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Original Research Article

The Impact of Macroeconomic and Banking Variables on Non-Performing Loans in Oil Cycles: Evidence from Iran

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The present study investigates the impact of macroeconomic and bank-specific variables on non-performing loans (NPLs). To avoid the identification problem, two models are employed to address this impact. The first one tests the effect of macroeconomic variables including the growth of oil revenues, inflation, and the growth of GDP without the oil sector on the growth of NPLs. Data is quarterly over the period 2004:3 to 2019:3. The transition variable in this setup is the growth of oil revenues and its threshold is 9 percent, which divides the sample into oil booms and oil recessions. According to the results, inflation has a significant positive effect on NPLs. During the oil boom, oil revenues decrease the NPLs. Due to the immense size of the government and its current and capital expenditures, when oil revenues are lower, the government forces banks to allocate loans to finance projects with long maturity. Furthermore, the present study used PSTR to test the impact of bank-specific variables consisting of interest rate spread, loan loss provision, loan to deposit ratio, and NPLs. To do so, monthly data of 10 banks is used over 2016:04 to 2020:12. The transition variable is the interest rate spread at 1 percent, which categorizes the banks into two groups of good and bad. Good banks collect deposits with a low-interest rate and allocate high-rate loans with less chance of default. So, interest spread is the most important prominent determinant of decreasing NPLs, while the loan to deposit ratio is dependent on the banks belonging to which group. For good banks, the loan to deposit ratio decreases the NPLs, while for bad banks, it worsens the growth of NPLs.

Keywords: NPLs, Iran, Oil Revenues, STR, PSTR**.**
JEL Classification*:* C01, E31, H5

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1 Introduction

Since researchers have access to more published data at the bank-level and aggregate banking system level, the interest in non-performing loans and their determinants has substantially increased recently. Numerous studies have been conducted on problem loans, NPLs, and the default rate. The results reveal valuable insights about the quality of loan portfolios and generally the fragility of banks. After banking crises during the 90s and after 2000, investigating the causes of financial vulnerability has been met with fundamental disagreement were due to the rapid increase of problem loans. Previous studies indicated NPLs act like a "financial pollution" with harmful effects on both economic development and social welfare. (González-Hermosillo, 1999 and Barseghyan, 2010)

NPLs have attracted renewed attention in recent years. It is due to the growing interest in understanding the stimulating variables of financial vulnerability. NPLs are such an indicator that is closely associated with weaknesses in the financial system. It can be confirmed by the strong observed link between the surge in NPLs and the occurrence of banking crises. Reinhart and Rogoff (2011) point out that the rise in NPLs can mark the onset of a banking crisis, while Sorge (2004) recommends using NPLs to test the financial system's vulnerability. In addition, NPLs have gained significance also after the global crisis. In particular, the global crisis prompted a surge in NPLs, thereby posing risks to liquidity and profitability of the banking system and financial stability in turn.

Iranian banking system experiencing a high ratio of NPLs to total loans which has already caused so many problems. As literature and empirical studies suggest, both macroeconomic and bank-specific determinants play important roles in NPL's dynamics. On one hand, there is a crucial issue of government itself as one of the main reasons for the higher NPLs, and the explained occurrence deals with an Oil-based structure. The size of the Iranian government is large in comparison to other similar economies. Because the government is the owner of the oil rents and its budget is highly dependent on this exogenous factor. Government allocates resources based on oil revenues to construction projects, but as oil recession begins as a result of sanctions or global price decline, banks are responsible to allocate resources to projects with long maturity. Therefore, a large part of loans is going to be categorized as government debt to the banking system.

On the other hand, due to high inflation expectations, people find it more convenient not to follow the regular payments as a rational decision. It is both

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because of the difficulty of the refinancing process, and the borrower's expectation that shaped as the late fee[1] is less compared to a potential gain of delay in repayments. Also due to bad economic performance, some borrowers are not able to contribute the reimbursements. Regulations, credit systems, and collaterals for a large number of loans are not so tight due to institutional factors in Iran. ultimately, both from Moral Hazard explained by delay and Adverse Selection and beyond all, the imposed governmental debt are all generating NPLs.

The remainder of this paper follows with a literature review. Then, some studies concerning macroeconomic, and bank-specific determinants would be addressed. Next, the Methodology and data through each specific model and the reason for distinguishing will be explained. After that, required tests and estimations of both models will be covered, and lastly comes the conclusion.

2 Literature Review

A non-performing loan is a defaulted loan, meaning the borrower fails to make the repayments of principal and interest defined in its loan contract and has no aim of returning in the future (Pilbeam, 1998). In the other words, loans are considered default when set on nonaccrual status, meaning that banks deduct all interest on the recorded loans but not collected (Koch and Macdonald, 2014). The issue of "non-performing loans" has drawn more attention in recent decades as numerous studies investigated bank failures and found that asset quality is an indicator of insolvency (Demirgüç-Kunt, 1989).

The banking sector provides various financial services and plays a fundamental role in the economy and society. Non-performing loans can be considered undesirable outputs or costs to a loaning bank, decreasing the bank's performance (Chang et al, 2011). NPLs are a major challenge for the banking industry, threatening profitability by losing interest income and the principal loan amount (Seyoum, 2016).

NPLs can erode the bank's profitability and depreciate the capital. Therefore, banks are not willing to take on new risks and invest in new customers (Hou & Dickinson, 2007). The deterioration in banks' loan portfolios' quality was the leading reason for difficulties in the banking system and financial crisis in developed economies. Partovi and Matousek (2019) argue that the increase in non-performing loans can affect the resources that are enclosed in unprofitable areas. Therefore, the sharp increase in NPLs has

[1] A late fee is a charge imposed on a consumer who fails to make the payment on a debt or other financial obligation by the due date.

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triggered prolonged instability and an economic downturn, hindering economic growth, and enhancing economic efficiency.

One of the basic requirements for sustainable economic development is the minimization of NPLs. The solid relationships between the credit market's friction and the risk of financial instability and between macroeconomic and financial shocks are emphasized by the rise in banking and loan defaults mortgage in the United States (Messai & Jouini, 2013). The emergence and aggregation of NPLs in the balance sheet of the banks are often considered topics related to macroprudential issues. In this regard, the current economic literature about the consequences of NPLs has mainly considered the impact of this problem on the performance of banks through issues such as profitability and lending (Nikolopoulos & Tsalas, 2017).

After the global financial crisis 2007-2009, it is determined that the excessive aggregation of NPLs in the banks' sheet impairs the stability of banks' systems resulting in emphasizing exacerbating the deteriorating economic downturn. Consequently, NPLs are an issue of the macroprudential matter, if it causes systemic risk and brings a threat to financial stability (Borio et al, 2001). Particularly, in a bank-based financial system, NPLs are sufficiently spread, abundant and persistent through the banking sector and affect critical sectors of the economy. Therefore, not taking the importance of NPLs into account may cause financial instability and generate significant system-wide costs, such as the reduction or misallocation of credit, depressed asset prices, or the reinforcement of downturn spirals (Suarez & Sánchez Serrano, 2018).

Taking into consideration financial stability has been regarded as one of the most important tools to contribute towards economic development, various theoretical and empirical studies have been conducted regarding exploring the determinants factors of non-performing loans.

Reflection of credit risk in NPLs as a result of macroeconomic development has been confirmed by business cycles studies. The main core of this finding is the relationship between the business cycle and borrowers' capacity to lend. It is also indicated that credit standards engage a gradual deterioration during economic booms when credit institutions apply increasingly liberal lending policies to hold or save their higher market share (Louzis et al, 2012).

Another strand of the literature examining the loan problem has been driven by some specific characteristics of banks such as the quality of management, policy choices, size, and market power. Bank-specific criteria are used as borrowing strategies like independent determinants in models to

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check loan problems (Monokroussos & Gortsos, 2017). There was found a heavy causal relationship between loan quality, cost efficiency, and bank capital, using a sample of US commercial banks for the period 1985–1994 (Berger & DeYoung, 1997).

Recently, various studies have provided a combination of the categories variables for estimating models to explain NPL's determinant factors. For example, investigation of the riskiness of Italian intermediaries' database by synthesizing macroeconomic and bank-specific factors during 1985–2002 (Quagliariello, 2007).

The present study tries to encounter the factors determining NPLs, namely the macroeconomic and bank-specific variables with a focus on oil revenues affecting NPLs. In this regard, the explanatory power of both macroeconomic and bank-specific variables will be addressed.

2.1 Macroeconomic Variables and NPLs

The macroeconomic environment and loan quality relationship has been investigated, which links the stage of the business cycle and banking stability (Messai & Jouini, 2013). King and Plosser (1984), Bernanke and Gertler (1989), and Bernanke et al (1998) were the first researchers who analyzed the relationship between credit risk and macroeconomic factors. These studies in addition to recent research provide ample evidence that a negative relationship exists between macroeconomic factors and NPLs. The mentioned findings suggest that when there is positive economic growth, debtors' income enhances, boosting repayment ability. On the other hand, when the acceleration of economy decrease, NPLs raises because of the increase of unemployment and the falling of availability of income; hence, borrowers face problems to paying back their debts (Jimenez & Saurina, 2006; Pesaran et al, 2006; Rajan & Dahl, 2003; Quagliariello, 2007 Salas & Saurina, 2002). Other macroeconomic factors that can affect NPLs include exchange rate, inflation, interest rate, and the real state price.

The macroeconomic factors affect the capacity of the borrower to pay its debts. Selection of GDP, unemployment, and interest rate as important determinants of NPLs may have resulted from life-cycle consumption models based on a theoretical point of view. Several empirical studies have found a negative relationship between NPLs and real GDP growth (Fofack, 2005; Dash & Kabra, 2010; Jimenez & Saurina, 2006; Salas & Saurina, 2002). Their results demonstrate that GDP growth is negatively associated with the NPLs, which decreases NPLs, financial distress, unemployment, and increases the revenue driven by GDP growth.

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It is possible that in addition to GDP growth, other macroeconomic variables, such as interest rates and unemployment, can be included as potential determinants of NPLs since such variables could provide more information concerning the impact of macroeconomic circumstances on firms and household stability (Messai & Jouini, 2013). Lawrence (1995) and Pop et al. (2018) argue that when the unemployment rate increases, households' cash flow streams should be negatively affected, and the debt burden would be increased. With the consideration of firms, when unemployment increases, decreased production may be followed due to a decrease in effective demand. This might result in a decrease in the fragile debt situation and revenue. The unemployment rate affects impaired loans positively. Dimitrios et al. (2016) Showed that the unemployment rate has no statistically significant impact on NPLs, using the system GMM to determine the important determinants of NPLs. Rinaldi and Sanchis-Arellano (2006) investigated NPLs in European countries and concluded that disposable income, monetary conditions, and unemployment considerably impact NPLs. Louzis et al. (2012) in the Greek banking sector, using dynamic panel data to investigate NPLs determinants for each kind of loan shows that NPLs are linked to the macroeconomic variables (GDP, unemployment rate, the interest rate) and management quality. Berge and Boye (2007) concluded that problem loans are highly connected to both the real interest rates and unemployment.

In the same field, the positive relationship between inflation and bad loans is evidenced. Fofack (2005), for example, states that in some Sub-Saharan African countries, inflationary pressures resulted in people making bad loans. Furthermore, Fofack (2005); Jesus and Gabriel (2006) consider inflation as a prominent factor leading to the quick loss in commercial banks' funds, causing a higher level of credit risk. Dimitrios et al. (2016) and a negative relationship between inflation and output gap was found by Pop et al. (2018). Skarica (2014) used data from 2007 to 2012 for seven European countries to study the macroeconomic determinants of NPLs. The findings suggest that both unemployment and inflation increase NPLs, while high real GDP growth rates have a negatively significant relationship with NPLs. Despite such research, Monokrousso and Gortsos (2017) and Nkusu (2011) reveal that the impact of inflation on the quality of bank assets is unknown. The higher inflation rate, and the lower real value of outstanding[1] debt, making servicing debt more easily. However, inflation can decrease real incomes (with sticky prices) and result that the monetary authority tightening interest rates.

[1] The total principal as well as interest amount of a debt that has yet to be paid.

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Concerning other macroeconomic factors, some research shows a positive relationship between interest rates and NPLs, especially in this case (Beck et al., 2013; Klein, 2013 and Louzis et al., 2012). The interest rate affects the difficulty in servicing debt, in the case of floating rate loans. This implies that the effect of the rate should be positive, and as a result, the increasing debt burden caused by rising interest rate payments should lead to a higher number of NPLs. Adebola et al. (2011) investigate the factors affecting NPLs in Islamic banks in Malaysia between 2007 and 2009. They apply ARDL[1] to test the industrial production index's effects, the interest rate, and the index of producer prices on NPLs. The findings revealed long-term relationships between variables and states that the interest rate has a significant positive long-term impact on bad loans. Moreover, Bloem and Gorter (2001) mention that "bad loans" may significantly rise owing to sudden changes in interest rates. They discussed different international standards on the recognition, measurement, and treatment of NPLs to address the issue from the management standpoint. Espinoza and Prasad (2010) investigated macroeconomic and bank factors affecting NPLs and their impacts in the GCC banking sector. Although they found that higher interest rates result in more NPLs, they could not find a statistically significant relationship between the mentioned factors.

A wide range of studies attempts to find out whether loan performance is highly influenced by the macroeconomic environment. How it remains the most crucial single risk for loan performance is the prominence of this issue. Regarding the other macroeconomic variables, in some cases could set binding rules to provide better management of the nonperforming debt issues which requires a vivid insight and understanding about the origin of NPLs to identify the fragilities of the financial sector. It is highly explicit that performance measures from the NPLs research could serve as indicators of more general future instability (Manz, 2019).

2.2 Bank Specific Variables and NPLs

The macroeconomic variables should not be considered exclusive NPL's determinants, viewed as exogenous to the banking industry. Indeed, maximizing efficiency and risk management as policy decisions for banks along with the banking industry's characteristic features are required to address the evolution of NPLs. The relationship between NPLs and bank-specific determinants has been drawn by Berger and DeYoung1 (997), Louzis

[1] Auto-Regressive Distributed Lag

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et al. (2012), and Sabbah (2013) who examined the relationship between Bank capital, loan quality, and cost-efficiency.

Berger and DeYoung (1997) tested four hypotheses related to banking management to analyze the relationship between the cost efficiency of banks, quality, and bank capital. They evidenced that the hypothesis of moral hazard and bad management can explain a crucial part of NPLs.

Berger and DeYoung (1997) and Podpiera and Weill (2008) mentioned that a high level of NPLs is a consequence of lack of collateral, bad control over borrowers, and inefficient credit scoring. The "bad management" hypothesis refers to a negative relation between problem loans and cost-efficiency. Li et al. (2007) investigated the Chinese banking system. They have shown that incentive contracts positively impact the management of NPLs. Louzis et al. (2012) confirmed the same result with a different sample consisting of Greek banks

The skimping hypothesis was initially offered by Berg et al. (1992) and further improved by Hughes and Mester (1993). Hence, Berger and DeYoung, (1997) developed the skimping hypothesis based on high-cost efficiency, which may reflect limited resources allocated to monitor credit risk, leading to higher problem loans in the future. Consequently, he showed a positive relationship between cost efficiency and NPLs. Abid et al. (2014) and Louzis et al. (2012) argue that an increase in NPLs results from a high level of efficiency. They state that although banks devoting less effort to assure higher loan quality will be more cost-efficient, there will be an increasing number of NPLs in the long term.

HU et al. (2004) investigated the association between the ownership structure and the banking sector's impaired loans in Taiwan. Their findings indicated that banks' size is negatively related to the NPLs. They also found that when the state owns the portion of bank capital, there is a decline in NPLs.

Using the return on assets (ROA) as a performance indicator, Godlewski (2005) shows that banks' profitability negatively affects the NPLs ratio level. On the other side, García-Marco and Robles-Fernández (2008) applying a panel of 129 banks in Spain between 1993 and 2000 show that a greater future risk follows high return levels on equity (ROE). They argue that if the bank industry's policy concentrates on profit maximization, it can result in a high-risk level. Messai and Jouini (2013) found that even though unemployment and the real interest rate have a positive impact on NPLs, ROA, on top of GDP growth, negatively affects NPLs.

Dimitrios et al. (2016) examined the hypothesis advanced by Berger and DeYoung (1997) such as bad management, i.e. that can affect NPLs. There is

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a negative relationship between ROA and the number of bad loans, and they found a negative association between the output gap and inflation.

According to other researchers, such as Ghosh (2015), Louzis et al. (2012), or Makri et al. (2014), there is a negative association between different capital ratios, market power, or efficiency ratios, and NPLs.

Podpiera and Weill (2008) also evaluated the causal relationship between NPLs and cost efficiency, while Ghosh (2005) found that lagged leverage affects NPLs. They mentioned that poor credit quality, liquidity risk, inefficiency cost, larger capitalization, the size of the banking industry, unemployment, inflation, and public debt increase NPLs.

2.3 Banking System's Profitability and NPLs

The stability of the bank industry is a primary factor for economic development and resilience against financial crises. Indeed, the profit and quality of the asset that a bank possesses determine banking success, and they are critical for banks' survival and growth. A significant threat to the banking sector is the predominance of NPLs (Koskei, 2020). Michael et al. (2016) argue that operational efficiency affected by non-performing assets in the loan portfolio influences banks' profitability, liquidity, and solvency position.

The global financial crisis outbreak has resulted in increasing the level of NPLs significantly, negatively influencing banks' liquidity and profitability and weakening the stability of the banking system. Great efforts have been put into controlling and decreasing NPLs, but the problem remains in both regulators' and banks' attention (Monokroussos & Gortsos, 2018).

Profitability is one of the bank-specific factors of NPLs. Therefore, profitability might affect the NPLs ratio negatively. Louzis et al. (2012) point out that a higher level of NPLs is consistent with low profitability and this represents the bad management II hypotheses. García-Marco and Robles-Fernández (2008) argue that profitability is linked with increased risk, which may end up as NPLs. This can be attributed to procyclical credit policy, which implies that better performance may generate future increases in NPLs as it reflects the free credit policy of the bank (Us, 2018).

The results are driven from several studies (as an example Godlewski, 2005 and Klein, 2013) showing profitability has a negative coefficient confirms the bad management II hypothesis, which states that past performance is a proxy for management quality; therefore, inferior performance is positively related with increases in future NPLs (Us, 2018).

Messai and Jouini (2013) argue that bank profitability decreases NPLs, while the unemployment rates, real interest rates, and weak credit quality

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positively influence the level of NPLs by examining 85 banks in Italy, Greece, and Spain for the period 2004–2008.

NPLs are considered as a component of probability, and a high amount of NPLs negatively influence net banks' profits (Koskei, 2020). Vinh (2017) noticed that NPLs had a prominent adverse effect on 34 Vietnamese commercial banks' profitability between 2005 and 2015 using the Generalized Method of Moment's methodology. Ghosh (2015) shows that greater capitalization, liquidity risks, poor credit quality, high-cost inefficiency, and banking industry size significantly increased NPLs, while high bank profitability decreases NPLs for all commercial banks and savings institutions.

Bloem and Gorter (2001) noted that non-performing assets (NPAs) affect all sectors. However, the strongest impact is on the financial institutions, which prefer to have large portfolios. Indirectly; the clients of these financial intermediaries are also involved like deposit holders, shareholders, and so on. Additionally, NPAs are affecting the banks and their intermediaries and, in a wider view, on the development path. NPAs mean an unsettled loan, for which they must incur financial losses for any bank. The cost of NPAs recovering is also significant. There are banking failures due to increasing NPAs because they affect banks' profitability and long-run survival.

2.4 Outcomes of High and Persistent NPLs

The rising trend of NPLs has a long-lasting negative impact on the country's financial sector. If loanable funds are blocked as NPLs, banks will not have enough reserve for issuing future loans, which will affect the economy in multiple ways. NPLs are a burden for both lenders and borrowers; they contract credit supply, distort the allocation of credit, worsen market confidence, and slow economic growth. When the NPLs problem is ignored, economic performance suffers. More specifically in the banking industry, increasing the drift of NPLs will affect the banking efficiency resulting in banking crises (Vouldis and Louzis, 2018). NPLs block the interest revenue, reduce investment openings as well as develop liquidity crises in the financial system, which results in bankruptcy problems. Banks will be forced to go after creative accounting and operations imposed on balance sheets will from NPAs on the right-hand side. Higher NPAs will end up with the following impacts:

The profitability of banks is adversely affected by an increase in doubtful debts. As a result of write-off bad debts, the return on investment decreases, and the capital adequacy ratio is disturbed as NPAs are playing a huge role, the cost of capital will increase. The gap between assets and liability will

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widen, the economic value additions by banks decrease as it is the net operating profit minus cost of capital that limits recycling of the funds (Koskei, 2020).

The cost of NPLs is significant for taxpayers and depositors more importantly in fiscal deficits. This would rise NPLs and cause a deterioration of bank assets and erosion of their capital. The majority of banks dealing with liquidity problems used interbank loans as a method of short-term financing (Koskei, 2020).

- The crucial assumption of the NPAs is that it prioritizes credit risk management over other aspects of the bank's functioning (Nachimuthu & Veni, 2019). Therefore, the entire bank's functioning system will be engaged in recovery procedures instead of focusing on business expansion. This view was supported by Yadav (2011) who stated that higher NPAs force banks employees to take NPAs recovery measures rather than seeking better investment options.
- According to NPAs, by having recovery as loan loss reserve, banks are permitted to credit money to their profit and loss account to the debit of loan account. It is recommended that interest or other costs which have already been deducted but not recouped have to be awarded. It is also critical to calculating the amount of gross NPAs. If one of the borrower's loan accounts is NPAs, all the loan accounts of the borrower are considered as NPAs. Many researchers accentuated the straddling effect of NPA and its influence on loan growth. A higher NPAs forces banks to invest in less risky assets, affecting the flow of capital for productive purposes. On the other hand, it is arguable that some banks will fall into moral hazards as their portfolio contains NPAs, and to gain profit, they might perform some risky decisions.

3 Data and Methodology

Based on the literature, both banking and macroeconomics variables affect NPLs. As empirical evidence and studies suggested, there is a state-dependent impact dealing with NPL's dynamics. Therefore, this study examines whether potential states use nonlinearities to tackle the impact and smooth transition regression to find the best transition variable. To do so, one method is that all the variables (macroeconomic and bank-specific variables) are introduced in a panel data framework and then testing the nonlinear hypothesis and determining the transition variable and its value carried out in this framework. But, in this method, the macroeconomic variables are fixed across the cross-sections of the panel and it leads to identification problems in regression

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analysis. So, this suggests analyzing the effect of macroeconomic determinants and bank-specific determinants in separate models. Incompatibility of data frequency of macroeconomic variables and bank-specific variables in Iran is another reason for analyzing these variable groups separately. While the banking data is available in monthly and annual frequency, macroeconomic variables are available quarterly.

3.1 Model for the Impact of Macroeconomic Variables on NPLs

To address the impact of macroeconomic variables on NPLs, this study uses inflation, GDP without oil, and oil revenues. The variables' selection is based on Iran's economy and banking sector structure. Inflation as a representative of the monetary sector always has a crucial impact on repayments decisions. The exchange rate is the nominal anchor in Iran and due to sanctions and oil shocks, it experienced such volatilities that lead to high inflations. This makes borrowers less tending to pay back and use the credit to make profits in parallel markets like housing, the stock market. The moral hazard problem in this sense is visible when some borrowers would delay their repayments due to an inflationary environment. In addition, inflation decreases the real value of NPLs

GDP as representative of real sector economy is expected to have a significantly negative impact on the standards on NPLs. While the economy is on the right track and making progress, credits are being repaid properly. Furthermore, there are lots of humongous governmental or semi-governmental companies that always need a considerable amount of credits as working capital and while the economy is performing well, still due to the high inflationary expectations, they find repayments not so feasible as a strategy. This is other than bureaucratic and corruption problems which can be found in some cases. Another probable cause of NPAs as rational decisions concerns firms that are always in shortage of credits even with high liquidity growth. As mentioned, due to high inflation rates and some significant jumps in nominal variables, the real amount of credits is always declining and this may tighten credit status up for firms to get refinances.

Lastly, oil revenues as one important factor affect both nominal and real sectors. Oil revenues deal with the dollars that make government allocate among imported goods and control the imported inflation price. On the other hand, the central bank can easily intervene and avoid rapid growth or even steady growth of exchange rate. Also due to the oil revenues' structure and expenditure, it plays a prominent role in the current and capital expenditures of the government. As a result, lots of projects which started when the

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government was enriched by oil revenues, still need credits to move forward but due to shortage in oil revenues, keeping up the finance flow would not be easy. Therefore, the government makes governmental banks that have a great share of the whole banking system allocate finance to these projects which will not be finished or get to return phase in the medium run. To put it simply, due to the shortage of oil revenues, the government makes banks pay loans to projects that there would be no repayment for quite some time. The same thing happened with current expenditure as well and banks step in to cover some deficits and again this categorizes as NPLs. All that can be done and happened especially in the last decade was to move every years' NPLs to the next year with both the base amount and interest upon it.

On the other hand, to avoid rapid growth of exchange rate or even steady exchange rate growth avoid rapid growth or even smooth the exchange rate trend, the central bank can quickly intervene also, due to the oil revenues' structure and expenditure plays a prominent role in the current and capital spending of the government. So, lots of projects which started when oil revenues enriched the government still need credits to move forward progress, but due to shortage in oil revenues, keeping up the flow of finance would not be easy. Therefore, the government force governmental banks that have a great share of the whole banking system, to finance these projects that will not be finished or get to the return phase in the medium run. Meaning, due to the shortage of oil revenues, the government forces banks to pay long loan maturities to the projects. A similar story happen for government current spending and banks stepped in to cover some deficits, and again this was categorized as NPLs. All that can be done and happened mainly in the last decade was moving every year's NPLs to the next year with both the principal and interest of loans.

Therefore, the table below shows the variables which will be used to define the impact of macroeconomic variables on NPLs. While economic variables are usually prone to switching regimes, recent research on univariate models indicates nonlinear specification, which provides better insight. The term regime switch refers to a sudden, abrupt change. Nonetheless, most economic variables smoothly change regimes, with the transition from one to the next requiring some time. The smooth transition regression model, unlike discrete switching models (Hanson, 1999), treats the transition as a continuous process that is influenced by the transition variable. This allows for regime-switching behavior to be incorporated both when the exact timing of the regime change is unknown with certainty and when the transition period to a new regime is brief (Van Dijk et al., 2002).

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So, for macroeconomic variables, the model to tackle the impact is STR, and data are quarterly over the 2004:3–2019:3 periods. Variables including are inflation, nominal NPLs growth, growth of GDP without oil, and growth of oil revenues.

Ultimately, for macroeconomic variables, the model to tackle the impact is STR and data are quarterly over the 2004:3–2019:3 periods. Variables including are inflation, nominal NPLs growth, growth of GDP without oil, and growth of Oil revenues.

A standard time-series STR model with transition logistic function introduced like:

$$NPL_t = \phi' z_t + (\theta' z_t) G(s_t, \gamma, c) + u_t$$

Table 1 shows the variables and their symbols that are used in this model:

Table 1
Definition of variables and parameters of model 1

Symbols	Definition
INF	Inflation
OIL	growth of Oil revenues
GDP	GDP growth
NPL	Non-performing loans
ω_t	Vector consisting of explanatory variables and their lags
s_t	Transition variable
Γ	Speed of transition
C	Threshold value
G	Logistic Transition function
U	Error term
$\phi' = (\phi_0, \phi_1, \dots, \phi_p)$	Linear coefficient vector
$\theta' = (\theta_0, \theta_1, \dots, \theta_p)$	nonlinear coefficient vector

3.2 Model for the Impact of Bank-Specific Variables on NPLs

For this part, this study uses the PSTR model developed by González et al. (2017) to study nonlinearity and the existence of a threshold effect in NPLs.

The PSTR model can be interpreted in two ways. Firstly, it may be considered as a linear heterogeneous panel model with coefficients that can change over time and among individuals. The assumption that the regression coefficients are bounded continuous functions of an observable variable, known as the transition variable, might lead to heterogeneity in the regression coefficients. As a result, they alternate between a small number (typically two) of "extreme regimes". Because the transition variable may be unique to each

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individual in the panel and to change over time. Second, one can think of the PSTR model as a nonlinear homogeneous panel model. In the context of single-equation smooth transition regression (STR) or univariate smooth transition autoregressive (STAR) models, the latter interpretation is frequent. (Teräsvirta, 1994)

The basic PSTR model with two extreme regimes is defined as:

$$y_{it} = \mu_i + \lambda_t + \beta_0' x_{it} + \beta_1' x_{it} g(q_{it}; \gamma; c) + u_{it}$$

$$\text{For } t = 1, \dots, T \text{ and } i = 1, \dots, N$$

Where i and t indicate the cross-sectional and time dimensions of the panel, respectively. The dependent variable y_{it} is a scalar and x_{it} is a k-dimensional vector of time-varying exogenous variables and μ_i and λ_t represent fixed individual effects and time effects in the transition function $g(q_{it}; \gamma, c)$. q_{it} is a continuous function of the observable variable and is normalized to bounded between zero and one. These two extreme values are related to regression coefficients β_0 and $\beta_0 + \beta_1$. Paper follows Teräsvirta (1994, 1998) and Jansen and Teräsvirta (1996), see also Teräsvirta et al. (2010) Chapter 3, by using the logistic specification:

$$g(q_{it}; \gamma; c) = (1 + \exp(-\gamma \prod_{j=1}^{m} (q_{it} - c_j))^{-1}$$

$$\text{With } \gamma > 0 \; and \; c_1 < c_2 < \cdots < c_m$$

Where $c = (c_1, \dots, c_m)'$is an m-dimensional vector of location parameters, and the slope parameter γ determines the smoothness of the transition.

If $\gamma \to 0$ there exists a linear model with fixed effects and when $\gamma \to 0$ and m=1 results as panel threshold regression model Hansen (1999) with the transition function becoming indicator function. With noting this, the estimation procedure first eliminates the individual effect μ_i and then applies nonlinear least square to the transformed data.

To this end, bank-specific determinants of NPLs among the factors that have been formerly demonstrated to be remarkable in the literature will be utilized (Pop et al, 2018). However, to refrain from multicollinearity issues, the present paper takes the determinants that correlate the most with the level of NPLs and removes other factors –such as ROA and size that correlate with included variables.

Variables used to tackle the bank-specific determinant are loan to deposit ratio, the spread of interest, loan loss reserve, and NPLs for 10 banks which

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the data are being published regularly and have been active since 2016:04 till 2020:12 in Tehran's exchange market and published necessary data frequently.

Table 2 describes the variables being used:

Table 2
Definition of variables of model 2

Variable	Name	Type	Definition
IS	Interest Spread	Ratio in percent	The difference between the interest rate a bank charges a borrower and the interest rate a bank pays a depositor is known as a spread. The margin of a bank can be determined by the interest spread. Because the difference between interest received and interest paid out is large, a widespread lead to a bigger profit margin.
LLR[1]	Loan loss reserve	Growth	The Loan Loss Reserve is a ratio used by banks to show the reserve that the company has in percentage terms to offset the expected losses that they would have suffered if a loan failed. The Loan Loss account is described as a counter-account to the total amount of loans outstanding. This ratio is intended to detect and compare the performance of the company's existing loan portfolio to that of other market competitors.
LTD	Loan to deposit ratio	Ratio in percent	By comparing a bank's total loans to its total deposits for the same period, the loan-to-deposit ratio is used to determine a bank's liquidity. The LTD is measured in percentages. If the ratio is excessively high, the bank may not have enough liquidity to fulfill any unexpected funding needs.
NPLs	Non-performing loans	Ratio in percent	NPLs to total loans

So, for bank-specific variables, the present study uses PSTR as described above with using monthly data starting 2016:04 to 2020:12 for 10 banks. Variables including are interest spread, NPLs growth, loan to deposit ratio, and growth of loan loss reserve.

4 Models and Tests

Based on the previous section, the impacts of the variables are estimated in the models and required tests are presented.

[1] One might think it has a perfect collinearity with NPLs, but also central bank sets specific regulations for this account, banks don't follow in a sensible way due to liquidity problems.

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4.1 Estimation Results of Macroeconomic Variables Impact

Investigation of the time series properties of data should be done before any conducted tests in econometric analysis. To report the order of integration of the variables, the below table presents the unit root test using Phillips and Perron's (1988b) test. As shown in Table 3, the relevant variables are integrated at zero order.

Table 3
Unit-root test

Variable	Type	PP	Critical value	Decision
INF	level	-3.96	-3.54	I(0)
OIL	Growth	-26.09	-3.54	I(0)
GDP	Growth	-6.73	-3.54	I(0)
NPL	Growth	-7.51	-3.54	I(0)

Source: Authors' calculations

The notion of underlying economic theory often provides no signals as to which variable should be considered for the transition variable under the alternative, choosing a transition variable appears to be difficult. Teräsvirta (1994) indicates that for each of the possible transition variables, the null hypothesis of linearity will be tested. The explanatory factors and the time trend are frequent possibilities for the transition variable. If the null hypothesis is rejected by more than one potential variable, the transition variable will be chosen based on the most significant rejection regarding the linearity hypothesis (i.e., the lowest p-value). The test is most powerful when the alternative hypothesis is correctly specified, which is done for the "right" transition variable. This intuitive and exploratory method may be justified by observing which test is most powerful when the alternative hypothesis is correctly identified (Lundbergh et al., 2003).

It is important to note that while numerous individual tests must be performed, the total significance level of the linearity test cannot be controlled for this heuristic technique.

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Table 4
Model type and transition variable

Transition variable	F P-value	F_4 P-value	F_3 P-value	F_2 P-value	Suggested model
INF_t	4.5260e-02	3.4259e-01	7.6030e-02	5.4584e-02	LSTR1
$* OIL_t$	2.5908e-02	1.1307e-01	3.4123e-01	1.7653e-02	LSTR1
GDP_t	7.5212e-01	8.0766e-01	8.0200e-01	1.9494e-01	Linear
INF_{t-1}	3.2262e-01	5.5049e-01	1.1485e-01	5.3079e-01	Linear
OIL_{t-1}	4.4740e-02	1.9240e-02	7.1037e-01	1.6209e-01	LSTR1
GDP_{t-1}	3.1540e-01	1.2017e-01	2.2139e-01	4.0857e-01	Linear
INF_{t-2}	2.9692e-01	2.3114e-01	2.7925e-01	6.5085e-01	Linear
OIL_{t-2}	3.6321e-01	5.2321e-01	3.9655e-01	1.9564e-01	Linear
GDP_{t-2}	5.5798e-01	3.9561e-01	4.2793e-01	7.3264e-01	Linear

*Variable rejecting linearity with the most power.
**Specified subset restrictions for AR part as zero to do not have a lag of dependent variable as an explanatory variable. It is discussed in the literature part.
Source: Authors' calculations

According to the results, the growth of oil revenues of the current period at value 9 percent is recognized as transition variable and transition value respectively. If the transition variable has already been decided upon, the next step in the modeling process is to decide on a transition function. The findings suggested that the LSTR1 function has two distinct regimes.

Based on linearity test, Based on the linearity test, the growth of oil revenues (OIL_t) is chosen as a transition variable with one breakpoint which generates two regimes with logistic transfer function as shown in the above table.

The Newton-Raphson algorithm is used to estimate model parameters, and the results are reported in Table 5. It's worthy of mention that only variables with statistically significant coefficients at the proper confidence level have been examined in the linear and non-linear terms. This holds for a linear part not taking OIL_t, OIL_{t-1}, GDP_{t-1} and OIL_{t-2} into account and leaving GDP_t and GDP_{t-2} out of the interpretation for the nonlinear part.

Estimated ultimate values for transfer rate parameter, γ and threshold value (c), are 8.13 and 9%, respectively.

$$G(OIL_t, 8.1334, 9) = \left\{1 + exp\left[-8.13 \prod_{j=1}^{J} (\log(OIL)_t) - (9)\right]\right\}^{-1}, \gamma > 0$$

The results of the estimation model are given in Table 5.

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Table 5
The results of the estimation (Dependent variable: NPL)

Variable	θ	ϕ
CONST	0.78***	-0.38***
INF_t	0.03**	-0.09**
OIL_t	0.13	0.12**
GDP_t	0.07**	0.16
INF_{t-1}	0.12***	0.52***
OIL_{t-1}	0.21	-0.18***
GDP_{t-1}	0.30	-0.04*
INF_{t-2}	0.16***	-0.30**
OIL_{t-2}	0.11	-0.15***
GDP_{t-2}	-0.15***	0.21
HQ= -8.09 , SC= -7.61	R^2adjusted: 67%	AIC= -8.36

*** Significant at 99% confidence interval
** Significant at 95% confidence interval
* Significant at 90% confidence interval
Source: Authors' calculations

Since the growth of oil revenues is considered as a transition variable, the two regimes that separated in the models are interpreted as oil boom, and oil recession. The threshold for regime change is 9% for the growth of the oil revenues. The crucial point is as methodology suggested in previous parts, the logistic function will be considered in nonlinear parts by having G=1 while for the linear part this is G=0. Therefore, for the first regime:

$$NPL_t = 0.78 + 0.03(INF)_t + 0.12(INF)_{t-1} + 0.16(INF)_{t-2} + 0.07(\mathrm{GDP}_t) - 0.15(GDP)_{t-2}$$

For the second regime, oil boom:

$$NPL_t = -0.38 - 0.09(INF)_t + 0.52(INF)_{t-1} - 0.30(INF)_{t-2} + 0.12(OIL)_t + -0.18(OIL)_{t-1} - 0.04(GDP)_{t-1} - 0.15(\mathrm{OIL})_{t-2}$$

The coefficients show the short-term impact as the variables included in the model are in growth forms. Variation of variables coefficients in two regimes indicates that the effect of oil revenues, GDP, and inflation on NPL are different in each regime.

In an oil recession, (when quarterly growth of oil revenues is below 9 percent and note it can be negative), inflation has a positive and significant effect on NPL. The reason is mostly related to nominal anchor. The structure of the economic performance in Iran is like when there are fewer oil revenues, the exchange rate fluctuates more, which reflects its impact on inflation. It is

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not rational for most borrowers to repay their loans on time, and the penalty for repayment delay would not exceed the expectation of inflation. Also, the refinance process is not easy, so in a market with a high correlation between inflation and exchange rate, borrowers who seek short-run gains do not repay their loans. Also, as inflation increase, the real value of loan decrease, which leads to a higher incentive for borrowers to do not repay on time. On the other hand, GDP growth decreases the NPL, which is expected. As real sector performance is enhanced, due to cash flow and the need of the firms to get finances, lots of payment in aggregate is probable to be made.

However, in the oil boom as expected oil revenues are significant and have a negative impact on NPL. Inflation would again increase the NPL due to its uncertainty and forming new expectations. GDP still is well behaved and as economic theory suggests, decreases the NPL. The important thing here is to discuss the oil revenue's role. Undoubtedly, the government is the owner of this source and decides on its spending. If there is a project as planned in government capital expenditure, it is more probable that government allocates the required finance without forcing banks to provide credits. This process is a huge and considerable amount of the total NPL imposed by governmental decisions.[1]

Figure (1) demonstrates the amount of transition function at different levels of oil revenue growth (as threshold variable). The transition speed from one regime to another is practically seamless, according to the logistic transition function of the regime shift.

[1] Just consider the NPLs cumulated since 2011 and government wanted to repay by governmental oil refinery's block (a large volume trade that occurs at once) stocks at the beginning of 2021. Nearly 30 percent of bank's asset was evaluated as government debt.

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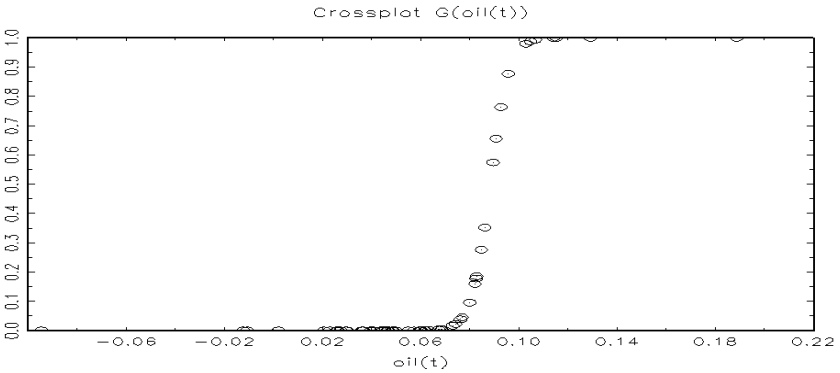

Figure 1. Logistic Function's Diagram for Regime Change.

Table 6 represents the results of the specification error tests for the smooth transition nonlinear model.

Table 6
Specification error tests for smooth transition nonlinear model

1. The autocorrelation error test*		
Lags	**P-value F**	**Null hypothesis: no autocorrelation**
1	0.36	Not rejected
2	0.19	Not rejected
3	0.58	Not rejected
4	0.81	Not rejected
5	0.82	Not rejected
6	0.78	Not rejected
7	0.87	Not rejected
8	0.84	Not rejected
2. Parameter fixed test in different regimes		
Transition Function	**P-value F**	**Null Hypothesis: Coefficients are Equal**
H_1	0.003	Rejected
H_2	0.0005	Rejected
H_3	0.04	Rejected
3. Non-linearity Test		
P-Value F	**Null Hypothesis: Extra non-linear nexus does not exist**	
0.24	Not Rejected	
4. Conditional Heteroskedactisity Test		
P-value F **P-value χ^2**	**Null Hypothesis: No Conditional Heteroskedactisity (ARCH effects)**	
0.49 0.32	Not Rejected	
5. Normality Test of Resides		
P-value χ^2	**Null Hypothesis: Resides have Normal Distribution**	
0.41	Not Rejected	

* Hypotheses are tested 95 confidence interval percentage.

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Source: Authors' calculations

Based on all diagnostic tests, non-linear estimation of macroeconomic determinants impact of NPLs is acceptable.

4.2 Estimation Results of Bank-Specific Variables Impact

As mentioned, the present study uses the PSTR model developed by González et al., (2017) to study nonlinearity. According to Levin et al., (2002), the unit root test should be addressed to prevent problems concerning non-stationary problems with the regression. The unit root test's results are presented in Table 7.

Table 7
Panel unit root test

Variable	Type	Definition	LLC with Intercept and trend	LLC with Intercept and without trend	Decision
IS	Level	Interest Spread	20.50	19.12	I(0)
LTD	Ratio	Loan to Deposit ratio	11.23	5.11	I(0)
NPL	Growth	Non-performing Loans	13.44	5.45	I(0)
LLR	Growth	Loan Loss Reserve	28.58	23.10	I(0)

Source: Authors' calculations

The next step would be to check whether there is a nonlinear relation or not. If there is, it is required to have the tests to verify the number of regimes that are reported in table 8. Paper will test loan to deposit ratio and interest spread as transition variables which will be shown with models 1 and 2 in tables 8 and 9, respectively.

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Table 8
Test of linearity or nonlinearity (Transition variable is IS)

Model 1						
	M=2			M=1		
Test	LM_w	LM_f	LR	LM_w	LM_f	LR
$H_0: r = 0$ $H_1: r = 1$	30.26	10.36	26.01	33.91	9.10	39.27
$H_0: r = 1$ $H_1: r = 2$	8.59	0.81	6.21	7.12	1.21	5.96

M is the number of breakpoints as threshold points.
r is the number of transition functions.
Source: Authors' calculations

Table 9
Test of linearity or nonlinearity (Transition variable is LTD)

Model 2						
	M=2			M=1		
Test	LM_w	LM_f	LR	LM_w	LM_f	LR
$H_0 = r = 0$ $H_1 = r = 1$	12.36	3.49	11.02	13.64	4.12	14.67
$H_0 = r = 1$ $H_1 = r = 2$	6.25	0.36	3.21	7.12	1.21	6.08

M is the number of breakpoints as threshold points.
r is the number of transition functions.
Source: Authors' calculations

Based on the results in Tables 8 and 9, the null hypothesis which declares there is one transition function with one or two transition values is not rejected. Now with the knowledge of nonlinear behavior, some breakpoints (M), should be tested to choose the best model.

Table 10
Number of breakpoints

Model 2						
	The transition variable is IS			The transition variable is LTD		
Test	*RSS*	*schwarz criterion*	*akaike criterion*	*RSS*	*schwarz criterion*	*akaike criterion*
$M = 1$	0.713	-5.32	-5.44	0.841	-4.21	-4.39
$M = 2$	0.999	-3.17	…	…	-4.09	-4.16

Source: Authors' calculations

Once again note that the data are monthly starting 2016:04 to 2020:12 for 10 banks. Based on RSS and information criteria, the model with interest

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spread as a transition variable, and one breakpoint seems to be the best model to investigate the nonlinear impact of bank-specific variables on NPLs. Based on the estimation, c as transition value for IS computed 0.0103 percent. It means that there are two regimes in which when the banks are in the high regime, they managed to absorb deposits with a low-interest rate and allocate loans with a high-interest rate, and loans' repayments are on the track. With verified regimes, now impact of explanatory variables can be addressed by PSTR estimation in the table below:

Table 11
Estimation of PSTR (Dependent variable: NPL)

$c = 0.0103$			$\gamma = 2.1$	
Regime	*IS*	*LTD*	*LLR*	*constant*
$IS < 0.0103$ $g(q_{it};\gamma,c) = 0$	-0.12***	0.32**	0.0014***	2.36***
$IS > 0.0103$ $g(q_{it};\gamma,c) = 1$	-0.26***	-0.09***	0.02	-3.03***

*** Significant at 99% confidence interval
** Significant at 95% confidence interval
* Significant at 90% confidence interval
Source: Authors' calculations

According to the threshold variable, it is possible to divide banks into good banks and bad banks from the interest spread perspective. Based on coefficients, when banks are not doing so well from the interest revenue perspective, they are located in the low regime and named bad banks. By definition and having Iranian banking structure in mind which interest rates are decided independently from the bank itself, this means loans portfolio are in bad shape that interest rates are below 1% and even negative. In this situation, LTD, as one of the moral hazard representatives, shows that loans are allocating without a good credit metric system, collateral, which causes a huge segment of the bank's resources to be frozen without proper return. As banks tend to show this by creative accounting as good loans, but still, these loans as assets are not liquid. On the other hand, interest spread decreases the NPL expected, but it does not play such a prominent role. However, LLR is not that effective and does not follow the theory as suggested in the Iranian banking system.

When banks are in the high regime, they managed to have a good interest operation and have a good cash flow every month due to repayments. Also, if the system of a specific bank is well-performing and avoids loans to be

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categorized as NPL, even LTD is simulating the bank's interest profit, which is crucial. LLR also is not that important same here in good banks regime.

5 Conclusion

This study attempts to ascertain the determinants of NPL in Iran's banking sector. To do so two separate models are estimated to examine the effect of macroeconomic variables and bank-specific variables that are based on González et al. (2017). There are two reasons for using two different approaches. The first is because of the incompatibility of data frequency of banking dataset and macroeconomic dataset (monthly and quarterly data for the banking sector available after 2016) The second reason is this study uses ten banks in a panel data framework and since the macroeconomic variables change only over the time and are fixed across the cross-sections, there is a high chance of identification problems. Also, for the time-series STR model, data starts from 2004:3 to 2019:3 quarterly, which happens to have a reasonable variation in tackling the oil booms and recessions.

Therefore, to tackle the macroeconomic determinants of NPLs, this study uses inflation, oil revenues, and GDP without oil from 2004:3 to 2019:3. The oil revenues variable is recognized as a transition variable and its threshold is 9 percent. This variable divides the model into two regimes. In oil recessions, inflation is the most prominent determinant of NPLs, and GDP has a negligible effect on reducing NPLs. In the oil booms, oil revenues play an important role in decreasing NPLs as expected. In the high oil revenues regime, exchange rate fluctuations are less effective to affect nominal anchor. Therefore, the exchange rate is more stable, the growth rate of inflation and inflationary expectations are low and well behaved. Also, the government does not put so much pressure on banks to finance their current or capital expenditure.

Moreover, using PSTR model and monthly data over the period 2016:04 to 2020:12 this paper addresses the bank-specific determinants on NPLs. The interest spread variable is recognized as a transition variable and its threshold level becomes 1 percent. The sample banks are categorized as bad banks if their interest spread is below 1 percent and are categorized as good banks otherwise. By operation, the paper focuses on how a bank attracts deposits with low rates and allocates a good portfolio of loans with a low chance of default. Loan to deposit ratio's impact on NPLs is dependent on whether a bank is categorized as a good bank or not.

Ultimately, it is suggested to avoid creative accounting to move NPLs defined as new loans. It may cause a systemic risk among the whole banking

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system. There must be strict regulations on allocating loans, especially those without proper collateral or credibility. As long as banks are experiencing low interest of spreads and just by renewing the NPLs trying to identify profit, NPLs would not be introduced as a problem. Furthermore, the government itself as a lender to the banking system and omnipotent to whether it has repayments is a significant source of the problem. It addresses budget planning again to be more precise and not reluctant to the Iranian economy's extraordinary situation. Undoubtedly, with inflation's impact on NPLs, the importance of monetary authority's policies in tackling price level control and, more crucially, the exchange rate is vivid. It would lead to better expectation formation and would improve the banking system's stability.

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