

ES 2 Final Project Report

Macroeconomic Analysis: Biased or Not?**Process and Plan:**

The process for deciding what I wanted to do for my final project was fairly easy. I knew that I wanted to work with some large macroeconomic data sets because I am minoring in economics. My initial thought was that this project was an opportunity to combine some of what I learned in ES 2 with ideas that I have learned from my economics classes. This is very important to me because I want to develop a relationship between my major in engineering and my minor in economics. I find both very interesting, and I want there to be a strong connection between them as I continue my educational journey at Tufts. My general plan was to find macroeconomic data sets such as GDP (Gross Domestic Product, or what many refer to as *Nominal* GDP), *Real* GDP (Gross Domestic Product adjusted for inflation based on a GDP deflator value), CPI (Consumer Price Index), inflation rate, and unemployment rate in the United States over time. These are the primary data points that are analyzed and tracked in the nation.

Theme:

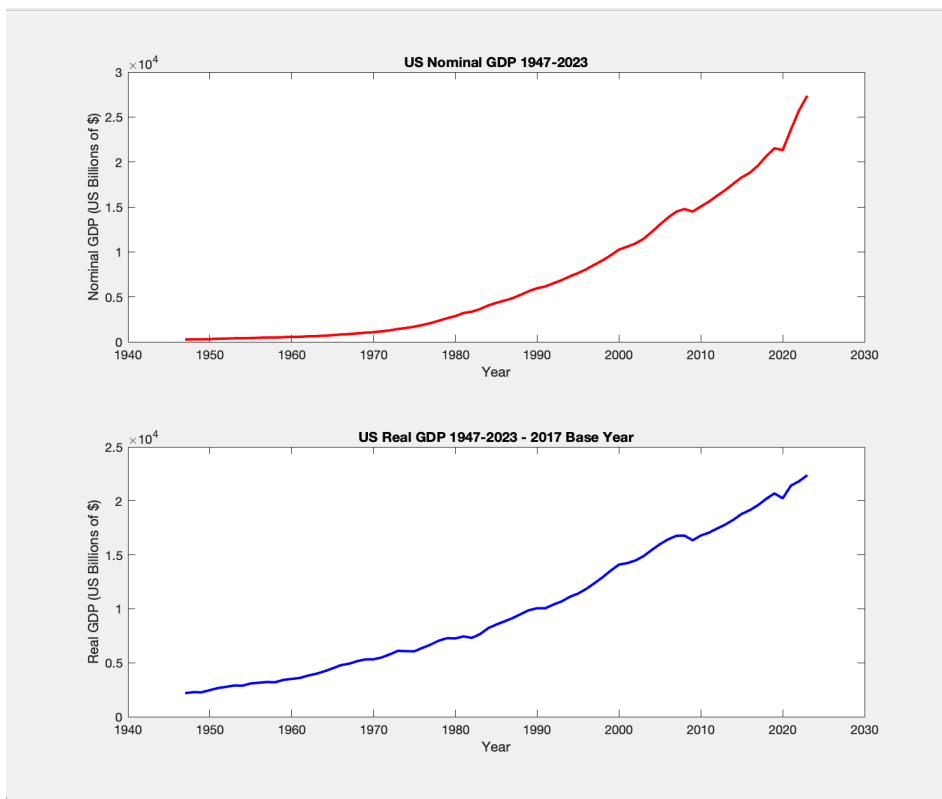
- The theme of this report is a macroeconomic analysis with an emphasis on historical data and human impact, as well as the discussion of raw economic ideas and terminology.

Questions:

- What do these data sets mean? What exactly are they showing?
- What are the possible historical and political implications of these data sets?
 - How can these data be explained by historical events and what do they have to say about American history?
- Are there any patterns? If so, are they predictable?
- Who is impacted by this data? How are people affected by this data?
 - Were different groups of people impacted differently during different economic periods?
- Who really benefits from economic analysis?
 - Is economic analysis truly holistic?
 - Is economic analysis equitable?
- Is there any bias based on who performs an economic analysis?
 - Gender, race, sexuality, etc.
 - Historically, economists are predominantly white men – I will certainly address this!

What do these data points mean and why are they important in economics?

- **Nominal GDP vs Real GDP:** Gross domestic product is a measure of the total output, in dollars, by expressing the total value of all domestic goods and services produced given current prices. Whereas, real GDP, is the measure of gross domestic product (total output) given a lock, or typically in economics called a “chained” price value, by expressing the total value of all goods and services produced in a year given a certain chained price on a selected base year. The following figure is a comparison between the two:

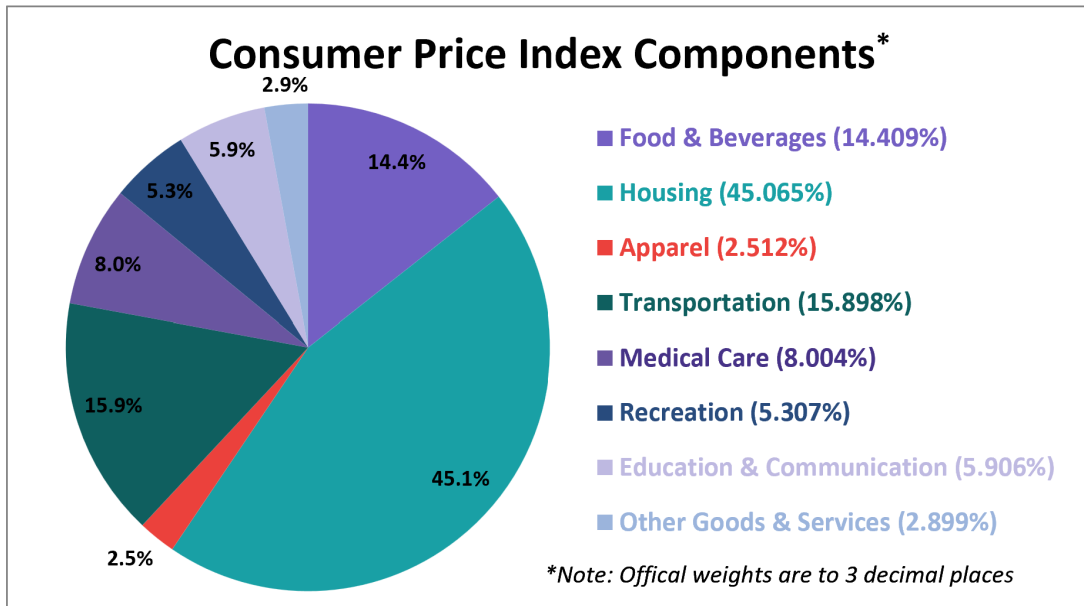


Comparing nominal GDP to real GDP is important because it enables economists to have a glance at how the entire economy is doing, as well as allowing the calculation of the inflation index called the GDP deflator. As seen in the figure, there is less exponential growth for real

GDP than nominal GDP. This is due to the fact that real GDP disregards inflation by chaining prices, so the exponential rise in nominal GDP is exaggerated by the presence of inflation. GDP is one of the most important pieces of data for examining how the market is doing as a whole, and heavily influences decisions such as, FED rate, banking terms, and even mortgage rates.

- **CPI and Inflation Rate– Consumer Price Index:** The consumer price index, or CPI for short, is a measure of inflation. The CPI is the average change in price paid by the average urban consumer for a basket of goods and services determined yearly by the Bureau of Labor Statistics based on trends in what people are buying. It takes the total cost for a market basket from a base year to the total cost for a market basket from another year and compares them in a ratio. Additionally, different items in the basket have different weights. For example, the typical market basket has the majority of the

weight to housing, then transportation and food coming after. The following is a fantastic visualization made by Jennifer Nash in her recent article on the consumer price index:



Source: BLS; The most recent annual reweighting was in December 2023

Source: Jennifer Nash on VettaFi

<https://www.advisorperspectives.com/dshort/updates/2024/04/10/inside-the-consumer-price-index-march-2024>

The following equations show how the CPI is calculated, and how it has trended over time in the United States:

$$\text{consumer price index} = \frac{\text{market basket of desired year}}{\text{market basket of base year}} \times 100$$

$$\text{CPI} = \frac{\sum_{i=1}^n \text{CPI}_i \times \text{weight}_i}{\sum_{i=1}^n \text{weight}_i}$$

The second equation demonstrates how the weight of each good or service in the market basket is taken into account by summing up the total CPI of a good or service and multiplying it by its given weight.

CPI as a metric is vital for economic analysis because it is generally considered one of the best metrics for inflation. However, the CPI does have some limitations. The CPI

does not account for substitution bias well, where consumers tend to change what they purchase for cheaper items when prices increase. Furthermore, the CPI does not take into account product improvement and quality changes which can lead to the CPI overstating inflation levels because it does not consider the increased value consumers may receive. Another downside of the CPI is that it does not take into account new products because of its fixed basket of goods. Additionally, it does not provide any information on asset price inflation such as bond or stock prices and often has a lag because of its slow change in basket and not accounting for changing consumer ideals.

- CPI vs GDP Deflator vs Inflation rate data set

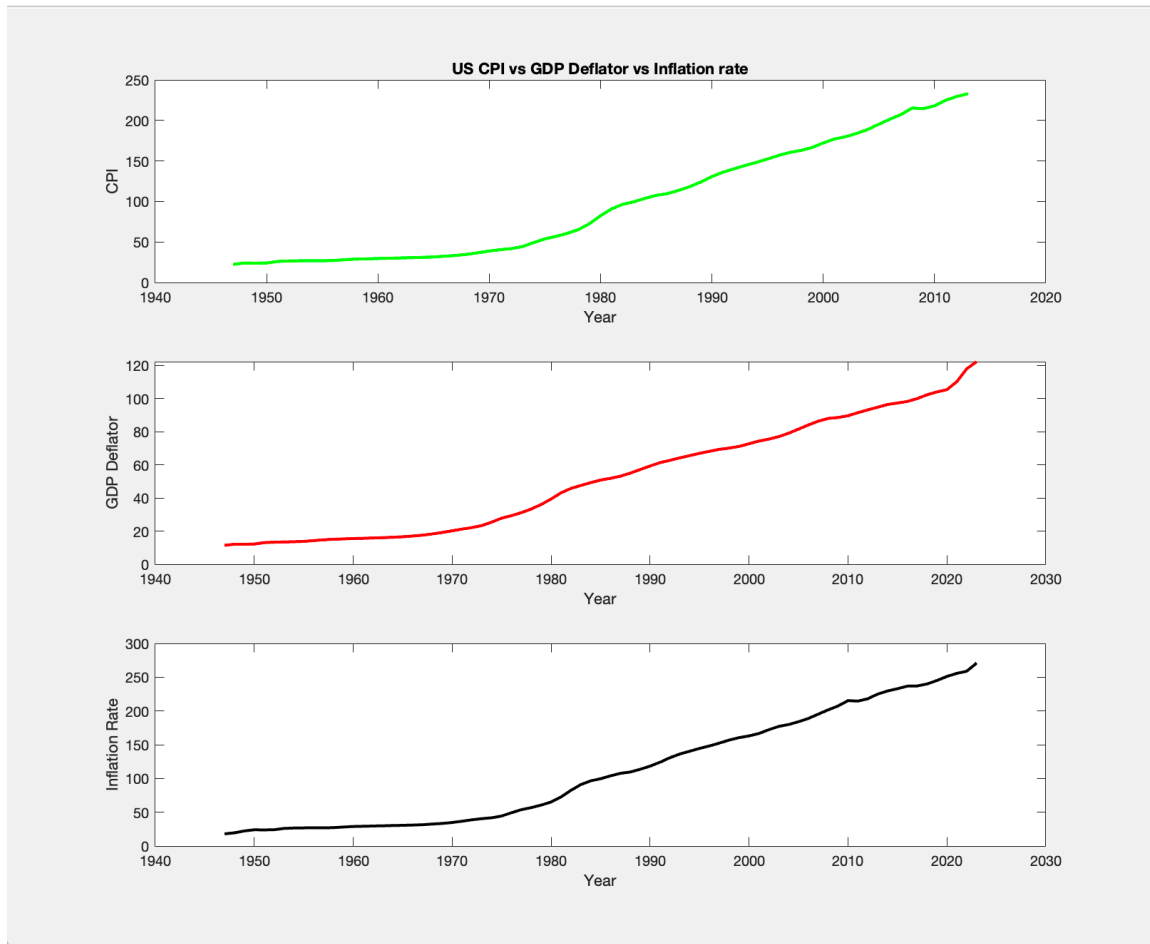
The CPI and the GDP deflator are both commonly used to measure inflation. Where the CPI is a measure of strictly consumer spending on goods and services, the GDP deflator is often considered more holistic because it takes into account the entire economy's production and consumption. Inflation is one of the most important metrics to the FED (US Federal Reserve Bank) and one of their main goals is to maintain slow and steady inflation: annual rate of 2%. Historically, this has been nearly impossible to do.

The GDP Deflator is calculated via the following formula:

$$\text{GDP deflator} = \frac{\text{Nominal GDP}}{\text{Real GDP}} \times 100$$

Very similar to CPI, it takes the nominal GDP (GDP based on current prices) and divides it by real GDP (GDP adjusted for inflation with chained price levels based on a specific base year).

The following figure shows the CPI vs the GDP deflator vs the inflation rate data from the Bureau of Labor Statistics:



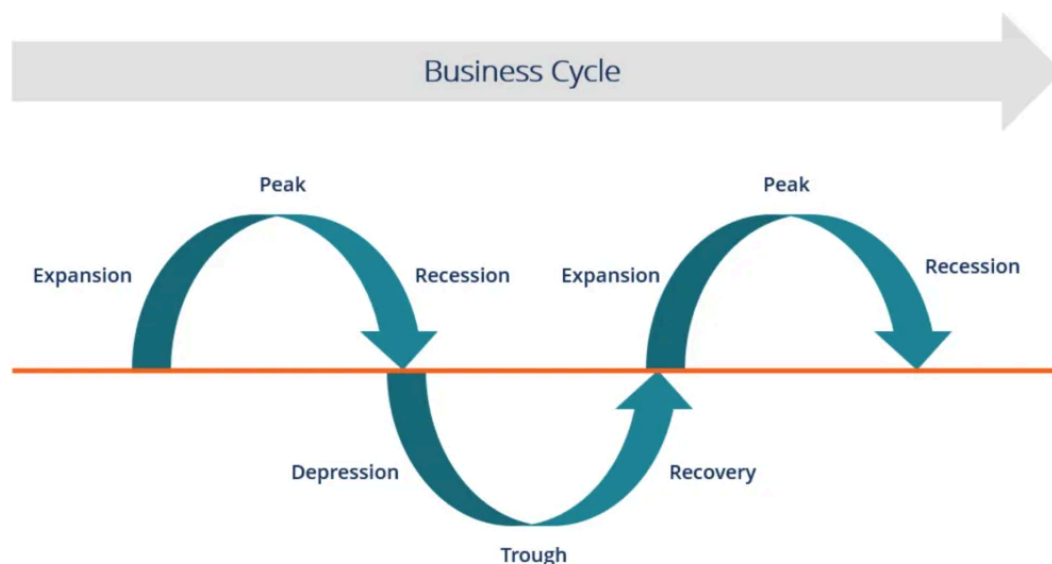
As seen in the plot above the three inflation metrics generally follow the same trend. Though there are some discrepancies such as the rate of inflation after 1970 being slightly sharper on the GDP deflator than the other two, they generally show the trend. The reason that CPI is slightly offset is because the data set I abstracted only had data until 2013.

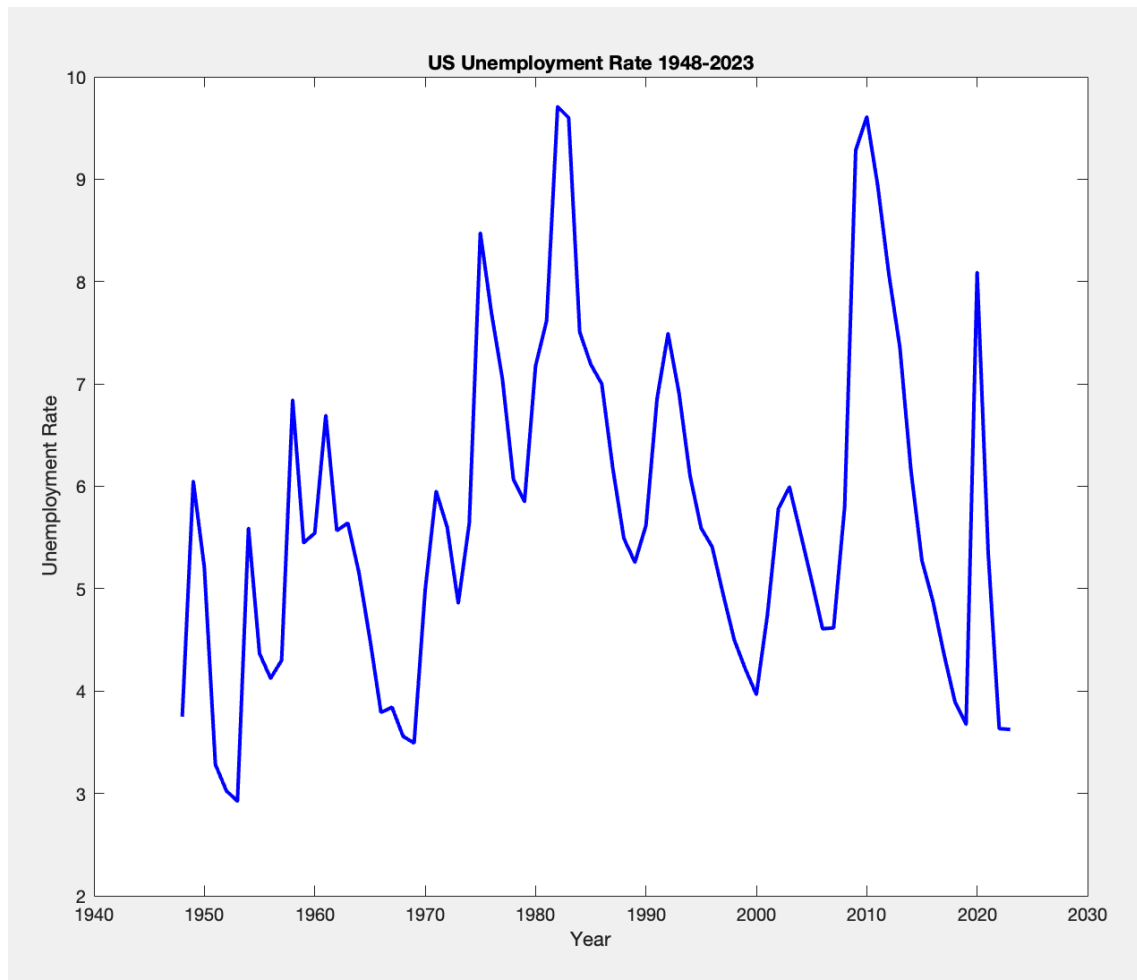
– Why is it so hard to maintain steady inflation?

There are many reasons why maintaining a steady inflation rate is impossible. The complexity of economic systems with numerous interconnected and unpredictable variables such as consumer behavior and international trade agreements create an unstable environment that is impossible to control. A good example of this is the major inflation that the US faced during the 1970s. As seen in the figures there is a sharp increase in the rate at which the inflation rate was increasing around 1970. There were a number of contributing factors that contributed to this increase such as the oil embargo, a huge budget deficit, low interest rates, and the collapse of managed currency rates. These factors caused the FED chair Paul Volker to issue its highest lending rate of all time at 21% in the mid 70s (Nielson). This is an important example because it demonstrates the interconnectedness of economic systems, domestic and international, that can directly affect inflation rates. The intense interconnectedness of different market variables are constantly

examined by economists today and this is a big reason why I decided to add this aspect to my project. I think inflation and the attempt to control inflation are some of the most important macroeconomic focal points, and have an impact on everybody and their lives. In the end, inflation is generally out of our control because of the vast array of variables around the globe that can influence it. This is a historical pattern that continues to repeat itself. For instance the COVID-19 pandemic. Nobody could have predicted it and it has left lasting scars on markets, prices, inflation rates, mortgage rates, investment return rates, and even international trade. Again showing that inflation is out of our control, influenced only by the vast factors around the world that can change at any moment. Inflation is truly unpredictable.

- **Unemployment rate:** The unemployment rate is a measure of how many people are currently unemployed. The formula for calculating this is taking the amount of people who are unemployed, defined as "people who do not have a job, have actively looked for work in the prior four weeks, and are currently available for work." – Bureau of Labor Statistics definition – divided by the total number of people in the labor force: "those in the civilian noninstitutional population, age sixteen years or older, who are employed or who are unemployed and seeking employment." – Bureau of Labor Statistics definition. This does not include discouraged workers – Those who have looked for work for longer than 4 weeks and have not found employment and are therefore discouraged. One of the goals of the FED is to keep the unemployment rate below 5%. It is a common notion that at said rate(s) the economy is very close to or at full capacity. This is one of the key reasons why unemployment is cyclical, and typically follows the pattern of the business cycle. The following diagram made by the *Corporate Finance Institute* and the figure show the sinusoidal nature of unemployment:





Though it is not a perfectly even cycle balanced about an equatorial line, it does follow an up and down trend that is otherwise cyclical in nature. The reason for this is because of the business cycle. While there is expansion, businesses hire more employees because sales are good and prices are going up. However, expansion cannot last forever, and at a certain point, due to the laws of supply and demand, businesses are forced to cut costs and lay off employees, i.e. recessions and depression. This can be seen in the diagram above illustrating the business cycle. Unemployment rate is important to analyze because it has a lot to say about the health of an economy. Let's look at the time period just before the 2008 financial crisis. The following figure shows this time period comparing the unemployment rate to nominal GDP:



As shown in the figure the unemployment rate before 2008 was below 5% and nominal GDP was increasing fairly rapidly. However, after 2009 the unemployment rate increased sharply to over 9% by 2009, while nominal GDP actually decreased. This illustrates the idea that unemployment is cyclical and is impacted by the business cycle. Though the 2008 financial crisis is an extreme case, this same thing happened during the Great Depressions in the 1930s, the recession in the 1970s, and during the COVID-19 pandemic. This pattern can be seen in the above plot detailing the unemployment rate from 1948-2023. Though many cases are not as extreme as the 2008 financial crisis or the COVID-19 pandemic, there are generally mini outbursts of unemployment quite regularly.

Who is impacted by these data sets? And how? Who benefits from this analysis?

On the surface level, everyone is impacted by an economic analysis. Economic studies are the basis for so many things like mortgage rates, federal funds rate, banking rates, stock market rates, and prices of everyday goods and services. From the cost of groceries to the mortgage rate, economic factors and analysis dictate a lot about what we buy and sell on a day to day basis. However, economic factors and impacts become a lot trickier when we take into consideration each and every individual's quirks and personal ideals. For example, a commonly discussed topic in economics is climate change and pollution.

Pollution is a negative externality (In economics a negative externality is something where an impact is made and the creator of said impact does not necessarily bear the costs as much as those who are actually impacted). Pollution poses a threat to both the global environment and economy. While the environmental and health implications of pollution are well understood, precisely valuing its social cost has proved to be a challenging endeavor for economists. This challenge arises from the variability of pollution's impacts, making it far from a one-price-fits-all scenario. The direct damage from climate change consists of natural disasters like extreme flooding and drought, causing problems such as the spread of disease, sea level rise, disrupted supply chains, and resource insecurity across the globe. These factors can cost businesses, households, and governments billions of dollars through property damage and emergency services, as well as rising food, healthcare, and shelter prices. There also exist less quantifiable consequences of pollution, such as habitat and species loss, dirty air, and environmental degradation in public parks. Despite climate costs being difficult to quantify, focusing on them in economic decision-making can help support the changes we need to make toward decarbonizing economies and mitigating the future damage of pollution.

Currently, the estimate of the "social cost of carbon is over \$50 per [metric] ton in today's dollar"(Environmental). In 2021, the United States Environmental Protection Agency reported that the US emitted 6.34 billion metric tons of carbon dioxide equivalents(US EPA). This data implies that the total cost of carbon in the US was a little over \$317 billion in 2021. However, this estimation may not encompass the full breadth of pollution's social cost. While this estimation "is the most robust and credible figure available, it does not yet include all the widely recognized and accepted economic impacts of climate change"(Environmental). The impacts derived from climate change include loss of biodiversity, damaged ecosystems, deforestation, contaminated water supplies, dirty parks, and medical problems. Translating the vastness of pollution's consequences into an economic cost has proved challenging because they extend far beyond the immediate environmental damage, and affect people's lives in many different ways depending on individual circumstances, values, and vulnerabilities.

The high variability of how pollution affects individuals involves ethical issues that reflect societal values. For instance, when pollution-related health problems arise that lead to death, some argue that the social cost is infinite because human life is priceless. In contrast, others attest that the social cost is that person's net worth plus what that person would have made throughout their life. Similar arguments surround habitat and species loss, as well as polluted parks. Many environmentalists argue that no price can be put on habitat and species loss, while others maintain that the price should be proportional to the total cost of the services used to study and protect them (Köljalg). Similarly, climate activists argue polluted public green spaces cannot be quantified as a cost, while others claim that the cost corresponds to the services used to maintain them. The diverse perspectives surrounding pollution's vast impacts involve ethical dilemmas that ultimately make it difficult for economists to reach a consensus on the complete cost of pollution.

Currently, as Russell Nichols discussed in his *Time* magazine article, the mainstream methods to incentivize producers to reduce emissions are "Carbon Taxes and Emissions Trading Systems" (Nichols). These protocols encourage producers to limit their greenhouse gas emissions and let the invisible hand move the market price toward a social optimum. "In these cases, the polluter pays proportionally for emissions produced" (Nichols). Additionally, "Many of the world's largest companies already use internal measures much like the social cost of carbon in their own decision-making processes" (Environmental). Furthermore, countries such as Canada, Mexico, and the United Kingdom have begun implementing carbon pricing into their public policy to move toward a carbon-neutral economy in light of the climate crisis.

Although there are still many uncertainties and a satisfactory price tag for pollution may never be fully quantified, the recent acknowledgment of pollution's economic implications by "46 national jurisdictions" through "direct carbon pricing, ... fuel taxes, and eliminating fossil fuel subsidies" (Nichols), underscores the positive trend in environmental accountability. Recognizing carbon's social cost is a vital step that producers and governments are taking toward a clean and sustainable future, economic and environmental.

In a 2020 paper published by the National Bureau of Economic Research, Paredes et al. ask some of the most critical questions regarding economic research and analysis:

"Does the unequal treatment of women in economics arise because of a pervasive bias against women that is present in the discipline, even among students in the earliest stages of their training? And, if economics is sexist, is it because it attracts individuals who are *ex ante* more sexist, or does economic training contribute to gender bias?" (Paredes et al. 2). Historically, economics has been dominated by white males. Though many economists claim that economic analysis is not biased or ideological, and economic analysis is merely visualization and

conclusions based on data that is collected and analyzed, this is simply not the case. As we learned in lab sections this semester, data is biased and flawed. Large scale data, like the data I used in this report has flaws. Some of them I have already stated, like the CPI being laggy or unresponsive to constantly changing nuances in the market sphere, or the GDP having many holes because similarly to the census, it relies on data from human beings. There are many people who struggle to access information needed to get the real numbers for GDP or CPI, there are unaccounted for persons in the workforce, there are undocumented immigrants who work in the US and contribute economic forces to the country, and there are those who are homeless or have disabilities who are not accounted for. These factors are just a few that have large scale impacts on the economy and are not expressed in economic data and statistics.

Economic teaching and ideals have a large impact on women. Women have been historically underrepresented in economics. There has only been one woman to ever serve as the FED chair: Janet Hellen from 2014 to 2018. Furthermore, economic practices can reinforce already existing gender biases. For instance, some common economic practices taken in their most simplistic version, can reinforce historical gender bias. For example, if we take the principles of economics on their most basic level, if markets are competitive and workers are paid for their marginal product, then the gender wage gap can must only reflect differences in the productivity between male and female workers. Furthermore, if the theory of comparative advantage holds, applied to the household sphere, it can be used to justify traditional gender roles. Gender bias is a key value that is embedded within economic data and analysis and they reflect the historical dominance of men in the field. Though there has been some sway in how this problem is being addressed at various universities and research institutions, it has not received the same attention as fields such as science, engineering, or medicine. These values are certainly aligned with the dominant values of society. To address this I believe that the field of economics should receive the same attention in addressing the strong gender bias that reflects the historical values of society in order to address the fallacies that may come from studying it as well the discrepancies in how data is analyzed and collected.

Overall, there are many problems that come with economic analysis and economic data. Economic ideals, data, and analysis impact everyone differently. How it is presented and discovered, what is reinforced by it, and how it is taught are all things that can be addressed to change the narrative of economics and expand solutions for all genders, classes, and races. Economics are a very important field of study in the United States and it impacts everybody's lives in myriad ways. Prices, what we do and do not want, how we spend our money, what we wear, what we think about politicians and who we vote for, and even what we eat and drink on a day to day basis are all important factors in our lives that are influenced by economics and economic analysis. Finding new ways to present data and discuss it, expanding opportunities and

influence for historically underrepresented groups in economics, and learning to apply economic principles as well as data analysis techniques in not only helpful and informative ways, but with fair and equitable solutions in mind, are important steps to take in order to level the playing field of economic data analysis and make it sustainable and equitable for all.

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