Link between financial system development and economic growth in Costa Rica: Cointegration and time series analysis.

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Abstract. This work aims to study the link between the development of the financial system and economic growth in Costa Rica using time series analysis. In this sense, the results of the estimated models show that the effect of economic growth is positive, when the development of the financial system increases, which is in line with some hypotheses from the economic theory. In addition, a baseline scenario for annual gross domestic product (GDP) growth in 2021 is forecasted and then contrasted with the results of a stress scenario simulation analysis.

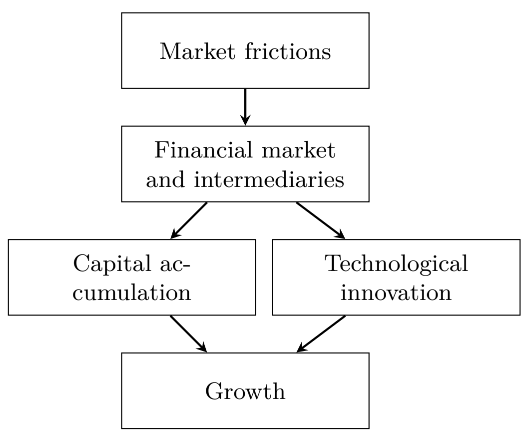
1 Introduction

Economic theories suggest that an efficient operation of the financial system generates positive impact in the economic growth of a country since it mitigates market frictions. In this sense, in order to solve such inefficiencies, the financial systems fulfill five basic functions: 1) mobilization of savings, 2) allocation of these savings in high-performance activities, 3) monitoring of managers and exert corporate control, 4) facilitation of the exchange of goods and service and

5) facilitation of the trading, hedging, diversifying, and pooling of risk (Levine, 1997).

On the other hand, through the functions of the financial system, economic growth is positively affected by the accumulation of capital as a result of the modification of the savings rates and by the relocation of non-performing resources to capital-generating technologies. It also promotes technological innovation, as financial intermediaries identify and provide resources to firms more likely to implement innovate products and better production processes (Levine, 1997). This means that the financial system development is manifested in an increase in access to credit, which results in more resources for investments, as well as promoting labor specialization and the entry of new technology, consequently generating more economic growth (Blanco, 2013). This theoretical relationship between financial system and economic growth is outlined in the Figure 1.

Fig. 1: Theoretical relationship between economic growth and financial development



Source: Levine (1997, figure 1)

Some authors warn of the destabilizing effect on economy as a consequence of financial liberalization, where the rapid growth of bank credit, public debt and stock prices stand out as strong predictors of the occurrence and intensity of financial crisis (Loayza et al., 2017). Similarly, there are discrepancies among experts on the direction of causality. For instance, empirical investigations based on panel data have shown that the financial development causes economic growth (Levine et al., 2000). On the other hand, some time series analyses have identified causality in both directions (Liu and Calderón, 2002).

In Costa Rica, the financial system began to modernize during the 80's decade, with deregulation reforms that led to the emergence of private banks and cooperatives, along with measures that eliminated portfolio limits and reduced state intervention in setting interest rates (Loría Sagot, 2013).

However, the development of the financial system has not been sufficient. A study carried out by Castro and Serrano (2013), focused on analyzing financial intermediation margin, concluded that the market structure of Costa Rican banking system is oligopoly, where the prices of financial services are higher than those that would be offered under a competitive equilibrium scenario. Likewise, using a different methodology Salas-Alvarado et al. (2015) affirm that the presence of large institutions in the Costa Rican banking market is associated with lower competition indicators, with the state banking segment being less competitive compared to private banks. Similarly, Yong (2007) highlights that Costa Rica has high levels of financial intermediation margin and market concentration, specially when measured by assets.

In accordance with the aforementioned, it suggests that the financial system in Costa Rica has not reached sufficient maturity, which is why it is particularly important to study the link between its performance and economic growth, and provide empirical evidence that could serve as input for the formulation of policy aimed at promoting economic growth. Therefore, the main goal of this paper is to study the relationship between Costa Rican financial development and the economic growth from 1997 to 2020 by using the analysis of multivariate time series analysis.

Due to the dynamic interaction over time between the time series involved, it is relevant to consider the past values of the variables in the analysis along with other important covariates, so the study was carried out using vector autoregressive (VAR) models. Also, to ensure that there is a long, consistent, and statistically significant relationship between the variables under study, a cointegration analysis was performed and, consequently, a Vector Error Correction Model (VECM) was estimated.

This paper is organized as follows. In Section 2, the time series methodology and the economic variables used in this study are described. The Section 3 presents the results of modelling and discussions from the empirical. Finally, the conclusions are presented in Section 4.

2 Methodology

2.1 Statistical methods

VAR models

These models consist of a system of equations that are estimated simultaneously, generating an equation for each endogenous variable, and the explanatory variables are lagged values of the endogenous variables. The equation 1 represents a VAR model for two dependent variables and their values lagged one period as independent variables (Enders, 2015)

$$\begin{aligned} y_t &= b_{10} + b_{12} z_t + \gamma_{11} y_{t-1} + \gamma_{12} z_{t-1} + \epsilon_{y_t} \\ z_t &= b_{20} + b_{21} y_t + \gamma_{21} y_{t-1} + \gamma_{22} z_{t-1} + \epsilon_{z_t} \end{aligned} \tag{1}$$

where y and z are stationary and the innovations ϵ_{y_t} y ϵ_{z_t} are uncorrelated white noises with standard deviation σ_Y y σ_Z and don't present serial correlation (Enders, 2015). The generalized VAR model is defined as:

$$\mathbf{y}_t = A_1 \mathbf{y}_{t-1} + \cdots + A_p \mathbf{y}_{t-p} + C D_t + \mathbf{u}_t \tag{2}$$

where $\mathbf{y}_t$ is a vector of K endogenous variables ($\mathbf{y}_t = y_{1t}, \ldots, y_{kt}, \ldots, y_{Kt}$), A_i is a matrix of coefficients of size $(K \times K)$ with $i = 1, \ldots, p$, $\mathbf{u}_t$ is a vector of white noise processes that do not vary in time of K dimensions and positive definite covariance $E(\mathbf{u}_t\mathbf{u}_t') = \sum u$, C is a matrix of coefficients of possible deterministic variables of size $(K \times M)$ and D_t are the deterministic variables associated with C, such as constants, trend, dummy variables, among others (Pfaff, 2008).

Granger causality

In Granger (1969) it is defined that a variable Y_t caused X_t if the prediction of X_t is better using all available information than if all information is used excluding Y_t.

$$\sigma^2(X|U) < \sigma^2(X|\overline{U - Y}) \tag{3}$$

where U represents all available information and $\overline{Y}$ the lagged values of Y. If this condition is met, it is asserted that Y Granger-causes X.

VECM

The economic chronological series, such as those analyzed in this paper, tend to have trend and are not stationary of order 0. In these cases, a model of the variables without any transformation can lead to a spurious regression, characterized by a high significance of the parameters, high R^2 and a auto-correlated error (Pfaff, 2008) and (Engle and Granger, 1987), but without a theoretical basis to justify that relationship. However, if the residual of the model with non-stationary variables is effectively stationary, it is affirmed that the series cointegrate in the long term, because there is a lineal combination between the variables that results in a residual with an integration order lower than that of the variables in question (Lütkepohl, 2005).

Assuming that the variables in equation 4 are non-stationary of order 0 and the residual is stationary of order 0, that is, the series cointegrate, the following equation represents the equilibrium in the long term:

$$y_t = \alpha_1 x_{t,1} + \alpha_2 x_{t,2} + \ldots + \alpha_k x_{t,k} + z_t \text{ para } t = 1, \ldots, T \tag{4}$$

In addition, the error correction model represents the change of a variable as a function of its deviations from an equilibrium level (Lütkepohl, 2005). This model is presented below for the long-term relationship described in the equation 5:

$$
\begin{aligned}
\Delta y_t &= \psi_0 + \gamma_1 \hat{z}_{t-1} + \sum_{i=1}^{K} \psi_{1,i} \Delta x_{t-i} + \sum_{i=1}^{L} \psi_{2,i} \Delta y_{t-i} + \epsilon_{1,t} \\
\Delta x_t &= \xi_0 + \gamma_2 \hat{z}_{t-1} + \sum_{i=1}^{K} \xi_{1,i} \Delta y_{t-i} + \sum_{i=1}^{L} \xi_{2,i} \Delta x_{t-i} + \epsilon_{2,t}
\end{aligned} \tag{5}
$$

This model explains the changes of the dependent variable based on its own history, the lagged values of the explanatory variables and the long-term equilibrium error of previous periods ($\gamma \hat{z}_{t-1}$), where γ determines the speed of adjustment and γ_1 must always be negative. Meanwhile, $\epsilon_{1,t}$ and $\epsilon_{2,t}$ are white noise processes (Pfaff, 2008).

2.2 Variables of interest

The variables under study are the annual growth of Costa Rica's real Gross Domestic Product (GDP) and bank loans to the non-financial private sector in terms of nominal GDP. In addition, exogenous variables associated with the variables of interest were included. The source of the data is the Central Bank of Costa Rica for all variables except the real GDP of United States, whose source is the US Bureau of Economic Analysis. The periodicity of the data is quarterly and goes from the first quarter of 2000 to the fourth quarter of 2020 for a sample of 84 observations. The variables are described below (Figure 2).

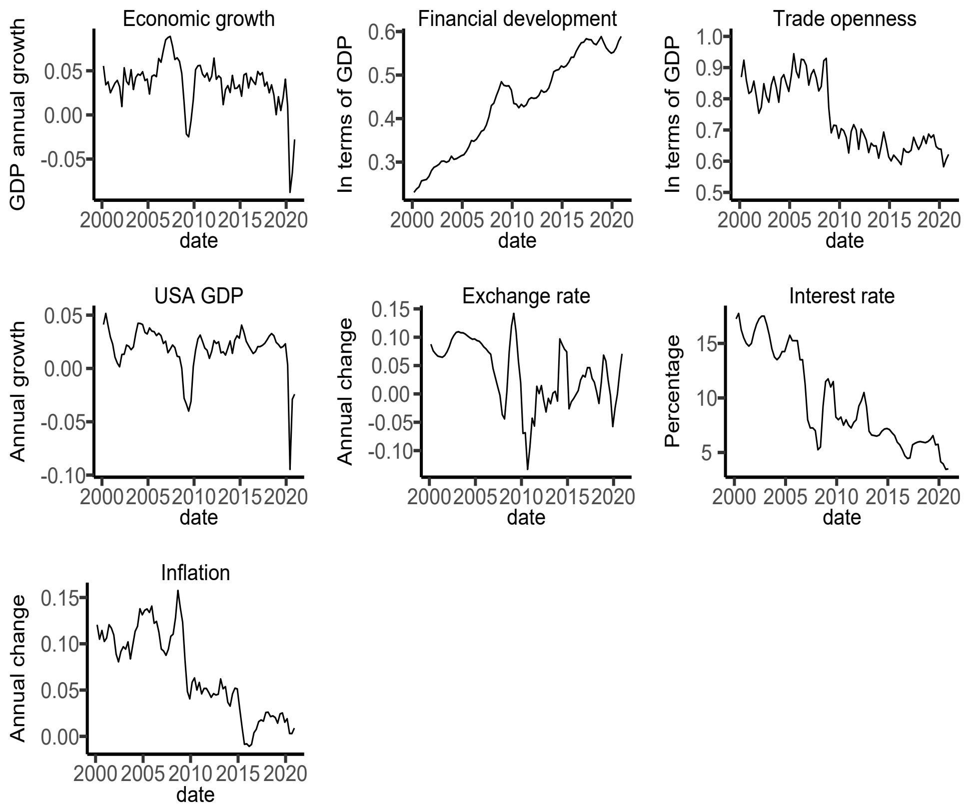


Fig. 2: Variables included in the analysis

Real GDP annual growth for Costa Rica

This variable represents the economic growth and is calculated as $log(\frac{GDP_t}{GDP_{t-4}})$.

Financial system loans

Although there are different ways to measure the development of the financial system, for this study the ratio bank loans to the non-financial private sector to nominal GDP was used, as it allows focusing on credits lent to productive activities (Swamy and Dharani, 2018).

Covariates

Based on the literature reviewed and the economic development model of Costa Rica, characterized by commercial openness (Oviedo et al., 2015); exogenous variables include the trade openness index, the United States' economic growth (the country's main trading partner (Banco Central de Costa Rica, 2021)) and the annual variation of the local currency exchange rate expressed in US dollar. Additionally, the inflation rate and the deposits interest rate (TBP) are also included. these indicators are explained below.

1. **Trade openness index:** It is calculated as total exports and imports in terms of nominal GDP.
2. **Annual growth of real GDP of USA:** Calculated as $log(\frac{GDP_t}{GDP_{t-4}})$.
3. **Inflation:** Represents the general annual increase in prices of products and services.
4. **Deposits interest rate (TBP):** Represents the financial cost incurred by the intermediaries to collect resources in local currency, in addition, it is used as a reference rate for most of the loans in Colones with a floating rate (Banco Central de Costa Rica, 2015).
5. **Annual variation of the exchange rate:** This variable shows annual variation of the exchange rate of the local currency in terms of US dollars.

3 Analysis and results

3.1 Preliminary analysis

The correlation matrix presented in Table 1 shows a correlation coefficient of -0.35 between economic growth and financial development. This indicates an inverse and moderate association between the variables, which contradicts the hypothesis of a highly positive relationship between economic growth and development of the financial system. However, drawing conclusions from a bi-variate relationship can be misleading, due to external factors being ignored.

Regarding the association between the exogenous and endogenous variables, the economic growth has a positive correlation with the

Table 1: Correlation matrix

	Economic growth	Financial develop-ment	Trade openness index	USA econ. growth	Inflation	TBP	Exchange rate YoY
Economic growth	1.00	-0.35	0.45	0.69	0.31	0.20	-0.15
Financial development	-0.35	1.00	-0.79	-0.30	-0.81	-0.91	-0.42
Trade openness	0.45	-0.79	1.00	0.28	0.89	0.73	0.48
USA econ. growth	0.69	-0.30	0.28	1.00	0.16	0.26	-0.04
Inflation	0.31	-0.81	0.89	0.16	1.00	0.77	0.50
TBP	0.20	-0.91	0.73	0.26	0.77	1.00	0.63
Exchange rate YoY	-0.15	-0.42	0.48	-0.04	0.50	0.63	1.00

trade openness index and the USA economic growth, according to the country's economic development model (Oviedo et al., 2015). On the other hand, there is a negative and high association between financial development and openness trade index, which has not theoretical basis, however, the parameter of the trade openness index is not significant for the financial development equation in the VAR and the VECM results.

3.2 VAR model

The VAR models with different lags were estimated along with all five exogenous variables, the constant and trend terms, and seasonality as a factor. According to the Akaike information criterion (AIC), the best model includes four lags of the two endogenous variables. The estimated model is as follows:

$$y_{1t} = \pi_0 + \sum_{i=1}^{4} \beta_{1i} y_{1t-i} + \sum_{i=1}^{4} \beta_{2i} y_{2t-i} + X_t B_1 + \Phi_1 D_t + S_t T_1 + \epsilon_{1t} \tag{6a}$$

$$y_{2t} = \psi_0 + \sum_{i=1}^{4} \beta_{1i} y_{1t-i} + \sum_{i=1}^{4} \beta_{2i} y_{2t-i} + X_t B_2 + \Phi_2 D_t + S_t T_2 + \epsilon_{2t} \tag{6b}$$

where y_{1t} is the economic growth, y_{2t} is the financial system's development, π_0 and ψ_0 are constants, X_t is the covariables matrix, D_t is

Table 2: Estimated coefficients of model VAR(4)

Variable	$y_{1,t}$	$y_{2,t}$
$y_{1,t-1}$	0.324 (3.77) ***	0.047 (1.04)
$y_{2,t-1}$	-0.055 (-0.22)	1.15 (8.83) ***
$y_{1,t-2}$	-0.037 (-0.4)	0.035 (0.7)
$y_{2,t-2}$	0.577 (1.53)	-0.235 (-1.18)
$y_{1,t-3}$	0.232 (2.1) *	0.085 (1.46)
$y_{2,t-3}$	0.23 (0.61)	0.019 (0.1)
$y_{1,t-4}$	-0.337 (-3.26) **	0.001 (0.02)
$y_{2,t-4}$	-0.676 (-2.77) **	-0.056 (-0.44)
const	-0.055 (-1.62)	0.041 (2.29) *
trend	-0.001 (-3.07) **	0 (2.36) *
trade openness index	0.157 (5.01) ***	-0.004 (-0.23)
USA econ.growth	0.585 (7.53) ***	-0.071 (-1.74).
inflation	-0.306 (-3.93) ***	-0.019 (-0.46)
tbp	-0.002 (-1.57)	-0.001 (-2.08) *
vartc	-0.141 (-3.19) **	0.042 (1.8).
est.d2	-0.006 (-1.3)	0.008 (2.95) **
est.d3	0.001 (0.12)	0.009 (4.08) ***
est.d4	0.011 (2.76) **	0.012 (5.83) ***

Notes:
Significance codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
t test in parenthesis

the trend, S_t is a matrix of dummy variables to capture seasonality, ϵ_{1t} and ϵ_{2t} are white noise processes.

The Table 3 shows that the model successfully satisfies all conditions. The Portmanteau test indicates that there is no statistical evidence to reject the null hypothesis that the autocorrelation of the residuals is different from zero. According to the result of the Arch test, there is not enough empirical evidence to reject the null hypothesis that the residuals are homoscedastic, taking as a reference a significance level of 5%. The residuals follow a normal distribution according to the Jarque-Bera test.

Since the model VAR(4) satisfies all model assumptions, we continue with the impulse response analysis. Figure 3 shows that the impact on economic growth is positive when financial development increases

Table 3: VAR model diagnostics test

Test	Statistics	P-value
Portmanteau	50.60	0.37
ARCH	31.04	0.94
Jarque-Bera	2.44	0.66

by one unit, and this impact is statistically different from zero, given that the confidence interval (grey dashed line) does not include the zero axis for the period $t + 3$.

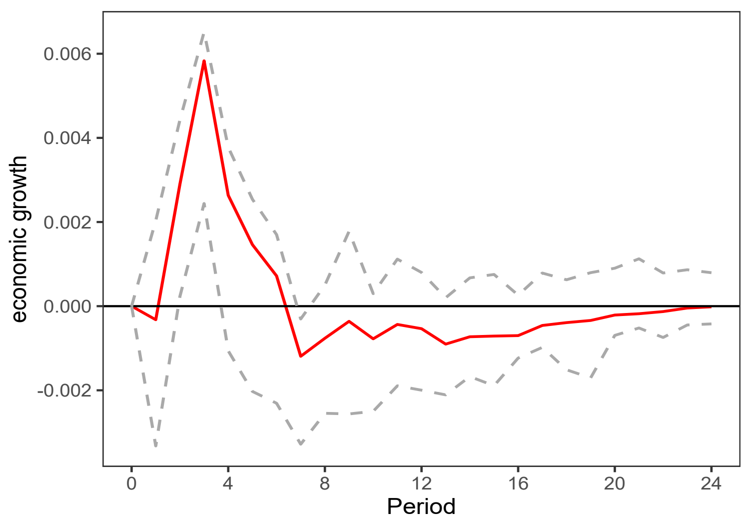


Fig. 3: Orthogonal impulse response from financial development.

Similarly, the impact on financial development, when a shock is applied to economic growth, is statistically significant for period 4 to 7 (Figure 4).

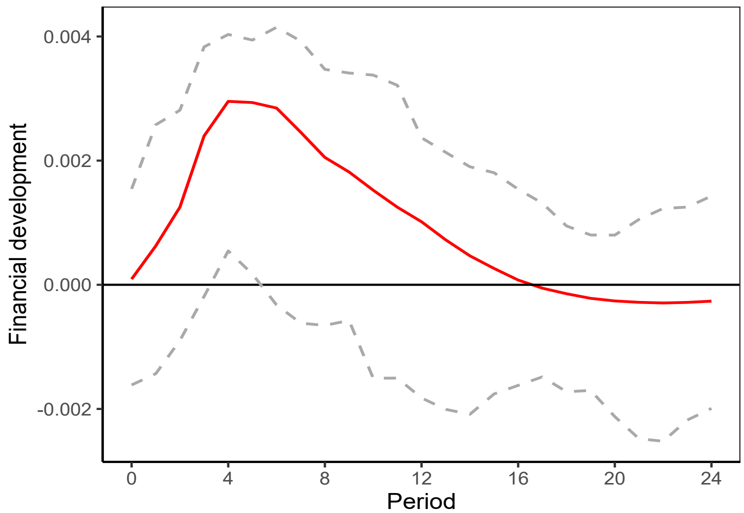


Fig. 4: Orthogonal impulse response from economic growth.

Following the VAR model analysis, it is possible to test the Granger Causality using the F test, in which the null hypothesis indicates that there is no Granger causality (Pfaff, 2008). In both cases, the null hypothesis are rejected, so the evidence suggests that financial development causes economic growth in a Granger sense, just as economic growth causes financial development in a Granger sense 4.

Table 4: Causality test

Test	Statistic	P value
F.S.D causes in a Granger sense E.C.	5.650	0.000
E.C. causes in a Granger sense F.S.D	3.205	0.015

Notes:
E.C. = Economic growth
F.S.D. = Financial system development

Cointegration analysis

To analyze the cointegration between the financial development and economic growth, two models were estimated, the first one includes only the endogenous variables (equation 7) and a second model that adds the exogenous variable (equation 8). These two models are represented in the following equations:

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + \mu + \epsilon_t \quad (7)$$

$$\Delta Y_t = \Gamma_1 \Delta Y_{t-1} + \cdots + \Gamma_{k-1} \Delta Y_{t-k+1} + \Pi Y_{t-k} + \mu + \Omega X_t + \epsilon_t \quad (8)$$

where (Y_{1t}, Y_{2t}) are the endogenous variables and correspond to $Y_{1t} =$ economic growth and $Y_{2t} =$ financial development , $k = 5$ and represents the model order. The model 8 includes an additional parameter Ω for the exogenous variables where $X_{it} =$ [trade openness, USA economic growth, inflation, interest rate and exchange rate (YoY)]. The hypothesis to be rejected is that the range of the matrix Π is different from zero (i.e., that the endogenous variables cointegrate in the long term) Johansen and Juselius (1990).

As shown in Table 5, for the model that only includes endogenous variables, there is not enough evidence to reject the null hypothesis, which means that the variables do not cointegrate. However, if the exogenous variables are included, the value of the statistic in the $H_0 : rk(\Pi) = 0$ is 47.57, so there is enough empirical evidence to reject the null hypothesis, taking a significance level of 1% as a reference. Based on these results and on the Costa Rican economic model, the inclusion of the exogenous variables is justified. That is, the endogenous variables cointegrate when the fixed effect of the exogenous variables are considered.

Table 5: Cointegration rank: maximum eigenvalue statistic

	Statistic		Critical values		
Hypothesis	Model 7	Model 8	10pct	5pct	1pct
r <= 1	3.58	10.94	6.50	8.18	11.65
r = 0	7.72	47.57	12.91	14.90	19.19

3.3 VECM

After confirming the existence of cointegration between the financial development and the economic growth, the VECM with different lags were estimated along with all five exogenous variables, the constant and trend terms, and seasonality as a factor. According to the Akaike information criterion (AIC), the best model includes five lags of the two endogenous variables. The estimated model is as follows:

$$\mathit{\Delta} y_{1t} = \psi_0 + \mathrm{ect1}_1 \hat{z}_{t-1} + \sum_{i=1}^{5} \psi_{1,i} \mathit{\Delta} y_{1t-i} + \sum_{i=1}^{5} \psi_{2,i} \mathit{\Delta} y_{2t-i} + \beta_1 \mathit{\Delta} X_i + \gamma_1 T_i + \alpha_1 \mathrm{S}_i + \epsilon_{1,t} \tag{9a}$$

$$\mathit{\Delta} y_{2t} = \xi_0 + \mathrm{ect1}_2 \hat{z}_{t-1} + \sum_{i=1}^{5} \xi_{1,i} \mathit{\Delta} y_{1t-i} + \sum_{i=1}^{5} \xi_{2,i} \mathit{\Delta} y_{2t-i} + \beta_2 \mathit{\Delta} X_i + \gamma_2 T_i + \alpha_2 \mathrm{S}_i + \epsilon_{2,t} \tag{9b}$$

where $\mathrm{ect1}_i$ is the error term correction term, ψ_i and ξ_i are the parameters of endogenous variables in first differences, β_i correspond to exogenous variables in first differences, γ_i is the trend parameter α_i is a vector of parameters of the variables that capture seasonality and ϵ_i are the innovation processes. The estimated parameters are shown in the following Table 6.

Regarding the diagnostic tests, the adjusted VECM successfully satisfies all the conditions as well, as it is shown in Table 7.

The VECM's results of the impulse response on economic growth when a shock is applied to financial development, are similar to those of the VAR, as can be seen in Figure 5. Nonetheless, there is a significant difference in the results of the impulse response on financial development when economic growth increases by one unit, since in the VECM results the impact is permanent (Figure 6), while the effect is transitory in the VAR model. This is discussed in depth in the next section.

Table 6: Estimated coefficients of the VECM

Variable	$\Delta y_{1,t}$	$\Delta y_{2,t}$
ect1	-0.659 (-5.78) ***	0.233 (3.65) ***
constant	-0.035 (-1.08)	0.012 (0.65)
Trade openness	0.149 (4.7) ***	-0.004 (-0.25)
cpib.usa	0.609 (7.77) ***	-0.064 (-1.46)
inflation	-0.319 (-4.08) ***	-0.026 (-0.6)
tbp	-0.001 (-1.12)	-0.001 (-1.35)
vartc	-0.136 (-3.06) **	0.046 (1.86).
est.d2	-0.004 (-0.81)	0.009 (3.2) **
est.d3	0.001 (0.27)	0.011 (4.11) ***
est.d4	0.01 (2.06) *	0.012 (4.39) ***
trend	-0.001 (-5.49) ***	0 (0.93)
$\Delta y_{1,t-1}$	-0.64 (-7.25) ***	0.067 (1.35)
$\Delta y_{2,t-1}$	0.058 (0.24)	0.221 (1.63)
$\Delta y_{1,t-2}$	-0.708 (-8.52) ***	0.089 (1.92).
$\Delta y_{2,t-2}$	0.44 (1.74).	-0.077 (-0.54)
$\Delta y_{1,t-3}$	-0.464 (-4.6) ***	0.2 (3.54) ***
$\Delta y_{2,t-3}$	0.642 (2.49) *	-0.122 (-0.84)
$\Delta y_{1,t-4}$	-0.868 (-7.41) ***	0.2 (3.05) **
$\Delta y_{2,t-4}$	0.027 (0.13)	-0.093 (-0.78)

Notes:
Significance code: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
t statistics in parenthesis

Table 7: VECM diagnostic tests

Test	Statistic	P value
Portmanteau	50.99	0.28
ARCH	41.84	0.61
Jarque-Bera	2.17	0.70

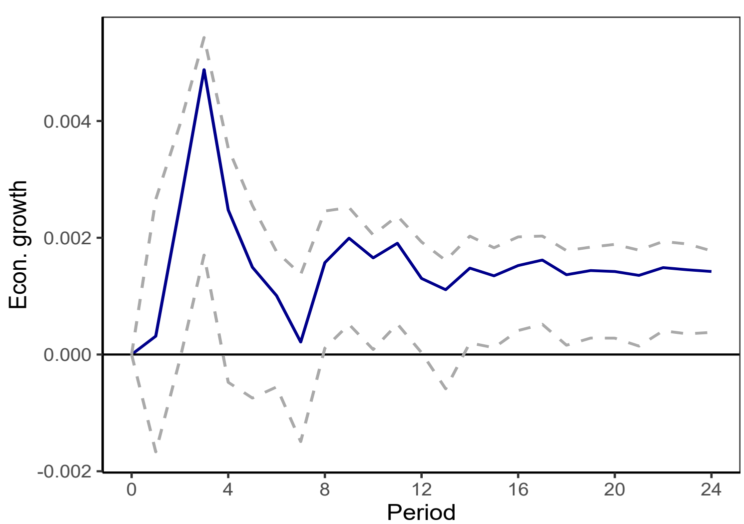


Fig. 5: Orthogonal impulse response from financial development

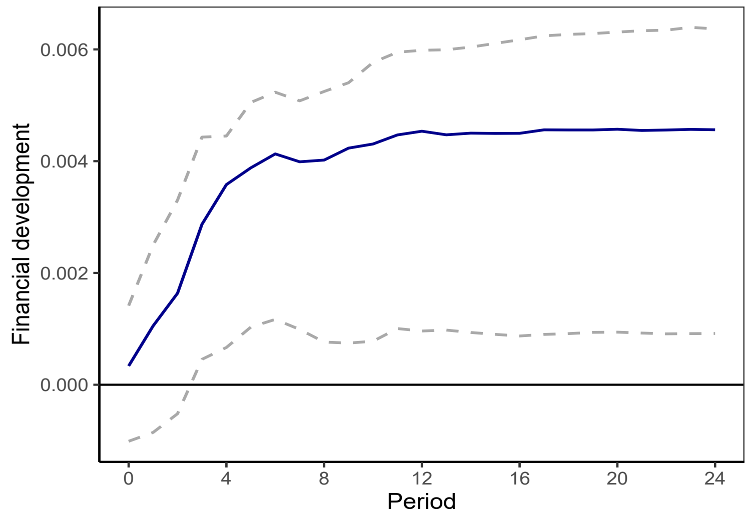


Fig. 6: Orthogonal impulse response from economic growth

3.4 Comparison between the VAR and the VECM

In the previous sections it was confirmed that the VAR model and the VECM satisfy all the conditions, so that either could be used to analyze the problem in question. For this reason, a comparison of the results of the models was performed to choose which one will be used for the simulation analysis.

As can be seen in Figure 7, there are no significant differences in the response of the economic growth to an impulse in the financial development between the two models, since it is statistically different from zero only in period $t + 3$ in both models.

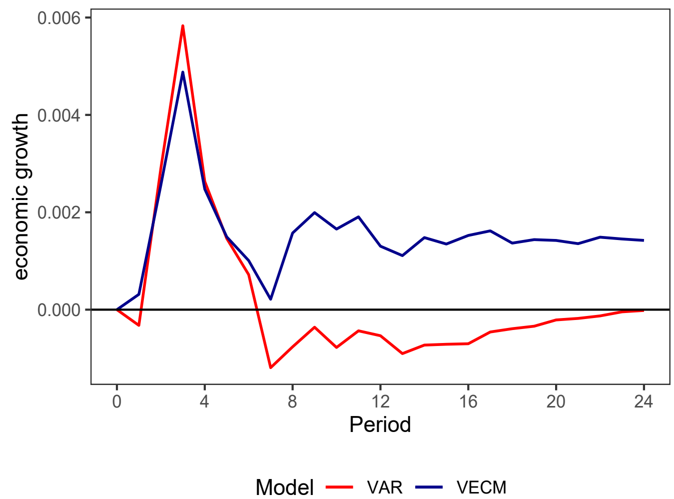


Fig. 7: Orthogonal impulse response from financial development

Contrary to the response in economic growth, there are significant differences in the response in financial development between the models, since the effect in the VAR is transitory, while the effect in the VECM is permanent (Figure 8).

Additionally, the Diebold - Mariano test was performed to compare the estimates between the models. The statistic of this test is calculated as follows (Enders, 2015):

$$DM = \frac{\bar{d}}{\sqrt{(\gamma_0 + 2\gamma_1 + \cdots + 2\gamma_q)/(H-1)}} \tag{10}$$

where $\bar{d} = \frac{1}{H}\sum_{i=1}^{H}[g(e_{1i}) - g(e_{2i})]$, $g(e_{1i})$ is the error of model 1 and $g(e_{2i})$ the error of model 2, for the period i in both cases. Table 8 shows the results of this test using the squared errors (SE) as a reference. The value of the statistic for the economic growth estimates is less than the p-value, so there is not enough empirical evidence to reject the null hypothesis that the SE of the VAR model estimates for economic growth are greater than the SE of the VECM ones, meaning that the economic growth estimates are statistically the same in both models.

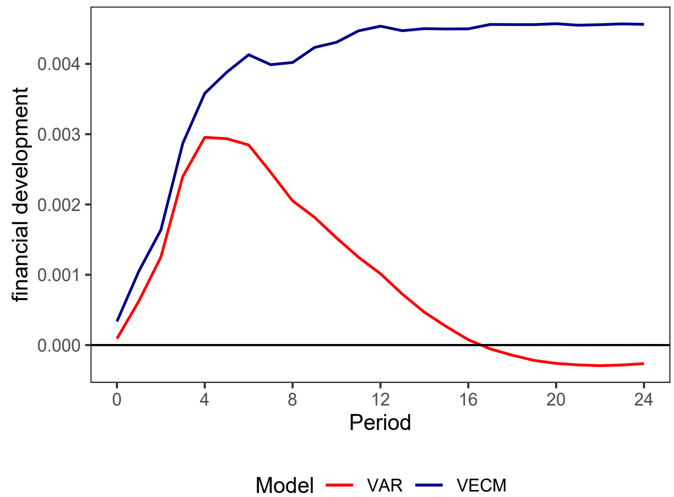


Fig. 8: Orthogonal impulse response from economic growth

In the case of the financial development estimates, with a significance level of 5%, the null hypothesis cannot be rejected, however, the alternative hypothesis is accepted if a significance level of 10% is used (Table 8), which means that the SE of the VAR financial development estimates is lower than the SE of the VECM estimates at a level of significance of 10%. Additionally, as previously discussed, there are relevant differences in the impulse-response function for the financial development, between the models. Therefore, based on the graphical analysis and the result of the Diebold - Mariano test, the VAR model was chosen for the simulation analysis that is discussed in the next section.

Table 8: Diebold - Mariano test

H1	Statistic	P-value
Economic growth		
$SE_{\text{VAR}} < SE_{\text{VECM}}$	0.362	0.641
Financial development		
$SE_{\text{VAR}} < SE_{\text{VECM}}$	-1.319	0.094

3.5 Simulation analysis

The inclusion of exogenous variables in this work is useful to study the relationship between the variables of interest and to perform the Granger test. However, in case of using this model for forecasting, it is necessary to define predicted values for the exogenous variables, either through additional econometric models (which would add more uncertainty) or other methods. In this study it was chosen to analyze the projections using simulations.

The year 2021 is the period under analysis and the results of the simulations are compared with a baseline scenario taking as a reference the latest observed values (as of October 1st) for the exogenous variables, with the exception of the annual growth of US GDP where a value of 0.0597 was assumed according to IMF (IMF, 2021) and the trade openness index assumed to be the average of the last 7 years. The assumed values for the exogenous variables in the baseline scenario are presented in Table 11.

Table 9: Values of the exogenous for the baseline scenario

Date	Trade openness index	US GDP	Inflation	TBP	Exchange rate (YoY)
2021-03-01	0.6609	0.0055	0.0047	3.4	0.0484
2021-06-01	0.7623	0.1150	0.0191	3.2	0.0659
2021-09-01	0.6457[a]	0.0569[a]	0.0191[a]	2.9	0.0380
2021-12-01	0.6457[a]	0.0569[a]	0.0191[a]	2.9[a]	0.0380[a]

[a] Estimated values

The baseline scenario estimates are shown in Table 10. Furthermore, the estimates are calculated for the entire year and the results are described in Table 11, in order to compare the estimates of the model with the estimates of the Central Bank of Costa Rica (BCCR).

This simulation was carried out having the main goal of a sensitivity analysis, in order to identify which variations in the exogenous variables could cause strong deviations from the baseline scenario. Therefore, the steps to run the simulation are as follows:

Table 10: VAR model estimates for the baseline scenario

	Economic growth			Financial development		
Date	Estimate	Lower lim.	Upper lim.	Estimate	Lower lim.	Upper lim.
2021-03-01	-0.01	-0.03	0.01	0.58	0.57	0.59
2021-06-01	0.10	0.08	0.12	0.56	0.55	0.58
2021-09-01	0.08	0.06	0.10	0.57	0.55	0.59
2021-12-01	0.05	0.03	0.08	0.58	0.56	0.61

Table 11: Annual estimates of the VAR model for the baseline scenario

	Modelo VAR			
Variable	BCCR	Estimate	Lower Lim.	Upper Lim.
Economic growth	0.039	0.0552	0.0314	0.079
Financial development	NA	0.5810	0.5560	0.606

1. The starting point is the baseline scenario described in Tables 10 and 11.
2. For each range of quantiles and each independent variable, 100 new data points were generated based on historical data, maintaining the base scenario for the rest of the variables.
3. With the new data sets, the values were estimated with the VAR model.

The results of the simulation for the economic growth are presented in Table 12 where each cell represents the median of the economic growth in each simulation, for instance, the median of economic growth for the data generated with trade openness index within the quantile range of $[0.0, 0.20]$ is 0.0434, keeping the base scenario for the rest of the variables.

Therefore, it is noted that values of the trade openness index greater than the 60^{th} percentile would be associated with an economic growth greater than the confidence interval of the baseline scenario (Table 12). On the other hand, it is observed that the economic growth of Costa Rica is highly correlated with the performance of the US economy, so that values of this variable below the 80^{th} percentile would be associated to economic growth in Costa Rica below the confidence interval of the base scenario. This is explained as an extraordinary growth is expected in US in 2021 (IMF, 2021). In addition, the economic growth of Costa Rica, would be below the confidence interval of the baseline scenario, when the values of the inflation rate are greater than the 60th percentile and interest rates values above 80th percentile.

Table 12: Medians of the simulations for economic growth

Quantiles range	Trade openness index	USA GDP	Inflation	Interest Rate	Exchange rate (YoY)
0 - 0.2	0.0434	0.0000†	0.0589	0.0507	0.0723
0.2 - 0.4	0.0517	0.0247†	0.0466	0.0463	0.0628
0.4 - 0.6	0.0668	0.0286†	0.0330	0.0413	0.0563
0.6 - 0.8	0.0862*	0.0332	0.0189†	0.0317	0.0503
0.8 - 1	0.0995*	0.0405	0.0077†	0.0208†	0.0460

* > Above the CI upper limit in the baseline scenario

† < Below the CI lower limit in the baseline scenario

Conversely, values of financial development below the confidence interval are only associated with interest rates above the 40th percentile. As expected, the variations of the other independent variables are not associated with strong deviations in financial development from the baseline scenario, as shown in Table 13.

Table 13: Medians of the simulations for financial development

Quantiles range	Trade openness index	USA GDP	Inflation	Interest rates	Exchange rate (YoY)
0 - 0.2	0.5782	0.5911	0.5823	0.5720	0.5683
0.2 - 0.4	0.5804	0.5882	0.5767	0.5630	0.5759
0.4 - 0.6	0.5832	0.5875	0.5707	0.5530†	0.5806
0.6 - 0.8	0.5868	0.5872	0.5642	0.5339†	0.5848
0.8 - 1	0.5896	0.5865	0.5590	0.5123†	0.5879

* > Above the CI upper limit in the baseline scenario

† < Below the CI lower limit in the baseline scenario

4 Conclusions

Analyzing the link between economic growth and financial development, ignoring the interaction of the variables over time and without controlling for third variables, could lead to erroneous conclusions. Therefore, through VAR and VEC models (which consider lagged values of the dependent variables) and adding exogenous variables relevant to the country's economic model, this study demonstrated the presence of this link as indicated by the theory.

With the impulse-response functions it is concluded that an innovation of one unit in the financial development causes a statistically significant increase in economic growth of around 0.4% and 0.6% for period $t + 3$, which then it disappears. The explanation for this behaviour is that the financial system works as a channel to allocate resources to activities that would generate more production, so it is not a means in itself to generate economic growth.

On the other hand, the impulse-response functions for the financial development when a shock is applied to economic growth, also show a statistically significant impact, nonetheless, the results of the VAR and the VECM are different, since the former exhibited a transitory effect while the latter presented a permanent impact. Furthermore, the Granger test provides evidence of a bidirectional causality among the variables, in line with what has been observed in other countries (refer to Liu and Calderón, 2002).

In the current economic context, characterized by high uncertainty aggravated by the appearance of an external factor such as the pandemic, it is essential to have tools that allow the design of different decision-making scenarios. Thus, in the final section of this paper, a simulation analysis was carried out in which it was detected that the economic performance of Costa Rica in 2021 would be strongly associated with the growth of the US economy.

5 References

Banco Central de Costa Rica (2015). Acta de la sesión 5703-2015.

Banco Central de Costa Rica (2021). Programa Macroeconómico 2021/2022. Technical report, Banco Central de Costa Rica.

Blanco, L. (2013). Finance, growth, and institutions in Latin America: What are the links? *Latin American Journal of Economics*, 50(2):179–208.

Castro, A. and Serrano, A. (2013). Margen de intermediación financiera y poder de mercado: El caso de Costa Rica.

Enders, W. (2015). *Applied Econometric Time Series*. John Wiley & Sons, Hoboken, New Jersey, fourth edition.

Engle, R. F. and Granger, C. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55(2):251–276.

Granger, C. J. W. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica*, 37(3):424–438.

IMF (2021). World Economic Outlook 2021. Technical Report October, International Monetary Fund.

Johansen, S. and Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration — With Applications To the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52(2):169–210.

Levine, R. (1997). Financial Development and Economic Growth: Views and Agenda. *Journal of Economic Literature*, 35(2):688–726.

Levine, R., Loayza, N., and Thorsten, B. (2000). Financial intermediation and growth: Causality and causes without outliers. *Journal of Monetary Economics*, 46(1):31–77.

Liu, L. and Calderón, C. (2002). The direction of causality between financial development and economic growth.

Loayza, N., Ouazad, A., and Rancière, R. (2017). Financial development, growth, and crisis: Is there a trade-off?

Loría Sagot, M. (2013). El sistema financiero costarricense en los últimos 25 años: Estructura y Desempeño.

Lütkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Springer, Berlin.

Oviedo, A. M., Sanchez, S. M., Lindert, K. A., and Lopez, J. H. (2015). El Modelo de Desarrollo de Costa Rica De Bueno a Excelente Diagnóstico Sistemático de País.

Pfaff, B. (2008). *Analysis of Integrated and Cointegrated Time Series with R.* Springer, New York.

Salas-Alvarado, A., Mora, J. C., and Agüero Rodríguez, O. E. (2015). Una Mirada a la competitividad del Sistema Bancario Nacional Costarricense a través del Indicador de Boone 2008-2013. *Revista de Ciencias Económicas*, 33(2):67.

Swamy, V. and Dharani, M. (2018). An alternate approach in exploring the causal link between financial development and economic growth—Evidence from advanced economies. *International Journal of Finance and Economics*, 23(1):55–76.

Yong, M. (2007). Competencia y regulación en la banca. El caso de Costa Rica.