PARETO

Undergraduate Journal of New Economists

University of Toronto Mississauga

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| **Title:** | Interest Rates and Price Levels: Quantifying Policy Effectiveness |
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| **Source:** | *PARETO: Undergraduate Journal of New Economists*, Vol. 2, Winter 2024 |
| **Published By:** | Department of Economics, University of Toronto Mississauga |
| **Stable URL:** | https://doi.org/10.33137/pugj.v2i1.44687 |

Economics
UNIVERSITY OF TORONTO
MISSISSAUGA

# Interest Rates and Price Levels: Quantifying Policy Effectiveness

*By* Ali Takahashi

*This paper estimates the causal effect of interest rates on household expenditure. The effect is estimated by conducting a semi-parametric model utilizing the [Robinson (1988)] Double Residual Estimator and a linear regression model. We find that the effect of interest rates on household expenditure is negligible across all models, when compared to results from a previous time period in which nominal rates were higher. The results raise concerns regarding the effectiveness of the current monetary policy regime, and therefore we expect greater use of fiscal policy to be beneficial. The question of how the current monetary policy regime will evolve throughout the next decade remains an interesting enquiry.*

***Keywords**: Monetary Policy, Fiscal Policy, Interest Rates, Quantifying Policy, Double Residual Estimator, Semi-parametric Regression*

***DOI**: https://doi.org/10.33137/pugj.v2i1.44687*


## I. Introduction

The main function of a central bank is to regulate inflation and maintain price stability in the economy. Historically, high inflation rates have had severe consequences, as seen in Zimbabwe in 2008. Inflation reached the outrageous level of 79 billion percent, and caused the Zimbabwe government to abandon its currency. Persistently high inflation has damaging economic and social consequences by increasing uncertainty surrounding economic indicators such as: income, standards of living, business competitiveness, etc. This is why central banks target a low but positive inflation rate around 2%, and conduct monetary policy to meet this target.

The Federal Reserve uses two main approaches to regulate the price level in the economy, Open Market Operations (OMO) and changing Reserve Requirements. The most common tool is Open Market Operations. OMO allows the central bank to sell or buy U.S. Treasury bonds in order to influence the quantity of bank reserves and the level of interest rates. The specific interest rate targeted in OMO is the federal funds rate. The second tool is to raise or lower the reserve requirement. The reserve requirement is the percentage of each bank's deposits that it is legally required to hold either as cash in the vault or on deposit with the central bank. However, the Fed board rarely changes the reserve requirement due to costs imposed on private banks.

One of the biggest concerns central banks in advanced countries around the world face is how to best conduct monetary policy in a low-interest rate environment. Global growth in terms of real GDP has been slowing across the major economies of the world, and the persistent trade war between the U.S. and China has brought concerns regarding the possibility of a recession in the near future. The US Federal Reserve has, on average, cut the overnight policy interest rate by over 5% in post-war recessions. Today's Fed Funds rate is around 1.5% in the US (the Bank

of Canada rate is around 1.75%). Hence, there is hardly any room to cut rates when the next recession hits the economy [Rogoff (2017)].

The goal of this paper is to quantify the causal effect of interest rates on household expenditure, and measure the effectiveness of the Fed's Open Market Operations, in periods of very low interest rates. To examine this, we make use of detailed household expenditure data sourced from the Consumer Expenditure Survey (CE), which is a nationwide household survey conducted by the U.S. Bureau of Labor Statistics. It provides information on the com- plete range of consumers' expenditure as well as income, education levels, and demographic characteristics. It is a comprehensive dataset that provides data for the years 1996 to 2018 in each quarter. We analyze the nonlinear relationship argument between interest rates and expenditure and apply that to our empirical model. For the empirical model, we conduct a semi-parametric regression. More specifically, we employ Robinson's Double Residual Estimator [Robinson (1988)]. Linear Regression is then conducted to see how our results change when the linear functional form is assumed.

The rest of the paper is organized as follows: Section 2 places our analysis in the context of the literature. Section 3 describes the data, along with rationale behind why we chose specific variables in our analysis; Section 4 introduces the econometric model with explanations regarding why our method is appropriate; Section 5 presents a discussion of the empirical results, Section 6 discusses implications of our results, and Section 7 concludes.

## II. Literature Review

Since the Financial Crisis of 2007-2009, central banks have taken extraordinary measures to boost demand and inflation. In spite of this, growth has been weak and inflation stayed consistently low. Researchers suggest several factors have played a role in this outcome, including large debt overhangs, and an impaired banking system. These arguments are variants of the view that at very low interest rates, monetary policy loses some of its traction. Examples include: [Stiglitz (2009)], [Gambacorta and Rossi (2010)], amongst many others. A 2017 study conducted by Claudio and Leonardo explored an additional mechanism which considers the effectiveness of bank lending in a low interest rate environment. Specifically, they looked at whether monetary policy was less effective in boosting lending at very low interest rates. The analysis was conducted with bank level data from Bankscope, in which they used consolidated balance sheet statements of major international banks from 1995 to 2014. The results suggested that, at very low interest rates, further reductions in short term rates may be less effective in boosting lending. This held after controlling for business and financial cycle conditions and different bank specific characteristics. However, it does not appear to reflect exclusively the impact of a financial crisis on banks, and indicates that other mechanisms may be at work [Borio and Gambacorta (2017)].

Analysis of nonlinearities in monetary transmission linked to the level of interest rates has been conducted in the previous literature. Early studies looked at the link between bank profitability and interest rates. These studies confirmed the long established positive link between interest rates and bank profitability. Examples include: [Samuelson (1945)], [FLANNERY (1981)], and [Hancock (1985)]. A more recent study by Borio and Gambacorta revisited the link between bank profitability and interest rates for a sample of 108 international banks and reached different

conclusions to traditional literature. This study allowed for nonlinearities in the relationship between interest rates and profitability. It found evidence that, controlling for aggregate demand, a reduction in both short-term interest rates and the yield curve slope depresses the return on assets, and that the effect increases at the margin. This estimated impact was significantly larger than in studies that did not allow for nonlinearities[Borio et al. (2017)]. Another recent study conducted by Claessens and Coleman supported this revisionist literature. Their study was based on a sample of 3,418 banks from 47 countries for the years 2005-2013. They classified countries for each year as being in a low or high-rate environment based on whether the three-month Treasury bill rate was below or above 1.25 percent. They found evidence that the negative impact of a decrease in the short-term interest rate is statistically larger in low-rate regimes [Claessens et al. (2018)].

These findings spurred further work on the possible nonlinear effects of low interest rates on consumption. To shed some light on this question, Internationale Nederlanden Groep (ING) released the results from an IPSOS survey conducted in Europe, US, and Australia in 2015. The survey asked 13,000 consumers how their saving behaviour had changed in response to low interest rates, and how they would react to negative interest rates. The results from the survey indicated that 31% of respondents had changed their behaviour, and of those that did, 38% said that they had saved less. However, 17% actually indicated that they had saved more [Cliffe (2016)]. This survey indicates the adverse effects of very low interest rates, but lacks information on how behaviour would have changed given increasing rates.

A recent Bank for International Settlements (BIS) research paper explored further the possible nonlinearities in relation to interest rates and consumption using formal panel data methods. In this work, Hofmann and Kohlscheen conducted a reduced-form regression linking real consumption growth to the level of the interest rate. They used annual data for a panel of 31 countries for the years 1995-2015. Nonlinearities were modelled using piece-wise regressions, allowing interest rate semi-elasticity to vary across different interest level thresholds. The results from the survey yielded two key insights. First, consumption growth seems linked to the level of nominal rates rather than real rates, which points to the empirical relevance of money illusion. Second, they found evidence that the interest rate elasticity of consumption growth increases with the level of the interest rate [Hofmann and Kohlscheen (2017)]. As seen in appendix figure A1, elasticity rises as the interest rate threshold rises. More specifically, elasticity rises from -0.3 for the full set of observations to above -1.2 when only observations with a nominal rate above 5% are included. We can see the nonlinearity also carries over to aggregate output growth, although in this case it is weaker and not statistically significant due to large confidence bands. This suggests that the nonlinearity works mainly through consumption.

Following this line of research, Claudio and Hofmann conducted a holistic study looking at whether monetary policy is less effective when interest rates are low. They highlighted two potential reasons why monetary policy may be less effective at persistently low rates: headwinds that typically blow in the wake of balance sheet recessions (debt overhang, high uncertainty, resource misallocation), and inherent nonlinearities linked to the level of interest rates (the impact of low rates on bank profits and credit supply and/or on consumption and saving behaviour). The study suggested that both conceptually and empirically there is support for the notion that monetary transmission is less effective when interest rates are persistently low. More specifically,

that the headwinds experienced during the recovery from balance sheet recessions can significantly reduce monetary policy effectiveness. However, the authors also noted that the relevant theoretical and empirical literature is much scanter than hoped, given that periods of consistently low interest rates have become more frequent and longer lasting [Borio and Gambacorta (2017)]. Also, many of the conceptual arguments highlighted in the paper have not been formalized by means of rigorous theoretical modelling, and the empirical work is limited geographically. This paper will seek to address some of these limitations in the existing literature.

## III. Data Description

This paper utilizes a strongly balanced panel data set which contains information about different household characteristics such as family size, family income, and quarterly household expenditure. Analysis focuses on the four quarters for the year 2018 for 868 households, comprising a comprehensive dataset of 3,472 observations. Data were sourced from the Consumer Expenditure Survey (CE) and provides information on the complete range of consumer's expenditure such as income, education level, and demographic characteristics. The dataset covers the years 1996 to 2018, however, the survey does not track the same group of households throughout the entire period. In the survey, each household is interviewed every three months over four calendar quarters. After the fourth interview, the sample household unit is dropped from the survey and replaced by a new sample household unit. Therefore, we restricted our analysis to the year 2018. This is ideal given the new macroeconomic environment of low interest rates that existed in 2018.

Some key variables included in this study are the size of family measured as persons per household (famsize), total quarterly household expenditure (totalexp), the after tax household income (fincatx), the Federal Funds Rate measured in percentage point units (fedrate) and the interest paid by a household on their loan in percentage point units (primplus). This interest rate is calculated by adding 1.5% to the prime rate of that quarter.[1] Table 1 below shows the summary statistics. It can be observed that most households surveyed in the sample have a family size of between one to three people, with the maximum size being nine people. Also of note is that households with high family income after tax tend to have higher quarterly expenditure compared to those with lower income.

The goal in this paper is to measure the effectiveness of interest rates to regulate the price level in the economy. However, the key question surrounds the interest rate we should focus on. This is a valid question as there are a wide variety of interest rates available. It is important to make use of a measure that mirrors the movement of the Federal Funds Rate, since this is the rate that the Fed controls in their Open Market Operations. An extreme example of this was seen in late 2008 when the Fed established a near zero target range for the Fed Funds Rate to combat the financial crisis. This paper will utilize the prime rate as a proxy for the Fed Funds Rate. The prime rate is the interest rate that commercial banks charge their customers, and it serves as the basis for most other interest rates. This includes rates for mortgages, small business loans, and personal loans. Therefore, households would react more to changes in the prime rate than that of the Fed Funds Rate. As seen in appendix figure A1, the prime rate

[1]Variable definitions sourced from the Consumer Expenditure Survey dictionary

Table 1—Summary Statistics

| Variable | Min | Q1 | Q2 | Q3 | Max | St. Dev |
|---|---|---|---|---|---|---|
| famsize | 1 | 1 | 2 | 3 | 9 | 1.40 |
| totalexp | 0 | 4037 | 7263 | 12657 | 93106 | 8742 |
| fincatx | -14285 | 29112 | 50693 | 89947 | 381021 | 55670 |
| fedrate | 1.45 | 1.60 | 1.83 | 2.07 | 2.22 | 0.28 |
| primplus | 6.00 | 6.13 | 6.38 | 6.63 | 6.75 | 0.28 |

perfectly mirrors the movement of the Fed Funds Rate which provides further support for our use of prime rate as a proxy for the Fed Funds Rate.[2]

## IV. Econometric Framework and Model

The purpose in this paper is to estimate the causal effect of interest rates on household expenditure. Therefore, total expenditure per quarter is the dependent variable with primplus being the key independent variable. Substantial evidence supporting the nonlinearity link between interest rates and consumption have been provided in the literature. The two key factors affecting household expenditure are the wealth of the household and the level of interest rates in the economy during the time period. The linear argument makes sense for total expenditure and income ranking, since people tend to spend more as the value of their assets rise according to the wealth effect behavioral economic theory. Therefore, we have conducted a semi parametric regression treating primeplus to be the non parametric variable and income rank as the parametric variable.

The partially linear model is defined as:

$$y_{it} = x_{it}\beta + m(z_{it}) + \epsilon_{it} \tag{1}$$

where y is ln of total expenditure, x is income ranking, z is primplus, i is the household, and t is the quarter. The goal is to estimate the function m(z) to see how primeplus affects total expenditure.

First, take the expected value conditioning on z:

$$E(y_{it}|z_{it}) = E(x_{it}|z_{it})\beta + m(z_{it}) + E(\epsilon_{it}|z_{it}) \tag{2}$$

Therefore (assuming $E(\epsilon_{it}|z_{it}) = 0$) we have that:

[2]Figure taken directly from the Board of Governors of the Federal Reserve System FRED database (fred.stlouisfed.org)

$$y_{it} - E(y_{it}|z_{it}) = (x_{it} - E(x_{it}|z_{it}))\beta + \epsilon_{it} \tag{3}$$

where we denote $y_{it} - E(y_{it}|z_{it})$ as $\epsilon_1$ and $x_{it} - E(x_{it}|z_{it})$ as $\epsilon_2$. We can obtain estimates of $E(y_{it}|z_{it})$ and $E(x_{it}|z_{it})$ by using Nadaraya Watson (NW) regression, and therefore make it possible to estimate $\beta$ by using:

$$\hat{\beta} = (\hat{\epsilon_2'}\hat{\epsilon_2})^{-1}\hat{\epsilon_2'}\hat{\epsilon_1} \tag{4}$$

Finally, $m(z_{it})$ can be estimated by regressing $(y_{it}x_{it}\hat{\beta})$ on $z_{it}$ non-parametrically. The Nadaraya Watson (NW) estimator was then utilized to obtain estimates of $E(y_{it}|z_{it})$ and $E(x_{it}|z_{it})$ as follows:

$$E(y_{it}|z_{it}) = \frac{\sum_{i=1}^{N} K\left(\frac{z_{it}-z_{ot}}{\lambda}\right) y_{it}}{\sum_{i=1}^{N} K\left(\frac{z_{it}-z_{ot}}{\lambda}\right)} \tag{5}$$

$$E(x_{it}|z_{it}) = \frac{\sum_{i=1}^{N} K\left(\frac{z_{it}-z_{ot}}{\lambda}\right) x_{it}}{\sum_{i=1}^{N} K\left(\frac{z_{it}-z_{ot}}{\lambda}\right)} \tag{6}$$

where K is the kernel function and h is the bandwidth. It is important to note however, that the selection of kernel is less important than the selection of bandwidth. It is also possible to substitute the NW estimator with the Local Linear (LL) or Weighted Naduraya Watson (WNW) estimators.

The next goal was to determine how the results would change if we assume that all the variables have a linear relationship. In other words, we try to determine what happens if the model follows the form:

$$y_{it} = x_{it}\beta_1 + z_{it}\beta_2 + d_t\beta_k + \alpha_i + \epsilon_{it} \tag{7}$$

where $d_t$ is a time dummy to allow the intercept of the regression to vary over time (including a dummy variable for each quarter in 2018) and $\alpha_i$ are the household-specific fixed effects.

First, a Pooled OLS regression was conducted based on the model above. Then, Fixed Effects and Random Effects regressions were run to take into account the unobserved heterogeneity. Finally, a Hausman Test was conducted to determine the relative suitability of the two specifications.

## V. Empirical Results

We first conducted the semi-parametric regression as outlined by the model in equation 1. This model was run to estimate the function of primeplus. The coefficient of income rank which was

assumed to follow a linear relationship with the natural log of total expenditure. The coefficient is 0.0181488 which implies that for every 1% increase in income rank, total expenditure increases by 0.018%. The result had a p-value of 0.00, and was statistically significant. Figure 1 highlights these results. As we can see from the figure, the function estimated is almost perfectly horizontal, and constant across different levels of primeplus. This result implies that primeplus has a very negligible effect on the natural log of total expenditure, which in turn implies the prime rate has a very negligible effect on total expenditure. This supports the opinion in the literature that monetary policy has become less effective in regulating the price level in the economy.

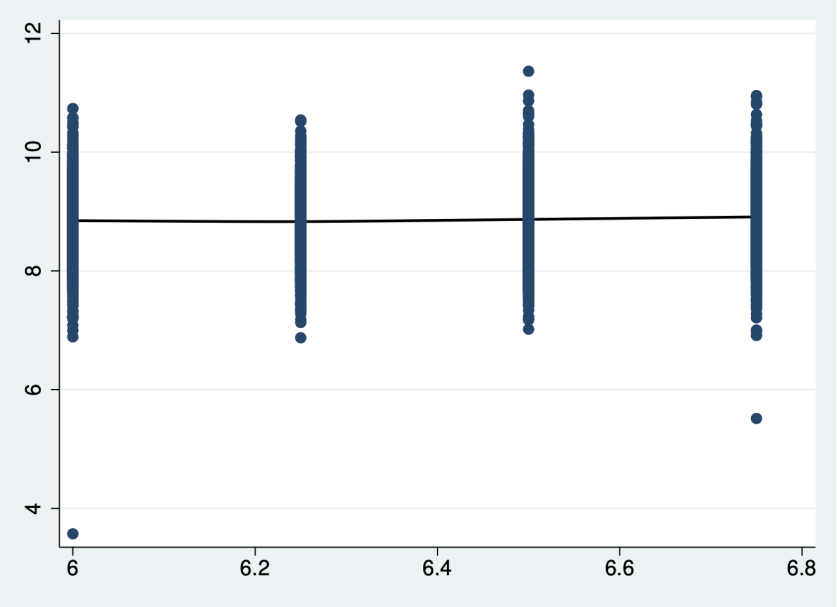


Figure 1. lntotalexp vs primeplus

Results from several specifications are shown in table 2 below. We can see that across all regressions conducted, the coefficient on primeplus remains below 0.1%. For example, the coefficient on primplus is 0.0538392 for the FE model which implies that for every 1% increase in average primplus the average effect on household expenditure increases by 0.0538392This effect is very negligible, and supports the result in the semi-parametric regression. The coefficients on the time dummies are not statistically significant at the 5% level for OLS, FE, and RE in quarters 3 and 4. This could be due to the time dummies being assigned only to the 4 quarters of 2018. A significant change in consumption cannot be observed due to the short time period. The overall results across all models support our thesis, and imply we are currently in a new macroeconomic environment where monetary policy is less effective.

Following estimation the Hausman Test was conducted to provide empirical support on whether an FE or RE model was more appropriate. The p-value obtained was 0.000 from the test. There-

fore, we reject the null hypothesis that there was no correlation between regressors and effects. This gives empirical support that FE is more appropriate than RE for our model.

Table 2—Regression Results from Linear Estimation

| Variable | OLS | FE | RE |
|---|---|---|---|
| Income Rank | 0.018 | 0.006 | 0.011 |
| Prime Plus | 0.084 | 0.054 | 0.064 |
| Quarter 2 | -0.044 | -0.037 | -0.040 |
| Quarter 3 | -0.020 | -0.014 | -0.017 |
| Quarter 4 | 0 | 0 | 0 |
| $R^2$ | 0.374 | 0.370 | 0.371 |

Our results across all models imply that the effect of rates on household expenditure are negligible with the effects ranging from around 0.05% to 0.08%. The next question is how negligible this prime rate effect is. This can be done by comparing our results to studies conducted in the past which focus on data from a time period before the low interest rate environment (between the years 1960-2000). Appendix table A2 indicates the estimated peak effect of a 1% interest rate cut on GDP and prices across various studies.[3] It is important to note that most results from previous studies pre-date any discussion regarding nonlinearities in the effect of interest rates. From appendix table A2, it can be seen that the estimated effects seem to be much higher than the results in our model. Taking an equally weighted average of the coefficients in the table, we get an estimated coefficient of 1.10%. This implies that for every 1% decrease in the interest rate, the average peak effect is an increase in price level of 1.10% between the years 1960- 2000. Although not a perfect comparison with our model, it does provide relevant evidence that changes in the prime rate have only negligible effects on household expenditure in the more recent period. This is an interesting result since it provides us with empirical support that we are in a new macroeconomic environment where monetary policy is less effective due to low nominal interest rates.

## VI. Implications

The results of our study have major implications on what monetary policy may look like in the future. Appendix figure A3 (Rogoff, 2017) plots policy interest rates for the US, the ECB, and the Bank of England since 2000.[4] We can see that the Fed cut the Fed Funds Rate by around 5% after the burst of the tech bubble in 2000, falling to a level of 1% in 2003. They

[3]This table was sourced directly from an OECD paper by Bouis et al. (2013)

[4]Appendix figure A3 was obtained from Rogoff (2017) and generated using data from the Federal Reserve, European Central Bank and Bank of England

then cut rates to a target range of 0% to 0.25%, as the financial crisis hit the economy in 2007 and 2008. We can see this target range being adopted by banks internationally in Europe and Japan (with Japan's rates now slightly negative). Paired with the results from our study, this implies central banks around the world will have trouble using monetary policy when needed, and will struggle meeting their inflation target of 2%.

In a persistently low rate world, we can expect to see situations in which the Fed would like to cut its policy rate but will be unable to do so (a notable example being the COVID-19 Pandemic). One potential solution to this problem, suggested by leading economists, is for the Fed to raise its inflation target. The idea is that if the inflation rate is on average 2% higher, then the level of nominal interest rates should also be 2% higher. This would imply that central banks have an extra 2% of nominal rate cuts to conduct monetary easing in a recession. Of course there is the plausibility of a 4% inflation target, however, this strategy is likely not without its drawbacks. The key drawback with this approach is that central banks have spent decades convincing the public they are committed to a 2% target, and 2% is considered to be the moral equivalent of price stability. Any sudden transition to a higher inflation target is likely to be disruptive, and will be very difficult to make the new target as credible as the old one Rogoff (2017). Another drawback is that higher levels of inflation sustained for long periods of time would likely lead to more frequent price adjustment, which would undermine the potency of monetary policy. Despite its drawbacks, the idea of raising inflation targets is an important route to consider.

Another route that has been analyzed by economists is the implementation of negative interest rates. Two key approaches have been discussed regarding the implementation of negative interest rates: 1) moving to a cashless society, since paying interest on bank reserves is a wide spread practice; and 2) taking steps to make large scale hoarding of cash costly by phasing out large denomination notes. Option 1 is generally considered not to be viable. Moving to a cashless society remains too high a price to pay simply to expand the central bank toolkit. For example, there needs to be a backup payment mechanism during internet/power outages.

The second approach has garnered attention as a potentially more realistic option. This idea starts with the observation that the zero bound is not exactly zero, since it is costly to transport and store large quantities of cash. This is the reason several central banks such as Japan, Sweden, and the Eurozone have been able to set small negative rates without triggering a massive run to cash Rogoff (2017). The limit of how low central banks can set rates without creating a bank run is ambiguous, since that value is sensitive to how long the negative interest rate policy is expected to persist. There is a strong case for phasing out large denomination notes such as $50 and 100$ notes, since it would have very little effect on ordinary retail transactions, and makes it less likely for a bank run to happen due to the increased cost of storage and transportation. India already implemented this in November 2016 when it phased out the country's two largest bills.

This approach is not without obstacles either. Tax laws would need to be adjusted so that lenders who are making interest payments get a deduction when rates are negative. There are psychological obstacles to negative interest rates stemming from money illusion, and there are opinions that negative interest rate policy might exacerbate financial instability. Another big constraint is that if central banks charge negative interest rates on bank reserves, it might be difficult for private banks to pass these costs onto depositors Rogoff (2017). The main idea with

this approach is to go to a less-cash society, not a cashless one.

Given the fact that central banks around the world have pushed monetary policy to the limits of its useful life, we expect to see an increased dependence on fiscal policy. There is almost no room to use further interest rate policy and Quantitative Easing in major economies around the world, and the question of how central banks will struggle to sustain expansion will remain to be an important discussion in the future. We have seen signs of this transition due to the COVID-19 pandemic, where central banks unleashed unprecedented fiscal and monetary stimulus to support the economy.

## VII. Limitations & Extensions

The key limitation in our study surrounds the measurement of interest rates for the same household over time. We are restricted to one specific year in the analysis in order to assess the same households over time. This is because of the nature of the survey in which it only interviewed the same household for four quarters before dropping them from the survey. In future studies it would be beneficial to obtain longitudinal survey data on households. For the semi-parametric model, the curse of dimensionality restricts us from adding too many variables, since power decreases as the dimension of conditioning variables increase. This leads to our linear model encountering potential issues of omitted variable bias, since we kept the number of variables consistent across all models. A larger dataset and a more precise understanding of the specification required could help improve the confidence in our model.

## VIII. Conclusion

We are currently in a new macroeconomic environment in which monetary policy has lost much of its effectiveness due to the low level of nominal interest rates. Central banks around the world have struggled to sustain economic expansion, since we are at or near the Zero Lower Bound in which central banks are constrained to cut rates when a recession hits. This paper has examined the causal effect of interest rates on household expenditure. We analyzed the nonlinearities between interest rates and consumption, and created a semi parametric model treating interest rates as the non-parametric variable. We focused our analysis on the year 2018 and ran both semi-parametric and linear regressions to obtain our results. Across all models, the results imply that the effect of interest rates on household expenditure are negligible. This result held even when compared to results from a time period before low interest rates, where the effects were significantly higher. We analyzed potential routes central banks could take to navigate the current macroeconomic conditions. We decided that a heavier dependence on fiscal policy in the near future will be beneficial. Nevertheless, we expect to see significant developments in the current monetary policy regime, and it will be interesting to see how the regime will evolve throughout the next decade.

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## APPENDIX

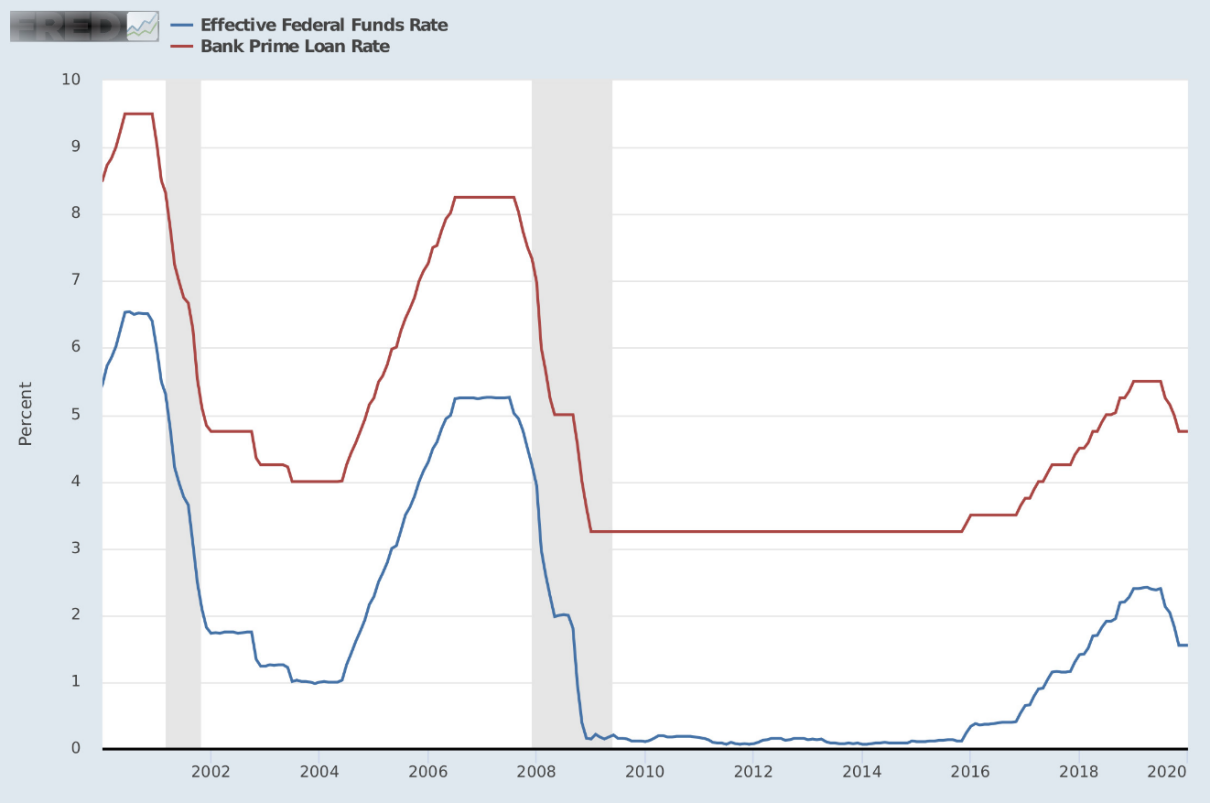


Figure A1. Federal Funds Rate vs. Prime Loan Rate

| | Sample | Approach | Estimated peak effect (per cent) of a 100 bp interest rate cut on | |
|---|---|---|---|---|
| | | | GDP | prices |
| **United States** | | | | |
| Leeper *et al.* (1996) | 1960-1996 | VAR | 0.35 | 1.00 |
| Bernanke *et al.* (1997) | 1965-1995 | VAR | 0.40 | 0.06 |
| Bernanke and Mihov (1998) | 1965-1996 | VAR | 0.40 | 0.50 |
| Christiano *et al.*, (1999) | 1965-1994 | VAR | 0.70 | 0.05 |
| Bernanke *et al.* (2005) | 1959-2001 | Factor Augmented VAR† | 0.60 | – |
| Gorodnichenko (2006) | 1965-1996 | Factor Structure VAR† | 0.80 | – |
| Romer and Romer (1994) | 1970-1996 | Narrative approach with single equation | 4.30 | 4.20 |
| Angeloni *et al.* (2003) | - | FRB/US Model* | 1.40 | 1.00 |
| Hervé *et al.* (2009) | - | OECD Global Model** | 1.10 | 0.70 |
| Coibion (2012) | 1970-1996 | VAR with Romer and Romer's (2004) shocks | 2.00 | 2.00 |
| NiGEM | - | Model based on historical data*** | 0.76 | 0.40 |

Figure A2. Cross Study Comparison of Interest Rate Effects

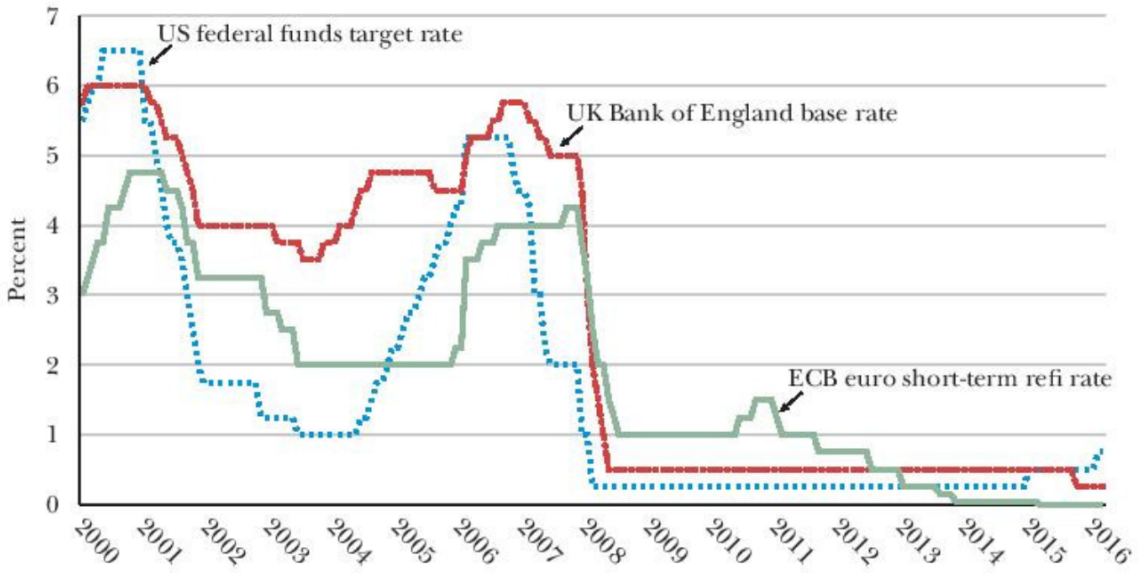


Figure A3. Policy Interest Rates for the Federal Reserve, European Central Bank and the Bank of England