## Introduction

###### 1.1 Background

The study of business cycles and GDP growth fluctuations is not a new line of research, but in the wake of the Housing Market Bubble and Financial Crisis of the last four years, a desire to better understand and predict the fluctuating market has been perceived to have utmost importance. The relative stagnation and decline felt, and still being felt, in the United States post 2007 have led many economists to question current economic tools for measuring business cycle fluctuations.

In this research, I propose to analyze the possible effects of agricultural commodity prices on national GDP per capita. I came to this question as a result of my interest in commodity prices and finance and their theoretical effect on GDP growth. I chose maize and soybeans as my two major agricultural commodities to examine.

According to the National Agricultural Statistics Service, in the United States alone there was an estimated 35 million hectares of maize planted for all purposes in 2010. Worldwide there are roughly 817 million tonnes of maize produced each year, with the United States being the largest producer of about 40% that value, or 326 million tonnes. There is greater maize production worldwide than rice or wheat. As such, I believe that if an agricultural commodity price is going to have a large enough influence on US business cycle fluctuations, it would need to be a very large commodity: maize.

Further, I chose soybeans because of their large significance to US Agricultural Commodities. According to the Economic Research Service of the USDA there are over 31.3 million hectares of soybeans planted in 2010, which brought in a forecasted $38.6 billion dollars in 2010. Further the US exports roughly fifty percent of all its soybean production, and is one of the largest soybean exporters in the world.

In combination with various other known independent variables, these two commodity prices will be tested to determine if they have a large enough effect on GDP per capita in the United States to afford them more attention as determinants of growth fluctuations.

## Methodology

1.1 Hypothesis

This work is focused on determining the effects of price fluctuations in two agricultural commodities: soybeans and maize, on the national GDP per capita. It will also examine the effects of inflation measured through the Consumer Price Index (CPI) and the Agricultural Price Index, money supply, nominal interest rate, and unemployment.

1.2 Data

The data covers the time range between 1982 and 2010. It has been gathered from reputable sources including the IMF, the Bureau of Labor Statistics, Federal Reserve, and the United States Department of Agriculture: Economic Research Service. All data was further annualized when provided in monthly values and computed in 2009 USD for a coherent analysis. The conversion factors utilized to convert to 2009 USD were generated from research done by Oregon State University from data provided through the Office of Management and Budget of the White House and the Congressional Budget Office.[[1]](#footnote-1)

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| --- | --- |
| Independent Variable | Mean |
| Maize Price (corn\_price) | 169.8243 |
| SoybeanPrice (soybean\_price) | 351.6624 |
| Agricultural CPI (AgrCPI) | 96.46247 |
| CPI (CPI) | 156.0737 |
| Interest Rate (Int\_rate) | 5.21 |
| Money Supply (MS) | 8942.896 |
| Unemployment (Enemp\_rate) | 6.277589 |

## Data Analysis

Independent Variables

The independent variables used in this study were chosen for their specific relevance, both proven in the literature and through multiple testing methods, towards understanding GDP growth fluctuations.

1.1 Commodity Prices

Upon review of the summary statistics we can see that per metric tonne, soybeans are nearly twice the average price of maize in 2009 USD. Maize ranged between a low of $107.78 in 2005 to a high of $291.81 in 1983. Closer inspection of the data shows a roughly linear decrease in maize prices since 1982, with small variance therein. Soybeans ranged between a per metric tonne low of $203.81 in 2001 to a high of $557.12 in 1983. 1983 was a record high year for many agricultural goods due to severe drought and a large reduction in PIK (payment-in-kind) government sponsored loans as part of agricultural programs.[[2]](#footnote-2) We see a steady decline in soybean prices until 2007 where they began to increase again possibly resulting from the overall financial crisis.

1.2 Consumer Price Indices

Review of the Agricultural CPI (Raw Materials Index) during the period from 1982 to 2010 shows a steady increase until 1990 where it slowly began to decrease until 1993 where there was an large increase until 1995 where a general decrease began for about a decade, whereupon it began to increase again. There is an immediate decrease in 2009, again most logically a result of the financial crisis. The record high was 125.35 in 2010, and the record low was 60.72 in 1982, describing an overall wealth increase for the United States during this time period. In contrast to the Agricultural CPI, the urban-consumers CPI data from the Bureau of Labor Statistics illustrates a gradual percent change per year increasing during the entire period, except for 2009 where there is a slight decrease in the urban-consumers CPI similar to the Agricultural CPI. The urban-consumers CPI shows a record low of 96.5 in 1982 and a record high in 2010 of 218.01, also describing an increase in overall wealth during this time period.

1.3 Nominal Interest Rate

The nominal interest rate, as measured by the Federal Funds rate, in contrast to the CPI, shows a gradual decrease over the time period. The highest recorded nominal interest rate from historical data provided by the Federal Reserve Bank, was in 1982 at 12.24%. There was an increase in 1989, coinciding with the Black Monday stock collapse of October 1987, leading into the early recession on the 1990s. The interest rate continued to fluctuate until 2000, with the increase during the dot com bubble crisis and the immediate decrease thereafter. The lowest recorded FFR was in 2009 at 0.16%, again confirming to the Federal Reserve’s response to the Financial Crisis.

1.4 Money Supply

With review of the money supply, in billions of dollars, it can be shown that it has steadily been increasing. Over this time period alone, there has been almost a 350% increase in the money supply since 1982 currently totaling 15857.57 billion USD. The average over this time period was 8942.896 billion USD, with a low of 4604.175 billion USD in 1982 and a high of 15857.57 billion USD in 2010, all prices normalized monthly.

1.5 Unemployment

Finally, unemployment data shows a gradual decrease in unemployment until 1990, following the early recession of the 1990s. The ramifications of this event led to increased unemployment and slower GDP for several years into the 1990s. The data then shows a continuous decrease until 2000 which can be attributed to the general recession of the last decade, ending in the financial crisis and the overwhelmingly high unemployment rates. 2000 had the lowest levels of unemployment, around 3.97%, which steadily increased to 9.63% at the end of the decade, which still does not match the 1982 level of unemployment at 9.71%. This high level of unemployment can be attributed to the early 1980s recession created by the contractionary monetary policy established by the Fed to control high levels of inflation.

2.1Dependent Variable

We can see a clear upwards trend in Nominal GDP per capita over the past 30 years. We see a slight drop during the early 90's and a larger drop in 2009. These both correspond to recession of the early 1990s and the housing bubble of 2007. The low began in 1982 with a total of $27,690.96 per capita GDP and increased generally to a high of $47,974.46 in 2007 at the height of the housing bubble prior to its collapse. GDP per capita did drop post 2007, but it is still in an upward leading trend line since 1982.

Regression Analysis and Procedure

3.1Summary Statistics and Correlation Table:



Due to the high correlation between MS, Int\_rate, and CPI, and the fact that CPI is a larger variable encompassing elements of money supply and interest rate, I decided to simplify the model and only use CPI as the regressor. Here is the complete model:

3.2 OLS Regressions



All three of these variables are highly significant, and the sign of the coefficients are in accordance with what we would predict. The coefficient of unemployment is negative, which implies that an increase in unemployment will result in a negative impact on per capita GDP. Also the model shows that an increase in the consumer price index will have a positive effect on per capita GDP. Finally, the lag variable also has a predictable positive effect on current per capita GDP. These variables are very descriptive of the model since we see such a high .

Now I want to test the effect that the prices of two agrarian goods (corn and soybeans) will have on per capita GDP. Our new model becomes:



All three of the original coefficients are still highly significant, but the two commodity prices are highly insignificant. Due to this high level of insignificance, we can conclude that the price levels of these individual goods do not have an appreciable effect on per capita GDP.

In lieu of using the individual prices of the two goods, instead I will use a basket of all agrarian raw goods called the agricultural CPI and see the effect that price changes of the agricultural CPI will have on per capita GDP. Here is the new model:



This model elucidates an interesting point. Despite the prices of corn and soybeans being insignificant in relation to per capita GDP, the aggregate agricultural good index does have an effect on per capita GDP. One conclusion that can be drawn from this is that individual prices provide too small of an effect on per capita GDP, but the aggregate whole of all agricultural prices is large enough to provide an effect. Moreover, this price effect also coincides with what we would expect. An increase in agricultural prices will have a negative impact on GDP. Moreover, by including the variable AgrCPI we see a small, but noticeable, increase in illustrating that this variable does add some explanatory power to the model.

3.3 Time Series Model

Consider the time series model. It is necessary to first take into consideration if the dependent variable has autocorrelation issues.



From the above chart a nice pattern is illustrated. Notice that the Autocorrelation term (AC) is 0.904 for the first lag. This high of an AC term concludes that a one lag model is sufficient. The autocorrelation graph is also roughly symmetric. The graph switches from positive to negative at about 10 and 11 lags.

Next a Dickey-Fuller test and a Phillips-Perron to test for stationarity issues was conducted.



Since the graph of GDP is noticeably linear, a trend in the command line can be included. Notice that the test statistic is -2.658, and less than the 10% critical value. Thus per capita GDP suffers from non-stationary issues. To compensate for this, the variable is de-trended by taking the first difference. The new difference variable is now defined as:

When stationary tests are now conducted, thenew variable is now highly stationary, above the 99% confidence level.





Even when the trend in the command line is included, the test statistic is still stationary over the 95% confidence level.



Next the ARCH and ARIMA time series models are run.

 The CPI and unemployment variables are highly significant, but the lag variable and agricultural CPI are significant at the 94.6% and 93.2% confidence level, respectively. Again, the sign of the coefficients are predictable. CPI and the lag variable have a positive effect on real GDP per capita while AgrCPI and the unemployment rate have a negative effect on GDP.

What is so surprising about these results is that the coefficients are the same despite the two different methods used to determine them. The ARCH model assumes that the current error term is a function of the previous error terms. Typically the error is characterized by

where is a function of previous error terms and is a random variable drawn from a gaussian distribution. is modeled by the function

The ARIMA model calculates the coefficients using an autoregressive moving average. Thus, it is quite striking that two different methods would produce the same coefficients. However, each model does produce different standard errors, which does conform to what is expected.

Comparing the two time series models to the OLS regression, the coefficients are again found to be nearly identical while the standard errors are different. One idea to determine why this might be the case, would be to implement an out-of-sample forecast. For example, this model contains twenty nine observations. The first twenty observations would be used to predict the twenty first observation. This prediction would then be used alongside the twenty observations to predict the twenty-second observations. This process would be repeated until all of the remaining observations would be predicted. Next these predicted values would be subtracted from the actual observed values and squared. Mathematically,

This would allow the accuracy of the model to better be determined when predicted the estimators. If is near zero, then the model does well in its predictions. It could then be concluded that the coefficients are relatively accurate.

## Conclusion

The purpose of this paper is to explore the effects that prices of certain commodities have on real per-capita GDP. Through multiple testing techniques, it is concluded that these prices do not have a significant effect, but when the aggregate agricultural commodity price index is utilized as a substitution variable for individual commodity prices, this did have a significant effect. Moreover, the effect that the variables had on GDP conformed to my predictions: unemployment and the agricultural CPI had a negative effect, while CPI and the lagged GDP had a positive effect.

Further research is necessary to better understand these effects. One approach is to do the same analysis but across multiple countries, not just the United States. This new model would then be transformed into a panel model. This paper solely dealt with agricultural prices in the US. In the United States agricultural goods make up only 1.2% of GDP[[3]](#footnote-3). But what about countries who have a larger percentage of GDP comprised of agricultural products? Moreover, how does the fact that the US is the world's largest exporter of corn and soybeans effect these agrarian economies?

A second approach would be an expansion of the current model to include variables such as government spending, aggregate domestic investment (12.8% of GDP in 2010), or testing the effects that industrial good prices have on GDP. For example, the industrial sector makes up 22.2% of the US GDP, how would changing steel prices affect this value?

In order to better determine the effects of commodity prices on per capita GDP, further research is necessary. This provisional review of the data provides a good foundation for future, expanded work.

1. Please see Appendix I for table of Conversion Factors utilized in this research. [↑](#footnote-ref-1)
2. Drabenstott, Mark, and Marvin Duncan. *Federal Reserve Bank of Kansas City Publication*. “Another Troubled Year for US Agriculture.” <http://www.kansascityfed.org/PUBLICAT/ECONREV/econrevarchive/1984/4q84drab.pdf> [↑](#footnote-ref-2)
3. CIA factbook: <https://www.cia.gov/library/publications/the-world-factbook/geos/us.html> [↑](#footnote-ref-3)