Athens Journal of Business & Economics 2025, 11: 1-32
https://doi.org/10.30958/ajbe.X-Y-Z

Understanding Inflation through Investigating US Economic Data over Fifty Years: Introducing the Losses Model

*By Hemmat Safwat**

Since 1988, the author has investigated the analogy between Macroeconomics and Macrohemodynamics. He progressively established a close relation between Knowledge and Energy leading to deal with knowledge in terms of the commonly used unit for energy Joule or kWh. After these endeavors the author decided to tackle inflation. He chose to investigate the US economic data between 1971 to 2024. For Inflation CPI, the influences of the Personal Consumption Expenditure PCE, Interest Rate, and Unemployment Rate were examined for intervals involving the seven formally recognized recessions encountered between 1971 to 2024. The author identified intervals outside the recessions which are referred to as Eras. The durations of both the recessions and the Era's intervals come into play as well. Some explanations were reached but some observed behaviors proved too complex for the recessions. For the 7 recessions intervals, and the Era's which were subdivided into two, i.e. total of 21 intervals, for each interval key data were selected, these subsequently assigned to 54 years in preparation for a second step simulating "calculated CPI". The author stipulated that the calculated CPI leads to end-losses at the level of end consumers. These annual end-losses in monetary values were converted to equivalent electrical energy using a recently introduced KEI (Knowledge Energy Index). The author argues that the end-losses cannot be recovered completely, and their cumulative effect form an ever-increasing trend.

Keywords: *Inflation, Consumer Personal Expenditure, Consumer Price Index, Recessions, Losses, Sustainability*

Preamble

It may be useful to learn how the author got started and continued his research in economics. It all started in 1987, when he took a course in economics as part of his MBA classes. In that course, he observed that the indifference curves shown on Price - Quantity diagrams for different utility levels had the same shape of isothermal (constant temperature) or isentropic (constant entropy) lines in PV Pressure – Volume diagram in Macro thermodynamics. He discussed this observation with professor Dr. Ibrahim Oweiss (a recognized economics expert and Economics professor at George Town University) and the two commenced investigating the analogy between Macro-economics and Macro-thermodynamics. That collaboration resulted in publishing Safwat HH, Oweiss IM (2002). The reaction to this book from the economics community was not encouraging. The author got busy with his job until he retired in late 2020. He embarked on his second concerted effort in economics investigations. He concentrated on business economics, and unfortunately, he did not have the support of his partner

*Director, Consultant, Greece.

Dr. Oweiss. So since late 2020 he carried out his economics investigations on his own producing *Safwat HH (2022)* and *Safwat HH (2024).* Recently, the author intensified search for previous published work in area of Macro-economics and Macro-thermodynamics combinations and found in Samuelson's Collected scientific Papers of *Samuelson PA (1983)*. Thus, the author got more emboldened and decided to venture in investigating a key topic in economics that is **inflation**. The question is **what can explain the continued rise in cost of living with time as we see it and continue to face.** The author hopes that this paper gives plausible explanations to this question.

Introduction

In search for answers to the underlined question, the author decided to examine what he learned from Macro-thermodynamics, as start, he thought of possibility of extending "the End-losses" that the second law of Thermodynamics contemplates for thermal cycles to Macro-economics. Simply, based on the second law of Thermodynamics in any thermodynamic cycle, that involves a sequence of processes that return to the same original state, will see rejected energy – "End-losses". By analogy the first law of Thermodynamics addresses the balancing of mass and energy. Thus, in a complete thermal cycle the sum of energies leaving a system is equal to those entering minus any accumulation, (by virtue of returning to the original state). This would signify that the accounting principles that are used in Macro-economics which form the equalization of the sums of output and the input, i.e. is equivalent to the first law of Thermodynamics.

The author embarked on investigating this premise and this paper is the result of his endeavors. Before moving to present the content of this paper, the author wants to underline an important finding related topic that is the knowledge energy index *Safwat HH (2025).* The relevance of this index is establishing a relationship of the human capital "knowledge" to electricity. The increasing trends of knowledge and electricity are well known to all concerned with the economic growth of a nation's economy. Against this background the author proceeded to tackle inflation in this paper, noting inflation is a primary topic in Macro-economics.

The paper is organized in three parts as follows, after the Introduction some relevant information that would help in explaining what led the author to use as bases to examine the premise that reject losses are behind inflation and some supporting info are noted. These convinced him of the merits to substantiate that premise. This information is found under Part I: **Relevant Information - From Electrical Systems, Work-Force Economic Cycle,** and **Human Capital and Energy.** Then, the paper's thrust shifts to the examination of pertinent US economic data between 1971 to 2024 in Part II. The aim here is to study inflation changes and key parameters that relate ultimately to the consumers consumption and the losses that can be encountered at end-consumers (households). Under Part II: **Study US Economic Data - Important Data**, **Review of US Data,** and**, Analysis of Select US Economic Data (1971-2024) with Focus on Inflation.** Accompanying the last section in part II, is the **Appendix** found at the end of the paper. In the Appendix

details of the analysis methodology of the select US economic data is described. Lastly, under Part III **Findings**, the following sections are found **Takeaway from the Appendix, Sustainability/Conservation/Waste,** and**, Concluding Remarks**.

Before moving to start Part I, the author would like to share three additional insights:

- The approach presented in this paper evolved after he explored several methodologies, some were based on published and others he devised. These had shortcomings. While these were useful, but they were not successful. Thus, they are not covered in the paper.
- The author elected to examine the economy of the USA over the last 50 years to understand what leads to the mysterious word "**inflation"**. Why the USA, because of the availability of excellent data as noted in the later parts of the paper. In the last 50 years, much better understanding of the complexities of the interactions of different parameters that affect inflation changes with time have been reached. To note the central role of the US's Federal Reserve Board "FRB" and Central Banks of nations, in setting the Monetary Policies and monitoring/taking necessary actions to control inflation to grow the economy and combat unemployment in timely manner. These bodies are supported by entities that compile and analyze data.
- When the author started reviewing available US economic data sources, he quickly saw the influence of the economic (business) cycles and hence it was imperative to examine the economic cycles associated with the encountered recessions in the USA between 1971 - 2024.

Relevant Information

From Electrical Systems

In this section, the author draws attention to two aspects that are crucial in the operation of the electrical systems (the grids in various countries), these are i) Supply and Demand, ii) Losses. The reader can refer to Safwat HH (2024) for two comparative diagrams of an electricity system and a products & services markets to see the similarities leading to analogous characteristics.

Electrical System and Demand – Supply

The electrical system (ES) has power generation subsystem consisting of power plants, and the other two subsystems transmission and distribution, through the latter end-consumers are connected. At a given instance, the various consumers (industrial, commercial and residential) get the electricity they need. The demand is the summation of what the consumers require at this time. On the side of the power generation that is the supply side, through the dispatch system of the power grid, the various power plants in the generation subsystem are operated depending on plants readiness, and capacities and efficiencies at the appropriate load (as close as possible to full load of the plant) in accordance with merit priorities established by the dispatch center.

This is the process to cope with the demand from the supply assets. One can refer to this aspect as coping with the mismatch of the aggregates of the supply and the total demand at a given instant. The controls from the dispatch center of the electrical grid and the generation plant use signals from the voltage and the synchronous speed of the network to adjust the controls of the generating plants including possible shutdown and start-up of generation units connected to the grid. Noting, that the dispatch center required the power plants to maintain a running reserve to respond to any sudden/unexpected increase in the demand. Historical data help the dispatch center to forecast possible future scenarios.

In this paper, we are concerned with Macroeconomics, thus we are dealing with the aggregate of the goods and services for a nation. In the big picture, this aggregates of the supply and demand, adjust based on the actions of the central bank, in the US these actions are by the FRB that beside setting the monetary policy. The FRB adjusts mainly the interest rate, and the money supply.

To note, that in recent years, with increased renewable energy in the generation mix in an ES to cope with the intermittent wind or solar energy, electricity storage e.g. in battery's took an increasing role in the ES, this is analogous to warehousing compared to use of ju-in-time production in products markets.

Comparing a nation's economy to ES operation, in the ES, we deal with one commodity that is electricity and the demand – supply is monitored and controlled based on momentary/instantaneous changes in the grid. In the case of the nation's economy, the aggregate demand and supply are much more complicated because of the variety of the goods and services, and we are generally concerned with much longer time to monitor the changes, e.g. the Consumer Price Index "CPI" over a month or quarter.

Electrical System – Energy-Losses

As noted earlier a typical ES consists of three subsystems, generation, transmission and distribution. The generation is primarily the power plants, the transmission included high voltage transmission lines and substations, and the distribution includes medium voltage substations and cabling to the end consumers. In recent years this delineation has changed because of the spread/increase of renewable energy, solar and wind power plants that have been installed closer to the consumers thus now distribution subsystems include generation and in some instances for large renewable plants they connect to the transmission subsystems. This change has altered the previously known unidirectional flow of electricity from the generation subsystem to the transmission then to distribution subsystems.

There are inherent energy losses in the transmission and the distribution subsystems (losses at substations and cables) as well as in the power plants in the generation subsystem. These are referred to technical losses. In some cases, there are an illegal (thefts) of electricity. The principals of the subsystems (the operators) attempt to minimize these losses in the design of the assets and through operation and maintenance activities as well a security measures. In the power plants, the highest efficiency is targeted but typically the plant design has one best efficiency set point and the operation dictates different points of operation depending on the demand, the off-best efficiency operation leads to higher losses. In the transmission

and distribution subsystems, depending on the economics the sizing of the cables and substations is also commensurate to best operation rating, However, the assets operate at different modes and hence there are larger losses. The principals of the generation, transmission and distribution try to minimize the losses to lower their tariffs. When we get to the end consumers, e.g. a household there are inefficiencies of old appliances that may be in use. In many cases the end customers are not pay attention to reducing their consumption particularly when the electricity prices are not high. This is why in different countries energy conservation is receiving considerable attention. From the perspective of the end customer, the household is paying indirectly for the losses at the ES subsystems. The thrust of ES subsystems operators is to minimize their costs to offer best tariffs. The losses at the end customers are difficult to estimate but on the aggregate level, the losses at the end users add up and have a negative effect. These losses end up as wasted energy to the surroundings. These losses cause unwanted effects to the environment, particularly if the electrical energy was generated from fossil plants. By analogy in the nation's economy, there are losses in the various steps, in the chains of the manufacturing, transport, and storage in the whole sellers and distributors etc. These losses are factored in the prices of the intermediate steps and hence they are indirectly born by the end customer. The sustainability programs in different countries target reducing the losses that are mentioned above whether in the ES or by analogy in the goods and services chains of production the incentives of the market as producers are competing on price. The losses at the end customer are more complex. Factors such as discipline, habits, proudness, income levels etc. come into play. The word waste stands out. From this point, onwards we shall use the term "End-Losses"

Work-Force Economic Cycle

It is interesting to see the workforce in an economy of a nation, individuals of the workforce are engaged in successive cycles, the cycle is composed of activities the workforce engages in their daily work that result into goods and services. And the cycle is completed when they and their households buy and consume goods and services. In an economy of nation, the first set of activities relate to the Gross Domestic Product (GDP), Gross National Product (GNP) and Gross National Income (GNI). While the latter is associated with the consumption Consumer Personal Expenditure (CPE). The author chose to use the word cycle as the we have a repetitive set of activities in the production and consumption sides over periods days or weeks etc. Noting the well-known formula for the four parts of the GDP

$$\mathbf{GDP = C + I + G + NX}$$

Where "**C**" is *Personal Consumption Expenditure* (goods and services people buy), "*I*" *Investment*– Business spending on fixed assets and unsold inventory as well as purchases of homes, **G** *Government Spending* Federal, State and Local governments spending in goods and services, **NX** *exports minus imports*.

This paper aims to investigate ultimately what happens with CPE and ultimately End-Losses in relation to inflation. The G an NX are not investigated.

Human Capital and Energy

Based on his review of price data for labor and electricity in the US and Europe the author recently proposed a Knowledge Energy Index (KEI), Safwat HH, (2025). This index reflects high values in the ratio of the average wage per hour to the electricity price per kWh. This suggests that the value of the labor which translates to application of knowledge is a lot higher than the value of electricity. Thus, knowledge has many folds higher value than electricity, and we know among energy forms electricity has the highest grade of energy (e.eg. fuel energy) because of it offers versatile utility.

This conclusion is essential to the treatment of the value added by the working population in a nation as a high value (grade) energy.

Application of the Newly Introduced Knowledge-Energy Index

From Safwat HH, (2025), for the US, in 2024 the KEI is approximately 200. This means that what human capital constitutes is more precious than electricity. Thus, the addition of knowledge by the humans does not follow what we encounter in thermal cycles when we are dealing with conversion of thermal energy to electricity. The human capital is knowledge which has higher grade than electricity.

In view of the KEI the author concentrated on examining the waste (End Losses) at the end customers as the main reason for the inflation. The following supported this notion:

a) Figure 1 (in Part II) represents the US Consumer Price Index "CPI" –this is the central parameter this paper is dealing with. We all know that due to inflation, we see the price of what we buy from goods and services is always increasing with time. Conversely stated, the same amount of money buys less goods/services. This is of paramount importance for the discussions of this paper.
b) From Macro-thermodynamics, we know that in actual processes, irreversibility's cause increase of entropy (defined (dQ/T), where dQ is change in heat units' energy and T is the absolute temperature. The author argues that in an enterprise, the tasks are combination of Knowledge & Energy application. Please refer to the Knowledge & Energy pair model Safwat HH, (2022). Without going into entropy changes and exergy (specialized topics in thermodynamics), it suffices to say that the rejection of very large heat (reject losses) from various power plants contribute to the increase of the temperature of the receiving body, what was perceived as an infinite body of waters in the earth, is not so when the heat rejected is very excessive.

Study US Economic Data

In this section, we cite important information from the US economic data that sets the stage for the presentation of what the author is offering through this paper.

Five parameters are included: **US Consumer Price Index CPI,** US M1 Money Stock, US Velocity of M1, US Federal Funds Effective Rate, and US Unemployment Rate. The first is central to the topic of the paper. the "CPI". Changes of the four other parameters influence the CPI changes. Other factors come into play indirectly or directly in secondary effects, but their mention is deferred to later.

Figure 1. *US Consumer Price Index US Federal Reserve Bank St.Louwis (n.d.)*

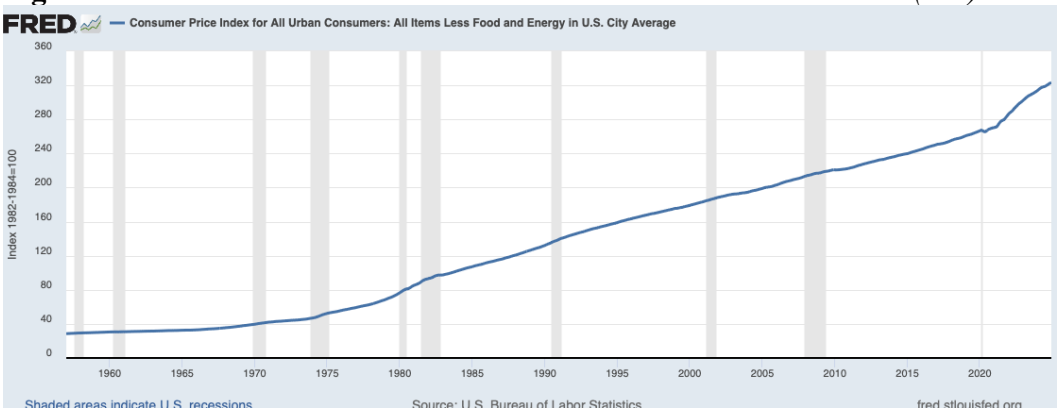
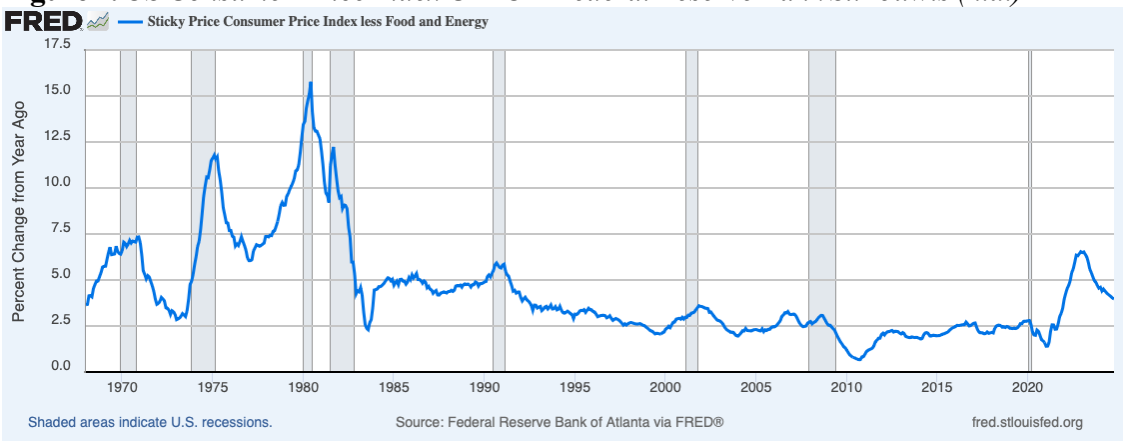


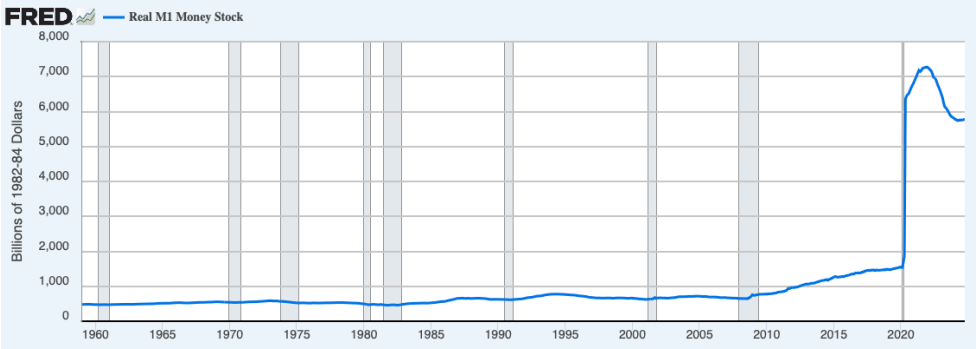
Figure 2. *US Consumer Price Index CPI UD Federal Reserve Bank St.Louwis (n.d.)*



Please note the shaded (grey) areas in Figure 2 and the following Figures 3, 4, 5 and 6 depict the formal recessions as endorsed by *National Bureau Economic Research (n.d.)*

In Figures 2 – 6, the durations in the figures represent the formally accepted recessions durations *National Bureau Economic Research (n.d.)*. Of interest for this paper are the seven recessions encountered after 1970 appearing in these figures. Just a comment about recessions, generally they are shocks that are encountered due to major event – could be like in 1973 due to oil embargo as a result of a political action(s), or in the case of the COVID 19 an epidemic. Major Climate disasters may cause of a start of a recession. The government and the central bank try to cope with these shocks to dampen their effects on the well-being of the nation's citizens.

Figure 3. *US M1 Money Stock UD Federal Reserve Bank St.Louwis (n.d.)*



In Figure 3, the extra-ordinary injection of funds in 2020 is noted with the steady gradual rise in M1from 2010 prior to 2020. M1 peaked around 2022 before starting to drop. The excessive high increase in 2020 is noted.

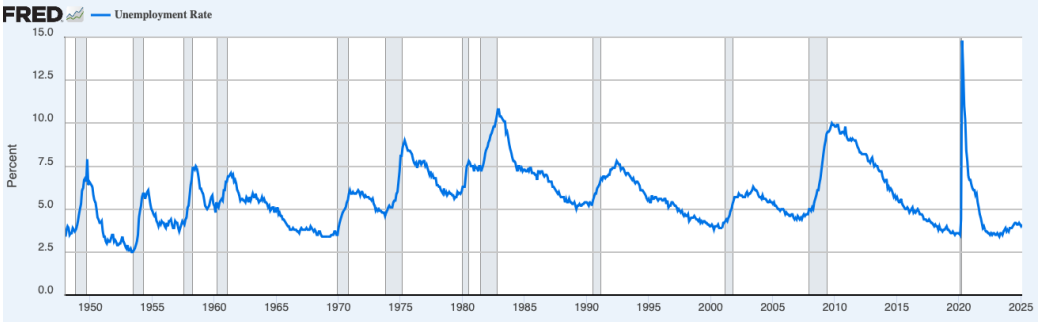
Figure 4. *US Velocity of M1 UD Federal Reserve Bank St.Louwis (n.d.)*

Referring to Figure 4, one notes the decrease in the Velocity of M1 during the recessions except for slow increase in the recession around 1974.

Figure 5. *US Federal Funds Effective Rate UD Federal Reserve Bank St.Louwis (n.d.)*

Figure 5 is a very important tool the FRB deploys to deal with inflation. Note that in recent years the FRD used slower pace in introducing changes in the interest compared to the time before 1990.

Figure 6. *US Unemployment Rate UD Federal Reserve Bank St.Louwis (n.d.)*



In Figure 6, we see the sharp increase in unemployment rate during recessions. The rise in unemployment due the COVID 19 crisis was extremely sharp in 2020.

Now we concentrate on evaluating the end-losses of the economy of a nation. If we start with the GDP and GNI we have what the aggregate of the workforces (the Labor) produces annually. Then if we look at the Personal Consumption Expenditure PCE, this is what the population spends, (the Population – the households (including the working population and associated members e.g. family). It is noted that PCE includes the earnings of working population plus the investments and others see below representative example Table 1 below.

The data found in *U.S. Bureau of Economic Analysis (n.d.),* was used to calculate the values shown in Table 1.

Table 1. *Example 2024 Per Capita Sources and Uses and Percentage of the Totals*

SOURCES	**SOURCES in $**		**Percentage of SOURCES %**	
INCOME		67,242.61		100.00%
FROM EMPLOYMENT		42,397.50		63.05%
ADDITIONAL SOURCES -e.	17,939.80		26.68%	
FROM GOVERNMENT	6,879.00		10.23%	

USES	**USES in $**		**Percentage of Uses %**	
INCOME	-	67,242.60		100.00%
Personal consumption		54,052.60		80.38%
Payments (taxes, Interest. Transfer)		10,449.60		15.54%
Personal Savings		2,740.10		4.10%

Recognizing that generally economics focus on the evaluating the input and the outputs of the production of a nation. The view suggested in this paper is to examine the utilizations by the households. There comes what is lost (wasted) or End-Losses between the PCE and what is utilized by the households.

We start by introduction of important parameters that the Federal Reserve Board (FRB) in the US monitors and uses in the decisions they undertake to steer the

economy as needed. The FRD takes steps to alter M1 (Figure 3), VM1 (Figure 4) and the federal funds rate interest Rate (Figure 5) with the obvious concern on Unemployment Rate (Figure 6). The parameters exhibited in Figures 3-6 play important roles in the movement of the CPI's direction (Figure 2)

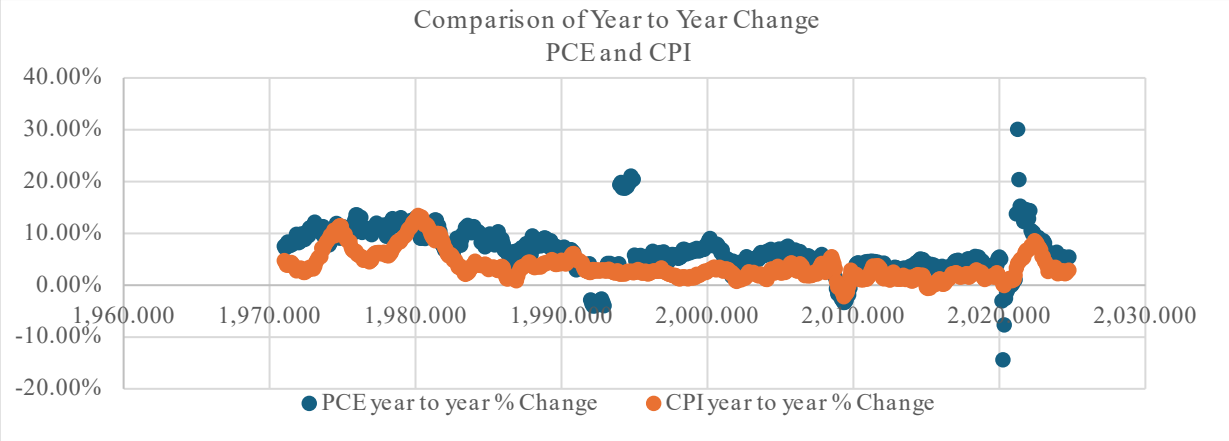
Figure 2 shows the large CPI values prior to recessions. Actions by the FRB leads to the reduction of the CPI, and the Interest rate of Figure 5 is a key parameter that the FRB uses. It is noted that since 2000 generally, the US was in a relatively low interest era till 2022. In this paper, the author opted to focus on the time between 1970 till now. Prior to this time, there were some recessions that were severe and of course the FRB has built on experience and learned lessons from the previous occurrences. The period between 1970 to 2024, there were seven recessions. The recessions cause changes in the trends of the economy. Prior to a recession – during a recession and after the recession. One notes that in the last three decades the FRB has managed to control recessions through monitoring and acting in a timely manner.

Review of US Data

In this section, we discuss select US economic data to gain insights on the working of the different economic indicators. The author chose the order of presenting these parameters as follows:

A. Under A., the PCE and CPI year to Yer Changes represent the spending of the consumers PCE and the changes in the CPI. This is fundamental to the theme of the paper. Comparison of PCE and CPI Year to Year Changes

Figure 7. *Comparison of PCE and CPI Year to Year Changes 1970-2024*



The data shown in Figure 7 were calculated from the sources in *U.S. Bureau of Economic Analysis (n.d.),* https://www.bls.gov.*U.S. Bureau of Labor Statistics (n.d.),* https://www.bls.gov. The exhibited data are examined in detail in the Appendix. The values at about 1993 and 2020 warrant examination.

Table 2. *Seven Formally recognized Recessions between 1971 and 2024 National Bureau Economic Research (n.d.)*

Recession #	**Start**	**End**	**Duration Year**	Preceding Duration Year	**Duration Month**	Preceding Duration Month
Rec.1	1,973.92	1,975.17	1.33	12.83	16	154
Rec.2	1,980.08	1,980.50	0.5	4.92	6	59
Rec. 3	1,981.58	1,982.83	1.33	1.08	16	13
Rec.4	1,990.58	1,991.17	0.67	7.75	8	93
Rec.5	2,001.25	2,001.83	0.67	10.08	8	121
Rec.6	2,008.00	2,009.42	1.5	6.17	18	74
Rec.7	2,020.17	2,020.25	0.17	10.75	2	129

The plots in Figure 7 show the year-to-year changes of the PCE and the CPI. As expected generally the PCE change leads the change of the CPI because the calculation of the CPI takes time from collecting the data to producing the results, this time has been reduced in recent years. The effect of the recessions can be seen considering the timings for the seven recessions shown in Table 2. Three recessions lasted about 1.5 year each. The most recent recession associated with the COVID 19 had the shortest duration (2 months). In Table 2, one can see the durations of intervals between successive recessions. Only a little over one year lasted between recessions 2 and 3. It is observed that outside the recessions the amplitude of the PCE year-to-year change is larger than the year-to-year change of CPI. The difference in the amplitudes is much less during the recessions. This is an important observation suggesting that during good times consumers spend more, that is expected and leads to increases of the spending and the waste at time of consumer confidence. However, there are other factors that come to play.

B. GDP & Gross National Income

Figure 8. *US GDP 1970 - 2024*

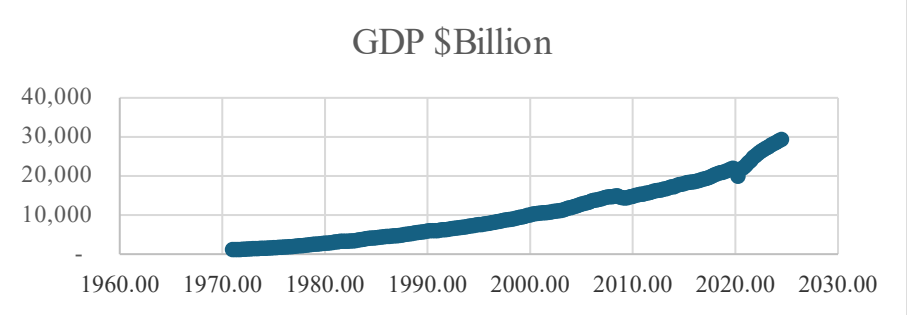


Figure 9. *GDP Year to Year Change*

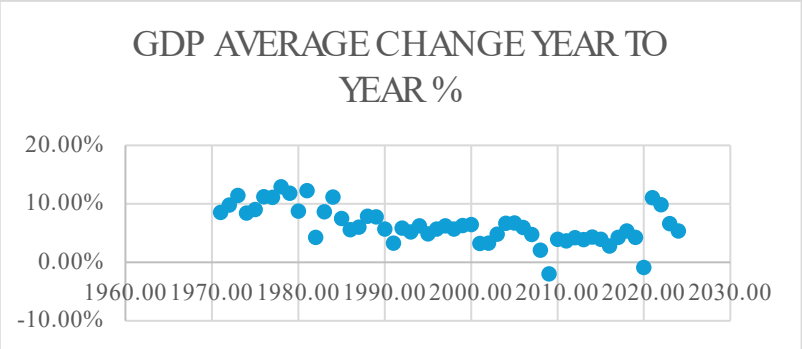
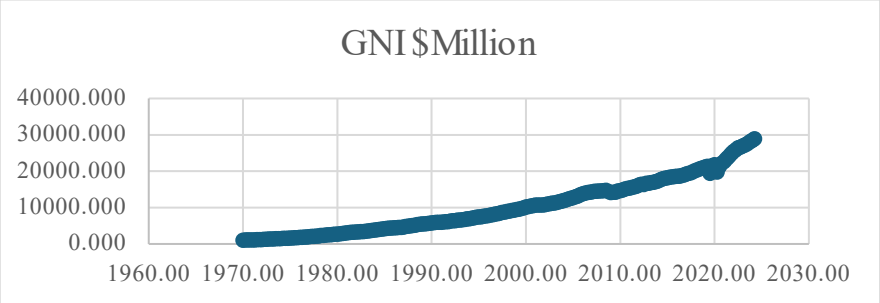


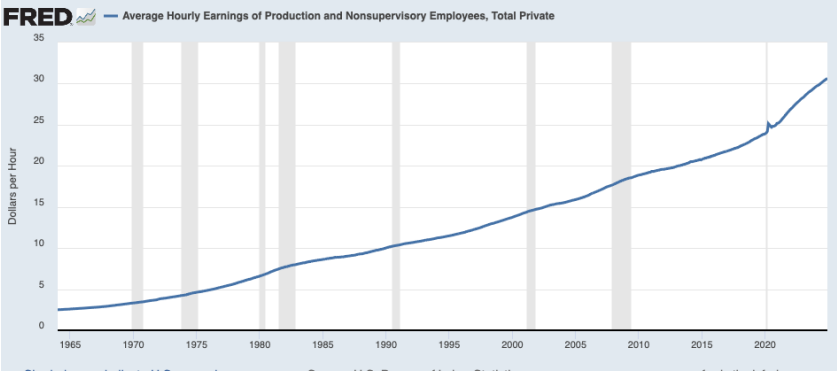
Figure 10. *US GNI 1970 -2024*



The plots in Figures 8, 9 and 10 show how the economy of the US has been doing over approximately 50 years period. The plots of the three Figures exhibit the same trends. Time of lower growth rates are reflected by milder slope, and strong economy is reflected by steeper slope. Innovations play a key factor in the steepness of the growth. Figures 8 and 10 show dips at approximately 2010 and 2020. The plot of Figure 9, it is interesting to see the year-to-year change in the GDP. A word of caution, is that the calculated values in Figure 9 are influenced by the averaging used by the author for quarterly or monthly data of the source data.

C. Average Wage

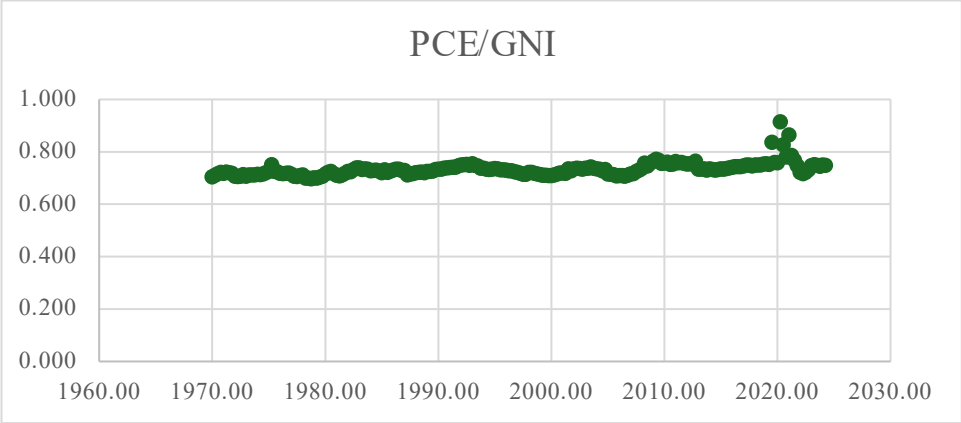
Figure 11. *Average Wage in the US in $/h. U.S. Bureau of Labor Statistics (n.d.)*



Referring to Figure 11, one sees that recessions temper the rising of average wage, prior to the recessions generally, the wages show steeper rise. Application of new innovations is accompanied by increase of the average wage. The observed dips in (2010) & (2020), Figure 8 and 10 also could be seen in Figure 11.

D. PCE and GNI

Figure 12. *Plot of Ratio of PCE to GNI*



The plot of the ratio between PCE and GNI is interesting. The ratio is approximately constant or lies in a small band, Again the unusual conditions of COVID 19 about 2020 shows extraordinary change (2020), The author notes, that other economic indicators are available among US data, e.g. the savings, and exports and imports. These parameters have indirect effect to the thrust of this paper and the author opted not to present them. Also, the effect of taxation is beyond the scope of this paper. Further elaboration on this is found under part III.

*Analysis of Select US Economic Data (1971-2024) with Focus on Inflatio***n**

The key data for the current analysis lie in PCE, and CPI for the time 1971-2024. In addition, the interest rate and the unemployment rate are included in the analysis. The recessions in this time are listed in Table 2, as noted before the recessions warrant close examination. Additionally, the data of the population and the ratio of the working force and population were also used in the analysis. For the CPE the per capita data was the starting point. The chosen data had the categories of goods and services expenditures. Please refer to the Appendix for the details of the steps used in analyzing the PCE data and application of the CPI data to the PCE data to estimate the end-losses from the end consumers. The methodology in the Appendix presents an interesting treatise.

Findings

Takeaway from the Appendix

Referring to Appendix, under step a, using derived PCE, CPI and Interest Rate presentations of 21 phases corresponding to 7 recessions and & Era.A and Era.B for the interval between two successive recessions, the durations of the intervals appear in the plate. Notes pertinent the observed trends appear on the right side of the plate. Recessions 4 and 7 show peculiar behaviors (hard to explain). The effect of the interest rate change can be seen. Increased interest rate leads to lowering the CPI one can say PCE leads CPI until the interest rate effect kicks-in. For the Era's the behaviors of the PCE and CPI are logical with the PCE value higher than that of the CPI. The trend of series (5) unemployment goes in the right direction as the interest rate is adjusted. A cautionary remark is to deal with intervals that show high standard deviations in the values. The outcome of step a, Appendix Tables 3.1 and 3.2 listing the CPI values for the various intervals together with duration of the interval. The objective of step b is to obtain approximates to full years durations of the calculated CPI values of Tables 3.1 & 3.2 of the Appendix. For the years of the study, 1970-2024, the data for annual PCE breakdown available for years 1997-2024 – Table 4.1 of the Appendix. Then the contents of this breakdown were expanded to years 1971 to 1996 through an approximate constant value of the % of the breakdowns (examples are in Table 4.2 of the Appendix). The last step c, of the Appendix involved assuming factors of losses in each category so that the losses sum would add to the CPI for that year as tabulated in table 4.2. These factors were selected to depict the end losses for the CPI of that year. To demonstrate the process, examples of how this process was handled are found in Table 4.3 of the Appendix. This process was then applied to all categories for all years between 1971-2024, Table 4.4 of the Appendix. Table 4.5 shows examples of the losses corresponding to the CPI of each year. Lastly Table 5.1 of the Appendix shows the losses by category that yield CPI value for the year between 2007 to 2024.

The bottom part of Table 5-1 of the Appendix is reproduced here as it captures the final results of the losses between 2007 to 2024.

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Population million	301.7	304.5	307.2	309.8	312.3	314.7	317.1	319.6	322.1	324.6	326.9	328.8	330.5	331.8	332.4	333.6	335.2	336.7
PCE $Billion	9,782	10,083	9,905	10,274	10,715	11,080	11,401	11,887	12,308	12,736	13,302	13,845	14,429	14,219	16,061	17,528	18,796	18,758
Losses $billion	*267*	*167*	*162*	*148*	*154*	*158*	*163*	*169*	*172*	*177*	*247*	*259*	*288*	*499*	*567*	*980*	*1,030*	*548*
Losses/PCE %	*2.73%*	*1.66%*	*1.63%*	*1.42%*	*1.44%*	*1.43%*	*1.43%*	*1.42%*	*1.40%*	*1.39%*	*1.86%*	*1.86%*	*1.96%*	*3.51%*	*3.53%*	*5.48%*	*5.48%*	*2.77%*
PRICE $/kWh	0.115	0.119	0.127	0.125	0.128	0.129	0.130	0.136	0.138	0.135	0.136	0.136	0.136	0.134	0.139	0.152	0.167	0.174
KEI	*181*	*180*	*174*	*180*	*179*	*181*	*183*	*180*	*180*	*190*	*192*	*198*	*204*	*217*	*218*	*210*	*200*	*199*
Losses GWh	2,323	1,403	1,276	1,172	1,205	1,229	1,249	1,246	1,244	1,312	1,815	1,911	1,972	3,718	4,088	6,330	6,165	3,135

Business Cycle Indicators

From *Wessels WE(2012), P. 618, e*ach month, the U.S. Department of Commerce publishes a series of economic indicators (three), including the widely followed leading indicator (10 components), coincident indicator (4 components) and lagging indicator (7 component) are designed, respectively, to lead, coincide, and

lag the business cycle. The need for all this data is clear as the FRB must have rigorous and complete set of data to make the appropriate decisions in the right time. This reflects the complexity of getting a good handle on the anticipation of a business cycle. The author recognizes the difficulties but through this paper he attempted to focus on what could be the main factors. To test his hypothesis (the premise of inflation is function of end-losses). He opted for the Interest rate, unemployment affecting CPI and CPE as outlined in part II and the Appendix.
ك

Other Parameters

An important factor that affects the GDP and hence the parameters that have been studies in this paper, is the National Debt, there is the obvious impact to now and the future.

Demographic changes and increase of the % of the work force of the population has bearing on many economic indicators.

Taxes, and incentives that induce the households to invest and save are obvious factors that influence the sources and uses per Table 1. Recognizing that there is a large element of how the public perceives the conditions these two factors is another level that also dependent on the strata (segments) of the society. For instance, some choose to invest in stock and other financial instruments, they follow the financial markets e.g. DJ, S&P 500, The financial markets provide a dynamic interaction of the wide spectrum of the components of the indicators of Business Cycles. Others, invest in Real Estate.

There are wide range of soft factors that affect the behaviors of the end customers and have a bearing on the end-losses, the interest in sports, recreation, travels and engagement in community activities. The influence of media, advertisements, and social media. Affluence and the careless attitudes influence end-losses.

- **Analogy of end-losses in Economy to end losses in an Electrical System.** In an ES, if we focus on the end customers, we see a financial negative impact on the end user that is not prudently watching his/her electricity consumption. The aggregate of the end losses means waste on the scale of the society and have an undesirable effect on the economy of the nation. And as have now been well recognized the unnecessary production of electricity is accompanied by undesired climate impact. If the generation of that extra electricity that could be avoided, is from fossil fuels, then we have deal with GHG (greenhouse gases) that we should avoid. There is a similar parallel in the economy that this paper brings upfront. A reduction of the end-losses means has an accompanying reduction of the avoided production that eventually goes to waste. This comes on the avoidable depletion of resources such as mined material etc.

Sustainability/Conservation/Waste

The increase in the end losses has undesirable effects and hence effort on various levels should be exerted to minimize the end-losses, that is part of the sustainability theme of the UN established - (2015). In the advanced economies, the findings noted

in the previous section point to the economic benefits and could lead to suggestions of ways to combat end-losses. In developing economies, the attention to reducing the end-losses could financial losses specially for the needy part of the society. Thus, programs that foster conservation and reduction of waste & perhaps the recirculation of waste.

Concluding Remarks

The following can be concluded:

1. The Knowledge Energy Index stipulating knowledge as a high-level energy, resulted in steering the author's thought process to focus on the end-losses at the end-consumers as the cause of inflation.
2. The analysis methodology of the Appendix enabled gaining insights for the interplay of key economic parameters during periods of business cycle. The methodology though relatively simple, still uncovered detailed characteristics. The methodology included some features to cope with unavailability of some data. If complete sets of economic data are available more refined results could be obtained. The methodology may be expanded for use in modeling for economic analysis.
3. The obtained results support or make the premise that end-losses are behind inflation plausible.
4. Taking the examination of what happens at the end customer, is not usually addressed in Macroeconomics. It is recommended to investigate the behaviors of households to quantify the end-losses. This can contribute to sustainability programs.

Acknowledgements

The author dedicates this work to the late Economics Professor Dr. Ibrahim Oweiss from George Town University who passed away in November 2023. Professor Oweiss collaborated with the author since 1988 as noted earlier in the paper. Dr. Oweiss was instrumental in the joint effort that produced the first book in 2002. Dr. Oweiss inspired the author to take on further work building on the 2002 book.

References

BEA (n.d.) Bureau of Economic Analysis, United States. Available at: https://www.bea.gov
BLS (n.d.) Bureau of Labor Statistics, United States. Available at: https://www.bls.gov
Board of Governors of the Federal Reserve System (n.d.) Federal Reserve Board. Available at: https://www.federalreserve.gov/default.htm
National Bureau of Economic Research (n.d.) Available at: https://www.nber.org

Samuelson PA (1983) Rigorous observational positivism: Klein's envelope aggregation, thermodynamics and economic isomorphisms. In: Adams FG, Hickman BG (eds) *Global Econometrics: Essays in Honor of Lawrence R. Klein,* pp. 1–38. Cambridge, MA: MIT Press.

Safwat HH, Oweiss IM (2002) *Economics: New Horizons, Shifting the Paradigm.* Word Association.

Safwat HH (2022) *Business Economics – Knowledge and Energy.* Word Association.

Safwat HH (2023) Business economics knowledge & energy – Capital KEC. *IntechOpen Business and Management Annual Volume 2023.*

Safwat HH (2024) How close are macro-economics/macro-thermodynamics? The knowledge & energy pair: Economics in the net zero era. *Athens Journal of Business and Economics.* https://doi.org/10.30958/ajbe.X-Y-Z

US Federal Reserve Bank of St. Louis (n.d.) FRED Economic Data. Available at: https://fred.stlouisfed.org

United Nations (2015) Transforming our world: The 2030 agenda for sustainable development. Available at: https://www.un.org/sustainabledevelopment/development-agenda/

Wessels WJ (2012) *Economics Business Review Books* (4th ed.). Hauppauge, NY: Barron's.

U.S. Bureau of Economic Analysis (n.d.) Available at: https://www.bea.gov

U.S. Bureau of Labor Statistics (n.d.) Available at: https://www.bls.gov

Appendix

Details of the Analysis Methodology

In this Appendix, the author presents the details of the methodology he used. He opted to include the ample details. He acknowledges that he uses in some instances judgmental assumptions, that can be subject to change, but nevertheless the author feels that different reasonable assumptions will not alter the outcome.

The analysis starts from published US economic data – sourced from FRED (n.d.), BEA (n.d.), BLS (n.d.). These are sourced data with superscript "s". The data that the author generated has superscript "d" for derived. The derived data include statistical data e.g. averages, standard deviation etc. In some instances, because of the lack of the source data he could not locate for some periods, he introduced some derived data based on approximate trends he could establish from the source data. A particular importance the author put on deriving year to year changes for CPE^s, CPI^s and FRB set Interest $Rate^s$. Depending on the available sourced data being monthly, quarterly, the author worked out the derived year to year changes. The relevance of the year-to-year changes of the three parameters CPE^s, CPI^s and FRB set Interest $Rate^s$ is clear from the discussions in the body of the paper. The derived year-to-year CPE^d, CPI^d and FRB set Interest $Rate^d$ are central for the analysis covered in this Appendix. As noted earlier in some instances, the author used select source data to establish trends of the behavior of some parameters compared to other parameter(s). Examples of these are found in Figure 7 in the body of the paper. The author, started from per capita source data and used the source of population and the working- force data to obtain the aggregate US economy values (totals) or vice versa to obtain per capita.

The author chose the period between 1971-2024 as it is the most recent and reflects what was learned over a relatively long time. The effects of recessions as noted in the discussions of the paper have profound impacts on the economic data, and hence the treatment of the derived year-to-year CPE^d, CPI^d and FRB set Interest $Rate^d$ have been divided to two types of periods i) recession periods, ii) normal economy growth- referred to as ERA's. For the recession period the official recession durations listed in Table 2 of the paper were expanded to include short times pre the official (formal) recession and post the formal recession. derived year-to-year CPE^d, CPI^d and FRB set Interest $Rate^d$.

The analysis proceeded in three major steps (A, B and C):

A. (Step 1) The data of CPE^s, CPI^s and FRB set Interest $Rate^s$ of Figures 7, 2 and 5 were investigated in detail with particular attention to the formally declared seven recessions in Table 1 of the main paper. Further, the Employment Rate (Figure 6) was added to complement the view of the three basic noted parameters. Since the data used in the analysis are per capita, an Adjusted Employment Rate was used to factor the working % of the population. For each of the seven formally recognized recessions the interval was expanded to include a pre and after recession times, the expanded recession period is referred to as Overall, (1, 2, 3, --, 7, refer to the seven recessions). Then in

between the overall recessions, a period rereferred to as Era was used. (I, II, III, ---VII, seven Era's). Further, the author recognized two phases in the Era's one following the Overall of the preceding, the other is designated by B prior to the start of the following recession. These Overall-recession noted by A and one prior to the next Overall=recession noted by B, these can be seen e.g. II.A and II.B respectively for Era II.

This step concluded with establishing the average values for each of the 21 periods (7 Overall recessions, 7 EraA and 7 EraB). For each period, the average values for the derived values of CPE[d], CPI[d] and FRB set Interest Rate[d] and Unemployment were calculated. These were supplemented with the Standard deviation values.

Recessions

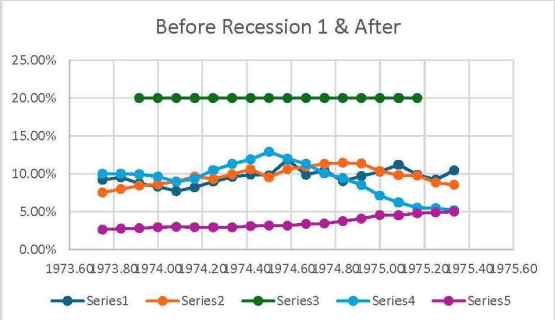
Plates 1-1 to 1-7, show the data for the 7 recessions. For each recession, the overall time was used as a basis, and in the plate for each recession one can see the table containing the key data for the recession. Tabular form at the top, Plots for the variation of key parameters is in the bottom of the plate. On the right side, of the table and the plot, supplementary notes have been entered with the aim of high lighting the different behaviors among the 7 recessions. Please note in the plot series (3) shows the formal duration of the recession.

Plate 1-1. *Recession 1*

Recession 1	Start	End	Duration	
			Years	Months
Overall	1973.75	1975.3	1.58	19
Pre.	1,973.75	1,973.92	0.17	2
Recession	1,973.92	1,975.17	1.33	16
After	1,975.17	1,975.33	0.17	2
OVERALL	PCE(1)	CPI(2)	Recession(3)	Interest(4)
Average	9.61%	9.69%		9.28%
STDEV	0.99%	1.15%		2.29%

(1) PCE, (2) CPI, (3) Recession, (4) Interest.

- Overall Duration 18 months, recession 16 months, short pre and short after.
- PCE and CPI are very close.

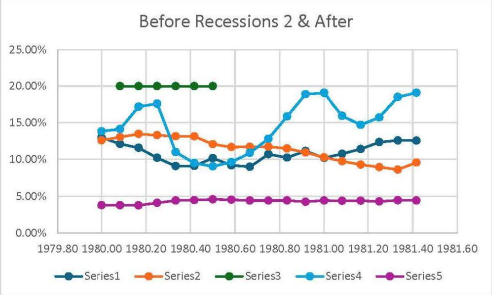


- Interest rate drops at the tail end and CPI starts to turn down.
- Unemployment Rate climbs at the later stage of the recession.

Plate 1 -2. *Recession 2*

Recession 2	Start	End	Duration	
			Years	Months
Overall	1,980.00	1,981.42	1.42	17
Pre.	1,980.00	1,980.08	0.08	1
Recession	1,980.08	1,980.50	0.42	5
After	1,980.50	1,981.42	0.92	11
OVERALL	**PCE(1)**	**CPI(2)**	**Recession(3)**	**Interest(4)**
Average	**10.84%**	**11.36%**		**14.63%**
STDEV	1.32%	1.63%		3.50%

- Overall duration 17 months, 1 month pre , and 11 month after.
- Average CPI higher than that of PCI.

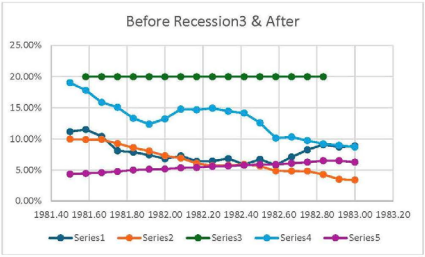


- CPI is lower than CPI early on, but changes to be higher later.
- Interest rate increased three occasions, two occurrences in after.
- Unemployment stays at the same level in after.

Plate 1 -3. *Recession 3*

Recession 3	Start	End	Duration	
			Years	Months
Overall	1981.50	1982.92	1.42	17
Pre.	1,981.50	1,981.58	0.08	1
Recession	1,981.58	1,982.83	1.25	15
After	1,982.83	1,982.92	0.09	1
OVERALL	**PCE(1)**	**CPI(2)**	**Recession(3)**	**Interest(4)**
Average	**7.86%**	**6.72%**		**13.37%**
STDEV	1.72%	2.09%		2.88%

- Overall duration 17 months, 1 month pre , and 1 month after.
- Average CPI larger than Average PCE.

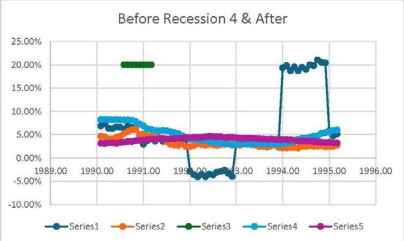


- Interest rate decreasing and then increased in the middle of the recession time, followed by decrease near the end of the recession
- Unemployment rate climbing up and flattens in after.

Plate 1 -4. *Recession 4*

Recession 4	Start	End	Duration	
			Years	Months
Overall	1,990.08	1,995.17	5.08	61
Pre.	1,990.08	1,990.58	0.50	6
Recession	1,990.58	1,991.17	0.67	8
After	1,991.17	1,995.17	4.00	48
OVERALL	**PCE(1)**	**CPI(2)**	**Recession(3)**	**Interest(4)**
Average	**5.92%**	**3.26%**		**4.90%**
STDEV	7.56%	1.07%		1.84%

- Overall duration 61 months, 6 month pre and 48 month after.
- Average PCE larger than Average CPI.
- STDEV for PCE is very high.

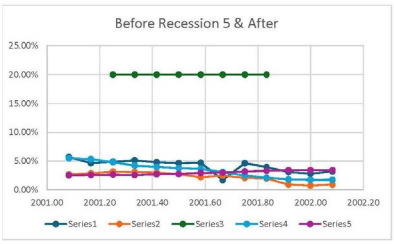


- The drop the CPE and increase during the after i is noted.
- The CPE, CPI and Interest rates as well as the unemployment rate are close for most of the time.

Plate 1-5. *Recession 5*

Recession 5	Start	End	Duration	
			Years	Months
Overall	2,001.08	2,002.08	1	12
Pre.	2001.08	2,001.25	0.17	2
Recession	2,001.25	2,001.83	0.67	8
After	2,001.83	2,002.08	0.25	3
OVERALL	PCE(1)	CPI(2)	Recession(3)	Interest(4)
Average	6.93%	2.28%		4.52%
STDEV	4.49%	0.62%		1.56%

- Overall duration 12 months, 2 months pre , and 3 months after.
- Average PCE is higher than average CPI.
- STDEV is high for PCE.

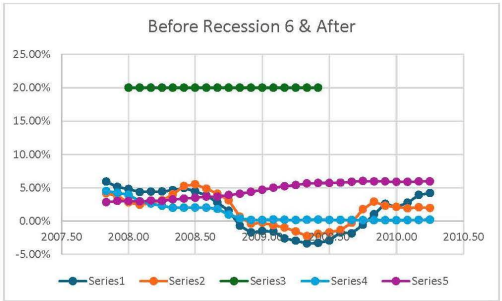


- Towards the end of the recession a dip in PCE.
- Unemployment rate flat and drops in after.

Plate 1-6. *Recession 6*

Recession 6	Start	End	Duration	
			Years	Months
Overall	2007.83	2010.25	2.42	29
Pre.	2007.83	2,008.00	0.17	2
Recession	2,008.00	2,009.42	1.42	17
After	2,009.42	2010.25	1.08	13
OVERALL	PCE(1)	CPI(2)	Recession(3)	Interest(4)
Average	1.43%	1.66%		1.15%
STDEV	3.13%	2.30%		1.39%

- Overall duration 29 months, 2 months pre , and 13 months after.
- Average CPI larger than Average PCE.
- STDEV is high for PCE, CPI and Interest.

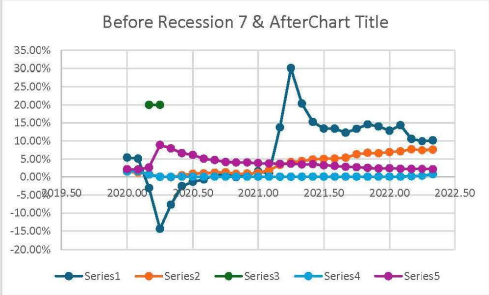


- PCE, CPI and interest rate drop in the latter part of the recession to negative values and then PCE & CPI climb in the after.
- Unemployment rate remains in the early part of the recess then climbs and tapers off later in after.

Plate 1-7. *Recession &*

Recession 7	Start	End	Duration	
			Years	Months
Overall	2020.00	2022.33	2.33	28
Pre.	2020.00	2,020.17	0.17	2
Recession	2,020.17	2,020.25	0.17	2
After	2,020.25	2,022.33	2.08	25
OVERALL	PCE(1)	CPI(2)	Recession(3)	Interest(4)
Average	7.01%	3.51%		0.24%
STDEV	9.34%	2.72%		0.40%

- Overall duration 28 months, 2 months pre , and 25 months after.
- Average PCE is higher than average CPI.
- STDEV is high for CPI

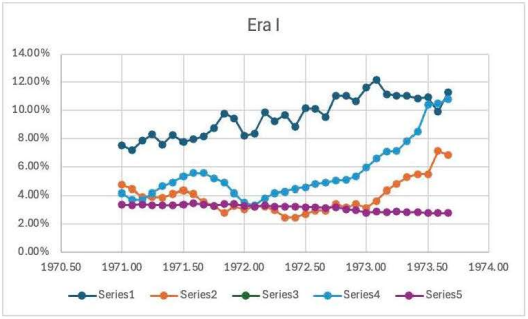


- CPE big drop just following the brief recession to large negative value, and hits a large value in early 2022.
- Unemployment rate tapers off in after.

Era's

In this section, the data for each of the Era's are exhibited for both Era.A and Era.B. Again. in Tabular form and plots showing the variations of the key parameters. On the right side and of the table, and the plots some notes are included. The times of Era.A and Era.B appear in the tables. The averages and STDEV for the Era.A &Era.B are in the tables.

Plate 2 -1. *Era I*



1:PCE, 2:CPI, 4: Interest, 5: Adjusted Employment Rate

- CPI healthy increase and tapering in last part of I.B
- Increased Interest and increase of CPI in IB
- Decrease in Unemployment rate through I.A and larger decrease in I.B

I	Start	End	Duration	
			Years	Months
	1971.00	1973.67	2.75	33
I.A	1971.00	1972.00	1.00	12
I.B	1972.00	1973.67	1.67	20
		PCE	CPI	Interest
I.A	Averages	8.21%	3.79%	4.57%
	STDEV	0.59%	0.59%	0.72%
I.B	Averages	10.43%	3.95%	6.22%
	STDEV	0.50%	0.50%	0.76%

- Duration total of 33 month
- I.A
  Averages PCE > CPI
  STDEV low compared to Averages
- I.B
  Averages PCE > CPI
  STDEV low compared to Average

Plate 2 -2. *Era II*

II	Start	End	Duration	
			Years	Months
	1975.42	1979.92	4.58	55
II..A	1975.42	1978.00	2.58	31
II.B	1978.00	1979.92	1.92	23
		PCE (1)	CPI (2)	Interest (4)
II..A	Averages	11.14%	**5.98%**	5.44%
	STDEV	1.02%	0.95%	0.64%
II.B	Averages	11.64%	**8.84%**	9.69%
	STDEV	0.81%	2.03%	2.08%

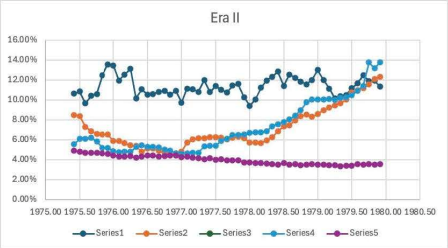
- Duration total of 55 month
- II.A

  Averages PCE > CPI

  STDEV low compared to Averages
- II.B

  Averages PCE > CPI

  STDEV low compared to Averages



- Fluctuating CPI in II.A & II.B
- Increased interest Rate and CPI in II.B
- Reduced unemployment rate in II.A and tapering down in II.B

Plate 2-3. *Era III*

III	Start	End	Duration	
			Years	Months
	1983.00	1990.00	7.08	85
III..A	1983.00	1987.00	4.00	48
III.B	1987.00	1990.00	3.00	36
		PCE (1)	CPI (2)	Interest (4)
III..A	Averages	8.57%	**2.90%**	8.51%
	STDEV	1.59%	0.99%	1.37%
III.B	Averages	7.51%	**3.98%**	7.86%
	STDEV	0.93%	0.53%	1.18%

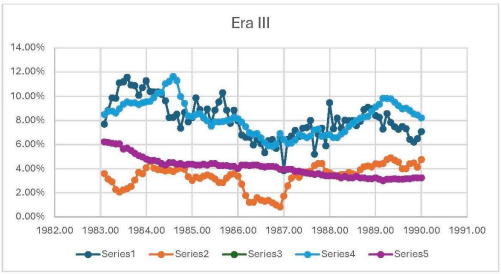
- Overall Duration 85 months
- III.A

  Averages PCE > CPI

  STDEV low compared to Averages
- III.B

  Averages PCE > CPI

  STDEV low compared to Averages



- PCE and Interest rate similar path in III.A & III.B.
- CPI drops as III.B
- CPI drops as III.B commencement is approached.
- Unemployment rate initially large and later small decreases in III.A, III.B

Plate 2 -4. *Era IV*

IV	Start	End	Duration	
			Years	Months
	1995.25	2001.00	5.83	70
IV..A	1995.25	1998.67	3.42	41
IV.B	1998.67	2001.00	2.33	28
		PCE (1)	CPI (2)	Interest (4)
IV..A	Averages	5.60%	**2.21%**	5.51%
	STDEV	0.60%	0.57%	0.22%
IV.B	Averages	7.20%	**2.50%**	5.54%
	STDEV	0.67%	0.70%	0.71%

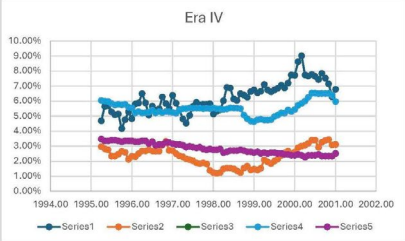
- Total Duration 70 months
- IV.A

  Averages PCE > CPI

  STDEV low compared to Averages
- IV.B

  Averages PCE > CPI

  STDEV low compared to Averages



- CPE fluctuating in IV.A but shows growth at the start of IV.B and tapering off later in IV.B.
- CPI fluctuating early in IV.A and decreasing later before it climbs up in IV.B.
- Interest held at a level in IV.A and then increased in IV.B

Plate 2 -5. *Era V*

V	Start	End	Duration	
			Years	Months
	2002.17	2007.83	5.75	69
V.A	2002.17	2004.75	2.58	31
V.B	2004.75	2007.83	3.08	37
		PCE (1)	CPI (2)	Interest (4)
V.A	Averages	4.63%	**1.87%**	1.40%
	STDEV	0.86%	0.49%	0.29%
V.B	Averages	5.95%	**2.74%**	3.52%
	STDEV	0.73%	0.80%	1.65%

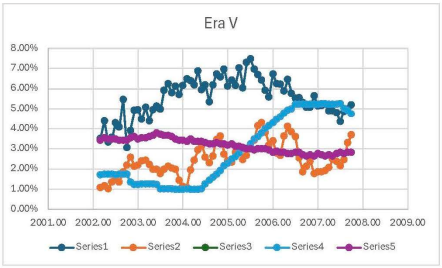
- Total Duration 69 months
- V.A

  Averages PCE > CPI

  STDEV low compared to Averages
- V.B

  Averages PCE > CPI

  STDEV low compared to Averages

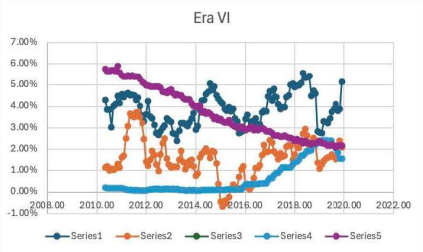


- PCE increase in V.A and drops in V.B
- CPI stays subdued in V .A and climbs in V.B
- Interest Rate increase in V.B

Plate 2 -6. *Era VI*

VI	Start	End	Duration	
			Years	Months
	2010.33	2019.92	9.67	116
VI.A	2010.33	2016.92	6.58	79
VI.B	2016.92	2019.92	3.00	36
		PCE (1)	CPI (2)	Interest (4)
VI.A	Averages	3.69%	**1.41%**	0.16%
	STDEV	0.64%	0.98%	0.11%
VI.B	Averages	4.30%	**1.96%**	1.66%
	STDEV	0.79%	0.43%	0.57%

- Total Duration 116 months
- VI.A
  - Averages PCE > CPI
  - STDEV low compared to Averages
- VI.B
  - Averages PCE > CPI
  - STDEV low compared to Averages

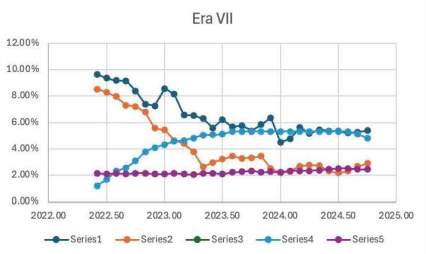


- Fluctuating PCE in VI.A & VI.B
- Fluctuating CPI with large drop as VI.B commences.
- Interest Rate increases at steep pace in V.I B
- Unemployment Rate continued decrease in Vi.A & VI.B

Plate 2-7. *Era VII*

VII	Start	End	Duration	
			Years	Months
	2022.42	2024.75	2.42	29
VII..A	2022.42	2023.42	1.00	12
VII.B	2023.42	2024.75	1.33	16
		PCE (1)	CPI (2)	Interest (4)
VII..A	Averages	7.86%	**5.48%**	3.64%
	STDEV	1.34%	2.02%	1.32%
VII.B	Averages	5.46%	**2.77%**	5.27%
	STDEV	0.47%	0.46%	0.14%

- Total Duration 29 months
  (VII.B still to continue beyond 2024)
- VII.A
  - Averages PCE > CPI
  - STDEV low compared to Averages
- VII.B
  - Averages PCE > CPI
  - STDEV low compared to Averages



- PCE & CPI decrease in VII.A and PCE flatten in VII.B.
- The interest rate increased in VII.A and flattens in VII.B
- Unemployment rate was flat and increased toward the end VII.B considered.

Notes

Excessive changes encountered in the CPE year to year, particularly in recessions and prior & after.

The CPI year to year shows large amplitude changes mainly in recessions and prior & after.

Long formal recessions longer approximately 1.5 year or longer.

Two short formal recessions with only a brief recovery. Formal recession 7 (COVID 19) was very short.

Year to year interest rate changes mostly exhibit small amplitudes.

The Adjusted Unemployment Rate year to year change generally has a slower pace.

Following a recession, the early part Era.A mostly has low CPI accompanied by lower interest rate compared to those before the recession. In the Era.B phase the CPI climbs.

Timeline & Preparation for inputs to the next step (2)

Based on the information of the recessions in Plate 1 and the Era's in Plate 2, the timeline for the period between 1971 to 2024 is compiled and is shown in Plate 3-1 with associated summaries.

From the data shown in plate 3.2, values for each year between 1971 to 2024 to be used in the simulations of the next step (4) is organized.

Plate 3-1. *Table showing the order of the 21 Intervals for the Recessions, Era'A's & Era.B's*

Phase	CPI	Start	End	Duration (years)
I.A	3.79%	1971	1972	2
I.B	3.95%	1973		1
Recession 1	9.69%	1974	1975	2
II.A	5.98%	1976	1978	3
II.B	8.84%	1979		1
Recession 2	11.36%	1980		1
Recession 3	6.72%	1981	1982	2
III.A	5.98%	1983	1987	5
III.B	3.98%	1988	1989	2
Recession 4	3.26%	1990	1994	5
IV.A	2.21%	1995	1998	4
IV.B	2.50%	1999	2000	2
Recession 5	2.28%	2001		1
V.A	1.87%	2002	2005	4
V.B	2.74%	2006	2007	2
Recession 6	1.66%	2008	2009	2
VI.A	1.41%	2010	2016	7
VI.B	1.96%	2017	2019	3
Recession 7	3.51%	2020	2021	2
VII.A	5.48%	2022	2023	2
VII.B	2.77%	2024		1

Plate 3-2. *Table showing the twenty-one Phases' Recessions, Era.A's & Era.B's in the increasing CPI*

Phase	CPI	Inflation Level	Start	End	Duration (years)
VI.A	1.41%	Very Low	2010	2016	7
Recession 6	1.66%		2008	2009	2
V.A	1.87%		2002	2005	4
VI.B	1.96%		2017	2019	3
IV.A	2.21%	Low	1995	1998	4
Recession 5	2.28%		2001		1
IV.B	2.50%		1999	2000	2
V.B	2.74%		2006	2007	2
VII.B	2.77%		2024		1
Recession 4	3.26%	Medium	1990	1994	5
Recession 7	3.51%		2020	2021	2
I.A	3.79%		1971	1972	2
I.B	3.95%		1973		1
III.B	3.98%		1988	1989	2
VII.A	5.48%	High	2022	2023	2
II.A	5.98%		1976	1978	3
III.A	5.98%		1983	1987	5
Recession 3	6.72%		1981	1982	2
II.B	8.84%	Very Hign	1979		1
Recession 1	9.69%		1974	1975	2
Recession 2	11.36%		1980		1

B. (Step 2) Data for main components of the Annual PCE per Capita for the year 1997 to 2022 together with CPI and Interest Rate are used to identify estimated losses at the end consumers from these components from the typical per capita expenditures. The estimates were calculated using assumed composition of the components for each period are shown in tables of Plate 4-5. The author was unable to find the comparable components for two periods 1971-1996, and for 2023-2024. Based on the nearly constant ratios of these components as can be seen from the second part of Plate 4, the author extended this to the split of these components for these periods from the data between 1997 and 2022, respectively.
The data in Plat 4-1, are merely the % of the components of the source data relative the PCE per capita.

Plate 4-1. *Weights of the components of the PCE for some years between 1997-2022*

									1997-2022	
#	Description	Unit	1997	2010	2019	2020	2021	2022	Average	STDEV
1	**PCE**	$/per Capita	20,308	33,164	43,659	42,853	48,318	52,542	33,669	8,373
3	**Durable goods**	% of 1	**12.9%**	**10.2%**	**10.6%**	**11.5%**	**12.5%**	**12.2%**	**11.8%**	**1.3%**
4	Motor vehicles and parts	% of 1	**5.3%**	**3.4%**	**3.8%**	**3.9%**	**4.4%**	**4.2%**	4.3%	0.8%
5	Furnishings and durable household equipment	% of 1	**2.9%**	**2.3%**	**2.4%**	**2.7%**	**2.8%**	**2.7%**	2.7%	0.3%
6	Recreational goods and vehicles	% of 1	**3.2%**	**2.9%**	**3.0%**	**3.6%**	**3.8%**	**3.7%**	3.2%	0.3%
7	Other durable goods	% of 1	**1.6%**	**1.6%**	**1.4%**	**1.4%**	**1.6%**	**1.5%**	1.6%	0.1%
8	**Nondurable goods**	% of 1	**23.3%**	**22.1%**	**20.9%**	**21.7%**	**21.8%**	**22.1%**	**22.1%**	**0.6%**
9	Food and beverages purchased for off-premises consumption	% of 1	**8.6%**	**7.7%**	**7.5%**	**8.4%**	**8.0%**	**8.0%**	7.8%	0.3%
10	Clothing and footwear	% of 1	**4.5%**	**3.1%**	**2.9%**	**2.6%**	**2.9%**	**2.9%**	3.4%	0.5%
11	Gasoline and other energy goods	% of 1	**2.7%**	**3.3%**	**2.4%**	**1.8%**	**2.4%**	**2.9%**	2.9%	0.6%
12	Other nondurable goods	% of 1	**7.6%**	**8.1%**	**8.0%**	**8.9%**	**8.5%**	**8.4%**	8.0%	0.2%
13	**Services**	% of 1	**63.8%**	**67.7%**	**68.6%**	**66.8%**	**65.7%**	**65.8%**	**66.1%**	**1.6%**
14	Household consumption expenditures	% of 1	**61.9%**	**64.8%**	**65.7%**	**63.4%**	**62.8%**	**62.7%**	63.4%	1.4%
15	Housing and utilities	% of 1	**18.2%**	**19.0%**	**17.7%**	**18.8%**	**17.6%**	**17.4%**	18.1%	0.4%
16	Health care	% of 1	**14.3%**	**16.6%**	**17.1%**	**16.6%**	**16.4%**	**15.9%**	15.7%	1.1%
17	Transportation services	% of 1	**3.8%**	**3.0%**	**3.3%**	**2.5%**	**2.9%**	**3.2%**	3.3%	0.3%
18	Recreation services	% of 1	**3.8%**	**3.9%**	**4.1%**	**3.3%**	**3.6%**	**3.7%**	3.8%	0.2%
19	Food services and accommodations	% of 1	**6.2%**	**6.2%**	**7.0%**	**5.8%**	**6.6%**	**7.1%**	6.3%	0.4%
20	Financial services and insurance	% of 1	**7.4%**	**7.5%**	**7.9%**	**8.1%**	**7.6%**	**7.2%**	7.7%	0.3%
21	Other services	% of 1	**8.2%**	**8.7%**	**8.5%**	**8.3%**	**8.2%**	**8.3%**	8.5%	0.2%

From the data found in BEA (n.d.), the author extracted the values of the major components of the goods (durable, nondurable) and services and used the % of the PCE of each year. Plate 4.1shows some of the computed percentages for some years. The last two columns, show the average % and the standard deviations among the % for the period 1987-2022.

Plate 4-2. *Expanding the period 1997-2022 to years before (1971-1996) and after (2023-224)*

#	Description	1971	1972	1980	1996	1997	2020	2021	2022	2023	2024
3	**Durable goods**	*12.92 %*	*12.92 %*	*12.92 %*	*12.92 %*	**12.92 %**	**11.47 %**	**12.51 %**	**12.16 %**	***12.16 %***	***12.16 %***
4	Motor vehicles and parts	*5.29%*	*5.29%*	*5.29%*	*5.29%*	**5.29%**	**3.85%**	**4.37%**	**4.17%**	*4.17%*	*4.17%*
5	Furnishings and durable household equipment	*2.90%*	*2.90%*	*2.90%*	*2.90%*	**2.90%**	**2.66%**	**2.80%**	**2.73%**	*2.73%*	*2.73%*
6	Recreational goods and vehicles	*3.16%*	*3.16%*	*3.16%*	*3.16%*	**3.16%**	**3.57%**	**3.78%**	**3.74%**	*3.74%*	*3.74%*
7	Other durable goods	*1.58%*	*1.58%*	*1.58%*	*1.58%*	**1.58%**	**1.38%**	**1.55%**	**1.51%**	*1.51%*	*1.51%*
8	**Nondurable goods**	*23.32 %*	*23.32 %*	*23.32 %*	*23.32 %*	**23.32 %**	**21.71 %**	**21.82 %**	**22.09 %**	***22.09 %***	***22.09 %***
9	Food and beverages purchased for off-premises consumption	*8.57%*	*8.57%*	*8.57%*	*8.57%*	**8.57%**	**8.42%**	**8.03%**	**7.96%**	*7.96%*	*7.96%*
10	Clothing and footwear	*4.47%*	*4.47%*	*4.47%*	*4.47%*	**4.47%**	**2.58%**	**2.92%**	**2.86%**	*2.86%*	*2.86%*
11	Gasoline and other energy goods	*2.67%*	*2.67%*	*2.67%*	*2.67%*	**2.67%**	**1.82%**	**2.40%**	**2.91%**	*2.91%*	*2.91%*
12	Other nondurable goods	*7.60%*	*7.60%*	*7.60%*	*7.60%*	**7.60%**	**8.89%**	**8.47%**	**8.36%**	*8.36%*	*8.36%*
13	**Services**	*63.76 %*	*63.76 %*	*63.76 %*	*63.76 %*	**63.76 %**	**66.82 %**	**65.68 %**	**65.76 %**	***65.76 %***	***65.76 %***
14	Household consumption expenditures	***61.85 %***	***61.85 %***	***61.85 %***	***61.85 %***	**61.85 %**	**63.41 %**	**62.82 %**	**62.72 %**	***62.72 %***	***62.72 %***
15	Housing and utilities	*18.24 %*	*18.24 %*	*18.24 %*	*18.24 %*	**18.24 %**	**18.84 %**	**17.65 %**	**17.44 %**	*17.44 %*	*17.44 %*
16	Health care	*14.29 %*	*14.29 %*	*14.29 %*	*14.29 %*	**14.29 %**	**16.58 %**	**16.40 %**	**15.86 %**	*15.86 %*	*15.86 %*
17	Transportation services	*3.83%*	*3.83%*	*3.83%*	*3.83%*	**3.83%**	**2.52%**	**2.86%**	**3.21%**	*3.21%*	*3.21%*
18	Recreation services	*3.76%*	*3.76%*	*3.76%*	*3.76%*	**3.76%**	**3.29%**	**3.57%**	**3.74%**	*3.74%*	*3.74%*
19	Food services and accommodations	*6.20%*	*6.20%*	*6.20%*	*6.20%*	**6.20%**	**5.80%**	**6.56%**	**7.06%**	*7.06%*	*7.06%*
20	Financial services and insurance	*7.39%*	*7.39%*	*7.39%*	*7.39%*	**7.39%**	**8.09%**	**7.63%**	**7.15%**	*7.15%*	*7.15%*
21	Other services	*8.15%*	*8.15%*	*8.15%*	*8.15%*	**8.15%**	**8.29%**	**8.16%**	**8.26%**	*8.26%*	*8.26%*

In plate 4-2, the red entries are extrapolated for years 1971-1986, and years 2023-2024. The extrapolations use the %'s of last available year. This was justified in view of nearly constant percentages among the data of years 1987-2022 as shown in the last two columns of Plate 4-1.

Plate 4-3. *Example of Calculating the Losses for one selected Target CPI Rate*

												1997-2022	
#	Description	Losses	1971	1996	1997	2010	2020	2021	2022	2023	2024	Average	STDEV
1	PCE Per capita	Selected %	3354	19360	20308	33164	42853	48318	52542	56075	58682	33669	8373
4	Motor vehicles and parts	3.00%	13	75	79	102	147	181	192	205	214	117	26
5	Furnishings and durable household equipment	0.30%	1	3	3	3	5	6	7	7	7	4	1
6	Recreational goods and vehicles	0.60%	1	3	4	5	7	8	9	9	10	5	1
7	Other durable goods	1.80%	2	11	12	17	28	33	35	38	40	19	6
9	Food and beverages purchased for off-premises consumption	4.40%	34	199	208	323	409	464	511	545	570	326	76
10	Clothing and footwear	0.50%	1	8	9	13	18	19	21	22	23	13	3
11	Gasoline and other energy goods	0.80%	1	7	7	8	9	11	12	13	13	9	1
12	Other nondurable goods	5.00%	4	26	27	54	39	58	77	82	85	48	15
15	Housing and utilities	5.50%	34	194	204	346	444	469	504	538	563	335	81
16	Health care	2.00%	10	55	58	110	142	158	167	178	186	107	32
17	Transportation services	1.40%	2	10	11	14	15	19	24	25	26	15	3
18	Recreation services	1.50%	2	11	11	20	21	26	29	31	33	19	5
19	Food service& accommodations	2.50%	5	30	32	51	62	79	93	99	104	54	16
20	Financial services and insurance	1.00%	2	14	15	25	35	37	38	40	42	26	7
21	Other services	5.50%	15	87	91	158	195	217	239	255	266	157	37

In Plate 4-3, to demonstrate the calculations for a particular target CPI rate, (for different years), the entered values in the third column are applied to the values of Plate 3-2. To calculate the losses corresponding to the target CPI Value.

Plate 4- 4. *Examples of selected Combinations of Components to obtain the Target CPI for the Interval*

#	1	2	4	5	6	9	10	14	15	18	19	21
Interval	VI.A	Rec. 6	VI.B	IV.A	Rec.. 5	VII.B	Rec. 4	III.B	VII. A	Rec.3	II.B	Rec. 2
Target CPI	1.41 %	1.66 %	1.96 %	2.21 %	2.28 %	2.77 %	3.26 %	3.98 %	5.48 %	6.72 %	8.84%	11.36 %
start year	2010	2008	2017	1,995	2,001	2024	1990	1988	2022	1981	1979	1980
end year	2016	2009	2019	1,998		2024	1994	1989	2023	1982		
Motor vehicles and parts	1.00 %	1.70 %	2.10 %	2.50 %	2.50 %	2.60 %	3.00 %	3.00 %	3.80 %	4.80 %	6.00%	7.50%
Furnishings and durable household equipment	0.20 %	0.20 %	0.20 %	0.20 %	0.20 %	0.20 %	0.30 %	0.30 %	1.95 %	3.00 %	3.90%	5.00%
Recreational goods and vehicles	0.20 %	0.20 %	0.20 %	0.20 %	0.20 %	0.20 %	0.30 %	0.60 %	1.95 %	3.00 %	3.90%	5.00%
Other durable goods	1.00 %	1.00 %	1.00 %	1.00 %	1.00 %	1.50 %	1.20 %	1.80 %	2.50 %	4.80 %	6.00%	7.00%
Food and beverages purchased	2.00 %	2.20 %	2.55 %	3.00 %	3.00 %	4.00 %	4.80 %	5.00 %	6.50 %	6.35 %	8.50%	10.50 %
Clothing and footwear	0.30 %	0.30 %	0.30 %	0.30 %	0.30 %	0.40 %	0.50 %	0.50 %	3.00 %	3.40 %	5.00%	6.00%
Gasoline and other energy goods	0.30 %	0.30 %	0.30 %	0.30 %	0.30 %	0.40 %	0.50 %	0.80 %	3.00 %	3.40 %	5.00%	6.00%
Other nondurable goods	2.00 %	2.00 %	2.00 %	3.00 %	3.00 %	3.80 %	3.90 %	5.00 %	6.50 %	7.00 %	8.50%	10.50 %
Housing and utilities	1.20 %	1.60 %	2.30 %	2.50 %	2.70 %	3.20 %	4.00 %	5.70 %	7.00 %	8.50 %	11.50 %	14.50 %
Health care	1.60 %	1.60 %	1.60 %	1.60 %	1.60 %	1.80 %	1.90 %	2.00 %	3.00 %	4.00 %	5.00%	6.80%
Transportation services	0.70 %	0.70 %	0.70 %	0.70 %	0.70 %	1.00 %	0.90 %	1.40 %	3.00 %	4.00 %	5.00%	6.80%
Recreation services	0.70 %	0.70 %	0.70 %	0.70 %	0.70 %	0.80 %	0.90 %	1.50 %	3.00 %	4.00 %	5.00%	6.80%
Food services and accommodations	0.70 %	0.70 %	0.70 %	0.70 %	0.70 %	0.80 %	0.90 %	2.50 %	3.00 %	4.00 %	5.00%	6.80%
Financial services and insurance	0.70 %	0.70 %	0.70 %	0.70 %	0.70 %	0.70 %	0.90 %	1.00 %	2.00 %	3.00 %	3.50%	7.00%
Other services	1.20 %	1.50 %	1.70 %	2.50 %	2.70 %	4.00 %	4.00 %	5.70 %	7.00 %	8.50 %	11.50 %	14.50 %

In Plate 4-4, examples from the 21 target CPI's (per Plate 3-1 & 3-2) are shown. The numbers in the top row, correspond to the designated intervals of Plate 3-1 / 3-2.

Plate 4-5. *Examples of the Estimated Losses for selected Samples of the 21 Intervals*

Interval	I.A		Rec. 1		II.A			V.A	VII..A		VII.B
Year	1971	1972	1974	1975	1976	1977	1978	2002	2022	2023	2024
CPI categorization	Medium	Medium	Very high		High			Very Low	High	High	Low
CPI	3.79%		9.69%		5.98%			1.87%	5.48%		2.77%
PCE	3,354	3,643	4,329	4,750	5,239	5,756	6,357	25,550	52,542	56,075	58,682
Durable goods	1,200	1,304	1,569	1,700	1,875	2,060	2,275	9,035	1,026	6,817	7,135
Nondurable goods	755	820	1,009	1,069	1,179	1,295	1,430	5,610	11,606	12,386	12,962
Services	2,154	2,340	2,760	3,051	3,364	3,696	4,082	16,515	34,549	36,872	38,586
Durable goods Losses	16	17	56	61	39	43	48	81	363	387	227
Nondurable goods Losses	42	45	135	148	119	130	144	164	1024	1093	609
Services Losses	70	76	229	251	156	171	189	225	1491	1591	788
All the losses	127	138	420	460	313	344	380	470	2878	3071	1623
All Losses % of fPCE	3.79%	3.79%	9.69%	9.69%	5.98%	5.98%	5.98%	1.84%	5.48%	5.48%	2.77%

In Plate 4-5, the target CPI is shown in the fifth row. The author included a categorization of CPI values below 2% as Very Low, between 2 to 3% as Low, between 3 to 5% as Medium, between 5 to 8% as High and above 8% as Very High. The values in 5th to 8th rows give the $value per capita for the CPE, expenditures in Durable, Nondurable and Services per annum. The calculated value corresponds to the chosen weights of plate 4-3 and plate 4-4.

C. (Step 3) Generalizing to CPE and relating the monetary values of the losses to Energy Units

Building on the results of the simulation of step 2, the losses per capita are generalized for the population. Further, using the KEI index the equivalent energy units (discussed in the body of the paper) for the losses are estimated.

Plate 5-1. *End Results*

	V.B	Recession 6		VI.A							VI.B			Recession # 7		VII..A		VII.B
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
	Low	VERY LOW		Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Very Low	Low	Low	Low	Recession # 7		High	High	Low
	2.74%	1.66%		1.41%						1.41%	1.96%			3.51%		5.48%		2.77%
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
PCE per Capita $	32,356	33,049	32,243	33,164	34,309	35,144	35,955	37,192	38,211	39,236	40,691	42,413	43,659	42,853	48,318	52,542	56,075	58,682
Durable $	11,178	11,060	10,366	10,724	11,282	11,572	11,815	12,173	12,290	1,200	12,896	13,436	13,715	14,217	16,585	1,026	6,817	7,135
NonDurable $	7,234	7,447	7,067	7,334	7,775	7,932	8,052	8,267	8,201	765	8,561	8,964	9,104	9,304	10,542	11,606	12,386	12,962
Services $	21,178	21,989	21,877	22,440	23,027	23,572	24,140	25,019	25,922	2,154	27,795	28,977	29,944	28,636	31,733	34,549	36,872	38,586
Losses Durable	124	76	69	47	49	50	52	54	56	58	108	113	115	187	229	363	387	227
Losses Non Dural	341	200	185	179	193	197	199	203	196	195	251	263	267	477	552	1,024	1,093	609
Losses Services $	419	272	273	246	251	256	262	271	281	291	397	414	429	642	925	1,491	1,591	788
Losses Sum $	884	548	527	472	493	504	513	528	534	544	756	789	811	1,505	1,706	2,878	3,071	1,623
% losses to PCE	2.73%	1.66%	1.63%	1.42%	1.44%	1.43%	1.43%	1.42%	1.40%	1.39%	1.86%	1.86%	1.86%	3.51%	3.53%	5.48%	5.48%	2.77%
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Population million	301.7	304.5	307.2	309.8	312.3	314.7	317.1	319.6	322.1	324.6	326.9	328.8	330.5	331.8	332.4	333.6	335.2	336.7
PCE $Billion	9,762	10,063	9,905	10,274	10,715	11,060	11,401	11,887	12,308	12,736	13,302	13,945	14,429	14,219	16,061	17,528	18,796	19,758
Losses $billion	267	167	162	146	154	158	163	169	172	177	247	259	268	499	567	960	1,030	546
Losses/PCE %	2.73%	1.66%	1.63%	1.42%	1.44%	1.43%	1.43%	1.42%	1.40%	1.39%	1.86%	1.86%	1.86%	3.51%	3.53%	5.48%	5.48%	2.77%
PRICE $/kWh	0.115	0.119	0.127	0.125	0.128	0.129	0.130	0.136	0.138	0.135	0.136	0.136	0.136	0.134	0.139	0.152	0.167	0.174
KEI	181	160	174	180	179	181	183	180	180	190	192	198	204	217	216	210	200	199
Losses GWh	2,323	1,403	1,276	1,172	1,205	1,229	1,249	1,246	1,244	1,312	1,815	1,912	1,972	3,718	4,088	6,330	6,165	3,135

Plate 5-1 uses the losses estimate of the CPE per capita from Step 2, and the population for the period 2007-2024, to calculate the CPE $billion. Then losses in for which the average electricity price in the US was available (2007-2024), hence the KEI to calculate the Losses in GWh. Please refer to the body of the paper for further discussions.