Origins and Consequences of

THE HUMPHREY-HAWKINS ACT OF 1978

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TO: Terry Fitzgerald, Vice President Federal Reserve Bank of Minneapolis
FROM: Humphrey School of Public Affairs capstone research team
DATE: December 20, 2016
Subject: Humphrey-Hawkins Act analysis

Executive Summary

The Full Employment and Balanced Growth Act of 1978, commonly known as the Humphrey-Hawkins Act shifted U.S. economic policy from a focus on price stability to a dual mandate which added an employment goal. The Act emended the Employment Act of 1946 to include specific numeric goals for inflation and employment while maintaining the one could not be sacrificed to achieve the other. This paper uses several statistical analysis methods to determine if there is a quantifiable effect on price stability or employment due to the passing of the Act along with discussion of any change in Fed behavior. Further comparisons are made to selected developed countries with central banking systems that have single mandates along with a compared dual mandate country.

Results

- **Unemployment:** no statistically significant impact from the Act
  - *Time Series models:* Unemployment, inflation and federal funds rate are interdependent and have short-term relationships. The Act did not change the Fed's policy that was more responsive to only inflation rate changes, not unemployment rate changes, and these policies continue. No evidence that the Act influenced unemployment using country comparisons.
  - *Phillips Curve:* predictive power of inflation on unemployment is not statistically significant though graphically comparison countries appear to show inverse relationship.
  - *DID model:* fixed effect model including years and country effect did not show a positive impact on unemployment before and after the act.

- **Price Stability:** no statistically significant impact from the act
  - *Chow Test:* inflation in the U.S. and compared countries showed no statistically significant change in inflation before and after the Act
  - *Time Series model:* regression discontinuity used to observe the change in inflation before and after the Act showed no statistical significance.
- **Change to Fed**
  - There is little evidence to suggest the Congressional testimony requirement led to increased coordination between fiscal and monetary policy.
  - The employment mandate was largely ignored by the Federal Reserve as a policy objective until 2008 under Chairman Bernanke.

The Humphrey-Hawkins Act aimed to move the U.S. economic policy into a dual mandate focus on improving employment and lowering inflation. There was no statistical impact found for the U.S. or compared to other countries. While Congressional testimony can be viewed as a net positive, it is unclear if any policy changes were made.

1. Introduction and Background

The Full Employment and Balanced Growth Act of 1978, otherwise known as the Humphrey-Hawkins Full Employment Act, was passed in response to the United States' economic downturn of the 1970s coupled with rising unemployment. Building upon the the Employment Act of 1946, the Humphrey-Hawkins Act amended U.S. economic policy from a single mandate focus on price stability to what is commonly known as a dual mandate to include an additional employment goal. The goal of this paper is to examine the consequences of the U.S. changing to a dual mandate through the Humphrey-Hawkins Act and to identify if impacts were made to price stability, through inflation, and unemployment along with any impacts to the U.S. Federal Reserve. Various statistical tests were used to measure impacts in the U.S. along with using other world countries with similar central banking systems as comparisons. Our analysis found there is little to no statistically significant evidence to support the Humphrey-Hawkins Act improving unemployment or price stability.

1.1 Historical Context

1.1.1 The Employment Act of 1946

Prior to the Humphrey-Hawkins Act, the Employment Act of 1946 was the prevailing legislation requiring the federal government to maintain price stability and maximize employment. The Act was a response to the Great Depression of the 1930s and the continuous fear of another depression at the end of World War II when many war veterans were returning home.[1] The legislation reflected Congressman Wright Patman's position that full employment would not be attainable if left to private enterprise and businesses, which meant the federal

[1] Santoni, G.J. The Employment Act of 1946: Some History Notes 6 (Fed. Reserve Bank of St. Louis, 1986) (detailing the history of the Employment Act of 1946)

government would be required to intervene.[2] The original bill wanted the government to ensure a "right" to a job, however the opposition forced the bill to make the government assist in gaining the economic planning mechanisms to maintain full employment, production, and purchasing power.[3] The bill established that it was the government's job to help with full employment, but it was largely ignored.

1.1.2 Economic Views and Phillips Curve

The Phillips Curve helped create the 1970s stagflation. The Phillips Curve—simply stated— is an economic concept that shows that inflation and unemployment have an inverse relationship. After the Phillips Curve was discovered in 1958 it had made its way into the thinking of policymakers and the Federal Reserve by the 1960s and 1970s.[4] Policymakers became increasingly optimistic that more inflation will lead to more employment. However, over time that relationship breaks down and it becomes less clear how monetary policy can pursue full employment.

From 1960 to 1970 the Phillips Curve was very pronounced. Higher inflation was leading to lower unemployment (Figure 18).[5] Many policymakers began to believe in the long-term Phillips Curve. They wanted more inflation to create more jobs. However, from 1970 to 1980 the Phillips Curve disappeared (Figure 19). By 1980 economists were thinking that the Phillips Curve was a short-term phenomenon that led to accelerating inflation and higher unemployment

[2] Goldberg, Michelle . "THE FED'S DUAL MANDATE: ONE TOO MANY?" *Boston University*. N.p., n.d. Web. 18 Dec. 2016.

[3] Steelman, A. (2013, November 22). Full Employment and Balanced Growth Act of 1978, commonly called Humphrey-Hawkins. Retrieved December 12, 2016, from http://www.federalreservehistory.org/Events/DetailView/3

[4] Dr. Econ, what is the relevance of the Phillips curve to modern economies? (2008). FRBSF. Retrieved December 12, 2016, from http://www.frbsf.org/education/publications/doctor-econ/2008/march/phillips-curve-inflation/

[5] Rolnick, A. (2016, September 26). Are Phillips Curves Useful for Forecasting Inflation? 40 years of debate. Lecture presented at UMN, Minneapolis.

in the medium and long run. Businesses and labor markets were raising prices in anticipation of inflation, thus inflation became a self-fulfilling prophecy.

1.1.3 Previous Monetary and Fiscal Policy

The 1970s stagflation was caused by both fiscal and monetary policy. Fiscal policy favored inflation because the US government favored looser fiscal policy starting in the mid 1960s.[6] The Council of Economic Advisers—a product of the Employment Act of 1946—had convinced President Johnson to not raise taxes in 1966 and 1967 to finance the war in Vietnam.[7] The CEA was ideologically committed to economic growth, thus they failed to advise Johnson about the dangers of inflation. During Nixon's administration the price-wage controls artificially held inflation down for a period of time, which also kept the monetary policy from tightening.[8]

By the 1970s, the Federal Reserve became too optimistic with how hot the economy could be without spurring inflation. Once inflation started to rise in the mid to late 1960s the Federal Reserve was too slow to respond. The war economy, price-wage controls, and oil shocks helped convince the Federal Open Market Committee (FOMC) to refrain from monetary policy tightening. To the contrary, the monetary policy continued to grow the money supply.[9][10] From the late 1960s through the early 1980s, inflation cycles ushered in both higher inflation and higher unemployment.[11] It is often cited that the FOMC placed too much emphasis on real output

6 "The Federal Reserve and the Financial Crisis: ." *Federal Reserve*. N.p., n.d. Web. 18 Dec. 2016.

7 Sloan, John W. "President Johnson, The Council of Economic Advisers, and the Failure to Raise Taxes in 1966 and 1967." *Www.jstor.org*. N.p., n.d. Web. 18 Dec. 2016.

8 "The Federal Reserve and the Financial Crisis: ." *Federal Reserve*. N.p., n.d. Web. 18 Dec. 2016.

9 Nelson, Edward. "The Great Inflation of the Seventies: What Really Happened?" St Louis Federal Reserve Bank, Jan. 2004. Web. 18 Dec. 2016.

10 "United States Money Supply M2 | 1959-2016 | Data | Chart | Calendar." *United States Money Supply M2 | 1959-2016 | Data | Chart | Calendar*. N.p., n.d. Web. 18 Dec. 2016.

11 Nelson, Edward. "The Great Inflation of the Seventies: What Really Happened?" St Louis Federal Reserve Bank, Jan. 2004. Web. 18 Dec. 2016.

and unemployment during this decade and ended up with a volatile economy of high and variable inflation.[12]

1.2 Augustus Hawkins and Hubert Humphrey

For the coauthors, interest in drafting legislation to address the challenging economic times for the U.S. in the 1970s was largely influenced by their political careers and early life despite one spending their formative years in Los Angeles and the other in South Dakota. The early lives of both men were largely effected by the country's growing unemployment during the Great Depression. Hubert Humphrey's initial time at the University of Minnesota was cut short as financial constraints dictated his return to the family pharmacy business in South Dakota. Also a son of a pharmacist, Augustus Hawkins studied economics at the University of California, Los Angeles with conditions preventing his goal of continued education in engineering. The lack of money for graduate work would lead Hawkins into the real estate business.

By the late 1930s as the Great Depression began to subside and the political lives of Hawkins and Humphrey, which would be built upon commitments to social service, started to form. For Hawkins, working in real estate and further education in government at UCLA led to a focus on housing policy and social welfare after being elected to California State Assembly beginning in 1935. There Hawkins introduced legislation for fair employment, fair housing and workmen's compensation. On the strength of such reforms and advocating for minority populations in his district of Los Angeles, Hawkins was elected to the House of Representatives in 1963 where he continued his work on social justice issues. During his first term, Hawkins was

[12] Bullard, James. "The Fed's Dual Mandate: Lessons of the 1970s." *Www.stlouisfed.org*. St Louis Federal Reserve Bank, Apr. 2011. Web. 18 Dec. 2016.

a contributor to the Civil Rights Act of 1964 authoring Title VII which prohibited employer discrimination.[13]

Upon returning to the University of Minnesota in 1937 to complete his degree, Humphrey studied political science at Louisiana State University before returning to Minnesota to work on a doctorate. Humphrey's political interest cut short his academics as he was elected mayor of the City of Minneapolis on second attempt in 1945 prior to his first term as U.S. Senator in 1949. It was in the Senate where Humphrey would begin his legacy for civil rights advocating for the end of school segregation and job discrimination to be a part of the Democratic party's platform despite the risk of opposition from Southern Democrats. This commitment would continue throughout Humphrey's legislative career as one of the primary authors of the Civil Rights Act.

Beyond their interest in social issues, the two Congressmen intersected directly on economic policy. Beginning in 1971, Humphrey and Hawkins served together on the Joint Economic Committee. During this period of the early 1970s, the two were part of the committee charged with reviewing national economic conditions and making policy recommendations leading to the drafting of the Humphrey-Hawkins Act.[14]

1.3 The Humphrey-Hawkins Full Employment Act

1.3.1 Previous Version of the Act

Initial drafts of the Humphrey-Hawkins Act began in 1975 with changes made over the following years. Prior to the the final version of the act being signed into law by President Jimmy Carter in October of 1978, previous iterations of the legislation did not pass through Congress. Originally, Humphrey advocated for a much more aggressive stance on the federal government's role in providing jobs in times of economic downturn which was opposed by

[13] "Augustus F. Hawkins Foundation." Augustus F. Hawkins Foundation. N.p., n.d. Web. 7 Nov. 2016.

[14] Solberg, Carl. Hubert Humphrey: A Biography. St. Paul, MN: Borealis, 2003. Print.

private industry. Because of opposition, the final version of the Humphrey-Hawkins Act relied on private business to be the primary driver of employment growth while government programs could be used to supplement employment in times of need.[15]

Additional changes were made in the method in which monetary policy would be influenced by the executive branch. While the final version did create the Congressional testimony for the President of the U.S. Federal Reserve allowing for monetary policy questioning, previous drafts of the Act did call for the executive branch to submit its recommendations for monetary policy with the Fed charged with responding with any divergent view points within 15 days.[16]

1.3.2 Goals of the Act

The Humphrey-Hawkins Act looked to build upon the existing economic policy legislation from the Employment Act 1946, which stated a goal for maximizing employment without any targets, by outlining specific short and medium term numerical goals. The Act contained a stated goal of reaching 3 percent unemployment for those 20 years of age and older within 5 years and a further goal of 4 percent for those 16 and older. Similarly, the Act stated an inflation target of 3 percent within 5 years. Importantly, the Act specified that the inflation target was not to come at the expense of meeting employment goal, thus the dual mandate.

The legislation looked to achieve these targets through much stronger coordination between the Fed monetary policy and the fiscal policy of the executive branch. To this end the Act created the requirement for Fed Chairmen to testify before Congress twice a year. The view of the authors was that this coordination was necessary to improve both employment and price

[15] Hawkins, Augustus and Humphrey, Muriel. Goals For Full Employment and How to Achieve Them Under the "Full Employment and Balanced Growth Act of 1978" N.p.: n.p., n.d. Print.

[16] Steelman, Aaron. "Full Employment and Balanced Growth Act of 1978." *Full Employment and Balanced Growth Act of 1978*. N.p., 22 Nov. 2013. Web. 18 Oct. 2016.

stability through extensive planning while remaining flexible to economic conditions. Numeric goals for employment and price stability were to be reviewed and amended each year based on economic research from major areas of industry if changes were needed.[17]

Beyond the inflation and unemployment targets, the Humphrey-Hawkins Act (HH Act) had an additional goal of increasing trust and transparency between the Fed, the executive and legislative branches and the public which had waned during the difficult economic times. Between the coordination required between monetary and fiscal policy to improve price stability while not neglecting full employment and the Fed Chairman going on the record before Congress, the Act impacted the operations of the Federal Reserve. Concluding discussions will examine if the Fed has changed its operational behavior along with effects on price stability and employment.

2. Description of the Dataset

We used yearly, quarterly and monthly data for the US and all the comparison countries. Most of the data is extracted from Organization for Economic Co-operation and Development (OECD), Bureau of Labor and Statistics and Federal Reserve Bank of both Minneapolis and St. Louis.[18] Also, the data is divided in two periods: before and after the HH Act of 1978. The "After HH Act" data was further divided into two groups to deeper analyze the immediate and non-immediate effects of HH Act.[19] The general time period for the data ranges from 1954 to

[17] Full Employment and Balanced Growth Act of 1978, Pub. L. No. 95-523, 92 Stat. 1887 (1978).

[18] Data for specific countries come from Australian Bureau of Statistics, Statistics Canada, Office of National Statistics of England, Federal Statistics of Germany, Statistics Bureau of Japan, Euro Stat.

[19] The data after HH Act was divided as "Miller + Volcker + Greenspan" and "Bernanke + Yallen" periods to do Granger Causality Test.

November of 2016. The variables we are using are Unemployment rate (Urate)[20], Consumer Price Index (CPI)[21], Long-term Interest Rate (INT)[22], Federal Funds Rate (R)[23] and Gross Domestic Product (GDP)[24]

We identified the following countries for comparison: Canada, Japan, Australia, England, Germany, European Central Bank. Our decision to use these countries as a comparison was based on the fact that they are very similar to the United States. First, all countries listed are developed countries, but also they hold similar economies characteristics such as GDP.

3. Empirical Approach

Below are the list of methods and tests we have utilized to examine the effect of Humphrey-Hawkins Act on unemployment rate and price stability.

3.1 Time series models: Vector Autoregression and dynamic model

[20] Unemployment - Unemployment rate - OECD Data. (n.d.). Retrieved December 19, 2016, from https://data.oecd.org/unemp/unemployment-rate.htm. Unemployment rate is the number of unemployed people as a percentage of the labour force, where the latter consists of the unemployed plus those in paid or self-employment. Unemployed people are those who report that they are without work, that they are available for work and that they have taken active steps to find work in the last four weeks (OECD).

[21] Prices - Inflation (CPI) - OECD Data. (n.d.). Retrieved December 19, 2016, from https://data.oecd.org/price/inflation-cpi.htm. Inflation measured by consumer price index (CPI) is defined as the change in the prices of a basket of goods and services that are typically purchased by specific groups of households (OECD).

[22] Interest rates - Long-term interest rates - OECD Data. (n.d.). Retrieved December 19, 2016, from https://data.oecd.org/interest/long-term-interest-rates.htm. Long-term interest rates refer to government bonds maturing in ten years. Rates are mainly determined by the price charged by the lender, the risk from the borrower and the fall in the capital value. Long-term interest rates are generally averages of daily rates, measured as a percentage. These interest rates are implied by the prices at which the government bonds are traded on financial markets, not the interest rates at which the loans were issued (OECD).

[23] Board of Governors of the Federal Reserve System (US), Effective Federal Funds Rate [FEDFUNDS], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/FEDFUNDS, December 19, 2016. The federal funds rate is the interest rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight. When a depository institution has surplus balances in its reserve account, it lends to other banks in need of larger balances.

[24] Domestic product - Gross domestic product (GDP) - OECD Data. (n.d.). Retrieved December 19, 2016, from https://data.oecd.org/gdp/gross-domestic-product-gdp.htm. Gross domestic product (GDP) at market prices is the expenditure on final goods and services minus imports: final consumption expenditures, gross capital formation, and exports less imports (OECD).

The effects of the HH Act could have an overtime effect, so we use two time-series models to analyze its impact over time: vector auto-regression (VAR) time series model and dynamic time series model. Specifically, these models are denoted by the following equations:[25]

$$\mathrm{Y_{c,t}} = \alpha_0 + \beta_0 X_{c,t-1} \ldots + \beta_1 X_{c,t-p} + \beta_2 Y_{c,t-1} + \cdots + \beta_p Y_{c,t-p} + \epsilon_{c,t} \quad (1)$$

$$Y_{c,t} = \beta_0 + \beta_1 Y_{c,t-1} + \beta_2 X_{c,t} + \beta_3 X_{c,t-1} + \epsilon_{c,t} \quad (2)$$

Where Y is the outcome of interest (either consumer price index or unemployment rate), X is a vector of general economic characteristics (including INT and GDP), and ϵ is the error term. Subscripts c indicates country, p indicates number of lags, t indicates the current time period, and t-1 indicates the time period before the current time period.

Vector autoregression time series model, as shown in equation (1) is used to analyze the dynamic relationships between three U.S variables over time: unemployment rate, federal funds rate and inflation rate. These three variables are explained by its own lags and lags of other variables. Co-integration test was conducted to establish whether these variables have a long-term or short-term relationships for policy inferences. VAR model is not a theoretical model, so inclusion of all variables influencing the interested variable is not necessary, and is immune to omitted variable bias. Hence, the detailed analysis of whether federal funds rate is more responsive to change in unemployment rate or to inflation rates is possible.

From this time series model (1) we conduct Granger Causality test. The intuition behind this test is the following: if we say that a variable "*change in federal funds rates"* that evolves over time *Granger-causes* (forecasts) another evolving variable *"change in unemployment rate"* based on its own past values *and* on the past values of *"change in inflation rate"*, we conclude

[25] Studenmund, A., & Cassidy, H. (1987). Using econometrics. *Chapter 11 Time Series Models, 389-411.*

that federal fund rates are responsive to change in unemployment rate. Hence, this test helps us establish whether unemployment rate changes affect federal fund rate changes over time compared to overtime effect of inflation rate changes on federal fund rates.

Model (2) is the dynamic time series model, and we use this to conduct trend estimates and differential effect estimates among all the countries. Since unemployment rate is the new mandate for the Federal Reserve Bank after the passage of Humphrey Hawkins Act, first we use this model to look at the trend of unemployment rate before and after the year of 1978. We use equation (2) to get a predicted trend based on the real trend prior to the year of 1978, and then we compare this predicted trend to the real trend after 1978, and we do this separately for all the countries included in our sample, except Great Britain and European Central Bank due to data limitation. Afterwards, we use ttest to demonstrate whether the differences between the predicted and real trends are statistically significant.

Then in order to compare the differential trends among all the countries, we again use the dynamic time series model to see whether HH Act have an effect comparing with other countries. The baseline country is the US, and for sensitivity consideration, we randomly add or drop controlling variables to test whether our estimates are robust.

3.2 Phillips Curve

The Philips Curve represents the relationship between the rate of inflation and the Unemployment rate, and it assumes the relationship as, the lower the unemployment rate, the higher the inflation will be.[26]

To model the Phillips curve, we also ran a dynamic lagged model. Below is the equation used to produce the results.

[26] Phillips Curve. (n.d.). Retrieved December 20, 2016, from http://www.econlib.org/library/Enc/PhillipsCurve.html

$$\text{Urate} = \text{Urate}_1 + \text{CPI} + \text{CPI}_1 + PCE + INT + GDP + \epsilon \quad (3)$$

$$\text{Urate} = \text{CPI} + \text{CPI}_1 + PCE + INT + GDP + \epsilon \quad (4)$$

The first equation we look at the predictive power of the current inflation rate and last year's inflation rate on current unemployment. This is taking into consideration the unemployment rate of the previous year. In the second equation, we observe the results of the model when we disregard the unemployment rate of the previous year. Our controls in both equations are personal consumption expenditure (PCE), the interest rate (INT), and the gross domestic product (GDP).

To evaluate the impact of the Humphrey-Hawkins Act, our team decided to examine the stationarity of the Philips Curve and its associated parameters (inflation and unemployment). Given that the Philips Curve suggests that inflation and unemployment have a negative relationship, we were particularly keen to find out how, if at all, the Humphrey-Hawkins Act might have changed that relationship.

3.3 Difference-in-difference (DID)

We also adopted DID model to evaluate whether Humphrey Hawkins Act has an effect on unemployment rate comparing with other countries. The difference in difference method was used to compare the time period before the Humphrey Hawkins Act was passed and the period after (pre and post 1978). The method was useful in producing results that could parallel unemployment before and after the legislation and uncover any slight evidence of an effect. The equation is as below:

$$\text{Urate} = \beta_0 + D + After + D * After + X_t Y + \epsilon \quad (5)$$ [27]

[27] Angrist, Joshua D., and Jörn-Steffen Pischke. *Mostly harmless econometrics: An empiricist's companion*. Princeton university press, 2008.

where:

D is the treatment variable of whether or not the country is the U.S. or not (0,1)

After is period after the passage of the legislation (0,1).

D*after is the interaction term between the treatment and the time variable

$X_t Y$ are the covariates as well as time and year fixed effects

To empirically run the DID model, the key identifying assumption must be met. The assumption requires that the observed trend in the control group be similar to that of the comparison group before 1978(the year the act was passed). This parallel assumption trend for the control and comparison group is important because it provides us with confidence about the counterfactual of the treatment group. We can infer then from this assumption that the trend of the treated group would have followed a similar path as that of the comparison if not for the treatment. Running our data and looking at the trend, we conclude that the identifying assumption holds and that the DID method can be used to observe the outcome.

3.4 Taylor Rule

To evaluate the impact of the Humphrey-Hawkins Act, we chose to determine whether or not the act created an observable change in one or both components of the dual mandate (i.e. price stability and employment) using the Taylor Rule.

Taylor's rule is a proposed guideline for how central banks should alter interest rates in response to changes in economic conditions. It was introduced by John Taylor and was

established to adjust and set prudent rates for the short-term stabilization of the economy.[28] The equation of Taylor's rule is as below:

$$i_t = \bar{\imath} + \phi_X X_t + \phi_\pi(\pi_t - \bar{\pi}) \qquad (6)$$

where:

i = Federal Funds Rate; $\bar{\imath}$ = Natural Rate of Interest

π_t = Rate of Inflation; $\bar{\pi}$ = Inflation Target

ϕ_π = Responsiveness of Policy Rate to Inflation Deviations

ϕ_X = Responsiveness of Policy Rate to the Unemployment (or Output) Gap

X_t = Percent Deviation of Unemployment from Natural Rate of Unemployment

$X_t = (Y - Y^*)/Y^*$

Y = Unemployment Rate (or Real GDP); Y^* = Natural Rate of Unemployment (or Target GDP)[29]

3.5 Chow Test

To test the hypothesis that the dual mandate may have *caused* structural break, the research team conducted a series of Chow-type tests and recursive estimation tests to search for breaks at both known and unknown points in time, respectively[30].

4. Results

4.1 Impact of Humphrey-Hawkins Act on Unemployment Rate

Judging from the results of all of our models, we did not find any conclusive effect of Humphrey-Hawkins Act on unemployment rate.

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[28] R. (2013). Taylor's Rule. Retrieved December 20, 2016, from http://www.investopedia.com/terms/t/taylorsrule.asp

[29] The output gap and the unemployment gap are two closely related concepts. "Theoretically, if policymakers get the actual unemployment rate to equal the NAIRU, the economy will produce at its maximum level of output without straining resources…" (IMF, 2013)

[30] Chow, George (1960). 'Tests of Equality Between Sets of Coefficients in Two Linear Regressions.' Econometrica Vol. 28, No. 3. Pp. 591-605. July.

4.1.1 Summary of vector autoregression time series model (including Granger Causality Test)

Ensuring reliability before conducting vector regression analysis and granger causality test, it is essential to consider power of the test, number of lags and existence of time trends as the results are sensitive to it. The historic monthly data of the U.S was used to increase powers of the tests. Determining the correct number of lags is essential; too many lags could increase the error in the forecasts, too few could leave out relevant information.[31] LaGrange multiplier test and Akaike's information criterion (AIC) [32] were used to ensure no autocorrelation at the specified lag order when doing Granger Causality test.[33]

Co-integration test summarized in Table 4-5 show statistically significant results at 5% for existence of only short-term relationship between unemployment rate and federal fund rates; and inflation rate and federal funds rate from July of 1954-November of 2016. Since the relationships are short-term it gives us a policy argument that any changes in federal funds rate due to unemployment rate change or inflation rate change are indeed the policy changes, not residual effects from the previous changes in federal funds rates.

Vector Autoregression (VAR) analysis was conducted to analyze the dynamic relationships between three evolving monthly variables from July of 1954 to November of 2016 as summarized in Table 6. We found statistically significant results of all variables being inter-dependent on each other at 1% and 5% levels. This means that all changes in unemployment, inflation and federal funds can be explained by lagged variables of itself and lagged variables of the other two. In sum, changes in unemployment, inflation and federal funds rates are

[31] Akaike's information criterion (AIC), that is most accurate with monthly data.

[32] Ivanov, V. and Kilian, L. 2001. 'A Practitioner's Guide to Lag-Order Selection for Vector Autoregressions'. CEPR Discussion Paper no. 2685. London, Centre for Economic Policy Research. http://www.cepr.org/pubs/dps/DP2685.asp.

[33] Lastly, the unit root tests summarized in tables 1-3 reveal unit roots of the variables, which means that we need to transform all variables to their rate of change or first differences to get rid of time dependency.

interdependent on each other, but inflation rate is more precise in explaining the change in federal funds rate compared to unemployment rate.

Granger Causality test after vector autoregression was conducted to determine whether the federal funds rates are determined due to changes in unemployment or inflation rate. Granger Causality tests have statistically significant results at 1% level for both before and after periods of Humphrey Hawkins Act as summarized in Tables 7-8. The tests found that changes in federal funds rates are affected by changes in inflation rate only, not unemployment rate. Since the probability value was 0 for both periods, the possibility of type 1 or type 2 errors that make results erroneous are slim. From a policy perspective, these tests give a substantive evidence that HH Act didn't influence the Fed's policy, and that Fed's policies were always responsive to inflation rate changes even after HH Act.

There is a need to do Granger Causality tests to further analyze the aftermath of Humphrey Hawkins in two periods to analyze the immediate effects of the Humphrey Hawkins Act due to absence of long-term relationship between the variables.[34] The periods were further divided in "Miller + Volcker + Greenspan" and "Bernanke + Yellen" due to different policies of the Chairs.[35] The Granger Casualty Test conducted during the above-mentioned periods (summarized in Table 8-9) have statistically significant results at 5% level for both before and after Ben Bernanke, and yield the same results as before. This test gives a substantive evidence that the general Fed's policy hasn't changed in the immediate aftermath of HH Act, and continue to this date, even after introduction of new policies with Ben Bernanke.

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[34] This division is also useful to test the accuracy of the Granger Causality Test as the test could give misleading results if some of the variables are highly persistent James H. Stock and Mark W. Watson "Vector Autoregressions", 2001, retrieved from ://faculty.washington.edu/ezivot/econ584/stck_watson_var.pdf

[35] Policies of Chairmen Volcker and Greenspan could be summarized by Taylor Rule's policy recommendations, but starting from Ben Bernanke period "inflation targeting" was introduced in 2012 and "full unemployment rate" was mentioned during FOMC meetings.

In conclusion, unemployment rate, inflation rate and federal funds are all interdependent on each other, albeit having short-term relationships. Since the relationships are short-term any changes in federal funds rate should be considered the policy changes, not residual effects from the previous changes in federal funds rates. The granger causality tests give a substantive evidence that HH Act didn't influence the Fed's policy that were always responsive to inflation rate changes. Analysis of immediate aftermath gives a statistically significant evidence that the general Fed's policy hasn't changed in the immediate aftermath of HH Act, and continue to this date, even after introduction of new policies with Ben Bernanke, except, maybe, for few times of financial crisis.

4.1.2 Time Series Model

In order to analyze the impact of HH act on unemployment rate, first we look at the unemployment trends graph for all the countries including the US, as are shown in Figure 5 and Figure 6. In Figure 5, we can see that prior to 1978, the unemployment rate of the US was among the highest of all the countries. After 1978, it has been fluctuating around 4%-10%. However, when comparing with other countries, the unemployment rate of the US has dropped from the highest to be in the middle, even dropping to the lowest of 4% among all the other countries in the year of 2001. Judging from this trend graph, it is hard to tell whether the HH Act has an impact on unemployment rate, or the seemingly better ranking of the US unemployment rate compared with other countries is simply due to the fact that the unemployment rate of other countries has been increasing in general after 1978.

Similar trend has been discovered in Figure 6 as well, when comparing unemployment rate trends between the US and Australia. It can be seen that after the Reserve Bank Act passed in 1959 in Australia, starting from 1968, the unemployment rate for Australia was rather low at

2%. Although it keeps increasing since then, it is still lower than that of US before 1978. After 1978, because the unemployment trend for the US in general keeps at a constant level, the unemployment rate for Australia becomes higher from 1985-2007, and becomes lower than that of the US again after 2007.

The results from the trend graphs do not give us any solid evidence about the impact of HH Act on unemployment rate. Therefore, we move to time series analysis. Figure 7-Figure 11 demonstrate the comparison of predicted unemployment rate trends and real unemployment rate trends after 1978 for the US, Australia, Canada, Germany and Japan. For Humphrey Hawkins Act to have an effect on unemployment rate in the US, we would expect that there exists statistically significant difference between the predicted and real trends after 1978 only for the US. We can see from the graphs that for all of these countries, there seem to exist some differences between the predicted and real trends. And it can also be seen that the differences are larger for other comparison countries. After using paired t-test to test for the statistical significance of these trends (results are listed in Table 10-14), we find out that the differences between two trends for all the countries are significant at 1% level. Therefore, we reject the null hypothesis that there is no significant difference, and conclude that there exists statistically significant difference between the predicted and real unemployment rate trends for all of the 5 countries. This result is the opposite as what we have expected if the HH Act had an effect. Therefore, judging from this result, we conclude that HH Act does not have an impact on unemployment rate for the US.

Table 15 is the regression result for the dynamic time series model when comparing with other countries. For HH Act to have an impact, we would assume that significance for the variables after 1978 should only emerge for the US. It can be seen that only the variable of

interest rate has significance for both before and after period for the baseline country, which is the US. Although Australia has Reserve Bank Act, the fact that Canada has significance for interest rate both before and after 1978 can invalidate the significance we find here for the US. Also when looking at the baseline interest rate of the US, it can be seen that the interest rate after 1978 becomes more positive (from -0.610 prior 1978 to -0.176 after 1978), and this is the opposite as what we would expect for HH Act to have an effect. Therefore, judging from this result, we also conclude that HH Act does not have an impact on the unemployment rate in the US comparing with other countries.

4.1.3 Phillips Curve

We find that when we look at the trends of the countries overtime where unemployment and inflation are plotted, the theoretical framework holds. That is, it is clear an inverse relationship exists between these two variables.[36] To observe this framework, we have the plotted data of the U.S, Canada, and Germany (Figure 1-2). For the time series conducted to model this relationship, our results show something interesting and not completely consistent with the theoretical idea behind the Phillips curve. Looking at table 21 in the appendix, note that the pre 1978 coefficient for inflation (without unemployment) is statistically significant at 0.755. In the post years, this coefficient decreases to 0. 228 and is no longer statistically significant.

This leads us to conclude that pre 1978, we can confidently infer that the inflation is predictive of the outcome of unemployment, however after 1978, the can no longer confidently deduce a predictive relationship of inflation on unemployment. This finding brings into question

[36] Fitzgerald, Terry J., Brian Holtemeyer, and Juan Pablo Nicolini. "Is there a stable Phillips Curve after all?." *Economic Policy Paper* 13, no. 6 (2013).

our understanding of the Phillips curve and the relationship between the two variables in years after 1978.

To determine whether or not the Humphrey-Hawkins Act created a structural break in the Philips Curve, our team applied the Chow test. More specifically, we applied a Wald test and a Supremum Wald test to evaluate the existence of a structural break at known and unknown points, respectively. Additionally, we chose to visually analyze the structure of our data at 5 - 10 year intervals beginning in 1960 and continuing until 2015 (Figure 18-25). Ultimately, our analysis suggests that the Phillips Curve did not experience a structural break in 1978, instead it appears that a break occurred in 1981 which is consistent with other portions of our analysis (Table 13-15).

4.1.4 Difference-in-Difference

Our parallel trends assumption held when we took the aggregated unemployment data points of all countries and used them as the comparison for the U.S. This parallel trends graph (Figure 4) seems to conclude that the Humphrey-Hawkins Act may have had a positive effect on unemployment. There's an evident dip in the unemployment rate right after the year the legislation was passed (1978). With this in mind, we conducted our three separate ordinary least squares (OLS) regressions for DID. One simple OLS, on with covariates, and the final model including country and year fixed effects. The first two models indicate a decrease in unemployment with the interaction of the treatment and time binary variables (Table 21). The coefficient in the simple OLS (*D_after*) is -3.016 and statistically significant. Column three in the same table, which includes the controls, produces a coefficient of -3.194 and is also statistically significant. The fourth column includes our OLS estimate with covariates along with country and year fixed effects. The coefficient produced from this regression model has an

opposite effect on unemployment as compared to the previous two. In this model the statistically significant coefficient is 0.749. What this say is that unemployment has in fact increased at some point in the time after the passing of the act. This is contrary to our first two OLS models, which indicated that on average unemployment has fallen quite a lot.

To conclude, our DID method indicated that there are enough similarities between our comparison countries and the U.S. needed to conduct the regression. This is what we understand as the parallel trends assumption, however the DID fixed effects regression output deems the effects of the Humphrey-Hawkins act as non evident. Our statistically significant coefficient is positive failing to indicate the positive impact of the legislation.

4.2 Impact of Humphrey-Hawkins Act on Price Stability

Judging from the results of all of our model, we did not find any conclusive effect of Humphrey-Hawkins Act on price stability either.

4.2.1 Taylor Rule: Chow-Type Test Results

The research team ultimately conducted two Chow-type tests to search for a break in the 1st quarter of 1978, including a 'traditional' Chow test and a more robust Chow-type test. In both cases, the Chow-type statistic indicated the presence of a structural break, which represents a rejection of the null hypothesis. While these results seem to indicate that there was a structural break in the Taylor Rule in 1978, subsequent sensitivity testing seems to suggest that the detected structural break actually occurred after 1978 (Tables 16-18).

4.2.2 Taylor Rule: Recursive Estimation Results

To attempt to identify unknown breaks in the time series data, the research team used two Wald-type diagnostic techniques, including the Quandt Likelihood Ratio (QLR) test. According to the results of both tests, the data does contain a break points. While some of these break points

are in the vicinity of 1978, the breaks primarily occur well after the implementation of the Humphrey-Hawkins Act.

With both tests, the results suggested that there was not, in fact, a structural break in 1978. However, both tests seemed to indicate that there was almost certainly a break during the term of former Federal Chairman Paul Volcker 1980s and a break during the recession of 2008. To offer a more complete analysis, the research team also conducted a QLR test on unemployment and the inflation rate, in an attempt to identify a structural break in either component of the Taylor Rule. The results, displayed in Appendix A, Figures 12-15, also failed to identify an unknown structural break in 1978.

4.2.3 Taylor Rule Conclusion

On the basis of this analysis, it is difficult to conclude that the Humphrey-Hawkins Act caused a structural break at the time of its initial implementation. While there is, of course, the possibility that there was a lagged effect, the stagflation that characterized the ensuing period makes it particularly difficult to say what those effects were. As this paper will further explain, the approach adopted by the Chairman Volcker, which specifically (and almost exclusively) focused on price stability, further complicates the ability of this analysis to make a firm conjecture.

4.2.4 International Comparison of Inflation

In order to validate the change in inflation rate before and after the legislation of HH Act, we compared this rate between the US and other selected countries. We first considered using core inflation. However, due to its lack of availability for many of selected countries, we decided to use headline inflation.

First, we compare the change between the US and the countries with single mandate. As Figure 10 shows, change of inflation rate of the US does not show any distinct difference with these rates of other countries before and after the legislation of HH Act. Especially, after 1991, every country other than Japan, had serious economic downturn, maintains the inflation rate within the range of 0 to 5%, showing how each country elaborated on maintaining the price stability.

Second, we also compare the change between the US and Australia where they have the dual mandates. As it is described in previous section, Australia got its dual mandates in 1959, by Reserve Bank Act, which is 19 years earlier than that of the US. Figure 11 shows the change of inflation rate of the US and Australia. As we can see, there is no distinct difference in the change of inflation rate between these two countries. Other than 2009, during the time the US experienced serious financial crisis, inflation rate of each country after 1991 is within the range of 0 to 5%, showing the elaboration of reserve bank of each country on price stability.

4.2.5 Time Series Model

Since we could not observe any significant difference from the figures, we employed time series analysis. Using pooled regression and regression discontinuity, we attempted to find a change in the impact of each variable before and after the legislation of HH Act. Table 23 shows the impact of each variable, including lagged variables, on the inflation rate of each country. As we can see, there is no statistically significant difference in the impact of each variable before and after the legislation of HH Act. Furthermore, there is no statistically significant country-wise difference in each variable. It is possible to make a conjecture the reason; there is no difference in the inflation rate because reserve bank of each country elaborated on price stability regardless of the number of mandate.

5. Limitations of Data and Models

There exist a few limitations in our data. For example, we did not able to find data for some countries prior to the passage of Humphrey Hawkins Act, and we leave out some general economic trend variables to control for such as average annual wage, because quarterly data for this variable cannot be found for most of the countries. This limitation of our dataset can leads to the inconclusiveness of all of our results discussed above.

There also exist a few problems with the models we have adopted to evaluate the impact of HH Act. For time series model, if the sample size is small, and other things that can have great impact on the outcome are not controlled for (meaning the error term is not behaving well), our estimates tend to be biased. Also, because the time series models are dependent on lagged variables, they are much more likely to encounter serial correlation, which will surely cause bias in the OLS estimates. For DID model, although the common trend assumption seems to be met; however, when we compare the trends for each country separately with the US, the unemployment rate trends are not common (only Germany has a similar trend with the US before 1978). For Chow test, it depends on the variance of the data, which might cause bias in our estimates. Granger Causality Test could give misleading results if some of the variables are highly persistent. We tried to control for this limitation by diving the "after period" in two, and didn't find any of the variables being highly persistent in periods that are broken down.

Therefore, due to the limitations of both the dataset and the models, there is not enough evidence for us to make any causal conclusion of the impacts of Humphrey Hawkins Act on either unemployment rate or price stability.

6. Discussion of impacts to the Fed

One lasting effect of the Humphrey-Hawkins Act is the requirement for Fed Chairmen to give Congressional testimony. The Post-Vietnam environment led to distrust in the Government and the Stagflation of the 1970s helped lead to distrust in the Federal Reserve. In 1976 the Memorandum of Discussion—which required all discussions at FOMC meetings to be released—was terminated and led to more distrust. All these factors helped lead to the Humphrey Hawkins Act requirement that the Federal Reserve Chairman appear in front of Congress for two Congressional testimonies a year.

The Congressional Testimonies required the Chairman to state the current economic environment and policy objectives. In the 1980s and 1990s, Chairman Volcker and Chairman Greenspan started to use a short-term inflation target as part of its policy objective given in the Congressional testimonies. The success of the 1980s and 1990s can be "attributed in large part to inflation-targeting policy procedures that the Fed has adopted gradually and implicitly over the last two decades."[37]

Also, there is evidence the Humphrey Hawkins Act increased the level that the (FOMC) used meeting minutes to describe the content of its meetings. Historical evidence also suggests that this increased transparency was a response to the Humphrey Hawkins Act requirement that the Fed provide more detail in reporting of its goals and objectives.[38]

Our analysis has not found strong evidence for the Fed altering their policy following the passing of the Act. However, it stands to reason that the Fed used the price stability objective to reach the full employment objective. By the time the Humphrey Hawkins Act had passed, the

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[37] Goodfriend, Marvin. "Inflation Targeting in the United States?" *The National Bureau of Economic Research*. N.p., Dec. 2014. Web. 1 Dec. 2016.

[38] Acosta, Miguel. "FOMC Responses to Calls for Transparency." *SSRN Electronic Journal*(n.d.): 1-10. *FederalReserve.gov*. 2015. Web. 1 Dec. 2016.

Phillips curve was no longer working. The Federal Reserve's role in maintaining full employment became less certain. Thus, the Federal Reserve declared that it would pursue Price Stability after the Humphrey Hawkins Act, which would inherently achieve full employment. This helped the Federal Reserve to follow the dual mandate.[39] Volcker signifies the end of the Phillips Curve in a 1981 Senate testimony, "I don't think that we have the choice in current circumstances — the old tradeoff analysis — of buying full employment with a little more inflation. We found out that doesn't work, and we are in an economic situation in which we can't achieve either of those objectives immediately."[40] From 1978 to 2008, the Fed pursued price stability as a means to gaining maximum employment.

Thus while the Fed might have been reaching the employment mandate indirectly, employment was largely ignored until Chairman Bernanke's time. Since the adoption of the Humphrey Hawkins Act of 1978, the "Maximum Employment" mandate was not mentioned as a policy objective by the FOMC or the Chairman of the Fed until 2008. Instead, FOMC members believed that the Committee could achieve the dual mandate by achieving the price stability objective alone.[41] Thus, the Full Employment mandate was largely ignored as a policy objective until 2008. Chairman Bernanke was the first Chairman to state "Maximum Employment" as a policy objective in 2008. [42]

Chairman Bernanke continuously stated maximum employment as a policy objective throughout his terms as Chairman and acted on this policy objective. When the financial crisis hit

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[39] Thornton, D. (2012). The Dual Mandate: Has the Fed Changed Its Objective? Retrieved Nov 10, 2016, from https://pdfs.semanticscholar.org/fe95/91df09bf3b4a175223e409d600b6a40e34e8.pdf

[40] Steelman, A. (2013, November 22). Full Employment and Balanced Growth Act of 1978, commonly called Humphrey-Hawkins. Retrieved December 12, 2016, from http://www.federalreservehistory.org/Events/DetailView/39

[41] Thornton, D. (2012). The Dual Mandate: Has the Fed Changed Its Objective? Retrieved Nov 10, 2016, from https://pdfs.semanticscholar.org/fe95/91df09bf3b4a175223e409d600b6a40e34e8.

[42] Bernanke, B. (2008, February 14). Congressional Testimony. Retrieved Nov 10, 2016, from https://www.federalreserve.gov/newsevents/testimony/bernanke20080214a.htm

in 2008 there was a shift to save banks and revive the housing industry to ensure maximum employment. Congress has even criticized Chairman Bernanke for the over-emphasis of the Full Employment mandate over price stability.[43] Therefore, the Full Employment mandate did have implication on the Fed's policy objectives and actions, but not until after the start of the financial crisis of 2008.[44]

7. Conclusion

The Humphrey-Hawkins Act amended the previous legislation in order to bring a stronger focus on policy to help rising unemployment while not sacrificing price stability goals. The Act sought greater monetary and fiscal policy coordination from the Fed and executive branch to affect change during the difficult economic conditions of the early 1970s. Our analysis aimed to uncover if the Act had any measuring effect on these two parts of the dual mandate created by the legislation.

According to our analysis, the act had no statistically significant impact on unemployment. It cannot be said that the Fed was responsive to unemployment before or after the Act. Comparison to other countries with similar central banks suggest that there are other factors the influenced the unemployment rate after the Humphrey-Hawkins Act.

Similarly, analysis did not find statistically significant changes to price stability following the passing of the Act. While there may have been some effect on prices after 1978, the results may have been influenced in large part by the raising of interest rates under Chairman Volcker.

[43] Appelbaum, B. (2012). Republicans Sharply Question Bernanke for Fed's Focus on Job Market. Retrieved December 12, 2016, from http://www.nytimes.com/2012/02/03/business/economy/fed-chief-focuses-anew-on-us-debt.html

[44] Cassidy, J. (2016). Anatomy of a Meltdown. Retrieved December 12, 2016, from http://www.newyorker.com/magazine/2008/12/01/anatomy-of-a-meltdown

The Act did dictate a change in operation for the Federal Reserve with required testimony before Congress. However, there is little evidence that this achieved any improvement in coordination between monetary and fiscal policy. Further, employment goals largely went unnoticed in Fed policy following the passing of the Act. Price stability was potentially used as a means to achieve employment targets but it was not until under Chairman Bernanke that employment goals became more widely discussed.

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Appendix A: Figures

Figure 1: Trend Line of Unemployment and Inflation over time in U.S.

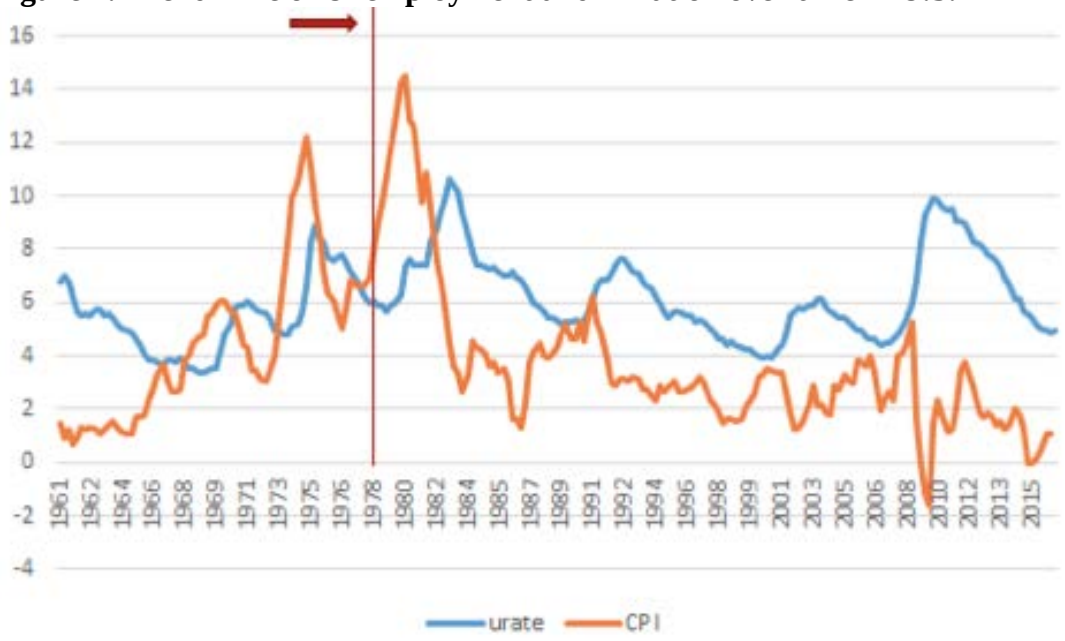


Figure 2: Trend Line of Unemployment and Inflation over time in Canada

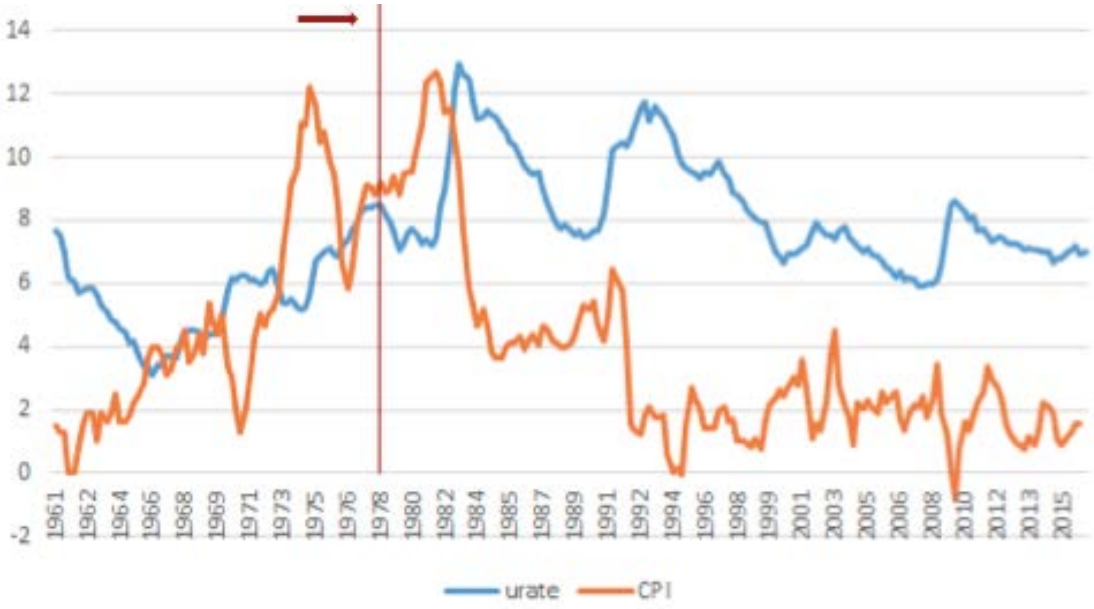


Figure 3: Trend Line of Unemployment and Inflation over time in Germany

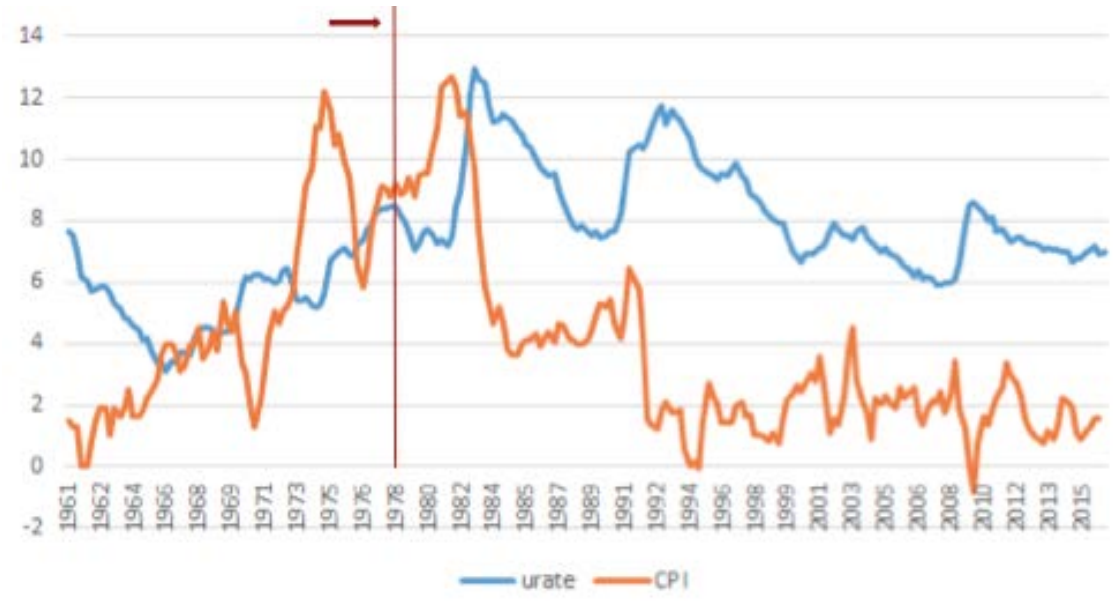


Figure 4: Parallel Trends Assumption Graph for U.S. and other countries

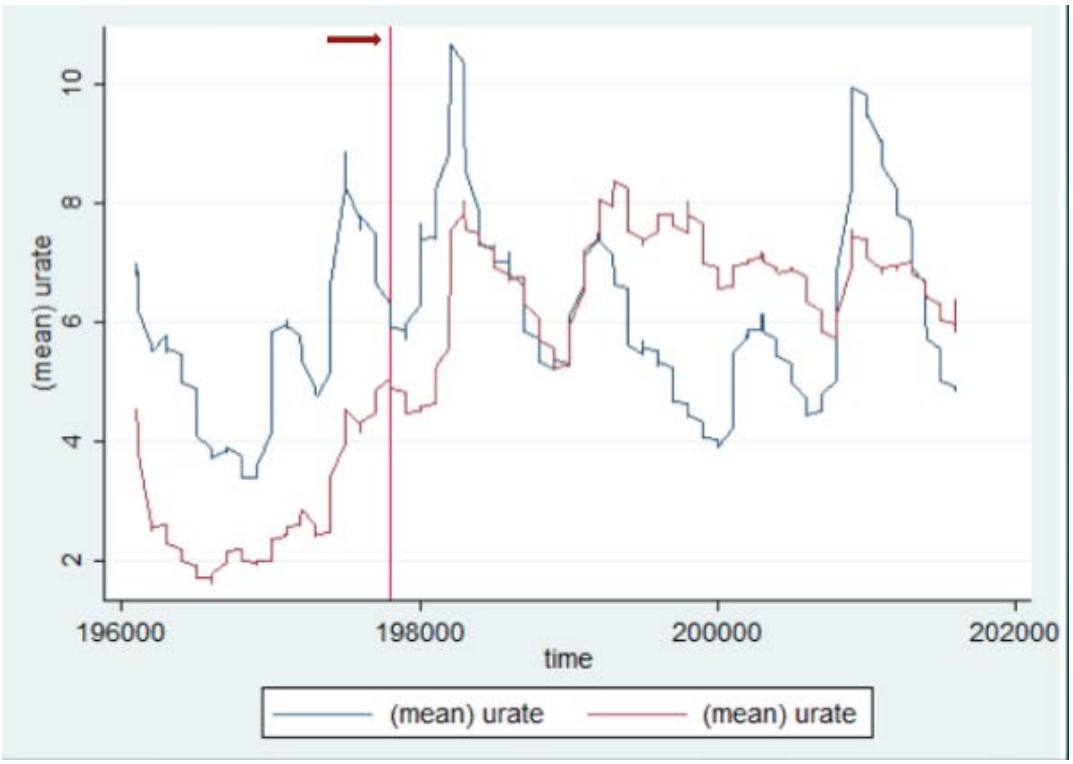


Figure 5: Unemployment Trend for All the Seven Countries

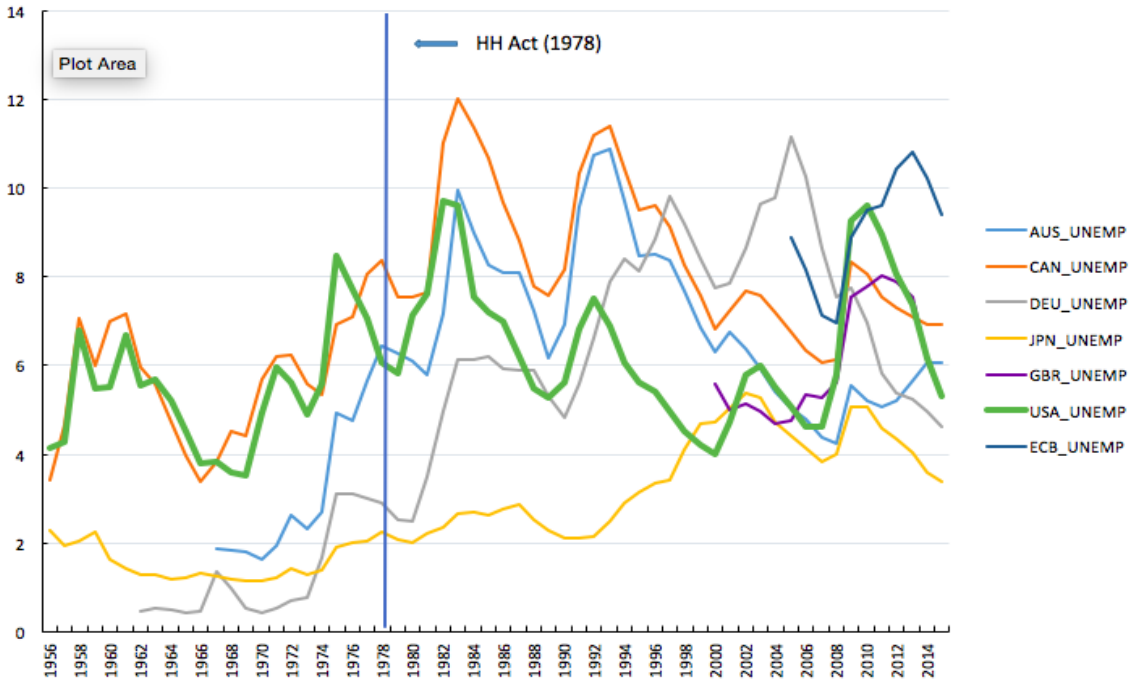


Figure 6: Unemployment Trend for US and Australia

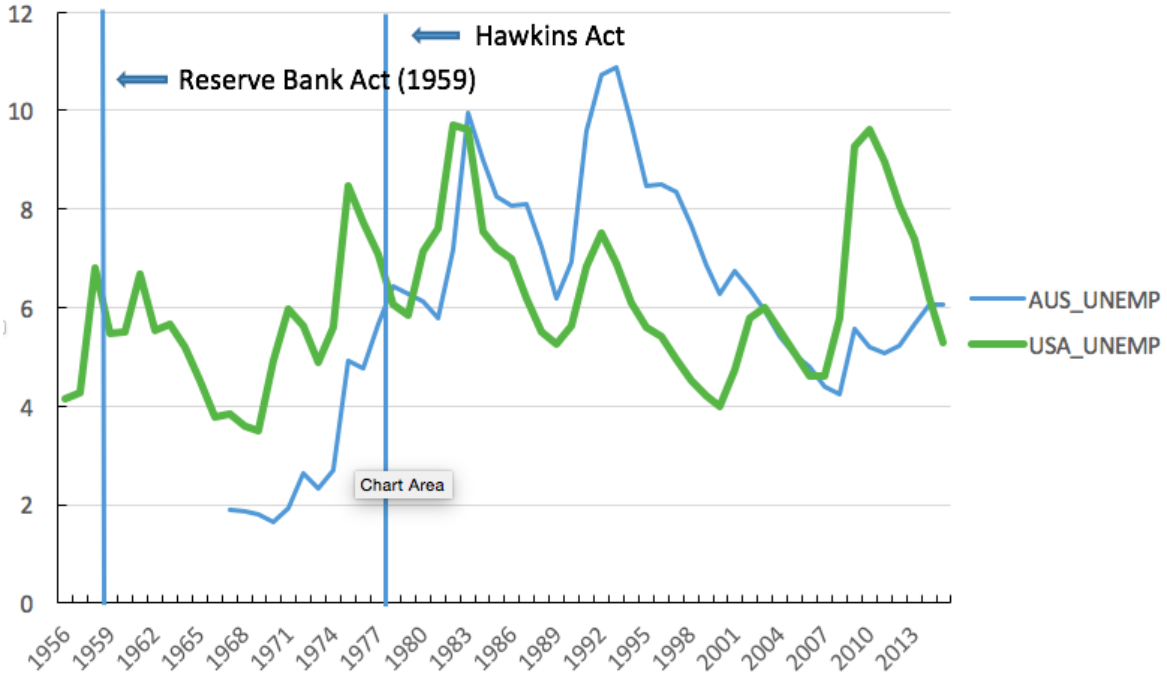


Figure 7: Predicted and Real Trend for the US

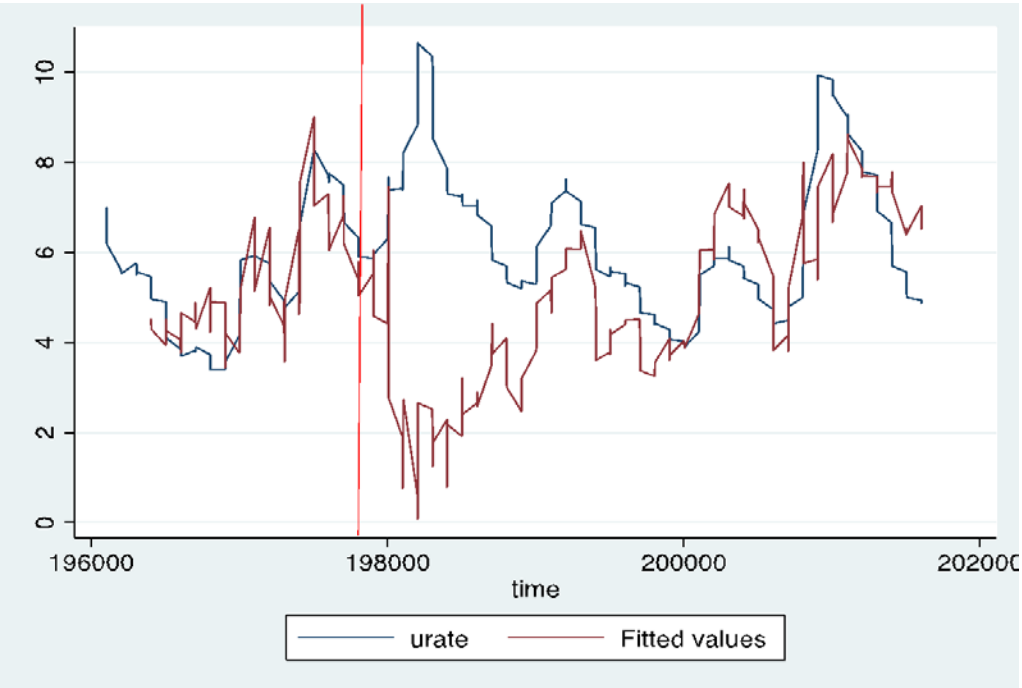


Figure 8: Predicted and Real Trend for Australia

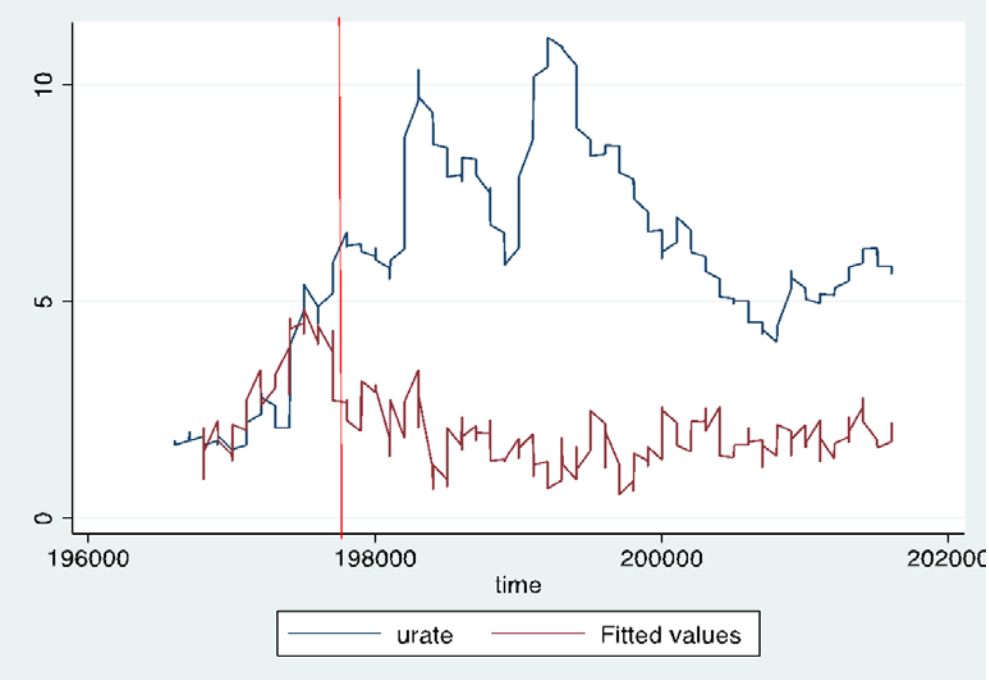


Figure 9: Predicted and Real Trend for Canada

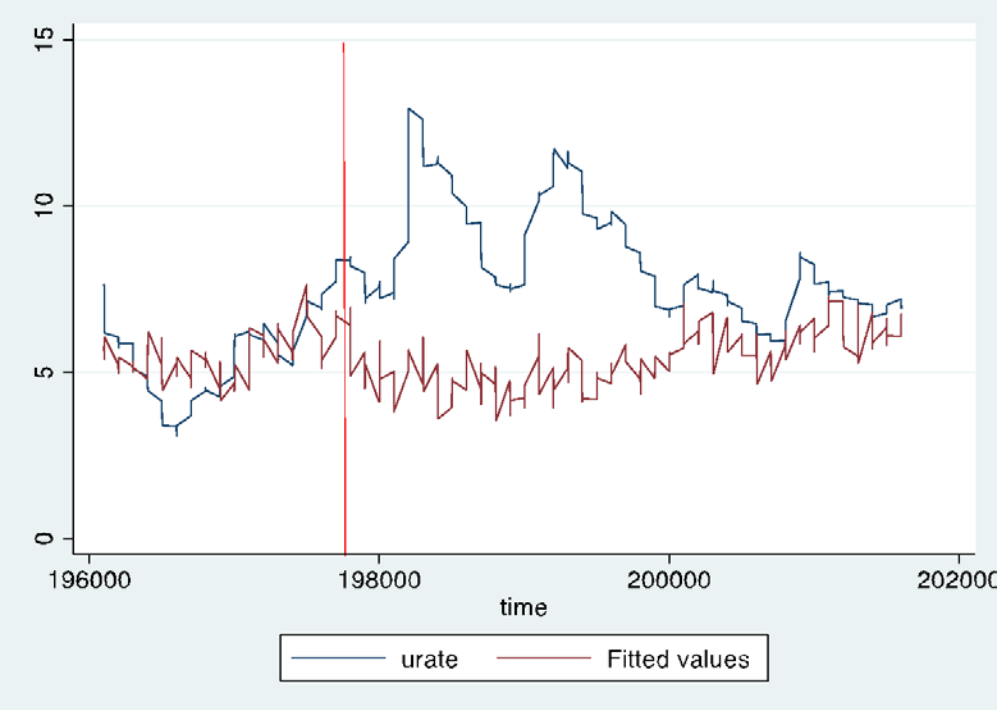


Figure 10: Predicted and Real Trend for Germany

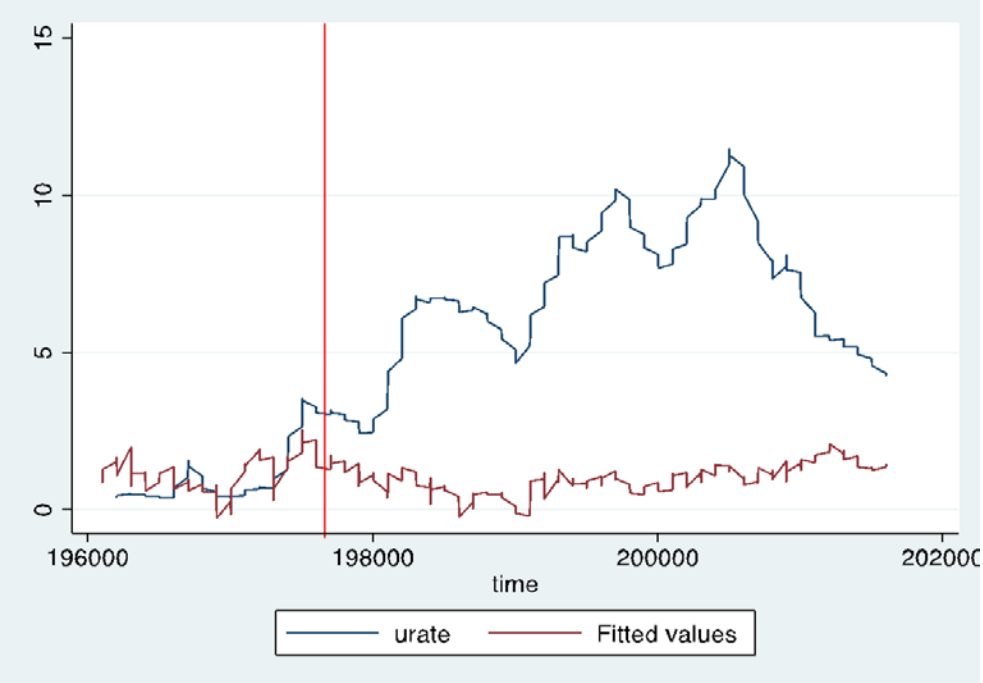


Figure 11: Predicted and Real Trend for Japan

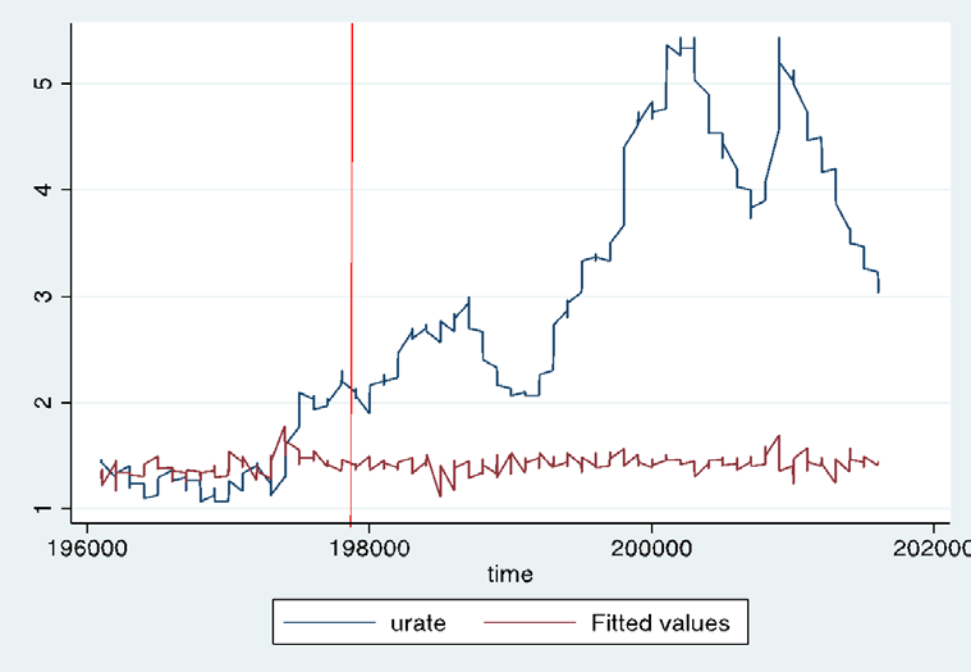
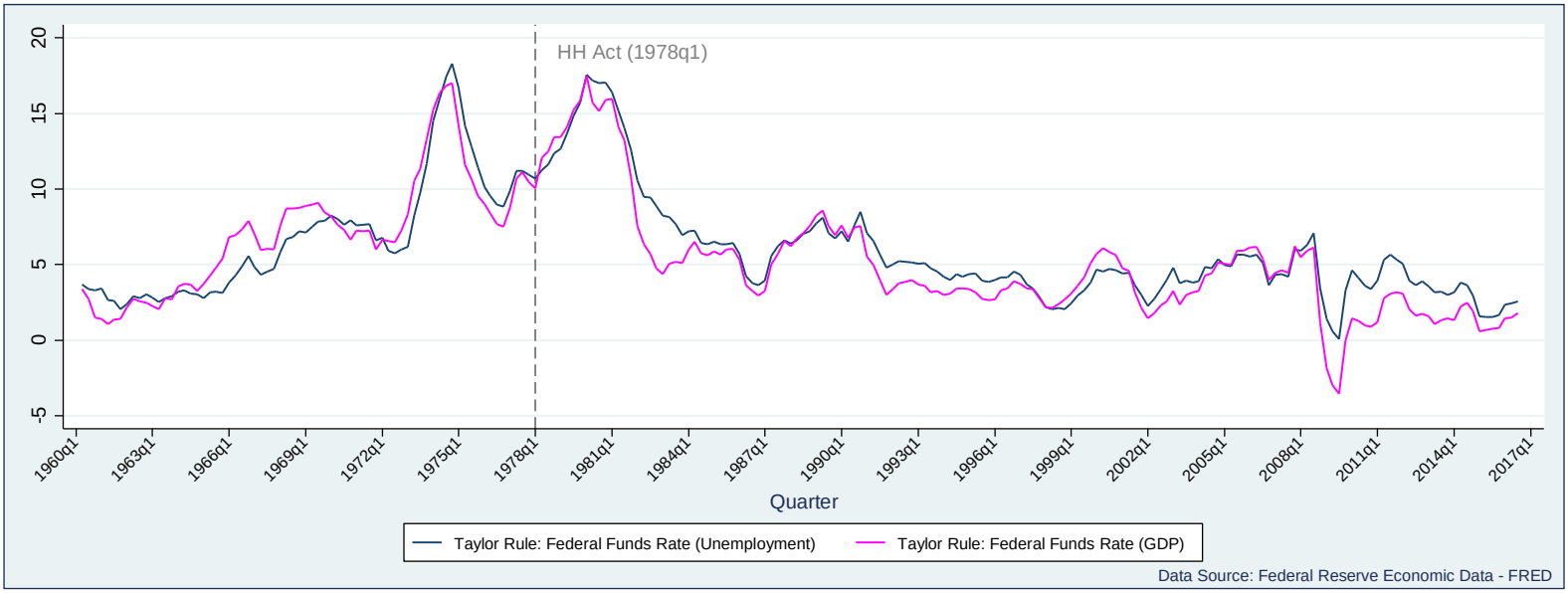
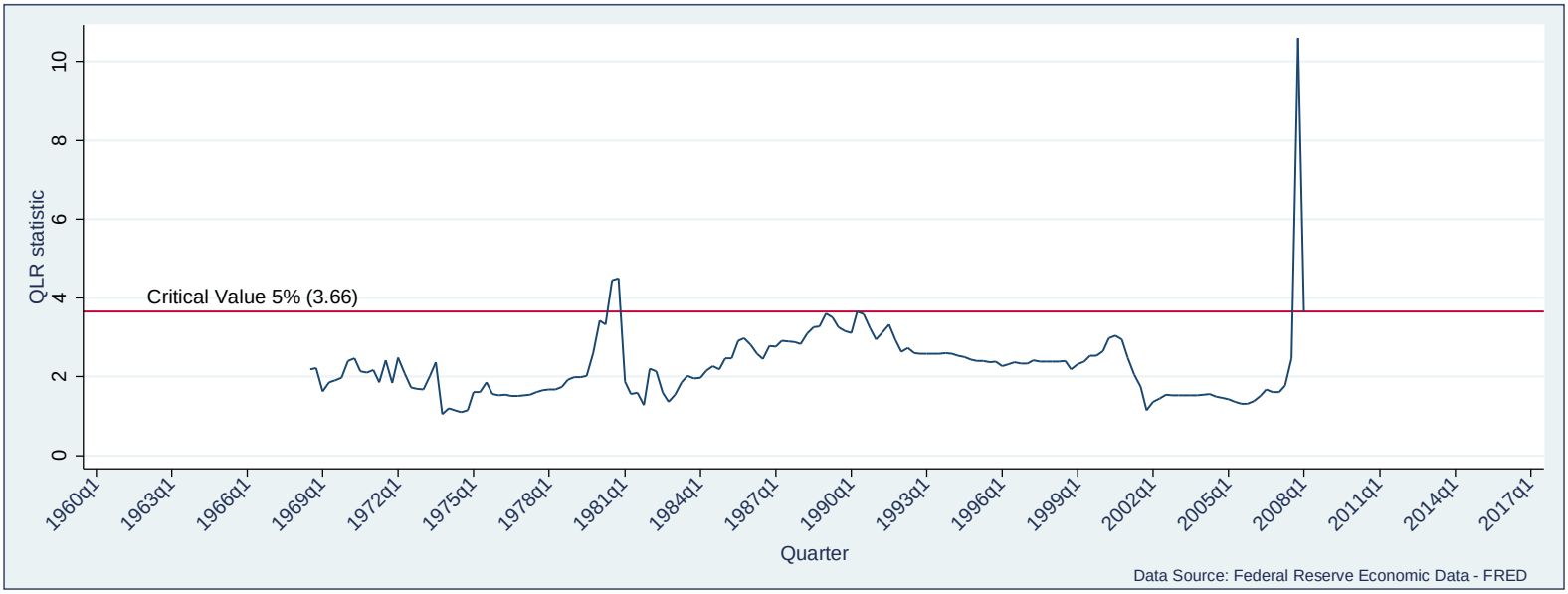


Figure 12. Taylor Rule: Output Gap and Unemployment Gap Comparison



Note: This graph suggests that the output and unemployment gap are comparable, which supports the Taylor Rule.

Figure 13. Testing for Breaks in the Federal Funds Rate (Quandt Likelihood Ratio Statistic)

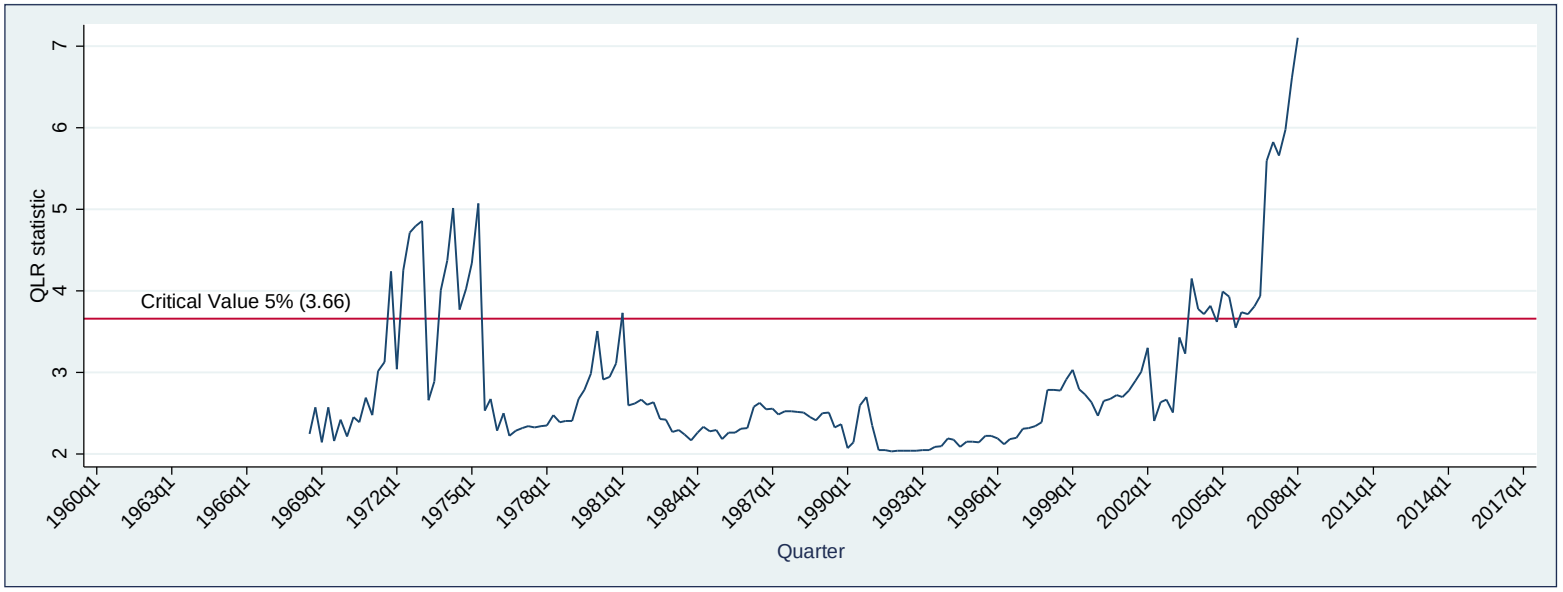


Note: This figure shows that there are structural breaks from the 3rd quarter of 1980 to the 1st quarter of 1981, but none in 1978.

Figure 14. Testing for Breaks in the Unemployment Rate (Quandt Likelihood Ratio Statistic)

Note: This figure shows that there are no structural breaks in the unemployment rate in 1978. (Data Source: FRED)

Figure 15. Testing for Breaks in the Unemployment Rate (Quandt Likelihood Ratio Statistic)



Note: This figure shows that there are no structural breaks in the unemployment rate in 1978. (Data Source: FRED)

Figure 16. Headline Inflation of Selected Countries (1961-2016)

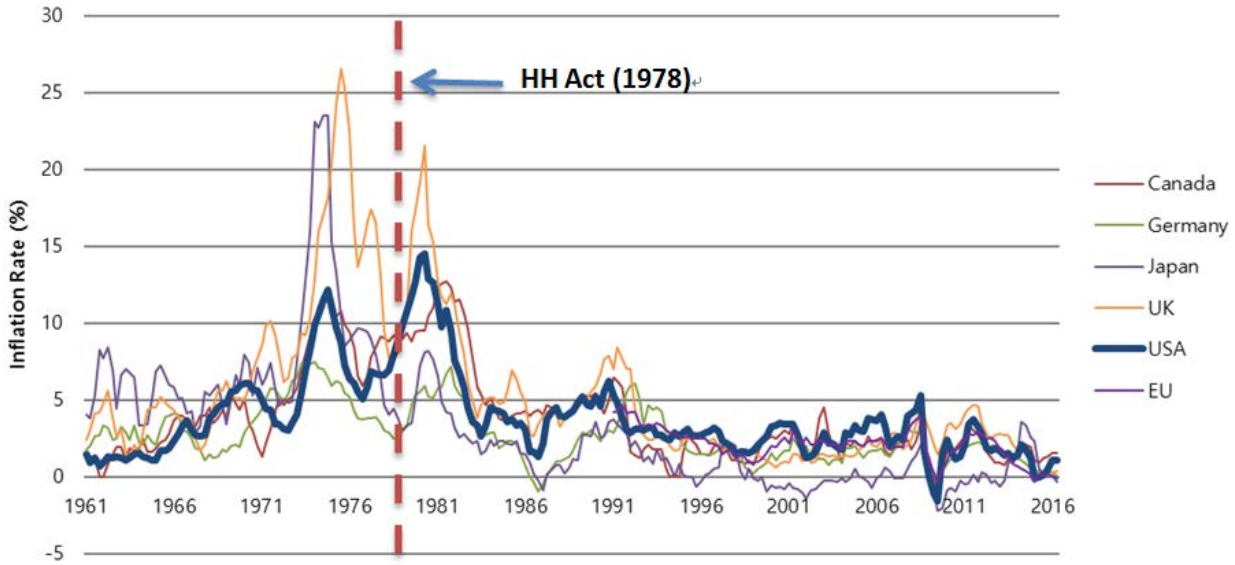


Figure 17. Headline Inflation of the US and Australia (1956-2016)

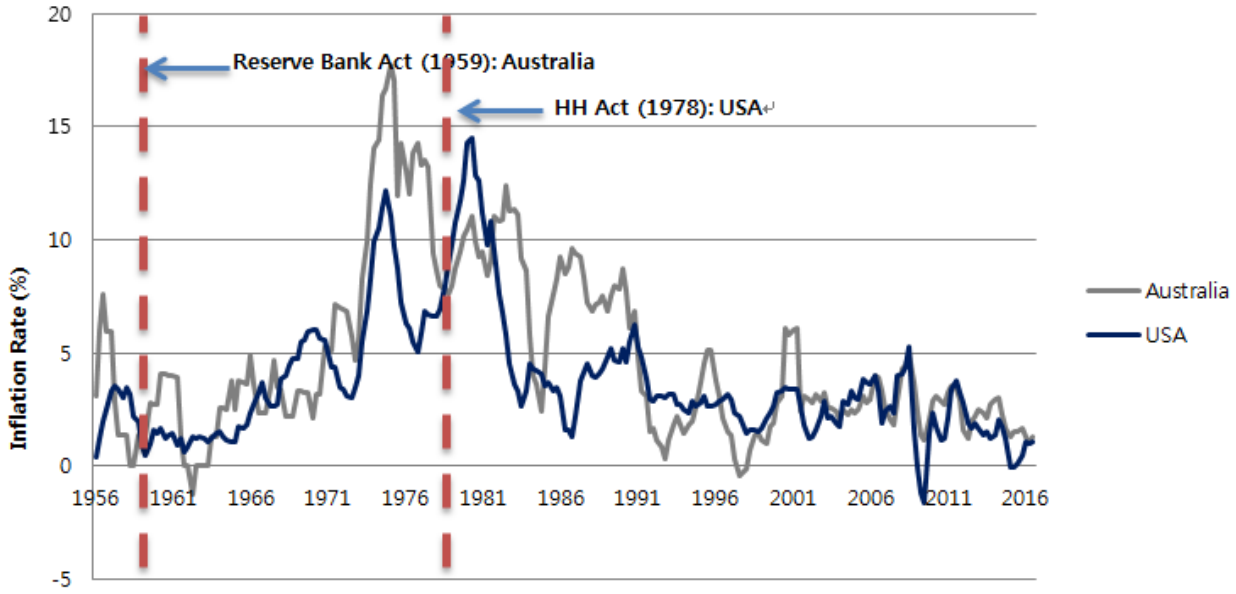
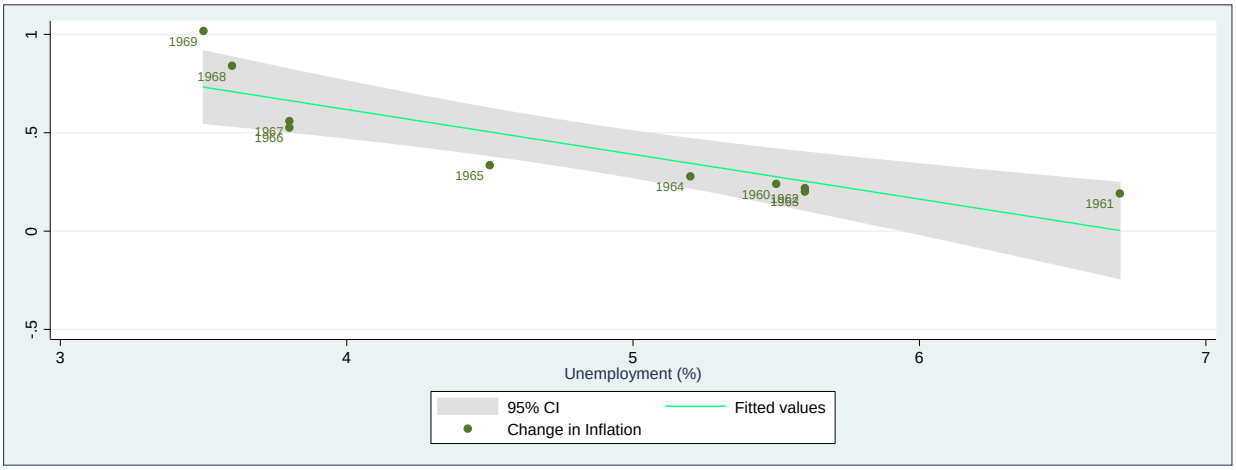
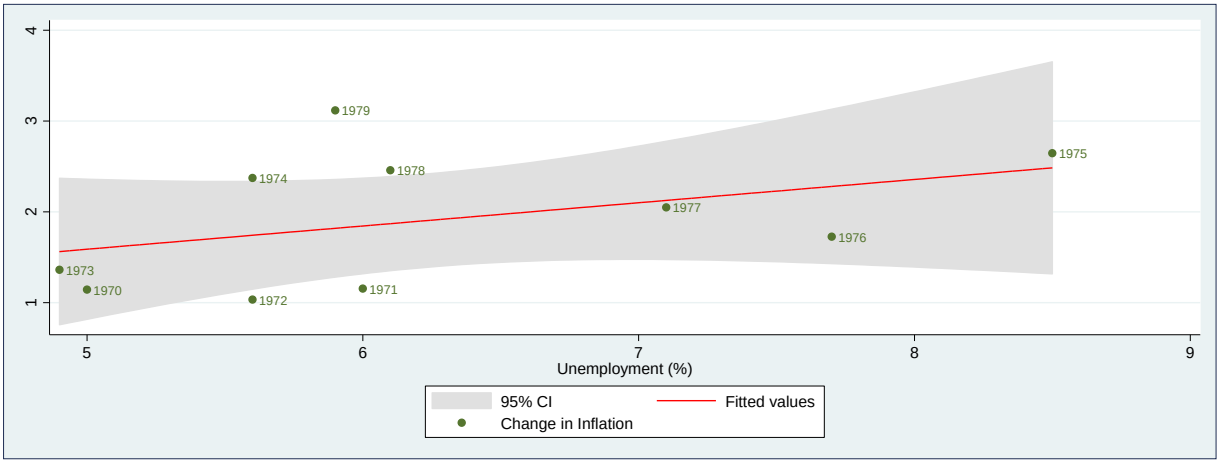


Figure 18. Phillips Curve: 1960 – 1970



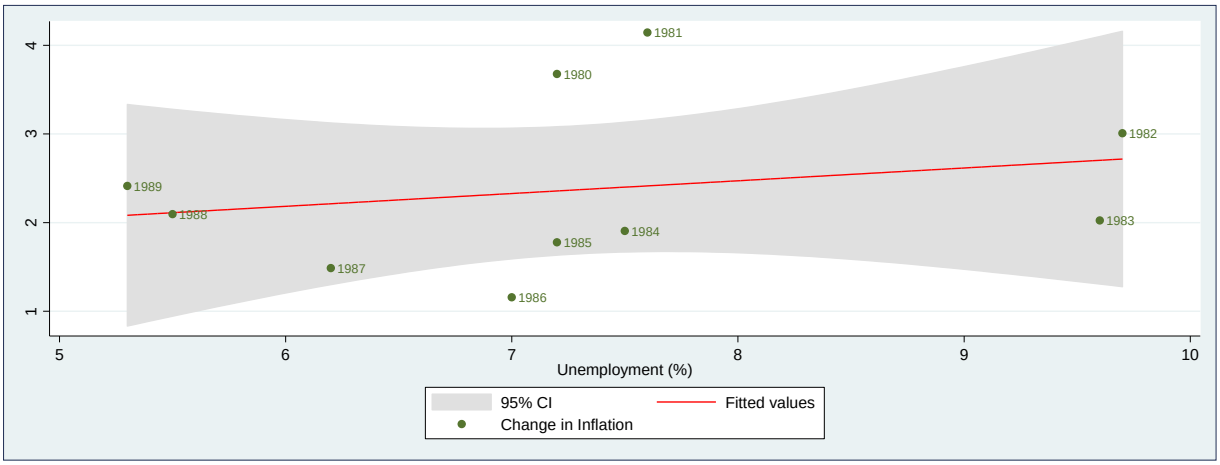
Note: This figure displays a relationship consistent with the Phillips Curve.

Figure 19. Phillips Curve: 1970 – 1980



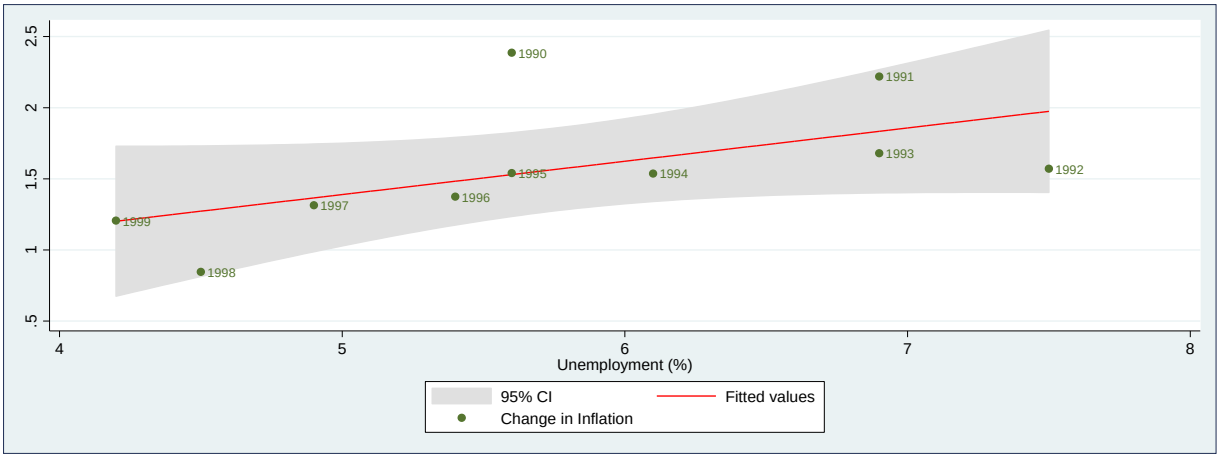
Note: This data does not appear to be consistent with the Phillips Curve.

Figure 20. Phillips Curve: 1980 – 1990



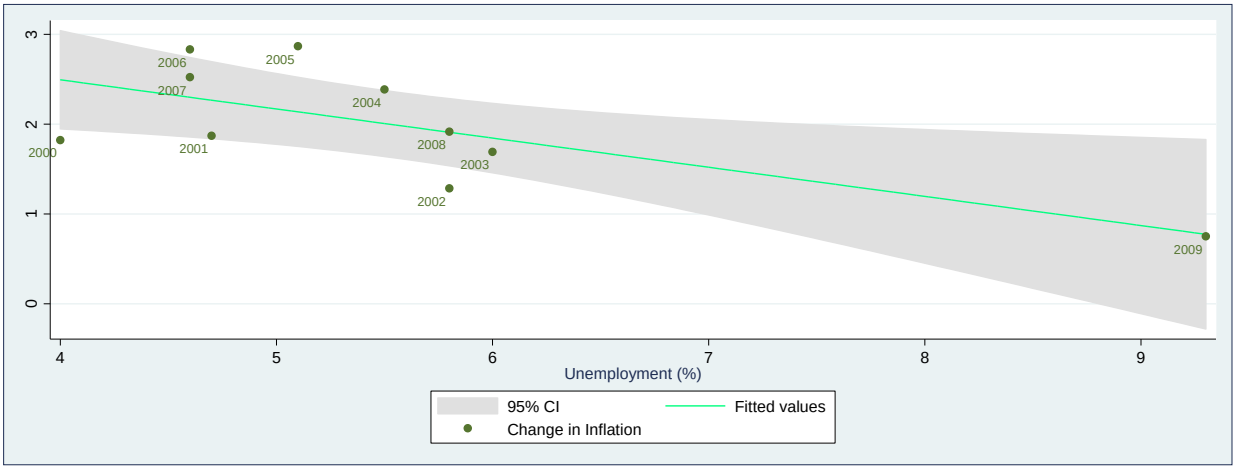
Note: This data does not appear to be consistent with the Phillips Curve.

Figure 21. Phillips Curve: 1990 – 2000



Note: This data does not appear to be consistent with the Phillips Curve.

Figure 22. Phillips Curve: 2000 – 2010

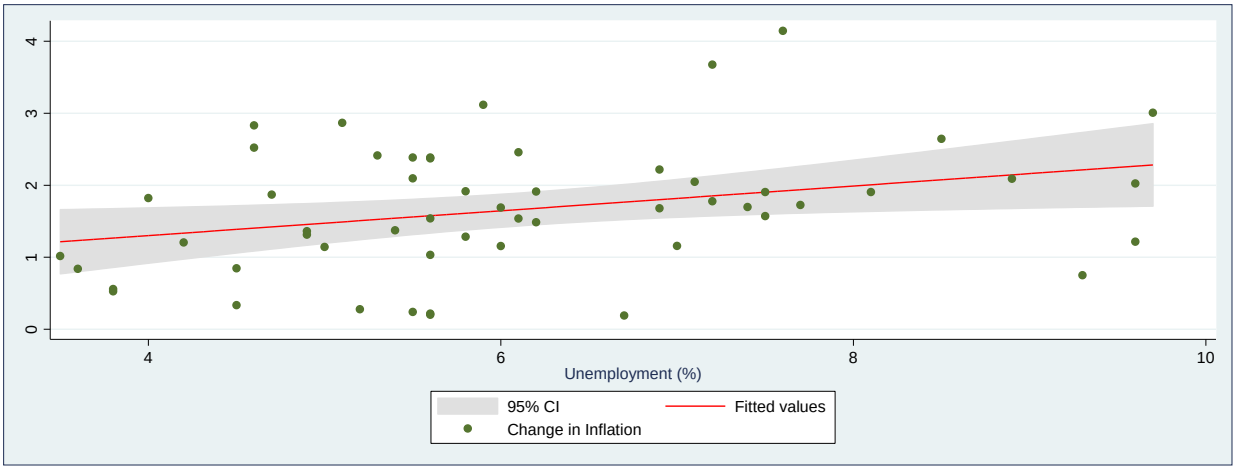


Note: This data appears, to an extent, to be consistent with the Phillips Curve.

Figure 23. Phillips Curve: 2010 – 2015

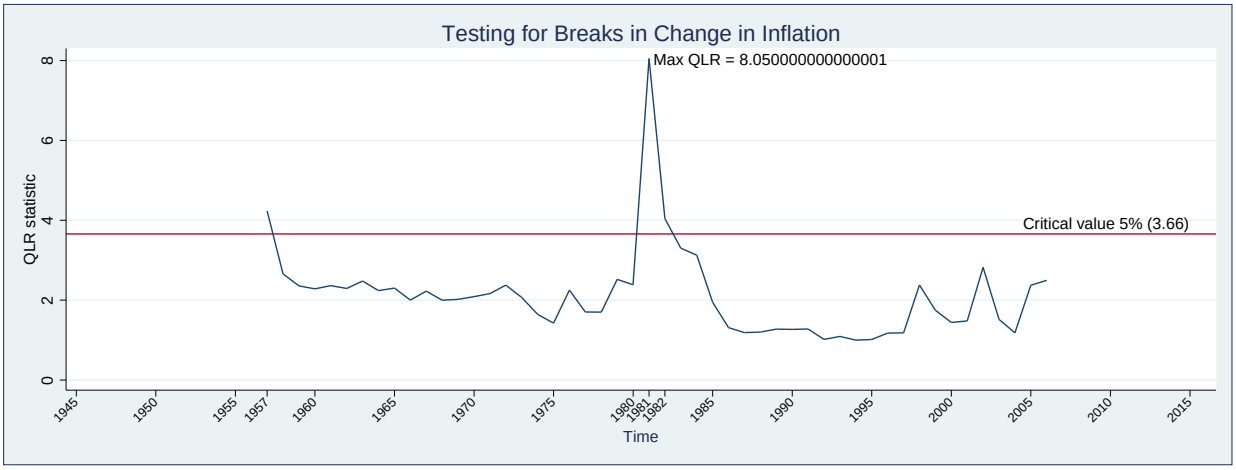
Note: This data appears, to an extent, to be consistent with the Phillips Curve.

Figure 24. Phillips Curve 1960 – 2015



Note: This data does not appear to be consistent with the Phillips Curve overall.

Figure 25. Phillips Curve 1955 – 2006: QLR Test



Note: The results of this QLR test suggests that the Phillips Curve experiences a structural break in 1981.

Appendix B: Tables

Table 1: Augmented Dickey-Fuller test for unit root on the U.S unemployment rate(lags12)

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       736

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
Z(t)             -3.028            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0323
```

Table 2: Augmented Dickey-Fuller test for unit root on the U.S CPI (lags12)

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       736

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
Z(t)             -2.081            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.2522
```

Table 3: Augmented Dickey-Fuller test for unit root on the U.S federal fund rates (lags12)

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       736

---------- Interpolated Dickey-Fuller ---------
Test         1% Critical       5% Critical      10% Critical
Statistic           Value             Value             Value
------------------------------------------------------------------------------
Z(t)             -2.062            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.2599
```

Table 4: Augmented Dickey-Fuller test for co-integration between the U.S federal fund rates and unemployment rate (lags12)

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       736

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
Z(t)             -3.080            -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0281
```

Table 5: Augmented Dickey-Fuller test for co-integration between the U.S federal fund rates and inflation rate (lags12)

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       736

                              ---------- Interpolated Dickey-Fuller ---------
                 Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
Z(t)             -2.772           -3.430            -2.860            -2.570
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0625
```

Table 6: Vector autoregression analysis on the U.S federal funds rate, inflation rate and unemployment rate (lags12)

1.	(1)	(2)	(3)
VARIABLES	Model 1	Model 1	Model 1
d.unrate = L,	0.0444	-0.553***	0.0150
	(0.0371)	(0.0938)	(0.0664)
d.unrate = L2,	0.183***	-0.0925	-0.0185
	(0.0378)	(0.0955)	(0.0676)
d.unrate = L3,	0.0977**	-0.148	-0.150**
	(0.0382)	(0.0967)	(0.0685)
d.unrate = L4,	0.122***	-0.127	-0.0232
	(0.0384)	(0.0970)	(0.0687)
d.unrate = L5,	0.111***	0.00150	-0.0657
	(0.0386)	(0.0977)	(0.0691)
d.unrate = L6,	0.0756*	0.162*	0.0883
	(0.0388)	(0.0982)	(0.0695)
d.unrate = L7,	0.00350	0.109	0.153**
	(0.0390)	(0.0986)	(0.0698)
d.unrate = L8,	0.0275	-0.123	0.0358
	(0.0388)	(0.0982)	(0.0695)
d.unrate = L9,	-0.0105	-0.183*	0.0897
	(0.0385)	(0.0974)	(0.0689)
d.unrate = L10,	-0.0484	-0.0712	-0.0563
	(0.0380)	(0.0961)	(0.0680)
d.unrate = L11,	0.0631*	0.0242	-0.179***
	(0.0371)	(0.0938)	(0.0664)
d.unrate = L12,	-0.138***	0.0846	0.0254
	(0.0372)	(0.0941)	(0.0666)
d.fedfunds = L,	-0.0150	0.355***	0.0689***
	(0.0148)	(0.0375)	(0.0265)
d.fedfunds = L2,	0.0111	-0.139***	0.0614**
	(0.0156)	(0.0395)	(0.0280)
d.fedfunds = L3,	-0.0247	-0.0209	0.0278
	(0.0158)	(0.0399)	(0.0282)
d.fedfunds = L4,	0.0248	-0.139***	-0.00672
	(0.0157)	(0.0398)	(0.0282)
d.fedfunds = L5,	0.0236	0.000878	0.0747***
	(0.0158)	(0.0399)	(0.0282)
d.fedfunds = L6,	-0.00400	0.00766	0.0375
	(0.0155)	(0.0391)	(0.0277)
d.fedfunds = L7,	0.0372**	-0.196***	0.0288
	(0.0155)	(0.0392)	(0.0277)
d.fedfunds = L8,	-0.0148	0.120***	0.0973***
	(0.0158)	(0.0399)	(0.0282)

d.fedfunds = L9,	0.0188	0.0810**	-0.0188
	(0.0158)	(0.0400)	(0.0283)
d.fedfunds = L10,	0.00653	-0.0385	0.0505*
	(0.0159)	(0.0401)	(0.0284)
d.fedfunds = L11,	0.0201	-0.115***	-0.0273
	(0.0157)	(0.0397)	(0.0281)
d.fedfunds = L12,	-0.0153	-0.0160	0.0793***
	(0.0147)	(0.0373)	(0.0264)
d.cpi = L,	0.0206	0.0518	0.229***
	(0.0182)	(0.0460)	(0.0326)
d.cpi = L2,	-0.0256	0.0136	0.0892***
	(0.0187)	(0.0472)	(0.0334)
d.cpi = L3,	0.00971	0.0147	-0.103***
	(0.0186)	(0.0470)	(0.0333)
d.cpi = L4,	0.0103	-0.0404	0.0390
	(0.0187)	(0.0473)	(0.0334)
d.cpi = L5,	-0.0198	0.0510	0.00453
	(0.0186)	(0.0471)	(0.0333)
d.cpi = L6,	0.0188	-0.0169	-0.000456
	(0.0186)	(0.0470)	(0.0332)
d.cpi = L7,	-0.0252	0.131***	0.0645*
	(0.0186)	(0.0470)	(0.0333)
d.cpi = L8,	0.0164	-0.0102	-0.0412
	(0.0186)	(0.0471)	(0.0333)
d.cpi = L9,	-0.0113	0.0154	0.0197
	(0.0186)	(0.0470)	(0.0333)
d.cpi = L10,	0.00437	0.0420	0.0882***
	(0.0185)	(0.0467)	(0.0331)
d.cpi = L11,	0.0232	0.00760	0.0792**
	(0.0183)	(0.0464)	(0.0328)
d.cpi = L12,	0.0276	0.0129	-0.452***
	(0.0177)	(0.0448)	(0.0317)
Constant	0.000479	-0.00156	0.000323
	(0.00621)	(0.0157)	(0.0111)
Observations	736	736	736

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

Table 7: Granger Wald causality test on the relationship between the U.S unemployment rate and federal funds rate/ inflation rate and federal funds rate/(1954m7-1978m3)

LM Test: Lag 6 (Prob> Chi 2 is 0.875) Ho: no autocorrelation at lag order
Null hypothesis: var 1 doesn't granger cause var 2

	observations	chi 2	prob
d.fedfund rate DOESN'T granger cause d.inflation	278	7.6767	0.263
d.inflation rate DOESN granger cause d.fedfundrate	278	26.8542	0
d. fedfund rate DOESN'T granger cause d.inflation	278	26.763	0
d.inflation rate DOESN'T grganger cause d.fedfundrate	278	10.32	0.112

Table 8: Granger Wald causality test on the relationship between the U.S unemployment rate and federal funds rate/ inflation rate and federal funds rate/1978m4-2006m1

LM Test: Lag 11 (Prob is 0.33440) Ho: no autocorrelation at lag order
Null hypothesis: var 1 doesn't granger cause var 2

	observations	chi 2	prob
d.fedfund rate DOESN'T granger cause d.inflation	114	21.235	0.059
d.inflation rate DOES granger cause d.fedfundrate	114	57.932	0
d. fedfund rate DOES grganger cause d.inflation	114	25.4	0.009
d.inflation rate DOES granger cause d.fedfundrate	114	16.329	0.0012

Table 9: Granger Wald causality test on the relationship between the U.S unemployment rate and federal funds rate/ inflation rate and federal funds rate (2006m2-2014m1)

LM Test: Lag 9 (Prob 0.62388) Ho: no autocorrelation at lag order
Null hypothesis: var 1 doesn't granger cause var 2

	observations	chi 2	prob
d.fedfund rate DOESN'T granger cause d.inflation	117	15.222	0.085
d.inflation rate DOES granger cause d.fedfundrate	117	33.815	0
d. fedfund rate DOES grganger cause d.inflation	117	4.5738	0.669
d.inflation rate DOES granger cause d.fedfundrate	117	10.99	0.276

Table 10: TTest Result of Post 1978 trend US

```
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   y_hat |     141    5.053979    .1663072    1.974788     4.72518    5.382777
   urate |     141    6.451773    .1337192    1.587828    6.187403    6.716143
---------+--------------------------------------------------------------------
    diff |     141   -1.397794    .2124771    2.523026   -1.817873   -.9777157
------------------------------------------------------------------------------
     mean(diff) = mean(y_hat - urate)                              t =  -6.5786
 Ho: mean(diff) = 0                         degrees of freedom =       140

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

Table 11: TTest Result of Post 1978 trend Australia

```
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   y_hat |     134    1.795212    .0505012    .5845938    1.695322    1.895101
   urate |     134    7.030962    .1553691    1.798528    6.723647    7.338276
---------+--------------------------------------------------------------------
    diff |     134    -5.23575    .1767003    2.045454   -5.585256   -4.886244
------------------------------------------------------------------------------
     mean(diff) = mean(y_hat - urate)                              t = -29.6307
 Ho: mean(diff) = 0                         degrees of freedom =       133

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

Table 12: TTest Result of Post 1978 trend Canada

```
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   y_hat |     152    5.387593    .0704426    .8684747    5.248412    5.526773
   urate |     152    8.376096    .1351614    1.666381    8.109045    8.643148
---------+--------------------------------------------------------------------
    diff |     152   -2.988504    .1729025    2.131685   -3.330124   -2.646883
------------------------------------------------------------------------------
     mean(diff) = mean(y_hat - urate)                              t = -17.2843
 Ho: mean(diff) = 0                         degrees of freedom =       151

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

Table 13: TTest Result of Post 1978 trend Germany

```
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   y_hat |     149    .9729726    .0366687    .4475986    .9005107    1.045434
   urate |     149     6.94112     .180299     2.20083    6.584827    7.297412
---------+--------------------------------------------------------------------
    diff |     149   -5.968147    .1847981    2.255748   -6.333331   -5.602963
------------------------------------------------------------------------------
     mean(diff) = mean(y_hat - urate)                              t = -32.2955
 Ho: mean(diff) = 0                         degrees of freedom =      148

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

Table 14: TTest Result of Post 1978 trend Japan

```
Paired t test
------------------------------------------------------------------------------
Variable |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
   y_hat |     152     1.42668    .0062427    .0769647    1.414346    1.439014
   urate |     152     3.43136     .086855     1.07082    3.259752    3.602968
---------+--------------------------------------------------------------------
    diff |     152   -2.004679     .086183    1.062535    -2.17496   -1.834399
------------------------------------------------------------------------------
     mean(diff) = mean(y_hat - urate)                              t = -23.2607
 Ho: mean(diff) = 0                         degrees of freedom =      151

 Ha: mean(diff) < 0           Ha: mean(diff) != 0           Ha: mean(diff) > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```

Table 15: Regression Results for Time Series Dynamic Model for Unemployment Rate

	Before	After		Before	After		Before	After
urate_lag	-0.0140	0.0120	INT	-0.610***	-0.176***	GDP_lag	0.0193	0.358*
	(0.0698)	(0.0869)		(0.102)	(0.0629)		(0.114)	(0.194)
AUS	-0.0321	0.0188	AUS	0.475***	0.340***	AUS	0.0581	-0.280
	(0.0977)	(0.111)		(0.125)	(0.0792)		(0.168)	(0.244)
CAN	0.219**	0.0727	CAN	0.266*	0.297***	CAN	-0.0104	0.0609
	(0.0856)	(0.113)		(0.137)	(0.0770)		(0.182)	(0.243)
DEU	0.0228	-0.0918	DEU	0.398***	-0.0415	DEU	0.0255	-0.268
	(0.0797)	(0.0990)		(0.114)	(0.0978)		(0.146)	(0.236)
JPN		-2.746	JPN		4.495	JPN		-1.442
		(5.909)			(11.79)			(2.558)
GBR		0.664	GBR		-0.294	GBR		-0.265
		(0.649)			(0.220)			(0.962)
ECB		0.319	ECB		-0.705***	ECB		-0.0687
		(0.574)			(0.262)			(0.455)
cpi	0.335***	0.0266	INT_lag	0.00355	0.0108	Observations	217	635
	(0.0754)	(0.0786)		(0.0521)	(0.0619)	R-squared	0.893	0.427
AUS	-0.190**	-0.380***	AUS	0.0510	-0.0494			
	(0.0835)	(0.112)		(0.0674)	(0.0797)			
CAN	-0.321***	-0.292***	CAN	-0.118*	0.00458			
	(0.0908)	(0.111)		(0.0701)	(0.0827)			
DEU	-0.342***	-0.534***	DEU	-0.0647	0.241**			
	(0.103)	(0.169)		(0.0764)	(0.0945)			
JPN		-1.839	JPN		-3.216			
		(3.717)			(8.133)			
GBR		0.553	GBR		0.165			
		(0.566)			(0.210)			
ECB		0.190	ECB		0.181			
		(0.421)			(0.496)			
cpi_lag	0.0167	0.0325	GDP	-0.107	-0.292			
	(0.0581)	(0.0844)		(0.149)	(0.187)			
AUS	-0.0351	-0.0206	AUS	0.0345	0.370			
	(0.0709)	(0.101)		(0.176)	(0.256)			
CAN	0.115	-0.0345	CAN	-0.0420	0.341			
	(0.0811)	(0.108)		(0.182)	(0.257)			
DEU	0.0562	-0.444***	DEU	-5.98e-05	-0.0144			
	(0.117)	(0.148)		(0.169)	(0.234)			
JPN		-1.610	JPN		-0.0234			
		(3.664)			(1.021)			
GBR		-0.377	GBR		0.0457			
		(0.475)			(0.815)			
ECB		-0.319	ECB		-0.0560			
		(0.520)			(0.684)			

(Standard Errors in Parenthesis. ***p<0.001, **p<0.05, *<0.1)

Table 16. Philips Curve – Chow Test Break Point

```
. reg change_inflation L(1/4).change_inflation L(1/4).unrate

      Source |       SS           df       MS      Number of obs   =       268
-------------+----------------------------------   F(8, 259)       =     90.33
       Model |  12.5339951         8  1.56674939   Prob > F        =    0.0000
    Residual |  4.49219426       259  .017344379   R-squared       =    0.7362
-------------+----------------------------------   Adj R-squared   =    0.7280
       Total |  17.0261894       267    .0637685   Root MSE        =     .1317
------------------------------------------------------------------------------
change_inflation |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------+------------------------------------------------------------
change_inflation |
             L1. |   .4248783    .061029     6.96   0.000      .304702    .5450545
             L2. |   .1780575   .0668078     2.67   0.008     .0465019    .3096132
             L3. |   .1591192   .0673996     2.36   0.019     .0263981    .2918402
             L4. |   .1722245    .062789     2.74   0.007     .0485825    .2958665
                 |
          unrate |
             L1. |  -.0495424    .028772    -1.72   0.086    -.1061993    .0071145
             L2. |     .00511   .0547796     0.09   0.926    -.1027601      .11298
             L3. |   .0814727   .0544511     1.50   0.136    -.0257505    .1886959
             L4. |  -.0396331   .0279053    -1.42   0.157    -.0945833    .0153171
                 |
           _cons |   .0412421    .031917     1.29   0.197    -.0216077    .1040919
------------------------------------------------------------------------------

. test L1.unrate L2.unrate L3.unrate L4.unrate

 ( 1)  L.unrate = 0
 ( 2)  L2.unrate = 0
 ( 3)  L3.unrate = 0
 ( 4)  L4.unrate = 0

       F(  4,   259) =    2.71
            Prob > F =    0.0304

. test L1.change_inflation L2.change_inflation L3.change_inflation L4.change_inflation

 ( 1)  L.change_inflation = 0
 ( 2)  L2.change_inflation = 0
 ( 3)  L3.change_inflation = 0
 ( 4)  L4.change_inflation = 0

       F(  4,   259) =  151.99
            Prob > F =    0.0000

. estat sbknown, break(tq(1978q1))

Wald test for a structural break: Known break date
                                  Number of obs  =        268
Sample:      1949q4 - 2016q3
Break date:  1978q1
Ho: No structural break
             chi2(9)      =   19.7128
             Prob > chi2  =    0.0198

Exogenous variables:           L.change_inflation L2.change_inflation
L3.change_inflation L4.change_inflation L.unrate L2.unrate L3.unrate L4.unrate
Coefficients included in test: L.change_inflation L2.change_inflation
L3.change_inflation L4.change_inflation L.unrate L2.unrate L3.unrate L4.unrate _cons
```

Table 17. Philips Curve – Chow Test Break Point Unknown

```
. estat sbsingle
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
..................................................    50
..................................................   100
..................................................   150
................................

Test for a structural break: Unknown break date

                            Number of obs =       268

Full sample:                1949q4 - 2016q3
Trimmed sample:             1960q1 - 2006q3
Estimated break date:       1999q4
Ho: No structural break

     Test            Statistic          p-value
-----------------------------------------------
     swald            62.8115           0.0000
-----------------------------------------------
Exogenous variables:           L.change_inflation L2.change_inflation
L3.change_inflation L4.change_inflation L.unrate L2.unrate L3.unrate L4.unrate
Coefficients included in test: L.change_inflation L2.change_inflation
L3.change_inflation L4.change_inflation L.unrate L2.unrate L3.unrate L4.unrate _cons
```

Findings

These results in combination suggest that there is not a break in 1978. The overall significance of unemployment and inflation remains intact. Additional analysis confirms that the Philips Curve does experience flattening over time with a break occurring in 1981.

Table 18: Chow Tests - Known Break

```
. reg fedfunds part1 pcepi_ch1 unemployment_percent_dev1 inflation_dev1 part2
unemployment_percent_dev2 inflation_dev2, noconstant

      Source |       SS           df       MS      Number of obs   =       225
-------------+----------------------------------   F(7, 218)       =    367.00
       Model |   8387.1767         7   1198.1681   Prob > F        =    0.0000
    Residual |   711.72502       218  3.26479367   R-squared       =    0.9218
-------------+----------------------------------   Adj R-squared   =    0.9193
       Total |  9098.90172       225  40.4395632   Root MSE        =    1.8069

------------------------------------------------------------------------------
-----
                fedfunds |      Coef.   Std. Err.      t    P>|t|     [95% Conf.
Interval]
-------------------------+----------------------------------------------------
-----
                   part1 |   7.238378   .5470956    13.23   0.000     6.160104
8.316652
                pcepi_ch1 |  -1.866554   .3156606    -5.91   0.000    -2.488692   -
1.244417
unemployment_percent_dev1 |  -3.221357   .5289303    -6.09   0.000    -4.263829   -
2.178885
          inflation_dev1 |    2.09277   .1268429    16.50   0.000     1.842775
2.342765
                   part2 |   4.221418   .3203152    13.18   0.000     3.590107
4.852729
unemployment_percent_dev2 |  -4.294162   .9918307    -4.33   0.000    -6.248967   -
2.339357
          inflation_dev2 |   1.323863   .1221637    10.84   0.000      1.08309
1.564637
------------------------------------------------------------------------------
-----

. * F-Tests
. test _b[unemployment_percent_dev1]=_b[unemployment_percent_dev2], notest

 ( 1)  unemployment_percent_dev1 - unemployment_percent_dev2 = 0

. test _b[inflation_dev1]=_b[inflation_dev2], notest accum

 ( 1)  unemployment_percent_dev1 - unemployment_percent_dev2 = 0
 ( 2)  inflation_dev1 - inflation_dev2 = 0

. test _b[part1]=_b[part2], accum

 ( 1)  unemployment_percent_dev1 - unemployment_percent_dev2 = 0
 ( 2)  inflation_dev1 - inflation_dev2 = 0
 ( 3)  part1 - part2 = 0

       F(  3,   218) =   41.54
       Prob > F =    0.0000

Findings:
The null hypothesis is no break. If the p-value is < 0.05 reject the null in
favor of the alternative that there is a break. In this example, we fail to
reject the null and conclude that the HH-Act does not cause a break in the
regression coefficients.
```

Table 19. Wald test for a structural break: Known break date

```
. estat sbknown, break(tq(1978q1))

                                  Number of obs  =        225
Sample:      1960q3 - 2016q3
Break date:  1978q1
Ho: No structural break

             chi2(3)      =   82.5611
             Prob > chi2  =    0.0000

Exogenous variables:           unemployment_percent_dev inflation_dev
Coefficients included in test: unemployment_percent_dev inflation_dev _cons


Chow Test - Unknown Break


. estat sbsingle
----+--- 1 ---+--- 2 ---+--- 3 ---+--- 4 ---+--- 5
.................................................    50
.................................................   100
.................................................   150
.......

Test for a structural break: Unknown break date

                             Number of obs =        225

Full sample:                 1960q3 - 2016q3
Trimmed sample:              1969q1 - 2008q2
Estimated break date:        2008q2
Ho: No structural break

     Test            Statistic          p-value
-------------------------------------------------
     swald           233.8123           0.0000
-------------------------------------------------
Exogenous variables:           unemployment_percent_dev inflation_dev
Coefficients included in test: unemployment_percent_dev inflation_dev _cons
```

Table 20. Quandt Likelihood Ratio – Algorithm STATA

```
The Quandt Likelihood Ratio statistic is the maximal Chow statistic

The QLR test statistic is the maximum of all the Chow F-statistics, over a
a range of tau, tau0 <= tau <= tau1: QLR = max[F(tau0),F(tau0+1)...F(tau1-1)

tset quarterly
sum quarterly
local time=r(max)-r(min)+1
local i = round(`time'*.15)
local f = round(`time'*.85)
local var = "VARIABLE OF INTEREST"
gen diff`var' = d.`var'
gen chow`var' = .
gen qlr`var' = .
set more off
while `i'<=(`f') {
 gen di = (_n > `i')
 cap gen d_`var'1 = di*l1.`var'
 cap gen d_`var'2 = di*l2.`var'
 cap gen d_`var'3 = di*l3.`var'
 cap gen d_`var'4 = di*l4.`var'
 qui reg diff`var' L(1/4).diff`var' di, r
 qui test di
 sca chow = r(F)
 cap replace chow`var' = r(F) in `i'
 qui reg diff`var' L(1/4).diff`var' di d_`var'1 d_`var'2 d_`var'3 d_`var'4, r
 qui test di d_`var'1 d_`var'2 d_`var'3 d_`var'4
 sca qlr = r(F)
 cap replace qlr`var' = r(F) in `i'
 dis "`i' " %tq quarterly[`i'] " " %8.3f chow " " %8.3f qlr
 drop di d_`var'1 d_`var'2 d_`var'3 d_`var'4
 local i = `i' + 1
 }
************************************
sum qlr`var'
local maxvalue=r(max)
gen maxdate=quarterly if qlr`var'==`maxvalue'
local maxvalue1=round(`maxvalue',0.01)
local critical=3.66 /*Replace with the appropriate critical value (see Stock &
Watson)*/
sum quarterly
local mindate=r(min)
sum maxdate
local maxdate=r(max)
gen breakr=quarterly if qlr`var'>=`critical' & qlr`var'!=.
dis "Below are the break dates..."
list quarterly qlr`var' if breakr!=.
levelsof breakr, local(break1)
twoway tsline qlr`var' , title(Testing for breaks in Federal Funds Rate (1960Q3-
Present)) ///
xlabel(`break1', angle(90) labsize(0.9) alternate) ///
yline(`critical') ytitle(QLR statistic) xtitle(Quarter) ///
ttext(`critical' `mindate' "Critical value 5% (`critical')", placement(ne)) ///
ttext(`maxvalue' `maxdate' "Max QLR = `maxvalue1'", placement(e))
```
[45]

[45] Code Source: Torres-Reyna, O.“Time Series 101,” accessed from http://www.princeton.edu/~otorres/#11

Table 21. Difference-in-Difference output

Urate	OLS	OLS W/CONTROLS	FE
D	**2.689*** **	**2.092*** **	
	(0.313)	(0.324)	
after	**3.944*** **	**4.361*** **	
	(0.168)	(0.204)	
D_after	**-3.016*** **	**-3.194*** **	**0.749** **
	(0.372)	(0.377)	(0.337)
CPI		**-0.235*** **	**-0.259*** **
		(0.0836)	(0.0878)
PCE		**0.411*** **	**0.0857**
		(0.0875)	(0.0907)
GDP		**0.0799**	**-0.304*** **
		(0.0713)	(0.0735)
INT		**-0.0470***	**0.0681** **
		(0.0259)	(0.0273)
Constant	**2.753*** **	2.654***	6.778***
	(0.146)	(0.224)	(0.148)
Observations	1,231	1,021	1,021
R-squared	0.316	0.330	0.051

Table 22. Phillips Curve times series output

Urate	PRE	POST	PRE	POST
CPI_1	0.0422	0.0209	0.755***	0.228
	(0.0746)	(0.0415)	(0.236)	(0.177)
urate_1	0.911***	0.987***		
	(0.0432)	(0.0190)		
CPI	-0.00771	-0.0359	0.122	0.590***
	(0.0990)	(0.0431)	(0.235)	(0.169)
PCE	0.0647	0.0402	-0.249*	0.737***
	(0.0400)	(0.0375)	(0.144)	(0.159)
GDP	-0.137***	0.252	0.0862	0.0786
	(0.05568)	(0.0426)	(0.148)	(0.172)
INT	-0.0520	-0.00358	0.700***	0.194**
	(0.0683)	(0.0131)	(0.125)	(0.0592)
Constant	0.428	0.179	6.361***	5.949
	(0.413)	(0.117)	(0.090)	(0.243)
Observations	41	115	54	153
R-squared	0.985	0.979	0.746	0.171

Table 23. Time Series Dynamic Model Result for Price Stability

Variable	Model 1		Model 2		Model 3		Model 4		Model 5	
	Before	After	Before	After	Before	After	Before	After	Before	After
CPI_{lag}	.9130	.9369	.7356	.9297	.8830	.9486	.7285	.9629	.7224	.9565
	(.0585)***	(.0217)***	(.0706)***	(.0319)***	(.0745)***	(.0213)***	(.1103)	(.0297)***	(.1236)***	(.0311)***
Australia	.0184	.0470	.0763	-.0623	.1035	-.0102	.2337	-.1514	.1891	-.1225
	(.0607)	(.1392)	(.0777)	(.0443)	(.0913)	(.0258)	(.1235)	(.04333)***	(1380)	(.0440)**
Canada	.0079	-.0257	.2023	-.0186	.0046	-.0054	.1899	-.0825	.1745	-.0754
	(.0707)	(.1313)	(.0885)*	(.0452)	(.0817)	(.0264)	(.1264)	(.0434)	(.1408)	(.0440)
Germany	-.0397	-.0376	.0937	-.0666	-.0094	-.0423	.1634	-.4070	.1554	-.0848
	(.0096)	(.1383)	(.0977)	(.0675)	(.1151)	(.0441)	(.1394)	(.3393)	(.1526)	(.0658)
Japan	-.0250	-.1024		-.1136	.0314	-.0894		.6604		-.1696
	(.0632)	(.1184)		(.0904)	(.0773)	(.0452)		(.9129)		(.1093)
UK	.0281	.0003		-.0028		-.0626		-.4034		-.0941
	(.0590)	(.1285)		(.0385)		(.1082)		(.8227)		(.1139)
EU	N/A	.0465		-.0506		.0021		2.3714		-.0684
		(.1874)		(.1065)		(.1107)		(2.2566)		(.1568)
Interest Rate			.2803	.2621					.1845	.1604
			(.1225)*	(.0617)***					(.1489)	(.0672)*
Australia			-.1305	-.0501					-.0470	-.0077
			(.1432)	(.0835)					(.1678)	(.0874)
Canada			-.0545	-.0562					-.0451	-.0085
			(.1820)	(.0847)					(.2040)	(.0886)
Germany			-.1516	.0842					-.1101	.1523
			(.1496)	(.1144)					(.1747)	(.1169)
Japan				2.3952						.8254
				(1.7693)						(1.7604)
UK				.1697						.2635
				(0.0896)						(.2178)
EU				.2593						.6576
				(.2050)						(.4203)
$Interest\ Rate_{lag}$			.1118	-.2242			.2785	-.0390	.1698	-.1596
			((.1452)	(.0603)***			(.1403)*	(.0240)	(.1756)	(.0648)*
Australia			.0192	.1026			-.1737	.1294	-.1794	.1099
			(.1646)	(.0841)			(.1573)**	(.0315)***	(.1965)	(.0875)
Canada			-.3532	.0749			-.3306	.0812	-.3846	.0740
			(.1963)	(.0843)			(.1504)*	(.0312)**	(.2255)	(.0889)
Germany			-.1706	-.0431				.0394	-.2763	-.1156
			(.1713)	(.1177)				(.0374)	(.2015)	(.1199)
Japan				-2.5178				-.1689		-.6329
				(1.7730)				(.3697)		(1.8206)
UK				-.1526				.0264		-.2435
				(.0895)				(.0595)		(.2196)
EU				-.2474				-.2437		-.7509
				(.2039)				(.2265)		(.4047)
Unemployment					-.0986	-.6383			-.2136	-.4211
					(.7806)	(.1730)			(.4916)	(.1987)*
Australia					.9460	.1673			1.1482	.1101
					(.7806)	(.2468)			(.6979)	(.2707)
Canada					-.5239	.4684			-.1506	.3122
					(.7243)	(.2303)*			(.6428)	(.2551)
Germany					.0248	.4445			.0586	.4640
					(1.1217)	(.2901)			(.4495)	(.3126)
Japan					-2.9810	-.9171				-.8502
					(1.8554)	(.4401)*				(.6824)
UK						.9851				1.1437
						(.4403)*				(.4763)*
EU						-.0906				.7998
						(.4241)				(.6917)
$Unemployment_{lag}$					-.1783	.5579	-.2101	-.0718	.0586	.3565
					(.4768)	(.1728)***	(.1362)	(.0339)*	(.4495)	(.1959)
Australia					-1.2353	-.1913	-.4148	-.0851	-1.4778	-.1752
					(.7369)	(.2463)	(.1989)*	(.0477)	(.6521)*	(.2677)
Canada					.6657	-.5185	.0323	-.0907	.1626	-.3815
					(.6955)	(.2293)*	(.1540)	(.0492)	(.6072)	(.2498)
Germany					-.1660	-.3836	-.3457	.0543	-.8722	-.4116
					(1.1056)	(.2935)	(.1794)	(.0438)	(.9134)	(.3130)
Japan					.9665	.9362		-.1818		.7479
					(1.8330)	(.4460)*		(.1949)		(.7052)
UK						-.8644		.0636		-1.0011
						(.4124)*		(.1316)		(.4530)*
EU						.1431		-.2013		-.8682
						(.4361)		(.2068)		(.6882)
# of Observation	402	1025	226	914	309	883	222	785	222	785
Adjusted R^2	.9282	.9396	.9470	.9473	.9221	.9426	.9503	.9434	.9510	.9474

● *: > 0.05, **: >0.01, ***: > 0.001