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An Empirical Investigation into the Investment–Saving Relationship Through Granger Non-Causality Panel Tests

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Abstract

The investment–saving relationship has been the subject of much debate. On the one hand, there is the conventional mainstream neoclassical school of thought that advocates for the idea that saving determines investment. On the other hand, heterodox economists (mainly in the post-Keynesian/structuralist tradition) posit an inverse relationship between these variables. This article empirically investigates the direction of causality in order to contribute to the existing literature on the topic. To this end, two Granger panel tests are applied to a dataset of 106 countries over the period from 1980 to 2023. The econometric techniques used are effective in accounting for both cross-sectional dependence and heterogeneity in the data. In summary, our findings align with the theoretical models that posit bidirectional causality as the most probable explanation of the mechanism driving investment and saving. More specifically, they are consistent with post-Keynesian (demand-led) assumptions describing an open economy operating below its maximum potential growth rate within a current account solvency constraint.

Keywords: investments; savings; saving–investment causality; Granger non-causality

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1. Introduction

This paper investigates the causal relationship between investment and savings for an international panel of countries over the period 1980–2023. The subject has been the focus of significant research attention since the 1980s, coinciding with the increasing liberalization of capital movements (Argimòn & Roldàn, 1994; Pata, 2018). The debate over the proper specification of the investment–saving relationship has implications beyond the interests of academia. Indeed, this nexus is considered a key driver in the formulation of economic policy directly affecting the mobilization of the resources necessary for economic growth and development. The impact of one variable on the other is of great help in designing economic growth strategies. From a theoretical standpoint, two main positions describe the relationship through essentially opposite causal mechanisms. The first view is derived from the conventional neoclassical growth model, which is used to illustrate the demand adjustment process. Investments are not constrained by limited growth prospects, and spending responds to saving through changes in relative factor prices. In short, saving determines investment (Nell, 2012). The second approach has its roots in the post-Keynesian school. From this perspective, investment requires neither prior saving nor deposit (Lavoie, 2006). The decision to invest is based on the expectation of future demand.

The priority relationship is inverse to the neoclassical perspective. Causality is key in distinguishing between economic theories (Lavoie, 2022). The objective of this paper is to analyze the direction of causality between investment and saving. To this end, the largest international dataset collected from an international source is processed through appropriate econometric techniques. The identification of a clear direction of this causality is of paramount importance in providing empirical support for either theory. This paper contributes to the literature in three ways. First, we contribute to the empirical literature analyzing investment and saving from both neoclassical and post-Keynesian perspectives. Unlike other studies, we do not impose a variable to be justified as the end point of the analysis exogenously. Secondly, to the best of author's knowledge, this is the first study to present a panel investigation using non-causality techniques across such an extensive data set. Ultimately, in order to fill a gap existing in the current literature, the novel panel Granger non-causality test proposed by Juodis et al. (2021) is applied in combination with the Dumitrescu and Hurlin (2012) procedure. The outcomes of our investigation do not reveal a specific direction in the relationship between the variables. Rather, they support a two-way (in the Granger sense) causality. Overall, these results are more compatible with a demand-led post-Keynesian framework that describes an open economy operating below its maximum potential growth rate within a current account solvency constraint (Nell, 2012). The remainder of the paper is organized as follows. The next section provides background and the literature to help narrow our focus. Section 3 provides data and methodology descriptions. Section 4 presents and comments on the empirical results. Finally, Section 5 concludes the paper.

2. Theoretical Background

The genesis of the debate on the investment–saving nexus can be traced to the different interpretative frameworks that have been adopted to identify the underlying mechanism.

2.1. The Supply-Led Growth Model

The predominant neoclassical economic paradigm presupposes a supply-led growth model as a foundational tenet. Both its "exogenous" version (Solow, 1956, 1957; Swan, 1956; Barro, 1997; Hall & Jones, 1999; Mankiw et al., 1992) and the "endogenous" one (Romer, 1986; Lucas, 1988; Grossman & Helpman, 1991) share the same framework. From this perspective, an increase (positive shock) in saving leads to absolute capital growth. In accordance with the law of diminishing returns, the resulting capital growth rate will be lower than the previous one. The adjustment mechanism acts through changes in relative prices. A decline in the cost of capital (interest rate) relative to the wage rate (for labor) encourages entrepreneurs to adopt more capital-intensive technologies. The new equilibrium is characterized by a higher level of capital per person and per capita income. All saving is identically invested (Dutt, 2006). In summary, an increase in saving results in a higher level of investment, which in turn leads to an increase in per capita income (Nell, 2012). Within this context, the distinction between the exogenous and the endogenous versions hinges on the triggering mechanism, which, in the former case, is policy-induced, whereas in the latter, it is the consequence of a higher propensity to save.

2.2. The Demand-Led Growth Model

One alternative (and minority) position, proposed by the heterodox (post-Keynesian) economists (Kaldor, 1955; McCombie & Thirlwall, 2004; Robinson, 1962; Taylor, 1983, 1991), is based on the demand-led growth model. In this context, the causality between saving and investment is assumed to operate in the reverse direction. For a first approximation, the initial trigger of the mechanism is the intention of entrepreneurs to enhance their profits from improved growth expectations (Keynes, 1936; Davidson, 2011). An understanding of future demand conditions is the crucial factor (Palley, 1996). Psychological factors affect agents' forecasts and the conditions under which investments decisions are made (Harvey

& Pham, 2023). An important assumption of the model is the capacity/ability of the banking system to respond to the demand for credit, given the endogenous nature of the money supply. In this situation, augmented investment results in augmented output and income per capita, which, in turn, gives rise to an increase in the saving rate (Nell, 2012). The positive relationship between the demand and productivity growth with increasing returns to scale (in contrast with the neoclassical hypothesis of diminishing returns) was initially outlined by Verdoorn (1949) and thereafter reiterated by Kaldor (1966).

2.3. Related Literature Hypothesis

The expansion of international trade and the concomitant issues associated with open economies introduce additional dimensions of analysis. In fact, investors may also resort to foreign capital. In this context, the seminal work of Feldstein and Horioka (1980) assumes a strict causal relationship "from saving to investment" for the analysis of capital mobility in the neoclassical framework. Differently, the extended ("weaker") version proposed by Nell and Santos (2008) of the current account long-run solvency constraint model (Coakley et al., 1996) relaxes this "one-way" link. They argue for a bi-directional causality in which investment must generate its own saving to contribute to the economic sustainability of the current account deficit. The conditions of current account solvency are then related to the import–export variables by Thirlwall (2002), McCombie (2004), and McCombie and Thirlwall (2004). With regard to the empirical aspect, it should be noted that extensive research attention has been devoted to the cointegration and correlation analysis of the relationship between variables. In this specific sense, the aforementioned pioneering work of Feldstein and Horioka (1980) constituted a pivotal contribution. The large amount of research that has resulted has been focused on the analysis of the "Feldstein–Horioka puzzle". Notwithstanding these efforts, a consensus has yet to be reached (Irandoust, 2019). Without pretenseattempting to provide an exhaustive review of the literature, and recognizing that a significant body of research is country-specific, we point to examples in Jos Jansen (1996), Payne (2005), Chakrabarti (2006), and Singh (2008). The positive correlation between saving and investment in the short run is influenced by the size of the country, as evidenced by the works of Harberger (1980), Murphy (1984), Baxter and Crucini (1993), and Bahmani-Oskoee and Chakratbarti (2005). Similarly, with a focus on technological or productivity shocks, the contributions by Rasin (1993), Glick and Rogoff (1995), Behera et al. (2024), Seshaiah and Vuyuri (2005), and Roche Seka (2011) show a specific direction in causality from saving toward investment. The dynamic nature of the relationship has been highlighted by Khan (2017), while its bidirectional causality is pointed out by Mishra et al. (2010). In the light of the two opposing theoretical mechanisms, the competing hypotheses to be tested using the data are as follows:

H1. *(The strict neoclassical framework) = saving precede (Granger cause) investment.*

H2. *(The strict post-Keynesian framework) = investment precede (Granger cause) saving.*

H3. *(Some variants of the previous theories appear more credible) = there is a bidirectional relationship (simultaneous Granger causality) between variables.*

3. Data and Methodology Framework

3.1. Data Description

This paper presents an empirical investigation into the lead–lag relationship between investment and saving. The objective is to gain a deeper comprehension of the mechanism that relate the two variables, with a particular focus on the neoclassical and post-Keynesian theoretical frameworks. In order to obtain the largest possible dataset, we gathered yearly data from 106 countries (*N*) and territories across the world. The time span covers the period from 1980 to 2023 (*T*), following data availability in the World Economic Outlook (WEO) database (IMF, 2024). The variables of interest are the Total Investment (INV) as a percentage of GDP (*I/Y*) and the Gross National Savings (SAV) as a percentage of GDP (*S/Y*). As in Jos Jansen (1996), we can argue that it is natural to use investment and saving rates, since the steady-state relation between the variables can be expressed in shares of income. The descriptive statistics of the full sample are resumed in Table 1.

Table 1. Descriptive statistics of the variables.

Variable	N	Mean	Median	SD	Min	Max	Skewness	Kurtosis
INV	4664	23.75	22.79	9.79	−11.19	115.10	1.49	10.49
SAV	4664	20.65	20.27	11.24	−98.14	81.57	−0.38	9.57

Source: Author's calculations in Eviews.

The WEO database originally contains 196 countries; however, not all units can be included for the purpose of this study, as some data are lacking. In order to build a balanced panel with the most relevant information and the longest time series, we had to exclude some units. The full list of excluded units, along with the reasons for exclusion, can be found in Table A1 in the Appendix A Section. It is not possible to obtain the same level of detail from another database with respect to both the temporal length and the number of countries included in the sample.

3.2. Methodology

The fundamental framework of this study is based on an analysis of causal empirical relationships. In this sense, it investigates the theory but without the presence of a complete structural model (Mouchart et al., 2020). In essence, the investigation focuses on the mechanism without inferring the temporal sequence of the mutual action of all other variables involved in the intermediate steps. In the present case, the sub-mechanisms and variables involved relate to the changes in relative prices for the supply-led model, with the increased bank credit anticipating growth expectations for the demand-led one. "Causality is probably the most crucial aspect of economics: this is how, in many instances, theories can be distinguished from one another" (Lavoie, 2022). In this study, we cannot suppose a direct and instantaneous causality between investment and saving. Indeed, both the neoclassical and post-Keynesian frameworks describe a mechanism in which these variables are involved in both the initial and concluding steps of the entire sequence, from saving to investment for the former, and vice versa for the latter. It is therefore possible to discern how a variable can contribute to the prediction of another, despite the potential for a post hoc ergo propter hoc fallacy in any "causality test" in econometrics (Pfaff, 2008). In the present analysis, it is first necessary to undertake an analysis of the properties of the panel. The initial investigation pertains to the potential existence of cross-sectional dependence (CSD). This phenomenon arises when individual panel members react not only to their own member-specific idiosyncratic shocks but also to shocks that are common across the other members. In this study, three of the most widely used tests are employed: the Breusch and Pagan Lagrange Multiplier procedure (Breusch & Pagan, 1980), the scaled version of the Lagrange Multiplier by Pesaran (2004) and, finally, its bias-adjusted version (Pesaran et al., 2008). Furthermore, it is important to consider the potential heterogeneity in individual dynamics, i.e., whether there is the presence of cross-sectional heterogeneity in the panel (Pesaran & Smith, 1995; Pesaran & Yang, 2024). To this end, the slope homogeneity test by Pesaran and Yamagata (2008) is performed. This procedure is an extended version of the Swamy (1970) test. The empirical significance of both CSD issues and heterogeneity within a panel analysis is evidenced in the literature (Lopez & Weber, 2017; Nazilogu & Karul, 2024). To evaluate the stationarity in the panel, the appropriate unit root tests are employed. Further details can be found in the subsequent Section 4.1. The Granger (1969) model is a technique widely used by economists to analyze the causal relationship (lead–lag) between variables. In the context of econometric analysis, the term "Granger causes" is employed to describe a situation in which the first event x_t is said "to cause" the second event y_t if the information content of the former event has predictive power for the latter. In the present analysis, two specific approaches have been proposed depending on the basic assumptions about the intrinsic structure of the panel itself. In this investigation, two recent methods are considered. The first procedure is the Dumitrescu–Hurlin (D-H) non-causality test (2012), which is an effective method for addressing the simultaneous presence of CSD and heterogeneity (Xie et al., 2022). In this case, the regression form is

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik} y_{i,t-k} + \sum_{k=1}^{K} \beta_{ik} x_{i,t-k} + \epsilon_{i,t} \quad \text{with} \quad i = 1, \ldots, N \text{ and } t = 1, \ldots, T \tag{1}$$

where $x_{i,t}$ and $y_{i,t}$ are the observations of two stationary variables for individual i in period t. Even though the coefficients are assumed to be time invariant, they are allowed to differ across individual through the subscripts i for each period t. The panel must be balanced, and the lag order is assumed to be identical for all individuals. As in the original Granger procedure, in the D-H test to investigate the potential existence of a "Granger-causality", the null hypothesis H0 states that β coefficients are all equal to 0 for each i (non-causality). The alternative hypothesis (H1) assumes that there is potential causality for some individuals but not necessarily for all. The D-H procedure calculates an average Wald statistic $\overline{W}$ resulting from the individual Wi obtained through the F tests of the K linear hypotheses $\beta_{\iota 1} = \ldots = \beta_{\iota K} = 0$, running the N regressions from (1), as follows:

$$\overline{W} = \frac{1}{N} \sum_{i=1}^{N} W_i \tag{2}$$

By using Monte Carlo simulations, Dumitrescu and Hurlin (2012) show that (2) performs well in investigating panel causality due to its good asymptotical behavior. To test the null hypothesis (H_0) coherently with the panel structure, two standardized statistics ($\overline{Z}$ and $\widetilde{Z}$) can be used (Lopez & Weber, 2017):

$$\overline{Z} = \left(\frac{N}{2K}\right)^{0.5} \times (\overline{w}_r - K) \quad \text{the distribution} \rightarrow N(0,1) \text{ with } T, N \rightarrow \infty \tag{3}$$

$$\widetilde{Z} = \left(\frac{N}{2K} \times \frac{T-3K-5}{T-2K-3}\right)^{0.5} \times \left(\frac{T-3K-3}{T-3K-1} \times \overline{W} - K\right) \quad \text{the distribution} \rightarrow N(0,1) \text{ with } N \rightarrow \infty \tag{4}$$

In addition to the D-H test, the very recent Juodis et al. (2021) technique (JKS) is proposed. The JKS test can be applied to both homogeneous and heterogeneous panels (Xiao et al., 2023). Its efficiency is based on the Dhaene and Jochmans (2015) Half-Panel Jackknife approach. As Xie et al., 2022, point out, traditional bidirectional causality models overlook asymptotic size (Nickell bias). In detail, the JKS procedure is more appealing for use with the GMM approach of Holtz-Eakin et al. (1988) when T is (even moderately) large. With respect to the D-H test, the JKS does not suffer from substantial size distortion for much smaller values of T than N (Xiao et al., 2023). It is essential to recall the fundamental steps required to define the statistical indicator necessary for the successful completion of the test. More details can be found in the original work by Juodis et al. (2021). Formula (1) can be rewritten as follows:

$$y_{i,t} = z'_{i,t}\,\gamma_\iota + x'_{i,t}\beta_\iota + \varepsilon_{i,t} \tag{5}$$

with $z_{it} = (1, y_{t-1}, \ldots, y_{t-k})'$, $x_{i,t} = (x_{i,t-1}, \ldots, x_{i,t-k})'$, $\gamma_\iota = (\gamma_{0,\iota}, \ldots, \gamma_{k,i})'$, and $\beta_\iota = (\beta_{1,\iota}, \ldots, \beta_{\kappa,\iota})'$. Stacking (4) over time, we obtain:

$$y_i = Z_i\gamma_I + X_i\beta_\iota + \varepsilon_\iota \quad (6)$$

with $y_t = (y_{i,1}, \ldots, y_{i,T})'$, $Z_i = (z_{i,1}, \ldots, z_{i,T})'$, $X_i = (x_{i,1}, \ldots, x_{1,T})'$, and $\varepsilon_\iota = (\varepsilon_{I,1}, \ldots, \varepsilon_{i,T})'$. Under the null hypothesis ($\beta_i = \beta = 0$), the pooled least-squares estimator of β is

$$\hat{\beta} = \left(\sum_{i=1}^{N} X_i' M_{Zi} X_i\right)^{-1} \left(\sum_{i=1}^{N} X_i' M_{Zi} y_i\right) \quad (7)$$

where $M_{Zi} = I_T - Z_i(Z_i{}'Z_i)^{-1}Z_i{}'$. Fernández-Val and Lee (2013) showed that as $N,T \to \infty$ with $N/T \to k^2 \notin [0; \infty]$ under general conditions, this relationship holds as follows:

$$NT^{1/2}\left(\hat{\beta} - \beta_0\right) \to J^{-1}N(-kB, V) \quad (8)$$

wherein $J = \text{plim}_{N,T\to\infty}(NT)^{-1}\sum_{i=1}^{N} X_i' M_{Zi} X_i$, V stands for the variance–covariance matrix, and B is the bias due to the same order of both N and T. To circumvent size distortion and remove the parametric bias, Dhaene and Jochmans (2015) propose the Half-Panel Jackknife estimator (HPJ in symbol $\tilde{\beta}$):

$$\tilde{\beta} = \hat{\beta} + [\tilde{\beta} - 1/2(\hat{\beta}_{1/2} + \hat{\beta}_{2/1})] = \hat{\beta} + T^{-1}\hat{B} \quad (9)$$

In (9), $\hat{\beta}_{1/2}$ is the estimator present in (7) obtained using the first half of the time series observations in all units, while $\hat{\beta}_{2/1}$ is obtained using all units but only the second half of our time series observations. From all the previous main steps, it is possible to obtain the Wald statistics for Granger non-causality $\hat{W}_{HPJ}$ defined for $N,T \to \infty$ with $N/T \to k^2 \notin [0, \infty]$:

$$\hat{W}_{HPJ} = NT\tilde{\beta}'\left(\hat{J}^{-1}\hat{V}\hat{J}^{-1}\right)^{-1}\tilde{\beta} \to \chi^2(P)$$

where $\hat{J} = (NT)^{-1}\sum_{i=1}^{N} X_i' M_{Zi} X_i$.

This investigation is intended to explore a general theoretical position. For this reason, the empirical analysis includes the whole set of countries without specific sub-samples (like for example income classifications or trade openness features). They could be useful for assessing differences across regions/countries but not for testing the validity of the theoretical framework that is the core subject of the present work.

4. Discussion Results

4.1. Panel Structure Analysis

The initial analysis is centered on the CSD test. We propose three appropriate procedure: Breusch and Pagan (1980), scaled LM Pesaran (2004), and its bias-adjusted subsequent version (Pesaran et al., 2008). The results are resumed within Table 2, and they fail to accept the null hypothesis (H_0 = no presence of CSD).

Table 2. Cross-section dependence test.

Variables	Breusch–Pagan LM	*p*-Value	Pesaran Scaled LM	*p*-Value	Pesaran CD	*p*-Value
INV	28.16	0.00	214.18	0.00	30.02	0.00
SAV	30,765.39	0.00	238.87	0.00	43.66	0.00

Source: Author's calculations in Eviews on IMF (2024).

Although, in this case, the likelihood of a dependence across countries is very low, the slope homogeneity test is run to remove all doubts. The panel is very large and includes very different units that follow various development trajectories, In Table 3 below, the results of Pesaran and Yamagata's (2008) slope homogeneity test are proposed. As the outcome shows, the null hypothesis of slope homogeneity can be rejected.

Table 3. Pesaran and Yamagata homogeneity test in slope coefficients.

Variables	Δ	*p*-Value	Δadj	*p*-Value
INV	49.48	0.00	51.26	0.00
SAV	48.55	0.00	50.29	0.00

Source: Author's calculation in Stata on IMF (2024).

To obtain robust findings in stationarity analysis in the case of the presence of CSD, second-generation unit root tests are recommended (Hurlin & Mignon, 2007), and we run the Bai and Ng (2004, 2010) and the Pesaran (2007) procedures. Table 4 explores the findings; both the tests fail to accept the null hypothesis of unit root presence. Since our variables exhibit stationary behavior in levels, the Granger non-causality approach can be applied without further preliminary precautions.

Table 4. Variables in levels: second-generation unit root tests for stationarity.

Variable	Test	Deterministics	ADF Lag Selection	Pooled Statistic	Prob
INV I(0)	Bai and Ng (PANIC)	Constant MQC	Akaike crit. max lag = 9	3.29	0.00 *
		Constant MQF	Akaike crit. max lag = 9	3.58	0.00 *
		Constant and trend MQC	Akaike crit. max lag = 9	5.95	0.00 *
		Constant and trend MQF	Akaike crit. max lag = 9	5.82	0.00 *
	Pesaran CIPS Truncated CIPS	Constant	Akaike crit. max lag = 9	−1.93 −2.06	≥0.10 <0.10 *
	Pesaran CIPS Truncated CIPS	Constant and trend	Akaike crit. max lag = 9	−2.60 −2.78	<0.05 * <0.01 *
SAV I(0)	Bai and Ng (PANIC)	Constant MQC	Akaike crit.max lag = 9	4.65	0.00 *
		Constant MQF	Akaike crit.max lag = 9	4.22	0.00 *
		Constant and trend MQC	Akaike crit.max lag = 9	6.29	0.00 *
		Constant and trend MQF	Akaike crit.max lag = 9	6.43	0.00 *
	Pesaran CIPS Truncated CIPS	Constant	Akaike crit.max lag = 9	−2.46 −2.46	<0.01 * <0.01 *
	Pesaran CIPS Truncated CIPS	Constant and trend	Akaike crit.max lag = 9	−2.68 −2.92	<0.01* <0.01 *

Source: Author's calculations in Eviews on IMF (2024). Notes: Bai and Ng-PANIC: the * rejects the null hypothesis of no cointegration of the idiosyncratic errors (unit root null). MQC is a PANIC option based on a VAR(1) representation and corrects for the serial correlation of arbitrary form through a non-parametric estimation. MQF is a PANIC option based on a VAR(1) representation and corrects for the serial correlation of arbitrary form through a filter procedure. Pesaran: the * rejects the null hypothesis of a unit root at the reported significance level.

4.2. Panel Granger Non-Causality Analysis

This sub-section reports the outcomes of the Granger non-causality test in the panel. Tables 5 and 6 summarize the results of the D-H test and the JKS test wherein the bi-directional association between the investment and saving variables for different lag selections. The lags (2, 5, and 9) are selected considering that these time horizons are coherent with the impact of macroeconomic policies in the short-, medium-, and long-term period. The classical theoretical literature on the average duration of economic cycles considers the existence of different economic cycles (Reijnders, 2009). The Kitchin cycles (3–5 years) and the Juglar cycles (7–9 years) are the main time horizons to take into consideration for the economic policy contexts. As highlighted in the Methodology Section, both of these tests can correctly deal with the presence of panel heterogeneity. As far as the D-H test is concerned, both the $\overline{Z}$ and the $\tilde{Z}$ statistics are reported in order to avoid criticism related to the panel structure.

Table 5. Dumitrescu–Hurlin panel Granger non-causality test.

Null Hypothesis	Lags	Wald	$\overline{Z}$	*p*-Value	$\tilde{Z}$	*p*-Value
SAV does not GC INV	2	5.29	16.96	0.00	14.63	0.00
INV does not GC SAV		3.88	9.67	0.00	8.11	0.00
SAV does not GC INV	5	7.81	9.14	0.00	6.44	0.00
INV does not GC SAV		7.26	7.35	0.00	4.98	0.00
SAV does not GC INV	9	13.65	11.29	0.00	5.16	0.00
INV does not GC SAV		11.15	5.22	0.00	1.32	0.19 *

Source: Author's calculations in Eviews on IMF (2024). Notes: Monte Carlo asymptotic definition–at various lags with N = 5000. The * accepts the null hypothesis at 0.05 level

Table 6. JKS panel Granger non-causality test.

Null Hypothesis	Lags	HPJ Wald	*p*-Value	BIC	Coef.	Std Err	*p*-Value
SAV does not GC INV	2	16.90	0.00	10,924.06	0.04	0.02	0.03
	5	66.64	0.00	8630.74	−0.07	0.01	0.00
	9	171.89	0.00	5683.10	−0.04	0.03	0.25
INV does not GC SAV	2	6.28	0.04	12,227.05	−0.06	0.04	0.17
	5	33.13	0.00	9807.47	−0.04	0.07	0.55
	9	479.19	0.00	6744.34	0.05	0.04	0.25

Source: Author's calculations in Stata on IMF (2024). Notes: BIC information criteria.

5. Discussion

On this specific technical point, we can report Lopez and Weber (2017): "For large *N* and *T* panel datasets, $\overline{Z}$ can be reasonably considered. For large *N* but relatively small *T* datasets, $\tilde{Z}$ should be favored". The provision of both indicators is an essential step in ensuring the acquisition of comprehensive information on this aspect. Additionally, we run the test adopting different lags (2, 5, and 9). This is a deliberate decision made to address two distinct requirements. The first need is technical in nature and concerns overcoming model selection in the D-H procedure. While the original paper by Dumitrescu and Hurlin (2012) does not address this aspect, a trade-off exists between the optimal size (with the smallest regression lags) and the best power when the lags align with the true autoregressive structure of the data. The Eviews procedure considers an asymptotic definition—selecting various lags—with 5000 replications (Eviews, 2024). The second requirement is of strictly economic origin. It is reasonable to propose an analysis that includes short-term (from an economic perspective), medium-term, and long-term scenarios. The 2-year short-term scenario is only the minimum temporal frame within which to ascertain whether one variable exerts an impact on another (and/or vice versa). More generally, investment decisions are long-term choices. At the macro level, there is no statistically evident impact within a few months after implementation. At the macro level, there is no statistically evident impact within a few months after implementation. Looking at the outcomes, both tables highlight a bi-directional relationship between investment and saving. The null hypothesis of the Granger tests is not supported except in the case of the D-H test for the Z tilde statistic at lag 9. Neither of the lead–lag relationships (investment precedes saving or its opposite) can be excluded. A clear one-way relationship cannot be detected. The bidirectional causality appears to represent the dominant interpretation of the results. It has been observed that this scenario plays out seamlessly for all the lag structures that have been selected. It is not possible to determine whether one variable is prevalent over the other. These findings reject both H1 and H2 of the study. If one were to examine the data in minute detail, however, one might note that in Table 5 for lag 9, the $\widetilde{Z}$ statistics accepts the null for the INV $\nrightarrow$ SAV direction (p-value = 0.19), while not supporting SAV $\nrightarrow$ INV. Thus, we can derive that only in the case of the D-H test, and the long run, saving lead to investment, supporting the H1 hypothesis. Nevertheless, such an interpretation is not supported by $\widehat{W}_{HPJ}$ for the same lag period. For clarity, the summary of the hypothesis and the outcomes of the tests at various lags are summarized in Table 7.

Table 7. Summary of the outcomes of the tests.

Hypothesis	Lag	$\overline{Z}$	$\tilde{Z}$	HPJ Wald
H1	2	0	0	0
sav $\rightarrow$ inv	5	0	0	0
	9	0	1	0
H2	2	0	0	0
inv $\rightarrow$ sav	5	0	0	0
	9	0	0	0
H3	2	1	1	1
inv $\leftrightarrow$ sav	5	1	1	1
	9	1	0	1

Source: Author's elaboration. Notes: 0 stands for hypothesis not supported, 1 for supported.

6. Conclusions

This study aimed to examine the nexus between investment and saving. In order to achieve the aforementioned objective, a preliminary analysis of the statistical properties of the panel was conducted. Then, two non-causality tests were proposed. To the best of the author's knowledge, this is the very first work applying these novel Granger techniques to such a large set of countries. This manuscript presents a Granger non-causality analysis drawing upon a balanced panel of 106 countries and territories worldwide, as documented in the World Economic Outlook (IMF, 2024). The time span is from 1980 to 2023. The primary conclusions of the research indicate that a "one-way" directional causality between the variables is not supported by empirical evidence. Our findings do not provide decisive confirmation for any of the corner solutions represented by the different opposing views. The analysis indicates that a bidirectional causal relationship appears to be the most reliable outcome. The actual direction of the causal relationship between investment and saving represents a controversial issue and subject of debate in competing theories attempting to represent macroeconomic models. On the one hand, there is the neoclassical (mainstream) theory, in which the proposed direction is from saving to investment. This hypothesis is supported by the supply-led mechanism. On the other hand, the post-Keynesian (heterodox) perspective advocates for the diametrically opposed concept, a demand-driven mechanism. As international trade becomes more open, the neoclassical position reinforces its beliefs through the Feldstein and Horioka (1980) hypothesis. Under these conditions, however, post-Keynesians also consider the possibility of a bidirectional link between the same variables. This would be the case for an economy operating below its maximum potential growth rate within a current account solvency constraint model (Coakley et al., 1996; Nell & Santos, 2008; Nell, 2012). In open economies, this finding suggests that the current account long-run solvency constraint plays a pivotal role in formulating effective economic policy. The issue is of particular importance with regard to economic policy, given the considerable discrepancy in the practical consequences. The reasonable equilibrium between exports and imports is crucial. As Bagnai (2009) has observed, an excessive imbalance in current account positions for large economies is regarded by the majority of scholars as a destabilizing factor for the orderly development of the global economy. A persistent and imbalanced increase in imports raises the external debt, which cannot be sustained in the long term. From this perspective, achieving an optimal equilibrium among the sectors that underpin the economy—namely, agriculture, industry, and services—is paramount. In order to point out the potential limitations of the conclusions presented, it is essential to acknowledge that the Granger methodology is employed as a tool to facilitate predictive activities.

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Appendix A

Table A1. List of the countries excluded from the panel dataset and specific motivations.

Excluded Country	Reason
Afghanistan	Full data are only available starting in the year 2002
Andorra	Full data are only available starting in the year 2000
Antigua	Full data are only available starting in the year 2014
Armenia	Full data are only available starting in the year 1995
Aruba	No data for investments
Azerbaijan	Full data are only available starting in the year 1992
Bangladesh	Full data are only available starting in the year 1981
Belarus	Full data are only available starting in the year 1994
Bhutan	Full data are only available starting in the year 1981
Bolivia	Full data are only available starting in the year 1983
Bosnia and Herzegov.	Full data are only available starting in the year 1998
Brunei	No data for savings
Cambodia	Full data are only available starting in the year 1986
Chile	Full data are only available starting in the year 1981
Dem. Rep. Congo	Full data are only available starting in the year 1993
Croatia	Full data are only available starting in the year 1992
Czech Republic	Full data are only available starting in the year 1995
Djibouti	Full data are only available starting in the year 1991
Dominica	Full data are only available starting in the year 2000
El Salvador	Full data are only available starting in the year 1981
Eritrea	Full data are only available starting in the year 1992
Estonia	Full data are only available starting in the year 1993
Fiji	No data for savings
Georgia	Full data are only available starting in the year 1996
Ghana	Full data are only available starting in the year 1983
Grenada	Full data are only available starting in the year 2014
Guinea-Bissau	Full data are only available starting in the year 1997
Haiti	Full data are only available starting in the year 1995
Iraq	Discontinued series. No data for investments
Kazakhstan	Full data are only available starting in the year 1992
Kiribati	No data for investments and savings
Kosovo	Full data are only available starting in the year 2012

Table A1. *Cont.*

Excluded Country	Reason
Kuwait	Full data are only available starting in the year 1995
Kyrgyz Republic	Full data are only available starting in the year 1992
Lao P.D.R.	No data for investments and savings
Latvia	Full data are only available starting in the year 1992
Lebanon	No data for investments
Liberia	Discontinued series. No data for investments and savings
Libya	No data for savings
Lithuania	Full data are only available starting in the year 1995
Macao SAR	Discontinued series. No data for savings
Maldives	Full data are only available starting in the year 1990
Malta	Full data are only available starting in the year 1995
Marshall Islands	Discontinued series. No data for investments and savings
Mauritania	Full data are only available starting in the year 1990
Micronesia	Discontinued series. No data for investments and savings
Moldova	Full data are only available starting in the year 1992
Montenegro	Full data are only available starting in the year 2001
Mozambique	No data for investments from 2021 onwards
Myanmar	Full data are only available starting in the year 1998
Namibia	Full data are only available starting in the year 1990
Nauru	Discontinued series. No data for investments and savings
Nicaragua	Full data are only available starting in the year 1991
Nigeria	Full data are only available starting in the year 1990
North Macedonia	Discontinued series. No data for investments
Palau	Discontinued series. No data for savings
Papua New Guinea	No data for Investments and savings
Poland	Full data are only available starting in the year 1984
Puerto Rico	No data for savings
Qatar	No data for investments
Russia	Full data are only available starting in the year 1992
Samoa	No data for investments and savings
San Marino	Discontinued series. No data for savings
Sao Tomé and Princ.	Discontinued series for investments and savings
Serbia	Full data are only available starting in the year 2000
Slovak Republic	Full data are only available starting in the year 1993
Slovenia	Full data are only available starting in the year 1992
Somalia	Discontinued series. No data for investments and savings
South Sudan	Full data are only available starting in the year 2011
Sri Lanka	The 2023 year data are n/a
St. Kitts and Nevis	Investments and savings data starting in the year 2014
St. Lucia	Investments and savings data starting in the year 2014
St. Vincent and Gr.	Investments data starting in the year 2014
Sudan	No data for investments
Suriname	Investments and savings data starting in the year 1991
Syria	N/a data from 2011 onwards
Tajikistan	Full data are only available starting in the year 1992
Timor-Leste	Discontinued series. No data for savings
Tonga	No data for investments and savings
Trinidad and Tobago	No data for investments
Turkmenistan	Discontinued series. No data for investments and savings
Tuvalu	Discontinued series. No data for investments and savings
Uganda	Full data are only available starting in the year 1984
Ukraine	Full data are only available starting in the year 1992
Uzbekistan	Full data are only available starting in the year 1992
Vanuatu	Discontinued series. No data for savings
Venezuela	Investments and savings data n/a from 2018 onwards
West Bank and Gaza	Discontinued series. No data for savings
Yemen	Full data are only available starting in the year 1990
Zimbabwe	Discontinued series. No data for investments and savings

Source: Personal elaboration on IMF (2024).

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