**"The Impact of Trade Dynamics, Inflation, Tax and Unemployment on**

**Economic Growth, An Empirical Analysis"** by Aman Dongre

**Abstract :**

 In this empirical paper, I would like to discuss and investigate the effects of tax, effects of Imports/exports, Inflation, and unemployment and how these variables would affect the economic growth that is GDP growth rate for the country.

We would discuss how these variables will cause the growth rate to either increase or decrease in the subsequent years. We’ll see changes in these variables according to the economic changes which would also cause the growth rate of the economy to change. Also, we will notice if some other factors could affect the GDP growth rate and whether they should be included in the model. This paper will provide valuable insights into understanding the dynamics of economic growth at the national level.

**Introduction :**

Economic research has long been interested in the relationship between different macroeconomic parameters and economic growth. Through an empirical analysis, we examine in this paper how trade dynamics, inflation, tax policy, population, and unemployment affect economic growth. We seek to determine the strength and direction of these associations using econometric approaches to further our understanding of the factors that influence economic growth. The results of this study have significancefor practitionersand policymakers who are trying to come up with creative ways to support sustainable economic development in a variety of settings.

**Literature Review :**

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10030258/> - discusses **The impact of the COVID–19 pandemic on global GDP growth** by Joseph E. Gagnon, Steven B. Kamin and John Kearns. It was one of the first attempts to gauge the effect of the COVID–19 pandemic on real GDP.

**Similarities :**

* The dependent variable real GDP in this research paper and the GDP growth rate in our study are the same except the GDP growth rate is the Percentage change in real GDP.
* Both papers have an analysis of how global trade(import/export) affects the GDP although the sample size is different as this one is limited to the COVID -19 dynamics while ours includes all the 3 major events from 1990 – 2022.

While both the papers discuss the dynamics of trade, inflation on GDP we are focusing more on discussing more about how these variables affect GDP growth rate and what variables would be more significant than the others in our model.

**Econometric Models and Methodology Used :**

In our study for the GDP growth rate, the econometric models in EViews would be **ARMA** models which are used to analyze time series data. They also help to capture the autocorrelation of the data and OLS models with Operational Least square methodology along with **forecasting**, **Serial correlations Testing**, **Wald test** for Hypothesis Testing, **Heteroskedasticity** Tests, Stationary or non – stationary variables, ARMA maximum Likelihood tests.

**Empirical Analysis :**

In our econometric model for GDP growth rate, we will use the sample size from 1990q1 to 2022q4 where q represents the quarters in a year from 1 to 4 which is a **time-series** data model. The data is obtained from the FRED economic data | St. Louis FED. (<https://fred.stlouisfed.org/>) , For GDP growth rate - <https://fred.stlouisfed.org/series/USAGDPRQPSMEI>

The dependent variable for this model would be the GDP growth rate and the independent variables would be the **tax in receipts, import/export, real net exports(excluding imports), Unemployment rate, Federal Funds effective rate, Nasdaq, inflation,** and **population** with every variable being quarterly adjusted.

The main tests are Wald tests to check whether the variables are individually significant or jointly significant in the model. Also, the model could **suffer** from multicollinearity, heteroskedasticity, and autocorrelation hence we are doing those tests to make sure the model is adjusted before moving forward to **forecasting**.

For this model the estimated equation would be which can be used in Eviews -

GDP growth rate = B0 + B1 imp\_gr + B2 exp\_gr + B3 Fed er+ B4 inf + B5 Nasdaq\_gr+ B6 rnet exp + B7 Tax +B8 Unemp + u (Growth rate same period previous year)

(We will use a 5% significance level for this model)

GDP growth rate = B0 +B1\*Population + B2\*Tax + B3\*imp\_gr + B4\*exp\_gr + B5\*Fed\_er+ B6\*inf + B7\*Nasdaq\_gr+ B8\*rnet exp + B9\*Tax +B10\*Unemp + u

The Final equation is after removing the insignificant variable –

B1\*imp + B2\*exports + B3\*Fed\_er+ B4\*inf + B5\*Nasdaq+ B6\*rnet exp + B7\*Tax +B8\*Unemp + u .

**1.1**

We can estimate the model by least squares and the estimated output table can be seen below:–

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent Variable: GDP\_GROWTH\_RATE | | | |  |
| Method: Least Squares | | |  |  |
| Date: 04/10/24 Time: 19:23 | | |  |  |
| Sample: 1990Q1 2022Q4 | | |  |  |
| Included observations: 132 | | |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| C | 29.08662 | 8.956601 | 3.247506 | 0.0015 |
| POPULATION | -6.54E-05 | 3.58E-05 | -1.827059 | 0.0701 |
| TAX | -0.002148 | 0.001615 | -1.330399 | 0.1859 |
| IMP\_GR | 0.005157 | 0.003280 | 1.572542 | 0.1184 |
| EXP\_GR | -0.004271 | 0.004365 | -0.978461 | 0.3298 |
| FED\_ER | -0.507360 | 0.141231 | -3.592408 | 0.0005 |
| INF | 0.424531 | 0.267852 | 1.584947 | 0.1156 |
| NASDAQ\_GR | 0.000330 | 0.000153 | 2.158061 | 0.0329 |
| RNET\_EXP | 0.005081 | 0.003665 | 1.386313 | 0.1682 |
| UNEMP | -0.993893 | 0.162262 | -6.125224 | 0.0000 |
|  |  |  |  |  |
|  |  |  |  |  |
| R-squared | 0.378390 | Mean dependent var | | 2.454822 |
| Adjusted R-squared | 0.332533 | S.D. dependent var | | 2.071563 |
| S.E. of regression | 1.692439 | Akaike info criterion | | 3.962953 |
| Sum squared resid | 349.4507 | Schwarz criterion | | 4.181347 |
| Log-likelihood | -251.5549 | Hannan-Quinn criteria. | | 4.051698 |
| F-statistic | 8.251605 | Durbin-Watson stat | | 0.715411 |
| Prob(F-statistic) | 0.000000 |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

* The model has an **r-squared** value of 0.36 which means that **36%** of the values in this model of GDP growth rate can be explained by these variables.
* The **negative coefficients** in the output of the variables represent that a 1 unit decrease in those variables would **increase the GDP** growth rate by the same number.
* If we remove the population and tax variables one after the other, all the other variables except the **population** and **Tax** variable have a p-value of less than 0.05 which means they are significant in the model.

**1.2**

Therefore we could try to run the output again excluding the population variable first then estimating again excluding the Tax variable to see if it makes any difference.

* It can be observed now that every variable in this model is significant.

**1.3**

Also by Wald test, we can confirm this as shown below:-

|  |  |  |  |
| --- | --- | --- | --- |
| Wald Test: | |  |  |
| Equation: EQ01 | |  |  |
|  |  |  |  |
|  |  |  |  |
| Test Statistic | Value | df | Probability |
|  |  |  |  |
|  |  |  |  |
| F-statistic | 2.365854 | (2, 122) | 0.0982 |
| Chi-square | 4.731707 | 2 | 0.0939 |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Null Hypothesis: C(2)=0,C(3)=0 | | |  |
| Null Hypothesis Summary: | | |  |
|  |  |  |  |
|  |  |  |  |
| Normalized Restriction (= 0) | | Value | Std. Err. |
|  |  |  |  |
|  |  |  |  |
| C(2) | | -6.54E-05 | 3.58E-05 |
| C(3) | | -0.002148 | 0.001615 |
|  |  |  |  |
|  |  |  |  |
| Restrictions are linear in coefficients. | | | |

Hence the result is the same that these variables are jointly insignificant too due to their p-values being greater than 0.05.

**2**

**Hypothesis Testing**

Now we will do hypothesis testing for these variables which can be done through the Wald Test to determine whether the import and export variables affect the dependent variable GDP growth rate equally or not :

* For that the Null Hypothesis will be H0 – The import and export variables affect the dependent variable equally.
* Alternative hypothesis H1 – The variables do not affect the GDP growth rate equally.



Here the p-value(0.0003) is less than our alpha (0.05) hence we can reject the null hypothesis and say that the import/export variables do not affect the GDP growth rate equally.

**2.1**

**Testing for heteroskedasticity in the error term of the model to describe the unequal spread or error:-**

As the P-value is less than alpha (0.05) we can reject the null hypothesis which states that the model has homoskedasticity and conclude that the model has **heteroskedasticity** in the error term in the regression model and the usual testing statistics would not be valid.

**2.2**

Hence we will re-run the regression model with adjusted standard errors and the p-values which are observed below:-



Here the standard errors and the p-values are adjusted now and are valid because we have adjusted those values with the Huber – White Hinkley heteroskedasticity test which contains consistent standard errors and covariance.

**2.3**

We know that serial correlation can cause unreliable hypothesis test results in a regression model, So there’s a need to check if the model has serial correlation or not which is shown below:-



Here the null hypothesis for testing for serial correlation is that H0 = No serial correlation; H1 = There is a serial correlation.

In the output table from the Breusch Godfrey Serial correlation LM test, it is observed that the p-value is less than alpha (p-value<0.05) for **resid(-1) and resid(-4) terms** and we can conclude that there is no serial correlation in this model.

**2.4**

Now to construct an AR model that helps to adjust a model to account for the dependence of a variable on its own past values we will use a correlogram to check which AR terms could be added to the model.

* It is observed that AR(1) is more prominent and AR (4) is more prominent than others we will add these terms to the model.

Therefore with the ARMA Maximum Likelihood (OPG – BHHH) method, this can be done and the output Table is given below:-

As the AR(4) term has a p-value of 0.0507 which is **greater than** 0.05, the term is insignificant and we will keep only the AR(1) in the model.



The addition of the AR(1) and AR(4) terms causes the R-squared value to go up to 65.4% and is a good fit for the model.

**3**

**Testing stationary on non-stationary variables**:-

Whether the dependent variable is stationary or not is important to know in a model as non – stationary variables can lead to misleading conclusions in the model and improper forecasting. Hence we will observe whether the dependent variable in our model which is the GDP growth rate is stationary or not and how to adjust it.

**3.1**

A graph of GDP growth is given below –

The GDP growth rate ratio appears to be stationary in this case as it often revolves around the mean after a few years till now.

It is important to find the best suitable ARMA model in an economic model as It makes sure that all the data is effectively captured in the model. Sample Size (1990q1 2020q4)

Tests for autocorrelation also need to be done to find the best fit which can be done with the help of a correlogram which is shown below. Hence from here onwards we will find the best-fitting ARMA model for our analysis.

Here we can observe that all of the p-values of the lags are highly insignificant and there is no serial correlation present in the model.

**3.2**

Re-estimating the model again with AR terms one by one for AR(1) First –



Here AR(1) is highly significant due to its p -p-value less than 0.05 Schwarz Criterion is 3.67 and the AIC value is 3.45.

Now we will compare the Schwarz criterion and Akaike info criterion for all the estimation output tables to see which will fit the model the best among these.

The Schwarz Criterion and Akaike info criterion are the smallest for the AR(1), and AR(4) model which is 3.39 and 3.63 respectively. The smallest value of these criteria suggests that the AR(1), and AR(4) models would be the best fit among the other ones.

**3.3**

Now we can check whether the model has serial correlation or not including the AR(1) term,

The output table is given below :

It is observed that all the p-values are highly insignificant (all the p-values are greater than 0.05) up to 1 lag hence the null hypothesis can be rejected and we can conclude that there is no serial correlation in the model.

**3.4**

Unit root tests help determine whether a time series is stationary or non-stationary. Stationarity is an important assumption in many time series models because it ensures that the statistical properties of the series, such as mean and variance, remain constant over time.

Hence we will now check whether the GDP growth rate contains a unit root or not-





Since the p-value is significant, we can conclude that the null hypothesis can be rejected which is that the GDP\_growth\_rate contains a unit root, and say that it does not have a unit root and go ahead with the forecasting.

**4.0**

As the model is appropriate now we can forecast the data first for in-sample data as

Forecasting is typically associated with predicting future values based on historical data.

Forecasting on in-sample data can serve as a means to evaluate the performance of the model. By comparing the model's forecasts to the actual observed values within the sample period, we can assess how well the model captures the underlying patterns in the data and compare the dynamic and static forecasts which could be a better one for the model.

Below is the dynamic and static forecast of all of the sample data –



Dynamic Forecast



Static Forecast

**4.1**

Now we’ll change the sample size to check if the model can perform out-of-sample forecasting as well. First, we changed the sample size to 1990q1 – 2021q4 for in sample and we selected the AR(1) model by looking at the correlogram and checking the serial correlation as well as the AR(1) model doesn’t have a serial correlation in it which can be seen

below.



The in-sample forecasting is shown below –



Dynamic Forecast



Static Forecast

When we compare the Root Mean Squared Error, Mean Absolute error, and Mean Abs. Percentage error of both the forecasts which are all measures of forecast accuracy.

The RMSE focuses on large errors, MAE gives equal weight to all errors, and MAPE provides a percentage measure of error relative to the actual values.

We notice that in the Dynamic forecast, all the values of the RMSE, MAE, and MAPE are smaller than those of the Static forecast.

Therefore it can be said that the **Dynamic forecast** is better in this context.

We can notice in the forecasts that the GDP growth rate fell sharp around 2000 – 2002 due to the market crash. The 2000 stock market crash was a direct result of the bursting of the dot-com bubble. NASDAQ subsequently lost nearly 80% and the S&P 500 lost 50% to reach the October 2002 lows.

In 2008 it fell sharp again much more than the last time when the 2008 financial crisis happened.

In 2020 COVID – 19 hit the whole world abruptly. It disrupted the supply chain industry all around the whole which made the trade dynamics much worse. A rise in inflation, tax, and unemployment were all the result of the COVID – 19 which caused the GDP growth rate to fall sharp around 2019-2020.

The FED at that time implemented expansionary monetary policies to counter the inflation and implemented interest rate cuts and the disruption in the supply chain industry which slowly recovered around 2021 as the economy recovered.

**4.2**

Now we will try to do out-of-sample data forecasting for sample sizes 2022q1 to 2022q4 as out-of-sample forecasting allows for the evaluation of a model's performance in predicting unseen data. By comparing the model's forecasts with the actual observed values in the out-of-sample period, analysts can assess the model's accuracy and reliability.

The forecasts are shown below :



Dynamic Forecast



Static Forecast

Now for the 95% Confidence Interval,





Hence the forecasted values for both the dynamic and the static forecasts fall inside the 95% confidence intervals.

When we compare the same way we compared in-sample data, In this case also as the values of except RMSE, MAE, and MAPE. The static forecast is better for out-of-sample data too. If we forecast all the values in the model to compare with the out-of-sample forecast of 2021 – 2022, then it would show that the out-of-sample forecast shown above is the same as the forecast with all sample ranges till end included in it as seen below:-

**Findings and Conclusion :**

* In our study the Tax and population variables made the other variables highly insignificant and were removed from our model.
* The model suffered from heteroskedasticity and was adjusted accordingly.
* For our study, the static forecast was suitable for the model for both in-sample and out-of-sample data.
* The forecasts were accurate and worked for both out-of-sample data as well.
* The model explains the historical events accordingly when the GDP growth rate came way down and how the variables like trade and unemployment affected it according to their p-values with these values the variables go down and hence the GDP growth rate goes down.

In all the model has been adjusted and is able to explain the variables included in it with the forecasts being accurate.

References –

* (<https://fred.stlouisfed.org/>)
* <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10030258/>