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PUBLIC DEBT SUSTAINABILITY ANALYSIS: AN INTEGRATED APPROACH ON SELECTED G-20 ECONOMIES

MASTER'S THESIS

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Foreword

First of all, I would like to thank my supervisor, Assoc. Prof. Ata ÖZKAYA, for the patient guidance, encouragement and advice he has provided throughout my time as his student. I have been extremely lucky to have a supervisor who cared so much about my work, and who responded to my questions and queries so promptly.

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List of Abbreviations

ADF	:	Augmented Dickey–Fuller
ADF-GLS	:	Augmented Dickey–Fuller Generalized Least Squares
AKP	:	Adalet ve Kalkınma Partisi *(Lang: TR)*
BB	:	Budget Balance
BRICS	:	Brazil - Russia - India - China - South Africa
DFGLS	:	Dickey–Fuller Generalized Least Squares
DS	:	Debt Stock
EME	:	Emerging Market Economies
ERS	:	Elliott, Rothenberg and Stock
EU	:	European Union
EXP	:	Expenditure
G7	:	Group of Seven
GDI	:	Gross Disposable Income
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
HDI	:	Human Development Index
IBC	:	Intertemporal Budget Constraint
IMF	:	International Monetary Fund
IPS	:	Im, Pesaran and Shin
JDP	:	Justice and Development Party
KPSS	:	Kwiatkowski–Phillips–Schmidt–Shin
KSS	:	Kapetanios, Shin and Shell
LLC	:	Levin, Lin and Chu
LNV	:	Leybourne, Newbold and Vougas
NPV	:	Net Present Value
OECD	:	Organisation for Economic Co-operation and Development
OLG	:	Overlapping Generations
PB	:	Primary Balance
PP	:	Phillips-Perron

REV	:	Revenue
US	:	United States
USA	:	United States of America
USD	:	United States Dollar
VAR	:	Vector Autoregression
VECM	:	Vector Error Correction Models
ZA	:	Zivot-Andrews

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Résumé

L’objectif de cette thèse est à tester la soutenabilité de la dette publique dans des pays sélectionnés avec *l'algorithme Step-wise*. Premièrement, la stationnarité de la dette publique, le solde primaire, le solde budgétaire, les recettes publiques et des dépenses publiques de quatre économies développées (France, Allemagne, Italie et Japon) et de trois économies émergentes (Brésil, Chine et Turquie) ont été testés par des tests de racine unitaire, ADF, PP et KPSS. Plus tard, l'analyse de soutenabilité du stock de la dette publique de ces pays a été examinée par le test de cointégration de Johansen en appliquant les étapes appropriées de l'algorithme en fonction des niveaux de stationnarité obtenus. Enfin, les recettes publiques de l'algorithme pour la Russie ont été mises à jour en tant que recettes publiques non énergétiques (pétrole et gaz naturel), et l'algorithme a été exécuté à nouveau. D'après les résultats obtenus, aucun résultat statistique n'indique que la dette publique est insoutenable dans les économies émergentes, alors qu'elle l'est au Japon et en Italie. D'autre part, il a été observé que la dette publique de la Russie est soutenable indépendamment des revenus du pétrole et du gaz naturel.

Mots-clés: Soutenabilité de la dette publique, algorithme Step-wise, recettes publiques non énergétiques

Abstract

This thesis aims to test public debt sustainability in selected countries with the Step-wise algorithm. First, the stationarities of public debt stock, primary surplus, budget balance, public revenues, and public expenditure of four developed economies (France, Germany, Italy, and Japan) and three emerging economies (Brazil, China, and Turkey) were tested with ADF, PP and KPSS unit root tests. Later, the sustainability analysis of the public debt stock of these countries was examined by the Johansen cointegration test by applying the appropriate steps of the algorithm according to the obtained stationarity levels. Lastly, the public revenues in the algorithm for Russia were updated as non-energy (oil and natural gas) public revenues, and the algorithm was run again. According to the results obtained, there is no statistical finding that the public debt is unsustainable in emerging economies, while it is unsustainable for Japan and Italy. On the other hand, it has been observed that Russia's public debt is sustainable regardless of oil and natural gas revenues.

Keywords: Public debt sustainability, Step-wise algorithm, non-energy public revenues

Özet

Bu tez, bütünleşik test algoritması yöntemi ile seçilmiş ülkelerde kamu borç sürdürülebilirliğini test etmeyi amaçlamaktadır. İlk olarak, dört gelişmiş ekonominin (Fransa, Almanya, İtalya ve Japonya) ve üç yükselen ekonominin (Brezilya, Çin ve Türkiye) kamu borç stoku, faiz dışı fazla, bütçe dengesi, kamu gelirleri ve kamu harcama durağanlıkları ADF, PP ve KPSS birim kök testleri ile test edilmiştir. Daha sonra elde edilen durağanlık seviyelerine göre algoritmanın uygun adımları uygulanarak bu ülkelerin kamu borç stokunun sürdürülebilirlik analizi Johansen eşbütünleşme testi ile incelenmiştir. Son olarak Rusya için algoritmada yer alan kamu gelirleri enerji (petrol ve doğalgaz) dışı kamu gelirleri olarak güncellenmiş ve algoritma tekrar çalıştırılmıştır. Elde edilen sonuçlara göre, yükselen ekonomilerde kamu borcunun sürdürülemez olduğuna dair istatistiksel bir bulgu bulunmazken, Japonya ve İtalya için kamu borcunun sürdürülemez olduğu görülmüştür. Öte yandan Rusya'nın kamu borcunun petrol ve doğalgaz gelirlerinden bağımsız olarak sürdürülebilir olduğu gözlemlenmiştir.

Anahtar kelimeler: Kamu borcunun sürdürülebilirliği, bütünleşik test algoritması, enerji dışı kamu gelirleri

1. INTRODUCTION

The concept of sustainability of public debt has been defined in different ways, especially since the beginning of the 20th century. The most common approach to the sustainability of public debt is that the debt to Gross Domestic Product (GDP) ratio is in a dynamic equilibrium in the long run (Collignon, 2012). If this balance condition is met, the sustainability of the public debt can be hold. According to another approach, the ratio of public debt to GDP is critical. According to this criterion, known as "Convergence criteria" or "Maastricht criteria", public debt should not be more than 60% of GDP (Afxentiou, 2020; European Union, 1992).

Public debt has different characteristics compared to individual or corporate debt. Grenier (2006) classifies the characteristics of public debt under three main headings:

Impersonality: Grenier says that public debt should be free of personal values. That is, whether it is a king, a prince or a head of state, it should never be treated as an individual's commitment, but as a state or province's commitment. The reason for the debt and the investments to be used are not for the benefit of individuals, but for the benefit of the public. Daniel Defoe explains this situation in his article "Essay upon Publick Credit" written in 1710: *"As the public credit is national, not personal, so it depends upon no thing or person, no man or body of men, but upon the government, that is the Queen and parliament"* (Esposito, 2020).

Continuity: The second characteristic that is tied to impersonality in many ways is continuity. Here, the concept of continuity does not mean having a permanent public debt. This continuity means that commitments made independently of a monarch or government are recognized by future rulers and the debt is accepted by all. This concept of continuity sometimes causes problems in terms of public debt for two reasons. First, it is unclear to what extent moral sustainability will occur over a long period of time. Secondly, it is a conflict of interest that may occur between different successive rulers or governments. For example, in countries without strong supervisory mechanisms, a heavy debt committed by a government may be seen as a burden by the succeeding government, and this debt, which is not in the public interest, may not be recognized by the new government. In such a case, since the states cannot be compelled to pay their debts by law, there is a risk that the lenders will not be able to receive their receivables.

Knowing: According to Grenier, public debt should be knowable. This concept relates to transparency to the public as well as to information provided to lenders about the current state of public finances. Public trust and creditor trust, which are indispensable for the finances of a modern state, are only possible with transparent financial reporting.

Although these three characteristics find their place in Grenier's definition of public debt, only a few of today's more than two hundred countries meet these criteria. For this reason, in modern definitions, public debt and the sustainability of this debt stand out as more simplified. Considered a risk-free asset by markets, public debt has long been the focus of stock market transactions and the financial industry. This attractiveness of government bonds is explained by the inherent characteristics of a modern state that determine the specific nature of public debt:

• The state, unlike households and businesses, is an eternal economic agent.

• The state has the authority to decide on its income regardless of economic conditions (crisis or growth periods) through the amount of tax it determines;

• Government spending is limited;

• The government can lend and use debt monetization through the Central Bank as a last resort to finance its deficit;

• States have the power to coerce through financial pressure. This power can require financial institutions residing in the country to hold public securities through regulatory restrictions. In this way, the State can prevent the prices of its debts from being subject to the market price and borrow at lower rates.

Even if it seems sensible to lend to the State rather than to a household or a company, it is not quite likely to force the State to repay its debt, contrary to households and companies for which the indebtedness is governed by rules, regulations and well-defined procedures. The quality of governmental institutions and regulations in a country has thus become a key variable in the decision-making process of investors in the financial markets. The correlation between economic development and the quality of governance institutions has occupied the development economics literature since the early 1990s. This relationship stands out as a new criterion for international financial institutions (IMF, World Bank) to evaluate the nature of government interventions in the economic performance of nations. Therefore, the concept of good governance becomes an important indicator for the growth and development of states (Sundaram & Chowdhury, 2012).

The definition of the notion of public debt is the subject of discussion in the economic literature. The usual definitions proposed by the literature appear to be too general and, in a way, too demanding (Grenier, 2006): the debt of a State is generally defined as all of its future commitments, public corporations and organizations which depend directly on it (public enterprises, social security, etc.). Aybarç (2019) defines it as direct government fixed-term contractual obligations towards third parties that are not covered by foreign currency reserves or non-stock securities. According to Hakura (2020), the broadest definition of public sector debt combines general government with public nonfinancial corporations, publicly guaranteed debt and public financial corporations, including the central bank. These definitions correspond to that of the gross public debt. When we consider the concept of gross public debt, we notice that the construction of an indicator reflecting the level of indebtedness of a country proceeds from a difficult arbitration because it is necessary that this one be measured with the best precision possible, while taking care of retaining the economically sensible statistics.

Using gross debt has several advantages: it is easily measurable in comparison with net debt, it is directly linked to the amount of interest paid for debt service, it may provide a complete picture of current and future sovereign solvency, and it has been evaluated by mainstream literature to understand sustainability for so many years. Yet, its main flaw is that it takes neither financial assets nor real estate assets into account (Dabrowski, 2016). This is why some authors approach the notion of public debt in a broader sense, looking at the two sides of the accounting balance: the assets, what the general government holds, and the liabilities, what they owe. In addition, the debt can be reduced by selling non-financial assets such as state land or buildings, whereas these operations are neutral for public assets.

Once again, it is necessary to distinguish the assets held by government according to the level of development of the countries. State assets do not have the same value in an industrialized country and in a developing country: developed countries are in a slightly more advantageous position in this regard. Thus, the analysis of sustainability has no meaning on the theoretical and empirical level if we get rid of the level of development of the countries. The concept of sustainability, on the other hand, must be understood as a multidimensional concept that is difficult to define, as it requires the capacity of a State to provide a coherent budgetary policy not independent of the consent of its citizens.

Historically, economists have been interested in the notion of debt sustainability by making a clear distinction between developed and developing countries. From a methodological and analytical point of view, the boundary between advanced countries and developing countries must be drawn carefully, particularly in terms of country risk analysis. For instance, advanced countries can get into debt in their own (and strong) currency, which decreases several risks, most importantly exchange rate risk. Thus, the currency gives advanced countries increased credibility on the financial markets, unlike developing countries (Willems & Zettelmeyer, 2022). As another example, a country's income level plays an important role in the country's probability of failure or success on the sustainability of its debt. A low-income country is more likely to fail to sustain its debt compared to an advance country with a higher income. Lastly, good governance and institutional quality have become additional factors of distinction between countries: those whose governance is of good quality are considered advanced, while those whose governance is considered weak are considered as developing countries. The evaluation of governance is based on different criteria: corruption, respect for the law, government effectiveness, regulatory quality, political stability, etc. Between two countries with identical debt ratios, if one is politically unstable, it will present greater default risks than the other country in which the institutional quality is higher (Consiglio & Zenios, 2020).

As a result of the tests and studies developed for decades, some inferences can be made on the sustainability of fiscal policy in the case of advanced and developing countries. First of all, when the interest rate is assumed to be constant, the stationarity of the total public deficit is a necessary and sufficient condition for sustainability. On the other hand, it is only sufficient when the interest rate is assumed to be variable. As for the sustainability of the primary deficit, it is not easy to make a certain conclusion: it is neither necessary nor sufficient. In the case where the interest rate is variable, the stationarity of the overall deficit is equivalent to the existence of a cointegration between revenue and total expenditure including interest charges. When the interest rate is assumed to be constant, sustainability can then be conceivable by the presence of a cointegration relationship between the primary deficit and the public debt. Moreover, if the interest rate is not constant, the cointegration between these two series is not a sure proof of sustainability.

The economic crises in the 21st century within the Euro Zone and United States have enabled us to draw various lessons on the sustainability of the public debt of certain countries, whether industrialized or developing. The external constraint remains as a factor of vulnerability for all countries. Monetary integration does not reduce the danger; the disappearance of the exchange risk only gives the illusion that the exchange risk has disappeared. Greece, Portugal and Spain in the beginnings of 2010s could be examples of this idea.

Yet, these approaches seem to be seriously limited for analyzing the debt of developing countries. Indeed, the assumptions made are very restrictive and do not reflect the reality of the financing structure of these countries. The volatility of macroeconomic variables in these countries and exposure to interest rate or exchange rate dynamics make any approach based on estimates of long-term magnitudes fragile. Sovereign crises in developing countries can be considered as institutional and even political, which gives them a particular feature.

On the other hand, the analysis of debt sustainability in advanced countries is mainly based on an accounting approach with static indicators (stabilizing balance and structural balance), the use of criteria based on debt stabilization, and an actuarial approach based on the Intertemporal Budgetary Constraint (IBC). In the case of emerging countries and less advanced countries, this analysis is more complex due to strong instabilities in their economies. Therefore, the sustainability criteria differ from those of advanced countries: budget balances, the increase in public spending, debt ratios to GDP or government revenue, etc. Less developed countries are also the focus of special attention from international institutions.

Indeed, the question of the sustainability of public debt was for a long time considered as a problem exclusively reserved for developing countries due to the resurgence of debt crises since the beginning of the 1980s: Mexico in 1982, countries of sub-Saharan Africa in 1980s, Brazil in 1994, Argentina in 2001, etc. This problem is now one of the challenges of developed countries since the outbreak of the Greek sovereign crisis, 2008 global financial crisis, possible disintegration in Euro Zone, and 2020 Covid-19 crisis.

1.1. Historical Development of Debt Sustainability Analysis

Most suggestions for sustainability indicators have been inspired by this IBC analysis. Yet, it is econometricians who have been most interested in the question of sustainability with the development of time series econometrics, which is based on the actuarial approach. The pioneer article is that of Hamilton and Flavin (1986) who propose to test sustainability by conducting unit root tests on debt volume. If it appears stationary, then it will be sustainable. Subsequently Wilcox (1989) extends the model to the case of a stationary interest rate by using the notion of rational expectations, and linking it to conditional expectations. In the case where the debt is not stationary, it is necessary to question the causes of this non-stationarity. Two possibilities are to be considered: either the transversality condition is not respected, or the discounted sum of the anticipated primary surpluses is not stationary.

Trehan and Walsh (1991) show that compliance with the transversality condition (which corresponds to the nullity of the present value of the debt at infinity) will be verified in the case of a stationary debt/GDP ratio. Yet, this is not a necessary condition.

The second generation of sustainability tests is based on the work of Hakkio and Rush (1991) and Quintos (1995). They propose an analysis of sustainability in terms of cointegration between total public expenditure and public revenue. Hakkio and Rush (1991) suggest that a necessary and sufficient condition for sustainability is the existence of a cointegration relationship between total revenue and expenditure with a vector $(1, -b)$ under the condition $0 < b < 1$. Quintos (1995) clarifies this approach and proposes two concepts of sustainability based on the cointegration between income and expenditure:

- If the cointegration vector is $(1; -1)$, then there is strong sustainability. GDP per capita is then a stationary variable.
- If the cointegration vector is $(1, -b)$, we only speak of weak sustainability.

While the simplicity and effectiveness of the techniques used have been a genuine success, the question of the relevance of tests over a period of less than twenty years is called into question by certain macroeconometric approaches.

For Bohn, the demonstrations carried out by the previous studies were correct but they strongly restrict the alternatives satisfying the IBC. Above all, they avoid the possibility of a cointegration of the series of residues at higher orders. Bohn notably opposes to the publications of Quintos (1995) who defines weak sustainability when he has to differentiate the public debt series twice to obtain a stationary series. He shows that following this logic, one could define an absurdly weak sustainability for an even higher order of integration.

Bohn, in this reflection, criticizes above all the recent use of econometric tests to answer the question relating only to the compliance or not of the intertemporal budget constraint whereas the first tests of Hamilton and Flavin (1986) aimed to answer a more positive question about the very form of the Intertemporal Budgetary Constraint. He thus points out that it was later articles that gradually abandoned this dimension to focus above all on the question of the existence of budgetary sustainability.

Bohn proposed a new analysis of the sustainability of public finances in 1998. In this article, Bohn estimates a long-run fiscal reaction function for the United States and concludes that a significantly positive response of the primary fiscal balance to the level of public debt is sufficient evidence of public debt sustainability.,

A few years later, Bohn reproduced this study with data over a very long period (1793-2003) for the United States. These estimates lead to the same conclusion, suggesting that the American debt was largely sustainable over the given period. In this article, Bohn explains that failure to reject the unit root hypothesis for a time series cannot be a proof showing that this series is nonstationary. According to him, this remark is justified by the following observation: in the history of public debt, there are rare periods of strong increase in debt, followed by long periods of debt reduction. It would therefore be necessary to be able to test the stationarity of the public debt over a very long period to take long cycles into account.

For Bohn, the demonstrations carried out by the previous studies were correct but they strongly restrict the alternatives satisfying the IBC. Above all, they avoid the possibility of a cointegration of the series of residues at higher orders. Bohn notably opposes to the publications of Quintos (1995) who defines weak sustainability when he has to differentiate the public debt series twice to obtain a stationary series. He shows that following this logic, one could define an absurdly weak sustainability for an even higher order of integration.

Finally, Bohn (2007) shows that the stationarity condition of the public debt series is not a necessary condition to satisfy the transversality condition or the IBC. Indeed, it shows that the IBC or the transversality condition holds for an integrated series of order n, including very high n. Bohn argues the limitation of the choice of the order of integration to 0 or 1, and proposes a fractional approach.

According to Bohn, the rejection of cointegration, in other words the fact that the residuals of the regression between revenue and expenditure are not stationary in first differences, may be consistent with the Intertemporal Budget Constraint (IBC). We recall that the sustainability of public debt or public deficits is based in the standard case on compliance with the Government's IBC:

$$B_t = -\sum_{s=1}^{\infty} \frac{D_{t+s}}{(1+r_{t+j})^s} + \prod_{j=1}^{s} \frac{B_{t+s}}{(1+r_{t+j})^s}$$

This constraint is based on the idea that a budgetary policy is only sustainable if the initial level of public debt is fully offset by the sums of future budgetary surpluses, discounted at the interest rate paid on the public debt. In other words, the indebted government undertakes to pay off its debts sooner or later by creating a budget surplus.

This equation is expressed in a simpler way by the transversality condition which implies that at a constant interest rate, the debt is said to be sustainable if, with an unchanged fiscal policy, it is equal to the sum of the discounted primary surpluses. The second term of equation above must therefore tend to zero for the stability of the debt to be secured. This transversality condition is also known as a “Ponzi game”. A State must never pay its debt by contracting another debt. By imposing this condition, we verify that the public debt at each moment must be equal to the present value of its expected future primary surpluses.

Furthermore, in the same article (Bohn, 2007), he defends the use of a cointegration relationship between the primary budget balance and the public debt in the form:

$$(Primary\ balance)_t = \propto (debt)_t$$

This equation simply means that the series of primary fiscal balance and public debt must be cointegrated with a coefficient $\propto$.

1.2. A New Perspective on Sustainability Analysis: Step-Wise Algorithm

Özkaya, in his study in 2013, tested the sustainability of public debt of selected OECD countries with the combination of methodologies proposed by Trehan and Walsh (1991), Hakkio and Rush (1991) and Bohn (1995) mentioned above. In this study, which was carried out with the data set between 1999/Q4-2010/Q1, the stationarity of data sets such as public debt stock, public revenues and expenditures, budget balance and primary balance was analyzed, and as a result of the established algorithm, it was tested whether there is any systematic for the selected countries to pay their public debts. As a result of the analysis, it was concluded that Turkey's public debt is sustainable.

According to Özkaya, the use of all three methodologies alone in sustainability analyzes can lead to misleading results, bringing with it a one-way analysis. Özkaya, on the other hand, says that there are multiple variables and methods that can enable countries to pay their public debt by combining these methodologies with step-by-step stagnation and -when necessary- cointegration analyzes called "Step-wise Algorithm". It is possible, in the literature, to see this method proposed by Özkaya, either directly used or modified, sustainability analysis and the effects of economic crises on debt stock (Wysocki, 2017; Wysocki & Wojcik, 2018).

This study aims to apply the algorithm proposed by Özkaya to selected countries, including the 2009 and 2020 global crises. In addition, as a new perspective to the studies in the literature, the sustainability analysis of the public debt of Russia, which is one of the strongest countries in the world in terms of energy and oil income, will be examined by excluding these incomes and this debt will be increased even under conditions such as a possible oil and energy crisis or embargo. will examine whether it can be sustained.

The second chapter will explain how unit root, cointegration and Step-Wise algorithms are used in sustainability analysis and will explain the evaluation criteria of the results obtained.

In the third chapter, the historical development of public debt sustainability analyzes in terms of both developed and developing countries and different approaches will be examined, and then stagnation and co-integration-based studies in the literature on selected countries will be summarized.

In the fourth chapter, the stationarity of each collected data set will be tested, and then the sustainability of the public debt of the selected countries will be tested with the help of the Step-Wise algorithm. Later, for Russia, the algorithm will be modified to examine the above-mentioned condition, and public revenues will be replaced with energy revenues.

In the last chapter, the test results will be summarized and studies on potential fiscal policies that can be implemented in the post-Covid-19 period will be summarized.

2. METHOD AND MATERIAL

In a stochastic universe, sustainability is expressed as a property of stationarity in statistical time series. A sustainable public debt is therefore a stationary public debt. The different sustainability tests are based on unit root tests (stationarity tests) and on cointegration tests. In this section, we will take a closer look at the stationarity and cointegration tests that will be used in the analysis of public debt sustainability and see the evolution of the use of these tests in debt sustainability analysis over time.

2.1. Stationarity tests

Several empirical studies have been carried out on the sustainability of fiscal policy. These tests are placed in a stochastic perspective in the extension of the work of Hamilton and Flavin (1986). They are the first to have empirically tested the sustainability of fiscal policy in the case of the United States over the period 1960-1984. To do this, they relied on the Intertemporal Budget Constraint by conducting a unit root test on the present value of the public debt and on that of the primary surplus. However, it should be noted that this analysis assumes a context of dynamic efficiency -the interest rate is lower than the growth rate. It thus allows the debt/GDP ratio to increase over time (at the maximum of the difference between the interest rate and the growth rate). In the opposite case where the interest rate is higher than the growth rate (situation of dynamic inefficiency), this analysis concludes that it is possible for a government to play a Ponzi game, as Collignon (2012) points out. The constraint then becomes solid, and in particular, it excludes the cases where the debt/GDP ratio is constant.

The work of Hamilton and Flavin was criticized by Kremers (1988) as their regression function did not take the delays into account and did not eliminate the autocorrelation of the residuals. Kremers also questioned the choice of the discount rate, which was based on a real rate.

Wilcox (1989) studied on Hamilton and Flavin's method of analysis by introducing a stationary interest rate, using the notion of rational expectations, formulated by Muth in 1961, and attuning them to conditional expectations. According to Wilcox, a sufficient condition for the satisfaction of the IBC is the stationarity of the debt stock in first differences because according to his results, the debt is a stationary process of $I(1)$. A strictly higher interest rate is then consistent with a decrease in the discount factor $\lim_{s\to\infty} \frac{B_{t+s}}{(1+r)^s} = 0$ such that the present value of the debt tends to zero as s tends to infinity.

Trehan and Walsh (1988), following the work of Hamilton and Flavin, applied stationarity tests to the series of debt and primary deficits in the United States over the period 1964-1984. They showed that compliance with the condition of transversality will be verified in the case of a stationary debt/GDP ratio. Yet, this is not a necessary condition. They conclude that the fiscal policy of United States was then unsustainable over the period considered and they subsequently conducted a new study in 1991 using the same period but including a variable discount rate. This time, they finally concluded that the fiscal policy was sustainable.

Fève and Hénin (1998) proposed another approach to empirically test the sustainability of public debt by improving the tests based on the notion of intertemporal solvency by considering the implications for economic policy of a high debt/GDP ratio. Their approach consists mainly in analyzing the property of the return of the debt to its average level or of the return of the debt to its deterministic trend after a shock. To do this, they decide to introduce the notion of effective sustainability as opposed to that of actuarial sustainability. Effective sustainability or net sustainability makes it possible to include the additional constraints of financial resources likely to be allocated to debt service in their model. The test proposed by Hénin and Fève makes it possible to avoid the problems of low power of the conventional tests of classical unit root and reinforces the criteria of sustainability (the debt/GDP ratio). They conclude that the stationarity of the debt/GDP ratio is a necessary but insufficient condition because a sufficient condition imposes constraints on certain statistical variables (mean and variance) of public debt.

2.2. Cointegration tests

The second generation of sustainability tests is based on the work of Hakkio and Rush (1991) and Quintos (1995). They proposed an analysis of sustainability in terms of cointegration between total public expenditure and public revenue. They suggest that a necessary and sufficient condition for sustainability is the existence of a cointegration relationship between total revenue and expenditure with a vector $(1, -b)$ under the condition $0 < b < 1$. Quintos (1995) enriched the work of Hakkio and Rush by introducing the distinction between strong sustainability and weak sustainability:

- If the change in expenditure is exactly compensated in the long term by equivalent revenue, we will say that sustainability is strong; that is, the cointegration relationship between revenue and sustainability expenditure is strong when the coefficient between the two variables is unity.
- If there is a persistent (but stable) gap between changes in revenue and expenditure, we only speak of weak sustainability. The cointegration coefficient is then between 0 and 1. In other words, revenue moves in the same direction as expenditure but to a lesser extent. In this case, the series of deficits is no longer necessarily stationary.

The works of Hakkio and Rush (1991) and Quintos (1995) have been widely criticized, in particular by Wickens and Uctum (1993). Critics have focused on the idea that cointegration tests are a more flexible generalization of the overall balance stationarity test. Moreover, the notions of strong and weak sustainability are also debatable as they do not prevent the debt/GDP ratio from reaching very high levels.

Jondeau (1992) shows that it is possible to combine unit root tests and cointegration tests to analyze the stationarity of public debt. He tests the hypothesis of the sustainability of French budgetary policy through the existence of a long-term relationship between revenue and expenditure during the period 1965-1990. It appears from his results that the sustainability hypothesis is rejected due to a change in the behavior of the Government over the period. The short-run dynamics are analyzed within the framework of tax smoothing theory, which establishes a relationship from income to expenditure. Here, Granger test procedure serves as the basis for most econometric work on the sustainability of fiscal policy. This test procedure is summarized as follows:

1. Carry out a stationarity test for public revenue and public expenditure (test 1);

2. If the two variables are stationary (and stationary in difference), we then test the null hypothesis of the absence of a cointegration relationship between overall revenue and expenditure (test 2);

3. If the variables are cointegrated, we want to end up testing the null hypothesis that the cointegration vector is (1; -1).

For tests 1 and 3, the null hypothesis corresponds to the sustainability of the fiscal policy, while the null hypothesis in test 2 corresponds to unsustainability. This is why in the case of the non-cointegration tests, not being able to reject the null hypothesis does not allow us to make a strict conclusion.

After all, there are several tests to analyze the sustainability of fiscal policy. First, we must test the stationarity of public expenditure and public revenue. If the two variables are stationary, we will then conclude that the State is solvent (the budgetary policy is sustainable). Otherwise, it will be necessary to perform a test on stationarity of the budget deficit and of the public debt. If they are stationary, it can be said that the State is solvent. Otherwise, it is necessary to look for a cointegration relationship between public expenditure and revenue that is stationary in the long term. If there is a cointegrating vector, the IBC is tested and the state is solvent. Otherwise we will say that the State is insolvent and the budgetary policy is unsustainable.

A third generation of sustainability model is presented in the article by Bohn (1995) which challenges the limitation of the choice of the order of integration to 0 or 1, and which proposes a fractional approach of cointegration. Bohn promotes an actuarial approach which consists in analyzing the evolutions of the primary balance according to the debt stock with a variable discount rate.

A few years later, Bohn in an article published in a working document in 2005, reproduced this study with data over a very long period (1793-2003) for the United States. These estimates lead to the same conclusion, showing that the American debt was largely sustainable over that period. In this article, Bohn explains that failure to reject the unit root hypothesis for a time series cannot be a proof to show this series is nonstationary. According to him, this remark is justified by the following observation: in the history of public debt, there are rare periods of strong increase in debt, followed by long periods of debt reduction. It would therefore be necessary to be able to test the stationarity of the public debt over a very long period to take long cycles into account.

The standard tests of sustainability have been questioned with the criticism of Bohn again (2007). He believes that the rejection of cointegration -in other words, the fact that the residuals of the regression between income and expenditure are not stationary in first differences- can be consistent with the IBC. Brand (2012) states that Bohn criticizes the recent use of econometric tests to answer the question relating only to the compliance -or noncompliance- of the intertemporal budget constraint, whereas the first tests by Hamilton and Flavin (1986) aimed to answer a more positive question on the very form of the Intertemporal Budget Constraint. The first question of Hamilton and Flavin was indeed to know if the States are subjected to the same budgetary constraint as the households. So, Bohn proposes an approach based on the estimation of a fiscal reaction function defining a cointegration relationship between the primary fiscal balance and the public debt. The use of reaction functions thus makes it possible to give substance to economic theory, since it makes it possible to no longer be restricted only with econometric methodology but also to take the budgetary behavior of governments into consideration. In fact, in his article published in 1998, Bohn had estimated a long-run fiscal reaction function for the United States and concluded that a significantly positive response of the primary fiscal balance to the level of public debt is sufficient evidence of public debt sustainability. Subsequently, many other studies using this approach by estimating a government budgetary reaction function based on the fan charts began to appear in the literature (Collignon, 2012; Celasun et al., 2006; Budina & Wijnbergen, 2007).

From the tests carried out on sustainability analysis, some lessons can be drawn on the sustainability of fiscal policy in the case of advanced countries. First of all, when the interest rate is assumed to be constant, the stationarity of the total public deficit is a necessary and sufficient condition for sustainability. On the other hand, it is only sufficient when the interest rate is assumed to be variable. As for the sustainability of the primary deficit, it is neither necessary nor sufficient. In the case where the interest rate is variable, the stationarity of the overall deficit is equivalent to the existence of a cointegration relationship between revenue and total expenditure. Finally, when the interest rate is assumed to be constant, sustainability can then be justified by the presence of a cointegration relationship between the primary deficit and the public debt. Moreover, if the interest rate is not constant, the cointegration between these two series is not a certain proof of sustainability.

2.3. Step-Wise Algorithm

Debt sustainability analyzes are sometimes made with the stability of the debt stock, sometimes with the econometric relationship of the primary balance with the debt stock, and sometimes with the cointegration relationship of public revenues and expenditures. The application of a single method could be misleading, but it also means ignoring the existence of different instruments that enable states to pay their debt. For example, it is highly misleading to say that debt is not sustainable for an economy whose public debt stock is not stable. In a scenario where public revenues are not stationary and co-integrate with public expenditures in the long run, the state may have the economic power to meet this debt in the long run. To give another example, the high amount of oil exports of the Gulf Countries can stand out as an important trump card in the borrowing of these countries.

In order to avoid the possible misleading results emerging from any sustainability tests, we will use the methodology proposed by Özkaya (2013): Step-wise Algorithm. This algorithm allows us to use different approaches suggested by Trehan and Walsh (1991), Hakkio and Rush (1991), and Bohn (1995), which were detailed in previous chapters. It is a combination of different approaches and enables us to better understand the sustainability analysis of states. This algorithm, which consists of four steps, examines them as a whole, instead of examining the stationarity of a single data set or the cointegration of only two data sets, as mentioned before. Moreover, the recent literature, which built up around tests of fiscal sustainability via tests of cointegration between debt stock and primary balance, or revenue and public expenditure in line with the pioneer work of Granger (1981) and Engle and Granger (1987). While Bohn criticizes the recent use of econometric tests to answer the question of whether or not the intertemporal budget constraint is well respected or not, the first tests by Hamilton and Flavin (1986) rather tried to answer a more positive question on the very form of the Intertemporal Budgetary Constraint. Here, one of the new approaches in modern era will be implemented in our methodology as one step in algorithm to assess the sustainability of public finances. This equation can be translated into a cointegration relationship (interpretable as a long-term equilibrium) which takes the following form:

$$Primary\ Balance = \beta Debt\ Stock_{t-1}$$

This is a cointegration relationship between the primary budget balance and the level of one-period lagged public debt. An econometric problem that arises is that the primary balance is a stationary process $I(0)$ while the public debt is a stationary process in first difference $I(1)$.

The algorithm works as follows:

Step 1: We start with the stationarity tests on public debt stock divided by real annual GDP. If at least two of three tests (ADF, PP and KPSS) give the stationarity at $I(0)$, we end the algorithm and state that the debt is sustainable. If not, we move to the Step 2.

Step 2: This step consists of three sub-dimensions:

a: We test the stationarity of primary balance to GDP ratio. If it is stationarity at levels, then we move to Step 3.

b: If primary balance to GDP ratio is stationary at $I(1)$, we move to the Step 4.

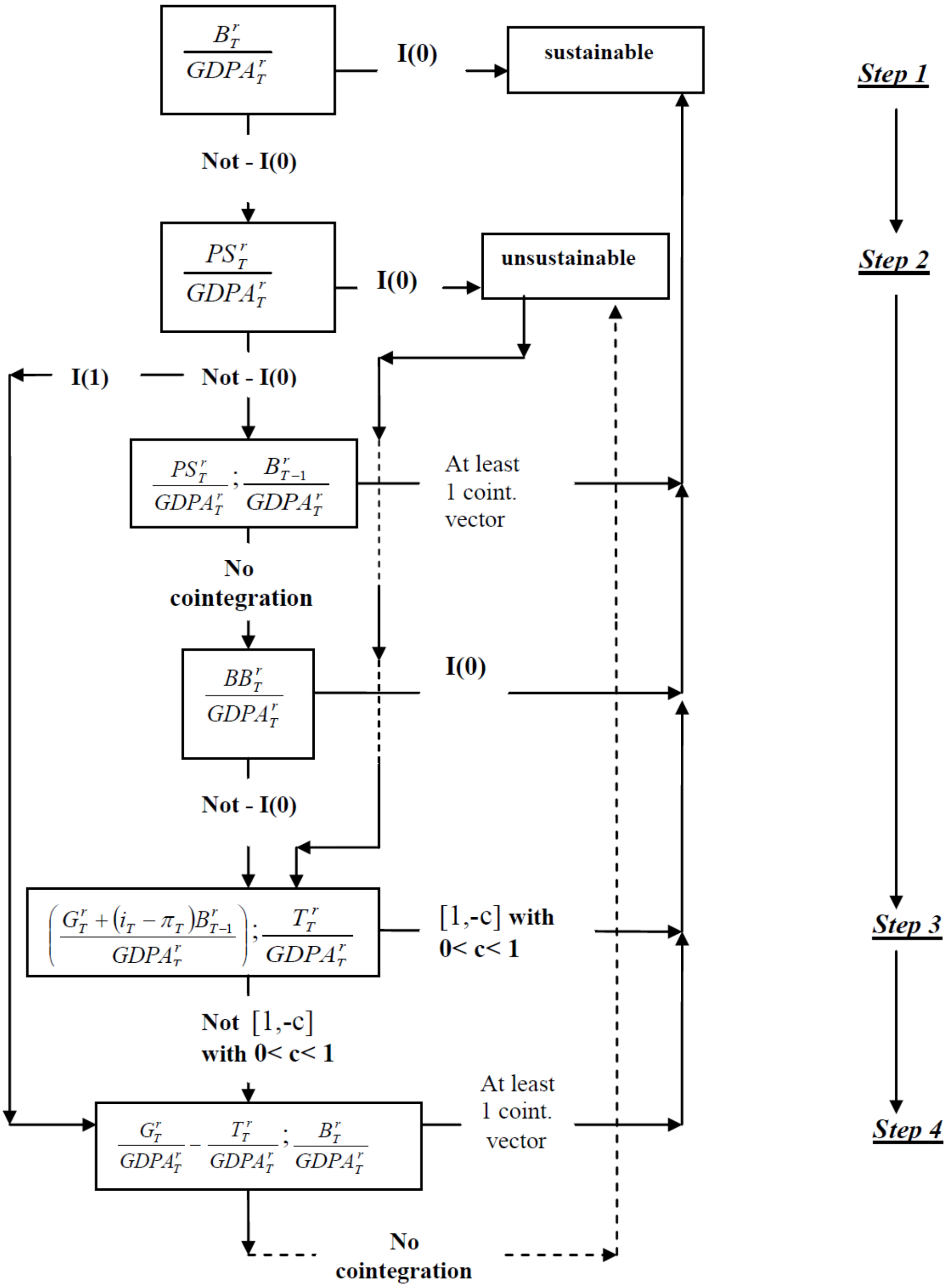
c: If primary balance/GDP ratio is not stationary at $I(0)$ or $I(1)$, then we look for a cointegration relationship between primary balance/GDP and one-period lagged debt stock/GDP ratio. If there is at least one cointegration, then the debt stock is sustainable. If not, we test for budget balances to GDP ratio for stationarity. If it holds, the debt is sustainable. Otherwise, we move to the Step 3.

Step 3: Here, we look for at least one cointegration relationship between government revenue to GDP and government expenditure to GDP ratios. If we can find a cointegration relationship, we also look for whether the cointegrating vector is a vector $[1, -c]$ under the condition that $0 < c < 1$. If it holds, the debt is sustainable. Otherwise, debt is not sustainable.

Step 4: We seek for at least one cointegration relationship between primary balance/GDP and debt stock/GDP ratios. If it holds, then the debt is sustainable. Otherwise, debt is not sustainable.

Here, we will use this algorithm for selected countries except Russia. For the Russian case, we will make a modification on Step 3, if needed. In particular, the ability of the Russian economy, which receives a large part of its income from the energy sector, to maintain its debt even if it is deprived of energy revenues as a result of a possible energy crisis or the political and economic embargoes it is experiencing today will be tested. To do so, we will look for the cointegration relationship between non-energy government revenues and government expenditure in Step 3 in order to look whether the country could cover its debts without its energy revenues. Here, we will look for possible stationarity in non-energy included budget balances over GDP ratio, as well.

Figure 2-1: Step-wise Algorithm proposed by Özkaya (2013)



While performing the ADF and PP stationarity tests, first of all, the stationarity was tested according to the drift and trend model. In the non-stationary condition, only the drift model was tested secondly. No drift & trend model was included in the analysis, depending if the second model is also non-stationary. If stationarity is obtained in any of these three analyzes, it is concluded that this series is stationary at $I(0)$, otherwise, the stationarity analysis is performed again by taking the first differences of the data.

Since there are two types of models in the KPSS test, the drift and trend model were used in the stationarity test first, and in case this model was found to be statistically insignificant, only the stationarity of the drift model was examined. Again, if both models give non-stationarity, then the first differences were included into analysis in order to see whether the series is stationary at $I(1)$.

2.4. Material

In this thesis, we will investigate the case of application of debt sustainability analysis on four developed countries (Germany, France, Italy, Japan) and three developing economies (Brazil, China, Turkey). In addition to the basic sustainability analyzes put forward by Trehan and Walsh (1991), Hakkio and Rush (1991) and Bohn (1995), the combined algorithm for the sustainability analysis of public debt developed by Özkaya (2013) will be used in order to test the public debt sustainability of selected countries mentioned above for the time period from 2006/Q1 to 2021/Q4.

Furthermore, in order to bring a new perspective to the literature, the sustainability of Russia's public debt will be included into our analysis on the basis of non-energy income and budget balance, rather than evaluating the state's total income and balance analysis in order to see whether the country’s public debt sustainability depends on its energy revenues. The most important purpose here is to test whether the public debt of energy exporting countries such as Russia is sustainable in case of a possible energy crisis. The concept of "continuity", mentioned before as one of the characteristics of public debt, is faced with the risk of being interrupted in a possible energy crisis that may occur in energy exporting countries and spread over many years. For this reason, we believe that it is more appropriate to test the public debts of energy and oil exporting countries as Russia with their non-energy revenues. For this reason, non-energy public revenues will be used instead of total public revenues for Russia in the algorithm to be applied. For the country, due to the lack of official data, we will test 41 observations covering the period 2011/Q4-2021/Q4.

The public debt stock, public revenues and expenditures, primary balance and budget balance data of Germany, Italy and France were obtained from Eurostat, Bloomberg and CEIC databases. Since the relevant data are currently proportional to GDP, no additional realization has been made.

The data for China was obtained from the database of the National Bureau of Statistics of China, and it was obtained by dividing the GDP retrieved from the same database. The data for Japan and Brazil were created using the CEIC database together with the central banks of the relevant countries and the Ministry of Finance. Real quarter GDP data for Brazil is taken and included in the calculations. Realization of the data for countries with relatively high inflation, such as Turkey and Russia, is made by real quarterly GDP calculations, as in the example of Brazil. In other saying, the variables which take place in algorithm are in real terms over real annual GDP.

The data used in the study were taken from following sources:

Brazil: Bloomberg, CEIC, Central Bank of Brazil

China: National Bureau of Statistics of China, Bloomberg

France: Bloomberg, Eurostat

Germany: Bloomberg, Eurostat

Italy: Bloomberg, Eurostat

Japan: Bank of Japan, Bloomberg, CEIC, Ministry of Finance of Japan

Russia: Bloomberg, CEIC, Federal State Statistics Service (Rosstat)

Turkey: Ministry of Treasury and Finance, TURKSTAT

3. LITERATURE REVIEW

3.1. Theoretical Review

3.1.1. Debt analysis and sustainability indicators in advanced countries

Advanced countries have been considered different from middle-income and low-income countries concerning their strong local currency (Mundell, 2000; Habib et al., 2016). They are being able to borrow in their own currency; thus, their debt sustainability analysis is restricted to compliance with the budgetary constraint of the State. IMF (2002) defines the sustainability of debt as the ability to cope with a budget constraint, apart from any major change in public revenue or expenditure, or to a cost of financing in the given market. By this definition, the sustainability of a State's public finances is based on the analysis of the State's budget constraint, which offers a perspective of the evolution of budgetary variables over a given period. Intuitively, the sustainability of the debt depends on the assumptions made on the growth of available resources of the State which will allow it to repay its debt, but also on the evolution of the primary deficit which is also a cause of the indebtedness (Pelinescu, 2000).

As Bouthevillain and Schlack (2007) point out that the analysis of the accounting equation of the state budget makes it possible to highlight the behavior of governments in different economic contexts in order to deduce the sustainable or unsustainable nature of fiscal policy. According to their idea, this deduction can be made either by two possible scenarios: strictly complying the budget constraint, or by comparing it to an absolute budgetary objective. Thus, the pure budgetary logic offers an easily interpretable and operational definition and it constitutes the dominant mainstream of the economic literature on the sustainability of public debt. The sustainability indicators resulting from this approach can also be fine-tuned either by ruling out the effects of the economic situation (example of the structural balance) or through econometric tests based on the debt accumulation equation or even the intertemporal budgetary constraint.

Public debt can be expressed in value, in volume or as a percentage of GDP. For convenience, it is related to the percentage of GDP in the economic literature, since it makes it possible to measure the wealth produced by the country and therefore its capacity to levy taxes. Therefore, the dynamics of public debt can be described using different equations: the government budget constraint, the dynamic accumulation equation, and the intertemporal budget constraint (Westerlund and Prohl, 2010; Owusu, 2021).

3.1.1.1. Balances approach to public debt sustainability

Escolano (2010) describes the dynamics of public debt as a change of three main elements: interest rate, the primary balance and the change of government assets. Let us denote B the debt, r the interest rate, T the taxes, G the public expenditure. The budget constraint is then can be written as:

$$B_t = (1 + r_t)B_{t-1} + (G_t - T_t) \qquad (1)$$

where

$$(G_t - T_t) = D_t \qquad (2)$$

Here, D is described as the primary deficit without debt charges. For the simplicity, this equation excludes the role of central bank monetary policy, and seigniorage revenues which are explicitly not considered. As a result, they end up in the nominal interest rate. Moreover, with this equation, we neglect the debt-deficit adjustment which includes transactions likely to affect the stock of outstanding debt but not the primary balance.

We can express the dynamics of debt/GDP ratio in a simple way by seeking to establish the accumulation equation of its dynamics. Let Y_t be the real GDP in t, so we have the dynamics of debt/GDP ratio:

$$\frac{B_t}{Y_t} = (1 + r_t)\frac{B_{t-1}}{Y_t} + \frac{D_t}{Y_t} \qquad (3)$$

Knowing that $Y_t = (1 + g_t)Y_{t-1}$ where g_t is the real GDP growth rate, we obtain:

$$\frac{B_t}{Y_t} = \frac{(1+r_t)}{(1+g_t)}\frac{B_{t-1}}{Y_{t-1}} + \frac{D_t}{Y_t} \qquad (4)$$

To simplify, we can denote $b_t = \frac{B_t}{Y_t}$, $b_{t-1} = \frac{B_{t-1}}{Y_{t-1}}$, and $d_t = \frac{D_t}{Y_t}$;

$$b_t = \frac{(1+r_t)}{(1+g_t)} b_{t-1} + d_t \qquad 5)$$

The dynamic accumulation equation is thus given by the variation of b_t as:

$$\varDelta b_t = \frac{(r_t - g_t)}{(1+g_t)} b_{t-1} + d_t \qquad (6)$$

Here, equation (6) describes the evolution of the debt ratio, i.e. public debt relative to GDP. In particular, it shows that the change in public debt is influenced by two factors that will determine the dynamics of public debt in the long term:

- The difference between the real interest rate and the real GDP growth rate,
- The amount of the primary deficit (as a percentage of GDP).

These two factors stated above will determine the conditions for the sustainability of the public debt, and a debt is said to be sustainable if it is stable.

Let's start by calculating the steady-state value of debt based on the three relevant economic factors. The stationary equilibrium corresponds to $b_t = b_{t-1} = b$ and $d_t = d$. So, we get:

$$b = \frac{(1+r)}{(1+g)} b \qquad (7)$$

$$\bar{b} = \frac{(1+g)}{(g-r)} d \qquad (8)$$

where $\bar{b}$ represents the steady state of the debt. We notice that $\bar{b} > 0$ for $d > 0$ and $g > r$, or $d < 0$ and $r > g$. Here, we talk about two possible scenarios (Checherita-Westphal & Semeano, 2021):

- $g > r$: It means that the real GDP growth rate is greater than the real interest rate. It leads us to the conclusion that the government is no longer obliged to generate primary surpluses. The growth rate of the economy makes it possible to finance both part of the primary deficit and debt service. This therefore leaves room for maneuver to the authorities with regard to budget deficits because they have the necessary resources to repay the public debt coming due. This situation corresponds to all developed countries up to the beginning of the 1980s. In this case, when the real GDP growth rate is higher than the real interest rate, the public debt is sustainable in the absence of large and chronic primary deficits. It should not explode and converges towards its stationary value. The state should be able to repay its debt without difficulty.

- $r > g$: Here, the real GDP growth rate is lower than the real interest rate. The budgetary policy of the public authorities is not sustainable. Only a primary surplus can ensure debt stability and should allow a return to a sustainable situation if the country does not resort to debt monetization. In such cases, the debt is not sustainable for a positive amount of primary deficit. In order to ensure the sustainability of its debt, the State is forced to achieve a primary surplus.

These two situations highlighted above correspond to what is known as the "snowball effect" (European Central Bank, 2009) which depends, when considering the debt relative to GDP, on the difference between the interest rate and the growth. If this critical gap is negative, that is, growth is higher than the interest rate, then for the same sequence of primary deficits, we will obtain a lower debt relative to GDP, provided that the deficits are not too large and recurrent. If this gap is permanently negative, then the debt has a downward trend. We speak of the snowball effect in the opposite case, where the interest rate is higher than growth and therefore the critical deviation is positive. The debt in points of GDP has an upward trend that only a negative primary deficit can offset. A special case is when the critical deviation is zero, which is the case of “golden rule” (Phelps, 2010) where the growth rate of the economy is equal to the interest rate. In this case, the evolution of debt relative to GDP depends only on the sequence of primary deficits.

3.1.1.1.1. Discrete-time sustainability indicators

The balances approach mentioned above is based on very restrictive assumptions on key variables (expenses, revenues and interest rates). Indeed, they are assumed to be exogenous and therefore independent of debt levels and economic growth.

In reality, the components of public budgets exhibit a smoothing effect on the economic cycle, and act as automatic stabilizers. During a recession, for instance, the amount of taxes collected by the State decreases in order to support economic activity. On the other hand, when economic activity experiences a significant boom, tax levies increase to offset the growth in aggregate demand.

With regard to the interest rate of the debt of a State, it is the macroeconomic situation of the country which determines its evolution. Depending on the expectations made by investors on the macroeconomic situation, they will choose between holding bonds, which are safe investments, or equities, which are risky assets.

Although based on very restrictive assumptions, the accounting approach has the advantage of proposing a definition of sustainability that is easily interpretable and operational in the sense that sustainability ensures the coherence of budgetary. Sustainability indicators are defined as ex-ante indicators because they provide information on the extent of the final adjustment in terms of fiscal policy. The objective is to stabilize the debt/GDP ratio. The development of these indicators is traditionally based on models that take the links between fiscal flows and stocks explained in equation (1) of the State budget constraint into account:

$$B_t = (1 + r_t)B_{t-1} + (G_t - T_t) = (1 + r_t)B_{t-1} + D_t$$

Two main indicators will be discussed now: the debt-stabilizing primary balance and the structural balance.

3.1.1.1.1.1. Debt-stabilizing primary balance

The balance stabilizing debt already discussed in the previous section (equation 6) is entirely built on the accounting identities of the following:

$$\Delta b_t = \frac{(r_t - g_t)}{(1 + g_t)} b_{t-1} + d_t \qquad (9)$$

It is the public balance for which debt and GDP grow at the same rate, and the debt/GDP ratio is constant. It thus corresponds approximately to the opposite of the product of nominal GDP growth and the debt ratio of the previous year. For example, the convergence criteria are based on economic indicators linked to the stabilizing balance. If the debt ratio is 40% of GDP and nominal growth is 4% of GDP, the debt-stabilizing balance is approximately equal to $-4\% \; x \; 40\% = -1.6\%$ of GDP.

This indicator proposes that there always exists a level of public deficit d_t which leaves the debt ratio b unchanged according to the growth g of GDP for a given year. Knowing the change in the debt burden r, this deficit can be expressed as a “primary balance”. Under the assumption of an equilibrated primary balance, when the nominal

GDP growth rate is lower than the interest rate on the debt, public debt can increase by a simple snowball effect. The greater the gap between these two rates (critical gap), the more binding the primary balance needed to stabilize the debt/GDP ratio. Conversely, dynamic economic growth reduces the constraints on the primary balance in order to stabilize the debt.

3.1.1.1.1.2. Primary structural debt balance

Structural balance is the budget balance which a government would have with its current policies if the economy was operating at its full potential (OECD, 2015). The constant primary structural balance is used to estimate the sustainability of public finances in European Union countries in a harmonized way. As we correct for the effects of the economic situation, we are reasoning in terms of structural balance because we do not take interest charges on the debt into account. Indeed, the cyclical balance and debt charges may vary at persistent policy depending on the macroeconomic situation (growth, interest rates) and the dynamics of public debt. In particular, it is assumed that the cyclical balance is supposed to be absorbed at a level much lower than that considered in the context of the sustainability analyses. The structural balance therefore makes it possible to overcome the impact of the economic situation on the balance and to develop a long-term strategy on the budgetary position. Under these assumptions, the sustainability gap corresponds to the difference between the primary structural balance and the balance stabilizing long-term public debt ratio.

The structural deficit, on the other hand, is difficult to measure. It very often occurs that the institutes do not agree among themselves on the methodology for assessing the structural deficit for a given year or even that an institute is led to significantly revise the proposed figures. Hence, it is difficult to find a trustworthy and commonly-held data for structural balance, which makes it almost impossible to perform an econometric analysis including more than twenty years. Still, the structural balance remains as an important indicator of sustainability, and is even a key element of the treaty on stability, coordination and governance within the Economic and Monetary Union signed in Brussels in March 2012.

3.1.1.1.2. Continuous time sustainability indicators

According to Blanchard et al. (1991), a fiscal policy is only sustainable if a government that has accumulated debt is able to generate sufficiently large primary surpluses in the medium or long term. This means that it must consider reducing its primary deficit by increasing taxes and/or by reducing public spending and transfers. Blanchard (1984) also points out that there are two methodological ways of assessing the sustainability of fiscal policy. The first method consists of reasoning in terms of discounted flows; in other saying, calculating the difference between the present value of the primary surpluses in relation to the level of initial debt relative to the GNP. The difference with the realized primary surplus thus corresponds to the difference in the budgetary adjustment. If the difference is positive, then the debt will be considered sustainable. The difficulty of interpreting this approach forces us to use a second sustainability indicator that is easier to interpret.

The construction of the Blanchard's sustainability indicator is based on the projection of public expenditure based on the initial level of debt. The indicator used is the 'sustainable tax rate' which, in the same spirit as the primary differential defined by Blanchard (1990), ensures the stabilization of the debt/GDP ratio. A gap between the equilibrium rate and the effective tax rate makes it possible to measure the sustainability of the country's debt:

$$t_n^* - t = \frac{\Sigma g}{n} + (r - q)d^* - t \qquad (10)$$

where t_n^* represents the fiscal pressure that stabilizes the debt/GNP ratio at the level $d^*$for a number of years, g represents the public expenditure, r represents the interest rates and q is the growth rate of the GNP. The sustainability index is therefore given by $t_n^* - t$. Despite the complexity of the calculations, the sustainable tax rate and the sustainability index can be interpreted in a simple way according to Blanchard: the sustainable tax rate is equal to the present value of planned future expenditures and transfers, plus the difference between the ex-ante interest rate and the growth rate multiplied by the ratio of debt to GNP. In other words, the government that has accumulated the debt will sooner or later have to raise taxes or reduce public spending. Moreover, the difference between the interest rate and the growth rate must be positive.

The magnitude of the gap $(t_n^* - t)$ is easy to interpret because it corresponds to the magnitude of the adjustment needed. If this indicator is positive, then current tax revenues are insufficient to stabilize the debt ratio for a given level of public expenditure. This suggests a possible recourse to debt monetization or other forms of debt cancellation.

The medium-term tax gap indicator is defined as the difference between the current tax ratio and that necessary to stabilize the debt ratio over the next N years (assuming constant interest and growth rates) (Blanchard et al., 1991; Chalk & Hemming, 2000). The interpretation of this indicator is similar to the tax gap indicator except that it requires projections of future expenditures and revenues.

In the long term, Blanchard et al (1991) identify other variables that can influence the sustainability of public debt. The aging of the population appears to be the main threat to the future sustainability of public finances. Indeed, the foreseeable increase in the proportion of elderly people will certainly weigh on certain public expenditure (pensions, health care, etc.).

The indicators developed by Blanchard to assess the sustainability of fiscal policy aim to assess the extent to which public authorities can keep taxation and government spending programs unchanged without facing an increase in public debt. From this analysis, it emerges that the assessment of the more or less sustainable nature of fiscal policy should not be limited to the short term but should also take place in a long-term perspective.

Blanchard's work has been the subject of various extensions. Talvi and Végh (2000) defined the macro-adjusted primary deficit, which is an indicator of debt sustainability trying to take the high volatility of macroeconomic variables into account; which means, at a given moment, the primary deficit may differ from which would exist under "normal" macroeconomic conditions. The problem of their approach was essentially based on the definition of a “normal” condition of economy.

Croce and Juan Ramon (2003) then defined the sustainable fiscal position indicator. According to their work, this indicator makes it possible to supplement the traditional analysis of sustainability indicators with a historical methodology including the authorities' reaction to shocks on the variables that determine debt dynamics over time. The authorities are thus likely to innovate in their tax and expenditure policies.

Calvo, Izquierdo and Talvi (2003) have proposed a currency lag indicator which makes it possible to account for the volatility of capital flows which is assumed to be higher than that of macroeconomic variables. This indicator compares the ratio between external debt and internal debt with the ratio of commercial and non-commercial goods.

Yet, debt sustainability indicators sometimes fail to explain long-term fiscal restraints including accrued contingent liabilities or future interest payments. Bagnai (2003) says: “The most relevant feature that the sustainability indicators fail to take into account is probably the impact of demographic evolution on the sustainability of fiscal policies.”

3.1.1.2. Actuarial approach to public debt sustainability

As Blanchard (1990) points out, the traditional approach to sustainability provides easily interpretable results thanks to its transparency and ease of application due to fully understood underlying assumptions. The deterministic baseline scenario can be adjusted for each variable in the debt accumulation equation to take country specificities and expert opinions into account. However, the deterministic scenario only yields relevant results if the medium-term trajectory of macroeconomic and fiscal variables is based on realistic assumptions. Assuming that the level of debt is identical from one period to another, we presuppose a healthy, effective and transparent management of the State's public finances, which is not the case in reality. In addition, the interest rate varies and therefore the debt burden generally imposed on States is not considered in this approach.

Also, the accounting approach does not consider the question of the rate of improvement of the primary balances of the countries and what levels of primary surpluses and taxation they can support. The baseline scenario is based on excessively optimistic fiscal projections and programs that overlook the political cycle and weakening commitment to fiscal consolidation as elections approach. Under these conditions, the public debt process will follow a perpetual cumulative process.

Improvement through an extension of the discussion has been made possible by implementing alternative approaches that go beyond the classic debt accumulation equation. Here, actuarial approaches (Leachman and Francis, 2001) are based either on strict compliance with the State's intertemporal budget constraint with econometric tests of stationarity, or on the link between the primary balance and the public debt ratio with cointegration tests.

3.1.1.2.1. State intertemporal budget constraint and stationarity conditions

The analysis of the sustainability of the budgetary policy is based on the analysis of the accounting equation defining the budget constraint of the public sector. This constraint, which we have already defined, relates the primary budget deficit, debt charges (nominal interest rates) and the increase in sources of financing. It is expressed as follows:

$$B_t = (1 + r_t)B_{t-1} + (G_t - T_t) = (1 + r_t)B_{t-1} + D_t \qquad (11)$$

This equation therefore links the public debt stock contracted during the previous period, plus interest, and the primary deficit contracted during the following period. Since we know that this equation must be verified in each period since a deficit in period t will require eventual debt repayment and interest payments, the constraints expressed in equation (11) are not independent. By recursively solving the debt accumulation equation, we obtain the State's Intertemporal Budget Constraint:

$$B_t = -\sum_{s=1}^{\infty} \frac{D_{t+s}}{\prod_{j=1}^{s}(1+r_{t+j})^s} + \prod_{j=1}^{s} \frac{B_{t+s}}{(1+r_{t+j})^s} \qquad (12)$$

Simply, this equation can be interpreted as follows: the public debt on date $t = s$ corresponds to the difference between the debt on date $t = 0$ discounted at the interest rate r, and all the public deficits discounted for each period of $t = 0$ to $t = s$.

Assuming that the interest rate is constant (Hamilton and Flavin, 1986), the condition below must be hold:

$$\lim_{s \to \infty} \frac{B_{t+s}}{(1+r)^s} = 0 \qquad (13)$$

This condition is called the transversality condition: at a constant interest rate, the debt is said to be sustainable if, with an unchanged fiscal policy, it is equal to the sum of the discounted primary surpluses. The second term of equation (12) must therefore tend to zero for the stability of the debt to be ensured (Kamihigashi, 2006; Pierre and Creel, 2016). This transversality condition is also known as the “Ponzi game” in economics. It emphasizes that a State must never pay its debt by contracting another one. By imposing this condition, we verify that the public debt at each moment must be equal to the present value of its expected future primary surpluses.

The sustainability conditions expressed in the IBC make it possible to understand that the present value of the sum of total public expenditure and the initial debt should be equal to the present value of future government revenues. If the discounted value of total primary public expenditure excluding debt charges is greater than the discounted value of the tax receipts of the State, it would no longer be solvent. State should generate at least a positive primary surplus in order to cover the initial debt and the accumulated deficits. At the end, the intertemporal solvency of the State is incompatible with permanent primary deficits.

In practice, the concept of intertemporal solvency is very limited for several reasons. Ostry (1995) has criticized the analyzes made on the sustainability of fiscal policy, particularly on the notion of IBC. First of all, he points out that most analyzes fail to determine the initial public debt ratio. Also, he states that nothing guarantees that this initial ratio is optimal for a given economy and nothing implies that it remains unchanged over time. There are indeed several budgetary positions for a State. The Intertemporal Budget Constraint of the State will always be verified, regardless of the initial level of the debt.

Moreover, the concept of solvency does not take into account the dynamics of debt in a global model integrating an uncertain environment. If we do not consider the evolution of the economic variables that enter into the determination of sustainability, there is a risk of biased results. A State can indeed be solvent at a given period and can become insolvent following shocks on the dynamics of supply and demand (Couillault, Bachellerie, 2005; Abbas et al., 2019).

One of the major criticisms of sustainability analysis rests on the long-term perspective of studies on IBC. Indeed, it prohibits any increase in the public debt in an infinite way (Ponzi game), whereas a temporary increase in the public debt within the framework of a stabilizing short-term budgetary policy can be beneficial for the economy of the country without being maintained in the long term.

For twenty years, an econometric approach has been developed, aimed at testing the sustainability of the debts observed over some period. It has been assuming that the determining behavior of budgetary flows over this period has been approximately stable, which corresponds with stationarity hypothesis. Since the study of Nelson and Plosser (1982), we know that most macroeconomic aggregates are not stationary and that they have a unit root in their characteristic process, which generates a so-called stochastic non-stationarity.

3.1.2. Debt analysis and sustainability indicators in developing countries

A developing country is a sovereign state with a less developed industrial base and a lower Human Development Index (HDI) relative to other countries (Nielsen, 2011). These countries, mostly in South America, North Africa and Asia, are indebted in foreign currencies. They have access to financial markets and receive external financing that is essentially private, expensive and at variable rates to support their growth.

In this section, we will see the analysis of the debt sustainability of developing countries. We will present the methods and indicators for analyzing debt sustainability provided by the economic literature and the analytical framework used by IMF and World Bank.

3.1.2.1. Theoretical framework for analyzing the debt of developing countries

3.1.2.1.1. Mathematics of public debt

At each period, the States must face the Intertemporal Budget Constraint which must be satisfied ex post. Thus, this constraint accounts for the dynamics of the debt. By referring to the accounting equation for the debt taken in its general form, we have:

$$B_t = (1 + r_t)B_{t-1} + G_t - T_t = (1 + r_t)B_{t-1} + D_t \qquad (14)$$

We note that the means of repayment of the debt are limited for the indebted State. To repay its debts (domestic and external), the government must either obtain a low interest rate or achieve a positive primary balance by reducing its expenditure or by having sufficient tax revenue.

To be able to repay its debt, a country must therefore generate sufficient overall income. As far as developing countries are concerned, the problem that arises is that the repayment of their debt is made from their insufficient domestic public savings and their highly volatile export earnings, in foreign currencies.

3.1.2.1.2. Dynamic debt equation and external constraint

Developed countries have public debts, the amounts of which are sometimes huge, but unlike developing countries, they can first resort to their domestic savings before borrowing foreign capital. The public savings can make it possible in the short term to finance the payment of debt service.

Trying to escape from debt by domestic savings was for a long time practically impracticable in developing countries due to heavy dependence on the primary sector and the preponderance of the informal sector. The majority of households had been living with incomes close to the subsistence level. By contrast, rich and well-to-do families sometimes preferred to invest their capital in banks abroad. This widespread capital flight therefore leads developing countries to resort to external borrowing in foreign currencies. Even if the situation has improved considerably over time in some developing countries over years, they still have to generate a trade surplus to cover their domestic deficits and pay off their debts to abroad.

We therefore need to write a new external debt accumulation equation to analyze the debt sustainability of developing countries which is obtained from the equilibrium in an open economy on the market for goods and services:

$$GDI_t + M_t = C_t + I_t + G_t + X_t \qquad (15)$$

where GDI is gross disposable income, M demand for imported goods, C demand for goods for consumption purposes, I demand for investment goods, G government expenditure, X exports.

Let;

$$A_t = C_t + I_t + G_t \qquad (16)$$

be the internal absorption or demand, and;

$$NX_t = X_t - M_t \qquad (17)$$

is the net exports or trade balance of goods and services. Adding to each side of the equation, net unilateral transfer income U_t and minus debt interest rD_{t-1}; we get the following equation:

$$GDI_t - rD_{t-1} + U_t = A_t + NX_t - rD_{t-1} + U_t \qquad (18)$$

Here, D measures the stock of external debt and r the interest rate. The gross national product Y_t is given by the right-hand side of equation above, so the expression $Y_t - A_t$ corresponds to the total current account balance of the economy which we will denote by CA_t. We thus have the following equation:

$$Y_t - A_t = CA_t = NX_t - rD_{t-1} + U_t \qquad (19)$$

Setting $Z_t = NX_t + U_t$ where Z defines the current account balance excluding debt burden, also called the primary current account balance, the equation can be rewritten as:

$$CA_t = Z_t - rD_{t-1} \qquad (20)$$

Assuming that the indebtedness process is determined by an external current account deficit, the relationship between the outstanding external debt and the current account balance can be expressed by the equation below:

$$D_t - D_{t-1} = -CA_t \qquad (21)$$

From the equations (20) and (21) above, we can therefore establish the equation accounting for the fundamental dynamics of the accumulation of external debt:

$$D_t = (1 + r)D_{t-1} - Z_t \qquad (22)$$

In this equation, the process of indebtedness is partially explained by the past inheritance of the debt but also by the primary balance of the current account generated by the country. For developing countries, this balance plays an important role in the process of debt accumulation.

3.1.2.1.3. Interpretation of the dynamic external debt equation

By rewriting the fundamental dynamic debt equation, we can proceed to its interpretation. To do this, we divide the sides of equation (22) by D_{t-1} and we obtain the following:

$$\frac{D_t - D_{t-1}}{D_{t-1}} + \frac{Z_t}{D_{t-1}} = r \qquad (23)$$

Assuming a zero current account primary balance, the source of external debt growth is therefore the interest rate r:

$$\frac{D_t - D_{t-1}}{D_{t-1}} = r \qquad (24)$$

If the primary balance of the current account is negative, then the stock of external debt grows faster than the interest rate:

$$\frac{D_t - D_{t-1}}{D_{t-1}} > r \qquad (25)$$

If the current account primary balance is positive, $Z_t > 0$, then two scenarios which depend on the magnitude of the current account surplus need to be considered:

- When the current account primary surplus covers less than interest payments, i.e. $Z_t < rD_{t-1}$, then the stock of external debt grows less quickly than the interest rate

$$0 < \frac{D_t - D_{t-1}}{D_{t-1}} < r \qquad (26)$$

- When the primary surplus generated by the country covers more than interest payments, i.e. $Z_t > rD_{t-1}$, the stock of external debt is then reduced over time:

$$\frac{D_t - D_{t-1}}{D_{t-1}} < 0 \qquad (27)$$

We can conclude that in the external debt dynamics equation, the primary current account balance plays a vital role in the process of debt accumulation or reduction. A State must therefore resort to surpluses on its current account to maintain the payment of the service of its debt.

3.1.2.2. Econometric analysis of the sustainability of the external debt of developing countries

The definition of external debt sustainability adopted here is that made by the IMF. According to the IMF, a country's external debt is sustainable if it can meet its current and future external debt service obligations in full, without recourse to debt rescheduling or the accumulation of arrears and without compromising growth (Mustapha and Prizzon, 2015). So, in the case of developing countries that are particularly vulnerable in terms of their external debt, efforts should be made to limit the weight of this debt. From the relationship between the primary balance of the current account and the external debt, many authors have tried to exploit the information provided by the series of debts and the series of balances considered together.

The bibliographic references related to the sustainability of external debt are many and varied, but the best-known approach is that associating the debt accumulation equation with a balance reaction equation considered by Uctum and Wickens (1993). The work of Hénin and Fève (1998) is in line with Uctum and Wickens' work: They attempt through an econometric evaluation to explain the sustainability of the external debt of developing countries. To do this, they start from the definition of the sustainability of the external debt according to the IBC of the State. However, unlike developed countries, they point out that many constraints weigh on the resources allocated to debt service. Indeed, actuarial sustainability, which is based on compliance with the standard transversality condition (the debt grows less quickly than the interest rate), does not consider the economic resources necessary to ensure the repayment of the debt.

In practice, this condition may prove to be insufficient, especially when the interest rate is higher than the growth rate of the economy. At the same time, it is also necessary to take into account the existence of random disturbances on the expected balances which lead to a strengthening of the sustainability criteria in the developing countries. This is why the two authors propose using the notion of effective sustainability (or net sustainability) which imposes that in the long term the ratio of the debt to the volume of resources D makes it possible to lead them tends to zero.

This new transversality condition implies that the debt variable discounted and normalized at infinity is equal to zero:

$$\lim_{n\to\infty} \frac{D_{t+s}}{(1+r)^{t+s}} = 0 \qquad (28)$$

3.1.2.2.1. Dynamics of the current primary balance and effective debt sustainability

Hénin and Fève (1998) establisdh the debt accumulation equation in terms of ratios by relating the magnitudes to GNP (or gross exports). The debt accumulation equation then becomes:

$$d_{t+1} = (1+r)(1+g)^{-1}d_t - nx_{t+1} \qquad (29)$$

where d is the public debt relative to GNP, nx is the net exports relative to GNP, r is the interest rate and g is the growth rate.

We can also rewrite this equation in terms of the current account balance (ca):

$$d_{t+1} = (1+g)^{-1}d_t - ca_{t+1} \qquad (30)$$

From the equations (29) and (30), we can deduce an autoregressive dynamic of the form:

$$d_{t+1} = \varphi d_t - \xi_{t+1} \qquad (31)$$

ξ defines the current account balance as a percentage of GNP. In a deterministic environment, the sustainability condition is given by the stationarity property. This property holds if the balance ξ is exogenous: the debt process then converges for the values $\varphi < 1$. In a stochastic universe, the net sustainability, as defined by Hénin and Fève (1998), is given by the condition $\varphi < 1$ but also the stationarity of the term ξ.

The authors thus define a second equation allowing to take into account the endogenous character of the current account balance variable ξ:

$$\xi = \alpha + \beta d_{t-1} + \vartheta_t \qquad (32)$$

ϑ_t can be interpreted as an autonomous component of the balance. Substituting it into the autoregressive equation, we get the following:

$$d_{t+1} = (\varphi - \beta)d_t - \alpha - \vartheta_{t+1} \qquad (33)$$

The sustainability conditions resulting from equation above are given by:

- $(\varphi - \beta) < 0$
- $\vartheta_{t+1} \sim I(0)$ (meaning the autonomous balance is stationary)

The authors, by characterizing the conditions of net effective sustainability, have made it possible to highlight several testable hypotheses such as the stationarity of the debt and current account balance ratios. Effective sustainability also suggests that the auxiliary relationship between balance and past debt plays a key role in sustainability.

3.1.2.2.2. Representation of the interactions between external debt and current account balance

The conditions defined above show that it is still possible to assess the sustainability of the external debt by the usual econometric tests of unit root, such as the ADF (Augmented Dickey-Fuller) test, applied to the debt ratios and current account balance. Before proceeding with these tests, the two authors define a structural model consisting of the debt accumulation equation and the auxiliary equation, i.e., relations which respectively become:

$$d_t + ca_t = \varphi d_{t-1} + \delta + e_t \qquad (34)$$

$$ca_t = \alpha + \beta d_{t-1} + \mu_t \qquad (35)$$

where $\varphi = (1 + g)^{-1}$. In equation (34), we introduce a random number e which ensures that the system constituted by the two equations (34) and (35) does indeed constitute a non-degenerate bivariate Gaussian Process with two distinct random numbers. Thanks to these two equations (34) and (35), we have following representation of the dynamics of the debt:

$$d_t = \delta - \alpha + (\varphi - \beta)d_{t-1} + (e_t - \mu_t) \qquad (36)$$

This illustrates two alternative sustainability testing strategies:

- The usual approach, testing the null hypothesis of unit root $\varphi - \beta = 1$ in the single equation (36) above,

- Second approach, setting $\varphi - \beta = 1$ as a joint restriction on the coefficients of the system of equations (34, 35).

In the case of developed countries, we had already defined several approaches to provide a rapid diagnosis of public debt sustainability. The macroeconomic indicators obtained are essentially based on the dynamic debt equation. So, they have real limitations and are not relevant enough to identify economic policy recommendations, particularly in the case of developing countries. These limits are also explained by the difficulties of statistical analysis of public debt data in these countries (Fève and Hénin, 1998):

- The data available on external debt is more numerous and detailed than that on public debt, while in some countries the series of debt are limited in time. The breakdown of public debt between short and long term and by currency of issue is rarely available;
- Available data only rarely includes government-guaranteed borrowing, local government debt, or public enterprise debt;
- Comparisons between countries are in fact often complex because of the differences in the definitions used.

3.1.2.2.3. The specificities of the debt of emerging countries

Developing countries resort to external funding for their economic development. Consequently, the debt crises experienced by these countries during the 1980s showed the risks linked to excessive indebtedness with private creditors (Paris Club, London Club) (Rieffel, 1985). Subsequently, these countries favored the channel of the financial markets to finance their debt. This type of process has also shown its limits with the recruitment of new financial crises and the development of new types of risk.

3.1.2.3. Increase in financing the emerging debt by international and domestic financial markets

Emerging countries have intermittent access to international financial markets. Most of these countries were heavily indebted until the early 1990s to international banks. Since then, these countries have followed the advice of the International Financial Institutions in terms of debt restructuring. The Brady Plan was based on the securitization of bank loans into public bonds with partial waiver of debts and favored issues on the markets (Ünal et al., 1993). Its implementation enabled a significant reduction in the public debt of emerging countries before it began to increase again in the mid-1990s. The growth in public debt was then explained by the influx of capital foreigners to emerging countries thanks to the development of bond markets. The financing of their public debt was profoundly modified during the 1990s with an increasing proportion of bond securities. The stock of their public securities issued on the international markets was thus multiplied by five over the period 1994-2000.

A significant change in the public debts of emerging countries is a fairly general trend to develop national bond markets on the recommendations of international institutions. In some countries, the development of local pension funds has allowed a growth of more than ten points of GDP in public bond debt. Yet, the participation of international investors in search of profitable assets still creates a source of instability on the emerging bond markets. It is important to note that bond debt in local currency is not growing at the same pace in each emerging country. Moreover, it is also difficult to compare the size and structure of emerging local bond markets with those of advanced countries. Within the same rating category, some countries may favor domestic financing of public debt (the share in foreign currency is low), while other countries fail to establish such a domestic capital market, and there are other countries totally dependent on international markets have managed to switch to financing in local currency. The structure and importance of the local bond market thus vary according to the country but their comparison with advanced countries is difficult to achieve, in particular because of the low granting of long-term financing.

3.1.2.3.1. Concentration of risks on the external debt of emerging countries

The choice of debt by the financial markets has made it possible in recent decades to support the growth of developing countries, in particular that of emerging countries. However, they cannot borrow on international financial markets in their own currency: this is called “original sin” (Eichengreen et al, 2003). In addition to internal fragilities in emerging economies, the heavy dependence on foreign capital flows therefore exposes the external debt portfolio of these economies to risks that can trigger unsustainable debt dynamics.

3.1.2.3.1.1. Foreign exchange risk and unsustainability of the external debt of developing countries

To pay a lower risk premium than developed countries, developing countries are forced to borrow on international markets in hard currencies. Developing countries are therefore faced with exchange rate risk since the structure of revenue and expenditure is not in the same currency as the external borrowings made. The exchange rate thus becomes a determining factor in a country's ability to pay. If the foreign currency in which the foreign debt is contracted appreciates, the amount of the debt certainly does not change, but the debtor country will have to export more of its products, for example, to obtain the foreign currency necessary for repayment. Consequently, developing countries do not have unlimited access to foreign currencies and are dependent on the availability of foreign currencies to repay their debt.

To service the debt in foreign currency, developing countries must therefore generate foreign currency resources over a long period. The refinancing of their debt in foreign currency is linked to the confidence granted by investors in the solvency of the State. Indeed, investors should give a positive judgment on the State's capacity only if they believe that the latter will be able to repay its long-term debt, and have short-term foreign currency enabling it to service its foreign currency debt.

Developing economies may thus be constrained by currency rationing since they may face a mismatch between debt denominated in foreign currencies and debt denominated in local currency, which is called as “currency mismatch” (Fratzscher et al, 2004). The currency that the developing country borrows limits the ability of central banks to act as lender of last resort.

3.1.2.3.1.2. Interest rate risk and unsustainability of the external debt of developing countries

Countries borrowing foreign currencies are also placed in a vulnerable position in the face of international monetary policies and conditions linked to the actions of hard-currency countries. Tight monetary policy in creditor countries can temporarily raise nominal interest rates to high levels. The interest rate is beyond the control of the borrowing country, at least if it is a developing country. The analysis of the costs and risks of a debt portfolio in the case of developing countries therefore reveals that the costs constitute the set of annual interest payments in foreign currencies and the effects of changes in exchange rates; while the risks are future cost variations and their effect on the state budget. We can define interest charges by the following equation:

$$I_t = \sum_{j=1}^{m} e_{jt} I_{jt}^{FX} + I_t^{DX} \qquad (37)$$

where I_t defines the set of interest payments in domestic currency at time t, e_{jt} the exchange rate between domestic currency and currency j, I_{jt}^{FX} the set of interest payments denominated in foreign currency j and I_t^{DX} interest payments in national currency. In this equation, it appears that the increase in the cost of servicing the debt is attributable to unanticipated variations in the exchange rate. Debt denominated in foreign currencies or indexed to currencies is therefore considered riskier than that denominated in national currency.

The increase in the cost of debt service can also be attributed to unanticipated changes in market interest rates. Short-term or floating-rate debt is considered riskier than long-term or fixed-rate debt. There is therefore a refinancing risk for the borrowing countries which corresponds to the fact of not being able to obtain new financing when the debt matures, or to obtain it at an abnormally high rate knowing that the short-term debt is considered riskier than long term. (IMF and Worldbank, 2020)

3.1.2.3.1.3. Imperfect information and instability of capital flows in emerging countries

Unlike industrialized countries, mobilizing quality information on the public debt of emerging countries is a very difficult task. The difficulty in evaluating the fundamentals of these countries leads to an increase in the risk premium linked to their bond issues. There is therefore, in addition to exchange rate and interest rate risks, an informational risk results in imitative behaviors that drives the economy into self-fulfilling crises.

These irrational behaviors are largely explained by the asymmetry of information due to the non-existence of a real entity at the international level, responsible for monitoring, for potential investors and lenders, the use of funds granted to debtor countries like the role of banks in the financing of bank loans. It follows logically that the perception of creditors is dominant in conditioning the refinancing of borrowing States. It also explains the rebirth of crises and “contagion effect”, which explains the possibility of spread of economic crisis or boom across countries or regions (Pericoli and Sbracia, 2003). However, it is difficult to determine with precision the factors that could explain the crises of confidence on the part of the main donors.

Models integrating the behavior of investors make it possible to partly explain the crises of confidence and the instability of capital flows at the origin of many crises of the capital account as well as the intermittent access to the markets of developing countries. In the current context of financial globalization, recourse to financing through bond issues for semi-industrialized countries and less advanced countries provides a significant financial windfall for their growth and development. Claims on these countries are high yield assets with high premiums. The prices of these securities are extremely volatile and subject to arbitrage with securities and assets offering comparable yields. This partly explains the discontinuities in access to capital markets on the part of emerging countries and the crises of reversals of capital, which is called as “sudden stop” (Hutchison and Noy, 2006; Accominotti and Eichengreen, 2016). Eventually, they find themselves obliged to apply counter-cyclical policies like reduction of their deficits, tightening of economic policy, etc. in order to retain foreign capital and defend the stability of their currency.

3.1.2.3.2. The increasing complexity of crisis mechanisms in emerging countries: debt crisis, financial crises and currency crises

In the 1980s, sovereign debt crises were mainly explained by the large public deficits of developing countries. With the opening of capital markets in emerging countries and their integration into international financial markets, new and more complex crises have been identified. Currency, interest rate and fundamental risks in emerging economies now create scenarios that can trigger debt crises.

The Mexican and Brazilian crises in the 1990s are perfect examples of capital account crises that could undermine the solvency of emerging States. They appeared following the strong monetary depreciations which subsequently weakened the public finances of the countries concerned. Figure 2-1 and Figure 2-2 illustrate this explanation well.

Figure 3-1 Evolution of the Mexico's public debt (% of GDP, left column) and the exchange rate (in USD, right column)

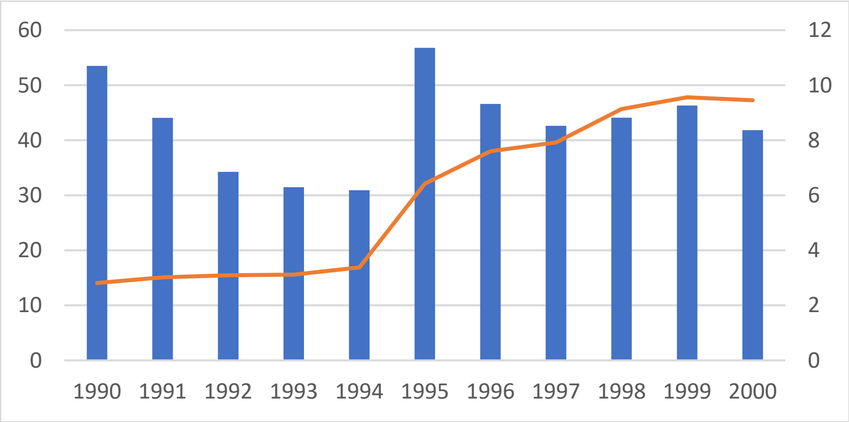
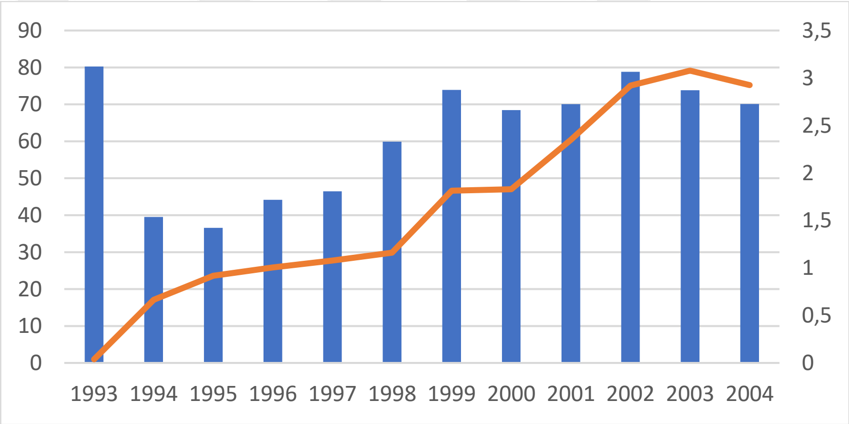


Figure 3-2 Evolution of the Brazil's public debt (% of GDP, left column) and the exchange rate (in USD, right column)



An economic and financial crisis can impact the public finances of a State. For example, following the 2008 financial crisis, most States had to resort to recovery plans to support the banking sector. In fact, they took on part of the impact of the financial crisis, but they efficaciously revalued their public debt. In the case of developing countries, the currency crises increased the weight of public debt heavily.

In the case of Mexico (1994-1995) and Brazil (1998-2002), for example, the causes of the crisis were linked to the internal weaknesses of the countries, namely the increase of the current account deficit. These deficits were financed by external borrowings, a large part of which were short-term. The tightening of American monetary policy and internal political unrest led to an outflow of capital, a drop-in reserves and issues of short-term Mexican government securities indexed to the dollar (Sachs et al, 1996; Peach and Richard, 1997). The crisis of confidence in the currencies thus forced the authorities to abandon a policy of tightening, which resulted in a bubble of the debt denominated in foreign currencies (mainly dollars) or indexed to the exchange rate.

3.1.2.4. Debt sustainability indicators for emerging countries

Assessing the debt sustainability of emerging countries has been made feasible using debt ratios. The ratios approach thus serves as a reference for most of the work of international institutions which favors the balance of payments deficit as the main cause of the indebtedness of developing countries. This approach is complemented by a balance sheet approach of other sectors to take into account capital account imbalances impacting the public sector. Analyzes of debt ratios lead to the conclusion that over the last decades, emerging countries have reduced their debt considerably. This evolution contrasts with that of developed countries but especially with that of low-income countries.

3.1.2.4.1. Ratio approach

The ratio approach is based on the use of different debt sustainability indicators. This approach is most often used in the economic literature on the subject because of its ease of implementation and interpretation. Several methods have been used to attempt to determine these sustainability thresholds.

The construction of debt sustainability indicators for developing countries using this approach has gradually evolved. Indeed, empirical applications were initially based on the use of macroeconomic and financial variables expressed in nominal value or in present value. Subsequently, other approaches attempted to integrate qualitative indicators in order to provide more information on governance and institutional quality in particular.

The debt sustainability indicators of developing countries are obtained either from the calculation of the public debt in nominal value, or by a calculation of the public debt in present value. The nominal (face) value of a loan is equal to the loan amount borrowed and is defined as the sum of all principal payments. It is not linked to the interest rate of a loan. To compare the value of a loan over time considering that the available resources can be invested and grow, the Net Present Value (NPV) seems to be more useful. It defines the sum of all future obligations of the existing debt (capital plus interest), discounted at the market interest rate and therefore makes it possible to consider accrued interest not yet due as well as fluctuations in the price of securities in the refund assessment.

The calculated indicators are then put into perspective in relation to the risk areas determined empirically by the International Financial Institutions and according to the economic literature. The ability to properly manage the external debt is based on the analysis of two main indicators that underpin the country's credibility in relation to the international community (Jensen, 2021):

- The evolution of the debt ratio (debt burden indicators)
- The country's short-term solvency (liquidity indicators)

3.1.2.4.1.1. Debt burden indicators

The definition of external debt sustainability used by IMF staff is as follows: "A country can be said to achieve external debt sustainability if it can meet its current and future external debt service obligations in full, without recourse to debt rescheduling or the accumulation of arrears and without compromising growth." In the case of developing countries that are particularly vulnerable in terms of their external debt, efforts should be made to limit the weight of this debt. This is why the calculation of debt burden indicators allows us to better assess the repayment capacity of countries.

Here, it is a question of bringing together all the sources of available income that the State can devote to the repayment of its debt. In practice, debt burden indicators are among the sustainability indicators most used by debt managers, particularly in developing countries, because of their simplicity and the ease with which their results can be interpreted. The main resources used to analyze the repayment capacity of countries are: GDP, export earnings and tax revenue.

The debt burden indicator most used to analyze debt sustainability is the debt-to-GDP ratio. It makes it possible to measure the ability to repay the debt from the GDP considered as the source of income. With GDP as the denominator, this ratio gives us a lot of information on the country’s ability to repay its debt. GDP contains information on the potential of the productive sector of goods intended for export. However, doubts may hang over the reliability of export prices, particularly with the undervaluation and overvaluation of the currency in real terms. Exchange rate fluctuations can therefore distort the calculation of GDP and ultimately of the debt-to-GDP ratio.

The reference thresholds, also called sustainability thresholds or over-indebtedness thresholds, consider the different levels of development of the countries and the structure of the loans through the discounted value of the debt to the GDP. For example, in the case of the Maastricht Treaty, the sustainability threshold for the Debt/GDP ratio retained within the euro zone was 60%.

On the other hand, other sources of revenue can be used more precisely: the public debt/exports ratio and the public debt/public revenue ratio. The public debt/exports ratio is defined as the ratio of total debt outstanding at year-end to the economy’s exports of goods and services for any given year. This dynamic ratio makes it possible to measure viability since exports represent an essential source of income for the economy of developing countries. This ratio therefore makes it possible to understand the difficulties in discharging the debt obligations of debtor countries. This indicator, like all the others based on the stock of debt, is subject to two main criticisms:

- The recourse to external borrowing by low- or middle-income countries makes it possible to finance investments whose profitability is most often in the medium and long term. These investments are often made in human capital or in infrastructure (roads and highways) which generate positive externalities on growth but measurable in the medium and long term. The debt burden indicator is therefore competent to highlight the countries whose external debt is significant but in the short term.
- A second weakness lies in the structure of loans made by debtor countries: some loans are on highly concessional terms, while others are subject to high interest rates.

Debt-to-GDP and debt-to-export ratios provide no information on the country's ability to mobilize domestic resources to repay its debt. The present value of debt-to-fiscal revenue ratio identifies the economies for which debt is a significant fiscal burden. A gradual increase in this indicator reflects the inability of the country's budget to be allocated to servicing its debt.

3.1.2.4.1.2. Liquidity indicators (short-term solvency)

Liquidity indicators make it possible to better assess the capacity of States to meet their financial liabilities, i.e. the repayment of debt service taking into account the burden and interest on the debt. We find the same variables in the denominator as those found in the case of the burden indicators: export revenues, government revenues, primary budget balance (which measures the difference between public revenue and public expenditure, excluding public debt burden.)

Although they give an idea of the financial health (short-term solvency) of the indebted State, the liquidity indicators suffer from the same limitations as the debt burden indicators. The limits are summarized in two main points: the lack of consensus on the reference thresholds and on the variables to be used in the denominator of the ratios. For example, taking the case of the liquidity indicator involving the primary budget balance, the interpretation can be confusing. For instance, if the balance is negative, one might think that the State has succeeded in going into debt at a negative rate and that its financial situation has not deteriorated. On the other hand, one could also think that this corresponds to a situation of public finance crisis when the indebted State can still ensure the payment of the service of its debt.

To better understand the complexity of economic and financial crises in developing countries, particularly in middle-income countries, the IMF has developed an analytical framework that complements the analysis of sustainability by ratios. The balance sheet approach thus makes it possible to identify financial vulnerabilities in aggregated balance sheets by sector of the economy. Four types of potential imbalances can appear in balance sheets:

- Imbalances in terms of currencies (currency mismatch)
- Imbalances in terms of maturities (maturity mismatch)
- Imbalances in terms of capital structure
- Imbalances in terms of solvency

This analytical framework provides the advantage of being able to easily identify the illiquidity risks of the countries analyzed. For this reason, IMF have tried to apply this method in the work on public debt analysis. Yet, no indicator has made it possible to draw up comparative analyzes between countries due to statistical difficulties. In addition, the balance sheet analysis suffers from other limitations, in particular the absence or failure to considering off-balance sheet commitments which greatly underestimate the weight of the indebtedness of the country's public authorities (Allen et al, 2002).

Despite all these criticisms and the lack of consensus on a typical method of analyzing the debt sustainability of emerging countries, much progress has been made. Improvements to analytical frameworks gradually incorporate the structure of balance sheets and allow the development of diagnoses and the detection of unsustainability risks. This is why the public authorities of emerging countries must use all of their potential resources effectively to fight against the internal fragilities of their economies.

3.1.2.5. Differences of debt sustainability assessments of developed countries than developing countries

We recall from our dynamic debt equation that the evolution of the public debt ratio is linked to the growth rate of the economy and the interest rate paid on the debt:

$$\Delta b_t = \frac{(r_t - g_t)}{(1+g_t)} b_{t-1} + d_t \qquad (38)$$

If the interest rate is higher than the growth rate ($r > g$), it is then necessary for the government to generate a surplus primary balance to stabilize the debt ratio. This analysis would be incomplete in the case of emerging countries since the foreign currency component of the external debt must also be taken into account. The explanatory factors for this spectacular reduction in their debt are mainly strong economic growth and good management of public finances. The remarkable growth in middle-income countries in last fifteen years has been consistent with overall deleveraging in relative terms as shown in the following chart:

Figure 3-3 General Government Gross Debt (% of GDP)

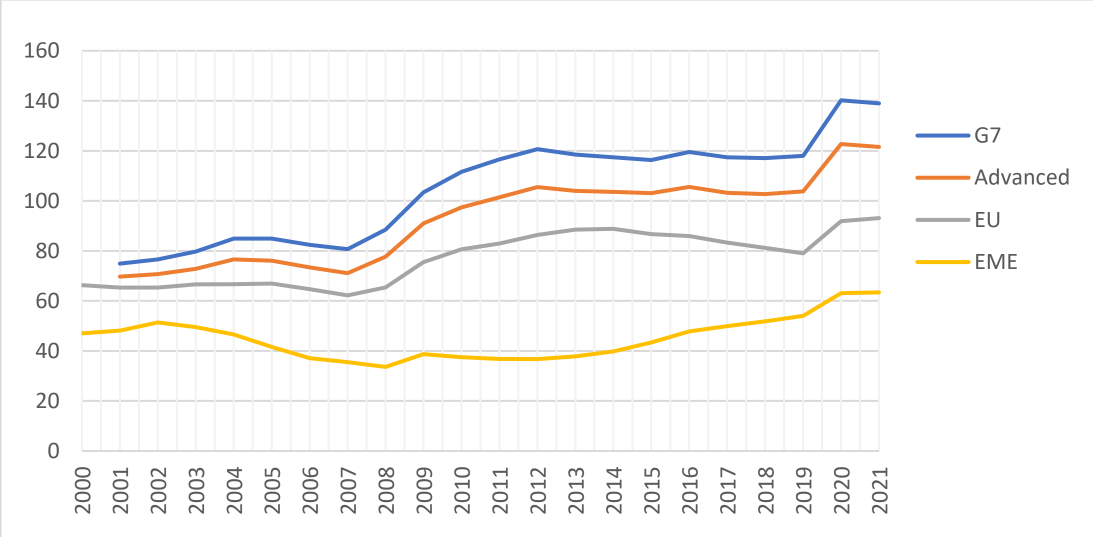
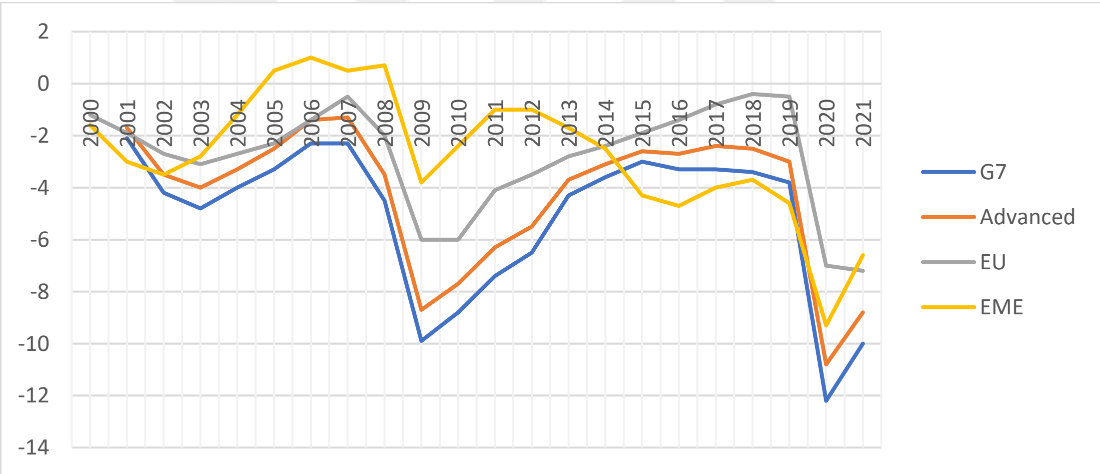


Figure 3-4 General government net lending/borrowing (% of GDP)

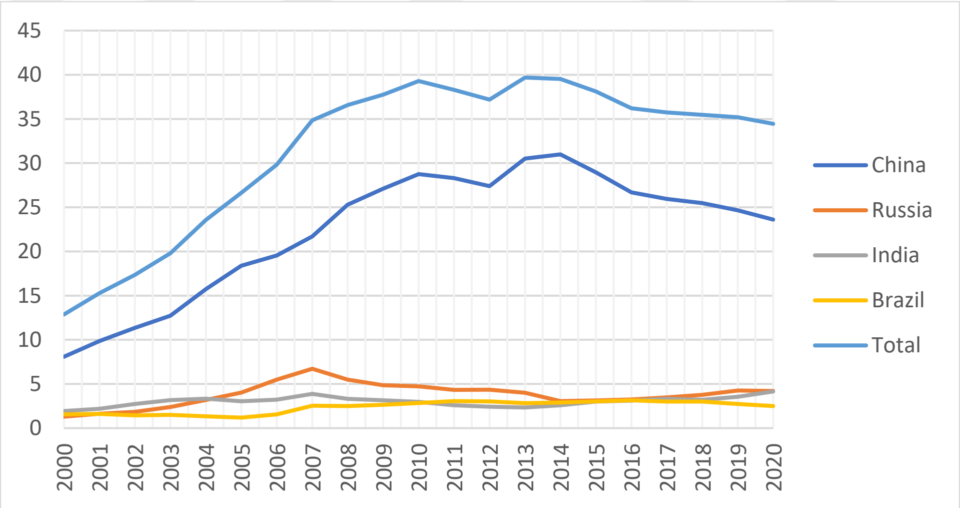


The remarkable observation that we are making today is that the debt of semi-industrialized countries is now significantly lower than that of advanced countries: while the debt/GDP ratio of developed countries has been more than 100% since 2011, in emerging countries, it was below 60% before the Covid crisis. While the trend worsened in advanced countries after the 2008-2009 crisis, it stabilized thereafter.

Emerging countries have succeeded in liberating themselves from primary specialization by developing their export industries within the framework of real policies aimed at boosting export sectors. This process was possible thanks to the influx of multinational firms from the developed countries. Today, semi-industrialized countries offer, through their expanding multinational firms, many prospects in terms of economic growth. By doing so, they can free up external resources and loosen the currency constraint.

Since the end of the 1990s, the development model of middle-income countries has been based on exports, which allows them to have a current account surplus and sustained growth. By doing so, they have succeeded in accumulating foreign exchange reserves. When we list the eleven countries with the highest total reserves, including gold, the result is as follows: China, Japan, Switzerland, United States, Russian Federation, India, Hong Kong, Saudi Arabia, Korea, Singapore, and Brazil (Worldbank, 2022). Five of these eleven countries are among the largest emerging economies. Considering that Switzerland is included in the list due to its financial system and giving that the USA is excluded, four of the nine largest countries with respect to total reserves are emerging market economies, and the biggest features of these countries are specialization in various fields such as technology and energy exports. It clearly shows the importance of exports in total reserves.

Figure 3-5 Total reserves of China, Russia, India and Brazil (including gold, World average in percentage)



Largely thanks to their trade surpluses, emerging countries have become the creditors of the industrialized world. The constraint of reimbursement in foreign currency is generally linked to all the trade surpluses that developing countries can generate.

Improved performance in terms of public debt management in semi-industrialized countries is therefore one of the factors that has contributed to their deleveraging. Since the beginning of the 1990s, the principles set out in the

"Washington Consensus" (budgetary discipline, the reorientation of public expenditure, tax reforms) have been applied either under pressure from international financial institutions or by countries of their own free will (Birdsall et al, 2010). The application of these rules aimed to respond to the issue of intergenerational equity in order not to penalize future generations who would have to bear the heavy burden of an "irresponsible" budgetary policy.

However, these rules have been applied differently depending on the country: some have chosen to apply them to the budget balances (overall or primary), others on the increase in public spending, and some have preferred to apply these rules to debt ratios (to GDP or public revenue). However, the impact of tax rules remains highly criticized. We note in particular that the announcement effect of a rule will reassure the financial markets in the short term but will be all the more appreciated if the authorities implement real budgetary discipline.

Until now, we have developed the idea that the choice of public debt sustainability indicators should be made taking into account the level of development of the countries. We selected two categories of countries: advanced/industrialized countries, and developing/emerging countries. In the following chapter, we will examine the sustainability analyzes of public debt available in the literature. We will examine the literature on the economy of eight selected countries (Germany, Italy, Japan, France as developed countries; Brazil, China, Russia, Turkey as emerging market economies) separately for each one of them. Later, we will see the methods used in debt sustainability analysis in general terms.

3.2. Empirical Review

3.2.1. Sovereign Debt Crises and Their Economic Impacts

When we look at European countries in particular, it can be said that the public debt crises experienced in recent years (such as Spain, Greece, Italy) are the result of high economic morale, optimistic expectations for the future and low interest rates (Szczygielski, 2012). On the other hand, public debt management, which was stagnant until 2008 and was seen as successful in general terms, was turned upside down after the mortgage crisis that broke out in the USA, and the effects of the crisis that reached global dimensions affected the whole world. In this process, the deteriorations in the bank balance sheets were tried to be corrected with the help of the states, but such expansionary measures increased the debt burden of the countries.

The environment of trust, which was shaken by the global financial crisis, had a negative impact on capital movements. The credit contraction that emerged as a result of the tightening of lending policies of banks in the crisis environment (Candelon & Palm, 2010) caused the imbalances in the macroeconomic and financial structures of European countries to be exposed and the burden of the public increased (Panetta, 2011; Gros & Alcidi, 2010).

It can be said that the 2008 crisis caught the European countries off guard, because it was thought to be an unexpected situation in the Eurozone, and the emergence of the crisis was not considered possible (Beker, 2014; Begg, 2012; Volz, 2012). The rule of "each country is responsible for its own debt" in the provisions of the Maastricht Treaty and the limitation of international aid packages delayed the measures taken against the crisis (Brender et al, 2012; Shambaugh, 2012). It is possible to say that the articles in the Maastricht Treaty are effective in preventing the crisis, not in the measures and measures that can be taken in a crisis (Siekmann, 2011). In addition, although monetary policy is subject to a common practice within the European Union, it delayed taking measures against the crisis due to the implementation of fiscal policies at the private and national level in each country (Dombert, 2013).

Here, it is necessary to open a parenthesis to the Maastricht Treaty. Although there are rules that must be followed to keep the public debt under control, the Maastricht Treaty is one of the criteria that neither the member states nor the countries waiting for membership attach importance to. In fact, there have been countries that have been accepted as members despite not complying with the debt and budget deficit criteria (Wood, 2012). For this reason, with the 2008-2009 crisis, public borrowing increased tremendously and never even approached the level of the Maastricht criteria.

The 2008 Global Financial Crisis caused especially developed countries to experience the greatest recession after the Great Depression and the Second World War. However, the crisis in question has different characteristics from the previous financial crises: While previous crises were seen regionally and mostly affected developing countries, 2008 Financial Crisis originated from developed countries and affected them the most (Hernandez & Gamarra, 2011; Naudé, 2009). As a matter of fact, toxic assets (investments that are difficult or impossible to sell at any price because the demand for them has collapsed) based on mortgage loans were not included in the balance sheets of underdeveloped countries. However, European banks had a significant amount of these assets in their balance sheets (Brok & Langen, 2012;). For this reason, developed countries and European countries were mostly affected by the crisis (Overbeek, 2012). With the financial crisis, the value of the assets in the balance sheets of European banks decreased and their value uncertainties increased. For this reason, it has made borrowing difficult. On the other hand, some countries have announced precautionary packages against the recession while some also had to support local banks with aid packages (Nelson, 2012)

Many developing countries have seen their external public debt increase since the global financial crisis of 2008. Yet, The Covid-19 crisis has brought this increase to a historic point. As of January 2020, forty-four percent of least developed countries and low-income developing countries already had high-risk or distressed debt (United Nations, 2020). As a result of interest rate and exchange rate fluctuations, financing through national or international financial markets, as opposed to traditional public financing, increases financing costs, shortens the average maturity of securities and increases risk and vulnerability.

According to the United Nations (2020), the effects of Covid-19 are asymmetrical with the economic conditions of the countries. For example, it has been observed that the impact of Covid-19 in low-income countries is less than in many high-income countries. Many sectors, markets, production opportunities, in other words, macroeconomic indicators affecting the economy in middle and high-income countries have been negatively affected by Covid-19. According to IMF reports, the negative course of macroeconomic indicators is expected to continue in many countries in the coming years (IMF, 2020).

3.3. Country-Based Public Debt Sustainability Analysis

When we look at the country-based studies as well as studies dealing with communities such as the European Union, OECD, EMEs, and so on, it is possible to say that the sustainability analysis of public debt gained importance especially in the 2000s. The examples in the literature of the public debt sustainability, using the unit root tests and cointegration analysis, for selected countries will be discussed in this section.

Grilli's study in 1988 is considered to be one of the first and most important analyzes of German public finance. In this study, Grilli examined the German public debt from 1950 to 1986 and concluded that the non-stationary fiscal deficits hypothesis, that gives us the result of an unsustainable public debt, can be rejected as a result of this study.

In 1995, Caporale investigated the whether the governments can engage in bubble finance between 1960-1991, by regressing the stock of outstanding debt on a distributed lag of the primary surplus. Also, he tried to engage the current debt stock to the following period's primary surplus and debt stock by specifying an AR process for the primary surplus. As a result, he found that German public debt is not sustainable.

Vanhorebeek and van Rompuy (1995) focused on the sustainability and solvency of the public sector for eight European countries between 1970-1994. They used stationary tests for public debt and deficit, and Trehan-Walsh procedure in order to test the solvency. As a result of these analyzes, it was concluded that German public debt is sustainable.

Payne (1997) studied on G-7 countries for the 1949-1994 time period. Having inspired by the study of Hakkio and Rush (1991), he performed his debt sustainability analysis by investigating the cointegration between public revenues and expenditures. Eventually, he stated that the public debt was sustainable for Germany.

Bravo and Silvestre (2002) studied on the time period 1960-2000 in order to test the debt sustainability by performing unit root tests (Dickey-Fuller and the Augmented Dickey-Fuller), and cointegration tests for public expenditures and revenues. As a result, German public debt has been shown to be sustainable.

In their 2006 article, Grenier et al. conducted non-parametric and semi-parametric regressions with time depending coefficients for Germany between 1960-2003. They found that the primary surplus-to-GDP ratio positively responds to higher debt ratios, which indicates a piece of solid evidence for sustainable public debt.

Two years later, Grenier and Kauermann (2008) conducted another study examining the public debt sustainability in Italy and Germany. By performing semi-parametric estimations using penalized spline smoothing, they show public debt policy in Germany to be stable but with a declining tendency.

Fincke and Grenier (2011) examined the sustainability of public debt policies from 1975 to 2006 in federal states located on the former West Germany before 1991. Analyzing the real budget deficit with stationarity tests, they also allow for time-varying reaction coefficients by resorting to penalized spline estimation. As a result of these analyzes, when comparisons are made on the basis of states, it has been concluded that despite the implementation of a sustainable debt policies, debt cannot be sustainable in all regions, with one exception, due to the ratio of public debt to GDP that is expected to boom in the long run.

In their 2014 study, Burret et al. developed a descriptive strategy for panel cointegration tests that combine cross-section-specific time-series evidence with panel cointegration analysis. In addition, the authors who designed their work with second-generation panel cointegration analyses concluded that the public debt of the German federal regions they examined was not sustainable.

In another study in which the formal tests on fiscal sustainability including stationarity and cointegration tests, and the estimation of Vector Autoregression (VAR) and Vector Error Correction Models (VECM) were conducted for Germany between 1850-2010, the fiscal sustainability hypothesis was rejected for the period from 1950 to 2010. For this reason, it is seen that Germany's public debt, which has started to move away from its sustainability goals, needs a severe consolidation (Burret et al., 2013).

Uctum and Wickens (2000) performed stationarity tests on public debt for the 1965-1994 time period for the United States and eleven European countries including France. They also conducted Augmented Dickey-Fuller and Phillips-Perron tests for the undiscounted debt. They concluded French public debt to be sustainable.

In 2004, Boissinot et al. tested the sustainability of France's fiscal policy and public borrowing with a cointegrated VAR model with debt-to-GDP ratio, primary spending, the interest burden, and public revenue. As a result of these tests covering the period between 1978-2002, they found that French public debt was "weakly sustainable" for the given time period.

Afonso (2005) studied on fifteen European countries for the period between 1970 and 2003. He investigated the sustainability of budget deficits of these countries by cointegration tests between public revenues and expenditures, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, and concluded that the French public debt was sustainable.

In his work, Samizafy (2014) focused on the former French colonies and the French economy, and performed the ADF unit root test to determine the stationarity of the data series. Then, he applied Johansen tests in order to determine the existence of a cointegrating relationship between government expenditure and government revenue, if any.

In his 2013 article, Aldama used stationarity and cointegration tests to test the sustainability and fiscal reaction functions, and concluded that the French public debt was not sustainable for the time period 1979-2012.

Baglioni and Cherubini (1991) put one of the first examples of public debt sustainability analysis for the Italian economy between 1979-1991. They applied stationary tests for public debt and deficit, and concluded that the Italian fiscal policy is not consistent in the long run, and public debt was one of the major problems for the Italian economy.

Papadopulos and Sidiropoulos (1999) examined the stationarity in order to analyze fiscal sustainability of five European countries, including Italy, between 1961-1994, and they defined Italian public debt as unsustainable.

In their study on eleven European Union countries, Bravo and Silvestre (2002) performed cointegration analyzes between the public revenues and expenditures of these countries. In this study covering the years 1960-2000, the authors concluded that the debt of six countries, including Italy, is not sustainable.

Bartoletto et al (2013) analyzed the Italian public debt between 1861-2010 by stationarity and cointegration tests. Except from the 1914-1945 period, which included the First and Second World Wars, they made inferences that Italy's public policies and indebtedness were sustainable.

In their study conducted in 2017, Brady and Magazzino analyzed the sustainability and solvency of the Italian public finances with Unit root and stationarity tests. Working with a large dataset covering the years 1862-2013, the authors ultimately show that public debt and deficit variables are not stationary at levels, but stationary in $I(1)$.

Magazzino and Mutascu (2019) investigated the relationship between public debt and primary deficit for Italian economy. As a result of stationarity and cointegration tests, they concluded that Italian economy seems sustainable in the long run.

Fukuda and Teruyama (1994) examined the public debt sustainability of Japan by using the similar methodology as Hamilton-Flavin used and cointegration tests, and tried to compare the period before the World War II, and after. As a result of their work, they concluded that the debt seems unsustainable.

Ihori et al. used followed the Bohn’s criteria (1998) in order to investigate the sustainability of the Japan’s public debt. They concluded that the Japan’s public debt could be sustainable if and only if the country has a positive primary balance. They also found that the Japanese public debt was not sustainable during the 1990s.

Ono (2008) searched for the possibility of nonlinearities and sustainability in fiscal policies of all G-7 countries by using traditional stationary tests. The result was interesting: G-7 countries except Japan have nonlinear effects and hold fiscal sustainability.

In 2011, Doi et al. analyzed the Japanese fiscal sustainability by using quarterly expenditure, revenue and debt data via three different approaches: calculating the minimum tax rate stabilizing the debt/GDP ratio given the future government expenditures, estimating the response of the primary surplus when the debt/GDP ratio increases, and estimating a fiscal reaction function and monetary policy function with Markov switching. As a result of their work, they concluded that the Japanese public debt is not sustainable for the 1980-2010, which was parallel with the work of Ihori et al. (2003).

Hosono and Sakuragawa (2011) investigated the fiscal sustainability of Japanese economy by providing a dynamic stochastic general equilibrium model between 1981-2008. They strictly stated that if the country continues to perform as it performed during the last decade, the debt will definitely not be sustainable.

Arai and Ueda (2013) tried to estimate the size of primary deficit of Japanese economy in order to attain a sustainable debt target. To do so, they constructed an OLG model in which the government maintains a constant ratio of the primary deficit/GDP. As a result, they found that the country must have a positive primary balance in order to have a sustainable public debt.

Arai et al. (2014) used OLG model in order to estimate the necessary primary balance level to attain a sustainable debt for Japan. They concluded that the country needs to have a large primary surplus to prevent from its debt/GDP ratio diverge infinity. In other words, the debt was found unsustainable.

Akamatsu and Hiraga (2015) investigated whether the Japanese public debt is sustainable or not by applying the fiscal stabilization rule in which each local government improves their primary balance in the current year when they issue additional debt the previous year. Their results correspond with the previous studies mentioned above: They found that Japanese prefectural government debts were not sustainable between 1956-2007.

Rocha (1997) aimed to test whether the Brazil’s public debt is sustainable by performing unit root and cointegration tests on the stock of the debt, and public revenue and government spending between 1980-1993. She concluded that the fiscal policy seemed unsustainable for public debt.

In 2000, Luporini tested the sustainability of Brazil’s public debt by using traditional unit root tests (ADF and PP) from 1966 to 1996. He found it as sustainable until 1981, and unsustainable for federal debt after 1981.

Issler and Lima examined the revenue to GDP and expenditure to GDP ratios in order to test the debt sustainability of Brazil from 1947 to 1992 by using unit root tests. As a result, they found that public deficit was stationary and they say that budget deficit of the country could be balanced through changes in taxes.

Giambiaci and Ronci (2004) investigated the Brazil’s economy in terms of public debt sustainability for the 1995-2002 period. They tested the existence of stationarity of the discounted public debt: if it was stationary, then the public debt was said to be sustainable. As a result of their work, they found debt policies in president Cardoso’s period as sustainable.

Luporini (2015) used ADF, ADF-GLS and KPSS tests on public debt, government revenue and government expenditure in order to look for public debt sustainability between 1991-2011. His results show that Brazil’s debt was sustainable after 2000s.

In their study, Campos and Cysne (2022) performed multiple cointegration analyzes to test the long-term relationship between the income and expenditures of the Brazilian government and the debt stock. In this study covering the years 1997-2018, it was concluded that the ratio of public debt to GDP was unsustainable, especially since the mid-2010s.

Li (2001) investigated the effects of government revenue and government expenditure on public debt sustainability in China by performing ADF tests on these variables for the period 1950-1977. For the real data, they were found to be stationary.

Lau et al. (2013) used ADF, KPSS and DFGLS unit root tests in order to conclude whether the external debt of selected Asian countries was sustainable between 1981-2010. External debt was found to sustainable.

Buscemi and Yallwe (2012) used Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), ADF-Fisher Chi-square, and PP-Fisher Chi-square for a panel unit root tests on different variables like tax revenue, public debt, government expenditure and domestic saving in order to examine the public debt sustainability of China, India and South Africa covering 1990-2019. China's public debt was found sustainable.

Cuestas and Regis (2018) tested the sustainability of public debt between 1992-2016 with the help of stationarity analysis in order to test a potential debt crisis that the Chinese economy may experience. As a result of these analyzes, the authors suggesting that public debt has entered a dangerous path, also said that debt accumulation has found to be non-stationary.

Arı and Koç (2018) investigated four countries with the highest GDP (US, China, Germany, and Japan) in order to look for public debt sustainability. In their study, they searched for casual relationship between public debt and public investment between 2000-2015. As a result of ADF and ZA unit root tests, they say: "China has only strong unidirectional causality running from public investment to domestic public debt. This indicates that public investment, which is one of the channels of economic growth, leads to domestic public debt, and thereby it is a less domestic debt-dependent country with respect to the investment, but vice versa is not true."

In 2019, Phiri used asymmetric unit root test augmented with Fourier function in order to test the public debt sustainability in BRICS countries. For China, the selected time interval was between 1982-2016. As a result of conventional analysis, Chinese debt seemed sustainable.

Wang (2019) tried to test the sustainability of thirty-one local governments in China by using debt and economic growth data. He conducted conventional unit root test on both variables, and then, he investigated for long term relationship between these two variables by cointegration tests. He found there may not exist long term cointegration between growth and local government debt. Moreover, the economic growth of local government is the Granger cause of local government debt, but vice versa is not hold.

Joy and Panda (2020) used both traditional unit root tests and the enhanced methodology firstly proposed by Bohn (2007) to test the sustainability of public debt in BRICS countries between 1980-2017. As a result, China and India seemed to have slightly better public debt sustainability coefficients comparing to other countries.

In 2011, Afonso and Jalles investigated the public debt sustainability of eleven countries including Russia for the period 1880-2019 via systematic analysis of the stationarity properties of the first-differenced level of government debt. They found that the Russian public debt is sustainable.

As a result of a study conducted by Bozoklu and Yılancı (2014) with quarterly data covering the years 1996-2009 of eight countries including Russia, linear panel unit root test findings showed that Russia's debt is sustainable.

Balıkçıoğlu (2013) conducted a panel data analysis to test the Russian economic and fiscal performance with the variables of public debt, budget balance, public revenue and expenditure, GDP growth rate, current account balance and such macroeconomic indicators. She mentions that the oil prices directly affect the growth of the country and its public debt performance.

Phiri (2019) conducted a research on fiscal sustainability for BRICS countries. In his research, he applied the KSS unit root tests augment with a flexible Fourier form to the fiscal budgets of BRICS counties. For the time period between 1996-2016, he concluded that the Russian fiscal policy sustainable.

Bahmani-Oskooee and Domac (1995) examined the long-term cointegration relations between the annual export and import variables for the 1947-1990 period for Turkey, using the Engle-Granger method. The authors, who also examined the effects of cointegration between the two data on the external debt stock during this study, observed that the external debt stock also moves away from sustainability in the event that cointegration breaks down.

Utkulu (1998) examined the long-term trend of Turkey's exports and imports, following the methodology of Hakkio and Rush (1991). As a result of this study, no cointegration was found between exports and imports, implying that Turkey's external debt is not sustainable.

Önel and Utkulu (2006) investigated the sustainability of Turkey's external debt with the help of intertemporal budget constraint. In addition to the conventional cointegration tests, Zivot–Andrews unit root test and Gregory–Hansen cointegration test are also implemented in their analysis in order to find out if there is a possible structural break that may be due to the economic crisis in Turkey at the beginnings of 2000s. They conclude that Turkey's external debt is weakly sustainable.

In their study (2007) investigating the sustainability of the total public debt stock, Gürbüz et al. found that the public debt stock data is not stationary as a result of ADF and PP tests for the period between 1988-2002 period. Thus, it has been found that Turkey’s public debt was unsustainable.

Ceylan (2010) studied on the annual data of public det stock of Turkey for the period 1985-2008. In addition to ADF unit root tests, he also applied Leybourne, Newbold, Vougas test (LNV test) and Sollis test to compare his findings. He found that although the series was not stationary (so unsustainable) according to the ADF test, he showed that the series was stationary (that is, sustainable) in the nonlinear tests.

Ucal and Alici (2010) applied the unit root tests (ADF, PP and ERS) on Turkish public debt data by working on three different time periods: 1989-2008 as a whole, 1989-2000 as the first part, and 2001-2008 as the second part. It is stated at the end of study that public debt is unsustainable.

Şen et al. (2010) applied ADF and PP unit root tests to the total public debt stock data in Turkey for the period 1975-2007. It was concluded that the series was not stationary, therefore public debt in Turkey was unsustainable for the given period.

Konat (2021), using Turkey's external debt data set, made a nonlinear panel unit root analysis for the period between 1999 and 2016. Observing that the series is stationary according to the findings, he concluded that the external debt is sustainable.

Hepsağ (2011) made a structural break unit root analysis with quarterly data for Turkey between the period 1990/Q1 and 2008/Q4. As a result of his analysis, he determined that public debt was unsustainable.

4. RESULTS AND FINDINGS

In this chapter, we will question the public debt sustainability indicators of the selected countries based on the actuarial approach defined in the second chapter. Afterwards, we will try to escape from the criticism of Bohn (2007) to provide a more positive approach applied to the field of public finance thanks to the step-wise algorithm proposed by Özkaya (2013). Later, sustainability analyzes will be tested by changing one or more of the criteria in the algorithm for a selected country (Russia), and it will be examined whether each step enables the sustainability condition to hold if stationarity disappears in previous step.

4.1. A first look at the sustainability of the public debt of selected countries

4.1.1. Graphical analysis of budget deficit to GDP

At the end of the Second World War, the debt of the advanced countries decreased rapidly, largely thanks to strong, sustained and balanced growth in a social and demographic context favorable to economic recovery.

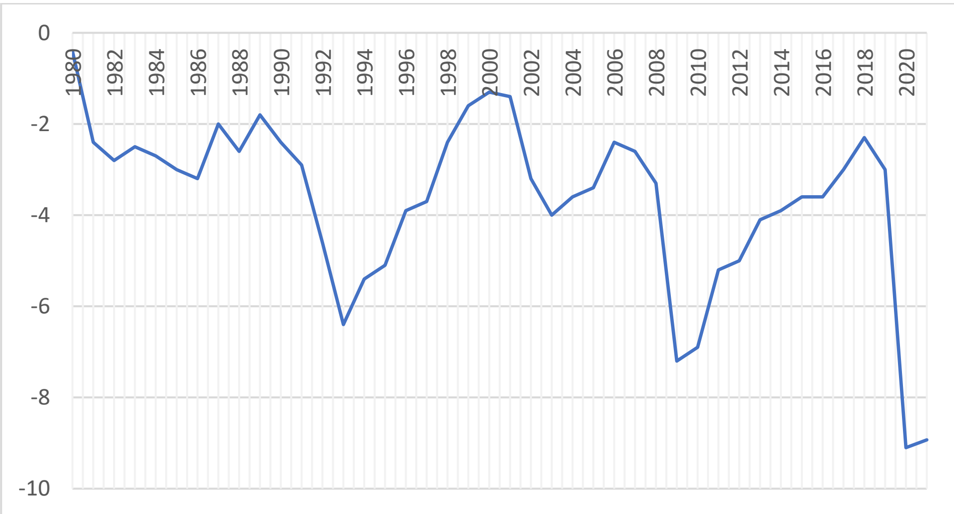
It was not until the early 1970s (first oil shock in 1973, and second oil shock in 1979) that the first signals of debt problem appeared. In 1980s, the first signs of divergences are visible between the countries which maintain budgetary deficits (like France and Italy) and those which have budgetary surpluses (Japan and Germany) at the beginning of 1970s.

Until the end of the 1990s, austerity measures characterized all countries in different proportions. Most of the advanced countries have considerably reduced their debt/GDP ratio, especially thanks to the reduction in public expenditure, except for

Japan, which was hit hard by the real estate and financial crisis in the early 1990s. Since revenues were falling less quickly than public expenditure during this period, all these countries managed to generate a budget surplus at the end of the 1990s. Until the early 1980s, France, Germany and Italy experienced sustained growth in their public expenditure and revenue without creating distortions in their budget balance. At the start of the 2000s, however, we witnessed a gradual but slow rise in public spending in almost all advanced economies.

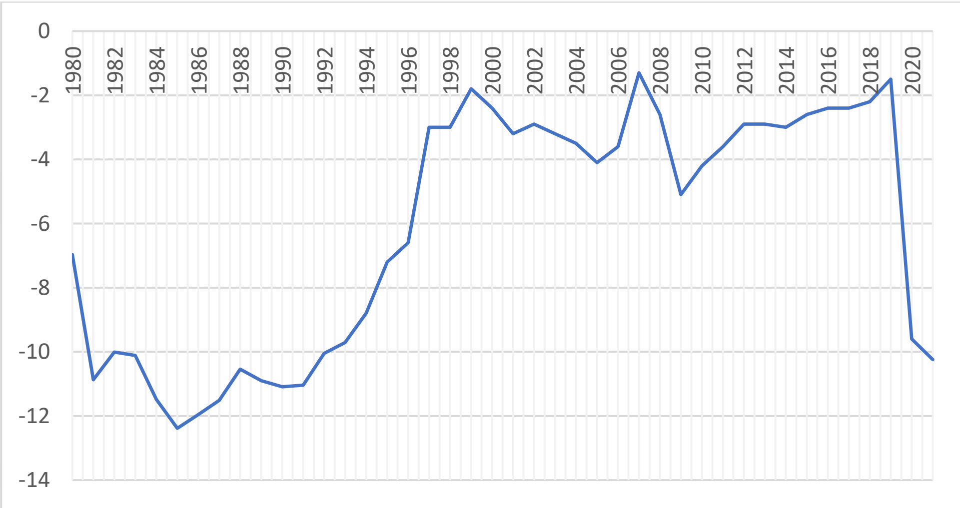
During the period 1980-1993, France had been experiencing an increasing budget deficit from almost balanced budget up to −6.5%. The lowest rate of debt/GDP ratio observed for the country was during 1992-1993 when the country had a regional election. After the elections, the French government managed to reduce the budget deficit to −1.40% until 2001, and between 2001-2008 it balanced the budget deficit by not being less than −4%. The budget deficit, which experienced a sharp increase with the 2008 crisis, entered the recovery phase after 2009 and reached −2% levels again until the Covid crisis. In 2020, this deficit was −9.10%, the lowest level of the last forty-one years. During 1980-2021, French economy has never experienced a budget surplus.

Figure 4-1: France, Budget Deficit, % of GDP, 1980-2021



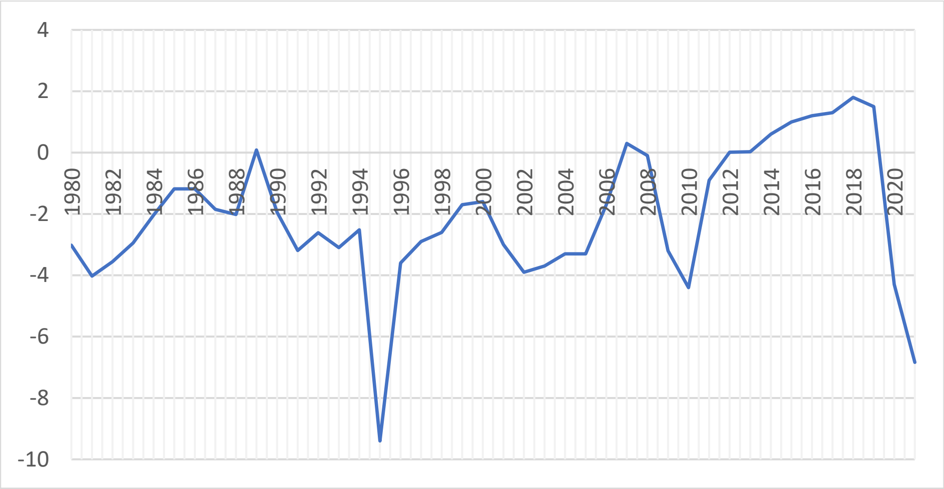
Between 1980 and 2000, the Italian economy managed to reduce the budget deficit from −12% to −2%, especially within the framework of compliance with the Maastricht criteria. On the other hand, the rising trend, especially in the 1990s, shows that an economic policy that will set an example for many European countries has been followed. As a matter of fact, until 2008, the Italian economy did not have a large budget deficit and moved around −3% on average. Although the effects of the 2008 crisis reduced the budget deficit from −1% to −5%, it is possible to say that the effects of the crisis were not felt as severely compared to other major economies. Because the effects of the 2008 crisis were immediately compensated, and the country managed to reduce the public debt to GDP ratio to −1.8% until the Covid crisis. The global crisis in 2020, on the other hand, caused the largest budget deficit experienced by the Italian economy in the last twenty-eight years and reached −10%.

Figure 4-2: Italy, Budget Deficit, % of GDP, 1980-2021



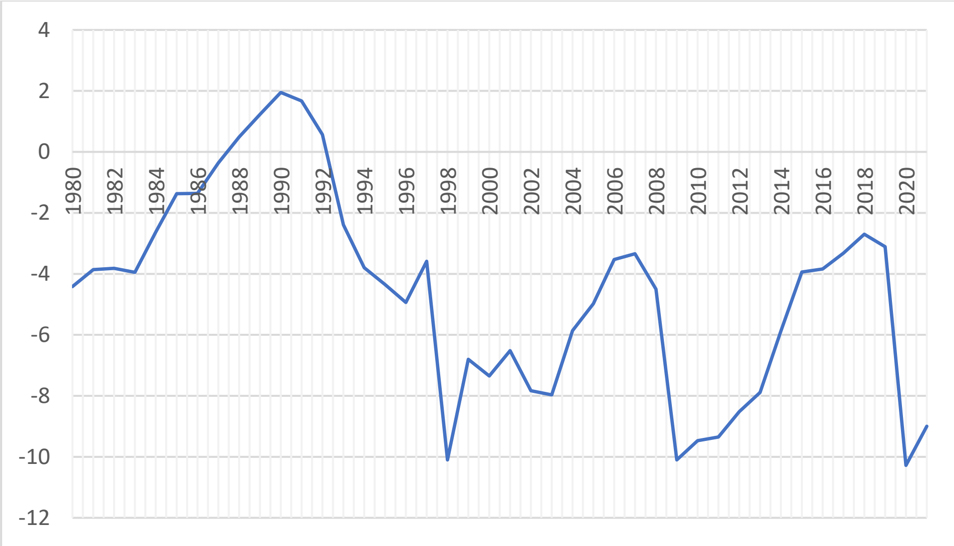
Germany, one of the strongest economies in today's Europe, was following a strong economic policy in the 1980s even before the Berlin Wall came down. Except for the one-year sharp decline that occurred in 1995, possibly due to the German federal elections, the country's economy generally followed a stable trend and had a budget deficit of −3% on average. The German economy, which had a budget surplus in 2007, showed a budget balance in 2008, and although it experienced a 4% decrease in 2009 due to the effect of the crisis, it had no difficulty in recovering the effects of this. The German economy, which had a budget surplus continuously until the Covid crisis in the 2010s, is the country that has the most successful budget policy among the G-7 countries. Nevertheless, the 2020 Covid crisis also dealt a major blow to the German economy, and within a year the relevant rate fell from 1.50% to −6.80%.

Figure 4-3: Germany, Budget Deficit, % of GDP, 1980-2021



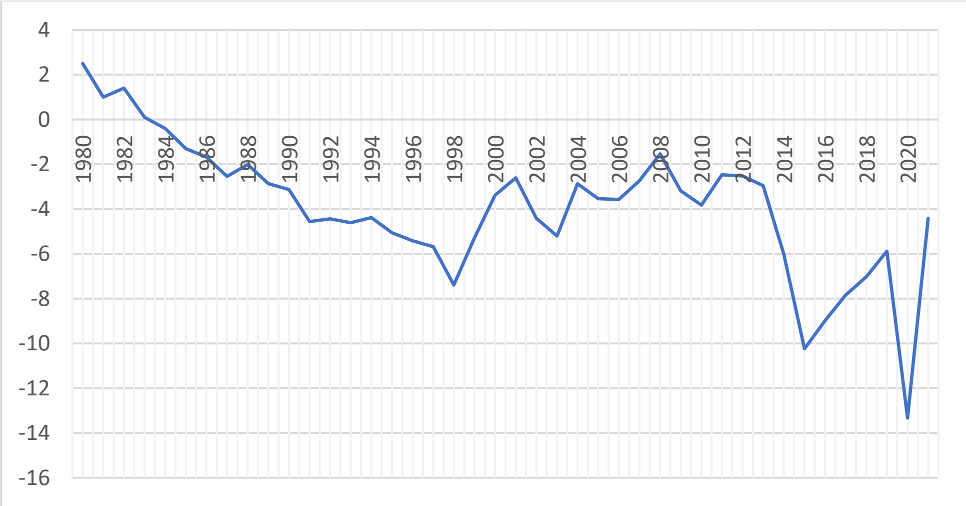
Compared to the average for OECD countries, local authorities play an important role in public finances in Japan. This is explained in particular by the demographic profile of the country in which the gap between social benefits and revenue from contributions is gradually widening. While the Japanese economy had a budget deficit in the early 1980s, it had a budget surplus in the first years of the 1990s. As a matter of fact, 1992 was recorded as the last year in which the Japanese economy had a budget surplus. Starting from 1993, the country experienced a sharp deterioration in its budget deficit, which would be caused by the weight of central government and local government spending, but also the deflation of the real estate and stock market bubble of the 1990s. Since this period, the country's economy has had large budget deficits and the public debt/GDP ratio has been observed between -2% and -10%. The budget deficit, which started to recover in the period until the 2008 crisis, fell below -10% with the 2008 crisis, decreased again until the 2020 Covid crisis, but again fell below -10% with the Covid crisis.

Figure 4-4: Japan, Budget Deficit, % of GDP, 1980-2021



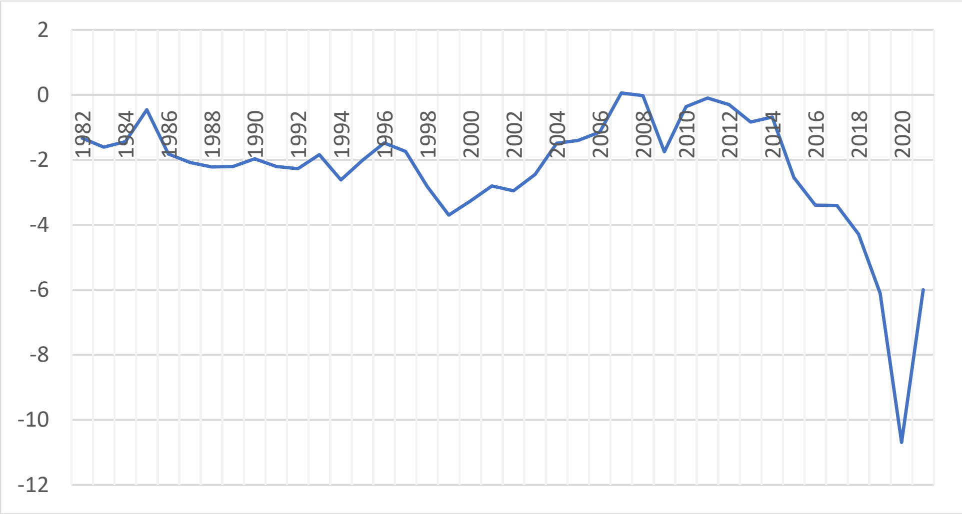
The Brazilian economy went through a stagflationary process in the 1980s. The economy, which had a budget surplus, started to run a budget deficit within the scope of financial stability and anti-inflation policies implemented between 1980-2000. With the 1986 Cruzado Plan, a tight fiscal policy was implemented, which envisaged monetary reform and reducing budget deficits. The program succeeded in reducing inflation in the short term, but in the long term, although contractionary fiscal policies initially reduced public deficits, they led to an increase in deficits after a while. The Bresser Plan, which was put into practice in 1987, aimed to strengthen the country's macroeconomic structure and to put the country in a position to fight against inflation. However, as a result, public sector wages increased rapidly, resulting in higher public deficits and inflation. The crisis environment in the late 1990s and the strong fiscal policies followed as a result of the agreements made with the IMF in the early 2000s reduced the increase in the budget deficit, reaching reasonable levels. Nevertheless, the 2010s were not very bright for the Brazilian economy, and the massive protests in 2013 across the country plunged the country into a new financial crisis. As a matter of fact, large budget deficits were given during this period, and with the 2020 Covid crisis, the country's economy had the largest budget deficit of the last fifty years with 13.3%.

Figure 4-5: Brazil, Budget Deficit, %GDP, 1980-2021



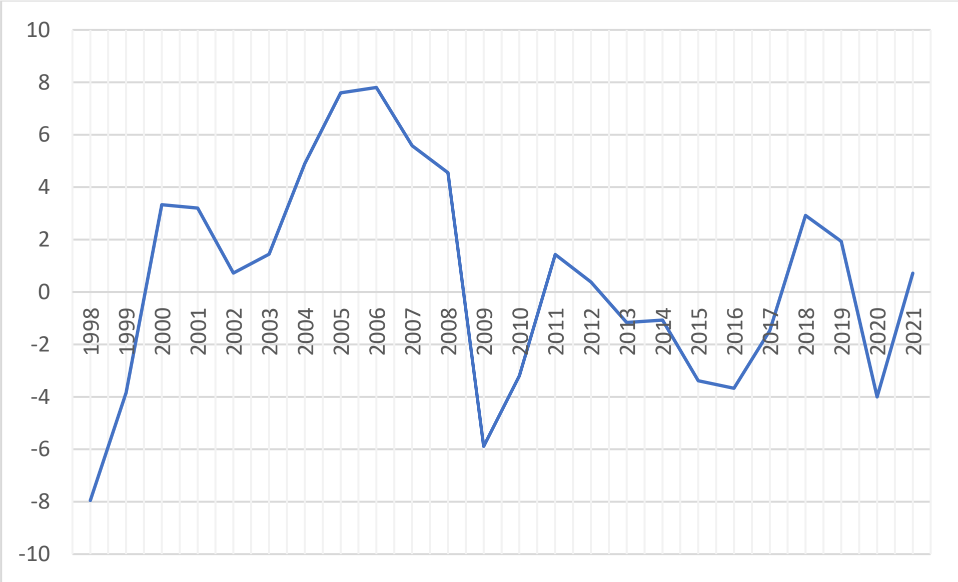
After Mao's death, China started to implement a different economic model. In particular, the fact that the economic problems and famines experienced by the people could not be overcome by the policies of the Mao period and the successful results of the economic models implemented by the Far East countries, especially Taiwan, Hong Kong and South Korea, caused China to review its economic policies. Reform movements based on "profitability and modernization of public enterprises" in the mid-1980s yielded successful results. Foreign direct capital investments that came to the country since the beginning of the 1990s have been a driving force especially in the export industry and growth. As one of the world's largest exporters and with record foreign exchange reserves, the Chinese economy has managed to keep its budget deficit at a reasonable level in the last forty years. The Chinese economy, which continued to grow with the 2010s, but whose growth rate decreased, tried to make another breakthrough with new development plans and government support packages. Although the budget deficits in this process remained at a reasonable level, China, which was the source of the Covid crisis and received a massive reaction from the whole world, had a budget deficit of almost 11% in 2020.

Figure 4-6: China, Budget Deficit, %GDP, 1982-2021



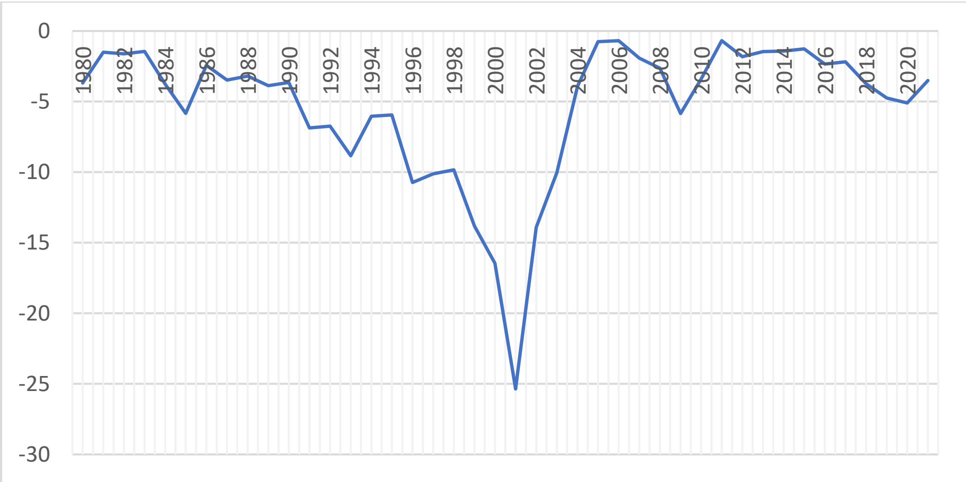
Russia, one of the countries that will be the subject of this thesis, stands out as perhaps the most interesting economy among the countries studied. The country, which has one of the largest natural gas and oil reserves in the world, continued to pay its debts from the Soviet Union, which dissolved in 1991, until 2017. Although the huge debts paid and the fiscal policies implemented after the collapse of the Soviet Union led to large budget deficits until the beginning of the 2000s, the Putin period was a turning point in Russian history. The Putin government, which set out with the goal of "strong state", re-nationalized some of the enterprises that were privatized in the 1990s like Gazprom, the largest publicly listed natural gas company in the world. Natural gas and oil exports, which developed the country's economy almost alone, provided strong and high growth rates. Although politically discussed, Russia under Putin has provided "unprecedented macroeconomic stability," as the World Bank put it. The budget deficit in the 2008 global crisis was compensated in just a few years, and the country managed to maintain its strong economic structure. As a matter of fact, even the 2020 Covid crisis did not cause a deterioration in the budget, and the country had a budget deficit of only 4% in this process.

Figure 4-7: Russia, Budget Deficit, %GDP, 1998-2021



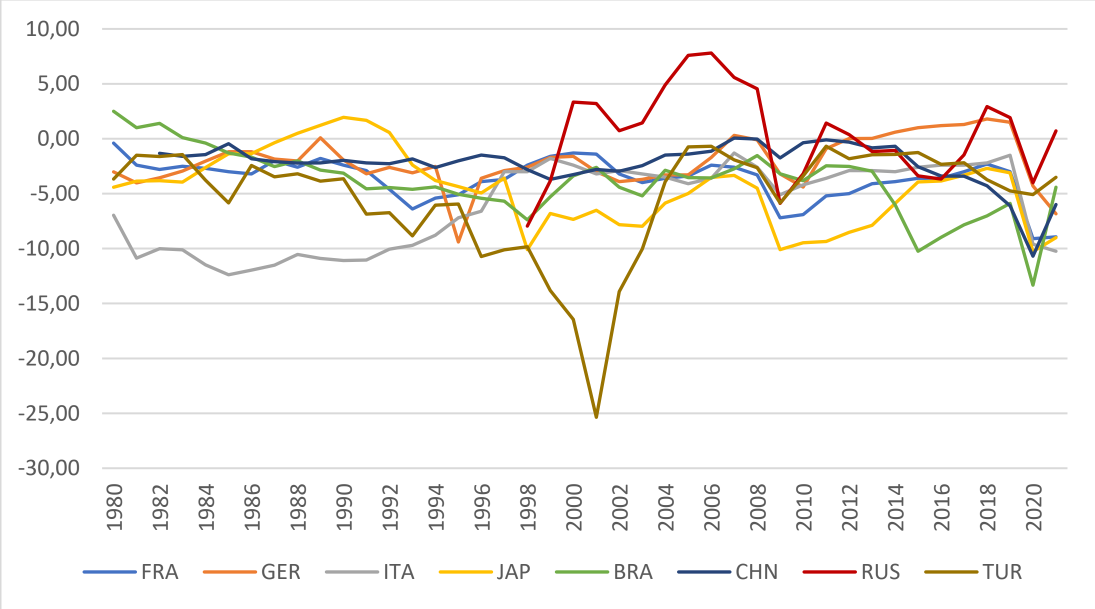
Although it is not a European Union country, one of the European economies most suitable for the Maastricht criteria belongs to Turkey. Although the political crises and military coups in the 1960s and 1980s hindered growth, when we look at the budget deficits, it is seen that the Turkish economy after 1980 had a budget deficit of 4% on average until the 1990s. In the 1990s and beyond, on the way to the biggest economic crisis in the country's history, large budget deficits were incurred and the people were crushed under heavy inflation. As a result of the crises in 1994 and 1999, the budget deficit first reached 10%, then 15%, and with the 2001 crisis, 25%, one of the largest budget deficits seen so far. The agreements with the IMF and the fiscal policies implemented by the Justice and Development Party (JDP, known as AKP in Turkish) after the 2002 elections have largely eliminated the public deficit. In the period between 2002 and 2008, which can be called the "golden era" of the JDP, the budget deficit was almost zero. Even though the country's economy entered a small crisis environment in the 2008 crisis, the effect of this was eliminated and an average of 3% budget deficit has been seen until the Covid crisis. The remarkable point here is that although budget deficits have not been observed in the last fifteen years, it can be thought that a major reason for this is the result of the Build-Operate-and Transfer model. In this model, instead of making direct investments, the public transfers these investments to private companies and become indebted to these companies in the long term. On the other hand, the increase in private sector debt, fluctuations in exchange rates and interest rates, and political imbalances pose a major problem for the Turkish economy in the long run. For this reason, although it prevents the public deficit from being seen suddenly and at a high rate, it poses a danger to the Turkish economy by spreading the debt over many years. Therefore, private sector debts will also be included in the analysis of debt sustainability for Turkey.

Figure 4-8: Turkey, Budget Deficit, %GDP, 1980-2021



When we consider the countries together, it is seen that especially the Italian economy separated from other economies and had higher budget deficits in the pre-2000 period. Russia, which does not have data for this period, but was crushed by high budget deficits and debt payments after the collapse of the Soviet Union, can be considered among the countries that had budget problems in this period. When we look at the period after 2000, it can be said that the budget deficits in the Italy acted similarly to the countries other than Turkey and Russia, and a stability was achieved in the public finances. Here, Russia's budget surplus and Turkey's huge budget deficit with the 2001 crisis are the most striking peaks and troughs. It is seen that the countries selected in general terms until the 2008 crisis took steps to correct their budget deficits. The 2020 crisis, on the other hand, creates a similar effect in every country, causing a collective deterioration in the budget.

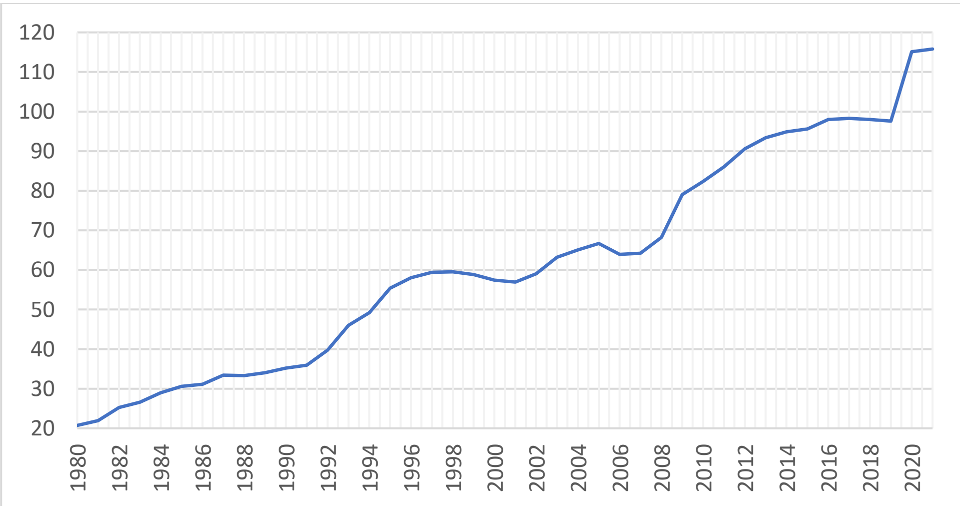
Figure 4-9: Public Deficit, Selected Countries, %GDP, 1980-2021



4.1.2. Graphical analysis of public debt to GDP

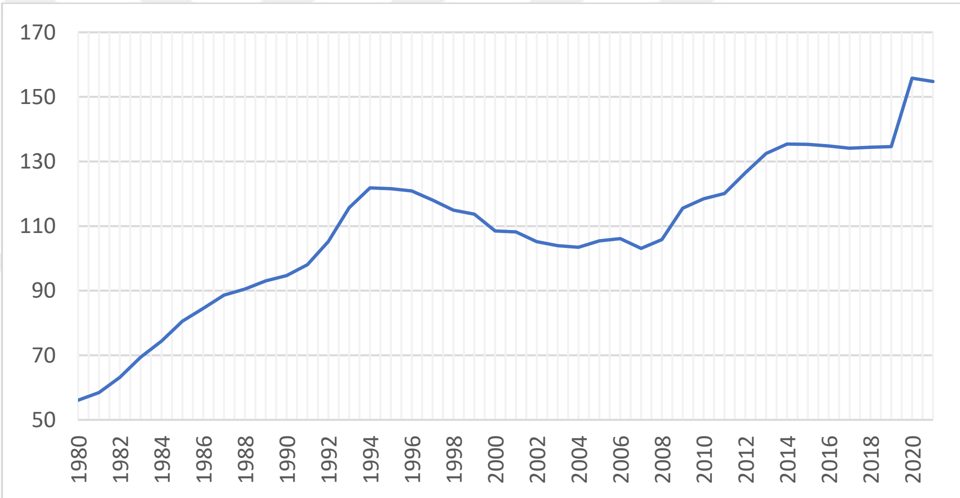
Until 2002, the French economy managed to keep the ratio of public expenditures to GDP below 60% in accordance with the Maastricht Treaty. Since 2002, it has not been able to meet this criterion again. The public sign/GDP ratio, which reached 80% in the period until the 2008 crisis, entered an increasing trend with the 2008 crisis, and in 2020 it exceeded 100% for the first time in its history.

Figure 4-10: France, Public Debt, % of GDP, 1980-2021



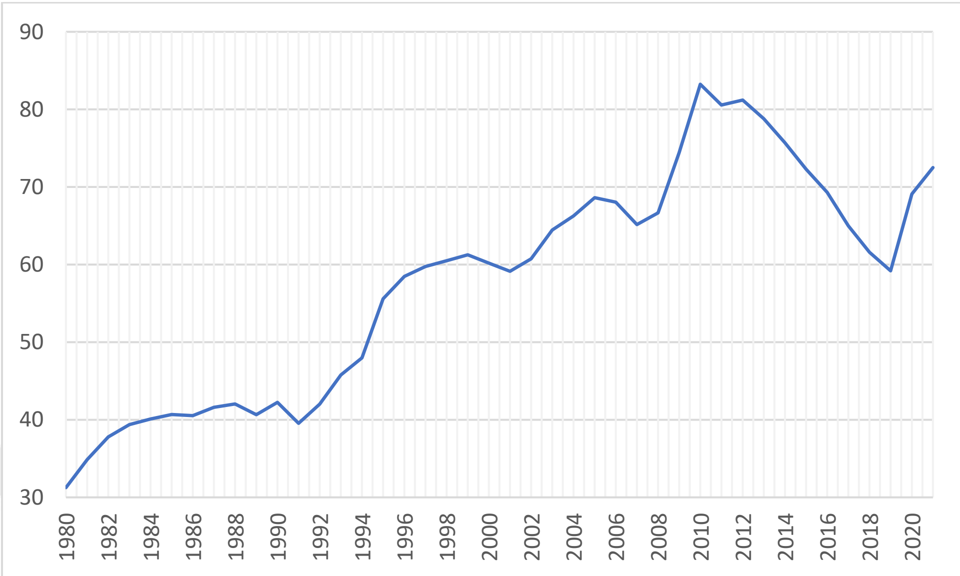
Italy was not classified among the high-risk countries in the euro zone during the sovereign crisis threatening the union in 2009 because their debt to GDP ratio have been always above 100% after 1991. However, it was facing serious difficulties in the management of its public finances and its debt. Before 1980s, Italian National Bank was buying back unsold State bonds and financing the State. By doing so, the public debt to GDP ratio had been floating below 60%. From 1980 to 1994, the Italian debt to GDP ratio doubled from 60% to 121% because the Government has turned its face to the private sector to incur debt through private banks and insurance companies, which are concerned with maximizing their profit. Moreover, with the Maastricht Treaty in 1992, Italian lira depreciated, which mechanically led to an increase in the debt of the country. The public debt/GDP ratio of Italy, which was already in an economic depression before the 2008 crisis, followed an increasing trend for the following twelve years and reached 156% with the Covid pandemic, which dealt a great blow to the country.

Figure 4-11: Italy, Public Debt, % of GDP, 1980-2021



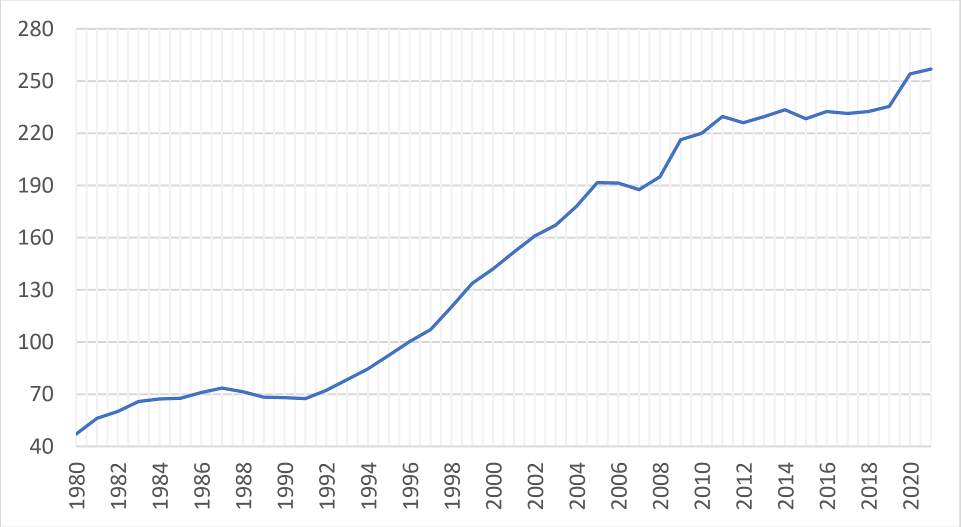
The debts of Germany, as West and East, were directly related to efforts to finance war reparations, while others were related to loans from foreign creditors (American private banks, French government and Britain). It experienced relative stability during the 1980s before experiencing stronger growth in the early 1990s after German reunification and the payment of debts owed by the *Reich* as agreed in the London agreements (1953). The country’s gradual deleveraging was possible thanks to the growth of its economy characterized by current account surpluses and great budgetary rigidity. Although the 2008 crisis caused a huge deterioration in Germany's debt/GDP ratio, as in the rest of the world, the country managed to compensate this increase over the years thanks to its strong economic policies, and this ratio, which rose to over 85% with the crisis, reached 59% by 2019. Nevertheless, after the Covid crisis, there was an upward break, but its severity was relatively low compared to other countries.

Figure 4-12: Germany, Public Debt, % of GDP, 1980-2021



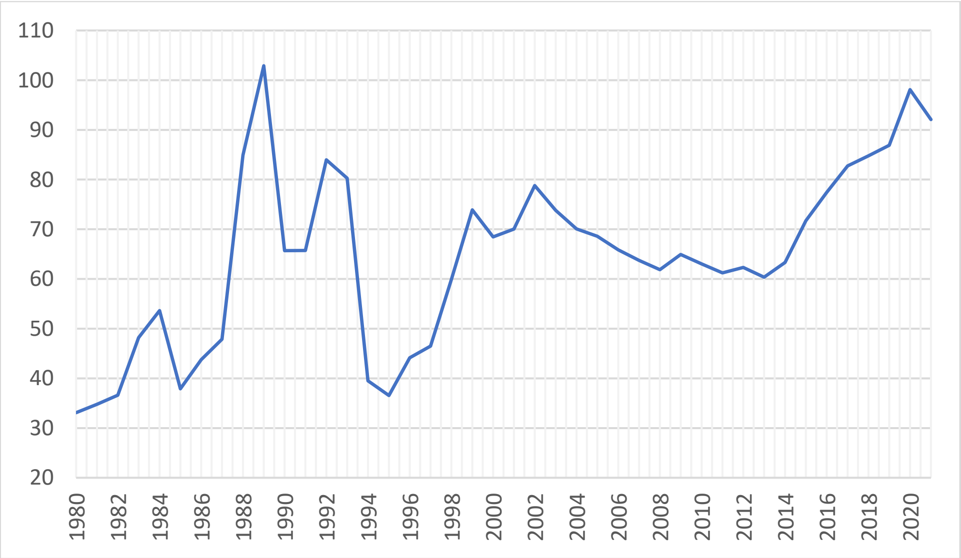
Unlike many countries for which the public debt exploded due to the financial crisis in 2008, Japan had been already experiencing a sharp deterioration in its public finances before the crisis. According to OECD, Japan's gross public debt to GDP ratio increased from 47% to 187% between 1980 and 2007. After the 2008 crisis, the economy experienced a non-stoppable increase until 2019 and exceeded the 200%. With the last Covid crisis, the Japanese debt to GDP ratio has reached a record level of 254% in 2020. A good question is made on the position of the financial markets on the Japanese sovereign rating. Although the country's debts exceeded its GDP since 1996, Japan still enjoys wide approval from credit institutions. There are, of course, some reasons for this finding. Despite the high indebtedness rates of the Japanese economy, there are of course certain reasons why it is able to obtain loans from international credit institutions and has a strong position among developed countries. First of all, Japan has a large stock of private savings. On the other hand, the country's economy can compensate this situation by giving high current account surpluses under the leadership of its advanced technology. The fact that the country's credit rating has been AA or AAA in the last 20 years is a clear indicator of this situation. Moreover, speculative fluctuations are limited because the debt is mainly held by residents through public pension funds, public financial institutions, postal banks, postal life insurance, and by the Bank of Japan.

Figure 4-13: Japan, Public Debt, % of GDP, 1980-2021



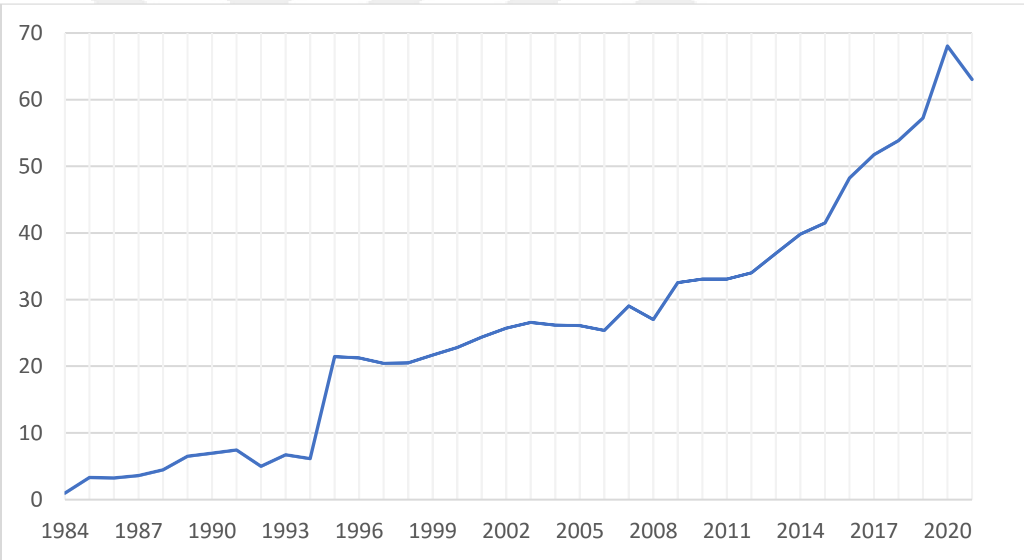
The effects of the economic crises that Brazil experienced in the 1980s can be easily observed when looking at the public debt. The debt-to-GDP ratio, which was around 35% before the 1980s, has exceeded 100% in just ten years. In the 1990s, as mentioned earlier, this debt ratio regained its former levels thanks to the tight fiscal policies and IMF agreements, and remained at a relatively reasonable level in the 2000s. The public debt/GDP ratio, which started to increase again in the post-2009 period, has recently reached 100% again, threatening the sustainability of Brazil's public debt.

Figure 4-14: Brazil, Public Debt, % of GDP, 1980-2021



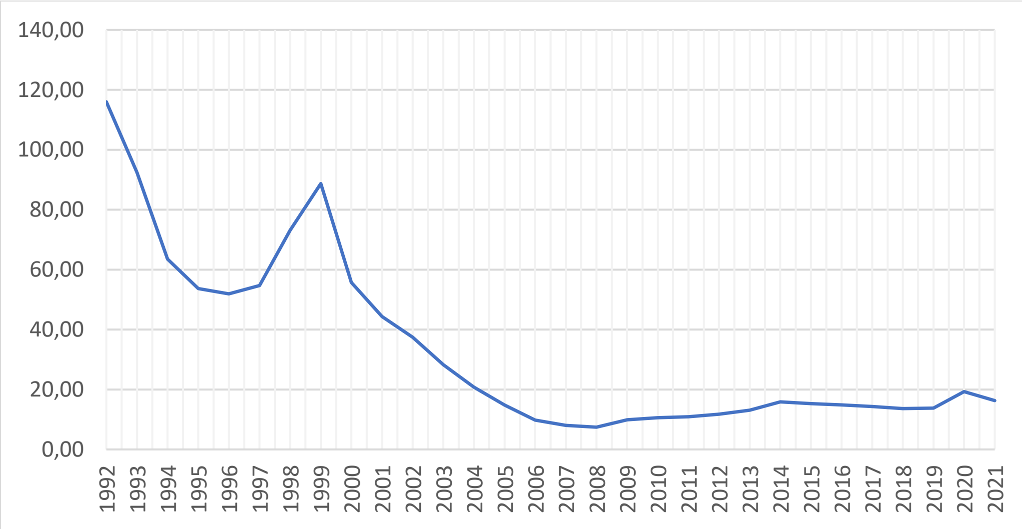
Although the ratio of public debt to GDP shows that China's indebtedness is on a rising trend, China did not have a major debt problem until the 2010s, thanks to the country's strong economic structure, stable financial policies, high foreign investments and foreign exchange reserves. However, the increase in indebtedness accelerated in 2010, and the public debt/GDP ratio below 30% reached the highest levels in the country's history by 2020 (60%). On the other hand, the huge increase in the indebtedness of private companies is putting the Chinese government under pressure. Problems such as the inability of large companies such as China Evergrande Group, Sinic and Fantasia are predicted to have a significant impact on China's public debt. As a matter of fact, the fact that China is the country with the highest nominal debt increase in recent years paves the way for debt problems that the country may face in the long run. Still, China, which has the highest GDP after the USA, seems to have the necessary investment, foreign exchange and trade volume to ensure sustainable borrowing globally.

Figure 4-15: China, Public Debt, % of GDP, 1984-2021



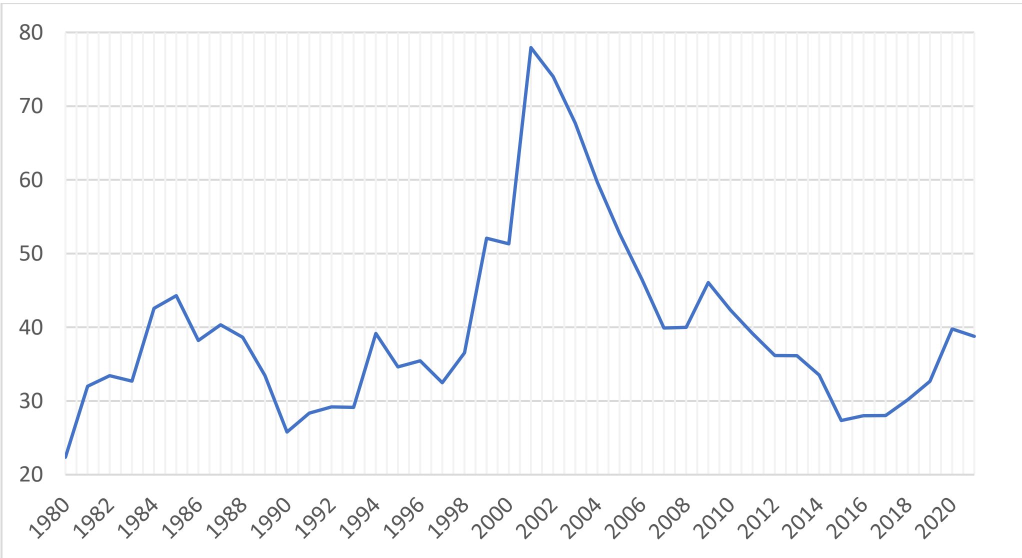
The strongest economy in the world with the lowest public debt/GDP ratio is Russia. After the Soviet Union, Russia's huge debts, which were 120% of GDP in 1992, experienced a great decline in the post-2000 period, and this ratio fell below the record low level of 20%. In this respect, the Russian economy is the country with the lowest indebtedness rate among the countries discussed. Even in the 2008 crisis and the 2020 Covid crisis, this rate did not exceed 20%. The biggest share here, of course, belongs to the energy sector. The fact that Russia is one of the world's largest economies in natural gas and oil exports has contributed to the Russian state's large foreign exchange reserves and minimizing public indebtedness.

Figure 4-16: Russia, Public Debt, % of GDP, 1980-2021



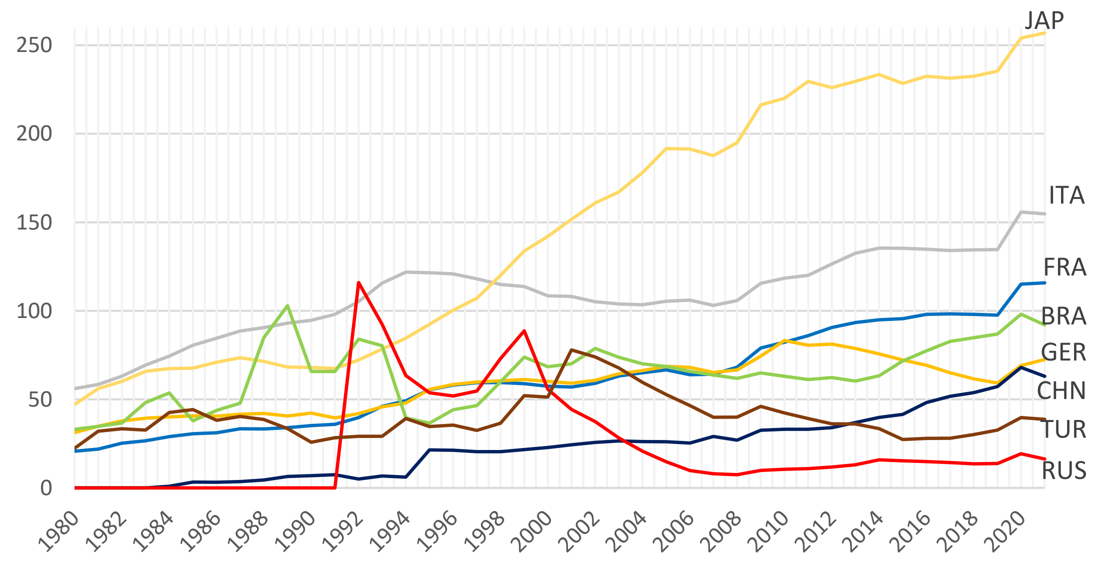
Turkey is one of the countries that follow the most stable and reliable public indebtedness policy, not only among the selected countries, but also compared to almost all European Union countries. Except for the large public debt/GDP ratio created by the 2001 crisis, Turkey has a public indebtedness that complies with the Maastricht criteria. This ratio, which was in an increasing trend until the 2001 crisis, experienced a sharp decline after 2002, decreasing from 78% to 40%, and remained at an average of 36% after 2007. As mentioned earlier, the state's investment in the private sector, contrary to the direct investment policy, and the privatization of many state institutions are among the main reasons for this ratio being lower than most of European countries.

Figure 4-17: Turkey, Public Debt, % of GDP, 1980-2021



When we consider the public debt-to-GDP ratios of all selected countries together, the most striking thing is the great rupture that Japan experienced towards the end of the 1990s.

Figure 4-18: Public Debt, Selected Countries, %GDP, 1980-2021



4.2. Unit root tests and cointegration analysis

In order to perform unit root tests, it is needed to determine the appropriate lag length for each variable separately for each country. The table below shows the results of optimal lag selection results for each country.

Table 4-1: Lag Selection Results of Selected Countries and Variables

Country	DS/GDP	PS/GDP	BB/GDP	Rev/GDP	Exp/GDP
Brazil	3**	5***	6***	5**	6***
China	1***	1***	1***	1***	2***
France	1**	6***	6***	5**	5***
Germany	2***	10**	2*	5**	9**
Italy	2**	2**	2**	5**	2*
Japan	1**	5**	1*	2**	7**
Turkey	1*	2***	2***	5**	6***

The asterisk next to each lag level in the table shows how many criteria the selection is based on. For example, a lag level with three stars gives a common result in SIC-AIC and HQ information criteria. The lag level with two stars represents any two of these information criteria that give a same result. Lag levels with a single star, on the other hand, say that SIC is selected if each information criterion gives a different result.

4.2.1. Unit root tests on debt stocks

First, the ratio of public debt to GDP is tested for stability. When we consider it in general terms, both ADF and PP tests do not show stationarity at the levels for the selected seven countries. With respect to the KPSS test, public debt stock is stationary at $I(0)$ for France, Germany and Italy. Yet, it is not sufficient condition to talk about the sustainability of public debt.

Table 4-2: ADF Test Results for Debt Stock to GDP

		ADF test at level		ADF test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.908608	0.6377	-3.315043	0.0738	$I(1)$
	Drift	0.080714	0.9617	-3.012134	0.0395	
	No-trend and Drift	1.261722	0.9459	-2.746833	0.0068	
China	Trend	-2.490061	0.3314	-4.338439	0.0065	$I(1)$
	Drift	0.378158	0.9799	-4.147979	0.0021	
	No-trend and Drift	2.159285	0.9917	-3.496345	0.0008	
France	Trend	-2.351250	0.4008	-5.257226	0.0003	$I(1)$
	Drift	-1.031988	0.7366	-5.308686	0.0000	
	No-trend and Drift	1.775286	0.9808	-4.720652	0.0000	
Germany	Trend	-1.570415	0.7932	-3.509574	0.0474	$I(1)$
	Drift	-1.402971	0.5751	-3.498679	0.0113	
	No-trend and Drift	-0.045262	0.6638	-3.526423	0.0007	
Italy	Trend	-2.461876	0.3454	-3.784138	0.0242	$I(1)$
	Drift	-0.677266	0.8443	-3.927761	0.0033	
	No-trend and Drift	1.664436	0.9756	-3.514814	0.0007	
Japan	Trend	-1.431791	0.8417	-4.755417	0.0015	$I(1)$
	Drift	-0.673634	0.8453	-4.794251	0.0002	

	No-trend and Drift	2.861769	0.9988	-3.863232	0.0002	
Turkey	Trend	-0.784034	0.9613	-4.690219	0.0019	$I(1)$
	Drift	-2.089018	0.2497	-4.033620	0.0024	
	No-trend and Drift	-0.669944	0.4229	-4.105779	0.0001	

Table 4-3: PP Test Results for Debt Stock to GDP

		PP test at level		PP test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.962833	0.6098	-8.269729	0.0000	$I(1)$
	Drift	0.449640	0.9836	-7.930672	0.0000	
	No-trend and Drift	1.568158	0.9702	-7.669323	0.0000	
China	Trend	-2.029698	0.5703	-5.570954	0.0002	$I(1)$
	Drift	0.510203	0.9854	-5.455619	0.0000	
	No-trend and Drift	2.992024	0.9991	-4.868868	0.0000	
France	Trend	-2.135441	0.5163	-6.082212	0.0000	$I(1)$
	Drift	-0.721729	0.8333	-6.142859	0.0000	
	No-trend and Drift	2.186178	0.9926	-5.615964	0.0000	
Germany	Trend	-1.469594	0.8297	-5.945297	0.0000	$I(1)$
	Drift	-1.333345	0.6089	-5.970774	0.0000	
	No-trend and Drift	-0.022315	0.6716	-6.018747	0.0000	
Italy	Trend	-2.373935	0.3893	-5.608105	0.0001	$I(1)$
	Drift	-0.472279	0.8891	-5.670562	0.0000	
	No-trend and Drift	1.789344	0.9814	-5.499837	0.0000	
Japan	Trend	-1.414099	0.8474	-7.140528	0.0000	$I(1)$
	Drift	-0.695174	0.8401	-7.198159	0.0000	
	No-trend and Drift	3.543523	0.9998	-6.208131	0.0000	
Turkey	Trend	-0.628614	0.9737	-6.406976	0.0000	$I(1)$
	Drift	-2.077720	0.2542	-5.692520	0.0000	
	No-trend and Drift	-0.788400	0.3706	-5.726871	0.0000	

Table 4-4: KPSS Test Results for Debt Stock to GDP

Variables	Test Types	KPSS test at level LM-Stat	KPSS test at level p-value	KPSS test at first difference LM-Stat	KPSS test at first difference p-value	Integration Order
Brazil	Trend	0.240796	n.s.	0.109335	>.10	$I(1)$
	Drift	0.791285	n.s.	0.472961	>.01	
China	Trend	0.179982	>.01	0.092248	>.10	$I(1)$
	Drift	0.850586	n.s.	0.224424	>.10	
France	Trend	0.141025	>.05	0.059485	>.10	$I(0)$
	Drift	0.932568	n.s.	0.061032	>.10	
Germany	Trend	0.188556	>.01	0.144308	>.05	$I(0)$
	Drift	0.259632	>.10	0.170760	>.10	
Italy	Trend	0.101048	>.10	0.055035	>.10	$I(0)$
	Drift	0.938800	n.s.	0.070078	>.10	
Japan	Trend	0.163359	>.01	0.180232	>.01	$I(1)$
	Drift	0.888561	n.s.	0.189423	>.10	
Turkey	Trend	0.210845	>.01	0.073708	>.10	$I(1)$
	Drift	0.494434	>.01	0.547847	>.01	

4.2.2. Unit root tests on primary balances

The second stationarity test was applied to the ratio of primary balance to GDP. A stationary primary balance at $I(0)$ means that the debt cannot be sustained at this step. Here, ADF and PP tests give same results, stating that the PB/GDP ratios of selected countries are stationary at $I(1)$, except Turkey and Italy. For Italy, ADF test shows that PB/GDP ratio is stationary at $I(0)$, while PP test says so at $I(1)$. For Turkey, both ADF and PP tests mention about stationarity at $I(0)$. Interestingly, KPSS test shows that all countries have a stationary primary balance to GDP ratio at $I(0)$. In short, it can be said that Turkey and Italy have a stable PB/GDP ratio in the general evaluation.

Table 4-5: ADF Test Results for Debt Stock to GDP

		ADF test at level		ADF test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-2.620053	0.2733	-3.829599	0.0220	$I(1)$
	Drift	-0.367374	0.9074	-3.863934	0.0041	
	No-trend and Drift	-0.843473	0.3463	-3.545554	0.0006	
China	Trend	-2.449677	0.3505	-4.441254	0.0049	$I(1)$
	Drift	-1.674055	0.4374	-4.447211	0.0009	
	No-trend and Drift	-0.153180	0.6254	-4.450735	0.0000	
France	Trend	-2.620218	0.2733	-2.991311	0.1438	$I(1)$
	Drift	-2.563376	0.1065	-3.033134	0.0379	
	No-trend and Drift	-0.546167	0.4761	-2.951773	0.0038	
Germany	Trend	-1.870841	0.6555	-2.672367	0.2519	$I(1)$
	Drift	-1.942218	0.3110	-2.590704	0.1013	
	No-trend and Drift	-1.472431	0.1303	-2.571038	0.0111	
Italy	Trend	-2.909082	0.1670	-4.276347	0.0064	$I(0)$
	Drift	-2.478843	0.1256	-4.053707	0.0023	
	No-trend and Drift	-2.361528	0.0187	-4.070458	0.0001	
Japan	Trend	-1.845333	0.6696	-2.998337	0.1417	$I(1)$
	Drift	-1.740442	0.4059	-3.062618	0.0352	
	No-trend and Drift	-0.258408	0.5888	-3.053111	0.0029	
Turkey	Trend	-3.368738	0.0652	-4.607884	0.0024	$I(0)$
	Drift	-2.663388	0.0863	-4.605525	0.0004	
	No-trend and Drift	-3.003881	0.0033	-4.373235	0.0000	

Table 4-6: PP Test Results for Debt Stock to GDP

		PP test at level		PP test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.979039	0.6012	-4.505523	0.0032	$I(1)$
	Drift	-1.912219	0.3248	-4.514908	0.0005	
	No-trend and Drift	-1.936122	0.0511	-4.550972	0.0000	
China	Trend	-2.235345	0.4597	-5.805997	0.0001	$I(1)$
	Drift	-1.427902	0.5607	-5.771234	0.0000	

	No-trend and Drift	-0.091300	0.6470	-5.765602	0.0000	
France	Trend	-1.980633	0.6003	-4.184001	0.0082	$I(1)$
	Drift	-1.718560	0.4171	-4.273462	0.0011	
	No-trend and Drift	-0.648969	0.4322	-4.299505	0.0000	
Germany	Trend	-1.675850	0.7504	-3.882502	0.0186	$I(1)$
	Drift	-1.625251	0.4639	-3.862421	0.0040	
	No-trend and Drift	-1.570077	0.1087	-3.882213	0.0002	
Italy	Trend	-1.907722	0.6388	-3.833366	0.0212	$I(1)$
	Drift	-1.340007	0.6057	-3.905931	0.0035	
	No-trend and Drift	-1.464577	0.1325	-3.991511	0.0001	
Japan	Trend	-2.349200	0.4020	-8.132650	0.0000	$I(1)$
	Drift	-2.336945	0.1639	-8.174920	0.0000	
	No-trend and Drift	-0.979077	0.2899	-8.235608	0.0000	
Turkey	Trend	-2.490051	0.3319	-5.627030	0.0001	$I(0)$
	Drift	-1.891715	0.3341	-5.758050	0.0000	
	No-trend and Drift	-2.394839	0.0172	-5.814512	0.0000	

Table 4-7: PP Test Results for Debt Stock to GDP

		KPSS test at level		KPSS test at first difference		Integration Order
Variables	Test Types	LM-Stat	p-value	LM-Stat	p-value	
Brazil	Trend	0.084210	>.10	0.094507	>.10	$I(0)$
	Drift	0.857292	n.s.	0.115095	>.10	
China	Trend	0.073112	>.10	0.079583	>.10	$I(0)$
	Drift	0.794529	>0.01	0.110226	>.10	
France	Trend	0.106614	>.10	0.066139	>.10	$I(0)$
	Drift	0.265576	>.10	0.069873	>.10	
Germany	Trend	0.123086	>0.05	0.061247	>.10	$I(0)$
	Drift	0.139712	>.10	0.181420	>.10	
Italy	Trend	0.153907	>0.01	0.044413	>.10	$I(0)$
	Drift	0.356511	>0.05	0.147348	>.10	
Japan	Trend	0.116792	>.10	0.058957	>.10	$I(0)$
	Drift	0.137498	>.10	0.070212	>.10	
Turkey	Trend	0.110818	>.10	0.056141	>.10	$I(0)$
	Drift	0.769941	n.s.	0.090092	>.10	

4.2.3. Unit root tests on budget balances

The third unit root test we perform is on budget balances. According to the results, budget balance is stationary at level for Germany with respect to ADF test. PP test shows that there is no stationary condition for any selected countries at $I(0)$. KPSS test, conversely, suggests that all series are stationary at levels. As a result, when all three test results are evaluated together, the ratio of public deficit to GDP is found to be stable at $I(0)$ for Germany, and at $I(1)$ for other countries.

Table 4-8: ADF Test Results for Budget Balance to GDP

		ADF test at level		ADF test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-2.438026	0.3568	-2.554315	0.3021	$I(1)$
	Drift	-1.154889	0.6878	-2.626377	0.0938	
	No-trend and Drift	0.034910	0.6899	-2.543984	0.0118	
China	Trend	-2.448607	0.3510	-4.391570	0.0056	$I(1)$
	Drift	-1.569403	0.4899	-4.401691	0.0010	
	No-trend and Drift	0.096658	0.7085	-4.378403	0.0000	
France	Trend	-2.623830	0.2717	-2.871833	0.1793	$I(1)$
	Drift	-2.601761	0.0985	-2.899969	0.0517	
	No-trend and Drift	-0.138646	0.6315	-2.880987	0.0047	
Germany	Trend	-3.028677	0.1331	-3.022817	0.1348	$I(0)$
	Drift	-3.011604	0.0394	-3.048322	0.0361	
	No-trend and Drift	-2.883806	0.0046	-3.068561	0.0027	
Italy	Trend	-2.826415	0.1938	-4.433552	0.0041	$I(1)$
	Drift	-2.716991	0.0770	-4.227224	0.0013	
	No-trend and Drift	-0.731063	0.3958	-4.252547	0.0001	
Japan	Trend	-2.137886	0.5148	-4.255398	0.0068	$I(1)$
	Drift	-2.106969	0.2427	-4.257148	0.0012	
	No-trend and Drift	-0.767446	0.3798	-4.290673	0.0000	
Turkey	Trend	-2.973692	0.1480	-4.599113	0.0025	$I(1)$
	Drift	-2.787135	0.0660	-4.673963	0.0003	
	No-trend and Drift	-1.336916	0.1660	-4.640158	0.0000	

Table 4-9: PP Test Results for Budget Balance to GDP

Variables	Test Types	PP test at level t-stat	PP test at level p-value	PP test at first difference t-stat	PP test at first difference p-value	Integration Order
Brazil	Trend	-2.283325	0.4365	-4.699018	0.0018	$I(1)$
	Drift	-1.746974	0.4031	-4.725820	0.0003	
	No-trend and Drift	-0.873959	0.3335	-4.762570	0.0000	
China	Trend	-2.248648	0.4526	-5.770053	0.0001	$I(1)$
	Drift	-1.330154	0.6079	-5.742803	0.0000	
	No-trend and Drift	0.145796	0.7237	-5.705081	0.0000	
France	Trend	-1.920610	0.6321	-4.207613	0.0077	$I(1)$
	Drift	-1.865732	0.3461	-4.289651	0.0011	
	No-trend and Drift	-0.251251	0.5918	-4.325593	0.0000	
Germany	Trend	-1.599834	0.7821	-3.849434	0.0203	$I(1)$
	Drift	-1.935381	0.3144	-3.833056	0.0043	
	No-trend and Drift	-1.844409	0.0624	-3.863540	0.0002	
Italy	Trend	-1.901132	0.6422	-3.933022	0.0163	$I(1)$
	Drift	-1.657523	0.4476	-4.003742	0.0026	
	No-trend and Drift	-0.399471	0.5359	-4.010309	0.0001	
Japan	Trend	-2.226778	0.4667	-7.632520	0.0000	$I(1)$
	Drift	-2.271639	0.1842	-7.660007	0.0000	
	No-trend and Drift	-0.856012	0.3412	-7.715957	0.0000	
Turkey	Trend	-2.090501	0.5408	-5.515107	0.0001	$I(1)$
	Drift	-2.138109	0.2309	-5.570932	0.0000	
	No-trend and Drift	-0.966500	0.2950	-5.574133	0.0000	

Table 4-10: KPSS Test Results for Budget Balance to GDP

Variables	Test Types	KPSS test at level LM-Stat	KPSS test at level p-value	KPSS test at first difference LM-Stat	KPSS test at first difference p-value	Integration Order
Brazil	Trend	0,107000	>0.10	0.084545	>0.10	$I(0)$
	Drift	0.717304	>0.01	0.088322	>0.10	
China	Trend	0.070085	>0.10	0.084026	>0.10	$I(0)$
	Drift	0.812217	n.s.	0.110025	>0.10	
France	Trend	0.108957	>0.10	0.073757	>0.10	$I(0)$
	Drift	0.124758	>0.10	0.075097	>0.10	

Germany	Trend	0.119768	>0.05	0.068728	>0.10	$I(0)$
	Drift	0.183216	>0.10	0.175550	>0.10	
Italy	Trend	0.135371	>0.05	0.052443	>0.10	$I(0)$
	Drift	0.198891	>0.10	0.130715	>0.10	
Japan	Trend	0.122184	>0.05	0.060714	>0.10	$I(0)$
	Drift	0.136190	>0.10	0.079498	>0.10	
Turkey	Trend	0.098265	>0.10	0.048935	>0.10	$I(0)$
	Drift	0.282866	>0.10	0.049157	>0.10	

4.2.4. Unit root tests on government revenue

The ratio of public revenue to GDP is the fourth stationarity test applied here. This test, which alone does not give a definite judgment about the sustainability of debt, will be evaluated together with the stationarity test of public expenditures to be carried out in the next stage and the cointegration between them will be examined. According to the test results, the ADF and PP test results are not stationary at $I(0)$ for any country. On the other hand, according to the KPSS test, the public revenues of Germany, Japan and Turkey are stationary at level. As a result, it can be concluded that among the seven countries, none of the public revenue data are stationary at $I(0)$.

Table 4-11: ADF Test Results for Government Revenue to GDP

		ADF test at level		ADF test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.395054	0.8522	-3.778637	0.0250	$I(1)$
	Drift	-2.436911	0.1364	-3.295599	0.0197	
	No-trend and Drift	0.894123	0.8986	-3.205943	0.0018	
China	Trend	-1.214684	0.8956	-5.825476	0.0001	$I(1)$
	Drift	0.592286	0.9880	-4.308016	0.0013	
	No-trend and Drift	-1.166079	0.2188	-4.172381	0.0001	
France	Trend	-1.823479	0.6805	-2.302826	0.4256	$I(1)$
	Drift	-1.133318	0.6968	-2.284084	0.1805	
	No-trend and Drift	0.847161	0.8908	-2.100095	0.0353	
Germany	Trend	-1.517782	0.8121	-3.358539	0.0674	$I(1)$
	Drift	0.844198	0.9940	-3.234898	0.0230	

	No-trend and Drift	2.284880	0.9942	-2.334614	0.0201	
	Trend	-2.435342	0.3582	-2.229121	0.4647	
Italy	Drift	-1.986800	0.2917	-2.452594	0.1324	$I(1)$
	No-trend and Drift	1.100407	0.9278	-2.298587	0.0220	
	Trend	-2.546830	0.3055	-4.281369	0.0063	
Japan	Drift	0.055156	0.9596	-4.032803	0.0024	$I(1)$
	No-trend and Drift	1.479498	0.9643	-3.538820	0.0006	
	Trend	-1.453333	0.8341	-2.952300	0.1546	
Turkey	Drift	-1.767713	0.3926	-2.768162	0.0693	$I(1)$
	No-trend and Drift	-0.470958	0.5072	-2.764329	0.0065	

Table 4-12: PP Test Results for Government Revenue to GDP

		PP test at level		PP test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
	Trend	-2.694176	0.2426	-6.367650	0.0000	
Brazil	Drift	-2.713741	0.0773	-6.357784	0.0000	$I(1)$
	No-trend and Drift	0.975120	0.9111	-6.331616	0.0000	
	Trend	-1.287647	0.8789	-9.812959	0.0000	
China	Drift	0.708635	0.9911	-4.962474	0.0002	$I(1)$
	No-trend and Drift	-1.164337	0.2195	-4.843892	0.0000	
	Trend	-1.310707	0.8762	-5.819834	0.0000	
France	Drift	-1.121016	0.7024	-5.885445	0.0000	$I(1)$
	No-trend and Drift	1.159295	0.9350	-5.777719	0.0000	
	Trend	-2.053969	0.5607	-4.122592	0.0097	
Germany	Drift	0.170871	0.9686	-4.047899	0.0023	$I(1)$
	No-trend and Drift	2.103445	0.9910	-3.596139	0.0005	
	Trend	-2.335645	0.4090	-5.902706	0.0000	
Italy	Drift	-2.284812	0.1800	-5.984756	0.0000	$I(1)$
	No-trend and Drift	1.534526	0.9681	-5.795510	0.0000	
	Trend	-1.862407	0.6620	-5.625929	0.0001	
Japan	Drift	0.217689	0.9717	-5.546339	0.0000	$I(1)$
	No-trend and Drift	2.090725	0.9907	-4.998017	0.0000	
	Trend	-1.704595	0.7377	-9.893827	0.0000	
Turkey	Drift	-1.856683	0.3503	-9.838327	0.0000	$I(1)$
	No-trend and Drift	-0.506690	0.4930	-9.851125	0.0000	

Table 4-13: KPSS Test Results for Government Revenue to GDP

		KPSS test at level		KPSS test at first difference		Integration Order
Variables	Test Types	LM-Stat	p-value	LM-Stat	p-value	
Brazil	Trend	0.206296	>0.01	0.033689	>0.10	$I(1)$
	Drift	0.663880	>0.01	0.185019	>0.10	
China	Trend	0.229599	n.s.	0.093237	>0.10	$I(1)$
	Drift	0.543015	>0.01	0.900292	n.s.	
France	Trend	0.169779	>0.01	0.114915	>0.10	$I(1)$
	Drift	0.780760	n.s.	0.149437	>0.10	
Germany	Trend	0.138826	>0.05	0.050575	>0.10	$I(0)$
	Drift	0.969048	n.s.	0.128930	>0.10	
Italy	Trend	0.173281	>0.01	0.101290	>0.10	$I(1)$
	Drift	0.616462	>0.01	0.176152	>0.10	
Japan	Trend	0.116555	>0.10	0.108266	>0.10	$I(0)$
	Drift	0.916119	n.s.	0.202549	>0.10	
Turkey	Trend	0.181849	>0.01	0.064076	>0.10	$I(0)$
	Drift	0.185021	>0.10	0.207320	>0.10	

4.2.5. Unit root tests on government expenditure

It is possible to say that the stationarity tests applied to public expenditures give similar results with public revenues. According to the ADF and PP tests, none of the countries have a stationary government expenditure at $I(0)$. The KPSS test, on the other hand, gives more positive results and the ratio of public expenditures to GDP of countries appears to be stationary at $I(0)$. As a result, all of the seven countries gave a stationarity result of public expenditure to GDP ratio at the first differences, $I(1)$.

Table 4-14: ADF Test Results for Government Expenditure to GDP

		ADF test at level		ADF test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.670250	0.7516	-2.484284	0.3345	$I(1)$
	Drift	-1.417293	0.5676	-2.415671	0.1421	
	No-trend and Drift	0.787459	0.8803	-2.300877	0.0219	
China	Trend	-0.112814	0.9931	-3.364433	0.0695	$I(1)$
	Drift	-1.385735	0.5809	-2.452917	0.1338	
	No-trend and Drift	-0.197927	0.6094	-2.528114	0.0126	
France	Trend	-2.200946	0.4800	-3.193304	0.0961	$I(1)$
	Drift	-1.618968	0.4666	-3.227639	0.0234	
	No-trend and Drift	1.315918	0.9510	-2.921815	0.0042	
Germany	Trend	-1.000979	0.9352	-2.341979	0.4048	$I(1)$
	Drift	-1.181070	0.6763	-2.270012	0.1852	
	No-trend and Drift	0.771795	0.8773	-2.175250	0.0297	
Italy	Trend	-2.791017	0.2062	-3.955917	0.0155	$I(1)$
	Drift	-2.158435	0.2234	-3.857598	0.0041	
	No-trend and Drift	0.700270	0.8641	-3.790517	0.0003	
Japan	Trend	-2.178911	0.4916	-2.305643	0.4238	$I(1)$
	Drift	-1.649354	0.4511	-2.352501	0.1598	
	No-trend and Drift	1.176030	0.9367	-2.019517	0.0425	
Turkey	Trend	-3.162857	0.1023	-4.159565	0.0092	$I(1)$
	Drift	-2.826638	0.0609	-4.022915	0.0026	
	No-trend and Drift	0.381803	0.7911	-3.930848	0.0002	

Table 4-15: PP Test Results for Government Expenditure to GDP

		PP test at level		PP test at first difference		Integration Order
Variables	Test Types	t-stat	p-value	t-stat	p-value	
Brazil	Trend	-1.066454	0.9263	-5.293425	0.0003	$I(1)$
	Drift	-1.561621	0.4961	-5.080676	0.0001	
	No-trend and Drift	0.612069	0.8460	-5.082479	0.0000	
China	Trend	-0.064302	0.9941	-5.499090	0.0002	$I(1)$
	Drift	-1.507784	0.5210	-4.747379	0.0003	
	No-trend and Drift	-0.064214	0.6562	-4.811317	0.0000	

France	Trend	-2.248970	0.4548	-4.131315	0.0095	$I(1)$
	Drift	-1.617324	0.4679	-4.181153	0.0015	
	No-trend and Drift	0.855731	0.8925	-4.173305	0.0001	
Germany	Trend	-1.164799	0.9089	-4.250839	0.0068	$I(1)$
	Drift	-0.954111	0.7643	-4.062880	0.0022	
	No-trend and Drift	0.562401	0.8351	-4.044838	0.0001	
Italy	Trend	-1.757959	0.7132	-4.012888	0.0132	$I(1)$
	Drift	-1.143991	0.6931	-4.033691	0.0024	
	No-trend and Drift	0.983269	0.9123	-3.967292	0.0001	
Japan	Trend	-2.568756	0.2956	-6.976213	0.0000	$I(1)$
	Drift	-1.930851	0.3164	-7.029628	0.0000	
	No-trend and Drift	0.594186	0.8421	-7.027525	0.0000	
Turkey	Trend	-2.591637	0.2855	-6.031376	0.0000	$I(1)$
	Drift	-2.616624	0.0950	-6.046120	0.0000	
	No-trend and Drift	0.153417	0.7272	-6.087704	0.0000	

Table 4-16: KPSS Test Results for Government Expenditure to GDP

		KPSS test at level		KPSS test at first difference		Integration Order
Variables	Test Types	LM-Stat	p-value	LM-Stat	p-value	
Brazil	Trend	0.130304	>0.05	0.103382	>0.10	$I(0)$
	Drift	0.893073	n.s.	0.218326	>0.10	
China	Trend	0.219076	n.s.	0.068103	>0.10	$I(0)$
	Drift	0.366045	>0.05	0.519088	>0.01	
France	Trend	0.111294	>0.10	0.051836	>0.10	$I(0)$
	Drift	0.602017	>0.01	0.052244	>0.10	
Germany	Trend	0.133394	>0.05	0.082864	>0.10	$I(0)$
	Drift	0.180464	>0.10	0.238669	>0.10	
Italy	Trend	0.094562	>0.10	0.080530	>0.10	$I(0)$
	Drift	0.430589	>0.05	0.104524	>0.10	
Japan	Trend	0.115746	>0.10	0.047787	>0.10	$I(0)$
	Drift	0.539389	>0.01	0.051054	>0.10	
Turkey	Trend	0.093176	>0.10	0.038171	>0.10	$I(0)$
	Drift	0.341208	>0.10	0.074596	>0.10	

4.3. Sustainability analysis with respect to algorithm

4.3.1. Step-wise algorithm results for Brazil

Step 1: Debt stock of Brazil is not stationary at level, but stationary at $I(1)$ with respect to ADF, PP and KPSS tests. We move to Step 2.

Step 2-b: When we test the stationarity of primary balance, ADF and PP tests give the stationarity at $I(1)$. Thus, we move to Step 4.

Step 4: Here, we look for at least one cointegration relationship between primary balance/GDP and debt stock/GDP ratios. First, we need to decide the lag order criteria and then, we need to find the appropriate VAR model in order to test for cointegration. According to the results on EViews, we have found that for Brazil, the debt stock to GDP and primary balance to GDP ratios are cointegrated. Thus, public debt is sustainable.

4.3.2. Step-wise algorithm results for China

Step 1: Debt stock of China is stationary at $I(1)$ according to three tests. We move to Step 2.

Step 2-b: Primary balance of China is stationary at $I(1)$ with respect to ADF and PP, but at $I(0)$ with respect to KPSS test. Here, we move to Step 4 to test the sustainability.

Step 4: According to the Johansen Cointegration test, there is at least one cointegration between primary surplus to GDP and debt stock to GDP ratios at differences. Thus, for China, the debt is sustainable.

4.3.3. Step-wise algorithm results for France

Step 1: When we look at the stationarity of government debt stock of France, ADF and PP tests show that debt stock is not stationary at level, but stationary at $I(1)$. We move to step 2.

Step 2-b: After the first step, we look for if primary balance is stationary. According to ADF and PP, primary balance is stationary at $I(1)$ while KPSS says it is stationary at $I(0)$. Thus, we move to Step 4.

Step 4: We look for the cointegration between primary surplus and debt stock in this step. According to the Johansen Cointegration Test, there is at least one cointegration between two variables. Thus, for France, it can be said that the debt is sustainable.

4.3.4. Step-wise algorithm results for Germany

Step 1: Debt stock is stationary at differences for Germany with respect to ADF and PP; that is, at $I(1)$. KPSS test gives the stationarity at $I(0)$. Then we move to Step 2.

Step 2-b: According to the ADF and PP, primary balance is stationary at $I(1)$ for Germany while KPSS test says it is stationary at level. Here, we move to Step 4 in order to test for sustainability.

Step 4: When we look for the cointegration between two variables, primary balance/GDP and debt stock/GDP, Johansen Cointegration test gives the following result: there is at least one cointegration between these variables. Thus, we say that government debt for Germany is sustainable.

4.3.5. Step-wise algorithm results for Italy

Step 1: ADF and PP tests shows that the debt stock is stationary at $I(1)$, while KPSS gives the stationarity at $I(0)$. Then, we move to Step 2.

Step 2-a: ADF and KPSS tests imply that the primary balance is stationary at $I(0)$ while PP test says it is stationary at $I(0)$. Thus, for the first time until now, we move to Step 3.

Step 3: Here, we look for the stationarity of government expenditure/GDP and government revenue/GDP for the cointegration. If both series are not stationary at $I(0)$ but at $I(1)$, we can perform the cointegration analysis between two series. We have already found that EXP/GDP and REV/GDP ratios are stationary at $I(1)$. Thus, we continue with the Johansen Cointegration test on them. When we perform the cointegration analysis, we conclude that there is no cointegration relationship between two series. Thus, we say that the public debt is not sustainable for Italy.

4.3.6. Step-wise algorithm results for Japan

Step 1: For Japan, all three tests give the stationarity at differences. Thus, we move to Step 2.

Step 2-b: While we have the stationarity for primary balance to GDP ratio at $I(0)$ with respect to KPSS test, we will move to the Step 4 because ADF and PP tests give the stationarity at $I(1)$.

Step 4: When we implement the cointegration test, it is concluded that there is no cointegration relationship between debt stock/GDP and primary balance/GDP ratios for Japan. Thus, debt is unsustainable for the country.

4.3.7. Step-wise algorithm results for Turkey

Step 1: For Turkey, all three tests give the stationarity of public debt/GDP at differences. Thus, we move to Step 2.

Step 2-a: As in Italian case, we have the stationarity for primary balance to GDP ratio at $I(0)$ with respect to all test. Thus, we move to Step 3.

Step 3: Here, we will look for the cointegration between government revenue and government expenditure. First, we look for stationarities of both variables. For the government revenue, series is stationary at $I(1)$ with respect to ADF and PP tests. For the government expenditure, series is again stationary at $I(1)$ with respect to same tests. When we look for the cointegration between two series, Johansen cointegration analysis gives at least one cointegration. Then, we look for the estimated co-integrating vector if it is a vector [1,-c] under the condition that 0 < c < 1. We found that the $c = 0.614891$ for Turkey, which means that public debt is sustainable for Turkey.

Looking at the results obtained in the overall framework, the following tables summarize the debt sustainability analysis for seven countries and indicate the relevant steps of the algorithm:

Table 4-17: Stationarity Analysis of DS, PS, BB, REV and EXP for Selected Seven Countries

Country	Debt stock/GDP	PS/GDP	BB/GDP	Rev/GDP	Exp/GDP
Brazil	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$
China	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$
France	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$
Germany	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(0)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$
Italy	$I(1)$; $I(1)$; $I(0)$	$I(0)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$
Japan	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$
Turkey	$I(1)$; $I(1)$; $I(1)$	$I(0)$; $I(0)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$

Table 4-18: Results of Step-wise Algorithm and Sustainability

Country	DS/GDP	PS/GDP	BB/GDP	Rev/GDP	Exp/GDP	Steps	No of Coint	State
Brazil	$I(1)$	$I(1)$	$I(1)$	$I(1)$	$I(1)$	1; 2b; 4	1(+)	Sus
China	$I(1)$	$I(1)$	$I(1)$	$I(1)$	$I(1)$	1; 2b; 4	1(+)	Sus
France	$I(1)$	$I(1)$	$I(1)$	$I(1)$	$I(1)$	1; 2b; 4	1(+)	Sus
Germany	$I(1)$	$I(1)$	$I(0)$	$I(1)$	$I(1)$	1; 2b; 4	1(+)	Sus
Italy	$I(1)$	$I(0)$	$I(1)$	$I(1)$	$I(1)$	1; 2a; 3	No Coint.	Unsus
Japan	$I(1)$	$I(1)$	$I(1)$	$I(1)$	$I(1)$	1; 2b; 4	No Coint.	Unsus
Turkey	$I(1)$	$I(0)$	$I(1)$	$I(1)$	$I(1)$	1; 2a; 3	1(+)	Sus

Note: "Sus" refers for "sustainable", and "Unsus" refers for "unsustainable.

4.4. Debt sustainability analysis of Russia with respect to non-energy government revenues

In this part of the thesis, in addition to the analysis and algorithm applied above, a different method will be applied for Russia. The primary purpose here is to test whether the debt of an energy exporting economy such as Russia is sustainable in the long run if energy revenues are negatively affected due to a war, embargo or similar reason. For this reason, the ratio of debt stock to GDP applied in the first stage of the algorithm will be tested here as well. The algorithm will be terminated under the condition that the debt becomes stationary, but the cointegration of non-energy revenues with expenses will still be tested. On the other hand, the stability of the non-energy budget balance will also be included in the analysis.

The important point here is to test the impact of a possible loss in energy revenues on the sustainability of public debt, as mentioned before. Therefore, each step in the algorithm will be carefully analyzed.

For the seven countries analyzed in the previous section, 64 observations from 2006/Q1-2021/Q4 were tested. For Russia, we will test 41 observations covering the period 2011/Q4-2021/Q4, since the official quarterly data have been shared regularly and completely since 2011/Q1. Thus, we made our annual calculations (debt stock, revenue, expense, GDP, etc.) starting from 2011/Q4.

Table 4-19: Stationarity Test Results for Debt Stock/GDP for Russia

		At level		At first difference		Integration Order
Test	Test Types	t-stat	p-value	t-stat	p-value	
ADF	Trend	-2.438940	0.3549	-3.288835	0.0839	$I(1)$
	Drift	-1.142734	0.6887	-3.450080	0.0153	
	No-trend and Drift	1.112695	0.9281	-3.051289	0.0032	
PP	Trend	-2.040169	0.5622	-4.876172	0.0017	$I(1)$
	Drift	-0.954834	0.7599	-4.997484	0.0002	
	No-trend and Drift	1.377101	0.9554	-4.840544	0.0000	

		At level		At first difference		Integration Order
Test	Test Types	LM-Stat	p-value	LM-Stat	p-value	
KPSS	Trend	0.087740	>0.10	0.059212	>0.10	$I(0)$
	Drift	0.685859	>0.01	0.059449	>0.10	

Table 4-20: Stationarity Test Results for Primary Balance/GDP for Russia

		At level		At first difference		Integration Order
Test	Test Types	t-stat	p-value	t-stat	p-value	
ADF	Trend	-2.734568	0.2293	-3.143292	0.1117	$I(0)$
	Drift	-2.657932	0.0908	-3.183742	0.0291	
	No-trend and Drift	-2.684522	0.0086	-3.241403	0.0019	
PP	Trend	-2.088843	0.5361	-2.758362	0.2205	$I(0)$
	Drift	-2.055759	0.2630	-2.745170	0.0757	
	No-trend and Drift	-2.065274	0.0387	-2.782171	0.0066	

		At level		At first difference		Integration Order
Test	Test Types	LM-Stat	p-value	LM-Stat	p-value	
KPSS	Trend	0.101136	>0.10	0.058855	>0.10	$I(0)$
	Drift	0.120481	>0.10	0.103736	>0.10	

Table 4-21: Stationarity Test Results for Non-Energy Budget Balance/GDP for Russia

		At level		At first difference		Integration Order
Test	Test Types	t-stat	p-value	t-stat	p-value	
ADF	Trend	-1.877860	0.6457	-3.317560	0.0796	$I(1)$
	Drift	-1.190017	0.6685	-3.364640	0.0191	
	No-trend and Drift	-0.613154	0.4449	-3.405468	0.0012	
PP	Trend	-2.315226	0.4165	-2.879480	0.1799	$I(1)$
	Drift	-1.158462	0.6828	-2.997945	0.0439	
	No-trend and Drift	-0.595217	0.4532	-3.149545	0.0024	

		At level		At first difference		Integration Order
Test	Test Types	LM-Stat	p-value	LM-Stat	p-value	
KPSS	Trend	0.106976	>0.10	0.100549	>0.10	$I(0)$
	Drift	0.484641	>0.01	0.145463	>0.10	

Table 4-22: Stationarity Test Results for Non-Energy Government Revenue/GDP for Russia

		At level		At first difference		Integration Order
Test	Test Types	t-stat	p-value	t-stat	p-value	
ADF	Trend	-2.602304	0.2815	-3.638698	0.0396	$I(1)$
	Drift	-0.198574	0.9303	-3.831850	0.0057	
	No-trend and Drift	1.654879	0.9741	-3.351339	0.0014	
PP	Trend	-2.906831	0.1713	-5.525424	0.0003	$I(1)$
	Drift	-0.106682	0.9417	-5.578578	0.0000	
	No-trend and Drift	1.524347	0.9664	-5.323158	0.0000	

		At level		At first difference		Integration Order
Test	Test Types	LM-Stat	p-value	LM-Stat	p-value	
KPSS	Trend	0.148015	>0.01	0.091450	>0.10	$I(1)$
	Drift	0.721746	>0.01	0.181595	>0.10	

Table 4-23: Stationarity Test Results for Government Expenditure/GDP for Russia

		At level		At first difference		Integration Order
Test	Test Types	t-stat	p-value	t-stat	p-value	
ADF	Trend	-2.716641	0.2366	-2.930113	0.1666	$I(1)$
	Drift	-2.693246	0.0856	-2.998107	0.0455	
	No-trend and Drift	0.586102	0.8381	-2.935539	0.0046	
PP	Trend	-2.225955	0.4629	-3.067621	0.1281	$I(1)$
	Drift	-2.151714	0.2265	-3.105091	0.0344	
	No-trend and Drift	0.295234	0.7664	-3.152984	0.0024	

		At level		At first difference		Integration Order
Test	Test Types	LM-Stat	p-value	LM-Stat	p-value	
KPSS	Trend	0.082996	>0.10	0.053969	>0.10	$I(0)$
	Drift	0.201649	>0.10	0.058763	>0.10	

Step 1: According to ADF and PP tests, we concluded that the debt stock for Russia between 2011/Q4-2021/Q4 is not stationary at $I(0)$, but at $I(1)$. Although KPSS test suggests the opposite, we move to the second step in our algorithm.

Step 2-a: Stationarity analyzes of the primary balance tells us Russia's primary balance/GDP ratio is stationary at $I(0)$ with respect to ADF, PP and KPSS. Thus, according to the algorithm, we move to the Step 3, which is the cointegration analysis between public revenues and public expenditures.

Step 3: Here, we look for at least one cointegration between total expenditures/GDP and total revenues/GDP. For Russian case, we made a modification in the algorithm in order to see whether the country’s debt sustainability depends on energy revenues or not. To do that, we used non-energy government revenues instead of total government revenues. As can be seen from Table 4-22 and Table 4-23, both series are stationary at $I(1)$. Hence, we can continue with the cointegration analysis.

After performing the Johansen Cointegration test, we saw that there are at least one cointegration between non-energy government revenue and government expenditure (please see Appendix). Moreover, the estimated co-integrating vector condition holds; that is, $0 < c < 1$. Thus, we conclude that Russia's public debt is sustainable even when the country is deprived of energy revenues.

Table 4-24: Stationarity Analysis of Russia

Country	Debt stock/GDP	PS/GDP	Non-energy BB/GDP	Non-energy Rev/GDP	Exp/GDP
Russia	$I(1)$; $I(1)$; $I(0)$	$I(0)$; $I(0)$; $I(0)$	$I(1)$; $I(1)$; $I(0)$	$I(1)$; $I(1)$; $I(1)$	$I(1)$; $I(1)$; $I(0)$

Table 4-25: Result of Step-wise Algorithm for Russia

Country	DS/GDP	PS/GDP	Non-energy BB/GDP	Non-energy Rev/GDP	Exp/GDP	Steps	No of Coint	State
Russia	$I(1)$	$I(0)$	$I(1)$	$I(1)$	$I(1)$	1; 2a; 3	1(+)	Sus.

5. CONCLUSION AND DISCUSSION

The global economic and financial crisis of 2008 and 2020 had many consequences, particularly in terms of the public debt of developing and developed countries. As a result of the analysis, although it was concluded that the public debt of the selected countries except Italy and Japan was sustainable, the stationary structure of public revenues and expenditures appears to have begun to deteriorate after 2008 and 2020 crises comparing the same algorithm and methods used between 1999-2010 and the period between 2006-2021 which is used in this thesis. For example, although it was concluded that Italy's public debt was sustainable until the 2010s, the crises experienced in the last ten years and the sharp upward increase in the public debt stock reveal that this debt cannot be covered with public income-expenses. In addition, it is observed that Japan is in an unsustainable public debt in parallel with the literature.

On the other hand, it is seen that the sustainability of public debt is no longer a danger for developing countries, but for developed countries. The fact that two of the eight countries included in the analysis are in unsustainable debt and that these two countries are G-7 countries (Japan and Italy), raises question marks. Developing countries, which have managed to control and tighten their public finances with international agreements and criterions, follow a strong public debt policy.

As a result of the changes made in the algorithm applied for Russia, it has been analyzed whether Russia can maintain its public debt stock, especially despite the energy and natural gas embargoes applied with the recent Ukraine war crisis. While applying this analysis, public revenues are handled in two ways as non-energy and energy revenues. Even in a utopia where energy revenues are zero, it has been observed that Russia's public debt is sustainable. Even surprisingly, it is observed that the share of Russia's energy revenues in GDP has decreased by one percent in recent years, and the share of non-energy revenues in GDP has increased. In this way, it is seen that Russia does not have to maintain its public debt only with the energy sector.

Here, it is necessary to open a separate parenthesis for Turkey. Debt/GDP ratio and budget deficit/GDP ratio criteria, which are one of the most important and solid economic policies in the European Union membership and accession period, have been met strongly by Turkey for many years. So much so that many European Union members do not comply with these criteria, which are called the Maastricht Criteria, for many years and continue their economic policies with around one hundred percent overdue public debt stock/GDP ratios. It would not be wrong to say that especially the “Build-Operate-Transfer Models” implemented by Turkish Government and the transfer of public investments to the private sector in Turkey contribute to both the country's public debt being at a level in line with the Maastricht Criteria and not having a large budget deficit.

Finally, in this study, it is aimed that the algorithm change made for Russia can be applied in oil exporting countries such as the Gulf Countries in future studies. In this way, it will be possible to understand whether these countries, which obtain most of their investments from natural resources, have a strong fiscal policy that will enable them to take an action against a possible energy and oil crisis.

The world energy agenda is shifting towards renewable energy. Public institutions and private companies are also working to protect the ecosystem from increasing carbon emissions, and this new system brings many challenges to overcome. Renewable energy, recently recognized as the “mainstream” energy source, is now becoming the preferred choice. A strong combination of trends and demand trends evident in many developed and developing countries around the world is helping solar and wind compete with traditional sources and win the race. High investments in renewable energy sources in recent years are also a result of this. Although petroleum is one of the energy sources that are currently used and most harmful to the environment, the fact that natural gas causes relatively less carbon emissions and environmental pollution, shifts the demand in this direction. For example, according to a study by Hafezi et al. (2021), the future of natural gas is brighter in the electric power sector, as it has lower emissions than coal or liquid petroleum fuel. Moreover, they say that global demand for natural gas will grow under various scenarios is consistent with the majority of the Energy Information Administration's projections. Although the fluctuations in oil prices in recent years have caused serious imbalances in the economies of oil exporting countries, the fact that Russia is the world's largest natural gas producer and exporter in addition to oil strengthens the country's hand in the energy market. The fact that European countries mostly buy natural gas from Russia and, as mentioned earlier, the demand shifts towards natural gas along with renewable energy sources, which will enable Russia to have an even more important position in the energy sector in the long run.

Although it is easy to access the relevant data of the Euro Zone and OECD countries, it is not possible to say the same especially for countries such as China and Russia, whose democracies and transparency might be controversial. In addition, the fact that the Russian datasets have been published in full, especially since 2011, prevents the studies to be carried out for a long period of time. On the other hand, the fact that it is not possible to access every data set from official sources for China and the data obtained from public datasets are created by using approximate calculation methods can be considered as a limitation in terms of study.

5.1. Fiscal Policy and the Post-Covid-19 Recovery

In the post-Covid era, the sustainability of public debt has become one of the main goals of almost all countries and has been the focus of public finance studies. According to the report published by Euler Herms in 2021, the biggest global recession after the Second World War was due to the Covid crisis. It is said that the unprecedented support packages that came into effect with the Covid-19 crisis caused a significant deterioration in public finances. The report states that the increased debt burden due to Covid should be reduced with medium and long-term plans, otherwise many global bankruptcies may occur.

The European Union, on the other hand, published its study titled "European Semester Autumn Package" in 2021, which includes recommendations for the economic policies of member countries. In this study, it was stated that while the Eurozone countries were recommended to implement supportive fiscal policies in 2021, the policies implemented by the member countries due to the epidemic should be “temporary and target-oriented”, suitable for the conditions of the country. In the study, it was emphasized that countries such as Italy, France, Greece, Portugal and Spain, which had high public debt before the epidemic, should pay attention to sustainability in their budget expenditures. While it is stated that some budget expenditures planned by countries such as France, Italy and Lithuania do not seem temporary and are not balanced, it is said that the public debt in these countries will deviate from the sustainability target in the long run.

Especially European Union member countries advocate changes in fiscal rules with the "new period" after Covid. This initiative, led by Italy and France, states that the pandemic process is well managed in terms of macroeconomics, but there has been an increase in borrowing, especially due to investments made in the field of health, support packages and other factors that increase public expenditures. As a solution, it is argued that structural reforms that increase growth and new fiscal criteria should be implemented instead of solutions such as higher taxes and savings in social expenditures (Fraga, 2022). On the other hand, it can be said that some of Fraga's suggestions for Brazil are important not only for this country, but also for all countries with a high public debt/GDP ratio in the post-Covid period:

- Public debt should be sized to allow for access to financing at a reasonable cost, in case a fiscal expansion is needed.
- The primary balance should be set so that, in normal times, the debt-to-GDP ratio remains stable.
- If for whatever reason the debt ratio deviates from its target level, the primary balance should be adjusted to gradually bring the debt ratio back to the target.
- The average debt maturity should be long, with limited concentration at the short end. This would match the long-term horizons ought to have. It would also lower the risk of run-like financial or currency crises, driven by sudden stops in financing.

The COVID-19 pandemic has led to a massive expansion in the size and scope of government participation in public life. Not only have governments around the world exercised massive emergency powers, but policy makers have tried to offset some of the resulting collapse in private sector economic activity by unleashing a massive surge of government spending that would cause public debt to rise. In addition, as a result of this financial support, the high inflation problem, which started to take effect all over the world from the end of 2021, is also making its impact felt in

2022. The highest inflation figures of recent years have been seen in Europe and America. Here, in the medium term, it is foreseen that the borrowing costs of the governments will increase and the public debt ratios will deteriorate further, as the central banks increase the interest rates. Here, the study published by Chatham House in 2021 makes critical recommendations for debt sustainability in the post-Covid era:

- Maintain fiscal support for economies until recoveries are entrenched – and, by extension, resist calls to take immediate steps to tackle rising public debt burdens.
- Withdraw support gradually once recoveries are entrenched, with the pace of such withdrawal calibrated to the recovery in private sector demand.
- Adapt fiscal support throughout the recovery phase. In particular, move from providing blanket assistance across the economy to focusing on sectors most heavily affected by the pandemic. Public investment should be prioritized as the recovery builds momentum.
- Allow the medium-term transition to a post-COVID-19 economy to be determined as much as possible by market forces. The role of government should be limited to providing a platform for the transition, through investment in physical and human capital and the correction of market failures.
- Coordinate policy through international institutions, with a particular focus on ensuring that trade imbalances are not allowed to re-emerge.

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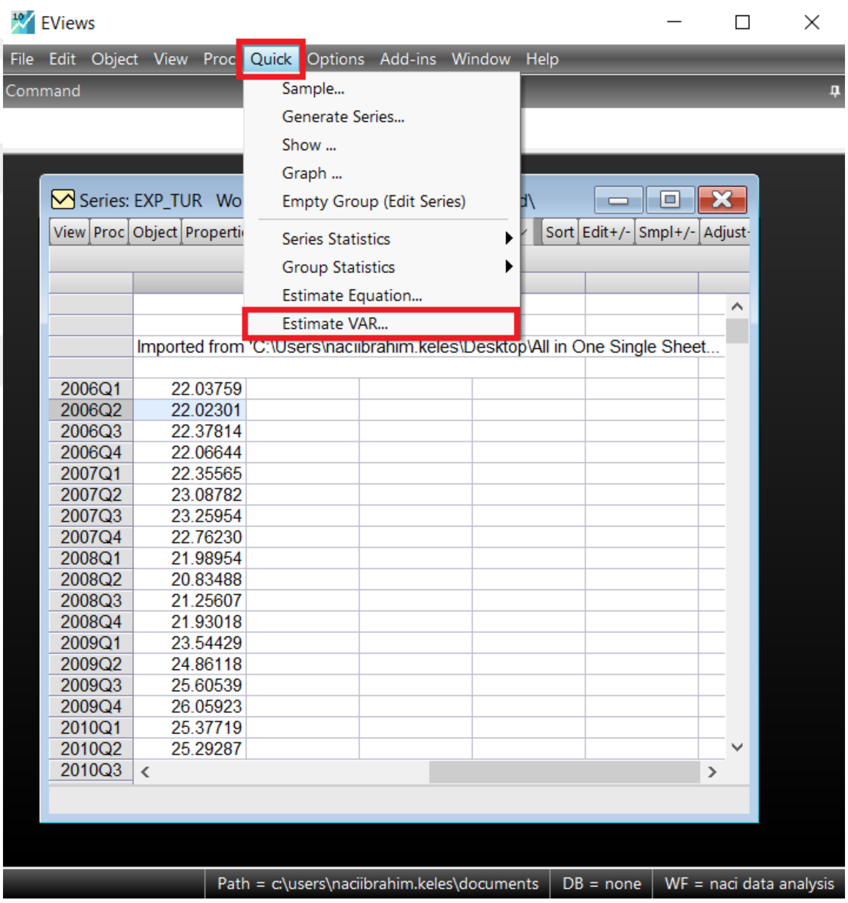
APPENDIX

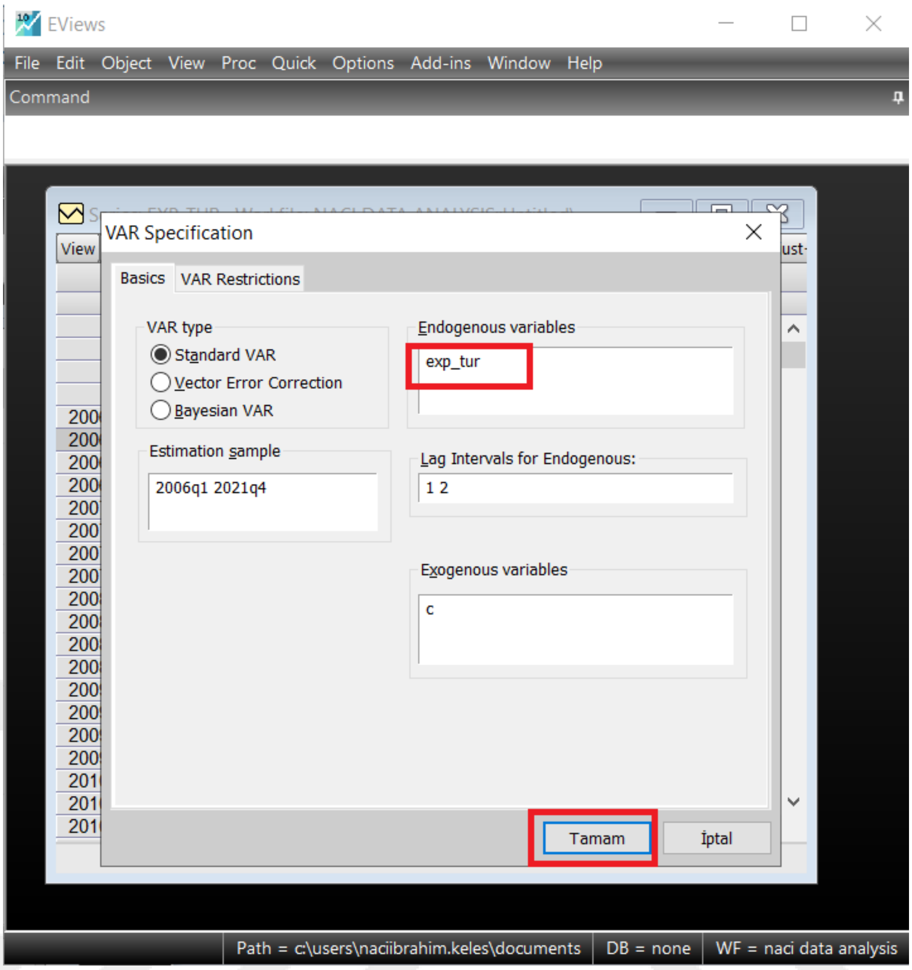
Lag Length Selection for Augmented Dickey Fuller (ADF) Tests on EViews

In order to apply the ADF test, a separate lag length analysis was performed for each data set. Appropriate lag lengths found as a result of these analyzes were applied in EViews, which is the main criterion determined in ADF stationarity tests.

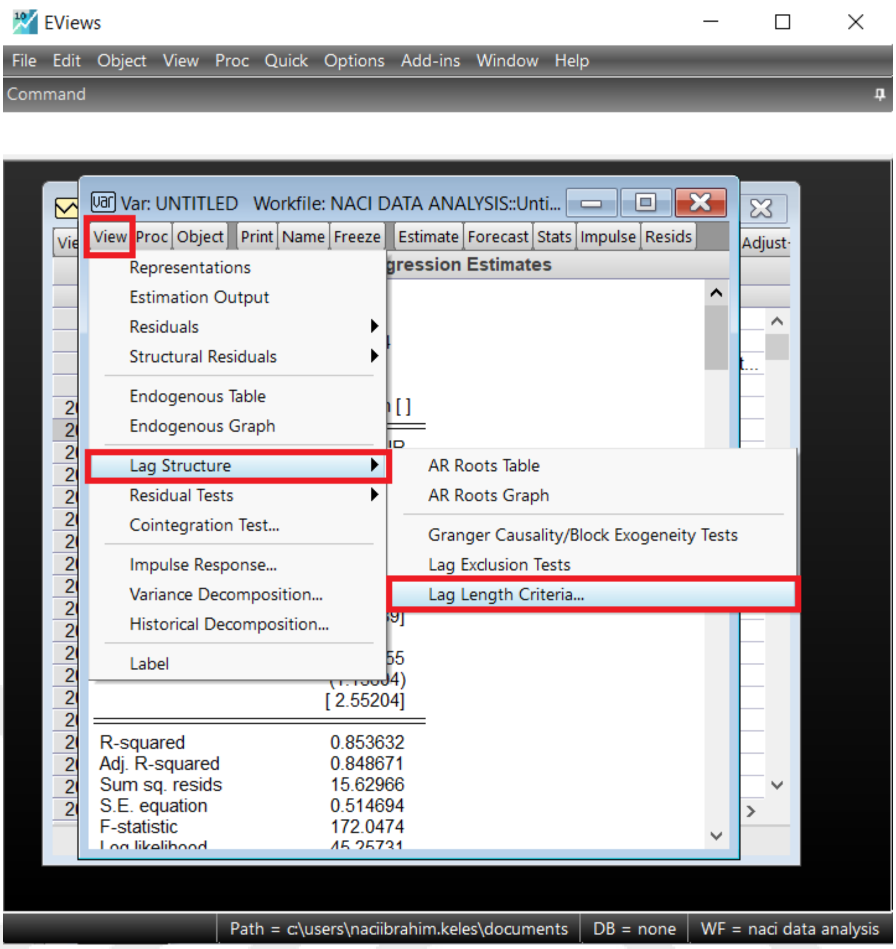
First, data is added to EViews by appropriate type and time range. Then, click the "Quick" button on the top panel and select the "Estimate VAR..." option.



The priority to be considered in the "VAR specification" window is the accuracy of the "Estimation sample" part. If this is correct, write the name of the data set that is wanted to be tested for the stationarity under "Endogenous variables" panel, and click OK.



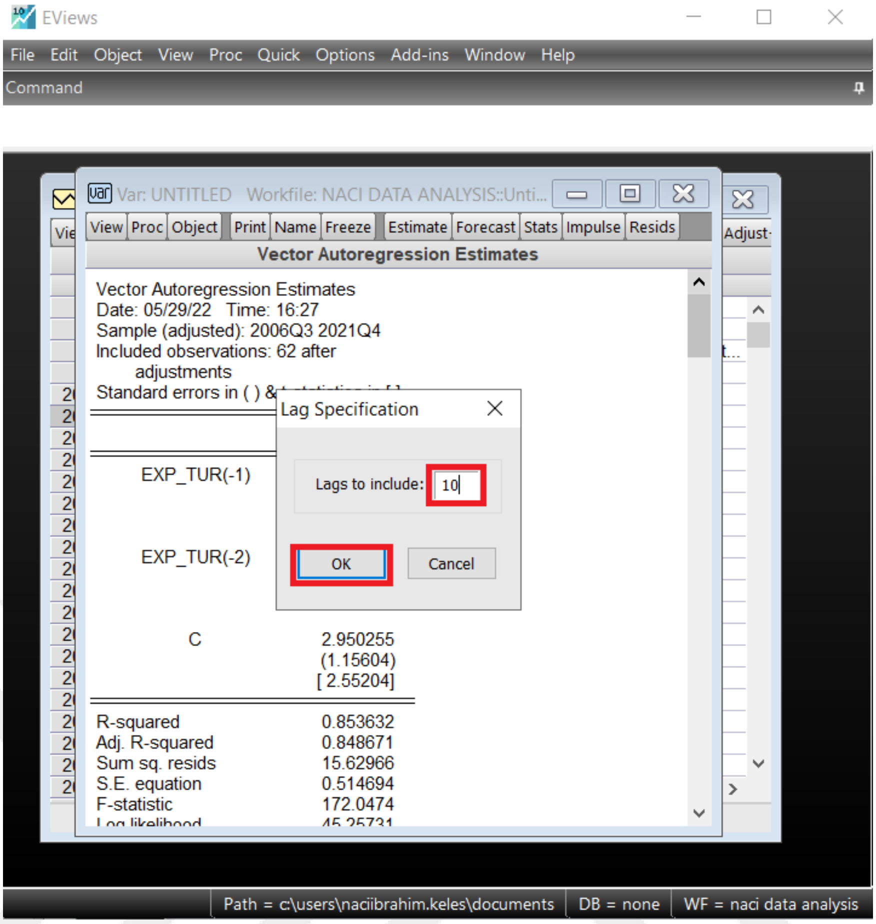
Click the "View" option from the top left panel of the new window that opens, then click the "Lag structure" button and click the "Lag Length Criteria..." button from the new menu.



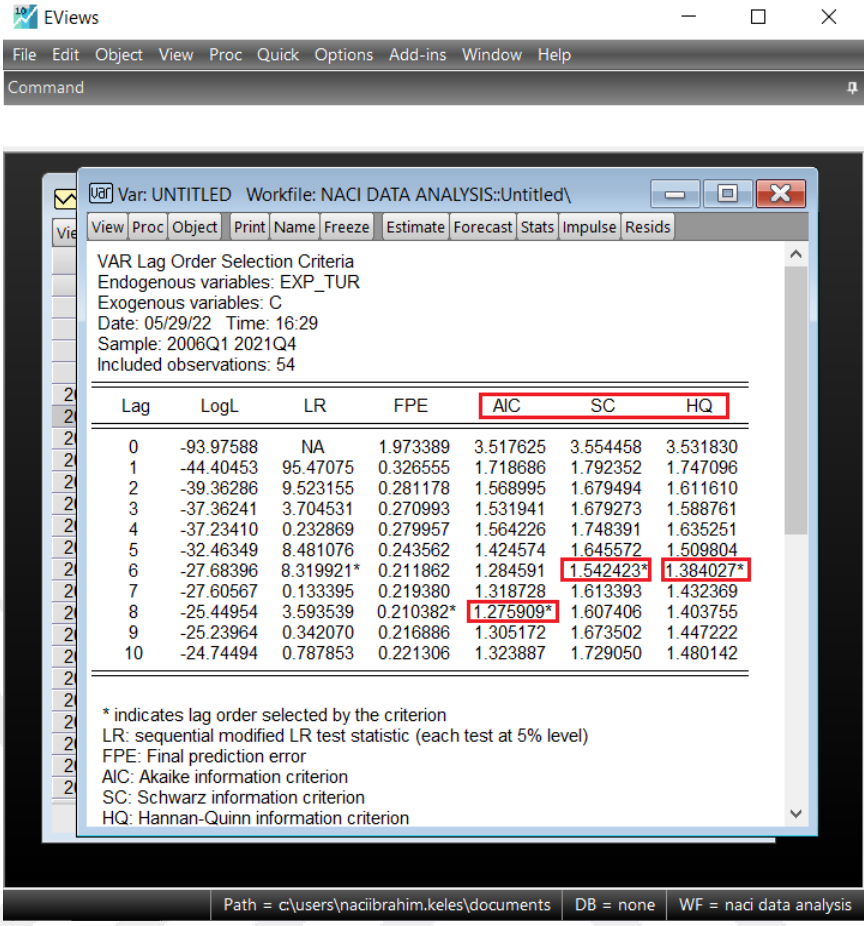
In the "Lags to include" field from the small window, an appropriate lag is written according to the type and length of the data set. The lag length to be used here can be chosen according to the formula proposed by Schwert (1989):

$$\rho_{max} = \left[12.\left(\frac{T}{100} \right)^{1/4} \right]$$

where T is the number of observations. Here, in our analysis for selected variable, there are 65 observations. According to the formula, we can use approximately ten lags for the data set.



Schwarz, Akaike and Hannan Quinn information criteria can be considered for lag length. If these three information criteria give a common lag length, the selection can be made accordingly. If two criteria give the same lag length and one criterion differs from the others, the lag length given by the majority can be taken into account. If all three give different results, the priority is the Schwarz criterion.

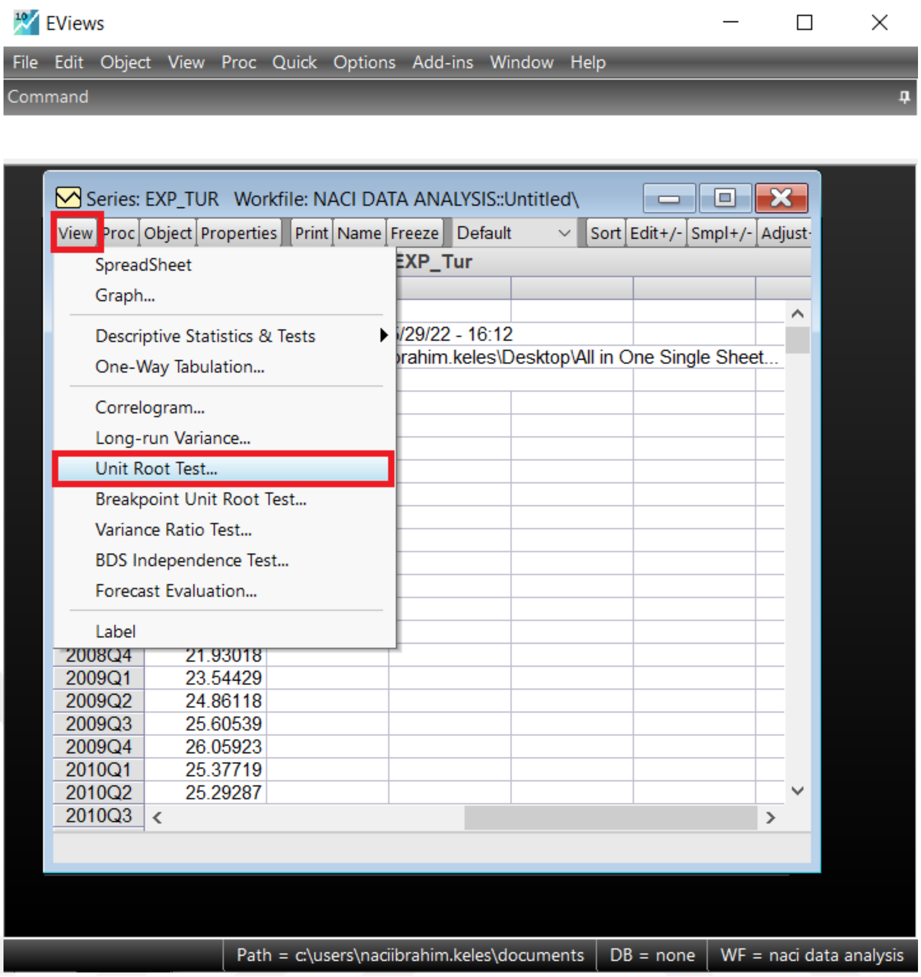


VAR Lag Order Selection Criteria
Endogenous variables: EXP_TUR
Exogenous variables: C
Date: 05/29/22 Time: 16:29
Sample: 2006Q1 2021Q4
Included observations: 54

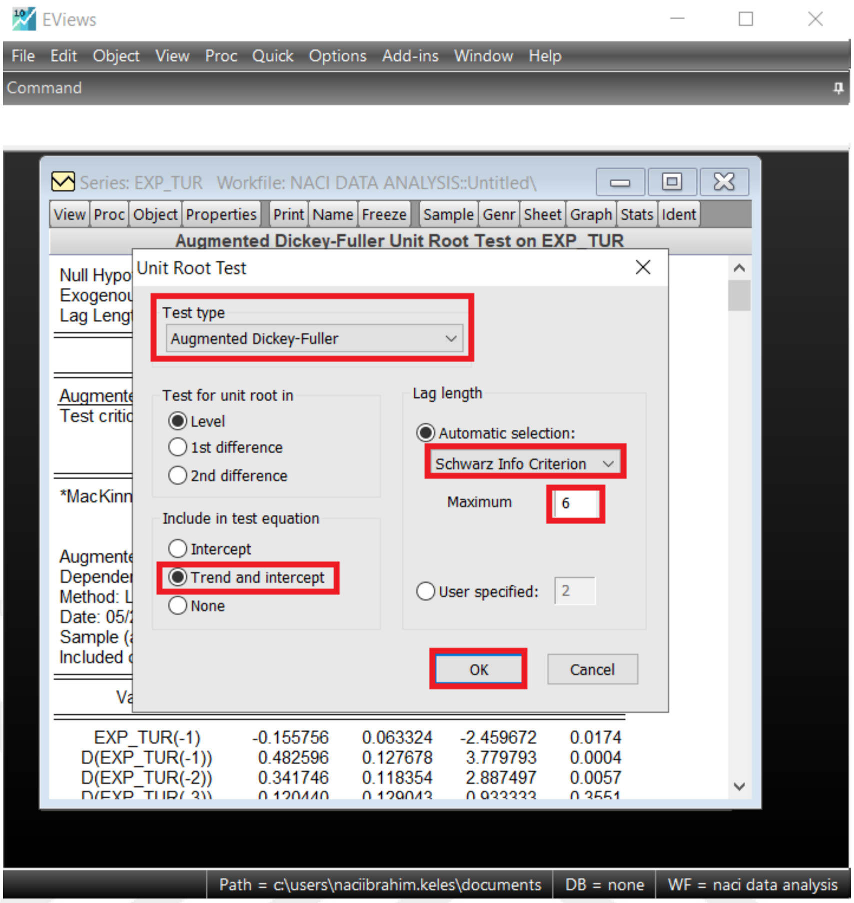
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-93.97588	NA	1.973389	3.517625	3.554458	3.531830
1	-44.40453	95.47075	0.326555	1.718686	1.792352	1.747096
2	-39.36286	9.523155	0.281178	1.568995	1.679494	1.611610
3	-37.36241	3.704531	0.270993	1.531941	1.679273	1.588761
4	-37.23410	0.232869	0.279957	1.564226	1.748391	1.635251
5	-32.46349	8.481076	0.243562	1.424574	1.645572	1.509804
6	-27.68396	8.319921*	0.211862	1.284591	1.542423*	1.384027*
7	-27.60567	0.133395	0.219380	1.318728	1.613393	1.432369
8	-25.44954	3.593539	0.210382*	1.275909*	1.607406	1.403755
9	-25.23964	0.342070	0.216886	1.305172	1.673502	1.447222
10	-24.74494	0.787853	0.221306	1.323887	1.729050	1.480142

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Now that the appropriate lag length has been found, the next step is to test for stationarity. Here, by going to the main window, the data set to which the test will be applied is opened. Click the "View" button from the top left panel and select "Unit root test...".



In the window that opens, the test type automatically appears as Augmented Dickey Fuller. In order to perform the first stationarity test according to "Trend and Intercept", the appropriate criteria and lag length found in the previous stage are selected from the right side and the "OK" button is clicked. ADF test is now completed.



Cointegration test results on EViews

In order to perform Johansen Cointegration Tests on EViews, there are three steps:

- Selecting the best possible lag order between two variables: we create a VAR model and then, perform a lag order selection analysis.
- Looking for appropriate model by Johansen Cointegration Test Summary: we compare five models and select the lowest information criteria.
- Performing cointegration tests with respect to selected lag and model

Brazil:

Table A-1: Lag-order selection for PB/GDP and DS/GDP ratios for Brazil

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-322.1881	NA	561.8423	12.00697	12.08063	12.03538

1	-187.5719	254.2750	4.454009	7.169330	7.390328	7.254560
2	-169.9735	31.93790	2.693910*	6.665684	7.034014*	6.807735*
3	-169.0776	1.559496	3.027785	6.780651	7.296314	6.979522
4	-166.7248	3.921291	3.229035	6.841660	7.504654	7.097351
5	-157.7404	14.30853*	2.698934	6.657051*	7.467378	6.969563
6	-155.3489	3.631451	2.886809	6.716628	7.674287	7.085959
7	-154.7325	0.890437	3.307420	6.841944	7.946935	7.268096
8	-148.5759	8.436821	3.097454	6.762070	8.014393	7.245042
9	-147.7525	1.067353	3.549418	6.879722	8.279378	7.419515
10	-146.1677	1.936987	3.974207	6.969174	8.516161	7.565786

Here, we selected the lag order as 2.

Table A-2: Johansen Cointegration Test Summary for Brazil (PB-DS)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	1	1	1	1
Max-Eig	0	1	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or	No Intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No Trend	No Trend	No Trend	Trend	Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-196.9381	-196.9381	-195.6568	-195.6568	-193.0552
1	-192.0070	-187.6709	-186.6820	-182.7495	-180.4001
2	-191.0531	-186.6608	-186.6608	-179.2239	-179.2239
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	6.719283	6.719283	6.742847	6.742847	6.723121
1	6.688753	6.579372	6.579738	6.483589	6.439347*
2	6.788625	6.710191	6.710191	6.531930	6.531930
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	6.996119	6.996119	7.088891	7.088891	7.138374
1	7.104006	7.029231	7.064201	7.002656	6.993019*
2	7.342297	7.333072	7.333072	7.224020	7.224020

Here, we select the five model: quadratic, intercept and trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-3: Cointegration test results for Brazil (PB-DS)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.339607	27.66264	18.39771	0.0019
At most 1	0.037831	2.352467	3.841466	0.1251

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.339607	25.31017	17.14769	0.0026
At most 1	0.037831	2.352467	3.841466	0.1251

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PB_BRA	DS_BRA
-1.062008	-0.081620
-0.284724	-0.183681

Unrestricted Adjustment Coefficients (alpha):

D(PB_BRA)	0.523497	-0.072978
D(DS_BRA)	-0.083475	0.311895

1 Cointegrating Equation(s): Log likelihood -180.4001

Normalized cointegrating coefficients (standard error in parentheses)	
PB_BRA	DS_BRA
1.000000	0.076854
	(0.02792)
Adjustment coefficients (standard error in parentheses)	
D(PB_BRA)	-0.555958
	(0.11862)
D(DS_BRA)	0.088651
	(0.23236)

China:

Table A-4: Lag-order selection for PB/GDP and DS/GDP ratios for China

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-193.2272	NA	99.42315	10.27511	10.36130	10.30578
1	-97.08596	177.1023*	0.779176*	5.425577*	5.684143*	5.517573*
2	-95.37052	2.979437	0.880850	5.545817	5.976761	5.699143
3	-93.71842	2.695536	1.002147	5.669391	6.272712	5.884048
4	-89.42702	6.550036	0.996640	5.654054	6.429752	5.930041
5	-88.40450	1.453047	1.184216	5.810763	6.758839	6.148082
6	-85.85615	3.353101	1.308511	5.887166	7.007619	6.285814
7	-85.47719	0.458738	1.636632	6.077747	7.370578	6.537726
8	-80.06087	5.986452	1.589783	6.003204	7.468413	6.524514
9	-76.70678	3.354092	1.748345	6.037199	7.674785	6.619840
10	-71.73137	4.451686	1.800797	5.985862	7.795825	6.629833

Here, we selected the lag order as 1.

Table A-5: Johansen Cointegration Test Summary for China (PB-DS)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	1	0	2
Max-Eig	1	1	1	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-122.3030	-122.3030	-119.9218	-119.9218	-118.6340
1	-115.1071	-113.5115	-112.4313	-112.3782	-112.3780
2	-114.2673	-112.0092	-112.0092	-108.7475	-108.7475
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	5.491435	5.491435	5.474862	5.474862	5.505826
1	5.352482	5.326589	5.323101*	5.364269	5.407741
2	5.489882	5.478662	5.478662	5.423806	5.423806
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	5.650447*	5.650447*	5.713381	5.713381	5.823850
1	5.670506	5.684366	5.720632	5.801552	5.884777
2	5.966919	6.035205	6.035205	6.059855	6.059855

Here, we select the first model: no intercept and no trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-6: Cointegration test results for China (PB-DS)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.277959	15.82522	15.49471	0.0446
At most 1	0.018185	0.844220	3.841466	0.3582

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.277959	14.98100	14.26460	0.0385
At most 1	0.018185	0.844220	3.841466	0.3582

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PB_CHN	DS_CHN
1.761538	0.125078
-0.577082	-0.117195

Unrestricted Adjustment Coefficients (alpha):

D(PB_CHN)	-0.108545	-0.047931
D(DS_CHN)	-0.901022	0.122087

1 Cointegrating Equation(s): Log likelihood -112.4313

Normalized cointegrating coefficients (standard error in parentheses)

PB_CHN	DS_CHN
1.000000	0.071005
	(0.01023)

Adjustment coefficients (standard error in parentheses)

D(PB_CHN)	-0.191207
	(0.10768)
D(DS_CHN)	-1.587184
	(0.46515)

France:

Table A-7: Lag-order selection for PB/GDP and DS/GDP ratios for France

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-309.0369	NA	345.2058	11.51989	11.59355	11.54830
1	-153.6782	293.4553	1.269323	5.914009	6.135007	5.999239

2	-143.5897	18.30874	1.013915	5.688509	6.056839	5.830560
3	-117.2612	45.83119	0.444283	4.861526	5.377188*	5.060396
4	-112.4130	8.080307	0.431985	4.830111	5.493106	5.085802
5	-106.2914	9.749199	0.401455	4.751534	5.561861	5.064045
6	-96.80486	14.40551*	0.330170	4.548328	5.505987	4.917660
7	-90.95812	8.445283	0.311659*	4.479931*	5.584922	4.906082*
8	-88.77327	2.994058	0.338128	4.547158	5.799481	5.030130
9	-87.35077	1.843978	0.378963	4.642621	6.042277	5.182413
10	-86.21270	1.390977	0.431395	4.748619	6.295606	5.345231

Here, we selected the lag order as 7.

Table A-8: Johansen Cointegration Test Summary for France (PB-DS)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	1	1	1
Max-Eig	0	1	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-111.0906	-111.0906	-105.7575	-105.7575	-102.9191
1	-106.4295	-98.97395	-95.69292	-91.94948	-90.50700
2	-104.5464	-94.55551	-94.55551	-88.87476	-88.87476
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	4.967522	4.967522	4.848483	4.848483	4.818539
1	4.943911	4.713355	4.631890	4.533910	4.518107*
2	5.019516	4.734125	4.734125	4.602670	4.602670
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	5.980198	5.980198	5.933493	5.933493	5.975883
1	6.101255	5.906866	5.861568	5.799755*	5.820119
2	6.321528	6.108471	6.108471	6.049350	6.049350

We select the fifth model: quadratic, intercept and trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-9: Cointegration test results for France (PB-DS)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.358078	28.08867	18.39771	0.0016
At most 1	0.056628	3.264484	3.841466	0.0708

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.358078	24.82419	17.14769	0.0032
At most 1	0.056628	3.264484	3.841466	0.0708

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PB_FRA	DS_FRA
-1.528264	0.259124
-1.111890	-0.568496

Unrestricted Adjustment Coefficients (alpha):

D(PB_FRA)	0.078757	-0.087361
D(DS_FRA)	0.251122	0.386571

1 Cointegrating Equation(s): Log likelihood -90.50700

Normalized cointegrating coefficients (standard error in parentheses)

PB_FRA	DS_FRA
1.000000	-0.169555
	(0.08588)

Adjustment coefficients (standard error in parentheses)

D(PB_FRA)	-0.120362
	(0.09347)
D(DS_FRA)	-0.383781
	(0.40597)

Germany:

Table A-10: Lag-order selection for PB/GDP and DS/GDP ratios for Germany

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-295.7618	NA	211.1290	11.02821	11.10188	11.05663
1	-150.1789	274.9900	1.115026	5.784403	6.005401	5.869633
2	-137.1815	23.58777	0.799697	5.451168	5.819498	5.593219
3	-128.8118	14.56961	0.681475	5.289324	5.804987*	5.488195*
4	-126.9503	3.102500	0.740116	5.368528	6.031523	5.624219
5	-123.8725	4.901668	0.769888	5.402684	6.213011	5.715195
6	-121.2397	3.997835	0.816154	5.453324	6.410983	5.822655
7	-113.7442	10.82695	0.724758	5.323858	6.428849	5.750010
8	-110.4471	4.518186	0.754578	5.349893	6.602216	5.832865
9	-102.2591	10.61404*	0.658259*	5.194783*	6.594438	5.734575
10	-100.4205	2.247161	0.730144	5.274835	6.821823	5.871447

Here we select the lag order as 3.

Table A-11: Johansen Cointegration Test Summary for Germany (PB-DS)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	1	1	1
Max-Eig	1	1	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-148.2872	-148.2872	-148.1925	-148.1925	-146.6142
1	-137.1518	-137.1370	-137.1354	-134.3708	-133.8130
2	-137.1497	-136.0774	-136.0774	-132.3285	-132.3285
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	5.342907	5.342907	5.406415	5.406415	5.420474
1	5.105059*	5.137899	5.171181	5.112361	5.127100
2	5.238325	5.269247	5.269247	5.210952	5.210952
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	5.761776	5.761776	5.895096	5.895096	5.978966
1	5.663551*	5.731297	5.799485	5.775570	5.825215
2	5.936440	6.037174	6.037174	6.048689	6.048689

We select the first model: no intercept and no trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-12: Cointegration test results for Germany (PB-DS)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.310081	22.27494	12.32090	0.0008
At most 1	6.76E-05	0.004054	4.129906	0.9583

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**

None *	0.310081	22.27088	11.22480	0.0004
At most 1	6.76E-05	0.004054	4.129906	0.9583

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PB_GER	DS_GER
-0.890505	0.016454
-0.066212	0.015468

Unrestricted Adjustment Coefficients (alpha):

D(PB_GER)	0.244614	0.001966
D(DS_GER)	0.198529	-0.011376

1 Cointegrating Equation(s): Log likelihood -137.1518

Normalized cointegrating coefficients (standard error in parentheses)

PB_GER	DS_GER
1.000000	-0.018478
	(0.00327)

Adjustment coefficients (standard error in parentheses)

D(PB_GER)	-0.217830
	(0.05336)
D(DS_GER)	-0.176791
	(0.17312)

Italy:

Table A-13: Lag-order selection for EXP/GDP and REV/GDP ratios for Italy

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-185.5562	NA	3.563633	6.946526	7.020192	6.974936
1	-64.38996	228.8696	0.046491	2.607036	2.828034	2.692266
2	-41.65874	41.25295	0.023251	1.913287	2.281617*	2.055337*
3	-36.42739	9.106438	0.022256	1.867681	2.383343	2.066552

4	-34.74930	2.796804	0.024336	1.953678	2.616673	2.209369
5	-28.51872	9.922785	0.022525	1.871064	2.681390	2.183575
6	-21.34673	10.89080*	0.020183	1.753582	2.711241	2.122914
7	-15.80121	8.010190	0.019266	1.696341	2.801332	2.122493
8	-11.22761	6.267527	0.019132*	1.675097*	2.927420	2.158069
9	-7.319600	5.065938	0.019557	1.678504	3.078159	2.218296
10	-3.486253	4.685202	0.020148	1.684676	3.231664	2.281288

Here, we select the Schwarz Criteria (2 lags).

Table A-14: Johansen Cointegration Test Summary for Italy (EXP-REV)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	0	0	0	0
Max-Eig	0	0	0	0	0

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or	No Intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No Trend	No Trend	No Trend	Trend	Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-54.61113	-54.61113	-53.79117	-53.79117	-53.31842
1	-49.36297	-48.31341	-47.78955	-47.76530	-47.48404
2	-48.75077	-46.99761	-46.99761	-44.73157	-44.73157
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	2.052824	2.052824	2.091514	2.091514	2.141587
1	2.011901	2.010276*	2.025887	2.057879	2.081444
2	2.122976	2.131069	2.131069	2.122346	2.122346
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	2.329660*	2.329660*	2.437559	2.437559	2.556841
1	2.427154	2.460134	2.510350	2.576946	2.635116
2	2.676648	2.753950	2.753950	2.814436	2.814436

The table above shows us that any model does not imply any cointegration relationship between data. Thus, we cannot select any model in order to perform cointegration test. In other words, no cointegration is concluded found between government revenue/GDP and government expenditure/GDP. Even we continue with the appropriate information criteria model, Model 2 with intercept but no trend, we have the following result:

Table A-15: Cointegration test results for Italy (EXP-REV)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.186559	15.22704	20.26184	0.2136
At most 1	0.042224	2.631606	9.164546	0.6515

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.186559	12.59543	15.89210	0.1540
At most 1	0.042224	2.631606	9.164546	0.6515

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

EXP_ITA	REV_ITA	C
0.592176	-1.001142	17.33768
0.311570	0.231360	-26.91691

Unrestricted Adjustment Coefficients (alpha):

D(EXP_ITA)	-0.100662	-0.101663
D(REV_ITA)	0.085171	-0.040355

1 Cointegrating Equation(s):	Log likelihood	-48.31341

Normalized cointegrating coefficients (standard error in parentheses)

EXP_ITA	REV_ITA	C
1.000000	-1.690616	29.27793
	(0.41820)	(19.4571)

Adjustment coefficients (standard error in parentheses)

D(EXP_ITA)	-0.059610
	(0.04254)
D(REV_ITA)	0.050436
	(0.02097)

Japan:

Table A-16: Lag-order selection for PB/GDP and DS/GDP ratios for Japan

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-360.2691	NA	2302.219	13.41737	13.49104	13.44578
1	-223.9707	257.4526	17.14843	8.517432	8.738430*	8.602662
2	-216.9009	12.83028	15.31829*	8.403737*	8.772068	8.545788*
3	-214.7739	3.702660	16.44934	8.473106	8.988768	8.671976
4	-213.3940	2.299818	18.18633	8.570147	9.233141	8.825838
5	-206.2138	11.43502*	16.25124	8.452364	9.262691	8.764875
6	-205.1632	1.595356	18.26753	8.561601	9.519260	8.930933
7	-203.4819	2.428652	20.11972	8.647476	9.752467	9.073628
8	-199.1819	5.892584	20.18371	8.636365	9.888689	9.119337
9	-195.7557	4.441330	21.00330	8.657618	10.05727	9.197410
10	-194.2023	1.898587	23.54433	8.748233	10.29522	9.344846

Here we select lag order as 2.

Table A-17: Johansen Cointegration Test Summary for Japan (PB-DS)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	2	1	0	0	2
Max-Eig	2	1	0	0	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or	No Intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No Trend	No Trend	No Trend	Trend	Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-257.5229	-257.5229	-252.5123	-252.5123	-252.4257
1	-249.3165	-249.3129	-246.6839	-243.1157	-243.0351
2	-247.1822	-246.1932	-246.1932	-240.8246	-240.8246
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	8.705669	8.705669	8.606960	8.606960	8.669694
1	8.567754	8.600422	8.547014	8.462811*	8.492955
2	8.628923	8.662072	8.662072	8.551625	8.551625
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	8.982505	8.982505	8.953005*	8.953005*	9.084948
1	8.983008	9.050280	9.031476	8.981878	9.046627
2	9.182595	9.284953	9.284953	9.243715	9.243715

We select the fourth model: linear, intercept and trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-18: Cointegration test results for Japan (PB-DS)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.265146	23.37538	25.87211	0.0991
At most 1	0.072367	4.582295	12.51798	0.6570

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized		Max-Eigen	0.05	

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None	0.265146	18.79309	19.38704	0.0608
At most 1	0.072367	4.582295	12.51798	0.6570

Max-eigenvalue test indicates no cointegration at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

PB_JAP	DS_JAP	@TREND(06Q2)
-0.633376	-0.122381	0.140969
0.074702	0.138307	-0.135488

Unrestricted Adjustment Coefficients (alpha):

D(PB_JAP)	0.292830	0.352704
D(DS_JAP)	1.144816	-0.359734

1 Cointegrating Equation(s):	Log likelihood	-243.1157

Normalized cointegrating coefficients (standard error in parentheses)

PB_JAP	DS_JAP	@TREND(06Q2)
1.000000	0.193221	-0.222568
	(0.04443)	(0.05078)

Adjustment coefficients (standard error in parentheses)

D(PB_JAP)	-0.185472
	(0.11946)
D(DS_JAP)	-0.725099
	(0.19884)

Turkey:

Table A-19: Lag-order selection for EXP/GDP and REV/GDP ratios for Turkey

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-165.0869	NA	1.669722	6.188403	6.262069	6.216813
1	-97.17036	128.2868	0.156547	3.821124	4.042123	3.906355

2	-85.93440	20.39118	0.119844	3.553126	3.921456*	3.695177
3	-83.11840	4.901925	0.125451	3.596978	4.112640	3.795849
4	-70.69289	20.70918*	0.092130*	3.284922*	3.947917	3.540613*
5	-68.62122	3.299324	0.099475	3.356342	4.166668	3.668853
6	-65.90958	4.117680	0.105145	3.404059	4.361718	3.773390
7	-63.69270	3.202156	0.113531	3.470100	4.575091	3.896252
8	-60.69065	4.113929	0.119501	3.507061	4.759384	3.990033
9	-58.39135	2.980565	0.129654	3.570050	4.969706	4.109842
10	-54.70026	4.511339	0.134276	3.581491	5.128479	4.178104

Here we select the lag order as 4.

Table A-20: Johansen Cointegration Test Summary for Turkey (EXP-REV)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	0	0	1	1	1
Max-Eig	0	0	1	1	1

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-95.07877	-95.07877	-94.41551	-94.41551	-93.70693
1	-93.28091	-87.45913	-87.15265	-83.16957	-82.53227
2	-93.27761	-86.35740	-86.35740	-81.22777	-81.22777
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	3.765382	3.765382	3.810695	3.810695	3.854472
1	3.840031	3.676581	3.700090	3.598968*	3.611263
2	3.975512	3.808726	3.808726	3.702636	3.702636
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	4.328782*	4.328782*	4.444520	4.444520	4.558722
1	4.544281	4.416043	4.474765	4.408856	4.456363
2	4.820612	4.724251	4.724251	4.688586	4.688586

We select the fourth model: linear, intercept and trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-21: Cointegration test results for Turkey (EXP-REV)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.316971	26.37548	25.87211	0.0433
At most 1	0.063704	3.883595	12.51798	0.7589

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.316971	22.49188	19.38704	0.0171
At most 1	0.063704	3.883595	12.51798	0.7589

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

EXP_TUR	REV_TUR	@TREND(06Q2)
-1.056242	-0.649474	0.049713
0.583274	-0.928310	-0.049591

Unrestricted Adjustment Coefficients (alpha):

D(EXP_TUR)	0.379579	0.052085
D(REV_TUR)	0.028835	0.112550

1 Cointegrating Equation(s): Log likelihood -83.16957

Normalized cointegrating coefficients (standard error in parentheses)		
EXP_TUR	REV_TUR	@TREND(06Q2)
1.000000	0.614891	-0.047066
	(0.26743)	(0.01242)
Adjustment coefficients (standard error in parentheses)		
D(EXP_TUR)	-0.400927	
	(0.08966)	
D(REV_TUR)	-0.030457	
	(0.06759)	

Russia:

Table A-22: Lag-order selection for EXP/GDP and non-energy REV/GDP ratios for Russia

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-124.6628	NA	12.13487	8.171793	8.264308	8.201950
1	-47.90135	138.6658	0.111132	3.477506	3.755052	3.567979
2	-35.40860	20.95557	0.064539	2.929587	3.392164	3.080376
3	-30.50481	7.592974	0.061505	2.871278	3.518885	3.082382
4	-23.93415	9.326093	0.053081	2.705429	3.538067	2.976848
5	-18.99448	6.373765	0.051487	2.644805	3.662474	2.976540
6	-9.423525	11.11466*	0.037623	2.285389	3.488088	2.677439
7	-0.791250	8.910735	0.029819*	1.986532	3.374262*	2.438898
8	2.731334	3.181689	0.033787	2.017333	3.590093	2.530014
9	9.856037	5.515899	0.031512	1.815740*	3.573530	2.388735*
10	13.37078	2.267575	0.039122	1.847047	3.789868	2.480358

Here, we select the lag order as 9.

Table A-23: Johansen Cointegration Test Summary for Russia (EXP/GDP and non-energy REV/GDP)

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	0	1	1	2	2

Max-Eig	0	1	1	2	2

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
	Log Likelihood by Rank (rows) and Model (columns)				
0	-7.356833	-7.356833	-2.880798	-2.880798	-1.289783
1	-2.024825	8.867915	12.96226	30.58646	31.16673
2	-1.261386	13.37078	13.37078	38.57575	38.57575
	Akaike Information Criteria by Rank (rows) and Model (columns)				
0	2.797215	2.797215	2.637471	2.637471	2.663857
1	2.711279	2.073038	1.873402	0.800873	0.827953
2	2.920089	2.105111	2.105111	0.608016*	0.608016
	Schwarz Criteria by Rank (rows) and Model (columns)				
0	4.462490	4.462490	4.395262	4.395262	4.514163
1	4.561585	3.969601	3.816224	2.789952*	2.863289
2	4.955426	4.232963	4.232963	2.828383	2.828383

We select the fourth model: linear, intercept and trend. Performing the Johansen Cointegration test with respect to selected lag and model structure, we have the following result:

Table A-24: Cointegration test results for Russia (EXP/GDP and non-energy REV/GDP)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.884580	82.91310	25.87211	0.0000
At most 1 *	0.402761	15.97858	12.51798	0.0127

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.884580	66.93452	19.38704	0.0000
At most 1 *	0.402761	15.97858	12.51798	0.0127

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

EXP_GDP	NON_ENG_REV_GDP	@TREND(12Q1)
-5.388850	-5.137639	0.977196
-1.552906	4.443265	-0.945497

Unrestricted Adjustment Coefficients (alpha):

D(EXP_GDP)	0.239410	0.182968
D(NON_ENG_REV_GDP)	0.142387	-0.051371

1 Cointegrating Equation(s): Log likelihood 30.58646

Normalized cointegrating coefficients (standard error in parentheses)

EXP_GDP	NON_ENG_REV_GDP	@TREND(12Q1)
1.000000	0.953383	-0.181337
	(0.12295)	(0.02407)

Adjustment coefficients (standard error in parentheses)

D(EXP_GDP)	-1.290142
	(0.48906)
D(NON_ENG_REV_GDP)	-0.767302
	(0.15583)