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مجلد (21) عدد (2) 2025

External Debt as a Stimulator of Economic Growth in Selected International Economies for the Period (2003-2022)

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Abstract

This study aims to analyze and measure the causal relationship between external debt and economic growth in three major industrialized countries: the United States, Japan, and China, over the period from 2003 to 2022. The core issue addressed by the study revolves around whether external debt can lead to positive outcomes that enhance economic growth, particularly given the variations in economic policies and the differing uses of external debt across the studied nations. The research methodology employed an econometric approach, utilizing (panel data) and causality tests. The findings revealed that external debt had a positive impact on economic growth in the three selected countries, effectively contributing to the enhancement of economic growth rates. Furthermore, differences in the magnitude of this impact were identified among the countries, with China ranking first in terms of the strength of the positive influence of external debt on economic growth, followed by Japan, and then the United States.

The results underscore the importance of utilizing external debt efficiently to finance productive sectors and development projects that promote economic growth. Based on these findings, the study recommends the formulation of economic strategies that ensure the optimal use of external debt to achieve sustainable economic development while mitigating associated risks.

Keywords: External Debt, Economic Growth, Causation, Panel Data.

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

الدين الخارجي المعزز للنمو الاقتصادي في اقتصادات دولية مختارة للمدة (2003-2022)

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المستخلص

تهدف الدراسة إلى تحليل وقياس العلاقة السببية بين الدين الخارجي والنمو الاقتصادي في ثلاث دول رئيسة: الولايات المتحدة الأمريكية واليابان والصين، خلال المدة من 2003 إلى 2022. ويتمحور الموضوع الرئيس الذي تتناوله الدراسة حول مدى قدرة الدين الخارجي على تحقيق نتائج إيجابية تُعزز النمو الاقتصادي، لاسيما في ظل تباين السياسات الاقتصادية واختلاف استخداماته بين الدول عينة الدراسة. اعتمدت منهجية البحث على منهج الاقتصاد القياسي، باستخدام (Panel Data) واختبارات السببية. وكشفت النتائج عن تأثير إيجابي للدين الخارجي على النمو الاقتصادي في الدول الثلاث المختارة، مما أسهم بشكل فعال في تعزيز معدلات النمو الاقتصادي. كما حُددت فروق في حجم هذا التأثير بين الدول المختارة، حيث احتلت الصين المرتبة الأولى من حيث قوة التأثير الإيجابي للدين الخارجي على النمو الاقتصادي، تليها اليابان، ثم الولايات المتحدة الأمريكية.

وتؤكد النتائج على أهمية استخدام الدين الخارجي بكفاءة لتمويل القطاعات الإنتاجية ومشاريع التنمية التي تُعزز النمو الاقتصادي. بناءً على هذه النتائج، توصي الدراسة بصياغة استراتيجيات اقتصادية تضمن الاستخدام الأمثل للدين الخارجي لتحقيق التنمية الاقتصادية المستدامة مع التخفيف من المخاطر المرتبطة به.

الكلمات المفتاحية: الدين الخارجي، النمو الاقتصادي، السببية، Panel Data.

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Introduction

External debt is one of the most significant economic indicators used to diagnose the financial and economic conditions of countries. It reflects the extent to which a domestic economy relies on external financing to meet its developmental needs and achieve strategic objectives. However, external debt is not merely a financial burden added to the shoulders of nations; it can also serve as an effective tool to stimulate and promote economic growth if utilized wisely and invested in productive sectors that enhance the capabilities of the local economy.

Historically, the world has witnessed major shifts in the nature and roles of external debt. Developed countries have increasingly relied on it as part of their economic strategies to promote development and achieve high growth rates. Although external debt is often perceived as a negative indicator of an economy's weakness or inability to self-finance, international experience has demonstrated that the investment returns generated from the effective utilization of debt may exceed the associated borrowing costs, resulting in positive outcomes that enhance a country’s economic standing.

Importance of the Study: The importance of studying the relationship between external debt and economic growth lies in understanding the stark disparities between developed and developing countries in managing and utilizing this debt. This study aims to shed light on the experiences of three major industrialized nations: the United States of America, Japan, and China, which are among the most prominent global economies. It analyzes the role of external debt in enhancing economic growth rates during the period from 2003 to 2022.

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Problem of the Study: External debt is often viewed as an indicator of declining economic status, depleted financial reserves, and an inability to meet internal and external financial obligations. However, this perspective is subject to much interpretation and limitation. Countries that effectively invest borrowed funds have demonstrated that investment returns can exceed borrowing costs, leading to positive results that enhance economic growth. This outcome, however, depends heavily on the economic policies governing the use of financial resources obtained from external debt. Thus, the study addresses the following question: Can external debt lead to positive results that enhance economic growth?

Objectives of the Study: This study aims to achieve the following objectives:

1- **Analyze the causal relationship between external debt and economic growth:** By examining the causal relationship between external debt and economic growth rates in the selected countries using econometric tools.

2- **Measure the impact of external debt on economic growth in the selected countries:** We aim to estimate the quantitative impact of external debt on the economic growth of the United States, Japan, and China using regression models and panel data analysis.

3- **Provide policy recommendations to enhance the utilization of external debt:** Based on the findings of the econometric analysis, we aim to derive practical recommendations to guide decision-makers in formulating effective strategies for managing external debt and leveraging it as a tool to support economic development and achieve sustainable growth rates.

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Hypothesis: The study hypothesizes that the external debt of the United States, Japan, and China has been positively effective, significantly contributing to stimulating economic growth rates in these countries during the studied period.

Sample and Study Period: The study focuses on three major industrialized countries that resorted to external debt despite rapid scientific and technological advancements across various sectors during the period from 2003 to 2022.

Methodology: The study adopts both theoretical and applied approaches, utilizing econometric methods to analyze and demonstrate the causal relationship between economic growth and external debt in the selected countries. A econometric model is estimated to determine the magnitude of the impact of external debt on economic growth in these nations.

Structure of the Study: The study is divided into two main sections:

1- **Theoretical Section:** External debt in economic literature.

2- **Applied Section:** Measuring the causal relationship between economic growth and external debt.

3- **Conclusions and Recommendations.**

1-Theoretical Section: External Debt in Economic Literature

1-1 Conceptual Framework of External Debt

From the perspective of the International Monetary Fund (IMF), external debt is defined as the amount of debt liabilities or actual current liabilities incurred by residents of a country's economy at any given time, owed to non-residents. These liabilities require the debtor to make payments to repay the principal and/or interest, or service the debt, at specific points in the future **(IMF, 2003: 7)**. External debt is one of the main components

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

of cross-border capital flows, which are divided into two categories: external debt and foreign direct investment (FDI) on one hand, and indirect foreign investment, also known as foreign portfolio investment, on the other. It constitutes part of the obligations of the borrowing country concerned and is owed to non-residents.

In practice, external debt is categorized as follows **(Bin Tafat and Sahel, 2023: 35)**:

A. Short-term Debt: Debts that is payable within a period of time, usually one year or less from the due date. These debts are characterized by high costs.

B. Long-term Debt: Debts payable over a period exceeding one year, potentially extending beyond ten years from the maturity date. These debts are characterized by low costs and are easier for borrowers.

C. Credit provided by the IMF.

Within the framework of intellectual economic schools, opinions have generally varied regarding debt and its importance in the economy. Traditional economic thought cautioned against resorting to this type of financial resource except in exceptional circumstances, due to the financial burdens it would impose on future generations. Economic balance is achieved automatically without state intervention. In contrast, modern economic thought acknowledges the possibility of resorting to external debt, particularly since the experiences of developed countries during periods of recession have demonstrated that the problem lies not in a lack of domestic savings but rather in the absence of investment opportunities. This absence leads to insufficient aggregate demand needed to absorb the supply of goods

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

at the required level of utilization, especially when the borrowed funds are directed toward expanding productive investments **(Al Ali, 2002: 288)**.

Historically, developed countries have resorted to external debt through various sources with the aim of enhancing domestic savings and achieving desired rates of economic growth. For instance, Britain and the Netherlands relied on external debt during the 17th and 18th centuries as one of the primary sources of financing to support their economic programs. Similarly, the United States utilized external debt during the 19th century to strengthen its domestic resources, eventually becoming the leading country in terms of total external debt internationally **(Ghaish, 2019: 678)**. This trend was further solidified after the Bretton Woods Agreement shaped the international monetary system, which guided the global capitalist economy until the early 1970s. Following World War II, calls emerged to encourage international capital flows for productive purposes through international financial institutions such as the World Bank and the International Monetary Fund. These efforts aimed to reconstruct war-damaged economies and enhance international liquidity.

In contrast, developing countries often fell into what is known as the debt trap, owing to deep structural imbalances in their economies. However, in developed countries, external debt served as a tool for economic growth, enabling governments and the private sector to invest in infrastructure, capital projects, and innovation despite the complications caused by the international debt crisis.

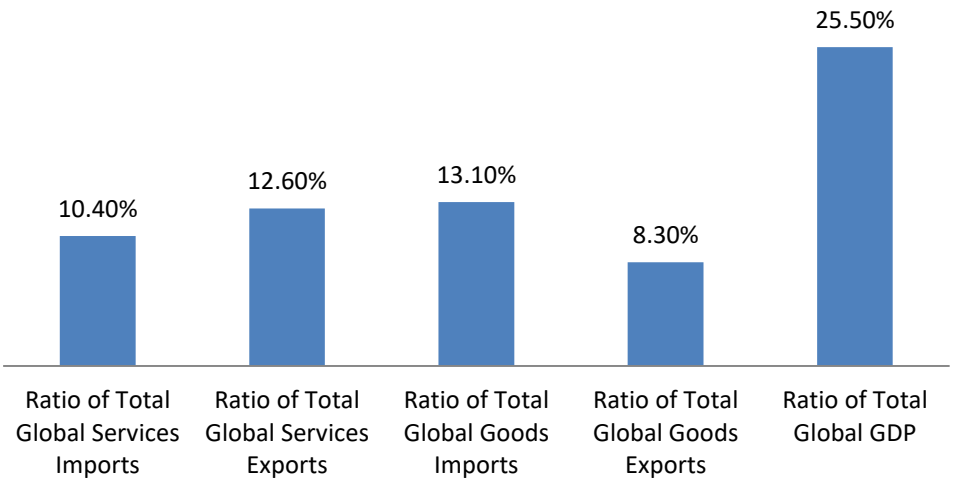
Analyzing the Development of External Debt in the Study Sample Countries: To illustrate the nature of the relationship between external debt and economic growth in each country, despite differing economic

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

characteristics, the developments in the external debt of each country can be described as follows:

1-1-1-Development of US External Debt: The United States remains the first and greatest economic power in the world, despite the narrowing gap between it and other advanced economies. The relative importance of its GDP in 2004 reached about (29.2%) of global GDP, while the percentage fell to approximately (25.5%) in 2022. In terms of international trade in goods and services, although the United States ranked second after China in merchandise exports, accounting for (8.3%) of world merchandise exports in 2022, it ranked first in service exports, accounting for (12.6%) of world service exports in 2022. Meanwhile, its imports of goods accounted for (13.1%) of global merchandise imports, and approximately (10.4%) of global service imports for 2022 **(data.worldbank.org)**. Figure 1 shows the main economic indicators of the United States for 2022.

Figure 1: Main Economic Indicators for the United States of America in 2022



Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

On the level of US external debt, it witnessed notable development during the period (2004–2022). The aforementioned financial accounts indicate the existence of a trade deficit, which was accompanied by an increase in government spending, both social and military. Bearing this deficit justifies resorting to borrowing, thereby accumulating and/or increasing external debt. During the study period, external debt rose from $6.95 trillion in 2003 to $24.5 trillion in 2022, an increase of $17.55 trillion. Table 1 shows the development of some indicators of US external debt for the period (2004–2022). Figure 2 illustrates the development of US external debt for the period (2003–2022).

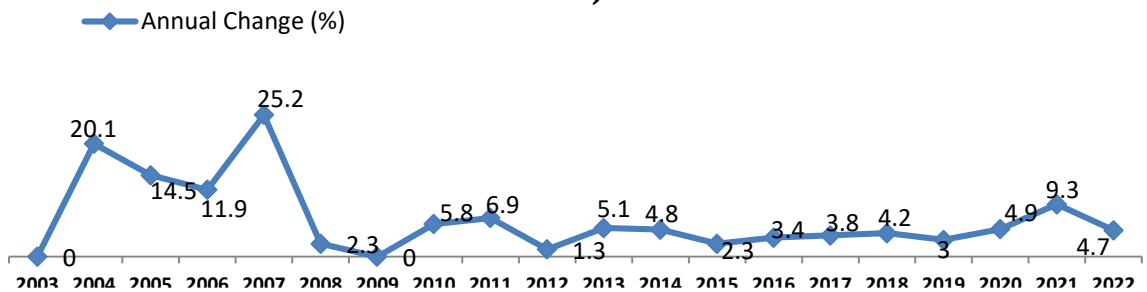
Table 1: Development of Some Indicators of US External Debt for the Period (2003-2022)

Year	External Debt ($ Trillion)	Annual Change (%)	GDP ($ Trillion)	External Debt / GDP (%)
2003	6.95	-	11.46	60.6
2004	8.35	20.1	12.22	68.3
2005	9.56	14.5	13.04	73.3
2006	10.7	11.9	13.82	77.4
2007	13.4	25.2	14.47	92.6
2008	13.7	2.3	14.77	92.7
2009	13.7	0	14.48	94.6
2010	14.5	5.8	15.05	96.3
2011	15.5	6.9	15.60	99.3
2012	15.7	1.3	16.25	96.6
2013	16.5	5.1	16.88	97.7
2014	17.3	4.8	17.61	98.2
2015	17.7	2.3	18.30	96.7
2016	18.3	3.4	18.80	97.3
2017	19	3.8	19.61	96.8
2018	19.8	4.2	20.66	95.8
2019	20.4	3	21.54	94.7
2020	21.4	4.9	21.35	100.2
2021	23.4	9.3	23.68	98.8
2022	24.5	4.7	26.01	94.1

Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W
2- https://ar.tradingeconomics.com/united-states/external-debt

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Figure 2: Development of US External Debt for the Period (2003-2022)



Source: The figure was prepared by the researchers based on the data from Table 1.

From Table 1 and Figure 2 we make the following observations:

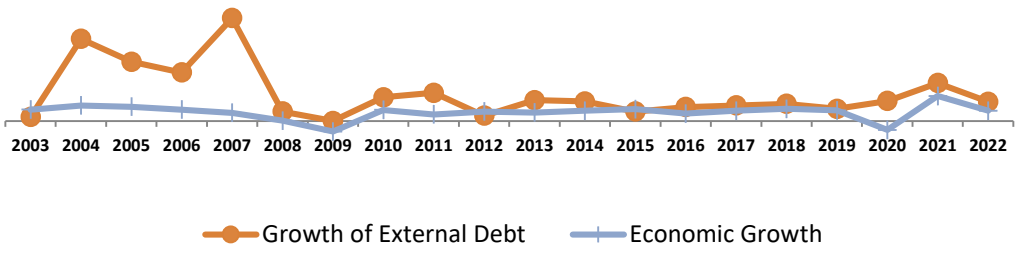
A. The nature of US foreign debt is that this debt constitutes part of foreign-owned US assets in the form of obligations with varying maturities on the US Treasury or US companies that are traded daily on international financial markets. Its value, in contrast to the face value of developing country debt, is subject to constant market fluctuations. Additionally, another portion of the debt is represented by real estate, direct investment in physical plant and equipment, and other properties whose market value at any given time may differ from their original cost. These assets do not have a specific rate of return or fixed maturities. The remainder is in the form of bank deposits and shares.

B. The most distinctive feature of US external debt lies in the fact that the US dollar constitutes the primary international reserve currency. This means that the United States can, at any time, meet its external obligations by issuing new dollar-denominated liabilities or cash, without the need to earn foreign currencies through export surpluses **(Jahangir, 1988:19)**. Despite the rise in the ratio of external debt to GDP, which reflects the extent of the country's indebtedness relative to the size of its economy and thus its ability to manage and repay debts, this indicates that the

United States remains in a position that allows it to maintain its credibility and, consequently, its financial cushion. This is especially true given the significant appeal of US bonds, which are considered low-risk investments for many countries, particularly advanced economies like Japan, which held approximately $1.3 trillion in US Treasury bonds in 2022.

C. Among the main factors contributing to the rise in external debt is the adoption by the United States of expansionary monetary policies, especially during periods of economic crises, such as the global financial crisis known as the mortgage crisis in 2008, amid increasing needs of the US government. The implementation of quantitative easing programs led to flooding the markets with liquidity and reducing borrowing costs through the adoption of low interest rates, with the aim of supporting stability in financial markets and achieving economic recovery. Similarly, during the Covid-19 pandemic, this reflects the impact of US external debt on periodic economic and non-economic crises, which have become more complex. This is evident through the higher growth rates of external debt compared to economic growth rates, as shown in Figure 3, which displays the development of growth in external debt and US economic growth for the period (2003–2022).

Figure 3: Growth of External Debt and US Economic Growth for the Period (2003-2022)



مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

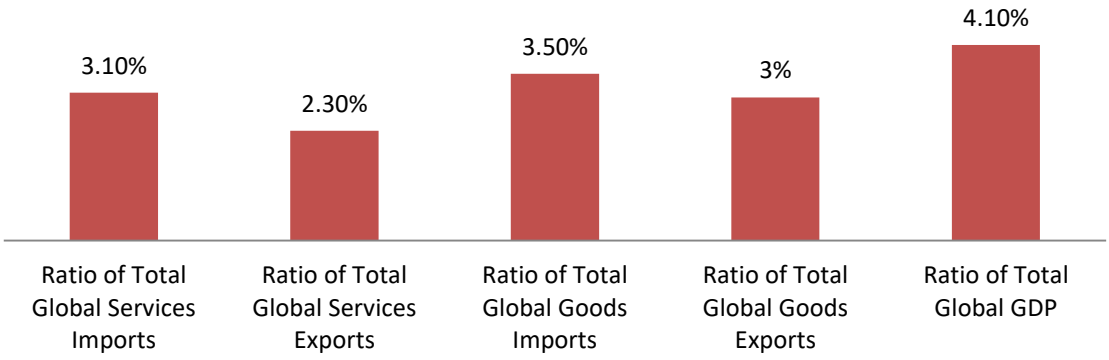
Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

2- https://ar.tradingeconomics.com/united-states/external-debt

1-1-2-Development of External Debt and Economic Growth in Japan

The Japanese economy is characterized by slow and fluctuating growth rates, alternating between highs and lows. This can be attributed to several factors, the most significant of which is the appreciation of the Japanese Yen, which negatively impacted import costs and subsequently led to a decline in surpluses within the Japanese trade balance **(Jorgenson & Motohashi, 2005: 466)**. This becomes evident when examining the main economic indicators. In 2022, Japanese merchandise exports accounted for (3%) of total global merchandise exports, down from (8.3%), (7.4%), and (5.1%) in the years 1990, 2000, and 2010, respectively. Meanwhile, Japanese merchandise imports in 2022 constituted (3.5%) of total global merchandise imports. Regarding trade in services, the relative importance of Japan's service exports reached (2.3%), while service imports accounted for (3.1%) of total international service exports and imports, respectively **(data.worldbank.org)**. Figure 4 illustrates Japan's main economic indicators for 2022.

Figure 4: Main Economic Indicators for Japan in 2022



Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

Japan's external debt witnessed significant development during the period (2003–2022), to the extent that Japan ranked first globally in terms of indebtedness volume. External debt increased from ¥145 trillion in 2003 to ¥582 trillion in 2022, reflecting an increase of ¥437 trillion, with a compound annual growth rate of approximately 7.20%. In 2022, the ratio of external debt to GDP reached 103.6%, which is considered a high ratio. Table 2 illustrates the development of some indicators of Japan's external debt during the period (2003–2022). Figure 5 clearly shows the development of Japan's external debt during the period (2004–2022).

Table 2: Development of Some Indicators of Japan's External Debt for the period (2003-2022)

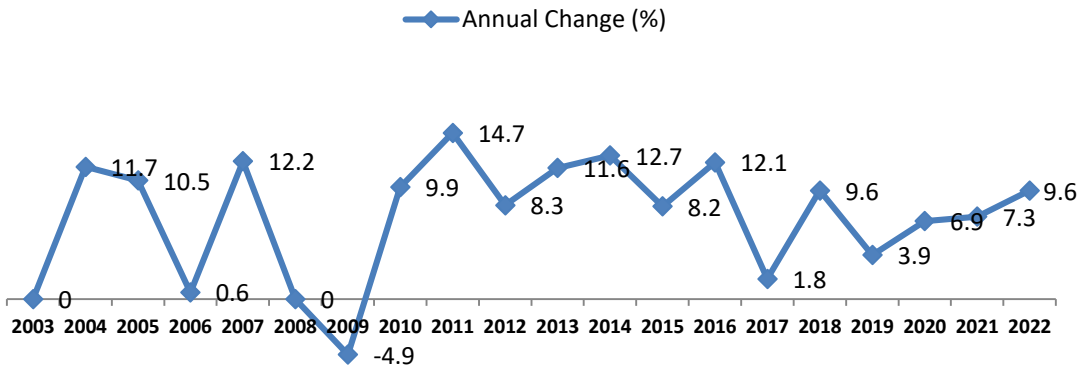
Year	External debt (¥ Trillion)	Annual Change (%)	Economic Growth (%)
2003	145	-	1.5
2004	162	11.7	2.2
2005	179	10.5	1.8
2006	180	0.6	1.4
2007	202	12.2	1.5
2008	202	0	-1.2
2009	192	-4.9	-5.7
2010	211	9.9	4.1
2011	242	14.7	0
2012	262	8.3	1.4
2013	292	11.6	2
2014	329	12.7	0.3
2015	356	8.2	1.6
2016	399	12.1	0.8
2017	406	1.8	1.7
2018	445	9.6	0.6
2019	463	3.9	−0.4
2020	495	6.9	4-1
2021	531	7.3	2.6
2022	582	9.6	1

Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

2- https://ar.tradingeconomics.com/united-states/external-debt

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Figure 5: Development of Japan's External Debt for the Period (2003-2022)



Source: The figure was prepared by the researchers based on the data from Table 2.

From Table 2 and Figure 5 we make the following observations:

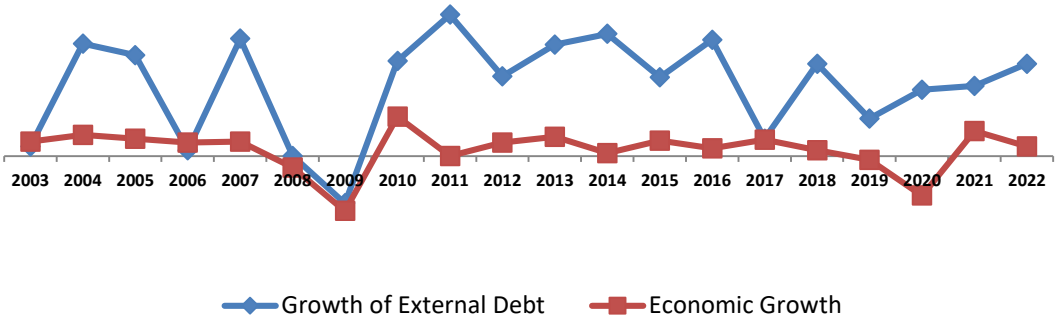
A. One of the main reasons for the rise in Japanese debt is the stimulus policies adopted by the government to strengthen the economy, particularly its investments in public projects, infrastructure, research, and development, in addition to the implementation of fiscal stimulus packages.

B. What characterizes Japanese debt is that it is primarily denominated in the local currency (Yen), which significantly impacts debt servicing operations without affecting the economy. Additionally, Japan holds foreign exchange reserves, a large portion of which is invested in American debt **(Al-Saqqa, 2012, 126)**. This means that Japan retains substantial foreign currency reserves, a significant portion of which is invested in US Treasury bonds, mitigating the risks of Japanese debt on its foreign trade sector and thus contributing to the stability of the Japanese Yen. Furthermore, the strong capacity of the Japanese business sector to achieve trade surpluses, especially given Japan’s high domestic

savings rate, plays a crucial role. Also, Japanese citizens holding government bonds reduce the risks associated with external debt.

C. Despite the substantial increase in external debt during the period (2003–2022), Japan owes only in its local currency, which enhances its financial independence and, consequently, its ability to meet its financial obligations. This reduces risks associated with fluctuations in foreign exchange rates. Moreover, Japan employs strategies to manage its public debt, including external debt, through effective debt management. Figure 6 illustrates Japan's external debt and economic growth for the period (2003–2022).

Figure 6: Growth of Japan's External Debt Growth and Economic Growth for the Period (2003-2022)



Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W
2- https://ar.tradingeconomics.com/united-states/external-debt

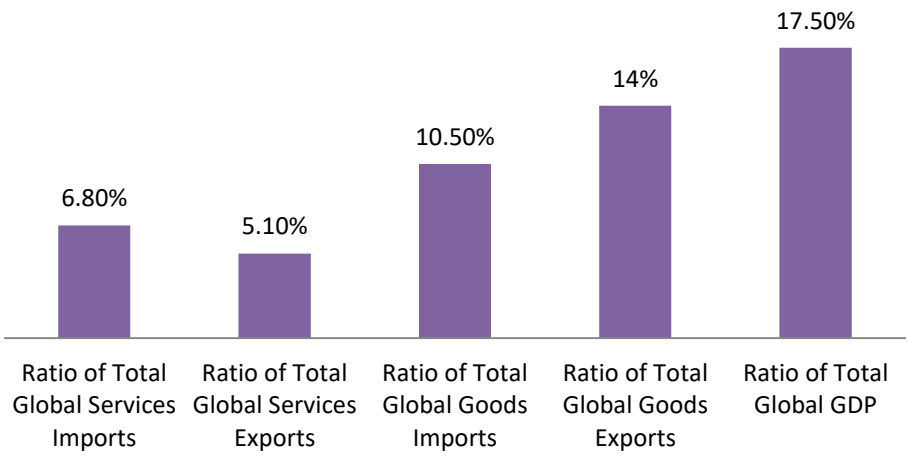
1-1-3-Development of External Debt and Economic Growth in China

China has taken significant steps toward liberalizing its trade systems, linked to the adoption of stabilization and structural adjustment prescriptions. This includes pursuing specific domestic policies and opening markets to the outside. Since 1978, China has implemented a new economic policy based on reform, opening-up, and gradual modernization. It has

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

adopted all available means by combining comprehensive planning with a free market economy through what is known as the socialist market economy, referred to as the Two-legged Walking Model. The main aspects of the reform included reducing the role of central planning in favor of increasing reliance on market forces for resource allocation, price determination, and output, achieved through the establishment of industrial free zones **(Abdul Ghaffar, 2002: 314)**. One of the most prominent outcomes of this policy was the development of GDP, achieving remarkable leaps in economic growth, which ranked among the highest globally. According to key economic indicators in China, Chinese GDP in 2022 accounted for (17.5%) of global GDP, compared to (3.5%) in 2000. Meanwhile, Chinese merchandise exports amounted to (14%) of total global merchandise exports in 2022, while Chinese merchandise imports for 2022 accounted for (10.5%) of total global merchandise imports. As for trade in services, the relative importance of its service exports was (5.1%), and service imports were (6.8%) of total international service exports and imports for 2022 **(data.worldbank.org)**. As shown in Figure 7.

Figure 7: Main Economic Indicators for China in 2022



مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

During the period (2003–2022), China's external debt experienced significant growth, driven by financial stimulus measures, particularly borrowing aimed at supporting infrastructure and the development of large corporations. As a result, external debt increased from $219 million in 2003 to $2.4 billion in 2022, reflecting an increase of $2.2 billion. Meanwhile, the ratio of external debt to GDP reached 13.7% in 2022. Table 3 illustrates the development of some indicators of China's external debt for the period (2003-2022). Figure 8 shows the development of China's external debt for the period (2004-2022).

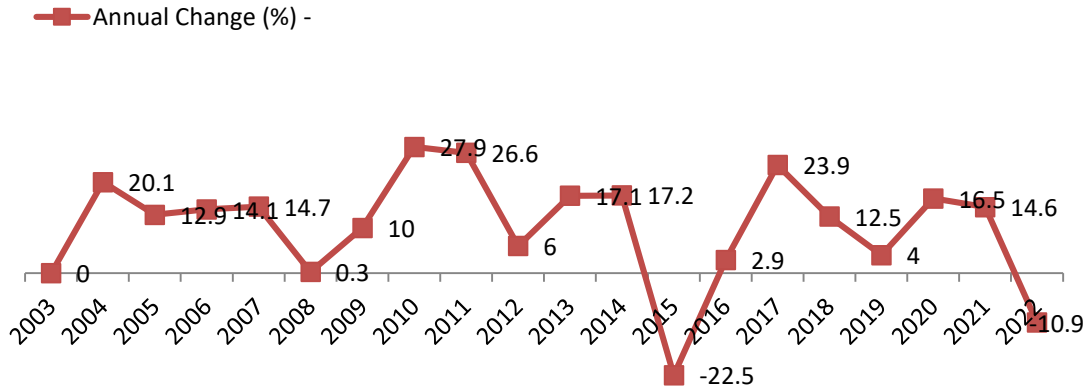
Table 3: Development of Some Indicators of China's External Debt for the Period (2003-2022)

Year	External Debt ($ Million)	Annual Change (%)	Economic Growth (%)
2003	219	-	10
2004	263	20.1	10.1
2005	297	12.9	11.4
2006	339	14.1	12.7
2007	389	14.7	14.2
2008	390	0.3	9.7
2009	429	10	9.4
2010	549	27.9	10.6
2011	695	26.6	9.6
2012	737	6	7.9
2013	863	17.1	7.8
2014	1780	17.2	7.4
2015	1380	-22.5	7
2016	1420	2.9	6.8
2017	1760	23.9	6.9
2018	1980	12.5	6.7
2019	2060	4	6
2020	2400	16.5	2.2
2021	2750	14.6	8.1
2022	2450	-10.9	3

Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W

2- https://ar.tradingeconomics.com/united-states/external-debt

Figure 8: Development of China's External Debt for the period (2003-2022)



Source: The figure was prepared by the researchers based on the data from Table 3.

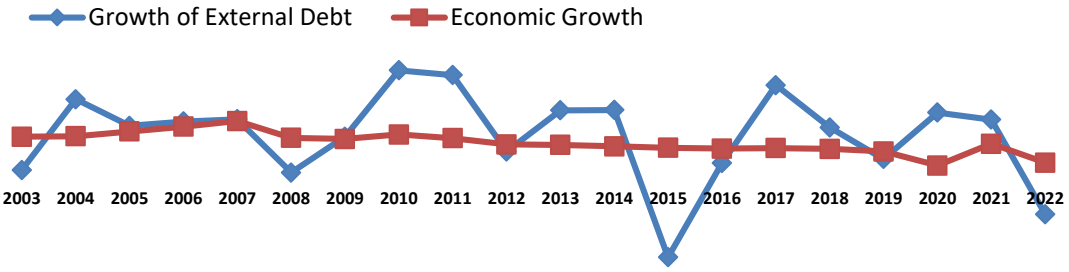
From Table 3 and Figure 8, we make the following observations:

A. Although China's external debt has risen, it remains relatively low compared to the development of external debt in both the United States and Japan.

B. Despite being one of the borrowing countries, the amount China lends within the framework of the international initiatives it launches exceeds the amount it borrows. According to experts, this borrowing is part of China’s strategy to hedge against a potential decline in the value of its foreign exchange reserves. Furthermore, China’s sustained trade balance surpluses at high levels have significantly enhanced its ability to achieve economic growth rates that surpass the growth rates of its external debt. This can be observed in Figure 9, which illustrates the growth of external debt and economic growth for the period (2003–2022).

Figure 9: Growth of External Debt and Economic Growth in China for the Period (2003-2022)

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025



Source: 1- https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations= US-1W
2- https://ar.tradingeconomics.com/united-states/external-debt

2- Applied Section: Measuring the Causal Relationship Between Economic Growth and External Debt

The study of causal relationships is based on two main approaches. The **first** approach relies on the tenets of economic theory regarding the form and nature of the relationship under investigation, determining whether one variable is the cause (independent) and the other is the response (dependent), as stipulated by economic theory. This includes clarifying the nature of the causal relationship, whether it is direct, inverse, or reciprocal in two directions. The second approach, which infers the nature and direction of the causal relationship between the two variables, is represented by previous reference studies that addressed the research variables directly or indirectly in other countries across time periods different from the time and place of the current study. Researchers often rely on these previous studies to determine causal relationships, as they are the result of extensive research and deep reflection on aspects of influence and response.

What is particularly noteworthy in this study is that the economic growth variable (R) has been considered in most economic and developmental studies, specifically, as a dependent variable. However, external debt (D) was an independent variable in some studies, while in others it was treated as a dependent variable. This situation necessitates testing the causal relationship

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

between economic growth and external debt in our study according to the following approaches:

First Approach: It is the model (Debt → Growth). In this approach, economic growth will be a dependent variable influenced by external debt, which represents the independent variable. The model is expressed by the following functional relationship: $R_t=f(D_t)$

Second Approach: This is the (Growth → Debt) model, which is contrary to the first approach. In this model, external debt is the dependent variable affected by economic growth. The model is represented by the following functional relationship: $D_t=f(R_t)$

Third Approach: This is a combination of the two models above, where the causal relationship between economic growth and external debt is reciprocal, referred to as feedback. This is expressed as (Growth ↔ Debt). This form of causal relationships is mathematically represented by a simultaneous model, as it describes a system of simultaneous equations where each variable influences and is influenced by the other at the same time.

Fourth Approach: This model diverges from the previous frameworks, emphasizing the separation (absence) of a causal relationship between economic growth and external debt, indicating the independence of influence and the lack of any correlation between the two variables, meaning there are no causal connections between them.

The construction of the econometric model of the study must be based on these four main models. Therefore, the process of model specification, which is one of the most important and initial stages in building the econometric model, must begin with identifying the functional relationship form and the potential

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

directions of influence and response among the variables within the econometric model. Formulating the econometric model requires determining which variable is the influencing variable (explanatory or independent variable) and which the affected variable (dependent variable).

2-1 Causality Test

In determining the functional relationships, economists have focused on relying on theoretical foundations linked to economic theory, including the ideas and perspectives it provides regarding the roles played by each of the variables in the studied econometric model, particularly whether a variable is classified as an independent variable or as a dependent variable. However, theoretical foundations remain a necessary but insufficient support unless complemented by empirical foundations represented by causality tests among the variables of the econometric model. The relationship between the independent variable (X) and the dependent variable (Y) can take one of four forms, namely **(Levine & Others, 2000:31-36)**:

1- Normal causal relationship: $Y=f(x)$

2- Inverse causality: $X=f(Y)$

3- Two-way causality (Feedback) : $Y=f(x) \leftrightarrow X=f(Y)$

4- Lack of causal relationship between the two variables (independence between X,Y) Independently

A causal relationship is defined as a sequential correlation of a particular event caused by another specific cause over a period of time, where the first is the responsive element (dependent variable) and the second is the causative element (independent variable) **(Heise, 1975: 3-4)**. The causality test falls within the econometric systems adopted in the process of model specification to produce efficient, consistent, and unbiased estimates

capable of best representing economic reality. Therefore, the subject of testing causal relationships has received significant attention since the mid-twentieth century, culminating in the introduction of the Granger Model in 1969, which served as a foundation for reliance in econometric studies to determine and analyze the form of functional relationships among the variables of econometric models. This is based on the assumption that causality is rooted in the past and present effects of the study variables, as illustrated in the following equations **(Granger, 1969: 424-430)**:

$$Y_t = \alpha + \sum_{i=1}^{m} \beta_{t-i} \; Y_{t-i} + \sum_{i=1}^{n} S_{t-1} \; X_{t-j} + U_{t\,j} \ldots\ldots\ldots(1)$$

$$X_t = \lambda + \sum_{j=1}^{n} \varepsilon_{t-j} \; X_{t-j} + \sum_{i=1}^{m} \phi_{t-i} \; Y_{t-i} + U_{t\,j} \ldots\ldots\ldots(2)$$

Where: Y_t, X_t: Dependent Variable and Independent Variable respectively.

$\phi, \lambda, \delta, \beta, \alpha$ Parameters of the first and second models

n ,m: Optimal Number of Lags stands for *(n* ,m*)*, which will be adopted in the causality test for both the adopted variable (Y_t) and the independent variable (X_t) , as there are many methods adopted in determining the optimal number of lags **(Hsiao, 1988: 95-102),** as the methodology of each method differs from the other in the statistical processing method followed to reach the optimal number of lags, as the failure to determine the optimal number of lags leads to different results in determining the form of the causal relationship that will be adopted in the above two equations, which in turn represents a flaw in the test outcome and gives biased and inconsistent results.

2-2 Applying Hsiao Causality to the Econometric Model of the Study

It is known that causal models require a relatively long time series (N ≥ 30) to determine the nature of the trend of the causal relationship between economic growth and external debt in the American, Japanese and Chinese

economies for the period (2022-2003). The data collection model (Panel Data) was adopted for the two study variables for the three countries of the study sample over a period of twenty years. This means that the collection method will result in the overall model having 60 observations. The Hsiao causality method will be adopted to determine the nature of the causal relationship between the variables of the econometric model of the study, which will be represented by one of the following two functional relationships:

$$R_t = f(Dt) \text{ or } D\,t = f(R_t)$$

Whereas:

R_t: The rate of economic growth in the three countries under study for the period (2003-2022).

D_t: External debt in the three countries under study for the period (2003-2022).

The Hsiao method **(Hsiao, 1997: 321-346)** for testing the causal relationship depends on performing a number of lags for both the dependent variable ($R_t = Y_t$) and the independent variable ($D_t = X_t$). The maximum level of lags has been set six intervals, starting with the dependent variable, according to the following formula:

$$Y_t = \alpha_i + \sum_{i=1}^{6} \beta_i \; Y_{t-i} + U_i$$

Whereas:

Y_t: The dependent variable of the model, representing the rate of economic growth (R_t) in the countries of the study sample.

β_t, α_t: Model parameters by lag duration ($i=1,2,3,4,5,6$)

Y_{t-i}: Time-lagged dependent variable.

U_t: The random error term of the model, assumed to follow distribution with mean zero and variance σ_u^2 denoted as $U_t \sim N(0, \sigma_u^2)$.

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

By adopting six lag periods, the model regression will be performed six times. In each stage, the time-lagged variable corresponding to the added lag period is included, so that the optimal lag period for the dependent variable can be determined. Hsiao specifies that this should be achieved by identifying the lowest Final Prediction Error (FPE) among the six lag stages applied to the model for the dependent variable (Y_t). The first Final Prediction Error (FPE) for the dependent variable is calculated according to the following formula **(Hsiao, 1988: 87)**:

$$FPE_m = \frac{\left(\frac{T+m+1}{T-m-1}\right) SSE_m}{T}$$

Whereas:

FPE_{m*} : First Final Predictive Error.

m: lag (we have six lag periods), $m=1,2,3,4,5,6$.

T: Number of model observations.

SSE: Sum of squared errors of the model by lag duration (m).

When selecting (FPE_m) f or each lag stage, the lowest value of the predictive error is chosen, thereby determining the optimal number for the lag period of the dependent variable in the adopted model, i.e., obtaining (m*).

As for the independent variable (X_t), which represents the external debt (D_t) of the countries in the study sample, the optimal duration of its lag will be determined based on the second predictive error ($FPE_{m*,n}$), where there are also six lag of the independent variable (X_t) that are included in the equation of the dependent variable (Y_t) with its optimal lag period (m*) according to the following formula **(Hsiao, 1988: 377)**:

Whereas:

$$Y_t = \alpha + \sum_{j=1}^{n} \beta_i Y_{t-i} + \sum_{j=1}^{n} \delta_j X_{t-j} + U$$

n: The lag of the independent variable (X_t); we have six lag periods.

X_{t-j}: The time-lagged independent variable for six instances within the model that contains the time-lagged dependent variable with the optimal lag period (m*). The second ($FPE_{m^*\,,\,n}$) is then calculated at each lag stage according to the following formula **(Hsiao, 1988: 99)**:

$$FPE_{(m^*,n)} = \frac{\left(\frac{T+m+n+1}{T-m-n-1}\right) SSE_{m^*n}}{T}$$

After determining the value of the second final predictive error ($FPE_{m^*\,,\,n}$), the lowest final predictive error is identified, thereby setting the optimal number of lags for the independent variable (n*). Upon completing the determination the first final predictive error (FPE_{m^*}) and the second final predictive error ($FPE_{m^*\,,\,n^*}$) for the model $R_t=f(D_t)$, the form of the functional relationship is reversed, i.e, $D_t=f(R_t)$, to find the first final predictive error (FPE_{n^*}) and the second final predictive error ($FPE_{n^*\,,\,m}$). Based on this, the nature of the causal relationship between the dependent and independent variables is determined according to the following:

A. The causal relationship is (Normal), that is, (X_t=D_t) causes(Y_t=R_t) according to the following formula $Y_t=f(x_t)$if:

$FPE_{(m^*)} > (FPE_{m^*,\,n^*})$

$FPE_{(n^*)} < (FPE_{n^*,\,m^*})$

B. The causal relationship is (Inverse), that is, (Y_t=R_t) causes (X_t=D_t) according to the following formula $X_t= f(Y_t)$ if:

$FPE_{(m^*)} < (FPE_{m^*,\,n^*})$

$FPE_{(n^*)} > (FPE_{n^*,\,m^*})$

The causal relationship of the model is two-way (Feedback), that is, both variables (X_t=D_t) and(Y_t =R_t) influence each other if:

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

$FPE_{(m*)} > (FPE_{m*, n*})$

$FPE_{(n*)} > (FPE_{n*, m*})$

C. Lack of causal relationship between the two variables, that is, there is independence (Independent) between (X_t=D_t) and(Y_t=R_t) if:

$FPE_{(m*)} < (FPE_{m*, n*})$

$FPE_{(n*)} < (FPE_{n*, m*})$

2-3 Econometric Estimation of the Model and Determination of the Causal Relationship Direction

The econometric model of the study was estimated according to the data collection method (panel data) using the Random Effects Model (REM). The Hsiao causality test formulas were applied by employing the Ordinary Least Squares Method (OLS), utilizing the statistical program (Minitab). The value of the first predictive error for the following two relationships (R_t = f(D_t) & D=f(R_t)) was calculated for six lags as shown in the table below:

Table 4: The First Final Predictive Error for the Hsiao Causality Test

Lag of (m)	R_t= f(D_t)	Lag of (n)	D=f(R_t)
	FPE (m)		FPE (n)
t-1	FPE (1) = 327230.1	t-1	FPE (1) = 329576.2
t-2 (*)	FPE (2) = 207605.5	t-2	FPE (2) = 405428.6
t-3	FPE (3) = 261612.8	t-3	FPE (3) = 279031.1
t-4	FPE (4) = 315235.2	t-4 (*)	FPE (4) = 163954.7
t-5	FPE (5) = 467287.5	t-5	FPE (5) = 183455.3
t-6	FPE (6) = 545265.7	t-6	FPE (6) = 233721.5

(*)The lowest predictive error represents the optimal number of lags for the dependent variable in the two models above.

Source: Application of the First Final Predictive Error formula to the estimation results of the equations of the estimated models for the Hsiao Causality Test, as presented in the research appendix.

The above table shows the following results:

1- The lowest final predictive error for the relationship $R_t = f(D_t)$ occurred at the second lag period, which had the lowest value, i.e.: **FPE $_{(m*)}$ = FPE $_{(2)}$ = 207605.5**

2- The lowest final predictive error for the relationship $D_t = f(R_t)$ occurred at the fourth lag period, which had the lowest value, i.e.: **FPE $_{(n^*)}$ = FPE $_{(4)}$ = 163954.7**

After determining the optimal lag period for the dependent variable in the above two relationships for the two study variables—economic growth (second lag period) and external debt (fourth lag period)—in the American, Japanese, and Chinese economies during the period (2003–2022), based on the lowest value of the first predictive error, we proceed to calculate the value of the second predictive error to determine the optimal lag period for the independent variable in the above two relationships. The regression of the independent variable was applied for six lag periods based on the optimal lag period for the dependent variable identified in Table 4 for the dependent variable in the above two relationships.

Table 5: The Second Final Predictive Error for the Hsiao Causality Test

Lag of (m)	$R_t = f(D_t)$	Lag of (n)	$D_t = f(R_t)$
	FPE $_{(m,n)}$ m=2		FPE $_{(n,m)}$ n=4
t-1	FPE $_{(2,1)}$ = 229537.5	t-1	FPE $_{(4,1)}$ = 314945.5
t-2	FPE $_{(2,2)}$ = 180528.3	t-2	FPE $_{(4,2)}$ = 357972.1
t-3	FPE $_{(2,3)}$ = 192338.7	(*) t-3	FPE $_{(4,3)}$ = 293855.4
t-4	FPE $_{(2,4)}$ = 242736.8	t-4	FPE $_{(4,4)}$ = 309150.2
t-5 (*)	FPE $_{(2,5)}$ = 178118.2	t-5	FPE $_{(4,5)}$ = 372731.4
t-6	FPE $_{(2,6)}$ = 226205.7	t-6	FPE $_{(4,6)}$ = 335789.7

(*) **The lowest predictive error, which represents the optimal number of lags for the independent variable in the two models above**

Source: Application of the Second Final Predictive Error formula to the estimation results of the equations of the estimated models for the Hsiao Causality Test, as presented in the research appendix.

From Table 5, which presents the results of the second predictive error, note the following:

1- That the lowest value of the second final predictive error for the relationship $R_t = f(D_t)$ was at the fifth lag, i.e.:

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

$$FPE_{(m^*,n^*)} = FPE_{(2,5)} = 178118.2$$

2- The lowest value of the second final predictive error of the relationship $D_t = f(R_t)$ was at the third lag period, i.e.:

$$FPE_{(n^*,m^*)} = FPE_{(4,3)} = 293855.4 .$$

Based on the values of the first and second final predictive errors of the study model, which determine the optimal number of lags for the dependent variable and the independent variable for each model, the Hsiao causality test revealed the following:

1. For the functional relationship $R_t = f(D_t)$:

$$FPE_{(m^*)} = FPE_{(2)} = 207605.5$$

$$FPE_{(m^*,n^*)} = FPE_{(2,5)} = 178118.2$$

$$\therefore \quad FPE_{(m^*)} > FPE_{(m^*,n^*)} \ldots\ldots\ldots\ldots (1)$$

2. For the functional relationship $D_t = f(R_t)$

$$FPE_{(n^*)} = FPE_{(4)} = 163954.7$$

$$FPE_{(n^*,m^*)} = FPE_{(4,3)} = 293855.4$$

$$\therefore \quad FPE_{(n^*)} < FPE_{(n^*,m^*)} \ldots\ldots\ldots\ldots (2)$$

From the two inequalities above, it is confirmed that the first predictive error in the first relationship was greater than the second predictive error, while in the second relationship, the first predictive error was smaller than the second predictive error. This indicates, according to Hsiao's causality conditions, that the econometric model is represented by the first functional relationship ($R_t = f(D_t)$), meaning that external debt is the influencing factor stimulator economic growth in the study sample countries during the years (2003–2022).

2-4 Results of the Causal Relationship and Estimation of the Econometric Model of the Study

Based on Hsiao's causality conditions which show that the causal relationship takes its normal form (Normal), i.e., (X_t=D $_t$) causes(Y_t =R_t) according to the following formula Y_t=f(X_t), if:

$$\{ FPE_{(m^*)} > (FPE_{m^*, n^*}) \rightarrow 207605.5 > 178118.2 \}$$

$$\{ FPE_{(n^*)} < (FPE_{n^*, m^*}) \rightarrow 163954.7 < 293855.4 \}$$

He assures us that the first predictive error in the first relationship was greater than the second predictive error. In the second relationship, the first predictive error was smaller than the second predictive error. This indicates, according to Hsiao's causality conditions, that the econometric model is represented by the first functional relationship ($R_t = f(D_t)$, meaning that external debt is the influential variable enhancing economic growth in the countries of the study sample during the period (2003–2022).

Based on the direction of causality, the model will be estimated according to the causal relationship, which showed that economic growth is the dependent variable and external debt is the independent variable. The panel data model will be based on the Random Effects Model (REM) in order to determine the magnitude and nature of the impact that external debt has on economic growth in the three countries of the study sample during the period (2003–2022), according to the following functional relationship of the econometric model:

$$R_t = f(D_{USA}, D_{Japan}, D_{China})$$

$$R_t = \alpha + \beta_1 D_{USA} + \beta_2 D_{Japan} + \beta_3 D_{China} + U_t$$

Regression Analysis: R_t versus D USA; D Jaban; D China

The regression equation is:

R_t = 3.39 + 0.089 D USA + 0.184 D Japan + 0.252 D China

The results indicate that the impact of external debt on economic growth was more pronounced in China, with a coefficient of 0.25, compared to Japan at

0.18 and the United States at 0.09. This disparity can be attributed to structural factors, including:

- The role of Chinese industrial policies in directing debt toward productive projects.
- The reliance of the United States on debt to finance trade deficits rather than investment.

Predictor	Coef	SE Coef	T	P	VIF
Constant	3.3869	0.6736	5.03	0.000	
D USA	0.0889	0.4168	3.76	0.052	1.152
D Japan	0.1844	0.5018	1.81	0.076	1.189
D China	0.2513	0.7528	4.77	0.000	1.159

S = 3.32358R-Sq = 81.1% R-Sq (adj) = 80.8%

$R^2(R_t D_{USA})$ =57.8% & $R^2(R_t D_{Japan})$ =73.9% & $R^2(R_t D_{China})$=66.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	3	408.31	136.10	12.32	0.000
Residual Error	53	585.45	11.05		

Durbin-Watson statistic = 1.869

2-5 Analysis of the Econometric Estimation Results for the Study Model

The results of the tests of the estimated model indicate its acceptance in economic, statistical, and econometric terms. Economically, the linear relationship of the estimated model was consistent in terms of the magnitude and signs of the model's parameters with the theoretical logic of the study. Statistically, the model was significant based on the (F) test at a significance level of (0.01), and the estimated parameters were statistically significant at (0.01). The coefficient of determination (R^2) test demonstrated the

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

importance of the role that the independent variables included in the model (external debt of the study sample countries) have on the dependent variable (economic growth rates of the study sample countries). The total impact explained by the coefficient of determination was approximately (81.1%), while the impact of the random error term (U_t) accounted for about (18.9%). In econometric terms, the estimated model did not suffer from common econometric issues. The value of the Variance Inflation Factor (VIF) was at low levels, not exceeding ten units, confirming that the model is free from the problem of Multicollinearity among the independent variables. Additionally, the Klein test confirmed that the coefficients of determination for the independent variables were lower than the overall coefficient of determination of the model, indicating the absence of heterogeneity problems in the estimated model. Furthermore, the calculated value of the Durbin-Watson (D-W) test, which was approximately (1.87), indicates that the estimated model is free from autocorrelation in the residuals, as the Durbin-Watson value falls within the acceptance region for the null hypothesis of no autocorrelation.

Based on this, it is possible to analyze the impact of the independent variables, which represent the contribution of external debt to promoting economic growth. The results of the econometric estimation of the model show that China's external debt was the most influential in driving economic growth. China’s external debt is relatively lower compared to the development of external debt in both the United States and Japan. Moreover, China is one of the countries whose global lending initiatives exceed the external debt of other nations. According to specialists, China's borrowing is aimed at hedging the Chinese economy against declines in the value of its

foreign exchange reserves, as well as benefiting from continuous surpluses in the trade balance at high levels, which greatly enhanced the possibility of sustaining economic growth rates that exceed the growth rates of its external debt. When China's external debt increases by one unit, the growth of the Chinese economy increases by (0.25).

In second place in terms of the strength of the impact of external debt on enhancing economic growth was the Japanese economy, which achieved growth of (0.18) when its external debt increased by one unit. This modest and neutral positive impact of Japan's external debt on economic growth aligns with the theoretical reality of Japan, where its growth rate remained slow and fluctuated between rises and declines. This is due to several reasons, the most important of which is the rise in the value of the Japanese Yen, which caused higher import costs and a decline in surpluses in Japan’s trade balance.

The economy of the United States came in third place as a promoter of economic growth, achieving an increase of (0.09) when its external debt escalates by one unit. This finding is also consistent with the theoretical perspective on US external debt, as the rate of growth of US external debt exceeds the rate of economic growth, justifying the diminished impact of external debt on the high growth rate of the US economy.

Conclusions and Recommendations

A. Conclusions

Through what was presented in the theoretical and practical aspects of the study, it was confirmed beyond any doubt that the hypothesis from which the study was launched — that the external debt of the study sample countries has effectively contributed to enhancing the pace of economic

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

growth during the studied years (2003–2022) — holds true. In this regard, the researchers concluded the following:

1- Causal models require relatively long time series (N ≥ 30). This necessitated the adoption of the panel data model in the process of compiling the time-series data of the study (twenty years) for three cross-sections, which included each of the three study sample countries, resulting in 60 observations. The compilation model is one of the econometric methods adopted in studies that suffer from a low number of degrees of freedom due to the small size of the time series. Therefore, the data compilation method was an inevitable necessity and an econometric benefit to avoid measurement problems.

2- The application of the Hsiao causality model, which was tested in four directions, showed that the first direction represents the econometric study model, i.e., external debt (D) is the causal factor in economic growth (R). This aligns with the theoretical aspect of the study.

3- When ascertaining the causal relationship between external debt and economic growth, the econometric model of the study was applied to determine the magnitude and trends of the effects caused by external debt on the economic growth of the study sample countries. The results of the econometric estimation of the model showed that the Chinese economy exhibited the strongest positive impact of external debt on economic growth, with a 25% increase in growth when China's external debt increased by one unit. The Japanese economy ranked second with an 18% impact, while the United States ranked third with a 0.09% impact. These results reflect the reality of the external debt situation in those countries

مجلة الغري للعلوم الاقتصادية والادارية
مجلد (21) عدد (2) 2025

and the positive effects that contributed to promoting economic growth in their respective economies.

B. Recommendations

To achieve the objectives of the study, the researchers recommend the following proposals:

1- Adopting a development strategy based on addressing the imbalance in the stability of the exchange rate through external borrowing directed toward supporting productive sectors that enhance the competitive position of domestically produced goods for export, thereby gaining a foothold in the global market capable of compensating for losses resulting from debt servicing.

2- The need for countries to develop clear strategies for external debt, ensuring that these debts are directed toward supporting productive sectors such as industry, agriculture, and technology. These strategies should also focus on enhancing the competitiveness of domestically produced goods and increasing exports to offset external debt servicing costs. Avoid using external debt to cover current deficits or unproductive consumer spending to ensure sustainable economic returns.

3- Countries should improve the management of their external debt by adopting effective fiscal and investment policies that ensure the maximum use of borrowed funds. Emphasis should be placed on directing external debt toward major infrastructure projects, scientific research, and technological development that contribute to promoting long-term economic growth. It is advisable to take advantage of the Chinese experience in achieving persistent trade surpluses and use them

as a means to ensure the stability of the national economy and achieve growth rates that exceed those of foreign debt.

4- The need to develop accurate control and follow-up mechanisms to ensure that external debt is used efficiently and effectively in alignment with national development goals. Specialized bodies should be established to monitor the performance of projects financed by external debt and assess the extent to which they achieve the desired objectives. Transparency and disclosure about the use of external debt should be enhanced through periodic reports to legislators and the international community to ensure confidence in the state's ability to manage its debt sustainably.

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Statistical Appendix

Hsiao Results of the Estimation for Regression Equations of the Hsiao Causality Tests Model

1- Regression Analysis

The regression equation is

$$R_t = 530 + 1.771\ R_{t-1}$$

Predictor	Coef	StDev	T	P
Constant	530	3213	2.78	0.009

R_{t-1} 1.771 0.798 8.28 0.000

S = 9558 R-Sq = 89.8% R-Sq(adj) = 89.1%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1.26689E+12	1.26689E+12	1531.73	0.000
Error	22	14881197299	676418059		
Total	23	1.28177E+12			

2- Regression Analysis

The regression equation is

R_t = 5686 + 1.88 R t-1 - 0.843 R t-2

Predictor	Coef	StDev	T	P	VIF
Constant	5686	4927	1.15	0.261	
R t-1	1.8776	0.1763	10.65	0.000	4.1
R t-2	-0.8426	0.2210	-3.81	0.001	6.1

S = 20463 R-Sq = 96.3% R-Sq(adj) = 95.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	2	1.27298E+12	6.36490E+11	1519.98	0.000
Error	21	8793717443	418748450		
Total	23	1.28177E+12			

3- Regression Analysis

The regression equation is

R_t = 5195 + 1.58 R t-1 + 0.147 R t-2 - 0.841 R t-3

Predictor	Coef	StDev	T	P	VIF
Constant	5195	4476	1.16	0.259	
R t-1	1.5811	0.2038	7.76	0.000	4.1

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R t-2 0.1465 0.4668 0.31 0.757 7.3

R t-3 -0.8415 0.3586 -2.35 0.029 3.0

S = 18568 R-Sq = 92.1% R-Sq(adj) = 91.7%

Analysis of Variance

Source DF SS MS F P

Regression 3 1.27488E+12 4.24959E+11 1232.63 0.000

Error 20 6895159069 344757953

Total 23 1.28177E+12

4- Regression Analysis

The regression equation is

R_t = 4723 + 1.82 R t-1 - 0.197 R t-2 - 1.25 R t-3 + 0.708 R t-4

Predictor Coef StDev T P VIF

Constant 4723 4383 1.08 0.295

R t-1 1.8162 0.2600 6.99 0.000 7.7

R t-2 -0.1968 0.5171 -0.38 0.708 4.1

R t-3 -1.2540 0.4568 -2.74 0.013 9.3

R t-4 0.7079 0.5035 1.41 0.176 1.2

S = 18130 R-Sq = 87.6% R-Sq(adj) = 86.3%

Analysis of Variance

Source DF SS MS F P

Regression 4 1.27553E+12 3.18882E+11 970.10 0.000

Error 19 6245507435 328710918

Total 23 1.28177E+12

5- Regression Analysis

The regression equation is

R_t = 4815 + 1.78 R t-1 - 0.268 R t-2 - 0.967 R t-3 + 0.889 R t-4- 0.629 R t-5

Predictor	Coef	StDev	T	P	VIF
Constant	4815	4416	1.09	0.290	
R t-1	1.7836	0.2646	6.74	0.000	1.4
R t-2	-0.2677	0.5273	-0.51	0.618	4.4
R t-3	-0.9667	0.5698	-1.70	0.107	2.6
R t-4	0.8892	0.5497	1.62	0.123	1.7
R t-5	-0.6294	0.7362	-0.85	0.404	7.2

S = 18260 R-Sq = 94.4% R-Sq(adj) = 93.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	5	1.27577E+12	2.55154E+11	765.24	0.000
Error	18	6001765737	333431430		
Total	23	1.28177E+12			

6- Regression Analysis

The regression equation is

R_t =51+1.69 R t-1 -0.13 R t-2- 0.940 R t-3 +1.07 R t-4 -0.68 R t-5 -0.58 R t-6

Predictor	Coef	StDev	T	P	VIF
Constant	51	4520	1.13	0.272	
R t-1	1.6914	0.3068	5.51	0.000	3.6
R t-2	-0.1528	0.5669	-0.27	0.791	5.9
R t-3	-0.9404	0.5811	-1.62	0.124	9.5
R t-4	1.0737	0.6318	1.70	0.107	7.8
R t-5	-0.6582	0.7503	-0.88	0.393	4.6

R t-6 -0.5801 0.9249 -0.63 0.539 8.3

S = 18576 R-Sq = 92.7% R-Sq(adj) = 91.4%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	6	1.27591E+12	2.12651E+11	616.27	0.000
Error	17	5866030070	345060592		
Total	23	1.28177E+12			

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Regression Analysis

The regression equation is

D_t = 19483 + 1.30 D t-1

Predictor	Coef	StDev	T	P
Constant	19483	20251	0.96	0.346
D t-1	1.3009	0.04657	27.94	0.000

S = 88489 R-Sq = 97.3% R-Sq(adj) = 96.1%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	6.11142E+12	6.11142E+12	780.48	0.000
Error	22	1.72268E+11	7830365399		
Total	23	6.28369E+12			

Regression Analysis

The regression equation is

D_t = 19773 + 1.48 D t-1 - 0.271 D t-2

Predictor	Coef	StDev	T	P	VIF
Constant	19773	20601	0.96	0.348	

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D t-1 1.4791 0.3436 4.30 0.000 5.6

D t-2 -0.2714 0.5185 -0.52 0.606 2.6

S = 89986 R-Sq = 85.7% R-Sq(adj) = 84.8%

Analysis of Variance

Source DF SS MS F P

Regression 2 6.11364E+12 3.05682E+12 377.50 0.000

Error 21 1.70049E+11 8097553442

Total 23 6.28369E+12

Regression Analysis

The regression equation is

D_t = 9624 + 0.905 D t-1 - 0.786 D t-2 + 2.25 D t-3

Predictor Coef StDev T P VIF

Constant 9624 13852 0.69 0.495

Co t-1 0.9055 0.2537 3.57 0.002 6.7

Co t-2 -0.7860 0.3589 -2.19 0.041 5.9

Co t-3 2.2526 0.4305 5.23 0.000 3.6

S = 59909 R-Sq = 93.9% R-Sq(adj) = 92.7%

Analysis of Variance

Source DF SS MS F P

Regression 3 6.21191E+12 2.07064E+12 576.92 0.000

Error 20 71782013938 3589100697

Total 23 6.28369E+12

Regression Analysis

The regression equation is

D_t = 9509 + 0.855 D t-1 - 0.756 D t-2 + 2.23 D t-3 + 0.132 D t-4

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مجلد (21) عدد (2) 2025

Predictor	Coef	StDev	T	P	VIF
Constant	9509	14214	0.67	0.512	
D t-1	0.8553	0.3818	2.24	0.037	5.6
D t-2	-0.7559	0.4044	-1.87	0.077	6.8
D t-3	2.2330	0.4547	4.91	0.000	3.5
D t-4	0.1324	0.7377	0.18	0.859	4.0

S = 61413 R-Sq = 95.9% R-Sq(adj) = 94.6%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	6.21203E+12	1.55301E+12	411.76	0.000
Error	19	71660481237	3771604276		
Total	23	6.28369E+12			

Regression Analysis

The regression equation is

D_t = 10242 +0.997 D t-1 -1.13 D t-2 +2.29 D t-3 -0.096 D t-4 + 0.717 D t-5

Predictor	Coef	StDev	T	P	VIF
Constant	10242	14360	0.71	0.485	
D t-1	0.9974	0.4215	2.37	0.029	6.3
D t-2	-1.1334	0.6112	-1.85	0.080	5.5
D t-3	2.2911	0.4638	4.94	0.000	4.3
D t-4	-0.0959	0.7932	-0.12	0.905	5.1
D t-5	0.7174	0.8654	0.83	0.418	3.4

S = 61925 R-Sq = 88.7% R-Sq(adj) = 87.3%

Analysis of Variance

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مجلد (21) عدد (2) 2025

Source	DF	SS	MS	F	P
Regression	5	6.21466E+12	1.24293E+12	324.13	0.000
Error	18	69024991150	3834721731		
Total	23	6.28369E+12			

Regression Analysis

The regression equation is

D =10184+0.288 Dt-1+0.252 D t-2+0.879 Dt-3+1.09 D t-4-0.884 D t-5+2.88 Co t-6

Predictor	Coef	StDev	T	P	VIF
Constant	10184	10934	0.93	0.365	
D t-1	0.2882	0.3726	0.77	0.450	8.4
D t-2	0.2515	0.5943	0.42	0.677	1.9
D t-3	0.8795	0.5163	1.70	0.107	3.4
D t-4	1.0894	0.6818	1.60	0.128	5.2
D t-5	-0.8835	0.7853	-1.13	0.276	6.1
D t-6	2.8820	0.7690	3.75	0.002	7.3

S = 47153 R-Sq = 90.4% R-Sq(adj) = 89.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	6	6.24589E+12	1.04098E+12	468.19	0.000
Error	17	37798461581	2223438917		
Total	23	6.28369E+12			