{6}$$

$$FINANCE_{i,t} = \alpha_{3i} + \sum_{p=1}^{K+m} \beta_{3i,p}\, GDP_{i,t-p} + \sum_{p=1}^{K+m} \gamma_{3i,p}\, FINANCE_{i,t-p} + \sum_{p=1}^{K+m} \delta_{3i,p}\, GIN_{i,t-p} + \varepsilon_{3i,t} \tag{7}$$

where GDP is economic growth, $FINANCE$ constitutes the proxies of financial development, and GIN measures the income inequality for each individual country i (i = 1, …, N) at time t (t = 1, …, T). Since the models are heterogeneous panel data, the coefficients α_{1i}, α_{2i}, and α_{3i} are fixed across time while the coefficients of variables $\beta_{i,p}$, $\gamma_{i,p}$ and $\delta_{i,p}$ may differ both between and across the equations. Additionally, the errors $\varepsilon_{1i,t}$, $\varepsilon_{2i,t}$, and $\varepsilon_{3i,t}$ are assumed to be independently and normally distributed. Taking into consideration the cross-sectional dependence, this test suggests the use of bootstrapped critical values based on the bootstrapping technique to the trivariate Toda and Yamamoto (1995) framework.

3. Data

This study uses annual panel data from 23 European Union countries, namely, Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain and Sweden, over the period 1987 - 2017. Diverse proxies of financial development are used to capture not only the financial structure – the banking system and stock markets - but also the three dimensions of the financial system, such as depth, efficiency, and stability, as described by Cihak et al. (2012). More details about the indicators of financial development are summarized in Table 1. Economic growth (GDP) is measured by the annual percentage growth rate of GDP per capita based on constant 2010 U.S. dollars, and income inequality is measured by the Gini index (GIN) as the estimate of disposable income after tax and transfers. The data were received from the Global Financial Development Database (2019), the World Development Indicators of the World Bank, and the Standardized World Income Inequality Database derived by Solt (2019). All variables are transformed into their natural logarithms.

4. Results

Prior to determining the causality directions between financial development, economic growth, and income inequality, the empirical analysis requires the implementation of cross-sectional dependence tests, namely, Breusch and Pagan (1980), Pesaran (2004), and Pesaran et al. (2008). The results are reported in Table 2. The null hypothesis of no cross-sectional dependence is rejected at the one percent significance level and implies that the European Union countries are strongly integrated, and that a shock in one country can be disseminated to other countries.

Table 1. Definition of financial development indicators

Variables	Indicators
Banking depth	
Private credit (PRV)	Private credit by deposit money banks to GDP (%)
Bank assets (BAS)	Deposit money bank assets to deposit money bank assets and central bank assets (%)
Liquid liabilities (LLY)	Liquid liabilities to GDP (%)
Stock markets size and activity	
Stock market capitalization (SMC)	Stock market capitalization to GDP (%)
Value traded (VTR)	Stock market total value traded to GDP (%)
Banking efficiency	
Interest margin (INT)	Bank net interest margin (%)
Stock markets efficiency	
Turnover ratio (TOR)	Stock market turnover ratio (%)
Banking Stability	
Z-score (ZSC)	Bank Z-score
Non-performing loans (NPL)	Bank nonperforming loans to gross loans (%)
Stock markets stability	
Stock price volatility (SPV)	Stock price volatility

Table 2. Cross-sectional dependence tests

	PRV	BAS	LLY	SMC	VTR	INT	TOR	ZSC	NPL	SPV
LM	1392*	1500*	1366*	1240*	1565*	1497*	1459*	1437*	1542*	1232*
LM_{adj}*	149.3*	164*	145.7*	128.8*	171.9*	164.2*	158.9*	156.5*	170.2*	128.7*
LM_{CD}*	24.48*	26.91*	24.64*	23.28*	28.06*	26.86*	26.97*	26.37*	27.7*	22.98*

Notes: LM is the Breusch and Pagan (1980) test, LM_{CD}* is the Pesaran (2004) test, and LM_{adj}* is the Pesaran et al. (2008) test. * corresponds to the 1% significance level.

Subsequently, the second-generation panel unit root tests are more appropriate for checking the stationarity of variables. Table 3 presents the results of the CIPS test proposed by Pesaran (2007). In general, the test shows that liquid liabilities, stock market capitalization, value traded, margin interest, turnover ratio, bank Z-score, non-performing loans, stock price volatility, and economic growth are stationary at levels or integrated zero-order I(0). However, the private credit, bank assets, and income inequality are stationary at first differences or integrated first order I(1).

Table 4 shows the results of the panel cointegration tests developed by Westerlund (2007). The null hypothesis that assumes the absence of cointegration is rejected at a one percent significance level both in panels as a whole and in groups. Therefore, the three variables are cointegrated, and a long-run equilibrium relationship exists between financial development, economic growth, and income inequality.

Table 5 displays the results of the three information criteria. The maximum number of lags in panel VAR models differs and depends on the criterion. Following the Schwarz Bayesian information criterion, the optimal lag length is selected as one (K = 1).

Table 3. CIPS panel unit root test.

	Level			First Differences		Integration order
	Constant	Constant and trend		Constant	Constant and trend	
PRV	-1.857	-2.183	ΔPRV	-4.398***	-4.608***	I(1)
BAS	-1.501	-2.160	ΔBAS	-3.845***	-3.966***	I(1)
LLY	-2.501***	-3.109***	ΔLLY	-4.670***	-4.862***	I(0)
SMC	-2.631***	-2.748***	ΔSMC	-4.912***	-5.030***	I(0)
VTR	-2.508***	-2.854***	ΔVTR	-5.139***	-5.191***	I(0)
INT	-3.502***	-3.654***	ΔINT	-5.926***	-6.073***	I(0)
TOR	-2.765***	-3.384***	ΔTOR	-5.823***	-5.904***	I(0)
ZSC	-3.068***	-3.636***	ΔZSC	-6.081***	-6.242***	I(0)
NPL	-2.845***	-3.557***	ΔNPL	-5.828***	-5.961***	I(0)
SPV	-2.771***	-3.212***	ΔSPV	-5.665***	-5.721***	I(0)
GDP	-4.232***	-4.840***	ΔGDP	-6.110***	-6.287***	I(0)
GIN	-2.009	-2.331	ΔGIN	-3.800***	-4.084***	I(1)

Notes: For model with constant, the critical values are -2.3, -2.16 and -2.08 for significance level 1%, 5% and 10% respectively. For model with constant and trend, the critical values are -2.78, -2.65 and -2.58 for significance level 1%, 5% and 10%, respectively.

Table 4. Westerlund (2007) panel cointegration test.

Model: GDP, PRV, GIN				**Model: GDP, INT, GIN**		
statistic	**value**	**z-value**	**p-value**	**value**	**z-value**	**p-value**
Gt	-4.579	-14.634	0.000***	-3.711	-10.661	0.000***
Ga	-15.393	-8.393	0.000***	-13.012	-6.305	0.000***
Pt	-39.701	-26.495	0.000***	-25.953	-16.149	0.000***
Pa	-21.949	-19.032	0.000***	-18.851	-16.001	0.000***
	Model: GDP, BAS, GIN			**Model: GDP, TOR, GIN**		
Gt	-4.246	-13.111	0.000***	-4.258	-13.162	0.000***
Ga	-13.885	-7.070	0.000***	-14.562	-7.664	0.000***
Pt	-29.423	-18.761	0.000***	-28.245	-17.874	0.000***
Pa	-22.210	-19.287	0.000***	-25.064	-22.080	0.000***
	Model: GDP, LLY, GIN			**Model: GDP, ZSC GIN**		
Gt	-4.519	-14.360	0.000***	-4.065	-12.281	0.000***
Ga	-14.779	-7.854	0.000***	-14.245	-7.386	0.000***
Pt	-39.209	-26.126	0.000***	-26.824	-16.805	0.000***
Pa	-23.094	-20.152	0.000***	-24.603	-21.629	0.000***
	Model: GDP, SMC, GIN			**Model: GDP, NPL, GIN**		
Gt	-3.942	-11.716	0.000*	-4.085	-12.373	0.000***
Ga	-13.358	-6.608	0.000***	-14.516	-7.623	0.000***
Pt	-23.559	-14.348	0.000***	-24.805	-15.285	0.000***
Pa	-22.674	-19.741	0.000***	-23.605	-20.652	0.000***
	Model: GDP, VTR, GIN			**Model: GDP, SPV, GIN**		
Gt	-3.960	-11.800	0.000***	-3.822	-11.170	0.000***
Ga	-14.391	-7.514	0.000***	-13.600	-6.820	0.000***
Pt	-25.155	-15.549	0.000***	-25.838	-16.063	0.000***
Pa	-25.292	-22.303	0.000***	-24.738	-21.761	0.000***

Notes: Models with dependent variable: GDP and independent variables: FINANCE {PRV, BAS, LLY, SMC, VTR, INT, TOR, ZSC, NPL, SPV} & GIN. *** is the 1% significance level.

Table 5: Panel VAR Lag Order Selection criteria

Model	Lags	BIC	AIC	HQIC
GDP, PRV, GIN	1	-176.7299*	-26.24927*	-85.38438*
	2	-134.2542	-21.39371	-65.74504
	3	-105.8237	-30.58342	-60.15097
GDP, BAS, GIN	1	-166.3589*	-15.87825	-75.01336*
	2	-135.8928	-23.03236	-67.3837
	3	-99.37876	-24.13846*	-53.70602
GDP, LLY, GIN	1	-183.485*	-33.00436*	-92.13947*
	2	-139.7891	-26.92868	-71.28001
	3	-94.92619	-19.68589	-49.25344
GDP, SMC, GIN	1	-167.6071	-17.12647	-76.26158
	2	-145.1766	-32.31617	-76.66751
	3	-99.32264	-24.08234	-53.64989
GDP, VTR, GIN	1	-185.6031*	-35.12253	-94.25764*
	2	-153.3667	-40.50622*	-84.85755
	3	-102.0422	-26.80194	-56.36949
GDP, INT, GIN	1	-194.0911	-43.61052	-102.7456
	2	-138.5891	-25.72868	-70.08001
	3	-104.8003	-29.56002	-59.12758
GDP, TOR, GIN	1	-193.0783*	-42.59766*	-101.7328*
	2	-143.972	-31.11155	-75.46289
	3	-99.49836	-24.25806	-53.82561
GDP, ZSC, GIN	1	-186.9448*	-36.46419*	-95.5993*
	2	-143.064	-30.20357	-74.5549
	3	-106.2341	-30.99383	-60.56139
GDP, NPL, GIN	1	-171.3218*	-20.84122	-79.97633*
	2	-146.7352	-33.87475*	-78.22608
	3	-103.5986	-28.35831	-57.92587
GDP, SPV, GIN	1	-182.9764*	-32.4958*	-91.63091*
	2	-139.6847	-26.82428	-71.17561
	3	-98.25104	-23.01074	-52.57829

Notes: Schwarz Bayesian information criterion (BIC), Akaike information criterion (AIC), and Hannan and Quinn information criterion (HQ).

The Toda-Yamamoto panel non-causality test in heterogenous panels is conducted with additional lags equal to one (m = 1), and the order of panel VAR is specified as one (K = 1). Table 6 presents the results of the panel causality test. The results show that private credit Granger causes income inequality, economic growth Granger causes income inequality, and a unidirectional causality runs from economic growth to private credit. In addition, economic growth Granger causes bank assets, income inequality Granger causes bank assets, and a bidirectional causality exists between economic growth and income inequality. Liquid liabilities Granger cause both economic growth and income inequality, inequality Granger causes economic growth, and reverse causality exists from income inequality and economic growth to liquid liabilities and from economic growth to income inequality. Although income inequality Granger causes both margin interest and economic growth, causality does not exist between margin interest and economic growth. Similarly, bank Z-score Granger causes income inequality and economic growth Granger causes income inequality; meanwhile, no causality exists between bank Z-score and economic growth. Stock market capitalization Granger causes inequality but does not Granger cause economic growth, while inequality Granger causes economic growth. Economic growth Granger causes value traded, and inequality Granger causes growth without evidence of causality between value traded and inequality. The turnover ratio does not Granger cause both inequality and growth even if inequality Granger causes growth. Non-performing loans Granger cause inequality, inequality Granger causes growth, but no causal relationship exists between non-performing loans and economic growth. Stock price volatility does not Granger cause neither inequality nor growth, while inequality Granger causes economic growth.

The results reveal that a trivariate causality exists between economic growth, financial development, and income inequality when private credit, bank assets, and liquid liabilities are used as measurements to capture the banking depth of the financial sector. Also, the results show the absence of trivariate causality between economic growth, income inequality, and the efficiency and stability of the banking system. In terms of the stock market development, none of the dimensions of stock markets, such as size, efficiency, and stability, support a trivariate causality with economic growth, and income inequality. In summary, economic growth can lead to inequality and banking depth. These results confirm the demand following hypothesis in line with the findings of Hurlin and Venet (2008) and Al Nasser (2015), who found unidirectional causality running from economic growth to banking development and the findings of Younsi and Bechtini (2018) and Aremo and Abiodun (2020) who suggest a unidirectional causality from economic growth to income inequality. Also, the results are consistent with Gimet and Lagoarde-Segot (2011), Shahbaz et al. (2015), Sehrawat and Giri (2016), Azam and Raza (2018) and Younsi et al. (2022), who found that the direction of causality runs from financial development to income inequality.

Table 6. Trivariate Toda-Yamamoto approach for Granger non-causality test in heterogeneous panels.

Causality hypothesis	**Asymptotic Wald statistic**		**Bootstrap critical values 1%**	**5%**	**10%**
Private credit → economic growth	$Z_{N,T}^{Hnc}$	0.4587	5.3903	3.8642	3.1890
	$\tilde{Z}_{N}^{Hnc}$	0.1379	4.6585	3.2596	2.6406
Private credit → income inequality	$Z_{N,T}^{Hnc}$	10.6432***	4.1064	4.0835	4.0720
	$\tilde{Z}_{N}^{Hnc}$	9.4737***	3.4816	3.4606	3.4501
Economic growth → private credit	$Z_{N,T}^{Hnc}$	9.1702***	6.3749	5.8298	5.6008
	$\tilde{Z}_{N}^{Hnc}$	8.1234***	5.5610	5.0614	4.8515
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	1.6830***	0.4656	0.4445	0.4334
	$\tilde{Z}_{N}^{Hnc}$	1.2602***	0.1442	0.1248	0.1147
Income inequality → private credit	$Z_{N,T}^{Hnc}$	2.5477	3.9039	3.3180	3.0848
	$\tilde{Z}_{N}^{Hnc}$	2.0528	3.2960	2.7589	2.5451
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	17.6902***	4.6348	3.8019	3.4174
	$\tilde{Z}_{N}^{Hnc}$	15.9334***	3.9659	3.2024	2.8500
Bank assets → economic growth	$Z_{N,T}^{Hnc}$	9.8089	43.4446	42.3324	41.7730
	$\tilde{Z}_{N}^{Hnc}$	8.7089	39.5416	38.5221	38.0094
Bank assets → income inequality	$Z_{N,T}^{Hnc}$	6.8758	39.1808	39.0146	38.9206
	$\tilde{Z}_{N}^{Hnc}$	6.0202	35.6332	35.4808	35.3946
Economic growth → bank assets	$Z_{N,T}^{Hnc}$	5.6856***	4.4334	4.3725	4.3409
	$\tilde{Z}_{N}^{Hnc}$	4.9292***	3.7814	3.7255	3.6966
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	2.3301***	0.9214	0.8872	0.8691
	$\tilde{Z}_{N}^{Hnc}$	1.8533***	0.5620	0.5307	0.5140
Income inequality → bank assets	$Z_{N,T}^{Hnc}$	7.0248***	3.5893	3.4124	3.3104
	$\tilde{Z}_{N}^{Hnc}$	6.1568***	3.0076	2.8454	2.7519
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	27.6402***	4.6204	3.4512	2.9362
	$\tilde{Z}_{N}^{Hnc}$	25.0542***	3.9528	2.8810	2.4089

Table 6. Trivariate Toda-Yamamoto approach for Granger non-causality test in heterogeneous panels (cont'd).

Causality hypothesis	Asymptotic Wald statistic		Bootstrap critical values 1%	5%	10%
Liquid liabilities → economic growth	$Z_{N,T}^{Hnc}$	4.2594**	5.0896	4.2021	3.3814
	$\tilde{Z}_{N}^{Hnc}$	3.6218**	4.3828	3.5693	3.2295
Liquid liabilities → income inequality	$Z_{N,T}^{Hnc}$	4.5731***	-0.2430	-0.2618	-0.2706
	$\tilde{Z}_{N}^{Hnc}$	3.9094***	-0.5053	-0.5226	-0.5307
Economic growth → liquid liabilities	$Z_{N,T}^{Hnc}$	8.0763***	6.2952	5.6997	5.4907
	$\tilde{Z}_{N}^{Hnc}$	7.1207***	5.4880	4.9421	4.7505
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	1.2674***	1.1176	1.0779	1.0564
	$\tilde{Z}_{N}^{Hnc}$	0.8792***	0.7419	0.7055	0.6858
Income inequality → liquid liabilities	$Z_{N,T}^{Hnc}$	4.2594**	4.9394	4.1674	3.8194
	$\tilde{Z}_{N}^{Hnc}$	3.6218**	4.2451	3.5375	3.2185
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	9.9509***	3.8411	3.3754	3.1131
	$\tilde{Z}_{N}^{Hnc}$	8.8391***	3.2384	2.8115	2.5710
Market capitalization → economic growth	$Z_{N,T}^{Hnc}$	5.2801	9.8942	7.7624	6.6420
	$\tilde{Z}_{N}^{Hnc}$	4.5575	8.7871	6.8329	5.8059
Market capitalization → income inequality	$Z_{N,T}^{Hnc}$	2.8995***	1.4433	1.4203	1.4093
	$\tilde{Z}_{N}^{Hnc}$	2.3752***	1.0404	1.0194	1.0092
Economic growth → market capitalization	$Z_{N,T}^{Hnc}$	1.9262	5.4739	4.5183	4.0635
	$\tilde{Z}_{N}^{Hnc}$	1.4830	4.7351	3.8592	3.4423
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.3724	1.5426	1.5068	1.4906
	$\tilde{Z}_{N}^{Hnc}$	0.0587	1.1315	1.0986	1.0838
Income inequality → market capitalization	$Z_{N,T}^{Hnc}$	2.9649	7.8809	6.7257	6.1841
	$\tilde{Z}_{N}^{Hnc}$	2.4352	6.9415	5.8826	5.3862
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	14.2433***	4.3381	3.6574	3.3225
	$\tilde{Z}_{N}^{Hnc}$	12.7738***	3.6940	3.0700	2.7630
Value traded → economic growth	$Z_{N,T}^{Hnc}$	1.1796	8.0355	6.1042	5.1899
	$\tilde{Z}_{N}^{Hnc}$	0.7987	7.0832	5.3129	4.4748
Value traded → income inequality	$Z_{N,T}^{Hnc}$	-0.0282	7.6046	7.6387	7.6553
	$\tilde{Z}_{N}^{Hnc}$	-0.3084	6.6883	6.7196	6.7347
Economic growth → value traded	$Z_{N,T}^{Hnc}$	2.8295**	3.4393	1.5769	0.9944
	$\tilde{Z}_{N}^{Hnc}$	2.3111**	2.8701	1.1629	0.6289
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.5036	2.3519	2.3248	2.3101
	$\tilde{Z}_{N}^{Hnc}$	0.1791	1.8733	1.8485	1.8350
Income inequality → value traded	$Z_{N,T}^{Hnc}$	2.0401	6.1204	5.0660	4.5554
	$\tilde{Z}_{N}^{Hnc}$	1.5875	5.3278	4.3612	3.8931
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	18.6535***	4.2677	3.6032	3.2978
	$\tilde{Z}_{N}^{Hnc}$	16.8165***	3.6295	3.0203	2.7404

Table 6. Trivariate Toda-Yamamoto approach for Granger non-causality test in heterogeneous panels (cont'd).

Causality hypothesis	**Asymptotic Wald statistic**		**Bootstrap critical values 1%**	**5%**	**10%**
Margin interest → economic growth	$Z_{N,T}^{Hnc}$	2.3550	8.6626	6.7373	5.8305
	$\tilde{Z}_{N}^{Hnc}$	1.8762	7.6582	5.8933	5.0620
Margin interest → income inequality	$Z_{N,T}^{Hnc}$	1.0247	2.2741	2.2379	2.2204
	$\tilde{Z}_{N}^{Hnc}$	0.6567	1.8020	1.7688	1.7527
Economic growth → margin interest	$Z_{N,T}^{Hnc}$	0.0221	4.7852	3.4522	2.7693
	$\tilde{Z}_{N}^{Hnc}$	-0.2623	-1.5530	-1.0274	-0.7191
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.8792***	0.0231	-0.0098	-0.0260
	$\tilde{Z}_{N}^{Hnc}$	0.5234***	-0.2614	-0.2915	-0.3065
Income inequality → margin interest	$Z_{N,T}^{Hnc}$	6.4372***	3.9758	3.2987	3.0065
	$\tilde{Z}_{N}^{Hnc}$	5.6182***	3.3619	2.7412	2.4734
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	21.6030***	3.3796	2.8118	2.4931
	$\tilde{Z}_{N}^{Hnc}$	19.5202***	2.8153	2.2949	2.0028
Turnover ratio → economic growth	$Z_{N,T}^{Hnc}$	0.0250	6.5670	4.7432	3.9990
	$\tilde{Z}_{N}^{Hnc}$	-0.2597	-0.9825	-0.3854	-0.0516
Turnover ratio → income inequality	$Z_{N,T}^{Hnc}$	-0.1485	6.0880	6.1313	6.1524
	$\tilde{Z}_{N}^{Hnc}$	-0.4187	5.2981	5.3378	5.3571
Economic growth → turnover ratio	$Z_{N,T}^{Hnc}$	-0.0248	-1.5815	-1.1851	-0.9412
	$\tilde{Z}_{N}^{Hnc}$	-0.3053	-1.7323	-1.3689	-1.1454
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.3982	1.4309	1.3925	1.3729
	$\tilde{Z}_{N}^{Hnc}$	0.0824	1.0290	0.9938	0.9759
Income inequality → turnover ratio	$Z_{N,T}^{Hnc}$	0.3850	4.1538	3.3522	2.9881
	$\tilde{Z}_{N}^{Hnc}$	0.0703	3.5250	2.7902	2.4565
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	22.5776***	3.8111	2.3467	1.9264
	$\tilde{Z}_{N}^{Hnc}$	20.4135***	3.2109	1.8685	1.4832
Bank Z-score → economic growth	$Z_{N,T}^{Hnc}$	1.7012	5.6370	4.0200	3.2248
	$\tilde{Z}_{N}^{Hnc}$	1.2769	4.8847	3.4024	2.6734
Bank Z-score → income inequality	$Z_{N,T}^{Hnc}$	0.6911***	0.1097	0.0637	0.0435
	$\tilde{Z}_{N}^{Hnc}$	0.3509***	-0.1820	-0.2242	-0.2428
Economic growth → bank Z-score	$Z_{N,T}^{Hnc}$	0.9011	2.1825	1.3417	0.9974
	$\tilde{Z}_{N}^{Hnc}$	0.5434	1.7180	0.9473	0.6317
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.4918***	0.0655	0.0348	0.0176
	$\tilde{Z}_{N}^{Hnc}$	0.1682***	-0.2225	-0.2507	-0.2664
Income inequality → bank Z-score	$Z_{N,T}^{Hnc}$	1.5371	5.3508	3.9960	3.4147
	$\tilde{Z}_{N}^{Hnc}$	1.1264	4.6223	3.3804	2.8475
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	20.2310***	3.1793	2.0734	1.6270
	$\tilde{Z}_{N}^{Hnc}$	18.2625***	2.6318	1.6180	1.2088

Table 6. Trivariate Toda-Yamamoto approach for Granger non-causality test in heterogeneous panels (cont'd).

Causality hypothesis	**Asymptotic Wald statistic**		**Bootstrap critical values 1%**	**5%**	**10%**
Non-performing loans → economic growth	$Z_{N,T}^{Hnc}$	1.8858	8.8336	6.7034	5.7125
	$\tilde{Z}_{N}^{Hnc}$	1.4460	7.8149	5.8622	4.9539
Non-performing loans → income inequality	$Z_{N,T}^{Hnc}$	1.8681***	-0.1328	-0.1520	-0.1615
	$\tilde{Z}_{N}^{Hnc}$	1.4298***	-0.4044	-0.4219	-0.4307
Economic growth → non-performing loans	$Z_{N,T}^{Hnc}$	3.7638*	5.0676	3.8170	3.2405
	$\tilde{Z}_{N}^{Hnc}$	3.1675*	4.3627	3.2163	2.6879
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	0.1981	0.9391	0.9124	0.8986
	$\tilde{Z}_{N}^{Hnc}$	-0.1010	0.4208	0.4441	0.4559
Income inequality → non-performing loans	$Z_{N,T}^{Hnc}$	1.9772	3.4679	2.5869	2.1431
	$\tilde{Z}_{N}^{Hnc}$	1.5298	2.8963	2.0887	1.6819
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	22.3514***	3.0527	2.2540	1.8679
	$\tilde{Z}_{N}^{Hnc}$	20.2062***	2.5157	1.7835	1.4297
Stock price volatility → economic growth	$Z_{N,T}^{Hnc}$	0.1881	10.7557	7.2946	5.7571
	$\tilde{Z}_{N}^{Hnc}$	-0.1102	-1.4563	-0.7820	-0.3958
Stock price volatility → income inequality	$Z_{N,T}^{Hnc}$	-0.3495	-1.1612	-1.1335	-1.1210
	$\tilde{Z}_{N}^{Hnc}$	-0.6029	-1.3471	-1.3216	-1.3102
Economic growth → stock price volatility	$Z_{N,T}^{Hnc}$	-0.3586	3.4064	4.1773	4.5898
	$\tilde{Z}_{N}^{Hnc}$	-0.6114	2.8399	3.5466	3.9247
Economic growth → income inequality	$Z_{N,T}^{Hnc}$	-0.3957	0.8676	0.8961	0.9112
	$\tilde{Z}_{N}^{Hnc}$	-0.6454	0.5127	0.5388	0.5526
Income inequality → stock price volatility	$Z_{N,T}^{Hnc}$	1.0006	5.4201	4.6894	4.3985
	$\tilde{Z}_{N}^{Hnc}$	0.6346	4.6858	4.0160	3.7493
Income inequality → economic growth	$Z_{N,T}^{Hnc}$	25.9749***	5.7658	1.0478	0.5657
	$\tilde{Z}_{N}^{Hnc}$	23.5277***	5.0027	0.6779	0.2360

Notes: → means the first variable Granger causes the second variable while holding the third variable constant. The number of iterations for computing bootstrapped critical values is 10,000 times. *** ,** and * denotes significant level at 1%, 5 %, and 10 %, respectively.

5. Concluding remarks

This study examines the causality between financial development, economic growth, and income inequality for 23 European Union countries from 1987 to 2017, employing a trivariate Granger non-causality test of heterogeneous panels based on the approach of Toda and Yamamoto (1995). The results reveal that the direction of causality is ambiguous and depends on whether the financial development stems from the measurements of the banking sector or the stock markets. The measures of banking depth have been found to exert a trivariate causality with economic growth and income inequality. However, the measures of the other dimensions of the financial system do not tend to have a causal relationship with economic growth and income inequality.

To determine the trivariate causality, private credit and liquid liabilities constitute considerable measures that represent the overall size of the banking sector and the ability of banks to allocate more credit to the private sector relative to bank assets that measure the importance of commercial banks to allocate savings. Thus, financial development follows economic growth, but economic growth can also mitigate income inequality through a well-developed banking system that can be sufficient to allocate and mobilize capital, helping the poor to have equal business and education opportunities.

According to the above empirical results, policymakers should focus primarily on other growth-enhancing strategies. Governments must devise fiscal policies and support investments to improve economic growth. Economic improvements can stimulate financial services and succeed in higher levels of financial development. Policymakers should encourage reforms of the banking system to remove regulatory obstacles in order to deal with the problem of income inequalities.

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