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Is high inflation always bad?

- The link between inflation, institutions, and growth

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Abstract

Inflation targets are set by central banks worldwide to achieve stable and sustainable growth and the possibility of institutional quality affecting the inflationary effect on growth makes it essential to study the inflation-institution-growth relationship. This paper considers whether or not the relationship between inflation and growth is nonlinear in the shape of convexity and if it differs for different levels of institutional quality. A two-step system GMM approach is used on an unbalanced panel for a yearly regression with 160 countries from 2000 to 2018. The yearly regression is additionally divided into subsamples for low, medium, and high institutional quality. The same model is used for a regression with five-year averages with data covering 157 countries from 1995 to 2019. The results indicate a convex relationship, and institutional quality is estimated to be adversely correlated with the point of convexity when a convex relationship is observed. The implication is that inflation becomes less damaging to growth at a later stage than for countries with a low level of institutional quality. However, the results are not robust, and additional research is therefore needed to further determine the true nature of the relationship.

Keywords: Inflation, growth, institutional quality, two-step system GMM, convex

Table of Contents

1. Introduction

The view on the relationship between inflation and growth has changed throughout the decades. Going back to the 1960s, it was believed that inflation and growth were positively related in the short-run, whereas the relationship could go both ways in the long-run. However, one should consider the available data at that point in time. It gave results where the per capita growth rate actually rose when going from single to double-digit inflation. The relationship did not become negative until the inflation rate exceeded 20 percent. Since there were not many observations with inflation rates exceeding 20 percent at that time, the estimated relationships were, of course, sensitive to the inclusion of variables (Bruno & Easterly, 1996). The belief of a positive short-run relationship remained in the 1980s, but now the most prominent belief for the long-run was that the relationship was negative according to theory. Empirically there was a problem with no robust long-run, cross-sectional relationship between inflation and growth. There were also the empirical challenges of outliers driving the results, causality between inflation and growth, robustness, and how to determine whether the relationship is linear or not (Bruno & Easterly, 1996).

As is understandable, the indecisive relationship between inflation and growth has caught the interest of many researchers. Hence there exists a wide variety of studies using several different econometric approaches. Some researchers simply study the causality between the two,whether the relationship is negative or whether institutional quality has an effect. Furthermore,several studies determine the relationship as nonlinear, where much attention is given to find afirst nonlinearity, a threshold, for the start of the negative relationship between inflation and growth. This while also considering the effect of institutional quality on the said threshold (seee.g., Jude & Khan, 2014; Hanif & Khan, 2020; Khan & Senhadji, 2000). There is less researchon the nonlinearities of the relationship after said threshold and if those nonlinearities are affected by the institutional quality. In a paper by Fischer (1993), he finds a second nonlinearity as a diminishing marginal effect is observed even after the relationship turns negative.Similarly, Ghosh and Philips (1998) find the negative relationship to be convex. A convex relationship implies that each additional unit of inflation has a smaller negative marginal effecton GDP beyond the point of convexity. Thus, in this case, the marginal effect of high inflationwould not be as bad. However, neither of these papers relates their main findings to institutionalquality.

What is also important to note when studying the effect of inflation on GDP is the causality between the two, as pointed out by previous researchers. This fact is especially noteworthy because central banks worldwide are using inflation targets to contribute to stable and sustainable growth (Riksbanken, 2018). However, a specific inflation rate might not be furthest up in the list of priorities in less developed countries (Aisen & Vega, 2005). There is, for instance, the recent case of hyperinflation in Venezuela, the current record holder, and the common examples of Zimbabwe or post world war Germany (Amadeo, 2020). The list could go on, and it is safe to say that higher inflation rates, although not necessarily hyperinflation, is a more common problem than deflation. Thus, there is much theory about the costs of inflation in the literature. It is, however, hard to find theoretical explanations regarding a possible diminishing negative marginal effect of inflation on GDP. This, even though the above-mentioned research has found proof of such a relationship.

Further research regarding the subject is needed, and so, this thesis attempts to contribute to that. This paper investigates whether there exists a nonlinearity between inflation and growth and whether this relationship is affected by the level of institutional quality. By investigating this, we hope that additional information regarding the relationship will be provided at a deeper than a linear level, contributing to the policy-making of central banks and governments. For this, the first question at issue is formulated as follows,

Is the marginal effect of inflation on growth nonlinear?

Since researchers conclude that institutional quality primarily affects the threshold for the negative relationship between inflation and growth, we also suspect that the second nonlinearity is affected by that. Central banks finding themselves in different contexts might have to act in disparate manners to achieve stable and sustainable growth. Therefore, institutional quality is also considered in this paper, and the level of institutional quality is represented by an index provided by the Fraser Institute. It consists of an average score of the following categories: Size of government, legal systems and property rights, sound money, freedom to trade internationally, and regulation (The Fraser Institute, 2020). The second question at issue allows for our findings to be tailored to a specific context and leads as follows,

Does the marginal effect of inflation on growth differ for different levels of institutional quality?

A two-step system generalized method of moments (henceforth SGMM) approach is carried out to examine the two questions at issue. An unbalanced panel for 160 countries with data from 2000 to 2018 is used for the annual data and the subsamples of different levels in institutional quality. The levels are divided into low, medium, and high institutional quality. The estimation is also carried out with five-year averages of the variables with data ranging from 1995 to 2019 for 157 countries. The data set is not restricted to specific regions, with the purpose of having a representative distribution of the world. Thus, making it possible to draw conclusions that reflect the worldwide reality. A complete list of the countries used in the two regressions can be found in appendix 10. A squared inflation variable is included in addition to inflation to explore the nonlinearity of inflation on GDP. Similarly, squared institutional quality is included in addition to institutional quality to account for the marginal effect of institutional quality on GDP. To find robust results, regressions where outliers are removed, where inflation is used as an endogenous instrument, and with lagged explanatory variables areconducted.

In the five main regressions, the results indicate a convex relationship between inflation and growth, but inflation is not significant for the regression with medium institutional quality. When a convex relationship is observed, institutional quality is estimated to be adversely correlated with the point of convexity, meaning that the point is estimated to be higher for lower levels of institutional quality. Furthermore, squared inflation is only significant in the yearly, five-year, and low institutional quality regressions. The results of the robustness analysis vary by showing both convex, concave, and increasingly negative relationships for the different regressions. Thereby no robust conclusions can be drawn regarding a convex relationship.

This paper is distributed in the following way. Chapter two includes previous research and outlines the theoretical framework. Chapter three consists of the model specification, methodology, specification of the variables, and data. Chapter four contains the empirical result, the robustness analysis, and a discussion of the results. Lastly, chapter five provides the concluding remarks.

2. Previous research and theoretical framework

There is no shortage of research on the relationship between inflation and growth. However, it is still challenging to determine the exact causality between the two and is important to note when considering the following research results. Even so, there is agreement regarding the fact that the relationship is negative, although it might not be linear.

2.1 Inflation-growth

Central banks worldwide are setting inflation targets to facilitate price stability, which in turn contributes to stable and sustainable growth (Riksbanken, 2018). Today, the literature could primarily be divided into three views of how to set the inflation rate. The first view considers moderately negative inflation, while the second and third views consider zero inflation or slightly positive inflation. By looking at what other papers recommend, the most cited papers advocate for a rate around zero percent. Taken together, the consensual view states that optimal inflation is probably between -4 to 4 percent (Luther, 2019).

As central banks are setting inflation targets to ensure growth, studying the causality between the two is important. This approach used by central banks worldwide would be incorrect if inflation is endogenously determined by GDP instead of the other way around (Koulakiotis, Lyroudi, & Papasyriopoulos, (2012). Using a generalized autoregressive conditional heteroskedasticity (GARCH) model to analyze the causality, Koulakiotis, Lyroudi, and Papasyriopoulos (2012) find that inflation determines GDP at a 5 percent level of significance, while the opposite is found to hold at a 10 percent level. The result is a slight indication that the relationship is mostly going through inflation to GDP, but most likely not entirely.However, many argue that the effect should mostly go from inflation to growth and not as muchthe opposite (see e.g. Khan & Senhadji, 2000; Jude & Khan, 2014). One explanation for the findings of Koulakiotis, Lyroudi, and Papasyriopoulos can be made by simply referring to thebasic theory of supply and demand. It makes an argument that growth can potentially lead to inflation. This happens when aggregate demand increases more than aggregate supply, leadingto increased prices, thus causing inflation. Inflation can also go through other channels, like theincrease in employment that may come with growth. An increase in employment leads to wagesbeing pushed up and thereby inflation (Fregert & Jonung, 2014, p.332)

Moreover, there exists much theory on inflationary costs with a presumption that inflation is bad. However, the empirical evidence that inflation is harmful needs additional research (Barro, 2013). With a system of regression equations based on the neoclassical framework of growth, Barro (2013) explores the inflation-growth relationship further. The results show a significant and negative effect of inflation on growth. However, he states that it is important to note that the clear evidence for these adverse effects comes from the experience of high inflation. It is also concluded that an increase in inflation of ten percentage points per year causes a reduction of real GDP per capita by 0.2-0.3 percentage points.

The potential damage of inflation is considered to run through several different channels. One unavoidable consequence of inflation is that money holdings lose value over time, as long as the inflation is positive. This leads to the shoe-leather effect, which implies a decline in economic activity as inflation increases. The greater the inflation, the greater the decline in economic activity. The reason is that the population wants to hold as little money as possible when inflation is high and, therefore, zero in on transactions closer to the receipt of income. The storekeepers will also reduce their stocks due to a similar logic, leading to a search for still open stores and more demand for those (Driffill, Mizon & Ulph, 1990, p. 1017).

There is also the risk of inflation pushing people into higher tax brackets without them being wealthier in real terms. This happens if the tax brackets are not adjusted in line with inflation (Driffill, Mizon & Ulph, 1990, p. 1023). This is a growth-inhibiting mechanism as private investment is considered to be more economically efficient than governmental investments (Jude & Khan, 2014)**.**

Riksbanken, the central bank of Sweden (2018), provides an additional explanation for the costs of higher inflation. They state that high and volatile inflation implies uncertainty due to relative prices changing more often and to a greater extent. Aisen and Veiga (2006) clarifies that high inflation is associated with a volatile one. Riksbanken further argues that an increase in the fluctuations of relative prices makes purchase decisions for households and investment choices for companies more difficult. High inflation also leads to a redistribution of income as lenders are benefitted while the lending part suffers. The overall effect of the above is that the willingness, as well as the possibility to invest in products and growth-enhancing machinery, declines. What follows is that the overall pace of economic activity, and therefore growth, is reduced (Riksbanken, 2018).

2.2 Nonlinearities in the inflation-growth relationship

Not much literature is published regarding theories of why the negative marginal effect of inflation on GDP might not be as significant for higher inflation levels compared to relatively moderate ones. However, some research on the inflation-growth relationship has considered why the adverse effects might be decreasing at higher rates. Salahodjaev and Chepel (2014) find that in countries with hyperinflation, at least the private banks and the financial companies seem to have adapted to the environment. This might be considered an argument for the belief that it is possible to learn to live with high inflation, which could result in the second nonlinearity. In other words, a diminishing negative marginal effect of inflation on growth could be observed.

Another argument for reducing the marginal effect at higher levels of inflation is the adaptation of indexation mechanisms. Countries with high inflation are implementing measures to prevent the damage on growth, thus reducing the marginal effect for high inflation levels as countries with a past embossed with low levels of inflation likely will not have such tools implemented (Khan & Senhadji, 2000). This could be a possible explanation for the findings of Fischer (1993). He explores nonlinearities in the relationship between inflation and growth while also considering the causality between the two variables. This by using a cross-sectional regression methodology that includes panel regressions with varying time periods. Like other researchers will continue to do, Fischer concludes that there is a negative relationship between inflation and growth. He also concludes that there exist nonlinearities in the effect of inflation. When inflation rises, the relationship between inflation and growth weakens per additional percentage point of inflation. As the relationship between the variables is more potent at low and moderate levels of inflation, it does not seem like the outliers are the ones that drive this result. However, Fischer explains that it is still unclear which way the causation between inflation and growth runs, even if one can argue that it is more likely to run from inflation to GDP.

Ghosh and Phillips (1998) continued to study the nonlinear effect inflation might have on growth. A nonlinear relationship between inflation and growth is presumed, and the effect of inflation is found to have a significant negative relationship on growth. This result survives multiple robustness checks, but the authors do not want to rule out the possibility that a part of the negative relationship is a consequence of inflation being endogenously determined by GDP.

They also find two nonlinearities in the relationship in line with the result of Fischer (1993). At very low inflation rates, such as 2-3 percent a year, there is a positive correlation between inflation and growth. They are negatively correlated at higher inflation rates, but the relationship is convex, revealing the second nonlinearity of a diminishing marginal effect. This means that the reduction in growth associated with an increase of inflation from 10 to 20 percent is much larger than the effect of going from 40 to 50 percent of inflation.

A more recent study by Jude and Khan (2014) considers both whether the inflation-growth relationship is linear or not and how this may vary for countries with different levels of development. They use two different approaches to do so. Firstly a Panel Smooth Transition Regression Model (PTSR), and secondly, an SGMM model. A nonlinear relationship is estimated, as a lower threshold for a negative relationship is found in both the SGMM and the PSTR model. Levels of inflation below the threshold are estimated to have an insignificant effect on growth. Jude and Khan then study if this first nonlinearity is different for emerging and developed economies and find that the threshold is estimated at a level of 3.4 percent for advanced economies. In contrast, the corresponding value for low-income economies is 20 percent. They explain the result with the Balassa-Samuelson effect. It says that higher productivity leads to higher rates of inflation, where less developed countries often have higher growth due to catching up and thereby higher inflation rates than more developed countries (Jude & Khan, 2014).

2.3 Inflation-institution-growth

To add to the studies on the relationship between inflation and growth, studies of how institutions may have an effect in these settings have been made. The effect of institutional quality on inflation and GDP can be divided into two main effects. Firstly, bad institutions can cause higher inflation, implicitly implying that institutional quality might be an underlying determinant of the inflation-growth relationship. Secondly, different levels of institutional quality can lead to inflation affecting growth differently.

Salahodjaev and Chepel (2014) study the first effect and state that previous studies in the 1990s have found a strong positive impact of institutional development on growth and a low rate of inflation. Their research is conducted to see if an increase in institutional development is associated with a decrease in inflation rates and see if it holds for countries experiencing high inflation rates. As a measure of institutional development, the domestic credit to the private sector as a percent of GDP is used. This measures the quality and the quantity of the banking system. The results show that an increase in the quality of institutions and the level of institutional development of the banking system have a significant negative effect on inflation. However, in countries experiencing hyperinflation, the banking system does not decrease inflation since the private banks and the financial companies have adapted to that particular monetary environment. Aisen and Veiga (2005) lay out a more precise reason why countries with poor institutions have suffered from higher inflation than countries with better institutions. They explain that political instability can be seen as a part of the poor institutions and that short-term goals are likely to be prioritized over long-term ones by unstable governments. The higher probability of them having to leave office early is why price stability and inflation are not included in the short-term goals while financing projects with inflation taxation is.

Hanif and Khan (2020) study the second effect of institutions, that is if institutional quality matters for the effect inflation has on growth in the inflation-institutions-growth trifecta. They use a similar econometric approach as in the study published by Jude and Khan in 2014, but with five-year averages being used as observations. They find a minimum requirement for the level of institutional quality to observe a negative relationship between inflation and growth. This is in contrast with most of the published research during the past twenty years. One common conclusion during this period is that the relationship is nonlinear, independent of other factors. Another typical result regarding the second effect is seen in Jude and Khan (2014). They find that a greater level of inflation is essential for the existence of the negative inflation-growth relationship in developing countries compared to the level required in developed ones. The researchers conclude that a history of high inflation for the developing economies, lack of an independent central bank, absence of solid fiscal systems as well as the presence of the Balassa-Samuelson effect are all potential explanations for the result.

Emara (2012) further considers the effect of inflation volatility on GDP using an SGMM approach. In contrast to previously mentioned studies, inflation is found to have no significant effect on growth, rather inflation volatility has an effect. This, even for countries with a moderate level of inflation. It is also concluded that the degree of development in financial and legal institutions is essential since improving these institutions in institutionally poor countries will have a relatively big and significant effect in reducing the harm of inflation volatility on growth. For developed countries, this has a relatively small and insignificant effect. Thus, the level of institutional quality matters for the inflation-growth relationship.

Khan and Senhadji (2000) also find a lower threshold for inflation to affect growth. The threshold is between 1-3 percent for developed countries and between 7-11 percent for developing ones. Once again, indicating the second effect as institutions affect the relationship between inflation and growth. They also find that the effect should be mainly going from inflation to GDP and not the opposite. This as inflation cannot be endogenously determined in their models. Similar results are also found in the studies by Jude and Khan (2014), Salahodjaev and Chepel (2014), Hanif and Khan (2020), and Emara (2012). Khan and Senhadji provide additional explanations for the observed results in these studies. They argue that the argument regarding indexation mechanisms affecting the inflationary effect on growth can also be applied to the institutional perspective. The reason is that countries with poor institutional quality often have experienced high inflation in the past in comparison to their developed counterparts, resulting in them implementing inflation-preventive measures as indexation systems. More thoroughly, the indexation systems operate opposite to inflation as they counteract a part of the change in relative prices caused by inflation. Khan and Senhadji (2000), as well as Hanif and Khan (2020), further explain the mutual finding of the presented literature, the finding that the inflation-growth relationship differs with the level of institutional quality. They state that countries with poor institutional quality often are bad at collecting taxes. These countries, therefore, seek alternative measures as financing tools, one of them being inflation taxation. Therefore, the government of a developing country with poor institutions sometimes has an additional growth-harming cost of inflation when investing. This, as the resources used are collected by inflation taxation to a greater extent. Crucial growth-inducing investment, for example, education, could be financed by taxation in developed countries, while developing countries could have to opt into inflation taxation to do so. The result of this is that inflation does not affect growth to the same extent, or at all, for countries with a lower level of institutional quality. The reason being is that the negative effect of inflation on growth is counteracted by the positive effect on growth by the investments.

Summary

In summary, the existing research gives central banks support for their use of inflation targets. Even if the exact causality is difficult to determine between inflation and growth, empirical results show that the effect mostly goes from inflation to GDP. With supply and demand, theory explains how the effect could be going the other way around. Much theory also explains how inflation can be costly by distorting price signals, investments and causing redistribution of wealth. There is not much theory considering a diminishing marginal cost of inflation even though this second nonlinearity is empirically observed. The first nonlinearity, the threshold for when the negative relationship starts, is higher for developing countries. Possibly due to them having experienced higher and more volatile inflation in the past, leading to adaptation for such an environment. However, more research is needed on both the second nonlinearity, and the impact institutional quality may have on this diminishing marginal effect.

3. Methodology

3.1 Models and econometric approach

This paper implements a two-step SGMM approach to estimate the marginal effect of inflation on growth and whether or not the relationship differs for different levels of institutional quality. An unbalanced panel data set covering 160 countries from 2000 to 2018 is implemented for the yearly regression with subsamples of institutional quality. For the regression with five-year averages, an unbalanced panel including 157 countries from 1995 to 2019 is used to conduct the estimations. This econometric methodology is in line with parts of the previous research, more specifically in line with Emara (2012), Jude and Khan (2014), and Hanif and Khan (2020). The yearly model is used for the yearly regression and for the subsamples of low, medium, and high levels of institutional quality. They will be labeled as the yearly, low, medium, and high regression moving forward. The yearly model is specified as follows,

$$GDP_{it} = \beta 1(Inflation_{it}) + \beta 2(SqInflation_{it}) + \beta 3(lnInstQual_{it}) + \beta 4(lnSqInstQual_{it}) + \beta 5(GDP_{it-1}) + \beta 6(GDP_{it-2}) + \beta 7(GDP_{it-3}) + \beta 8(X_{it}) + \lambda_i + \delta_t + \varepsilon_{it} \quad (1)$$

For all variables, *it* represents the specific country *i* at time *t*. GDP_{it} is the dependent variable and stands for annual increase, alternatively decrease in the Gross Domestic Product. The first, second, and third lags of the variable are included as endogenous, instrumental, explanatory variables. Using the lags of the dependent variable as explanatory ones account for the dynamic process of GDP. In other words, it accounts for the fact that the variable is not entirely exogenous as the performance of the variable is affected by the performance of previous years. $Inflation_{it}$ is the annual inflation rate, while $SqInflation_{it}$ represents the squared values.

$lnInstQual_{it}$ and $lnSqInstQual_{it}$ are the logarithmic values of institutional quality. X_{it} is a vector containing the four control variables of population growth, terms of trade, government spending, and human development index. The latter three are represented as logarithmic values. λ_i is the country-specific fixed effects for country i, δ_t represents the time-specific fixed effect for each country at year t, and ε_{it} is the error term.

This paper also implements a secondary model with observations consisting of five-year averages in line with Khan and Senhadji (2000), Jude and Khan (2014), and Hanif and Khan (2020) as a complement to the yearly one. There are two main reasons for this, firstly to prevent business fluctuations from affecting the results to a large extent, and secondly, to allow for the inclusion of outliers without jeopardizing the robustness of the results (Khan & Senhadji, 2000). The model for five-year averages will be labeled as the five-year regression moving forward and is specified as follows,

$$GDP_{it} = \beta 1(Inflation_{it-1}) + \beta 2(SqInflation) + \beta 3(lnInstQual) + \beta 4(lnSqInstQual) + \beta 5(GDP_{it-1}) + \beta 6(X_{it}) + \lambda_t + \varepsilon_{it} \quad (2)$$

The variables are in line with the ones in the yearly regression, the only deviation being that the dependent variable is only included with one lag. The reason for the single lag is that the inclusion of further lags would invalidate the AR(2)-test due to the five-year regressions consisting of fewer time periods than the yearly one.

As previously stated, the dependent variable is not entirely exogenous as it is thought to be correlated with previous realizations of itself. As stated by Roodman (2009), SGMM is suitable for such dynamic variables. The estimator is also suited for panel data sets with few time periods, T, and many individuals, N. If the T/N ratio is too large, it should be noted that small sample bias is a possible consequence (Heid, Langer, & Larch, 2012). The largest ratio for the main regressions comes from the one concerning high institutional quality. The ratio gives a value of 0.33, not considered to make small sample bias a big problem in this paper. Furthermore, the SGMM model uses difference equations to eliminate the country-specific effects and level equations to prevent the instruments from becoming too persistent (Windmeijer, 1998).

The two-step version of SGMM is considered as this version uses a weighting matrix that is the inverse of the estimate of the covariance of the moments, making it asymptotically efficient (Hayashi 2000, p. 215, Roodman, 2007). However, it also gives rise to a possible problem as the elements in this matrix are quadratic in the number of instruments. Therefore, the instruments can become very large and make the matrix very imprecise, thereby causing instrument proliferation (Verbeek, 2012). Instrument proliferation may lead to an overfit of endogenous variables and thus fail to remove their endogenous components (Roodman, 2009).

One should consider the Hansen J test for joint validity of the instrument set. It has the null hypothesis that there is a joint validity of all the instruments leading to high p-values creating an argument for the validity of the results. However, one should be cautious of higher values as both a high and a very low instrument count weakens the test (Roodman, 2007). Roodman (2009) suggests that 0.1 should be the lower limit of the p-value and that values as high as 0.25, or bigger, could be signs of trouble. The failure of rejecting the Sargan test for overidentifying restrictions also gives support to the choice of instruments. However, the Sargan test does, unlike the Hansen test, suffer from the fact that it is only consistent when errors are homoscedastic. That errors are homoscedastic is rarely assumed in a context where GMM is preferred (Roodman, 2007). The Arellano-Bond AR-tests are important as well. For AR(1), the null is expected to be rejected due to using the lag of the dependent variable as an explanatory one. AR(2) should fail to be rejected, indicating that it is valid to use the second lag as it is not correlated with the disturbance in the error term (Roodman, 2009).

For the validity of the results, robustness checks will be conducted where outliers are removed, where inflation is used as an endogenous instrument, and with lagged explanatory variables. This is found in section 4.3.

3.2 Variables

Several country-specific explanatory variables have been included to account for the variance in GDP unexplained by inflation and squared inflation. Every variable has been log-transformed apart from the ones that take negative values. Squared inflation is not log-transformed even though it only takes positive values as the marginal effect of inflation on GDP would then be uninterpretable. This due to the effect of inflation and squared inflation on GDP being measured in different units. Each variable and its respective expected behavior is explained below.

GDP

The dependent variable consists of the annual percentage growth in real GDP. Lagged GDP is also included as an endogenous explanatory variable. The lag is expected to have a positive effect on GDP due to autocorrelation. The same is true for additional lags of GDP, but the relationship is anticipated to be weaker for each additional lag.

Inflation / SqInflation

Inflation is the primary explanatory variable of this paper. It is measured as the average percentage increase in consumer prices and is generally expected to affect growth negatively, according to the theory presented in section 3. The marginal effect of inflation on growth is of interest as inflation and squared inflation are included in the regression. Inflation ranges from -72.7 to 550.0 for the yearly data set, while the range for the data set consisting of averages is between -2.26 and 334 percent. Concrete conclusions cannot be drawn outside of the intervals. Any interpretations near the outliers must also be made with caution as the second-largest five-year average is for instance 190 percent. Inflation has been squared and included as an explanatory variable to study the marginal effect of inflation on GDP at more than the linear level. The marginal effect of inflation on GDP is the combined marginal effect of the inflation and the squared inflation variables. The marginal effect for different levels of inflation is ambiguous in line with the literature in chapter 2.

lnInstQual / lnSqInstQual

Institutional quality is represented by an index consisting of an average score of the following categories: Size of government, legal systems and property rights, sound money, freedom to trade internationally, and regulation. The marginal effect of institutional quality on growth is the effect of interest as the square of institutions is included in the regressions. The expectation of this marginal effect is ambiguous.

lnHDI

The Human Development Index is an average of life expectancy, education level, and GDP. It measures the overall standard of living in combination with human capital and is thus different from GDP per capita as it captures more than the material aspect of life (UNDP, 2020). HDI is expected to positively affect GDP because a longer life expectancy opens up the possibility of more years of working and thus actively increasing GDP. A second reason for the positive relationship is that an educated person will, on average, produce more than an uneducated counterpart. The last argument for the positive correlation is that a high GDP implies a high standard of living, which makes it possible for the population to be in good health and therefore add more to GDP.

PopGrowth

This variable is the annual percentage increase or decrease of the population. It is expected to affect GDP positively as more people can produce a higher output. The variable accounts for the variance in GDP explained by the change in population size as a substitute to a GDP per capita measurement. An argument could be made that an increase in the population in one country could affect GDP differently than an equally large increase in another country. One example would be if more children are born in a country, increasing the population but not increasing the able-bodied population. The population increase in another country could, on the contrary, consist of immigration of able-bodied persons. However, the measurement should be a positive addition to the model on average and is therefore included.

lnGovSpend

Expenditures as a share of GDP measure government spending. The expected sign of the variable is negative as governmental spending is regarded as less economically efficient than private investment (Jude & Khan, 2014).

lnToT

Terms of trade is the price ratio of exported and imported goods. An index represents it, with the year 2000 being used as the base year in this paper. An increase in terms of trade is expected to positively affect GDP similarly to technological advances since it implies that the value of output is increased for a certain level of inputs (Fox & Kohli, 1998).

3.3 Data

The data used in the yearly regression consists of 2672 observations from 160 countries during the nineteen years of 2000 to 2018, represented by an unbalanced panel. Several countries have been included despite having very few observations. Sudan and Libya do, for example, only have three observations each. This decision reflects our belief that a lack of data for a country is correlated with institutional quality. These few observations might therefore contain crucial data. Panel data is used to allow fixed effects to vary over time, thus accounting for additional unobserved heterogeneity (Bacchetta et al., 2012).

The sub-regressions of the yearly one, consisting of observations with either a high, medium, or low level of institutional quality, have 895, 891, and 888 observations, respectively. The logic behind the grouping is simply that the level of institutional quality is measured relative to the other observations. About one third of the observations are, therefore, in each group. The numbers differing slightly between the groups prevents identical observations from being in two different groups. This data set is also unbalanced.

The GDP, inflation, and population growth data are collected from the World Economic Outlook, provided by the IMF (IMF, 2021a). The World Economic Outlook reports the economic analysis of the IMF economists twice a year (IMF, 2021b). Human Development Reports, by the United Nation Development Programme, is our source of data for the Human Development Index (UNDP, 2020), while the data for terms of trade is collected from The World Bank (The World Bank, 2020). The Fraser Institute is an independent organization focused on research and education, and they provide the data for institutional quality (The Fraser Institute, 2020).

The data set of five-year averages includes 612 observations from 157 countries, with the same sources as in the yearly regression. Each observation is calculated as the average of the available yearly data within a five-year interval. The intervals are 1995-1999, 2000-2004, 2005-2009, 2010-2014, 2015-2019. An unbalanced panel data is once again used in line with the argumentation in 4.3.1.

3.4 Descriptive data

Scatter plots are presented as preliminary evidence of the inflation-growth, as well as the inflation-institution relationship. Figure 1 to 5 represents scatter plots containing observations of inflation and GDP for the data set used in each regression, while figure 6 to 10 consist of scatter plots with observations of inflation and institutional quality. All figures also include a linear trendline.

Figures 1, 2, and 3 illustrate a negative correlation between inflation and GDP[1]. However, this relationship turns weakly positive in figures 4 and 5. The scatterplots provide a clear explanation of this, as outliers seem to be the driving factor of the negative relationship. The highest inflation observations are all located in the sample of low institutional quality, with very few exceptions. The only regressions that exclude this part of the data are the ones with medium and high levels of institutional quality. We, therefore, expect findings of a negative relationship between inflation and growth to be driven by outliers located in the sample of low institutional quality. Regressions accounting for outliers are thus implemented to check the robustness of the results.

An adverse correlation between inflation and institutional quality is found in figures 6 to 10[2]. The absolute majority of inflation outliers are once again present, this time in figures 6, 7, and 8, which all include low levels of institutional quality. However, the negative nature of the relationship does survive the removal of low levels of institutional quality observations, thus the removal of the outliers, in contrast to the figures that represent the inflation-growth correlation. An implication of the persistent negative relationship is the possibility of institutional quality being the true determinant of the inflation-growth relationship.

Figure 1.

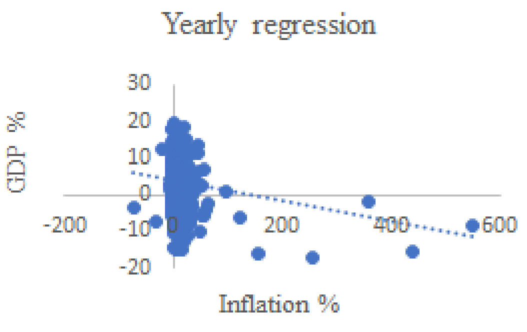
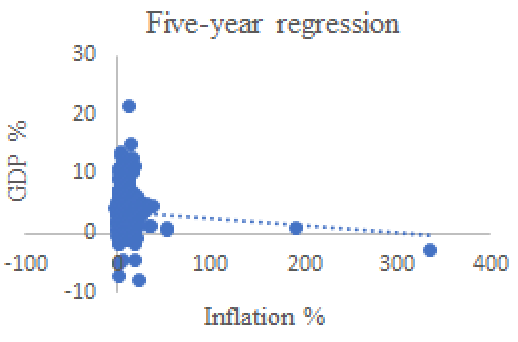


Figure 2.



[1] In line with the theoretical framework of Riksbanken (2018), Driffill, Mizon & Ulph (1990), Jude and Khan (2014), as well as the findings of Barro (2013)

[2] In line with the findings of Salahodjaev and Chepel (2014) and the explanation provided by Aisen and Veiga (2005)

Figure 3.

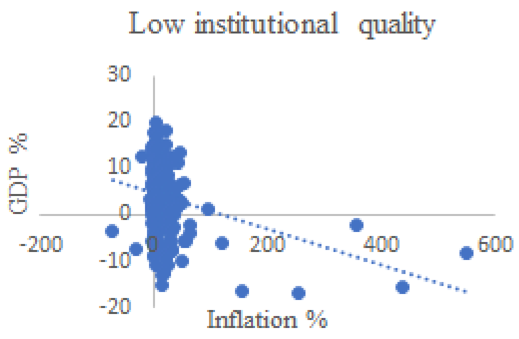


Figure 4.

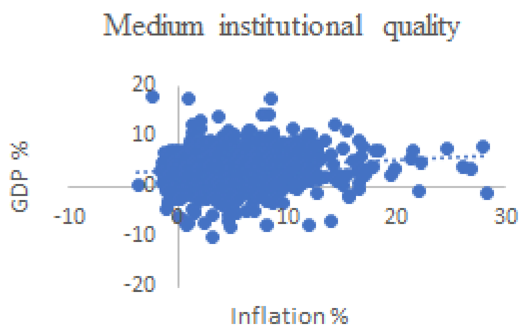


Figure 5.

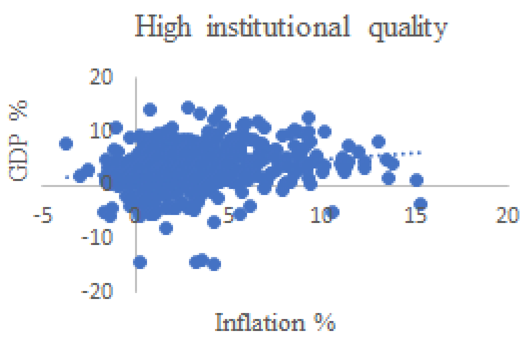


Figure 6.

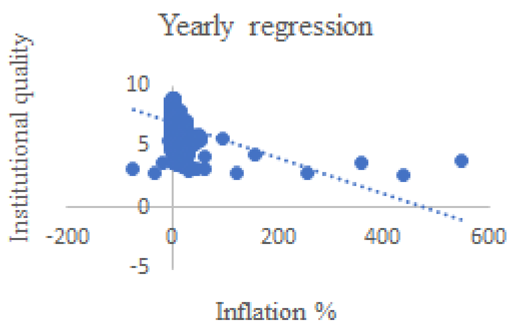


Figure 7:

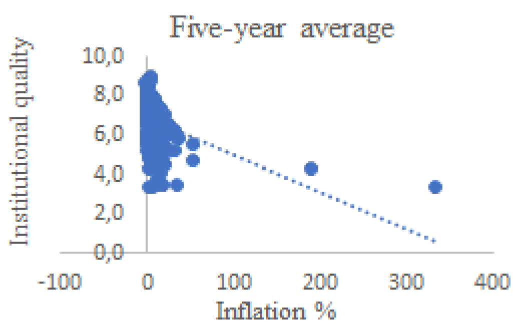


Figure 8:

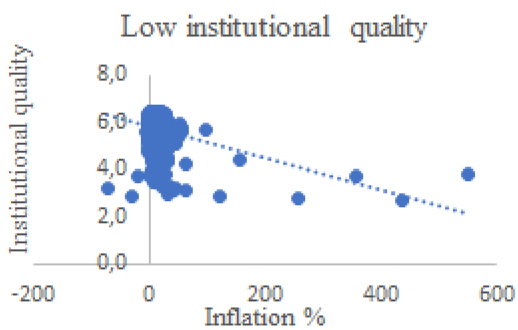


Figure 9:

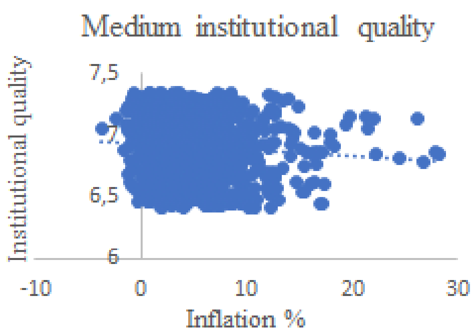
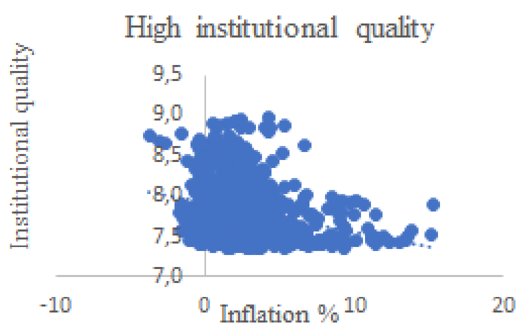


Figure 10:



4. Empirical results and discussion

4.1 Results

Table 3, located in section 4.4, presents the reader with an overview of the outcomes of all twenty regressions, while more in-depth explanations are found in the following sections.

4.1.1 Main yearly regression

The result of the yearly regression (1) is mostly in line with expectations. The marginal effect of inflation on GDP is estimated as convex, and the maximum negative marginal effect of inflation on GDP is achieved at an annual rate of 399[3] percent of inflation. GDP is expected to decrease by 17.3[4] percentage points at this rate of inflation annually. Inflation and squared inflation are significant at a one percent and five percent level, respectively, while both institutional quality and the squared version are estimated to be insignificant. The one-year lag of real GDP, as well as the three-year lag of real GDP, are both estimated to increase GDP. They are significant at a one percent level and a five percent level, respectively. The two-year lag of real GDP is surprisingly estimated to decrease GDP, but nowhere near any level of significance. The control variables do all have the expected sign apart from HDI. Government spending and HDI are significant at a three-star level, while both population growth and terms of trade are insignificant. Table 1 shows the estimated results of the yearly regression in its entirety, while the marginal effect of inflation on GDP can be seen in figure 11, under section 4.2.

4.1.2 Main five-year regression

The result of the five-year regression (2) can be seen in table 1, and the marginal effect of inflation on GDP is represented by figure 12, under descriptive results. It shows that the maximum negative effect of inflation on real GDP is believed to be at 139 percent of annual inflation. At this point, real GDP is estimated to be reduced by 6.48 percentage points per year. Inflation is significant at a five percent level, and squared inflation is significant at a ten percent level. Institutional quality and institutional quality squared are both insignificant. The lag of real GDP is, as expected, estimated to have a positive effect on real GDP at a significance level

[3] Calculated by taking the derivative of regression (1) and (2) with respect to inflation, setting it equal to zero, and solving for inflation.
[4] Calculated by inserting the point of convexity/concavity into the equation of the marginal effect of inflation on GDP. (i.e. $\beta 1*Inflation + \beta 2*SqInflation$).

of one percent. HDI does not have the expected sign as it has a negative effect on real GDP. However, it is not significant. The other control variables have the expected signs, but government spending is the only significant one, this at a one percent level.

Table 1. Illustrating the results of the yearly regression and the five-year regression.

Dependent variable: GDP	Yearly (1)	Five-year (2)
Inflation	-0.0862***	-0.0932**
	(0.0228)	(0.0407)
SqInflation	0.000108**	0.000335*
	(5.42e-05)	(0.000193)
lnInstQual	-11.2	-10.4
	(13.1)	(14.1)
lnSqInstQual	2.80	2.64
	(3.53)	(3.776)
GDP_t-1	0.391***	0.200**
	(0.0319)	(0.0770)
GDP_t-2	-0.0188	
	(0.0272)	
GDP_t-3	0.0745**	
	(0.0305)	
PopGrowth	0.0996	0.153
	(0.0623)	(0.105)
lnToT	0.482	0.253
	(0.320)	(0.391)
lnGovSpend	-1.39***	-1.400***
	(0.269)	(0.414)
lnHDI	-0.868	-1.150
	(0.599)	(0.935)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	2170	405
Instruments/Groups	=	0.210	0.110
AR(1) test, p-value	=	0.000	0.000
AR(2) test, p-value	=	0.639	0.757
Sargan test, p-value	=	0.594	0.482
Hansen test, p-value	=	0.673	0.564

4.1.3 Main subsamples of institutional quality

The countries are divided into groups in line with their level of institutional quality in the following regressions. This to analyze whether or not the effect of inflation on GDP differs between the groups of low, medium, and high institutional quality. A convex relationship between inflation and real GDP is implied in all three regressions. The global minimum point is estimated at 347 percent of inflation for low institutional quality (3), negatively affecting real GDP by 17.1 percentage points. It is believed to be at 16.6 percent of inflation for the medium regression (4), negatively affecting real GDP by 0.12 percentage points. Regarding the regression, for high institutional quality (5), the point is believed to be at 9.09 percent of inflation, with a negative effect of 0.95 percentage points on real GDP. The regressions show that inflation is significant for the countries with low institutional quality at a level of one percent and inflation squared at a five percent level. Inflation is also significant at a ten percent level for high institutional quality, but inflation squared is estimated as insignificant. Institutional quality and institutional quality squared are both insignificant for all three regressions. The first and third lags of GDP are significant at a level of five percent or less in all three regressions. The second lag of GDP is significant at a five and one percent level for medium and high institutional quality, respectively. In the low regression, only government spending has the expected sign, but none of the control variables are significant. For the medium regression, neither HDI nor terms of trade have the expected signs. Only population growth is significant. In the high regression, government spending is the only significant control variable. All control variables have the expected signs. Table 2 shows the results of the regressions, while figure 13-15 isolates the convex marginal effects. Note that these five regressions that have now been mentioned are considered the main regressions of this paper.

Table 2. Illustrating the results of yearly regressions for subsamples of institutional quality.

Dependent variable:	Low	Medium	High
GDP	(3)	(4)	(5)
Inflation	-0.0986***	-0.0142	-0.209*
	(0.0247)	(0.0625)	(0.124)
SqInflation	0.000142**	0.000429	0.0115
	(5.46e-05)	(0.00337)	(0.0109)
lnInstQual	-5.52	-102	267
	(24.1)	(399)	(184)
lnSqInstQual	0.705	28.7	-64.4
	(7.39)	(103)	(44.1)
GDP_t-1	0.371***	0.428***	0.487***
	(0.0401)	(0.0844)	(0.0584)
GDP_t-2	0.0317	0.120**	-0.0847*
	(0.0426)	(0.0472)	(0.0498)
GDP_t-3	0.0842**	0.220***	0.106**
	(0.0405)	(0.0444)	(0.0409)
PopGrowth	-0.104	0.139*	0.0522
	(0.272)	(0.0830)	(0.0735)
lnToT	-0.136	-0.606	0.412
	(0.730)	(0.389)	(0.430)
lnGovSpend	-0.391	-0.386	-1.63***
	(0.411)	(0.358)	(0.427)
lnHDI	-0.609	-1.15	0.164
	(1.060)	(0.704)	(1.565)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	588	547	660
Instruments/Groups	=	0.530	0.450	0.580
AR(1) test, p-value	=	0.000	0.000	0.000
AR(2) test, p-value	=	0.540	0.270	0.423
Sargan test, p-value	=	0.756	0.741	0.004
Hansen test, p-value	=	0.738	0.243	0.091

4.2 Estimated marginal effects

The following figures illustrate the marginal effect of inflation on GDP for regression (1) to (5), all implying a convex relationship. The scatter plots and the discussion in 3.3 indicate how only a few outliers may drive the results.

Figure 11.

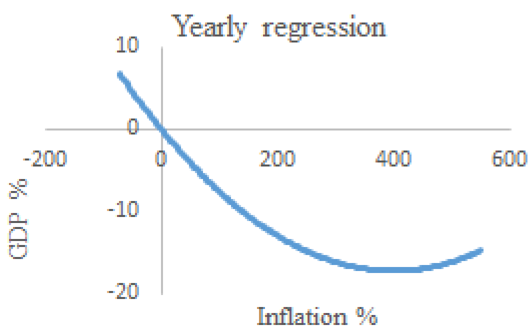


Figure 12.

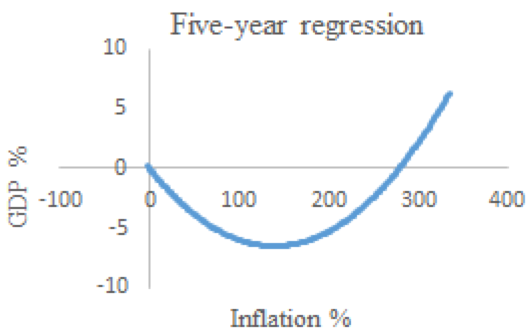


Figure 13.

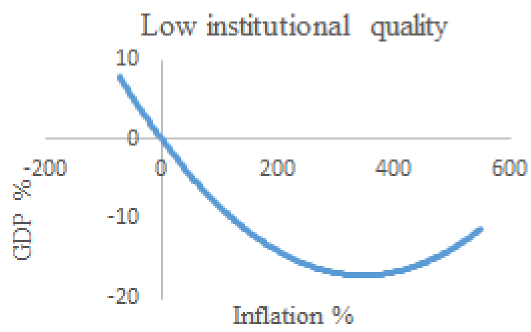


Figure 14.

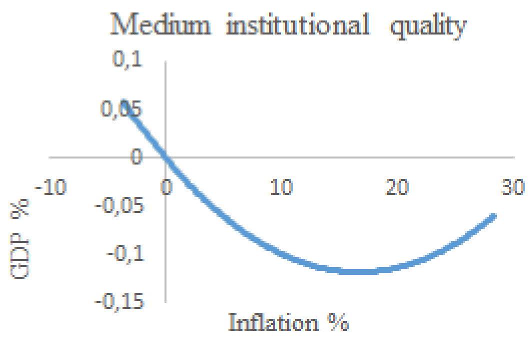
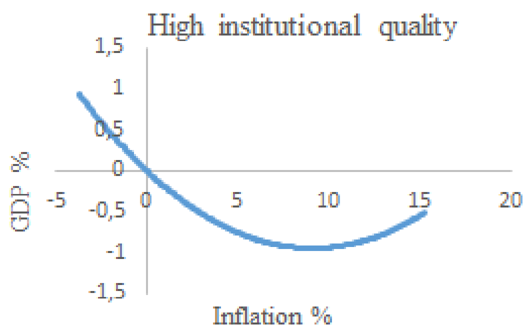


Figure 15.



4.3 Robustness

All the regressions from the robustness analysis can be seen in their entirety in appendix 1 to 6, labeled as tables A1 to A6. The marginal effects are graphically illustrated in figures 16 to 30, located in appendix 7 to 9.

4.3.1 Lagged explanatory variables

In order to test the robustness of the main results in regression (1) to (5), the explanatory variables have all been lagged in regression (6) to (10). This has been done in order to study the lagged effect on GDP that may come from the previous year. The motivation being that there could very well be a delayed effect in these types of regressions.

4.3.1.1 Yearly regression and subsamples of institutional quality

The yearly regression with lagged explanatory variables and the entire sample included (6) once again results in significantly estimated values of inflation and squared inflation, as well as insignificant values of the variables measuring institutional quality. However, the marginal effect of inflation is estimated to be concave instead of convex, with a decreasing marginal effect up until the point of concavity at 98 percent, which represents the main span of the data. At this point, inflation is expected to increase GDP by 2.8 percentage points.

The yearly regression with a subsample of low institutional quality (7) results in a concave relationship between inflation and GDP, contradicting the results of the corresponding regression (3). The largest positive effect on GDP is approximated at 111 annual percent of inflation, with an increase of 4.99 percentage points of GDP. The lagged regression with the sample of medium institutional quality (8) is interestingly estimated as negative with an accelerating marginal effect. The regression for high institutional quality (9) is the only one out of the three that somewhat resembled the results of the main regressions as it returned a convex relationship. This with the point of convexity being approximated at 8.7 percent of inflation, which is well within the set of data, implying that the negative marginal effect of inflation on GDP is diminishing until that point. The harmful effect on GDP is estimated at 0.88 percentage points at this level of inflation. Inflation is estimated as highly significant for regression (9), while the squared variant is insignificant.

4.3.1.2 Five-year regression

The lagged version of the five-year regression (10) resulted in a concave relationship between inflation and GDP. The point of concavity is estimated at 77 instead of 139 percent of inflation. The positive effect of inflation on GDP at that point is estimated to be 0.67 percentage points in the lagged regression, which can be compared to the negative effect of 6.48 percentage points in the main five-year regression (2). The main five-year regression (2) and the lagged version (10) only have two data observations beyond the point of convexity and concavity. This implies a high likelihood of a concrete conclusion regarding the exact values being misleading. What can be said is that the marginal effect of inflation on GDP is diminishing over the main span of data, but with different signs. Inflation did lose its significance in the lagged regression, and again, one, therefore, has to be careful with interpretations.

4.3.2 Inflation endogenously determined

An argument can be made for a bidirectional causality between inflation and GDP in line with the findings of Koulakiotis, Lyroudi, and Papasyriopoulos (2012). Not regarding inflation as endogenous while that is the case would invalidate the estimated effects. Inflation is therefore endogenously determined in regression (11) to (15) to account for the possibility of this being the case. Comparisons regarding instrument validity will be made between the regressions when inflation is considered endogenous and when considered exogenous. This will indicate the direction of the causality.

4.3.2.1 Yearly regression and subsamples of institutional quality

The yearly (11), the low (12), and the high regression (14) with inflation endogenously determined estimate the marginal effect as a convex function in line with the main regressions. All three regressions have significant values of inflation and squared inflation. The points of convexity estimate to 332, 302, and 7.52 percent, respectively. Which is not a large deviation from the corresponding measures of 399, 347, and 9.09 percent from the main regressions. The negative effects on GDP at these points estimate to 20.1, 24.9, and 0.770 percentage points. Similarities between the medium regression with lagged explanatory variables (13) and the main one (4) are somewhat absent as a concave relationship is now estimated instead of a convex one. The variables representing inflation are both insignificant, and any attempt at a concrete conclusion would likely be misleading.

4.3.2.2 Five-year regression

When inflation is endogenously determined in the five-year regression (15), the results become somewhat different from the corresponding main one (2). The estimation of the inflation-growth relationship is concave, with the point of concavity being at 89.0 percent instead of the previous convex estimation of 139 percent. This results in an estimated increase of 1.24 percentage points in GDP instead of the previously estimated decrease of 6.48 percentage points. Both results only have two data observations beyond the minimum or maximum point, and the point of concavity can therefore not be accurately determined.

4.3.3 Inflation outliers removed

The data set suffers from having quite a few outliers, as shown in figures 11-15, previously presented in section 4.2. There is a possibility of these outliers being the driving factors of the results while being anomalies. This paper, therefore, opts to run the main regressions without outliers in regressions (16) to (20) in a similar fashion to Jude and Khan (2014). Arellano and Bond (1991) argue that the Hansen test is sensitive to outliers in the two-step model, which this paper uses. This is another reason for this type of robustness check. Observations below -3 percent and above 30 percent are removed in the data sets for the yearly regression and its subsamples, while only averages beyond 20 percent are removed in the data for the five-year regression. The choice of boundaries is similar to the ones chosen by Jude and Khan (2014), who opted for an upper bound of 25 percent but not a lower one.

4.3.3.1 Yearly regression and subsamples of institutional quality

The yearly regression (16) and the low institutional quality one (17) with outliers removed result in the relationship between inflation and GDP having quite strong contrasts to the five main regressions. Both of them now estimate a concave relationship between inflation and GDP, but nowhere near any level of significance for either inflation or squared inflation. Interestingly, inflation, as well as squared inflation, are significant in (3) while insignificant in (17). Institutional quality and the squared version are significant in (17) but insignificant in (3). This observation will be further discussed in section 4.4. The medium (18) and high institutional quality regressions without outliers (19) do not have any significance level for institutional quality. However, (18) is similar to (4) in the sense that they both find the marginal effect of inflation on GDP to be a convex function. 19.1 percent of inflation is estimated as the point of convexity instead of the previous estimation of 16.7 percent. Both variables representing inflation are once again insignificant. A convex relationship is also found in the high regression without outliers (19). The lowest negative marginal effect is approximated at 9.13 percent of inflation, while the main regression with the subsamples of high institutional quality measured the value to be at 9.09 percent. The significance of inflation is non-existent for all four regressions.

4.3.3.2 Five-year regression

A concave relationship is found in the five-year regression without outliers (20), with the point of concavity being estimated at 7.46 percent of annual inflation. This is exceptionally low compared to the estimation of 139 percent in the main five-year regression (2), resulting in the positive effect on GDP being 0.450 percentage points instead of the previous negative effect of 6.48 percentage points. Inflation and squared inflation are both insignificant, while institutional quality and squared institutional quality are significantly estimated in the robustness check. This, at a one-star level. The complete opposite is true for the main regression(2), where both values of inflation are significant and institutional quality is insignificant.

4.4 Summary of regressions

Table 3. Illustrating a summary of all regressions and the estimated results.

Regression number	Explanation of regression	Relationship of the marginal effect between inflation and GDP	Point of convexity/ concavity (percent)	Estimated marginal effect on GDP at point of convexity/ concavity (percentage points)
(1)	Yearly regression with the entire sample	Convex	399	- 17.3
(2)	Five-year regression	Convex	139	- 6.48
(3)	Yearly regression with a sample of low institutional quality	Convex	347	- 17.1
(4)	Yearly regression with a sample of medium institutional quality	Convex	16.6	- 0.120
(5)	Yearly regression with a sample of high institutional quality	Convex	9.09	- 0.950
(6)	Yearly regression with the entire sample and the explanatory variables	Concave	98.0	+ 2.80

	implemented as one-year lags			
(7)	Yearly regression with a sample of low institutional quality and the explanatory variables implemented as one-year lags	Concave	111	+ 4.99
(8)	Yearly regression with a sample of medium institutional quality and the explanatory variables, implemented as one-year lags	Accelerating negative	-	-
(9)	Yearly regression with a sample of high institutional quality and the explanatory variables implemented as one-year lags	Convex	8.70	- 0.880
(10)	Five-year regression with the explanatory variables implemented as one-year lags	Concave	77.0	+ 0.670
(11)	Yearly regression with the entire sample and inflation endogenously determined	Convex	332	- 20.1
(12)	Yearly regression with a sample of low institutional quality and inflation being endogenously determined	Convex	302	- 24.9
(13)	Yearly regression with a sample of medium institutional quality and inflation being endogenously determined	Concave	3.30	+ 0.0400
(14)	Yearly regression with a sample of high institutional quality and inflation being endogenously determined	Convex	7.52	- 0.770
(15)	Five-year regression with inflation being endogenously determined	Concave	890	+ 1.24
(16)	Yearly regression with the entire sample and outliers of inflation removed	Concave	0.860	+ 0.100

(17)	Yearly regression with a sample of low institutional quality and outliers of inflation removed	Concave	9.45	+ 0.550
(18)	Yearly regression with a sample of medium institutional quality and outliers of inflation removed	Convex	19.1	- 0.190
(19)	Yearly regression with a sample of high institutional quality and outliers of inflation removed	Convex	9.13	- 0.880
(20)	Five-year regression with outliers of inflation removed	Concave	7.46	+ 0.450

4.5 Discussion

The marginal effect of inflation on GDP is estimated as convex in both the yearly (1) and the five-year regression (2). The yearly regression generated an estimation of 399 percent of inflation as the point of convexity, while the corresponding value of the five-year regression is at 139 percent. Both results are at the very outlines of the data with only two higher values each, implying that they are likely to be misleading. No conclusion regarding the point of convexity can therefore be drawn from these regressions. However, a nonlinear interpretation can be made since the marginal effect of both regressions is diminishing from the lowest observation until the point of estimated convexity. This is shown in figures 1 and 5, in section 4.3. Therefore, the implication of the main regressions is a positive confirmation of the first question at issue as nonlinearities are observed when interpreting them in a vacuum, without tests of robustness. A theoretical explanation for the outcome is the one presented by Khan and Senhadji (2000). They state that countries with a past colored by high inflation likely have developed an indexation system as a preventive measure, resulting in smaller changes in relative prices and, thus, less harmful to GDP in line with the previously presented theory. The higher the past inflation, the better the system according to this logic. Consequently, each additional percentage point of inflation could be correlated with a better indexation system, resulting in a diminishing marginal effect.

Low (3), medium (4), and high (5) levels of institutional quality are found to have differing threshold effects for the inflation-growth relationship, with the point of convexity being estimated at 347, 16.6, and 9.09 percent, respectively. The results imply that countries with lower institutional quality have a higher maximizing growth harming level of inflation than their counterparts with better institutional quality. A couple of reasons could be used to explain the observed phenomenon. Firstly, the argument regarding indexation systems mentioned in the paragraph above. Secondly, the belief of an existing correlation between institutional quality and the taxation ability presented by Khan and Senhadji (2000), as well as Hanif and Khan (2020). Previous papers have not attempted to estimate the point of convexity specifically, and such research is therefore not previously presented. Comparisons can, however, be made to the existing literature as it has found that a low level of institutional quality implies that the threshold for a negative relationship between inflation and growth is higher than for their counterparts (see e.g. Khan & Senhadji, 2000; Jude & Khan, 2014). In line with that, this paper also finds higher values for countries with lower levels of institutional quality, but regarding a point of convexity instead of a threshold. The following implication is that countries with better institutions arrive at a point of inflation where the negative marginal effect decreases onwards, at a lower rate of inflation than their counterparts with poor institutional quality. This, suggesting *yes* as the answer to the second question at issue since it is considered evident that institutional quality affects the inflation-growth relationship.

However, the above implication is drawn from the results displaying a convex relationship. This particular nonlinearity could be questioned with reference to the robustness checks as it results in ten out of twenty regressions being estimated as convex. For instance, regression (6), (7), and (9) with lagged explanatory variables estimate the inflation-growth relationship as concave, and an accelerating negative marginal effect is the outcome of regression (8). The outcomes of the regressions where inflation is endogenously determined are less deviating than those with lagged variables, but the Sargan and Hansen tests for instrument validity are not simultaneously valid for four out of the five regressions. The Sargan test fails for regression (11), (12), and (14), while the Hansen test fails for regression (11), (12), (13) at a five percent significance level. This is not the case for the main regressions, where only the Sargan test fails for regression (5). The regressions without outliers also contradict the main regressions with concave and convex results. The point of concavity is estimated at roughly 7 percent in regression (20) instead of the convex point at 139 percent in the corresponding regression (2).

One, therefore, has to question the validity of the nonlinearities found in the main regressions, implying that the answer to the first question at issue cannot be robustly determined.

The AR(1) and AR(2) tests align with the expectations in every regression. AR(1) fails to reject the null hypothesis of the first differences following an autoregressive process of order one, while AR(2) rejects the null, as more thoroughly discussed in section 3.1. The Hansen test suggests that the instruments are valid since the null hypothesis of validity is accepted for every regression at a five percent level of significance, apart from regression (11) to (15) which regards inflation as an endogenous instrument. Instrument validity being significantly worse when inflation is regarded as endogenously determined suggests that the causality runs mostly from inflation to GDP, strengthening the validity of the results found in this paper as it assumes that the causality runs in this direction. This finding is in line with Khan and Senhadji (2000) and Fisher (1993). However, Roodman (2009) suggested that the p-value for the Hansen test should be between 0.1 and 0.25 as a high p-value could be a sign of instrument proliferation, causing an overfit of endogenous variables and thus failing to remove their endogenous components. No regression achieves a p-value within the interval, although a few are close to the values suggested by Roodman. Once again, disregarding the five regressions with inflation endogenously determined. The Sargan test also implies validity of the instruments at a five percent level for every regression apart from the three regressions regarding high institutional quality, again disregarding the regression with inflation endogenously determined. Roodman (2007) explains that the assumption of homoscedasticity in the Sargan test is rarely fulfilled in the GMM context.

Inflation and squared inflation are significant in the main regression for low institutional quality (3) while being insignificant in the analogous one without outliers (17). The continuous effect of institutional quality shows that the variables (institutional quality and squared institutional quality), are significant in regression (17) without outliers but insignificant in (3). This could indicate outliers being the driving factor behind the inflation-growth relationship, at least in countries with relatively low institutional quality. When the outliers are accounted for, institutional quality appears to be the true driving factor of the relationship. The scatter plot of figures 6 to 10, in section 3.3, illustrates that high inflation levels are negatively correlated with institutional quality. This fact could be used to explain the observed phenomenon and is in line with Aisen and Veiga's (2005) explanation that short-term goals, such as printing money, are being prioritized by countries with relatively bad institutions. The finding is also in line with

Salahodjaev and Chepel (2014), who found an adverse relationship between the level of institutional quality and inflation. The explanation of institutional quality being an underlying variable correlated with inflation, and the true driver of the inflation-growth relationship when outliers are removed, could once again be seen in the five-year regression without outliers (20). This, as inflation, lost its significance and institutional quality achieved significance when comparing the main five-year regression (2) with the one without outliers (20). Thereby, inflation may be given an unfair amount of credit as a growth-determining factor.

The three regressions that include most of the upper end of inflation observations, thus the ones most affected by removing outliers, are the yearly, low, and five-year ones. The estimations of all three changed drastically when these outliers are removed in regression (16), (17), and (20). Another conclusion drawn from the robustness checks is thus that outliers of inflation are one reason for a convex relationship between inflation and growth, with a decreasing negative marginal effect for an overwhelming part of the data span. This result contradicts the finding by Fischer (1993) as he observes a diminishing marginal effect of inflation on GDP and does find it robust to the removal of outliers. In the same way, it contradicts the findings of Ghosh and Philips (1998), who find the relationship to be convex even after multiple robustness checks. No robust nor concrete conclusions regarding the marginal effect of the inflation-growth relationship being convex, concave, linear, or even accelerating will be drawn due to the vastly varying results combined with the tests for instrument validity not being entirely fulfilled.

5. Concluding remarks

The objective of this paper is to answer the two questions at issue. Firstly, whether or not the marginal effect between inflation and growth is nonlinear, and secondly if the relationship is different for different levels of institutional quality. This is done through an empirical approach that allows for nonlinearities between inflation and growth to be accounted for. This paper finds the following results. The main regressions (1), (2), (3), (4), and (5) all resulted in nonlinearities as a convex relationship between inflation and growth is estimated. The point of convexity is adversely correlated with institutional quality. The result thus aligns with the first, as well as the second question at issue. Despite this, we conclude that the first question at issue cannot be answered as the result is neither robust to lagged explanatory variables nor regressions where outliers are removed. The causality is found to be likely running from inflation onto GDP, supporting the assumption of that being the case. A possibility of institutional quality being the true driver of the inflation-growth relationship is also observed. A two-step SGMM approach is used to arrive at the results.

Despite the poor robustness of the results generated by the main regressions, we will present the possible implications. A convex relationship between the two variables of interest would imply that the marginal damage that inflation causes on growth decreases after a certain point, meaning that the cost of inflation is lower for each additional unit of inflation after that point. One consequence that follows this argument is that countries printing money as a financing tool has less of a harmful effect when the inflation is already beyond the point of convexity than when they are below that point. The opportunity cost of not printing money is, in other words, different for varying levels of inflation. This would lead to investments financed by inflation taxation being more lucrative beyond the point of convexity than prior to it and could therefore even be seen as growth-inducing when the benefits exceed inflation costs. An example of such investment could be the financing of education systems while already being beyond the point of convexity. A linear relationship would, on the contrary, imply a constant harmful effect of inflation on growth following such investment. Viewing the marginal effect between inflation and growth as constant mathematically implies that some investments financed by inflation taxation are harmful for all levels of inflation, while the convex counterpart could result in the investment being beneficial to growth at some levels of inflation and damaging at others. This only considers an isolated view of inflation and GDP. Inflation might have other, external harmful societal effects as the effect of inflation is a complex matter.

An aspect of the complexity concerning this paper is that factors other than inflation might influence growth and be disguised as inflationary effects. A case can be made for institutional quality fulfilling this role as this paper finds partial evidence of it being the true determinant of growth in the inflation-institutions-growth trifecta. The implication that follows is that the role of central bankers is smaller than previously presumed in the growth determining context. Hence, the government has to rely on central banks to a lesser degree in their quest to achieve desired growth, as investments for institutional improvements could yield better results. A secondary concern of governments is the institutional context when determining the optimal level of inflation, as this paper also finds evidence that the growth-harming effect of inflation is substantially different at different levels of institutional quality.

Even though the empirical challenges of outliers, robustness, causality, and whether the relationship is linear or not, presented by Bruno and Easterly in 1996 still stand today, the above examples show why it is essential to determine whether the relationship is nonlinear andhow it is related to institutional quality. This, as a nonlinear relationship gives very different implications for the policy actions compared to a linear one and may also be significantly affected by the institutional quality. Therefore, additional research is important to further determine the true nature of the inflation, institution and growth relationship.

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Appendix 1

Table A1. Illustrating the results of the yearly regression and its subsamples with lagged explanatory variables.

Dependent variable: GDP	Yearly, lag (6)	Low, lag (7)	Medium, lag (8)	High, lag (9)
Inflation_t-1	0.0573**	0.0888***	-0.00149	-0.201***
	(0.0243)	(0.0227)	(0.0689)	(0.0747)
SqInflation_t-1	-0.000293***	-0.000395***	-0.000896	0.0115
	(8.02e-05)	(9.87e-05)	(0.00266)	(0.0113)
lnInstQual_t-1	16.7	67.2*	-489	183
	(18.0)	(33.9)	(391)	(138)
lnSqInstQual	-4.22	-20.6*	128	-43.6
	(4.85)	(10.30)	(101)	(33.0)
GDP_t-1	0.424***	0.398***	0.454***	0.502***
	(0.0327)	(0.0358)	(0.0753)	(0.0527)
GDP_t-2	-0.0113	0.0653**	0.0964**	-0.0949**
	(0.0284)	(0.0314)	(0.0399)	(0.0465)
GDP_t-3	0.0781**	0.0649	0.218***	0.124***
	(0.0306)	(0.0472)	(0.0452)	(0.0421)
PopGrowth_t-1	-0.00644	-0.644*	0.0297	0.0945
	(0.0667)	(0.324)	(0.0673)	(0.0783)
lnToT_t-1	0.0858	-0.0285	-0.578	0.387
	(0.304)	(0.588)	(0.455)	(0.355)
lnGovSpend_t-1	-0.784***	-1.13***	0.197	-0.914***
	(0.207)	(0.389)	(0.356)	(0.337)
lnHDI_t-1	-1.53***	-1.86*	-2.42***	-2.08
	(0.488)	(1.033)	(0.804)	(1.48)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	2170	588	547	660
Instruments/Groups	=	0.210	0.530	0.440	0.580
AR(1)-test	=	0.000	0.000	0.000	0.000
AR(2)-test	=	0.572	0.320	0.196	0.537
Sargan-test	=	0.352	0.517	0.784	0.007
Hansen-test	=	0.485	0.475	0.394	0.090

Appendix 2

Table A2. Illustrating the result of the five-year regression with lagged explanatory variables.

Dependent variable: GDP	Five-year, lag (10)
Inflation_t-1	0.0175
	(0.0139)
SqInflation_t-1	-0.000114***
	(4.24e-05)
lnInstQual_t-1	-17.3*
	(8.92)
lnSqInstQual_t-1	4.87*
	(2.55)
GDP_t-1	0.172*
	(0.0882)
PopGrowth_t-1	-0.0777
	(0.101)
lnToT_t-1	-1.12***
	(0.372)
lnGovSpend_t-1	-1.41***
	(0.426)
lnHDI_t-1	-2.08**
	(0.827)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	455
Instruments/Groups	=	0.110
AR(1)-test	=	0.000
AR(2)-test	=	0.855
Sargan-test	=	0.473
Hansen-test	=	0.536

Appendix 3

Table A3. Illustrating the results of the yearly regression and its subsamples with inflation endogenously determined.

Dependent variable:	Yearly, endogenous	Low, endogenous	Medium, endogenous	High, endogenous
GDP	(11)	(12)	(13)	(14)
Inflation	-0.121***	-0.165***	0.0243	-0.206**
	(0.00863)	(0.00999)	(0.0692)	(0.0813)
SqInflation	0.000182***	0.000273***	-0.00368	0.0137**
	(1.98e-05)	(1.34e-05)	(0.00255)	(0.00622)
GDP_t-1	0.383***	0.348***	0.313***	0.457***
	(0.0298)	(0.0291)	(0.0548)	(0.0387)
GDP_t-2	-0.00725	0.000306	0.148***	-0.0961***
	(0.0220)	(0.0344)	(0.0411)	(0.0343)
GDP_t-3	0.0850***	0.0701**	0.164***	0.0788**
	(0.0205)	(0.0283)	(0.0363)	(0.0309)
lnInstQual	-19.5**	-29.6**	-135	334**
	(8.83)	(12.9)	(346)	(149)
lnSqInstQual	4.99**	7.35*	37.9	-80.1**
	(2.47)	(4.08)	(89.3)	(35.6)
PopGrowth	0.129**	0.00722	0.168**	-0.000570
	(0.0610)	(0.216)	(0.0718)	(0.0621)
lnToT	0.461	-0.235	-0.630**	0.459
	(0.311)	(0.713)	(0.262)	(0.400)
lnGovSpend	-1.41***	-0.289	-0.563**	-1.89***
	(0.267)	(0.406)	(0.272)	(0.352)
lnHDI	-1.10*	-0.462	-1.30*	-0.349
	(0.664)	(0.875)	(0.748)	(1.440)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	2170	588	547	660
Instruments/Groups	=	0.260	0.660	0.560	0.720

AR(1)-test	=	0.000	0.000	0.000	0.000
AR(2)-test	=	0.783	0.831	0.970	0.550
Sargan-test	=	0.000	0.000	0.118	0.000
Hansen-test	=	0.003	0.024	0.042	0.121

Appendix 4

Table A4. Illustrating the result of the five-year regression with inflation endogenously determined.

Dependent variable: GDP	Five-year, endogenous (15)
Inflation_t-1	0.0279***
	(0.00791)
SqInflation_t-1	-0.000157***
	(1.43e-05)
lnInstQual_t-1	-18.0**
	(7.42)
lnSqInstQual_t-1	4.84**
	(2.12)
GDP_t-1	0.0913
	(0.0694)
PopGrowth_t-1	-0.0458
	(0.0985)
lnToT_t-1	-1.10***
	(0.360)
lnGovSpend_t-1	-1.45***
	(0.419)
lnHDI_t-1	-1.84**
	(0.809)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	455
Instruments/Groups	=	0.150
AR(1)-test	=	0.001
AR(2)-test	=	0.756
Sargan-test	=	0.093
Hansen-test	=	0.150

Appendix 5

Table A5. Illustrating the results of the yearly regression and its subsamples with outliers removed.

Dependent variable: GDP	Yearly, outliers (16)	Low, outliers (17)	Medium, outliers (18)	High, outliers (19)
Inflation	0.0233	0.117	-0.0200	-0.192
	(0.0458)	(0.0834)	(0.0648)	(0.131)
SqInflation	-0.00130	-0.00619	0.000523	0.0105
	(0.00224)	(0.00389)	(0.00346)	(0.0114)
lnInstQual	-8.21	-65.8**	-50.7	236
	(10.6)	(30.7)	(428)	(176)
lnSqInstQual	2.35	19.0**	15.4	-57.0
	(2.86)	(9.24)	(111)	(42.1)
GDP_t-1	0.398***	0.381***	0.424***	0.495***
	(0.0363)	(0.0389)	(0.0844)	(0.0592)
GDP_t-2	0.0261	0.111***	0.124**	-0.0832
	(0.0287)	(0.0320)	(0.0475)	(0.0498)
GDP_t-3	0.0856***	0.0591	0.220***	0.111***
	(0.0311)	(0.0468)	(0.0438)	(0.0414)
PopGrowth	0.116*	0.212	0.139*	0.0568
	(0.0620)	(0.217)	(0.0821)	(0.0736)
lnToT	0.467	0.140	-0.613	0.436
	(0.298)	(0.713)	(0.389)	(0.427)
lnGovSpend	-1.00***	-0.280	-0.424	-1.55***
	(0.243)	(0.475)	(0.361)	(0.416)
lnHDI	-0.832	-0.468	-1.13	0.200
	(0.521)	(0.717)	(0.707)	(1.55)

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Observations	=	2080	519	543	657
Instruments/Groups	=	0.210	0.630	0.450	0.580
AR(1)-test	=	0.000	0.001	0.000	0.000
AR(2)-test	=	0.623	0.160	0.292	0.439

Sargan-test	=	0.177	0.546	0.788	0.003
Hansen-test	=	0.273	0.544	0.276	0.096

Appendix 6

Table A6. Illustrating the results of the five-year regression with outliers removed.

Dependent variable: GDP	Five-year, outliers (20)
Inflation	0.122
	(0.0885)
SqInflation	-0.00818
	(0.00571)
lnInstQual	-28.3*
	(16.0)
lnSqInstQual	7.52*
	(4.25)
GDP_t-1	0.271***
	(0.0704)
PopGrowth	0.157
	(0.102)
lnToT	0.0973
	(0.400)
lnGovSpend	-1.20***
	(0.384)
lnHDI	-1.02
	(0.855)

Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Observations	=	432
Instruments/Groups	=	0.110
AR(1)-test, p-value	=	0.002
AR(2)-test, p-value	=	0.915
Sargan-test, p-value	=	0.118
Hansen-test, p-value	=	0.273

Appendix 7

Figures illustrating the estimated marginal effect of inflation on GDP for regression (6) to (10), with the explanatory variables being lagged one year.

Figure 16.

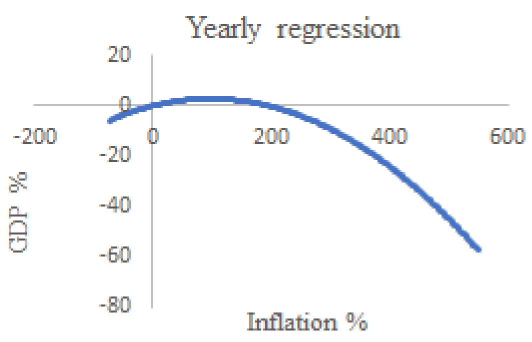


Figure 17.

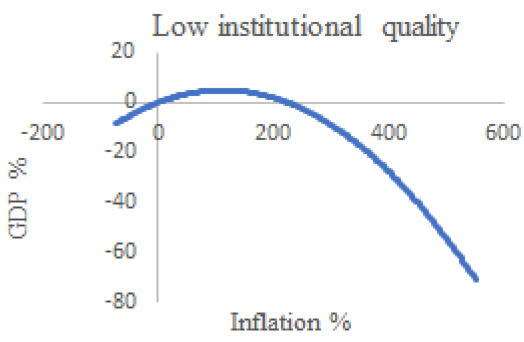


Figure 18.

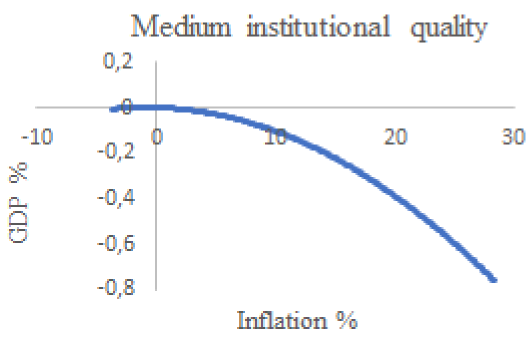


Figure 19.

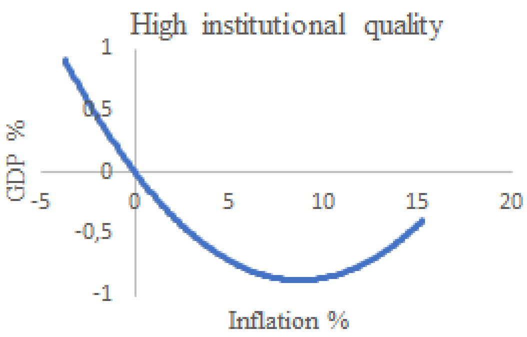
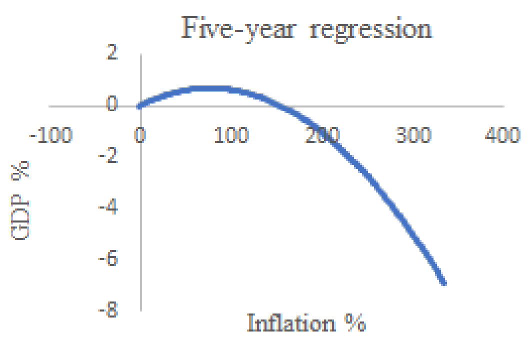


Figure 20.



Appendix 8

Figures illustrating the estimated marginal effect of inflation on GDP for regression (11) to (15) with inflation being endogenously determined.

Figure 21.

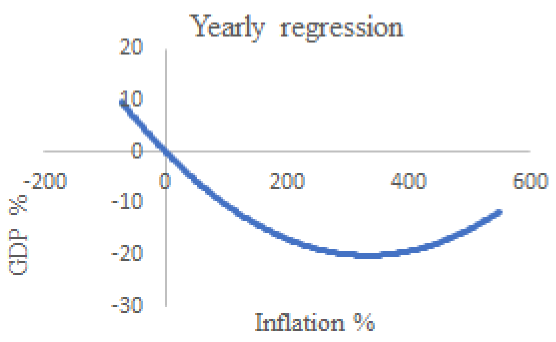


Figure 22.

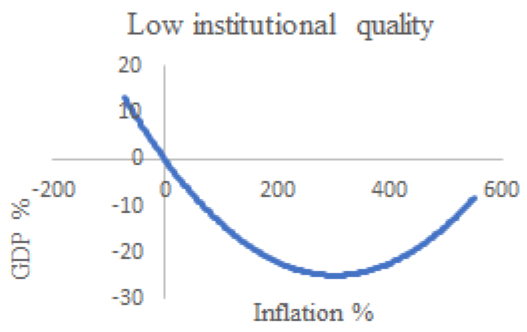


Figure 23.

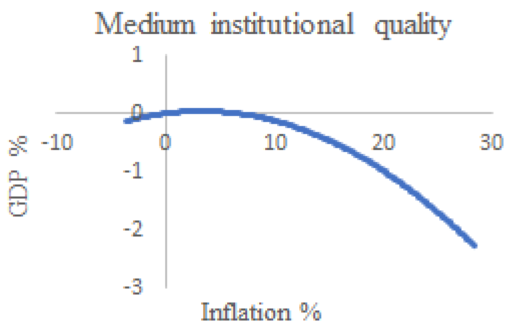


Figure 24.

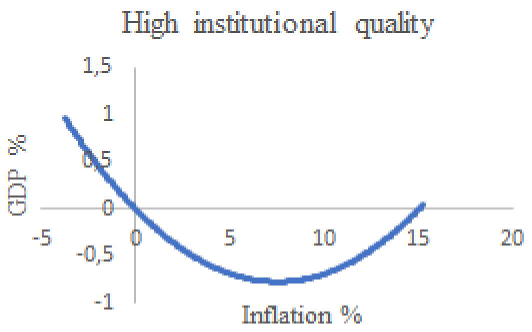
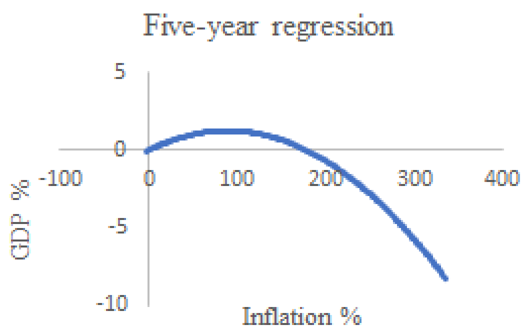


Figure 25.



Appendix 9

Figures illustrating the estimated marginal effect of inflation on GDP for regression (16) to (20) with outliers being removed.

Figure 26.

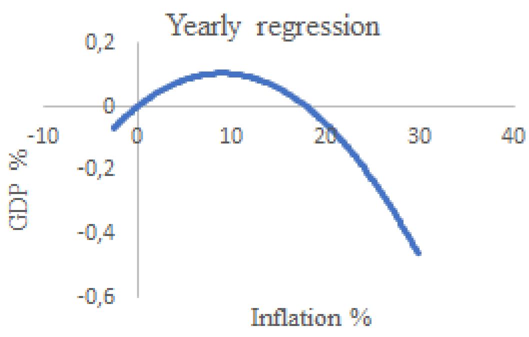


Figure 27.

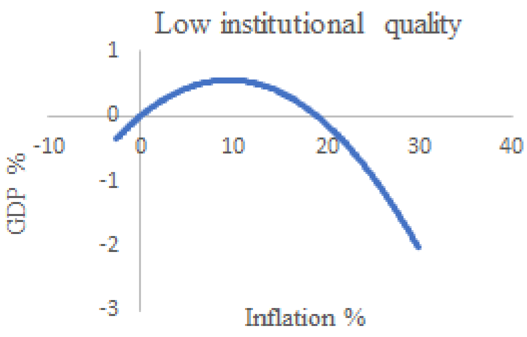


Figure 28.

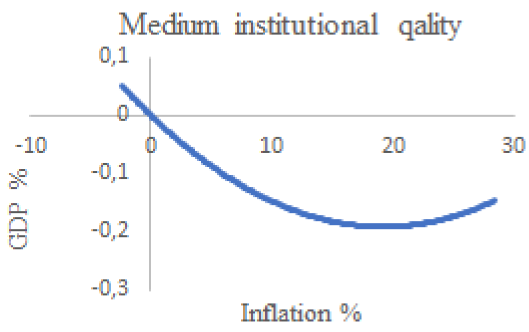


Figure 29.

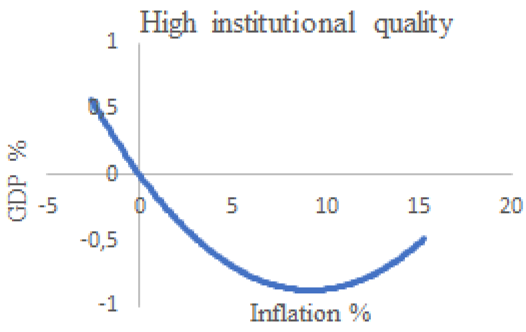
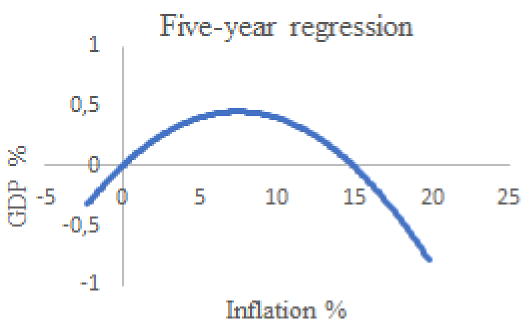


Figure 30.



Appendix 10

Table A10. Illustrating all countries included in the data set and their respective regions.

Africa	Asia	Europe	North America	Oceania	South America
Algeria	Armenia	Albania	Belize	Australia	Argentina
Angola	Azerbaijan	Austria	Canada	Fiji	Barbados
Benin	Bahrain	Belarus*	Costa Rica	New Zealand	Bolivia
Botswana	Bangladesh	Belgium	Dominican Republic	Papua New Guinea	Brazil
Burkina Faso	Bhutan	Bosnia and Herzegovina	El Salvador		Colombia
Burundi	Brunei Darussalam	Bulgaria	Guatemala		Chile
Cabo Verde	Cambodia	Croatia	Haiti		Ecuador
Cameroon	China	Cyprus	Honduras		Guyana
Central African Republic	Hong Kong SAR	Czech Republic	Mexico		Jamaica
Chad	India	Denmark	Nicaragua		Paraguay
Democratic Republic of the Congo	Indonesia	Estonia	Panama		Peru
Republic of Congo	Islamic Republic of Iran	Finland	The Bahamas		Suriname
Côte d'Ivoire	Iraq*	France	United States		Trinidad and Tobago
Egypt	Israel	Georgia			Uruguay
Equatorial Guinea	Japan	Germany			Venezuela
Eswatini	Jordan	Greece			
Ethiopia	Kazakhstan	Hungary			
Gabon	Korea	Iceland			
Ghana	Kuwait	Ireland			
Guinea	Kyrgyz Republic	Italy			

Guinea-Bissau	Lao P.D.R.	Latvia			
Kenya	Lebanon	Lithuania			
Lesotho	Malaysia	Luxembourg			
Liberia	Mongolia	Malta			
Libya	Myanmar	Moldova			
Madagascar	Nepal	Netherlands			
Malawi	Oman	North Macedonia			
Mali	Pakistan	Norway			
Mauritania	Philippines	Poland			
Mauritius	Qatar	Portugal			
Morocco	Russia	Romania			
Mozambique	Saudi Arabia	Serbia			
Namibia	Singapore	Slovak Republic			
Niger	Sri Lanka	Slovenia			
Nigeria	Syria	Spain			
Rwanda	Tajikistan	Sweden			
Senegal	Thailand	Switzerland			
Seychelles	Turkey	Ukraine			
Sierra Leone	United Arab Emirates	United Kingdom			
South Africa	Vietnam				
Sudan*	Yemen				
Tanzania					
The Gambia					
Togo					
Tunisia					
Uganda					
Zambia					
Zimbabwe					