Innovation, Financial Development and Economic Growth in Eurozone Countries

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Abstract

Using a panel vector auto-regressive model, we study interactions between innovation, financial development and economic growth in 18 Eurozone countries between 1961 and 2013. We focus on whether causality runs between these variables both ways, one way, the other way or not at all. Our empirical results show that development of the financial sector and enhanced innovative capacity in the Eurozone contribute to long-term economic growth in the countries in the region.

Keywords: Innovation, financial development, economic growth, Granger causality, Eurozone countries

JEL Classification: O43, O16, E44, E31

1. Introduction

Key drivers of sustained economic growth have received considerable attention from development economists, policy-makers and the corporate sector. Schumpeter (1911), an early thinker, argued that the economic growth of countries depends on financial market sophistication, which enables efficient allocation of financial resources and innovations that enhance economic productivity and meet markets' needs. Using endogenous growth theory, Levine (1997) shows that financial institutions play a key role in providing firms with information important for investment decisions, contributing to economic growth. King and Levine (1993) demonstrate that financial sector development contributes to economic growth by increasing innovative activities. In the same vein, Romer (1990) uses endogenous growth theory to show that technology, human capital development, and research and development (R&D) are important sources of economic growth.

Since the emergence of endogenous growth theory, several empirical studies have considered how financial market development might contribute to economic growth (for example, Levine, 1993; Pradhan et al., 2014), how innovation might impact upon economic growth (Cameron, 1998), and how financial market development might affect technological innovation (Hsu et al., 2014).

The contribution of this study is two-fold. Firstly, the results of this study shed additional light on relationships between variables in the dynamics between economic growth and financial sector development, and between growth and innovation, as prior empirical results on these variables are mixed – economic growth may even hinder financial development or innovation (Galindo and Mendez; 2014; Hsu et al., 2014). Secondly, the study examines the trivariate causal relationship between economic growth, financial sector development and innovation, as to our knowledge no prior empirical work considers the possible causal relationships between all three variables simultaneously.

The paper is structured as follows: Section 2 explains the empirical model and data used in the study; Section 3 presents and discusses the empirical results; and Section 4 indicates the derived policy implications.

2. Data, Variables, and Empirical Model

We use annual time series data obtained from *World Development Indicators* for 18 countries[1] in the Eurozone (1961-2013).

We use real per capita economic growth and five different indicators for innovation: number of patents by residents per thousand population (PAR), number of patents by non-residents per thousand population (PAN), number of patents by residents and non-residents per thousand population (PAT), real research and development (R&D) expenditure as a percentage of real gross domestic product (RDE), and researchers engaged in R&D activities per million population (RRD). These proxies for innovation have previously been used, for example, by Galindo and Mendez (2014).

We also use up to eight different indicators for financial development to construct a composite index of financial development (CFD) using principal component analysis (PCA) (procedural details are discussed by Pradhan et al., 2014). These indicators are domestic credit to private sector (DCP), domestic credit to private sector by banks (DCB), domestic credit provided by the financial sector (DCF), market capitalization of listed companies (MCL), turnover ratio (TUR), total value of traded

[1] Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

stocks (TRA), and number of listed domestic companies (LDC).[2] These proxies have been uses in earlier work such as Pradhan et al. (2014).

We consider three samples covering different periods and indicators. The sample choice was data-driven. The first sample (1961-2013) covers three innovation indicators (PAR, PAN and PAT), and we use three financial development indicators to construct CFD. With the second sample (1989-2013), we use same three innovation indicators and eight financial development indicators to construct CFD. With the third sample (1989-2013), we use all five innovation indicators and eight financial development indicators to construct CFD.

We use the following empirical model to investigate possible directions of causality among these variables.

$$\begin{bmatrix} \Delta \ln GROWTH_{it} \\ \Delta \ln CFD_{it} \\ \Delta \ln INNOVATION_{it} \end{bmatrix} = \begin{bmatrix} \eta_{1j} \\ \eta_{2j} \\ \eta_{3j} \end{bmatrix} + \sum_{k=1}^{q} \begin{bmatrix} \mu_{11ik}(L)\mu_{12ik}(L)\mu_{13ik}(L) \\ \mu_{21ik}(L)\mu_{22ik}(L)\mu_{23ik}(L) \\ \mu_{31ik}(L)\mu_{32ik}(L)\mu_{33ik}(L) \end{bmatrix} \begin{bmatrix} \Delta \ln GROWTH_{it-k} \\ \Delta \ln CFD_{it-k} \\ \Delta \ln INNOVATION_{it-k} \end{bmatrix} + \begin{bmatrix} \gamma_{1i} ECT_{it-1} \\ \gamma_{2i} ECT_{it-1} \\ \gamma_{3i} ECT_{it-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \end{bmatrix} \quad \textbf{(1)}$$

where $\Delta$is the first difference filter; *i* is the country specification in the panel; *t* is the time period; and ε is the error term. *Innovation* is defined as PAR, PAN, PAT, RDE, or RRD.

The ECT_{-1}'s are the lagged error-correction terms that represent the long-run dynamics; differenced variables represent the short-run dynamics between the variables. The above model provides robust results if the time series variables are integrated of order one (I (1)) and cointegrated. If the variables used in Eq. (1) are not cointegrated, the ECT_{-1}'s are removed in the estimation process. Several possibilities exist. For

[2] All monetary variables are measured in real U.S. dollars.

example, if neither μ_{12ik}, μ_{13ik}, μ_{21ik}, nor μ_{31ik} are significantly different from zero, financial development, innovation, and economic growth are not causally related. If only μ_{12ik} is statistically different from zero and other μ*'s* are not, then only financial development Granger-causes economic growth. If only μ_{13ik} is statistically different from zero and other μ*'s* are not, only innovation Granger-causes economic growth. If all μ_{12ik}, μ_{13ik}, μ_{21ik}, and μ_{31ik} are statistically different from zero, this suggests bi-directional causality between the three sets of variables.

3. Empirical Results and Discussion

The vector error correction modelling (VECM) framework is used to examine the possible Granger causal relationships between innovation, financial development, and economic growth. The first step is determining the order of integration and nature of cointegration among these three variables.

We use the Breitung unit root test with a constant and deterministic trend to determine the order of integration of the variables in our panel setting. The test confirms that all the variables are I (1). These results suggest cointegration between innovation, financial development, and per capita economic growth. A panel cointegration test (the Kao test with the setting of an individual intercept) is then employed to test the hypothesis that there is a long-run relationship among these variables. The results from this test demonstrate the existence of a long-run equilibrium relationship between the three variables in our three samples.[3]

The above findings support our VECM approach to examine the Granger causal relationships among the variables, the results of which are summarized in Table 1 for the three samples we consider.

[3]The unit root and cointegration test results are not reported here due to space constraints, but are available from the authors upon request.

Table 1. Results of Panel Granger Causality Test

Dependent Variable	Independent variables and ECT_{-1}											

Sample 1: 1961-2013

	Case 1				Case 2				Case 3			
	ΔPEG	**ΔCFD**	**ΔPAR**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAN**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAT**	**ECT_{-1}**
ΔPEG	------	5.85*	1.31	-0.75*	------	7.36*	12.4*	-0.75*	------	6.67*	4.82*	-0.75*
ΔCFD	6.82*	------	0.09	0.02	11.1*	------	5.99*	0.10	8.02*	------	6.42*	0.02
ΔINN	24.9*	6.58*	------	0.23	1.92	2.84	------	0.05	7.42*	7.18*	------	0.15

Sample 2: 1989-2013

	Case 1				Case 2				Case 3			
	ΔPEG	**ΔCFD**	**ΔPAR**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAN**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAT**	**ECT_{-1}**
ΔPEG	------	11.6*	1.84	-0.90*	------	21.2*	13.3*	-0.91*	------	15.4*	6.51*	-0.92*
ΔCFD	6.60*	------	5.34*	0.13	12.9*	------	8.22*	0.19	9.17*	------	0.80	0.15
ΔINN	21.8*	4.50**	------	0.22	3.02	3.17	------	-0.10	3.73	6.60*	------	0.09

Sample 3: 1989-2013

	Case 1				Case 2				Case 3			
	ΔPEG	**ΔCFD**	**ΔPAR**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAN**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔPAT**	**ECT_{-1}**
ΔPEG	------	22.9*	0.80	-1.07*	------	34.3*	13.9*	-1.07*	------	27.6*	7.27*	-1.13*
ΔCFD	6.47*	------	3.36	0.02	8.92*	------	1.48	0.03	7.77*	------	0.80	0.03
ΔINN	27.2*	0.71	------	0.32	5.84*	0.08	------	-0.06	9.34*	4.13**	------	0.18

	Case 4				Case 5			
	ΔPEG	**ΔCFD**	**ΔRDE**	**ECT_{-1}**	**ΔPEG**	**ΔCFD**	**ΔRRD**	**ECT_{-1}**
ΔPEG	------	30.6*	5.96*	-1.11*	------	26.9*	1.84	-1.09**
ΔCFD	7.02*	------	10.9*	0.03	6.37*	------	1.32	0.02
ΔINN	10.8*	3.19	------	-0.01	0.94	1.38	------	0.03

Note 1: PEG: per capita economic growth rate; CFD: composite index of financial development; PAR: number of patents – residents; PAN: number of patents – non-residents; PAT: total patents – both residents and non-residents; RDE: research and development expenditure; RRD: researchers in research and development activities; and ECT_{-1}: lagged error-correction term.

***Note 2*:** INN stands for innovation and indicates PAR, PAN, PAT, RDE, or RRD.

***Note 3*:** * and ** indicate that parameter estimates are significant at the 5% and 10% levels, respectively.

We first describe the long-run results, ascertained by examining the statistical significance of the ECT_{-1} coefficients. Table 1 shows that when ΔPEG is the dependent variable, the coefficients are statistically significant at a 10% level. This implies that economic growth tends to converge to its long-run equilibrium path in response to changes in financial development and innovation. This is true for all three samples considered. Therefore, the overall conclusion is that per capita economic growth in Eurozone countries is significantly influenced by both financial development and innovation. In other words, to stimulate long-run economic growth, it is important to enhance both innovation and financial sector development in the 18 Eurozone countries.

In the short run, however, the results are mostly non-uniform, with one exception: we found bidirectional causality between financial development and economic growth. This bidirectional causality is consistent with the findings of recent studies by Pradhan et al. (2014) and Hou and Cheng (2010). We summarize the *non-uniform* short-run results in Table 2, demonstrating that the short-run adjustment dynamics vary across samples/cases.

Table 2. Summary of Non-Uniform Short-run Results

Cases/Samples	**Innovation vs. Growth**	**FD vs. Innovation**
Sample 1		
Case 1	Innovation ← Growth	FD → Innovation
Case 2	Innovation → Growth	FD ← Innovation
Case 3	Innovation ↔ Growth	FD ↔ Innovation
Sample 2		
Case 1	Innovation ← Growth	FD ↔ Innovation
Case 2		FD ← Innovation

Cases/Samples	Innovation vs. Growth	FD vs. Innovation
	Innovation → Growth	
Case 3	Innovation → Growth	FD → Innovation
Sample 3		
Case 1	Innovation ← Growth	FD # Innovation
Case 2	Innovation ↔ Growth	FD # Innovation
Case 3	Innovation ↔ Growth	FD → Innovation
Case 4	Innovation ↔ Growth	FD ← Innovation
Case 5	Innovation # Growth	FD # Innovation

Note: X → Y denotes variable X Granger-causes variable Y; X ← Y denotes Y Granger-causes X; X ↔ Y denotes both variables Granger-cause each other; and X # Y denotes no causality.

4. Policy Implication and concluding remarks

The study aims to examine causal relationships between innovation, financial development, and economic growth simultaneously. We find that the variables are cointegrated. Most importantly, there is clear evidence that both financial development and innovation matter in the determination of long-run economic growth.

The empirical results suggest that to stimulate sustained economic growth in the Eurozone countries, policy-makers should give priority to financial sector reforms and development to ensure efficient allocation of financial resources to improve both productive and allocative efficiencies in the economy. The empirical results show that long-term economic growth is dependent on the Eurozone economies' ability to move up on the innovation scale to remain globally competitive. This requires the allocation of adequate resources for R&D activities to propel key economic sectors in these countries.

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