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Long-term linear trends in consumer price indices

Kitov, Ivan and Kitov, Oleg
IDG RAS

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Introduction

Consumer price index, CPI(-U), is the most popular measure of the average price increase for consumers (Cecchetti, Chu, Steindel, 2000). Inflation associated with the CPI covers all principal expenditure categories of urban consumers as described by a representative basket of goods and services. This basket is characterized by fixed weights for given expenditure items, which are reconsidered about every ten years. Because of many problems related to the fixed basket, since 2000 the Bureau of Labor Statistics, BLS, relies on the personal consumption expenditures price index, PCEPI, in its official reports to the Congress and long-term inflation projections (FRB of San Francisco, 2003). The PCEPI has adopted a more flexible approach allowing changing weights in the basket, hedonic regression, and introduction of new goods and services. A less volatile measure of the PCE price index is the core PCE price index, which excludes volatile and seasonal food and energy prices. Before 2000, the core CPI (CPI less food and energy) was used for these purposes (Bryan, Cecchetti, 1994). Because of relatively short history of PCEPI measurements we use CPI and its components (including core CPI) in order to reveal long-term trends in corresponding series.

Kitov (2006ab; 2007ab), Kitov, Kitov and Dolinskaya (2007ab) developed an approach which links together inflation (also measured by CPI), unemployment and the change rate of labor force level. Within this framework, severe empirical and theoretical problems experienced by conventional economic concepts, including the New Keynesian Phillips Curve, have been resolved. Natural assumption underlying our concept and associated model consists in the existence of some valid relationship between true values of measured parameters. These true values (of inflation, unemployment and labor force) can not be accurately defined and measured at the current level of overall understanding and availability of technical means.

The principal finding of our previous studies conducted for the USA, Japan, France, Austria, Australia, Germany and Canada consists in the presence of a linear and lagged link between labor force, inflation and unemployment. In some countries, this generalized link can be separated into two independent linear links between inflation and labor force and between unemployment and labor force. These linear dependencies on one variable, obviously, result in the existence of reliable Phillips curves in these countries.

Accurate projections of working age population and labor force participation rates allow predictions of inflation and unemployment at any time horizon. On the other hand, only

predictions of average (aggregated) inflation were made. Constituent parts of the overall inflation, as expressed by various expenditure categories (Bauer, Haltom, Peterman, 2004), commodities, goods and services, are driven by their own mechanisms along their own trajectories. Fluctuations in these components of the overall inflation may be very high with the only constrain on the overall inflation value. Therefore, our next natural step consists in analyzing various parts of the CPI and in revealing potential long-term trends. Important feature of our analysis is avoiding fluctuations and measurement noise associated with inflation. Effectively, we prefer to study index itself instead of its time derivative.

The remainder of the paper is organized as follows. Section 1 presents an analysis of the difference between the CPI and core CPI in the USA during the period between 1960 and 2007. In Section 2, we extend the analysis conducted in Section 1 to the differences between the (headline and core) CPI and such expenditure categories as energy, food, housing, transportation, medical care, education and communication, as defined by the BLS. Section 3 concludes.

1. CPI and core CPI

We start our analysis from the CPI and core CPI. There is no unique definition of core CPI inflation (Wynne, 1999). Several proxies are available, however, attempting to reproduce long-term trends in the observed CPI inflation (Clark, 2001). The most popular definition used for political reasons is associated with the headline CPI inflation that excludes the prices of food and energy. These two items are considered as having high volatility, which provides the largest fluctuations of the CPI relative to the core CPI. In some sense, the core CPI should provide the most reliable estimate of inflation trends over longer time horizons, and monthly CPI readings may give misleading signals on the long-term trends (Rich, Steindel, 2005).

The core inflation can be also defined as a moving average, with several years window length, weighted median (Smith, 2004), and as a “trimmed-mean” estimate (Dolmas, 2005). The Federal Reserve Board uses personal consumption expenditures, PCE, for its long-term outlook. Therefore, the PCE is an almost official measure of long-term inflation. Due to a longer period of observations, this paper considers the original measure of core inflation – the core CPI as published by the USA Bureau of Labor Statistics (<http://www.bls.gov>).

Figure 1 illustrates the evolution of the measured CPI and core CPI in the USA after 1960. Both indices are for all urban customers and seasonally adjusted. By definition, the core

CPI is the headline CPI less food and energy. In Figure 1, one can observe that the curves are very close before 1980 - the core CPI practically evolved in sync with the CPI. After 1981, the curves diverge with the core CPI growing faster than the CPI. The gap between the indices opens wider and wider before 2000, and then the curves start to converge. The CPI growth rate has been higher since 2002.

A better view on the periods of the CPI and core CPI divergence and convergence is represented by the difference between these variable, as displayed in Figure 2. The difference is apparently characterized by the presence of three distinct segments of linear trend and two short periods of change in the trends. Between 1960 and 1978, the difference is relatively stable and varies in a narrow range around +1 unit of index. Between 1979 and 1982, the curve falls to -2 and then suddenly changes its direction from downward to upward one.

Between 1982 and 1999, the core CPI was growing consistently faster and a gap of about 10 units was created through 1999. The curve between 1982 and 1999 is best represented by a straight line with small-amplitude deviations, the latter likely associated with measurement noise. The slope of the linear regression line presented in Figure 3 is -0.7 with $R^2=0.96$. In other words, during these eighteen years the headline CPI was growing by 0.7 units of index faster than the core CPI.

If to assume that the evolution of both indices is driven by independent stochastic process like random walks, then the deviation between the indices would be a stochastic process itself. From Figure 3, it is more reasonable and reliable to assume, however, that there is a tight link between these variables, which provides the observed linear growth of the difference between them. For purely stochastic and independent variables such a linear behavior is highly unlikely. Because the CPI inflation is predefined by the labor force growth rate (Kitov, 2006ab) the evolution of the core CPI is also predefined.

There was another period of high volatility between 1999 and 2003 similar to that observed between 1979 and 1982. The gap reached its peak value two times - in 1999 and in 2003. Since 2003, the gap has been closing in line with a faster growing CPI. Nevertheless, the CPI was consistently above the core CPI, as Figure 1 demonstrates. If to extrapolate the currently observed rate of convergence between the CPI and core CPI, as displayed in Figure 4, one can estimate the intercept time somewhere between 2009 and 2010. This linear trend of convergence

is very robust with $R^2=0.86$, as was the divergence trend between 1982 and 1999. The convergence is faster - approximately 1.6 units of index per year.

What will happen beyond 2010? It is likely that the CPI will “overshoot” the core CPI and will be growing further and further above the core CPI. On the other hand, GDP deflator and CPI will drop below zero level after 2012 (Kitov 2006b; Kitov, Kitov, Dolinskaya, 2007b). This means that the core CPI will be decreasing even faster than CPI and might reach negative zone earlier than in 2012.

There are several simple conclusions from the existence of periods of linear trends in the difference between the CPI and core CPI. First, prices for food and energy are driven by some forces effectively independent on those behind other goods and services. Second, there are “structural breaks” in these forces, which define time segments of different length. It is likely that these forces behind all major expenditure categories may have different characteristic periods. Third, having an initial interval for some next period of linear trend in the difference between the CPI and core CPI one can extrapolate the evolution of the index for food and energy at a horizon of about ten years. Forth, there exist some relatively short periods when current linear trends change to opposite ones. These periods are likely characterized by an elevated volatility.

Apparently, the exclusion of food and energy from the core CPI is somewhat artificial. It could be appropriate to exclude one by one major expenditure categories such as housing, transportation, etc., as defined by the BLS.

2. Long-term trends in consumer price indices

Following the approach developed in Section 1 we extend our analysis to the difference between price index related to individual commodities and expenditure categories and the headline (or core) CPI. As shown later on, this approach allows suppressing (or complete exclusion) the changes in the trends in the CPI since individual constituent parts of the CPI move more or less in sync, at least in the long run. Table 1 provides weights for these individual parts as represented by selected expenditure categories and commodities. For some of the indices in Table 1, mean (annualized monthly) growth rate or inflation, its standard deviation (proxy for volatility), and the ratio of the latter and the former are shown in the brackets.

As expected, the highest volatility belongs to the index for energy with standard deviation of inflation during the last 25 years of 0.1 (10%) and mean inflation rate of only 4.6%. Relative importance of energy for the CPI is lower than that associated with housing, transportation, and food. At the same time, the price volatility related to food is much lower than that for housing and transportation. Volatility in the core inflation is slightly lower than that in the headline inflation when estimated for the last 25 years.

As found for the difference between the core CPI and the headline CPI, there exist relatively long periods of solid linear trends and shorter periods of the trends' change. In physical terms, such change in state or stationary regime is called bifurcation. In this sense, future trend usually can not be predicted in such bifurcation points. The turning periods are characterized by higher volatility than that associated with the periods of linear trend. The difference between the core and headline CPI is effectively a weighted sum of energy and food prices. Corresponding weights for 2006 and 1996 are presented in Table 1. There was only a slight change in the weights during these 10 years: energy increased its input by 2 percentage points (from 6.7% to 8.7 %) and food decreased its input from 15.8% to 13.9%. As a whole, relative weight of energy plus food practically did not change.

In this Section, we represent the overall input of energy and food as two independent components. Figure 5 displays the difference between the core CPI and the index for energy for the period between 1960 and 2007, as published by the BLS. Before 1980, these two indices had been developing almost in sync with fluctuation around 10 units of price index (both indices are based on 1982-1984=100). Between 1981 and 1999, the difference grew from -10 to almost 80 units. Since 2003, a period of intensive recovery of the energy index has been observed. Qualitatively, one can distinguish three periods of linear trend and three turning periods with higher volatility. The most recent turning period likely started in 2005 and will be possibly extended in 2008.

Figure 6 provides a detailed view of the most recent period. The energy index grew much faster than the core CPI. Linear regression gives a slope of -14 for the difference curve. This assumes that the energy index grew by 14 units faster every year than the core CPI. Since August 2005, volatility of the energy price has been at an elevated level and one can likely classify the current period as a period of bifurcation. There is no indication of the direction and slope of the next linear trend, however. At the same time, current (the end of 2007) energy price

has likely reached its peak value. We would not expect any further increase in oil price beyond that dictated by overall price increase. Since the duration of the previous two periods of linear trend change was between 3 and 5 years (depending on definition), one can expect the current period will be finished in 2008 or in 2009.

Some important conclusions are straightforward. The growth of the energy index relative to the core CPI is likely defined by some linear mechanisms. These mechanisms include bifurcations when the difference reaches some peak value or intercepts zero line. The reasons behind these bifurcations are not clear, but they are usually several years in length and are accompanied by elevated volatility. The latter property is common for physical processes. The next step is to analyze expenditure categories listed in Table 1.

Figure 7 displays the difference between the core CPI and the index for food for the period after 1960. This curve differs from that in Figure 5. The first large change in the difference occurred in 1973 (not in 1979 as for energy) and lasted only 7 years. Around 1980, the difference started to grow from -7.0 to 13.0 in 1996. Between 1996 and 2003, the difference was effectively constant at the level of ~13.5 units of price index, i.e. a lengthy flat segment was observed. After 2003, the difference has been decreasing at a rate of 1.2 units per year, as Figure 8 demonstrates.

Overall, the difference between the core CPI and the food index was always lower than that between the energy index and the core CPI. The largest difference was only around 14 units. Since 2003, the food price index has been slowly catching up the core CPI. Extrapolating the current linear trend one can estimate the intercept point when the food price index will reach the core CPI. According to Figure 8, this will happen in 2014. Such a behavior differs from that observed for the energy index in terms of timing and amplitude, but the overall behavior distinguishing periods of linear growth and bifurcation is very similar. Therefore, principal mechanisms behind the evolution of the food price index are similar to those behind the energy index. They are likely not related to the changes in supply pressure induced by good crops and draughts. These mechanisms have to be a part of economic system itself and should be related to relationships between economic agent not to production of goods and services.

Table 1 shows that the index for housing has the largest input in the CPI – approximately 43%. Figure 9 displays the difference between seasonally adjusted headline CPI and the housing index for the period after 1967. Figure 10 details the period after 1998. One can conclude that

after 2008 the housing index will be likely evolving at a lower rate than that associated with the headline CPI. Currently, we observe a turning period with higher volatility. The difference between the core CPI and the housing index is characterized by an almost constant duration of negative and positive trends – around 11 years. Accordingly, the next linear trend has to be positive.

The difference for the transportation index had a longer period of positive slope – between 1980 and 2004, as Figure 11 demonstrates. During this period the difference was evolving at a rate of 1.5 units per year and reached the level of 30 units of index. Currently, a turning period is likely observed and a negative slope is developing. The current period is accompanied by an elevated volatility. The slope for the future linear trend, which is estimated as -1.25 units per year in Figure 12, will be possibly changed in near future but will define the duration of the recovery period for the transportation index. In any case, the prices for goods and services related to the index for transportation, as it defined by the BLS, are very likely to be growing faster than the headline CPI.

The index for medical care and the index for education and communication are characterized by the absence of turning points since 1980. The difference for medical care has a solid (-5.9 units per year as estimated in Figure 13) negative slope since 1982. There is no indication of possible turn in the trend. The index for education and communication has a positive trend (+2.2 units per year as estimated in Figure 14) since its introduction in 1993. Both indices show low volatility over time. Because of the absence of any information on turning points in the past, there is no clear understanding how far these trends can be extrapolated in the future and potential mechanisms, which will break the trends.

Conclusion

We have studied the headline CPI, core CPI and indices for some expenditure categories in the USA for the period after 1960. The principal finding of this study is the presence of long-term linear trends in the difference between the core CPI and the headline CPI. These linear trends indicate that price indices for various expenditure categories are driven by some internal economic forces, which produce linear trends for the differences between these indices.

Obviously, if some random external shocks to supply and/or demand drive relative prices then these driving forces would result in random differences.

The forces behind the observed price indices define periods of stable and constant annual increment between prices indices for various expenditure categories. For the difference between the core and headline CPI, duration of such periods of linear behavior varies for positive (18 years) and negative (8 years) trends. According to the observed slope in the current trend the headline CPI will reach the level of the core CPI in 2009 and then some new trend should be developed.

The observed linear trends change to some reversed direction during shorter time intervals of 2 to 4 years. These intervals of the turn in linear trends are often associated with an elevated volatility. Such volatility is a common feature in physical processes related with bifurcation, i.e. when a change in some parametric force causes the stability of equilibrium to change. In our case, bifurcation consists in the change of stable linear trends. In economics, similar changes in trend are usually called “structural breaks”. Since the latter term is related to the change in stochastic trends we prefer to use physical term “bifurcation” indicating the change between two stable deterministic trends - stationary regimes.

The difference between the headline (core) CPI and indices for individual expenditure categories such as energy, food, housing and transportation is similar to that between the core CPI and headline CPI. The index for energy will reach the core CPI in 2008, however. Then, one should not expect further increase in energy price beyond that dictated by the headline CPI. It is likely that oil price will be falling in absolute terms.

The difference between the core CPI and the index for food also has two linear branches after 1980, but the slope of the current trend is weak and the difference will intercept zero line only in 2014. Therefore, it is likely that food price will be growing at an somewhat elevated pace.

The difference between the headline CPI and the housing index is characterized by an almost constant duration of negative and positive branches – around 11 years. The current period of negative slope in the difference is closing to its turning point in the next year or two and characterized by higher volatility. The next trend has to be positive, i.e. the housing index will be growing at a lower rate than the headlining CPI.

The difference for the transportation index had a longer period of positive slope – between 1980 and 2004. During this period the difference reached the level of 30 units of index. Currently, a turning period with higher volatility is observed and a negative slope is developing. The slope for the future linear trend will define the duration of the recovery period for the transportation index.

The index for medical care is characterized by a solid negative slope since 1982. No indication of possible turn in the trend is observed. The index for education and communication has a positive trend since its introduction in 1993.

This paper is formally devoted to long-term trends in consumer price indices. The presence of lengthy periods of linear trends allows numerous practical applications. One of the opportunities we have tried is related to stock market indices. Apparently, faster growth in prices for some specific commodities or goods and services might result in an elevated rate of growth associated with relevant stocks. Here, we would not like to dig deeper in various possibilities and thus try only obvious combination: the difference between the headline CPI and the index for transportation and the difference between the DJIA and Dow Jones Transportation Average. Figure 15, where both differences are represented by their twelve-month moving averages, illustrates our general finding. The difference related to the price indices leads that related to stock indices by 2.5 years. One can consider the difference related to the price indices as a good indicator of the future evolution of the DJTA. Transportation related stocks will likely be growing at a rate higher than that associated with the DJIA. We are planning to extend this approach by using different individual indices (both consumer price and stock market) in our next paper.

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Tables

Table 1. CPI-U by expenditure category and commodity and service group. Relative importance.

Expenditure category	Relative importance, 2006	Relative importance, 1996
All items (CPI-U)	100% (0.036; 0.033; 0.93)	100%
All items less food and energy	77.40% (0.037; 0.027; 0.74)	77.53%
Energy	8.71% (0.041; 0.26; 6.4)	6.70%
Food	13.88% (0.033; 0.035; 1.05)	15.77%
Housing	42.69% (0.037; 0.045; 1.20)	41.35%
Apparel	3.73%	5.52%
Transportation	17.25% (0.034; 0.12; 3.68)	16.95%
Medical care	6.28% (0.058; 0.0335; 0.56)	7.36%
Education and communication	6.03%	-
Other goods and services	3.48%	7.12%

In brackets – mean value of (monthly annualized) inflation readings of corresponding item between January, 1980 and November, 2007; standard deviation (volatility); and the ratio of the latter and former – relative volatility.

Figures

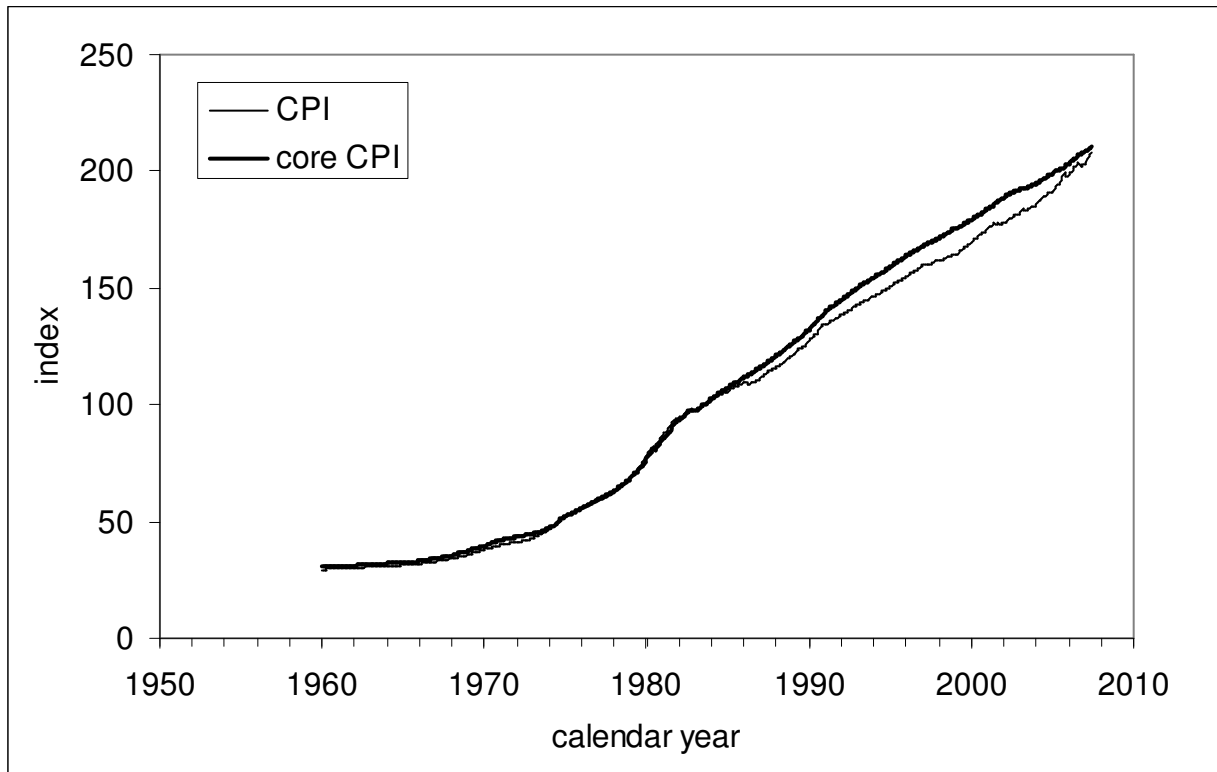


Figure 1. The evolution of headline CPI and core CPI in the USA between 1960 and 2007.

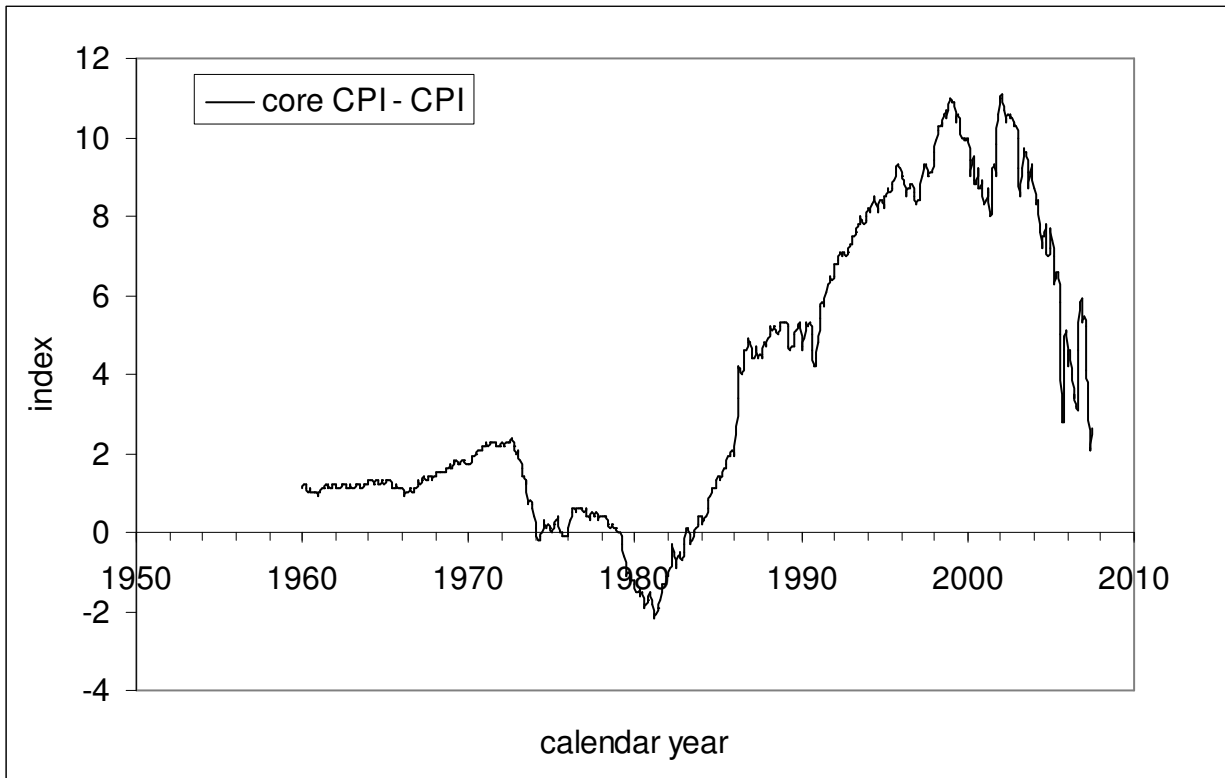


Figure 2. The difference between the core CPI and headline CPI.

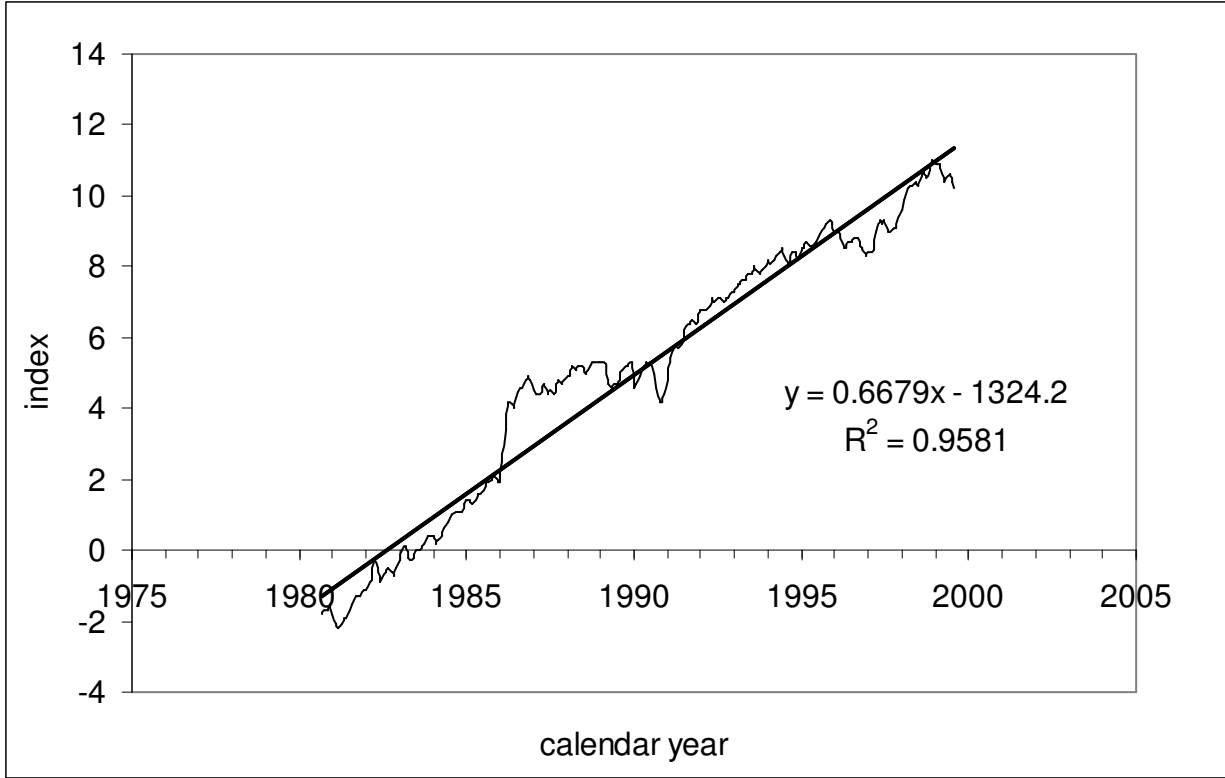


Figure 3. Linear regression of the difference between the core CPI and CPI for the period from 1981 to 1999. The goodness-of-fit is 0.96, and the slope is 0.67.

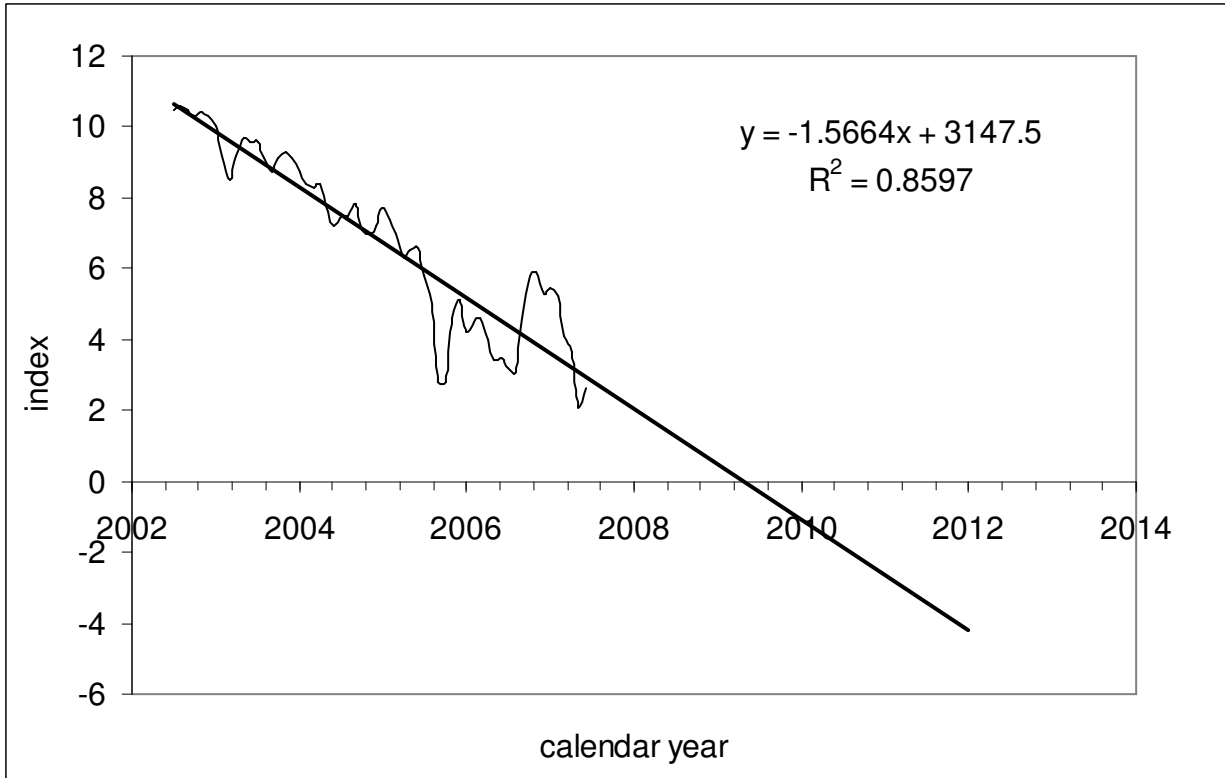


Figure 4. Linear regression of the difference between the core CPI and CPI after 2002. The goodness-of-fit is 0.86, and the tangent is -1.57. An elevated volatility has been observed from 2005.

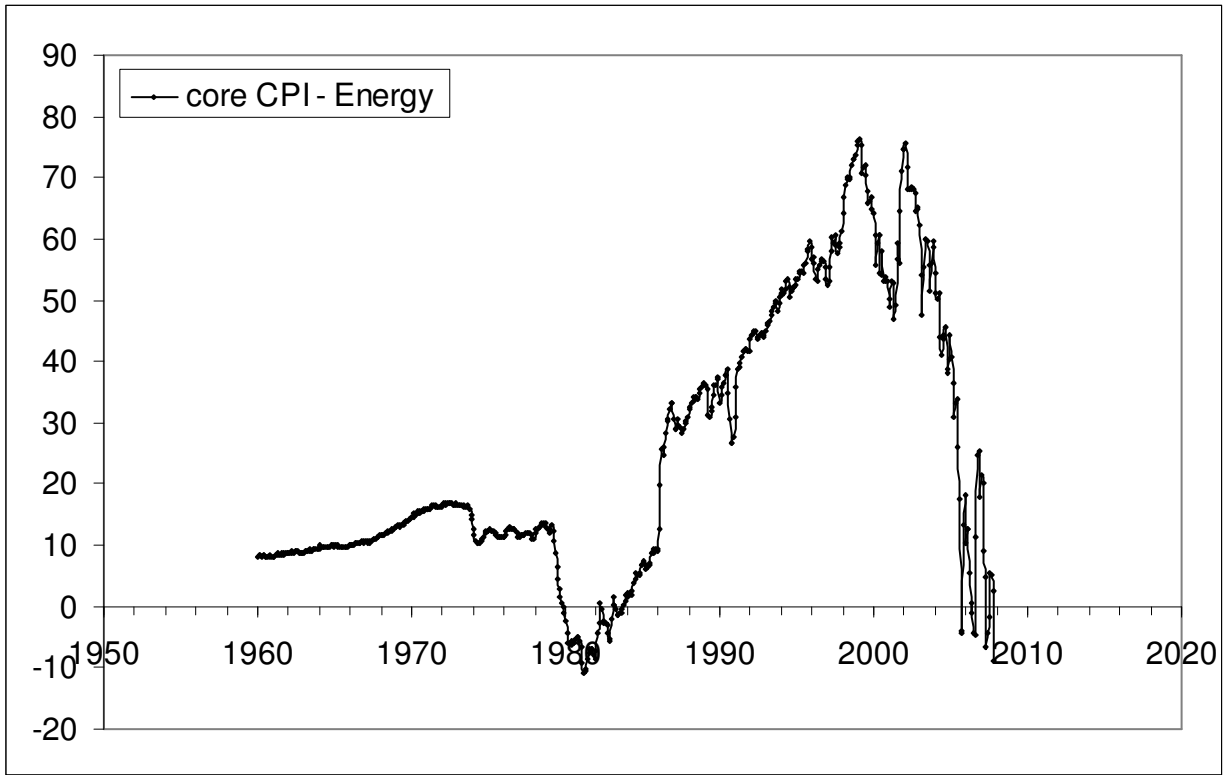


Figure 5. The difference between the core CPI and the index for energy between 1960 and 2007. There are three period of linear trend and three turning periods. The most recent turning period likely started in 2005.

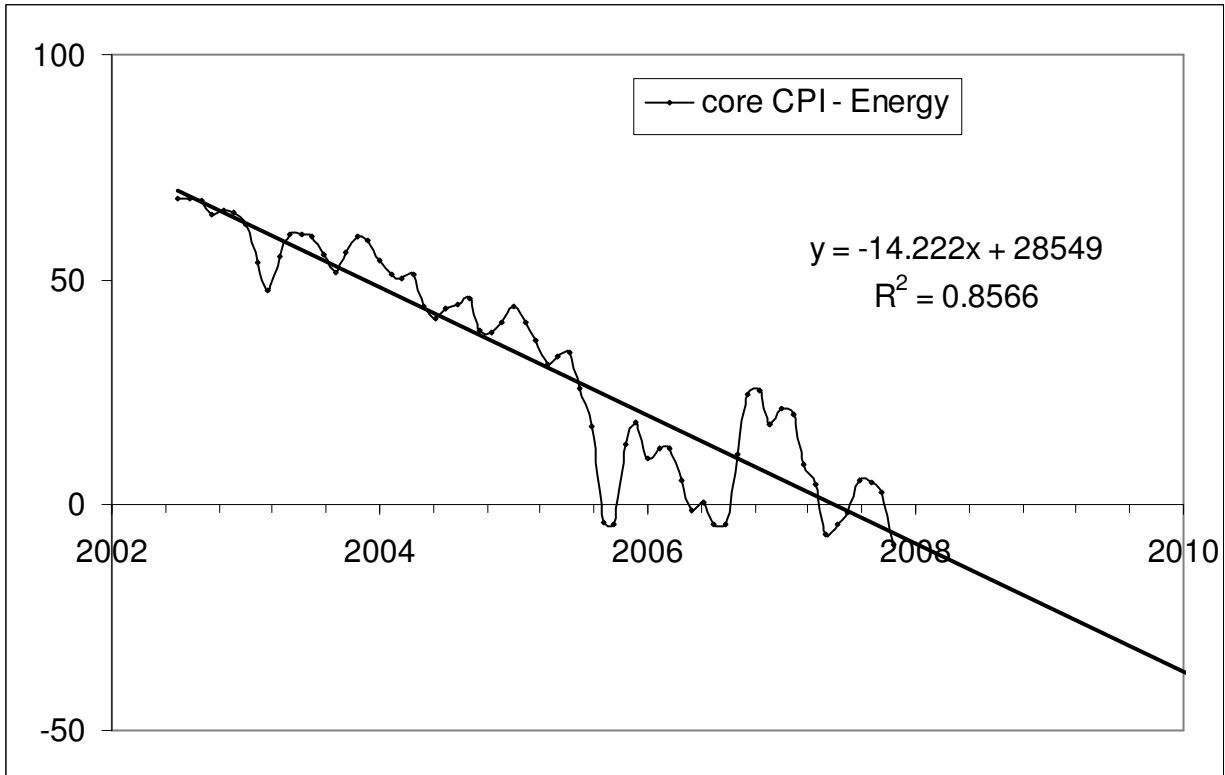


Figure 6. The difference between the core CPI and the energy index between 2002 and 2007. The most recent turning period started in 2005 with a high increase in corresponding price volatility. There is no indication of the direction of the next linear trend, but the current energy price has likely reached its peak value.

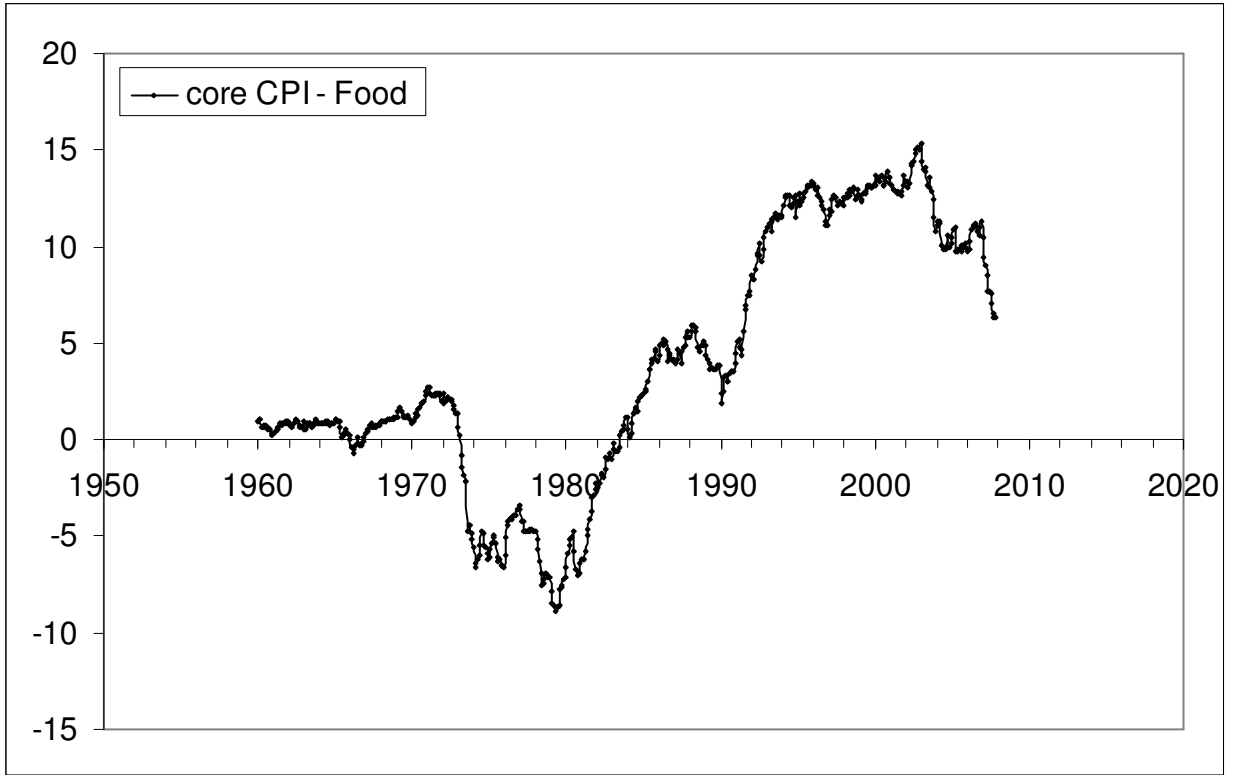


Figure 7. The difference between the core CPI and the index for food between 1960 and 2007. There are three periods of linear trend and two turning periods. The most recent period of linear trend started in 2003.

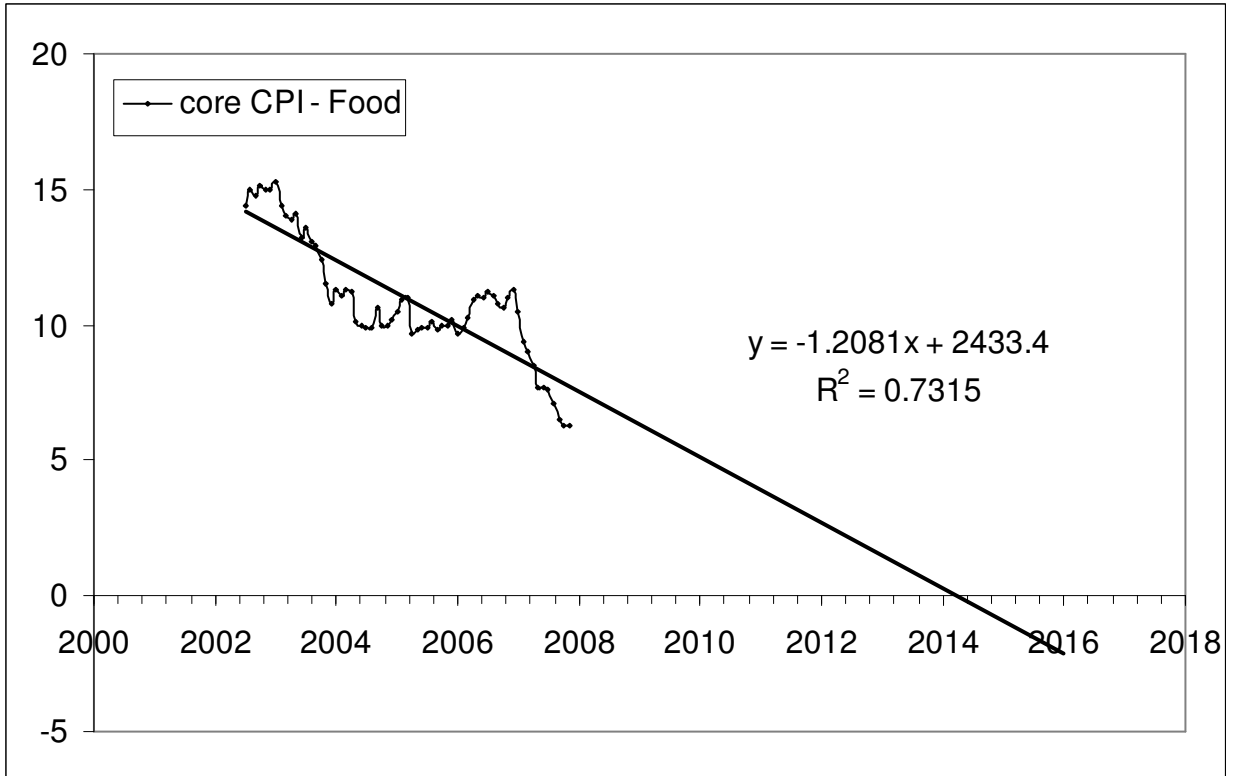


Figure 8. The difference between the core CPI and the food index between 2002 and 2007. The current period of linear trend will be likely finished in 2014. Since 2003, the food price index has been slowly catching up the core CPI.

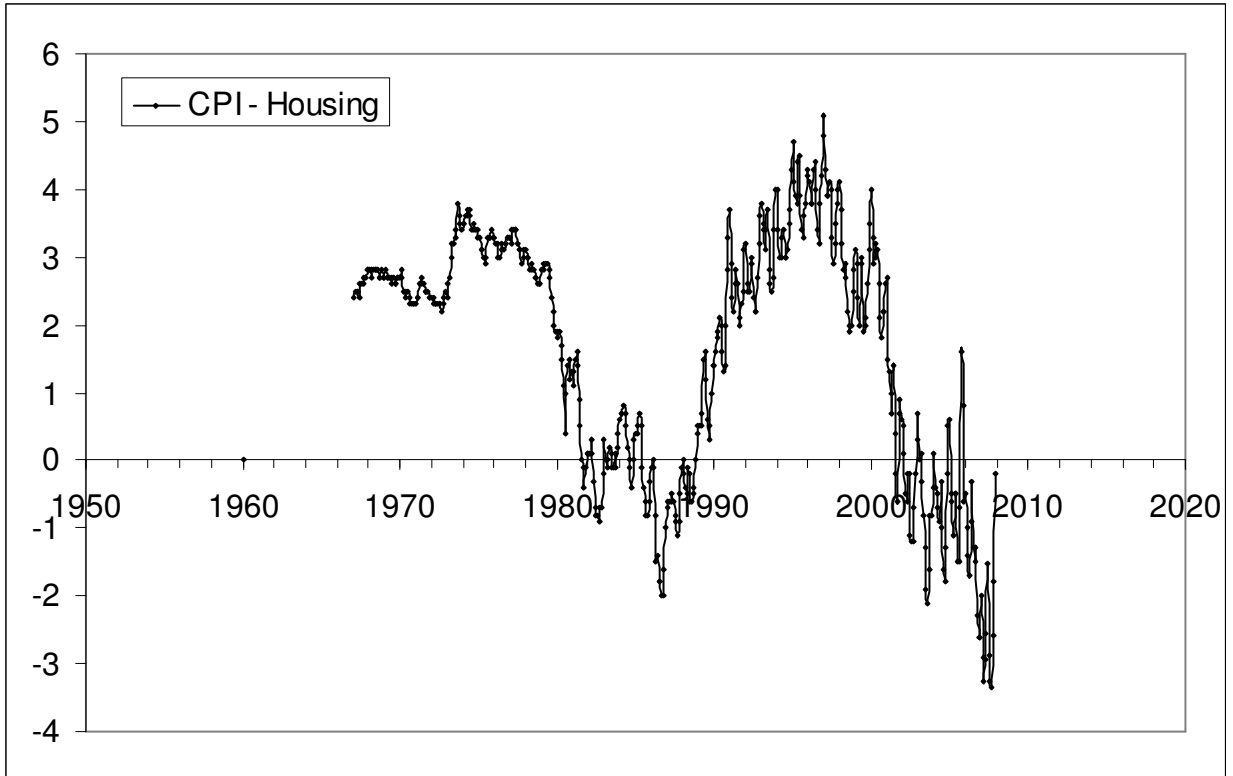


Figure 9. The difference between the headline CPI and the housing index between 1967 and 2007. Notice three periods of practically linear trend and two very short periods of trend change: in 1987 and 1998. The observed linear trend has been practically changing every 11 years. Notice an elevated relative volatility of the difference at higher frequency.

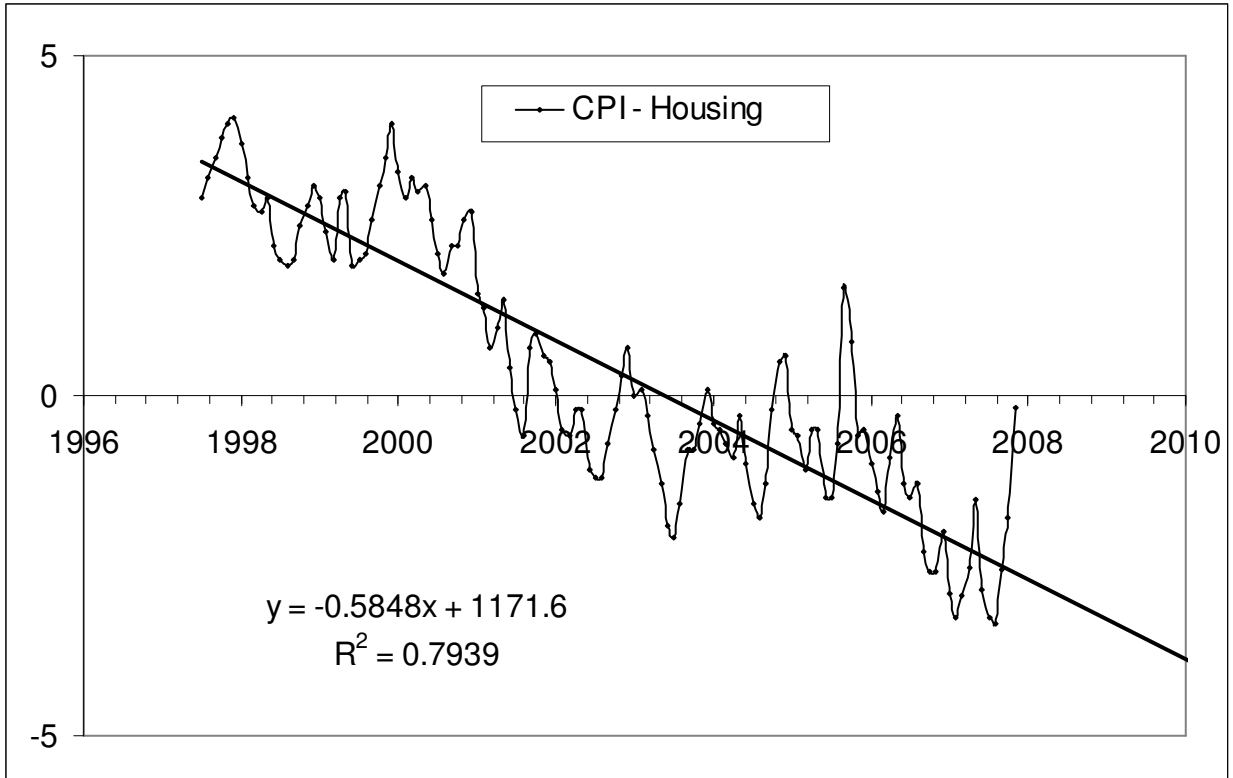


Figure 10. Same as in Figure 9 for the period after 1998. The housing index has been growing faster than the headline CPI. Currently, a period of the trend change is likely observed with the housing index changing to a rate below that associated with the CPI. One can expect that the next 10 years will be poor for the housing market.

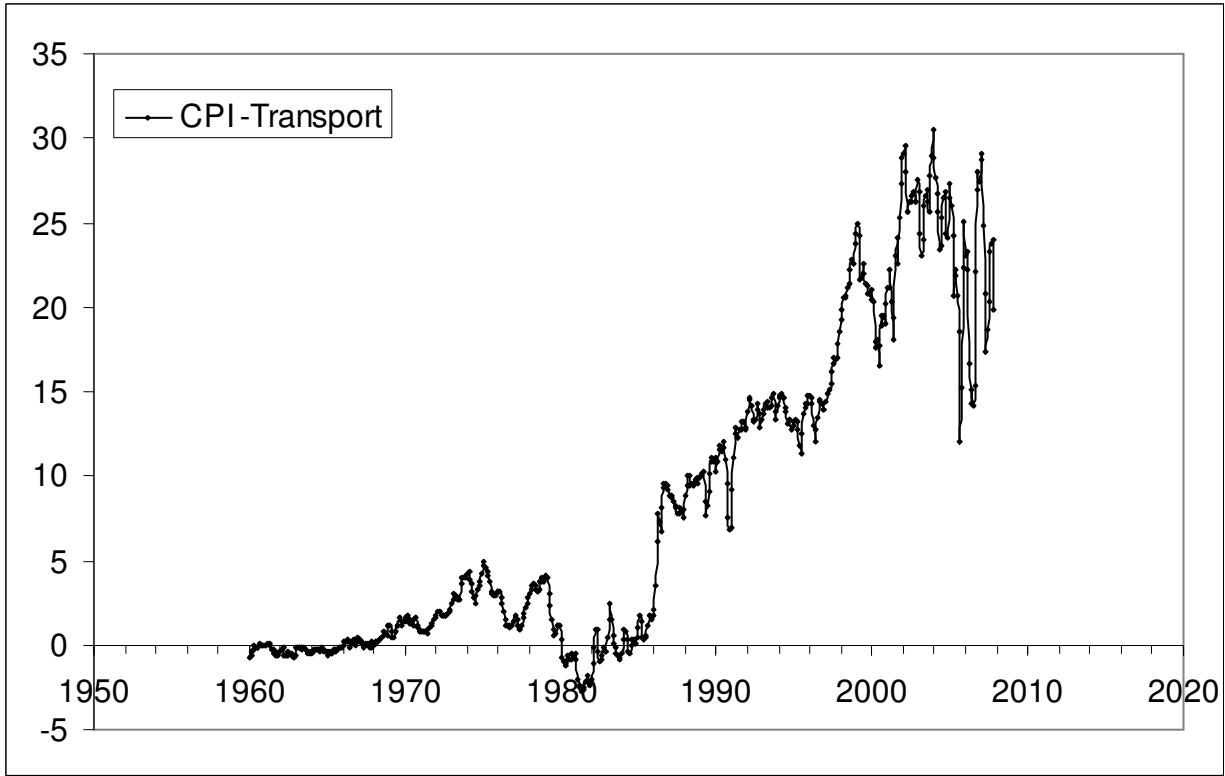


Figure 11. The difference between the CPI and the transportation index between 1960 and 2007. Notice two clear periods of practically linear trend: between 1960 and 1980; between 1980 and 2000. Currently, a period of turning to a new trend is observed – the transportation index will be growing faster than the CPI. This turn is accompanied by very high volatility.

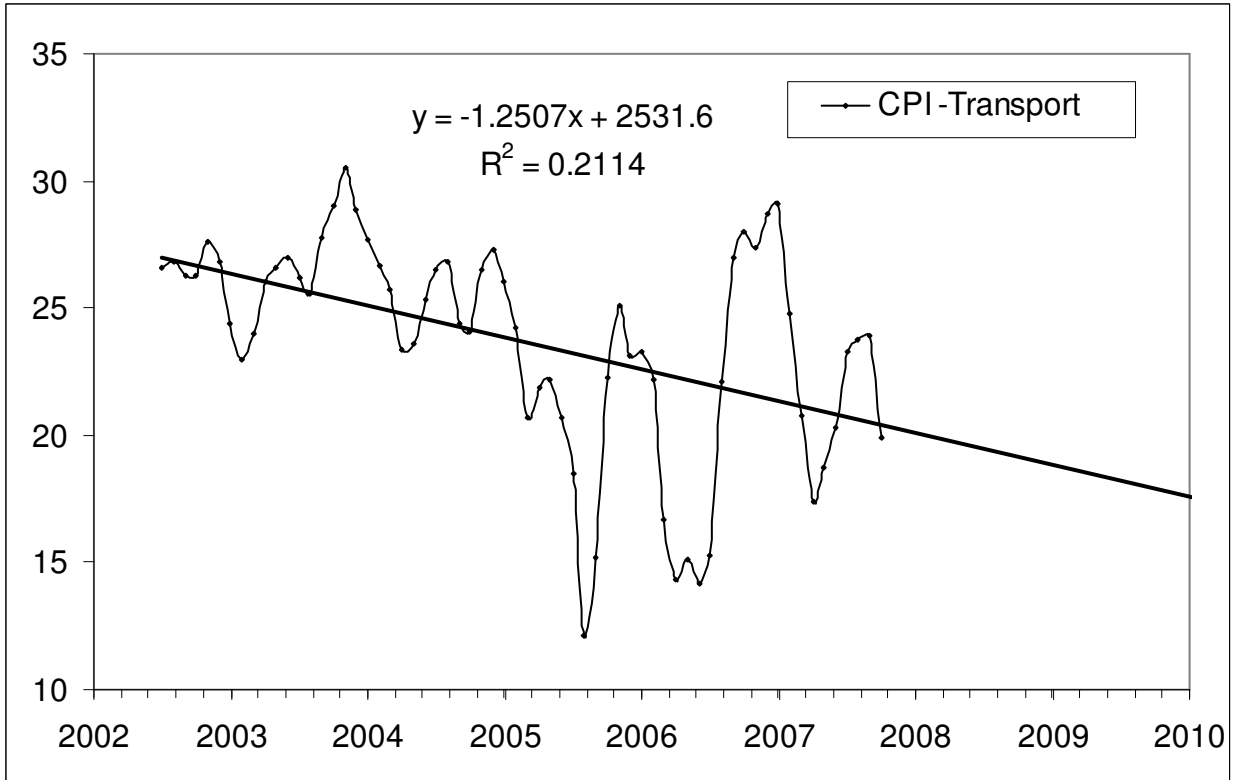


Figure 12. Same as in Figure 11 for the period after 2002. The transportation index likely started to grow faster than the CPI. New linear trend has not finally developed and more volatility might be expected in the housing expenditure category.

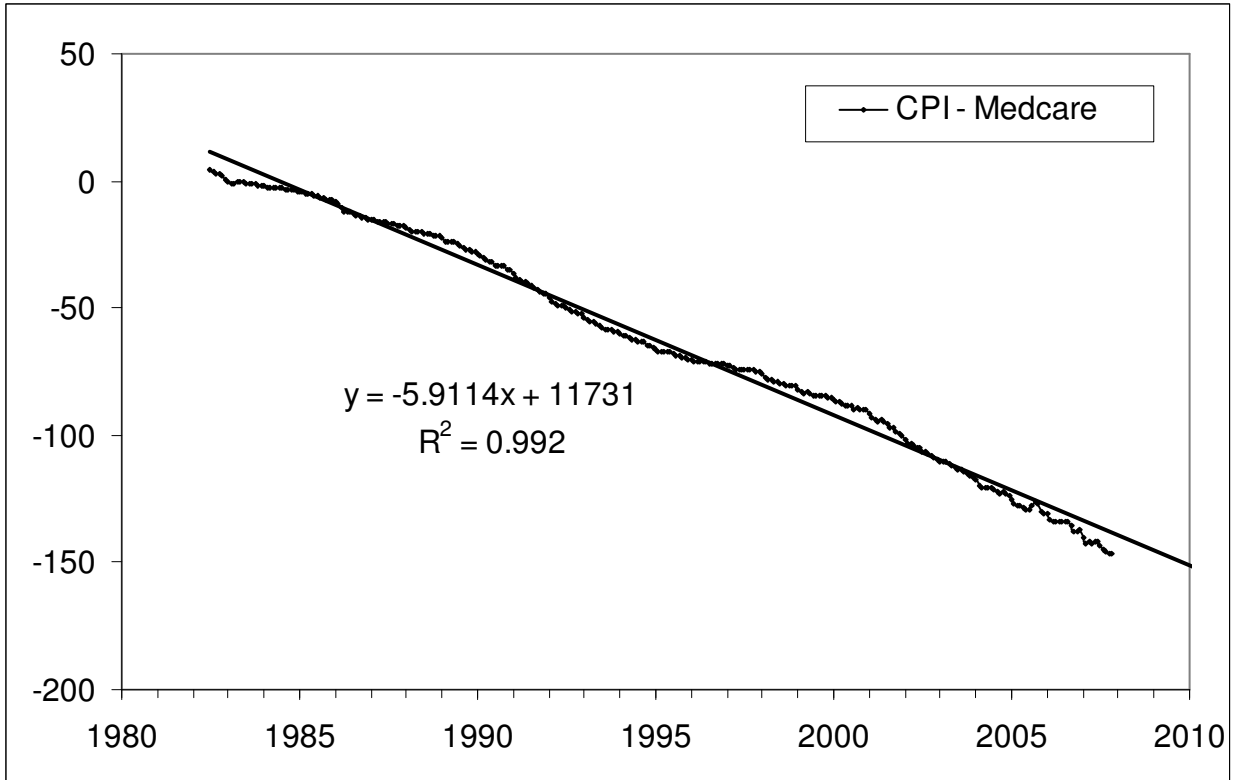


Figure 13. The medical care index has a solid linear trend relative to the CPI since 1980. No change in the trend is expected. In average, prices for medical care grow by 6 units of index per year faster than the CPI.

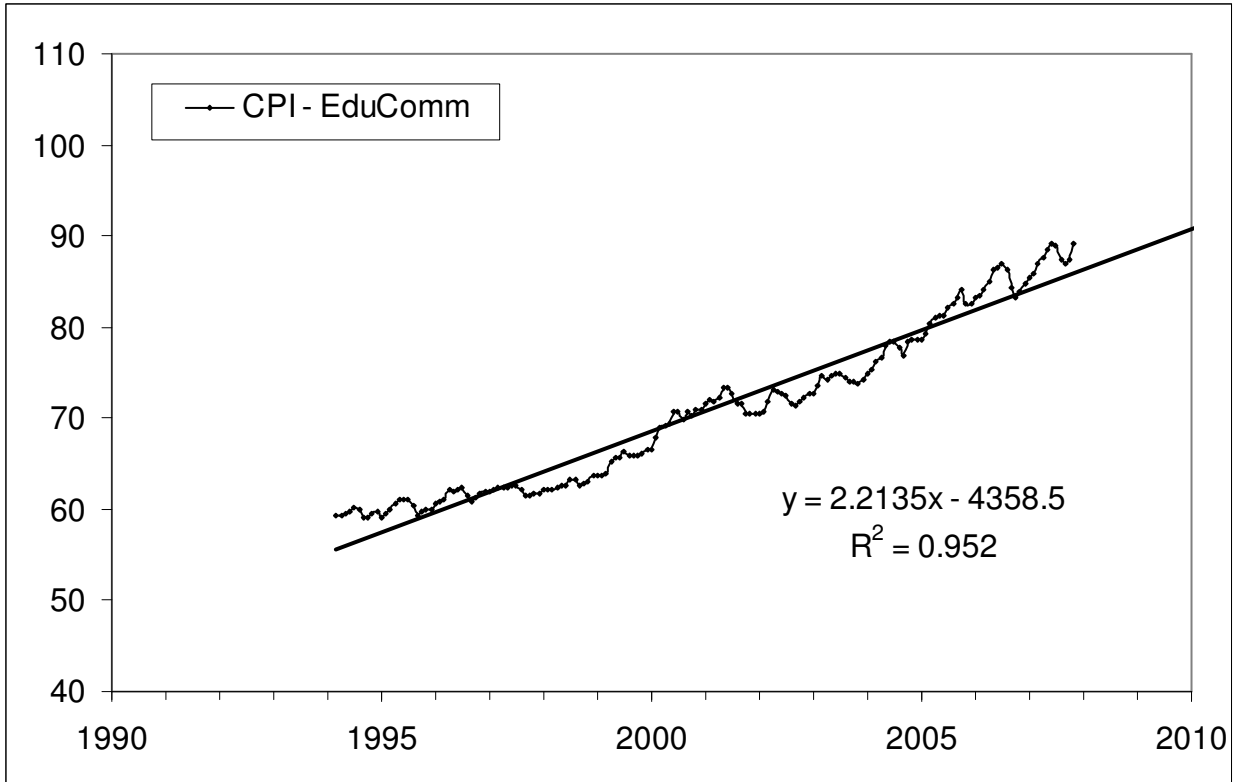


Figure 14. The education and communication index was introduced in 1993 and since then has a solid positive linear trend relative to the CPI. No change in the trend is expected. In average, prices for education and communication grow by 2 units of index per year less than the CPI.

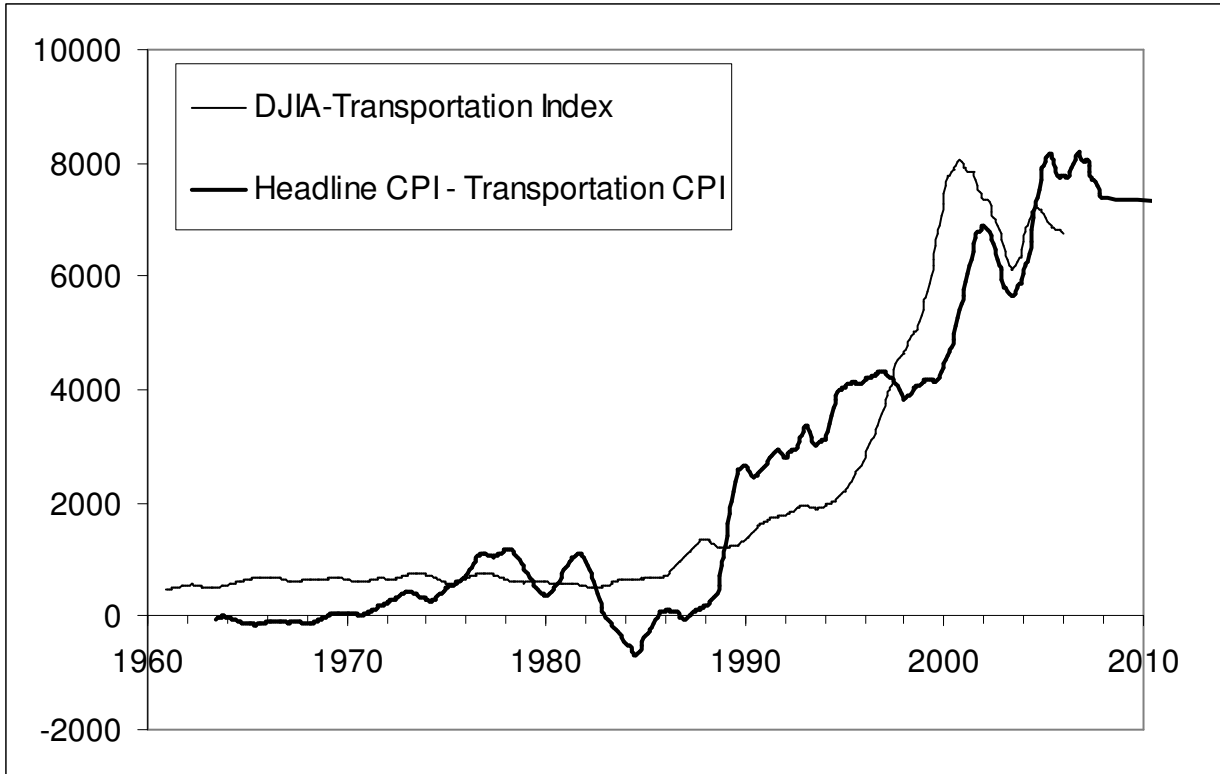


Figure 15. The difference between the headline CPI and the index for transportation (thick line) and the difference between the DJIA and Dow Jones Transportation Average (thin line). Both differences are represented by MA(12), i.e. twelve-month moving average. The difference related to the price indices is scaled by a factor of 25 and shifted 2.5 years ahead in order to reach visible synchronization. One can consider the difference related to the price indices as a good indicator of the future evolution of the DJTA. Transportation related stocks will likely be growing at a rate higher than that associated with the DJIA.