



Inflation – The Unwelcome Guest

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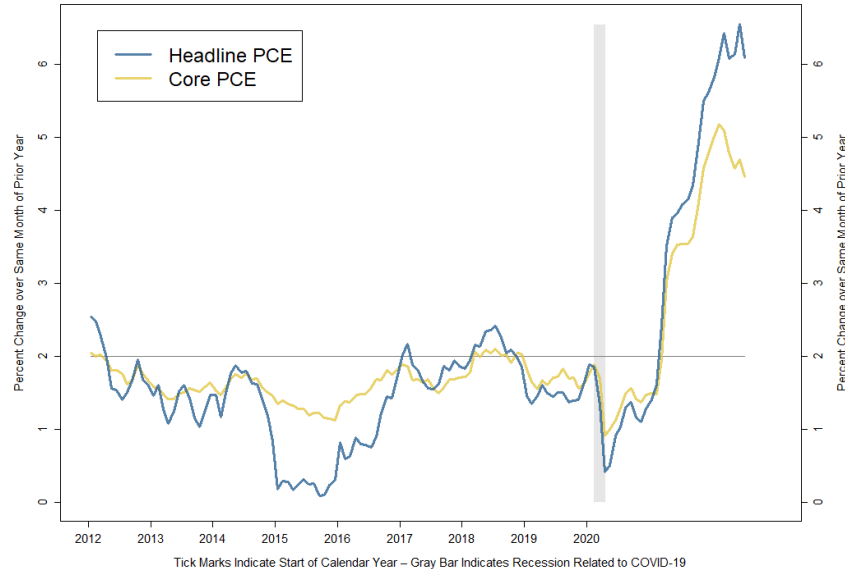
Inflation and the Federal Reserve

"Inflation is always and everywhere a monetary phenomenon"

The Fast and Furious Rise of Inflation



The inflation increase quickly turned broad-based, extending beyond food and energy



The PCE (Personal Consumption Expenditures) index is the Federal Reserve's preferred measure of price stability.

Unlike the CPI, which captures only expenditures made by households, the PCE also captures expenditures made on behalf of households (by government programs and employers).

Core PCE differs from headline PCE by excluding food and energy due to their high price volatility.

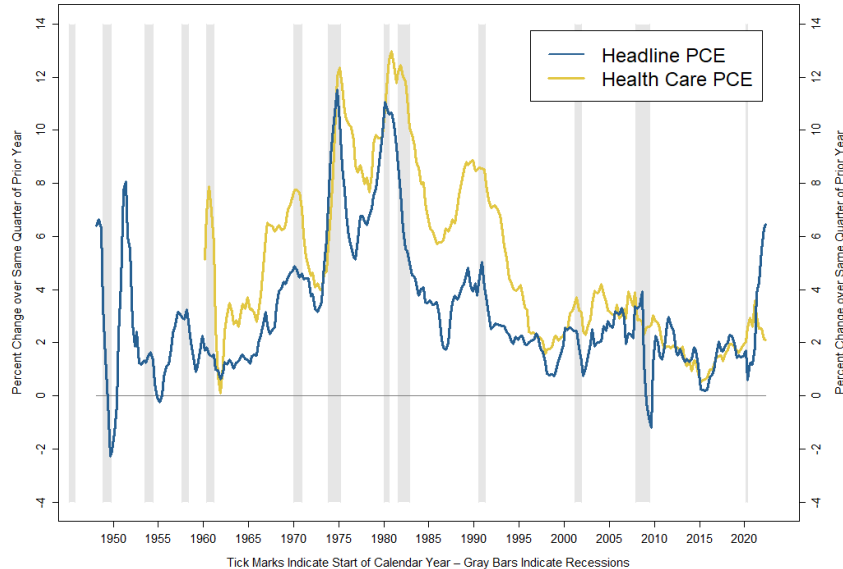
The Federal Reserve adopted inflation targeting in January 2012.

Sources: (1) Federal Reserve Bank of St. Louis, Personal Consumption Expenditures: Chain-type Price Index, Index 2012=100, Monthly, Seasonally Adjusted. PCECTPI. Personal Consumption Expenditures Excluding Food and Energy (Chain-Type Price Index), Index 2012=100, Monthly, Seasonally Adjusted, PCEPILFE. Accessed on August 29, 2022, <https://fred.stlouisfed.org/>. Latest observations: July 2022. (2) National Bureau of Economic Research (NBER), business cycle dates, <https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions>.

But...It Is not all Bad News



Medical inflation is contained – for now



Health care services in the PCE index include services purchased out of pocket by consumers and services paid for on behalf of consumers – for example, health care services paid for by employers through health insurance, as well as health care services paid for by governments through programs such as Medicare and Medicaid.⁽¹⁾

By source of funds, private health insurance accounts for the highest share of health care spending (28 percent), followed by Medicare (20), Medicaid (16), and consumer out-of-pocket (9).⁽²⁾

Source: Bureau of Economic Analysis, National Income and Product Accounts, Table 2.3.4, accessed on August 30, 2022, https://apps.bea.gov/iTable/index_nipa.cfm. Latest observations: Q2/2022.

Note: The personal consumption expenditure (PCE) deflator "arguably does a better job measuring medical inflation" than the consumer price index (CPI). Ben S. Bernanke (February 3, 2003) "Constrained Discretion" and Monetary Policy," <https://www.federalreserve.gov/boarddocs/Speeches/2003/20030203/default.htm>.

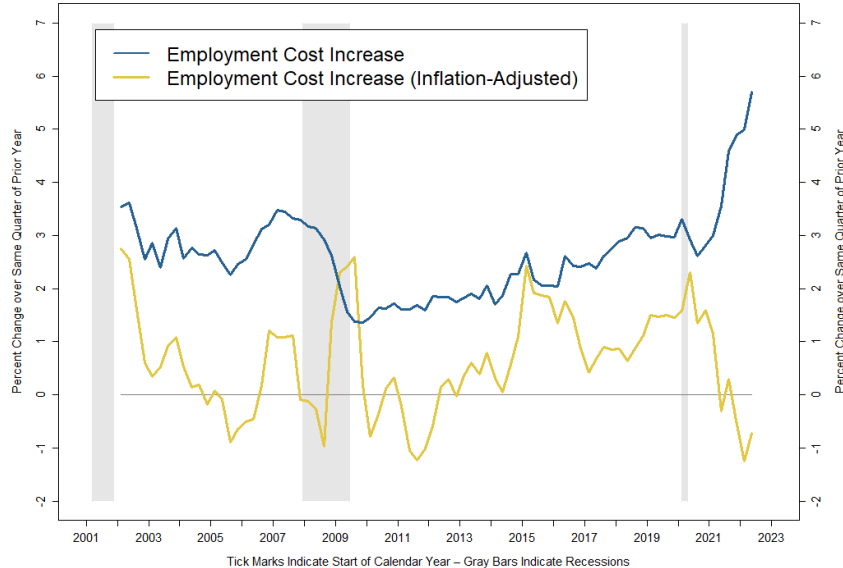
1) Bureau of Labor Statistics (BLS) (May 2011) "Differences between the Consumer Price Index and the Personal Consumption Expenditures Price Index." *Focus on Prices and Spending* 2(3), <https://www.bls.gov/opub/btn/archive/differences-between-the-consumer-price-index-and-the-personal-consumption-expenditures-price-index.pdf>. The Medical Care component of the CPI tracks out-of-pocket expenses only.

2) Centers for Medicare & Medicaid Services, *National Health Expenditures 2020 Highlights*, <https://www.cms.gov/files/document/highlights.pdf>.

It is not the Labor Market...



Compensation of labor fails to keep up with inflation, despite a hot labor market



The Employment Cost Index is a quarterly measure of the change in the cost of labor, free from the influence of employment shifts among occupations and industries.

The Employment Cost Index comprises changes in (1) wages and salaries and (2) employer costs for employee benefits.

Adjusted for general inflation, increases in employment cost have slowed following a minor spike early in the pandemic.

Note: Inflation-adjustment is based on the headline PCE.

Source: Federal Reserve Bank of St. Louis, Personal Consumption Expenditure Deflator, seasonally adjusted, accessed on August 30, 2022, <https://fred.stlouisfed.org/series/PCEPI>. Employment Cost Index: Wages and Salaries: Private Industry Workers, seasonally adjusted, accessed on August 30, 2022, <https://fred.stlouisfed.org/series/ECIWAG>. Latest observations: Q2/2022.

Notes: For the Employment Cost Index, see Bureau of Labor Statistics, "Employment Costs Trends: How to Use the Employment Cost Index for Escalation," May 18, 2016, <https://www.bls.gov/ncs/ect/escalator.htm>.

Let's Try to Find Answers to Three Questions



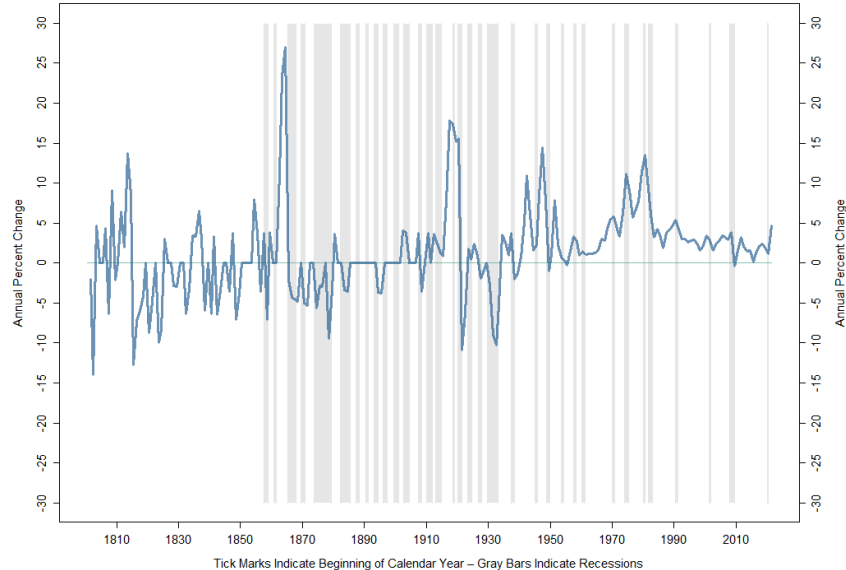
Understanding the nature of inflation and the cost of inflation fighting

- How does the rate of inflation behave?
 - How does the rate of inflation respond to changes in economic conditions?
 - What do we know about the ability to forecast inflation?
- How does the Federal Reserve behave?
 - What is the objective function of the Federal Reserve?
 - How can we measure the Federal Reserve's monetary policy stance?
- How does the rate of inflation respond to monetary policy actions?
 - What is the cost of inflation fighting?
 - Does the cost of inflation fighting depend on the nature of inflation?

Inflation in Historical Perspective



Rate of Consumer Price Index (CPI) inflation, 1801-2021



Prior to the creation of the Federal Reserve (December 1913), deflation (i.e., a negative rate of inflation) was a common phenomenon.

The rate of inflation tends to drop in economic recessions (indicated by gray bars) owing to excess capacity, and it tends to increase in economic recoveries.

Since the creation of the Federal Reserve, the rate of inflation tends to be higher (3.2% on average, 1914-2021, compared to -0.3% for 1801-1913) and more stable (standard deviation of 4.7%, compared to 5.6%).

Sources: (1) Federal Reserve Bank of Minneapolis (CPI inflation 1801-2020), <https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator/consumer-price-index-1800-> Annual data. Accessed on March 13, 2022. (2) Federal Reserve Bank of St. Louis (Consumer Price Index for All Urban Consumers: All Items in U.S. City Average), <https://fred.stlouisfed.org/series/CPAUCSL>. Annual data. Accessed on March 13, 2022. (3) National Bureau of Economic Research (NBER) (business cycle dates), <https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions>.

Note: NBER business cycle dates are available starting with the 1857/1858 recession.

Empirical Properties of the Rate of Inflation



The rate of inflation is highly persistent – once it is high, it remains high

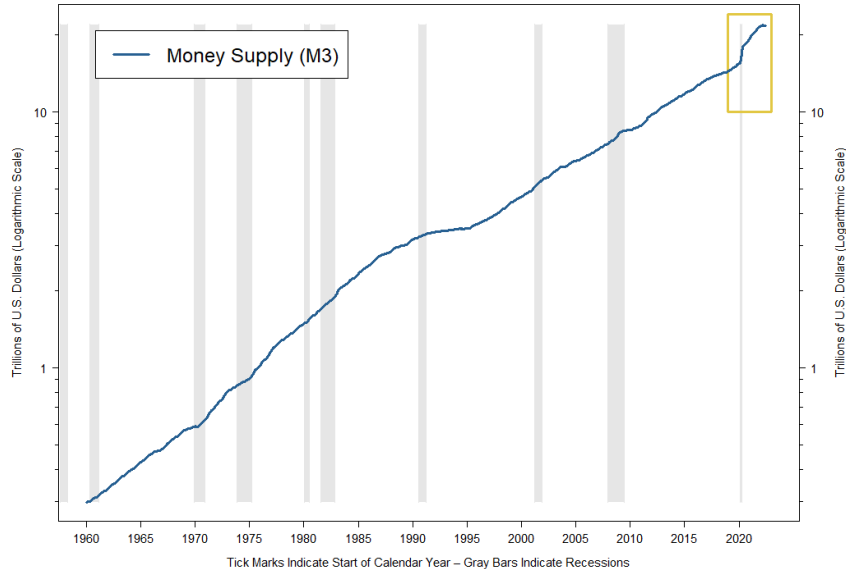
- The rate of inflation is close to a *random walk*
 - In plain English, *changes* to the rate of inflation are largely unpredictable – admittedly, there is a degree of mean reversion in the rates of inflation in energy and food prices
 - It has been shown that there is no macro-econometric model that consistently outperforms a random-walk based model in predicting the future rate of inflation¹⁾
 - A simple random-walk based model is to predict the inflation rate of the next four quarters by the inflation rate of the past four quarters¹⁾
- The random walk assumption is not inconsistent with causal narratives
 - The random walk property does not *a priori* invalidate theories that try to explain shocks to the rate of inflation with economic, societal, or physical factors
 - It is the *arrival* of such factors (natural catastrophes, pandemics, wars, financial crises, etc.) that must be considered random events

¹⁾ Stock, James, and Mark W. Watson (2009) "Phillips Curve Inflation Forecasts," in: J. Fuhrer, Y. Kodrzycki, J. Little, and G. Olivei (eds.) *Understanding Inflation and the Implications for Monetary Policy*. Cambridge: MIT Press, 99-202, <https://scholar.harvard.edu/files/stock/files/forecastinginflation.pdf>.

Monetary Expansion as an Enabler of Inflation



Monetary accommodation of massive pandemic-related fiscal expansion led to an unparalleled surge in M3



"Inflation is always and everywhere a monetary phenomenon in the sense that it is and can be produced only by a more rapid increase in the quantity of money than in output."

--Milton Friedman¹⁾

The following identity holds: $M \cdot v \equiv P \cdot \text{Real GDP}$, where v is known as the income velocity of money, M is the money supply, and P is the price level. For a given v , it follows: $\Delta\%P = \Delta\%M + \Delta\%\text{Real GDP}$, which implies that money supply not absorbed by economic growth finds its way into inflation.

Note that the money supply barely budged during the Quantitative Easing period (2007-2014) in response to the 2007-2008 Global Financial Crisis – the mild increase was quickly syphoned off.

Source: Federal Reserve Bank of St. Louis, M3, monthly observations, seasonally adjusted; accessed on August 30, 2022, <https://fred.stlouisfed.org/series/MABMMB01USM189S>. Latest observation: June 2022.

Note: Data is shown on a logarithmic scale. On a logarithmic scale, a straight line indicates a constant rate of growth. The monetary aggregate M3 comprises currency, deposits with an agreed maturity of up to two years, deposits redeemable at notice of up to three months and repurchase agreements, money market fund shares/units, and debt securities up to two years (<https://data.oecd.org/money/broad-money-m3.htm>). The 2020 recession (as indicated by a recession bar) lasted from February through April. The U.S. fiscal response to the COVID-19 pandemic amounted to \$5.2 trillion and is estimated to push the U.S. debt-to-GDP ratio from 79 percent before it emerged to 110 percent by the end of the 2023 budget year, according to projections cited by Christina Romer.²⁾

1) Friedman, Milton (1970) "Counter-Revolution in Monetary Theory." *Wincott Memorial Lecture*, Institute of Economic Affairs, Occasional Paper 33.

2) Romer, Christina D. (2021) "The Fiscal Policy Response to the Pandemic." *Brookings Papers on Economic Activity*, Spring, pp. 89-110.

The Federal Reserve Monetary Policy Stance



Dual mandate, main policy instrument, and Fed neutrality

Dual Mandate

- The Federal Reserve Act mandates that the Federal Reserve conduct monetary policy "so as to promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates."
- Even though the act lists three distinct goals of monetary policy, the Fed's mandate for monetary policy is commonly known as the *dual mandate*.¹⁾

Main Policy Instrument

- The FOMC (Federal Open Market Committee) started using the federal funds rate as its main policy instrument in October 1982.²⁾
- After the federal funds rate hit the *zero lower bound* during the Global Financial Crisis, the Federal Reserve announced large-scale asset purchases in November 2008, which commenced in March 2009.
- Asset purchases are a means of depressing long-term interest rates after exhausting the fed funds policy instrument.³⁾

Fed Neutrality

- The Fed considers its stance to be neutral if the real (i.e., inflation-adjusted) fed funds rate equals the *natural rate of interest*.⁴⁾
- The natural rate is "the real short-term interest rate expected to prevail when an economy is at full strength and inflation is stable."⁵⁾
- The natural rate of interest is a theoretical concept and cannot be observed directly. The New York Fed publishes econometric estimates.⁵⁾

1) Board of Governors of the Federal Reserve, "Monetary Policy Principles and Practice." <https://www.federalreserve.gov/monetarypolicy/monetary-policy-what-are-its-goals-how-does-it-work.htm>.

2) Thornton, Daniel (2005) "When Did the FOMC Begin Targeting the Federal Funds Rate? What the Verbatim Transcripts Tell Us." Federal Reserve Bank of St. Louis *Working Paper* 2004-015B, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=760518.

3) Federal Reserve Bank of St. Louis, "Quantitative Easing Explained." April 2011, <https://files.stlouisfed.org/files/htdocs/pageone-economics/uploads/newsletter/2011/201104.pdf>.

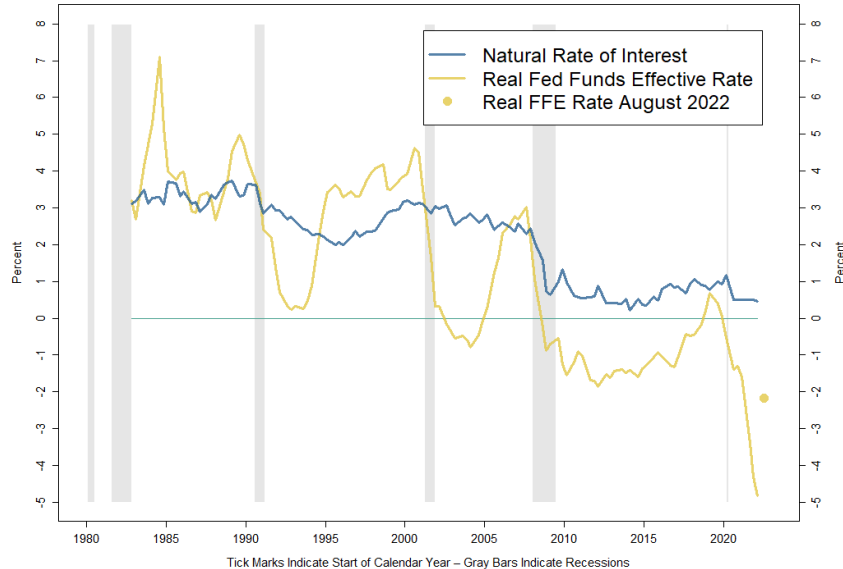
4) Federal Reserve Bank of San Francisco, "What is neutral monetary policy?" April 2005, <https://www.frbsf.org/education/publications/doctor-econ/2005/april/neutral-monetary-policy/>.

5) Federal Reserve Bank of New York, "Measuring the Natural Rate of Interest." <https://www.newyorkfed.org/research/policy/rstar>.

Monetary Policy Stance of Federal Reserve



The rise of inflation pushed the real federal funds rate deep into negative territory



Monetary policy is expansionary owing to a real federal funds rate below the natural rate of interest.

The Fed has a neutral stance when the real federal funds rate equals the natural rate of interest – neutral means no upward or downward pressure on the rate of inflation (or real economic growth).

As the Fed keeps hiking the fed funds rate, inflation may start declining and contribute to closing the gap between the real fed funds rate and the natural rate.

Note: Inflation-adjustment is based on the core PCE, which excludes food and energy. Plotted values are averages for the quarter (through Q2/2022) or month (August 2022).

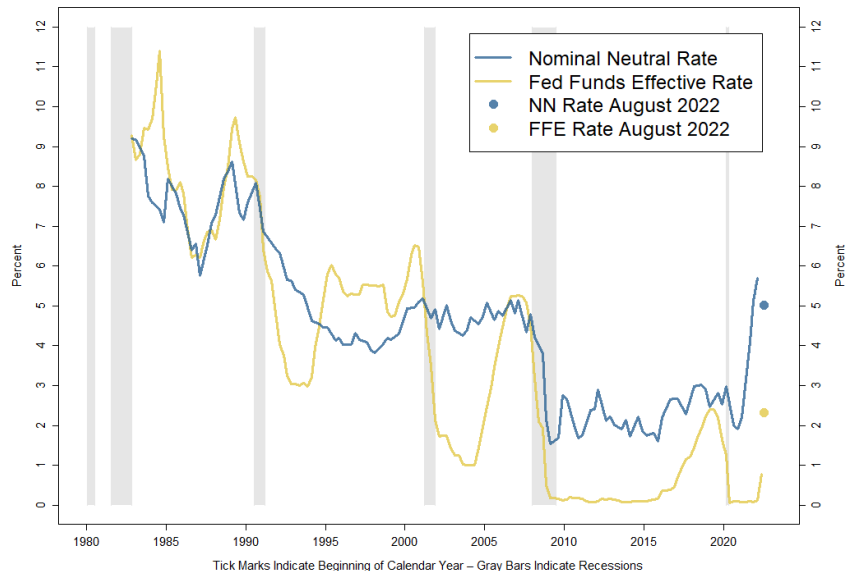
Note: The August 2022 value of core PCE inflation was approximated by the July 2022 value (<https://www.bea.gov>).

Sources: (1) Federal Reserve Bank of New York, Natural Rate of Interest; Laubach-Williams real-time estimates, one-sided, accessed on March 13, 2022, <https://www.newyorkfed.org/research/policy/rstar>. (2) Federal Reserve Bank of St. Louis, Personal Consumption Expenditure Deflator Excluding Food and Energy, percent change from quarter one year ago, seasonally adjusted, accessed on August 30, 2022, <https://fred.stlouisfed.org/series/BPCCRO1Q156NBEA>. Latest observations: Q2/2022. Notes: Contemporaneous core PCE (Personal Consumption Expenditure) inflation is used for inflation adjustment. Owing to the pandemic, the Federal Reserve Bank of New York ceased publication of estimates of the natural rate of interest in November 2020. Values following the final published estimate (Q2/2020) were set to 0.5 percent, based on the December 2020 and 2021 "FOMC participants' assessments of appropriate monetary policy: Midpoint of target range or target level for the federal funds rate—Longer Run" of 2.5 percent (<https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20201216.htm>, <https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20211215.htm>). Effective March 16, 2022, the median longer-run federal funds rate reads 2.4 percent, implying a natural rate of interest of 0.4 percent (<https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20220316.htm>).

Monetary Policy Stance of Federal Reserve



Real-time stance based on the concept of the natural rate of interest



Translated into nominal terms, the Federal Reserve has a neutral stance when the effective fed funds rate equals the nominal neutral rate, expressed as the natural rate of interest adjusted for (here, core) PCE inflation.

The Fed can achieve neutrality by hiking the fed funds rate and, in doing so, depressing the rate of inflation (and thus the nominal neutral rate).

The magnitude of the needed increase in the fed funds rate depends on the responsiveness of the rate of inflation to monetary policy tightening.

Note: Plotted values are averages for the quarter (through Q2/2022) or month (August).

Note: The August 2022 value of core PCE inflation was approximated by the July 2022 value (<https://www.bea.gov>).

Sources: (1) Federal Reserve Bank of New York, Natural Rate of Interest; Laubach-Williams real-time estimates, one-sided, accessed on March 13, 2022, <https://www.newyorkfed.org/research/policy/rstar>. (2) Federal Reserve Bank of St. Louis, Personal Consumption Expenditure Deflator Excluding Food and Energy, percent change from quarter one year ago, seasonally adjusted, accessed on August 30, 2022, <https://fred.stlouisfed.org/series/BPCCRO1Q156NBEA>. Latest observations: Q2/2022. Notes: Contemporaneous core PCE (Personal Consumption Expenditure) inflation is used for inflation adjustment. Owing to the pandemic, the Federal Reserve Bank of New York ceased publication of estimates of the natural rate of interest in November 2020. Values following the final published estimate (Q2/2020) were set to 0.5 percent, based on the December 2020 and 2021 "FOMC participants' assessments of appropriate monetary policy: Midpoint of target range or target level for the federal funds rate—Longer Run" of 2.5 percent (<https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20201216.htm>, <https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20211215.htm>). Effective March 16, 2022, the median longer-run federal funds rate reads 2.4 percent, implying a natural rate of interest of 0.4 percent (<https://www.federalreserve.gov/monetarypolicy/fomcprojtabl20220316.htm>).

What we (Believe we) Know



Acknowledging the role of randomness and the cost of inflation-fighting

- The rate of inflation is highly persistent
 - Once the rate of inflation is high, it remains high
- Random economic shocks alter the (persistent) level of inflation
 - Although the effects of these shocks on inflation are well understood, they are (nearly) unpredictable
 - Examples are the pandemic, the ensuing supply chain disruption, and the war in Ukraine
- Fed inflation-fighting is costly
 - Inflation-fighting puts the two Fed mandates in conflict with one another in the short term
 - Inflation-fighting is particularly (and potentially prohibitively) costly in the presence of adverse supply shocks
- The influence of long-term trends is a matter of debate
 - Some attribute the low and declining rate of inflation of the three decades preceding the pandemic to the increase in the supply of labor (mostly from China and Eastern Europe) and a resultant increase in international division of labor



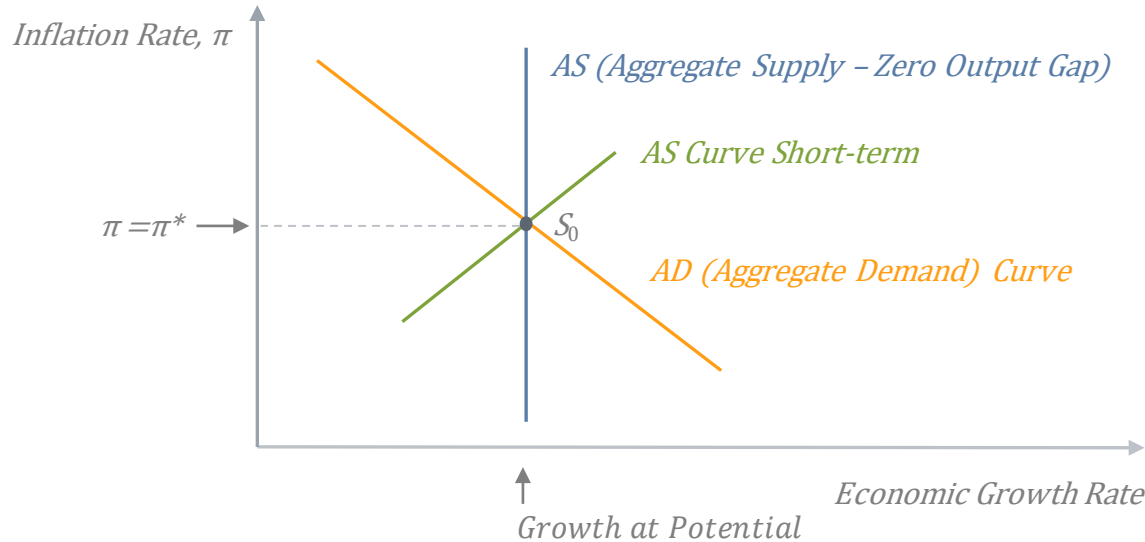
A Brief History of the COVID-19 Economy

From demand shock to supply shocks, followed by inflation-fighting

A Brief History of the COVID-19 Economy – Stylized



The economy in equilibrium (pre-pandemic)



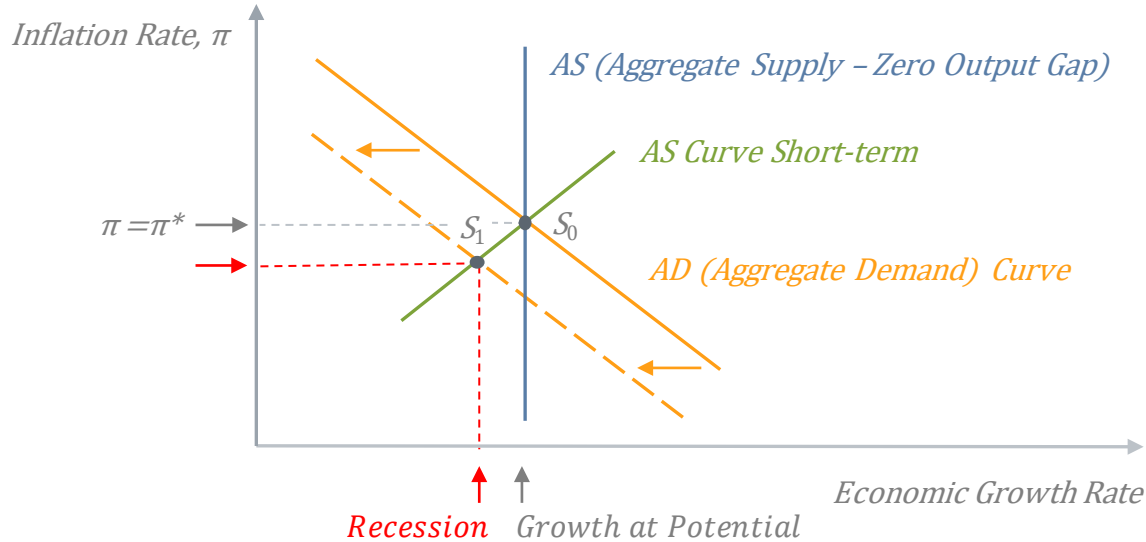
In S_0 , the economy operates at full potential and the central bank achieves its inflation target π^* . Real potential GDP growth is determined by the state of technology, the stock of natural resources, and the available physical and human capital stocks.

In introductory macroeconomics textbooks, the AD and AS curves are typically drawn as functions of the price level (as opposed to the rate of inflation) and real GDP (as opposed to the growth rate of real GDP). The Aggregate Demand curve depicts the relation between the growth of aggregate demand for goods and services and the rate of inflation at a growth rate of money supply that is in line with the inflation target and the growth rate of potential real GDP. At such a neutral growth rate of money supply, a higher rate of inflation is compatible with lower real economic growth only, all else being equal. For a real short-term rate of interest in line with the neutral growth rate of money supply, IS (investment and savings) and LM (liquidity preference and money supply) are in equilibrium along the Aggregate Demand curve. A change in monetary (or fiscal) policy stance moves the Aggregate Demand curve to the right (if expansionary) or to the left (if contractionary). The slope of the short-term Aggregate Supply curve is based on the Philips curve argument that wage inflation trails general inflation on the timeline, allowing for the economy to operate above potential short-term.

Adverse Demand Shock



The early months of the pandemic – adverse demand shock

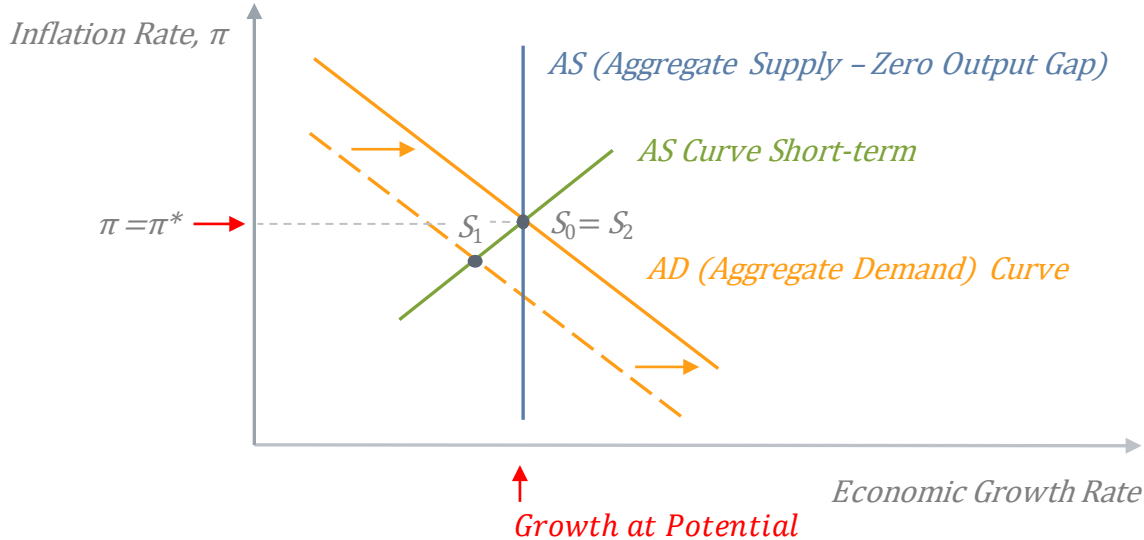


As the pandemic took hold in early 2020, consumer spending dropped, causing a shift in the *Aggregate Demand Curve* to the left. The rate of economic growth declined, and so did the rate of inflation. The economy moved to S_1 from the original state S_0 , entering a recession (which lasted from February to April 2020, peak to trough of economic activity).

Fiscal Stimulus With Monetary Accommodation



The U.S. fiscal response to the COVID-19 pandemic amounted to \$5.2 trillion

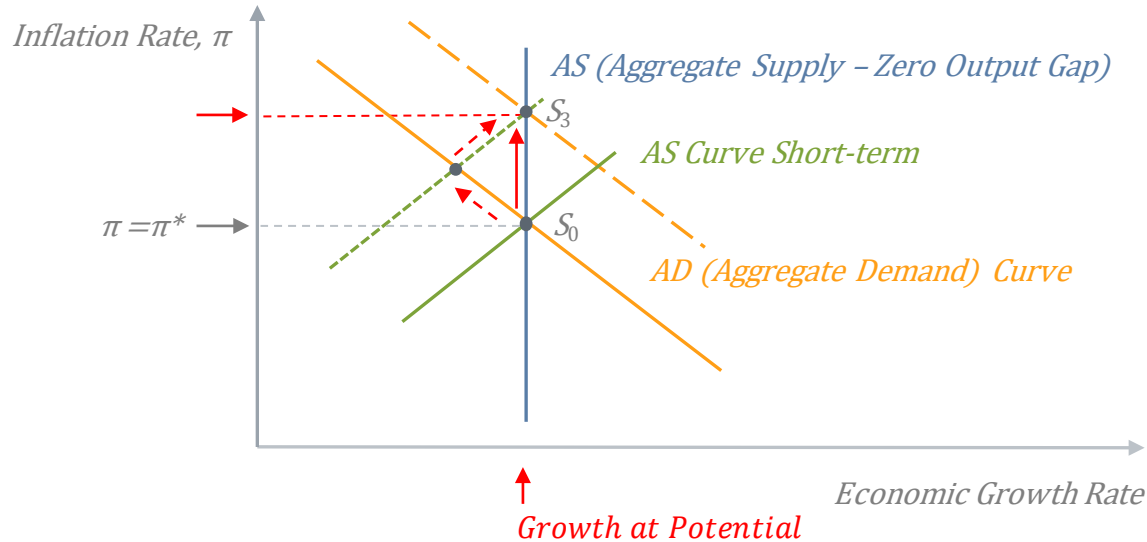


Fiscal expansion accommodated by monetary easing shifted the *Aggregate Demand curve* back to its original position S_0 .

Adverse Supply Shock Due to Supply Chain Disruption



As the rate of inflation increased, Fed monetary policy turned inadvertently expansionary



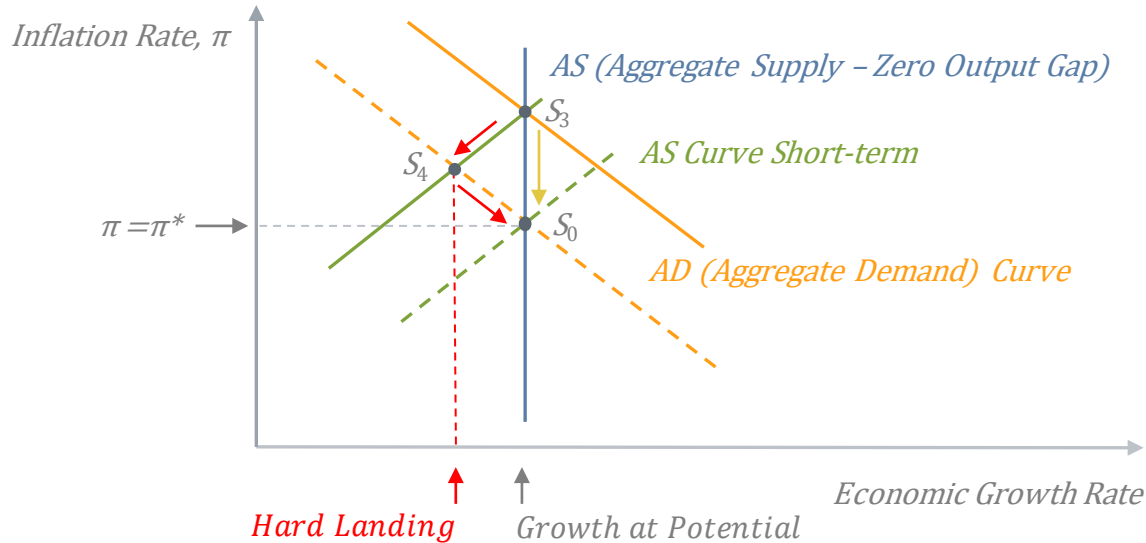
Supply chain disruptions caused an adverse supply shock, shifting the *Aggregate Supply curve* to the left, thus increasing the rate of inflation. As the Fed stood pat, the *real short-term interest rate* fell and money supply increased beyond target,¹⁾ shifting the *Aggregate Demand curve* to the right. Taken together, the economy moved to S_3 from S_0 .

1) The term "target" refers to an implied target as the Federal Reserve no longer explicitly targets monetary aggregates, relying on the federal fund rate as its main policy instrument instead. See Thornton, Daniel (2005) "When Did the FOMC Begin Targeting the Federal Funds Rate? What the Verbatim Transcripts Tell Us." Federal Reserve Bank of St. Louis *Working Paper* 2004-015B, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=760518.

Soft Landing or Hard Landing?



Fighting inflation may come at the expense of a recession – the hard landing



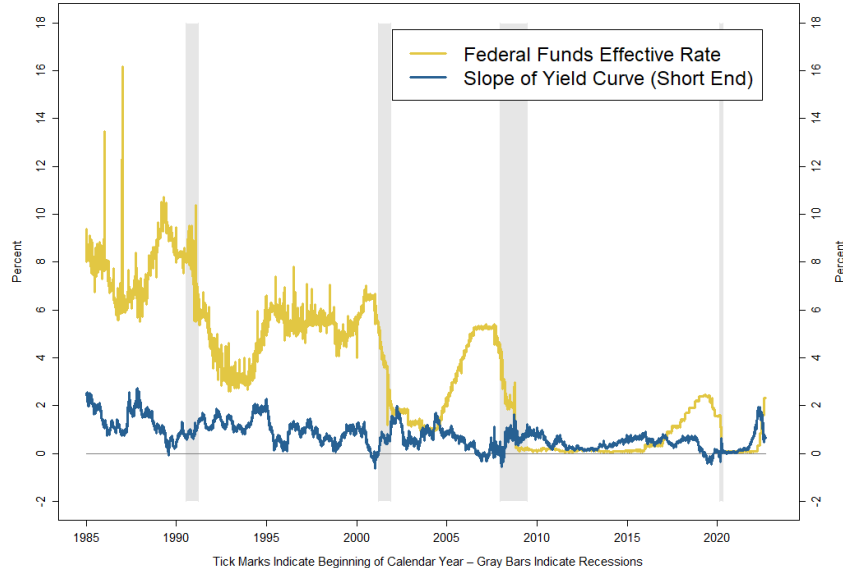
Fed tightening shifts the *Aggregate Demand curve* to the left. A soft landing (golden arrow) is a trip from S_3 straight back to S_0 . A hard landing (two red arrows) is a trip to S_0 via S_4 , involving a major economic slowdown and possibly a recession along the way. The inflation-fighting that Federal Reserve chairman Paul Volcker embarked on in late 1979 triggered a double-dip recession in the early 1980s.

In a hard landing, following the economy assuming state S_4 , the *AS Curve Short-term* moves to the right as slack in the economy (and the labor market) slows wage inflation and the labor market returns to equilibrium.

Monetary Tightening Increases Recession Risk



The Federal Reserve monitors the short end of the yield curve for recession risk



The short end of the yield curve informs on whether investors believe that the Fed will reverse course on monetary tightening to fight off an impending recession.¹⁾

Specifically, Federal Reserve research points to the spread between the 3-month Treasury rate 18 months forward and the current 3-month Treasury rate as an indicator of recession risk.²⁾

Past yield curve inversions (as indicated by a negative slope) were followed by recessions.

Sources: (1) Nasdaq, U.S. Treasury Zero-Coupon Yield Curve, daily, continuously compounded, accessed on September 4, 2022, <https://data.nasdaq.com/data/FED/SVENY-us-treasury-zero-coupon-yield-curve>. Latest observation: August 26, 2022. (2) Federal Reserve Bank of St. Louis, Federal Funds Effective Rate, DFF, daily; 3-Month Treasury Bill Secondary Market Rate, Percent, DTB3, daily; accessed on September 4, 2022, <https://fred.stlouisfed.org/>. Latest observations: September 1, 2022.

Note: The federal funds rate is the rate at which depository institutions trade federal funds (balances held at Federal Reserve Banks) with each other overnight. The Federal Reserve started using the federal funds rate as its main policy instrument in October 1982. The main components of the long Treasury yield are expected inflation, expectations about the future path of real short-term interest rates, and a (potentially negative) term premium.

1) Jon Hilsenrath (April 2, 2022) "Economists Seek Recession Clues in the Yield Curve." *Wall Street Journal*, referring to comments by Federal Reserve Chairman Jay Powell at the 2022 NABE Economic Policy Conference on March 21, 2022, https://www.youtube.com/watch?v=p_kGjqO7KLY (final two minutes).

2) Engstrom, Eric C., and Steven A. Sharpe (March 25, 2022) "(Don't Fear) The Yield Curve, Reprise", <https://www.federalreserve.gov/econres/notes/feds-notes/dont-fear-the-yield-curve-reprise-20220325.htm>.



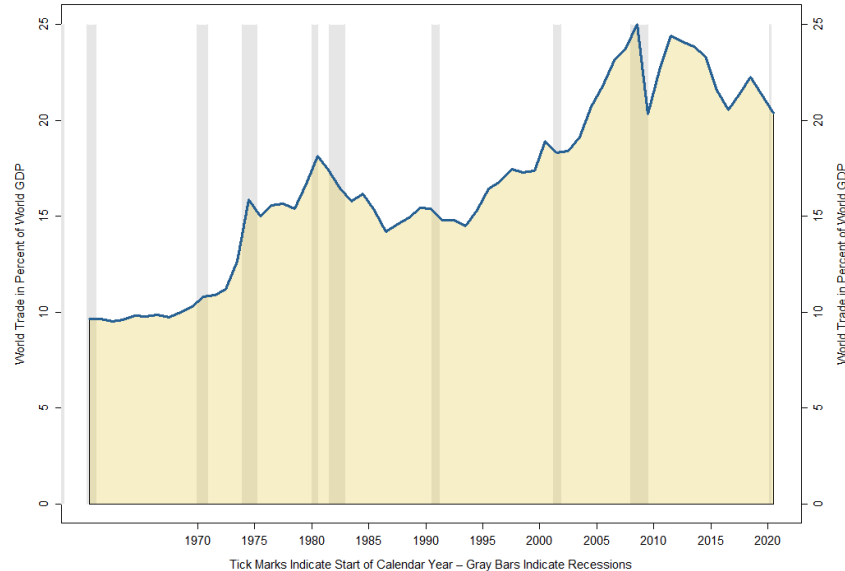
Foundational Challenges

Potential for continued inflationary pressure

The Process of Globalization Has Stalled



Following a recovery from the Global Financial Crisis, world trade has been on the decline



World trade is the result of international division of labor, which allows countries to focus their resources on what they are comparatively good at producing, and then trade these goods for what other countries are comparatively good at producing.

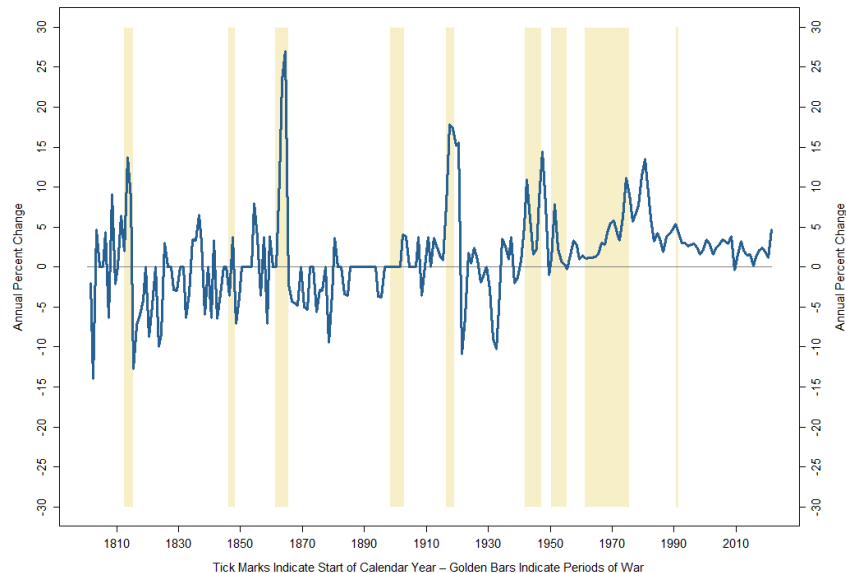
Increased division of labor generates favorable supply shocks, directly (via cheap imports and economies of scale for exporting firms) and indirectly (via increased competition, which drives process innovation and operational efficiency).

Sources: (1) World Bank, World Development Indicators: GDP in current U.S. dollars, World, accessed on March 16, 2022, <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD>. Annual data. Latest observation: 2020.
(2) World Trade Organization, World Trade, U.S. dollars, calculated as average of exports and imports, and excludes significant re-exports or imports for re-exports, accessed on March 16, 2022, https://www.wto.org/english/res_e/statis_e/trade_evolution_e/evolution_trade_wto_e.htm. Latest observation: 2020.

Inflation in Times of Military Conflict



Wars contribute to the rate of inflation, 1801-2021



Destruction and reallocation of resources to war efforts create scarcity.

Inflation spreads through world markets to countries not party to the conflict.

Note that the 1973/1974 spike in inflation during the Vietnam era was related to the first of two oil price shocks, the second of which occurred in 1978/79.

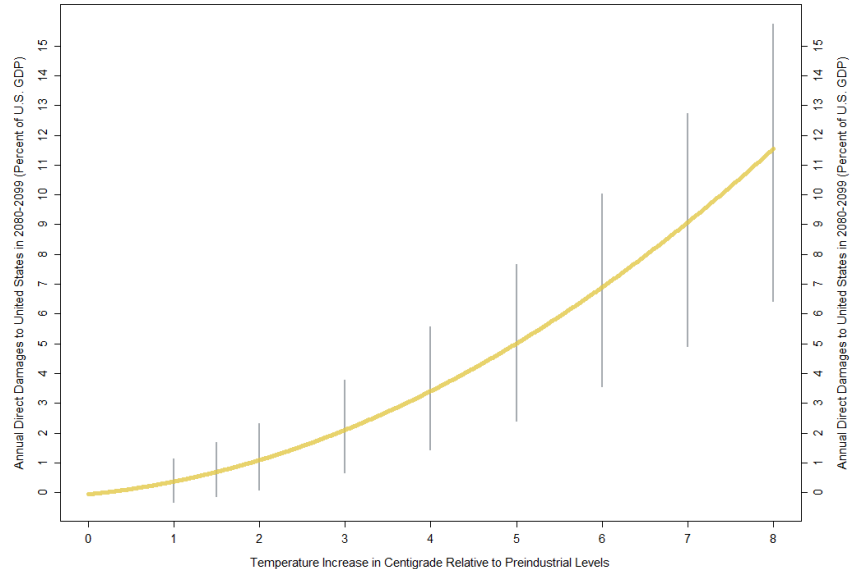
Shown are the War of 1812 (1812-1815), the Mexican-American War (1846-1848), the Civil War (1861-1865), the Spanish-American War (1898-1903), the Mexican Border Period (1916-1917), World War I (1917-1919), World War II (1942-1947), the Korean Conflict (1950-1955), the Vietnam Era (1961-1975), and the Persian Gulf War (1991-1991).

Sources: (1) For inflation data, see earlier chart. (2) Congressional Research Service (all war dates except War of 1812, Mexican-American War, and Civil War), *U.S. Periods of War and Dates of Recent Conflicts*, Updated June 5, 2020, <https://crsreports.congress.gov/product/pdf/RS/RS21405/28>. (3) Wikipedia (War of 1812), https://en.wikipedia.org/wiki/War_of_1812. (4) Encyclopedia Britannica (Mexican-American War), <https://www.britannica.com/event/Mexican-American-War>. (5) Library of Congress (Civil War), *Abraham Lincoln and Emancipation*, Timeline, <https://www.loc.gov/collections/abraham-lincoln-papers/articles-and-essays/abraham-lincoln-and-emancipation/timeline/>.

Climate Change



High annual damage inflicted by climate change is likely to contribute to scarcity



- Agricultural yields
- Human mortality
 - Adverse impact on mortality in current warm locations outweighs favorable impact in current cold locations
- Energy expenditures
- Coastal damage
- Property crime
- Violent crime

Note: The vertical lines represent 90 percent confidence intervals around the central estimate for a given temperature increase. Costs associated with mitigation are excluded.

See Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen, Robert Muir-Wood, Paul Wilson, Michael Oppenheimer, Kate Larsen, and Trevor Houser (2017) "Estimating Economic Damage from Climate Change in the United States." *Science* 356: 1362–69. Supplementary material available at <https://www.science.org/doi/10.1126/science.1235367>.



Thank you!

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