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Inflation, unemployment, labor force change in European countries

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Abstract

Linear relationships between inflation, unemployment, and labor force are obtained for two European countries - Austria and France. The best fit models of inflation as a linear and lagged function of labor force change rate and unemployment explain more than 90% of observed variation (R^2>0.9). Labor force projections for Austria provide a forecast of decreasing inflation for the next ten years. In France, inflation lags by four years behind labor force change and unemployment allowing for an exact prediction at a four-year horizon. Standard error of such a prediction is lower than 1%. The results confirm those obtained for the USA and Japan and provide strong evidences in favor of the concept of labor force growth as the only driving force behind unemployment and inflation.

Introduction

Current discussions around the Phillips curve are even more active and extensive than 30 year ago with a full set of models exploring various assumptions on real forces behind inflation. There is no unique and comprehensive model, however, which is able to explain all observations relevant to inflation in developed countries.

There are three principal ways to follow in the discussion on sources of inflation. The first way is to continue the investigation of inflation in the framework of the Phillips curve (PC). The second way is to admit that there is no real driving force behind inflation except unpredictable exogenous shocks of unknown origin such as productivity or supply shocks in modern real business cycle (RBC) models. The third way is to abolish the current paradigm and to use a different mechanism driving inflation and unemployment together, which is based on natural first principles (theoretical foundations) and validated by observations (empirical foundations). This paper adds to the development of the third concept using labor force change as the driving force behind both inflation and unemployment.

Conventional economists running along the first wide avenue are numerous and represent a good part of the theoretical power elaborating monetary policies of central banks in developed countries. In fact, the Phillips curve allows for a feasible monetary policy because of the assumption that there is an interaction between monetary controllable impulses or exogenous shocks and variables describing real economy such as real GDP, output gap, marginal cost, labor cost share, etc. (Unemployment is missing in this list of the variables associated with real economy because, according to our concept, it does not belong to the list). In the absence of such an interaction, no monetary policy is necessary with inflation completely reflecting money growth in developed economies, as mentioned in the Robert Lucas' Nobel Prize Lecture (Lucas, 1995). The money supply is an arbitrary choice of central banks, which does not influence any real economic variable. In the framework of the conventional Phillips curves, however, inflation is not neutral relative to the performance of real economies and central banks have to balance smoothing of price fluctuations and losses in real economic growth. These are only assumptions, however, not confirmed by empirical evidences to the extent adopted in hard sciences. Statistical inferences supporting the PC assumptions are not objective links or trade-offs between involved economic variables but non-zero correlation. See, for example, Ang *et al*. (2005), Ball (2000), Ball and Mankiw (2002), Ball *et al*. (2005), Stock and Watson (1999, 2002a, 2002b, 2003, 2005), Gali and Gertler (1999), Gali, Gertler, and Lopez-Salido (2001, 2005), Sbordone (2002, 2005), Rasche and Williams (2005), Piger and Rasche (2006), among others, where the statistical character of the links between inflation and many other economic and financial parameters is the primary objective. These authors have successfully found that functional dependencies between inflation and studied parameters unpredictably vary through time.

Despite similar outcomes sought under the PC approach one can distinguish several "schools of thought" elaborating various approaches both empirical and theoretical. There is a large group of economists who adopted numerous techniques of econometrics, which link inflation to own lagged values and some measures of real activity, which differ from unemployment as originally introduced by A.W. Phillips. In the simplest approximation, a NAIRU concept has been elaborated by Gordon (1988, 1998), Steiger, Stock, and Watson (1997a, 1997b), Ball and Mankiw (2002), among many others, in order to improve the original model. More complicated econometric PC models include hundreds of variables related to real activity aggregated in few indices, as presented by Marcellino *et al.* (2001), Stock and Watson (1999, 2002a, 2002b, 2003), Ang *et al*. (2005), Canova (2002), Hubrich (2005).

Another conventional approach is associated with the accelerationist or "expectation augmented" Phillips curve allowing only for backward-looking expectations

(Friedman 1968, Phelps 1967). Despite the Lucas (1976) and Sargent (1971) critique and failure to predict actual observations in the USA and other developed countries during the 1970s and 1980s, the model has survived and is often used by central bankers in the elaboration of actual monetary policy (Rudd and Whelan, 2005).

Fast growing in number and evolving in theoretical diversity is the group related to the New Keynesian Phillips Curve (NKPC) based on rational expectations not on lagged inflation. The expectations are usually modeled by a random price adjustment process, and thus intrinsically related to real marginal cost. In the most recent models developed by Gali and Gertler (1999), Gali, Gertler, and Lopez-Salido (2001, 2005), Sbordone (2002, 2005), among others, unit labor marginal cost is used as a marginal cost proxy. A hybrid model including lagged and future inflation values, various parameters related to real activity, and exogenous shocks, monetary and price ones, is also considered as an alternative to the pure cases of conventional PC or NKPC models with various degree of success (Rudd and Whelan, 2005).

One can also distinguish a group of economists applying a modern behavioral approach in order to explain the price adjustment process - Akerlof (2002), Mankiw (2001), Mankiw and Reis (2002), Ball *et al.* (2005), among others. In this framework, sticky prices used by the NKPC group are replaced with "sticky" information. This makes individual decisions on price change, i.e. on overall inflation when aggregated over the whole economy, to be imperfect due to imperfectness in processing of available information. Effectively, it means that the inflation expectations resulted from the imperfect information processing are not "rational" and do not meet axiomatic requirements of rational expectations used by the NKPC.

In practice, the conventional explanation of the price inflation lacks empirical justification extended beyond autoregressive properties of inflation itself and is also theoretically challenged by modern growth models insisting on independence of real economic performance on monetary issues, as introduced by Kydland and Prescott (1982). The real business cycle theory implies that variations in real economies are almost completely described by exogenous shocks in productivity and supply. Money is absent in RBC models or artificially introduced in some of them Gavine and Kydland (1996), Prescott (2004). Numerous econometric studies confirm the RBC assumption on money neutrality by statistical inferences: Atkeson and Ohanian (2002), Piger and Rasche (2005), Rasche and Williams (2005), among many others, have found that AR models explain evolution of inflation almost completely, with a marginal improvement from usage of real economic variables being only a statistical and transient one.

A study of inflation and unemployment as economic variables driven solely by labor force change has been carried out by Kitov (2006a, 2006b, 2006c) for the two largest economies – the USA and Japan. The study has revealed linear relationships between inflation, unemployment and labor force. In the USA, the linear relationships are also characterized by time lags with the change in labor force leading inflation and unemployment by two and five years, respectively. In Japan, labor force change, unemployment and inflation evolve synchronously. The revealed linear link allows a partial inflation control and provides clear foundations for a reasonable economic policy related to inflation and unemployment.

In this paper, the same approach linking inflation and unemployment to labor force change is applied to Austria and France. The reminder of the paper is organized in four sections. Section 1 briefly presents data sources and the model. Data on inflation, unemployment, and labor force for European countries is available from various sources. This diversity creates a number of problems but allows for an indirect estimation of the uncertainty related to various data series.

Section 2 is devoted to Austria as a country with elaborated statistics providing long time series with changing definitions and procedures. The changes are well documented and clear in corresponding curves. The importance of information on definitions and procedures for a successful modelling is illustrated and discussed.

Inflation and unemployment in France are considered in Section 3. The country represents an economy with a size in between those of the USA and Austria. The case of France is of a large importance for our concept because of the outstanding changes related to the rules of the European Monetary Union fixing allowed inflation to figures near 2%. The limitation violates the partition of labor force change into inflation and unemployment, which was natural for France and observed since the 1960s. An elevated unemployment is observed as a response to the fast growth in labor force started in 1996 and the fixed inflation. Section 4 discusses principal findings of the study and concludes.

1. Data sources and the model

The principal source of information relevant to the study is the OECD database (http://www.oecd.org/scripts/cde) which provides comprehensive data sets on labor force, unemployment, working age population, and participation rate. National statistical sources are used for obtaining original data on inflation (CPI and GDP deflator) and corroborative data on unemployment and labor force. As a rule, the data are available at the Eurostat web-site (http://epp.eurostat.cec.eu.int). An extended set of data on economic and population variables in Austria is obtained by the courtesy of Austrian national Bank employees[1].

In some cases, readings associated with the same variable but obtained from different sources do not coincide. This is due to different approaches and definitions applied by corresponding agencies. Diversity of definitions is accompanied by a degree of uncertainty related to corresponding measurements. For example, figures related to labor force are usually obtained in surveys covering population samples of various sizes: from 0.2 per cent to 3.3 per cent of total population (Eurostat, 2002). The uncertainty associated with such measurements cannot be easily estimated but certainly affects reliability of the inflation/labor force linear relationship (Kitov, 2006a, 2006c).

When using the term "accuracy" we refer not to the absolute difference between measured and actual values but to some estimated uncertainty of measurements. This uncertainty might be roughly approximated by variations in a given parameter between consequent surveys or between different agencies. For example, the US Census Bureau (2002) gives a very low measurement related uncertainty for the annual population estimates. At the same time, some micro-surveys conducted after decennial censuses indicate the presence of deviations from the census enumerated values as large as 5 per cent in some age groups (West and Robinson, 1999). Such errors are far above those guarantied by pure statistical approach used in the evaluation of survey/census results. Therefore, one can consider the uncertainty of several percent as the one characterizing the population estimates during and between censuses, at least in some age groups. Survey reported uncertainties are just a formal statistical estimate of the internal

[1] The author thanks Dr. Gnan from the OeNB for providing an extensive data set for Austria.

consistency of the measurements. (It is worth noting that population related variables could be potentially measured exactly because they are countable not measurable). In any case, the discrepancy between model predicted values and corresponding measurements has to be considered in the framework of measurements uncertainty.

The model, which we test in the study, links inflation and unemployment to labor force change rate. It is important to use the rate of growth not increment as a predictor in order to match dimension of inflation and unemployment, which are defined as rates as well. An implicit assumption of the model is that inflation and unemployment do not depend directly on parameters describing real economic activity (Kitov, 2006a). Moreover, inflation does not depend on its own previous and/or future values because it is completely controlled by a variable of different nature.

As defined in Kitov (2006a), inflation and unemployment are linear and potentially lagged functions of labor force:

$$\pi(t)=A_1 dLF(t-t_1)/LF(t-t_1)+A_2 \quad (1)$$

$$UE(t)=B_1 dLF(t-t_2)/LF(t-t_2)+B_2 \quad (2)$$

where $\pi(t)$ is the inflation at time t (represented by some standard measure such as GDP deflator or CPI), $UE(t)$ is the unemployment at time t (which is also potentially represented by various measures), $LF(t)$ is the labor force at time t, t_1 and t_2 are the time lags between the inflation, unemployment, and labor force, respectively, A_1, B_1, A_2, and B_2 are country specific coefficients, which have to be determined empirically. The coefficients may vary through time for a given country as different measures (or definitions) of the studied variables are used.

Linear relationships (1) and (2) define inflation and unemployment separately. These variables are two indivisible features of a unique process, however. The process is the labor force growth, which is accommodated in real economies though two channels. The first channel is the increase in employment and corresponding change in personal income distribution (PID). All persons obtaining new paid jobs or their equivalents presumably change their incomes to some higher levels. There is an ultimate empirical fact, however, that the US PID does not change with time in relative terms, i.e. when normalized to the total population and total income (Kitov, 2005b). The increasing number of people at higher income levels, as related to the new paid jobs, leads to a certain disturbance in the PID. This over-concentration (or over-pressure) of population in some income bins above its neutral value must be compensated by such an extension in corresponding income scale, which returns the PID to its original density. Related stretching of the income scale is called inflation (Kitov, 2006a). The mechanism responsible for the compensation and the income scale stretching, obviously, has some positive relaxation time, which effectively separates in time the source of inflation, i.e. the labor force change, and the reaction, i.e. the inflation.

The second channel is related to those persons in the labor force who failed to obtain a new paid job. These people do not leave the labor force but join unemployment. Supposedly, they do not change corresponding PID because they do not change their incomes. Therefore, total labor force change equals unemployment change plus employment change, the latter process expressed through lagged inflation. In the case of a "natural" behavior of an economic system, which is defined as a stable balance of socio-economic forces in corresponding society, the partition of labor force growth between unemployment and inflation is retained through time and the linear relationships hold separately. There is always a possibility, however, to fix one of the two dependent variables. For example, central banks are able to fix inflation rate by monetary means. Such a violation of the natural economic behavior would undoubtedly distort the partition of the labor force change – the portion previously accommodated by inflation would be redirected to unemployment. To account for this effect one should to use a generalized relationship as represented by the sum of relationships (1) and (2):

$$\pi(t)+UE(t)= A_1dLF(t-t_1)/LF(t-t_1)+B_1dLF(t-t_2)/LF(t-t_2)+A_2+B_2 \qquad (3)$$

Equation (3) balances labor force change, inflation and unemployment, the latter two variables potentially lagging by different times behind the labor force change. The importance of this generalized relationship is demonstrated in this paper on the example of France.

For the USA, there has been no need so far to apply relationship (3) because corresponding monetary policies and other potential sources of disturbance do not change the natural partition of labor force change, as observed since the late 1950s. Coefficients in relationships (1) and (2) specific for the USA are as follows: A_1=4, A_2=-0.03, t_1=2 years (GDP deflator as a measure of inflation), B_1=2.1, B_2=-0.023, t_2=5 years.

For Japan, A_1=1.77, A_2=-0.003, t_1=0 years (GDP deflator as a measure of inflation) (Kitov, 2006b). The labor force change rate measured in Japan is negative since 1999 and corresponding measures of inflation, GDP deflator and CPI, are negative as well. There is no indication of any recovery to positive figures any time soon if to consider the decrease in working age population and participation rate as observed in Japan from 1999.

The formal statistical assessment of the linear relationships carried out by Kitov (2006d) for the USA indicates that root mean square forecasting error (RMSFE) at a two-year horizon for the period between 1965 and 2002 is only 0.8%. This value is superior to that obtained with any other inflation model by almost a factor of 2, as presented by Stocks and Watson (1999, 2005), Atkeson and Ohanian (2001), Ang *et al.* (2005), Marcellino *et al.* (2005). When the entire period is split into two segments before and after 1983, the forecasting superiority is retained with RMSFE of 1.0% for the first (1965-1983) and 0.5% for the second (1983-2002) sub- period. In a majority of inflation models, the turning point in 1983 is dictated by inability to describe inflation process with one set of defining parameters. Therefore, special discussions are devoted to statistical, economic, and/or financial justification of the split and the change in parameters (see Stock and Watson, 2005). Our model denies the existence of any change in the US inflation behavior around 1983 or in any other point after 1960. Every inflation reading is completely defined by the labor force change occurred two years before.

The linear relationships between inflation, unemployment, and labor force change perform excellent for the two largest world economies during a long period. These relationships are expected to be successful for other developed economies with similar socio-economic organization. European countries provide a variety of features related to inflation and unemployment as one can conclude from the economic statistics provided by OCED and Eurostat. This diversity includes periods of very high inflation accompanied by high unemployment, periods of low inflation and unemployment, and other combinations complicated by transition periods. It is a big challenge for any theory of inflation to explain these empirical facts.

Currently, the diversity resulted in a well-recognized and thoroughly discussed failure of conventional economics to provide a consistent and reliable description covering the past 50 years and all developed countries. As a consequence, the current monetary policy of the European Central Bank is based mainly on invalidated assumptions and subjective opinions of economists and central bankers, but not on a robust model predicting inflation behavior under different conditions. In the USA, the current (and historical!) practice aimed at inflation control, as implemented by the Federal Open Market Committee, definitely, has no visible influence on the observed inflation, if labor force change is the driving force.

2. Austria

The first country to examine is Austria. It provides an example of a small economy in terms of working age population. At the same time, the Austrian economy is characterized by a long history of measurements and availability of time series and descriptive information relevant to the concept under study.

Austria has been demonstrating an excellent economic performance since 1950 and is characterized by an average per capita GDP annual increment of $467 (Geary-Khamis PPP - The Groningen Growth and Development Center and Conference Board, 2006) for the period between 1950 and 2005. This value is very close to that for the USA ($480) and Japan ($485) (Kitov, 2006e). Such a good performance distinguishes Austria from a raw of relatively weak performances of larger European economies such as France ($406), the UK ($378), Italy ($405), and Sweden ($381) during the same period.

It was discussed in Kitov (2006a, 2006b, 2006d) that data quality is the principal characteristic defining the success of any attempt of modelling inflation and unemployment as a function of labor force change. There are two main sources of uncertainty in the data related to our study. The first source is associated with measurement errors. It is a more important issue for the accuracy of labor force surveys, which usually provide original data on unemployment and labor force. In the surveys, measurement accuracy depends on sampling and nonsampling errors. The former is estimated using population coverage and some standard statistical principles, and the latter is more difficult to evaluate (CB, 2002).

The second source of uncertainty is important for both labor force, including unemployment as a constituent part, and inflation measurements and is associated with variations in definitions given to these economic variables. The definitions are often revised and modified, sometimes dramatically, as one can judge from the description given by the OECD (2005). When applied to labor force, such revisions introduce severe breaks in corresponding time series associated with the change in units of measurements. (In physics, it would have been practically impossible to obtain any reliable empirical relationship if measurement units had varied in such uncontrollable way as in economics.) Moreover, European countries have implemented the changes at different times creating asynchronous breaks. Modifications of methodologies and procedures related to inflation measurements are accompanied by introduction of new measures such as harmonized index of consumer prices (Eurostat, 2006a). The latter index has replaced the old CPI definition in official statistics of European countries.

Therefore, we start with a detailed description of the data obtained for Austria. We use six sources providing annual readings for CPI, GDP deflator, population estimates, unemployment rate, participation rate, and labor force level: Eurostat, OECD, AMS (Arbeitsmarktservice) Österreich (http://www.ams.or.at), HSV (Hauptverband der Sozialversicherungtraeger) Österreich (http://www.hsv.or.at), Statistik Austria (http://www.statistik.at), and the Österreichische Nationalbank (ÖNB – http://www.oenb.at). These sources estimate the same variables in different ways. Comparison of equivalent (by title) time series allows a quantitative evaluation of differences between them. The main purpose of such a cross-examination is twofold: 1) demonstration of the discrepancy between the series as a quantitative measure of the uncertainty in corresponding parameters and 2) determination of the degree of similarity between the series. The estimated uncertainty puts a strong constraint on the level of confidence related to statistical estimates using the data sets. One cannot trust any statistical inference with a confidence level higher than allowed by the uncertainty. On the other hand, equivalent time series obtained according to various definitions (procedures, methodologies, samples, etc.) of the same parameter represent different portions of some actual value of the parameter. For example, various definitions of employment are aimed at obtaining the number of those persons who work for pay or profit. The persons are the only source of goods and services sold for money. The definitions are designed in a way for corresponding estimates to approach the actual value. If consistent and successful, the definitions always provide close to constant and different estimates of the portions of the actual value. Thus, the estimates are scalable - one can easily compute values according to all definitions having only one of them. In this sense, various definitions and related estimates are exchangeable in the framework of the linear relationship between inflation, unemployment, and labor force.

Three different definitions of inflation rate are presented in Figure 1: CPI and GDP deflator as obtained using prices expressed in national currency (national accounts - NAC), and GDP deflator estimated using the Austrian shilling/Euro exchange rate (Euro accounts - EUR). The latter variable is characterized by the largest variations. The curves corresponding to the inflation measurements represented by the NAC CPI and NAC GDP deflator are closer (correlation coefficient of 0.92 for the period between 1961 and 2004), but differ in amplitude and timing of principal changes. There are periods of an almost total coincidence, however. The EUR GDP deflator series is characterized by correlation coefficients 0.86 and 0.82 as obtained for the NAC GDP deflator and CPI, respectively. Therefore, one can expect a better exchangeability between the NAC CPI and NAC GDP deflator than that in the two other combinations. Since the middle 1970s, inflation in Austria has a definition-independent tendency to decrease. The last 25 years are characterized by annual inflation rates below 5% for the NAC representations.

Standard labor force surveys conducted in Europe cover small portions of total population (Eurostat, 2006b). Levels of labor force and unemployment are estimated using specific weights (population controls) for every person in the survey to compute the portion of population with the same characteristics as the person has. Population controls or population portions in predefined age-sex-race bins are primarily obtained during censuses, which theoretically cover entire population. Between censuses, i.e. during postcensal periods, estimated figures are used as obtained by the population components change: births, deaths, net migration, as, for example, reported by the US Census Bureau (2002). Because of low accuracy of postcensal estimates, every new census reveals some “error of the closure”, i.e. the difference between pre-estimated and census enumerated values. To adjust to new population figures, the difference is proportionally distributed over the years between the censuses; similar to the procedures applied by the US Census Bureau (2004). Such population revisions may be as large as several percent. Thus, when using some current figures of labor force and unemployment, one has to bear in mind that the figures are prone to further revisions according to the censuses to come.

Figure 2 illustrates the differences in population revision procedures between OECD and Statistik Austria (NAC): two curves represent the rate of change in the population of 15 years of age and over in Austria. Between 1960 and 1983, the curves coincide since OECD uses the national definition. After 1983, the curves diverge, with the OECD curve being almost everywhere above that corresponding to the national approach. There are three distinct spikes in the OECD curve: between 1990 and 1993 and in 2002, which are related to population revisions. As explained by OECD (2005), "From 1992, data are annual averages. Prior to 1992, data are mid-year estimates obtained by averaging official estimates at 31 December for two consecutive years". And - "From 2002, data are in line with the 2001 census". The 2002 revision impulsively compensates the difference between OECD and Statistik Austria accumulated during the previous 20 years: the populations in 1982 and 2002 coincide. Such step adjustments are observed in the USA population data as well (Kitov, 2006a). They introduce a significant deterioration in statistical estimates, but are easily removed by a simple redistribution as demonstrated by Kitov (2006d). Sometimes such step adjustments are confused with actual changes in the economic variables under stud. One has to be careful to distinguish between actual changes and artificial corrections usually associated with the years of census or large revisions in definitions.

The national estimates in Figure 2 are visually smoother indicating some measures applied to distribute the errors of the closure and other adjustments over the entire period. In average, the population over 15 years of age in Austria has been changing slowly so far – at an annual rate below 0.5% - with occasional jumps to 0.7% - 1.0%. Such weak but steady growth supports, however, a gradual increase in labor force and prevents deflationary periods.

The level of labor force can be represented as a product of total population and corresponding participation rate (LFPR) both taken in some predefined age range. There is no conventional definition concerning the age range, however. Popular is an open range above 15 years of age and that between 15 and 64 years. The OECD series using the former definition is presented in Figure 3. OeNB (2005) provides another measure of LFPR - "the fraction of the working-age population that is employed or seeking employment", also presented in Figure 3. The curves have been evolving more or less synchronously, with the OECD curve well above that reported by the OeNB.

The LFPR is responsible for a substantial part of the labor force total change: ~ 8% increase from 1976 to 1996, i.e. 0.4% per year. The current LFPR value of about 59%, as reported by the OECD, is historically high. One can hardly expect a further increase in LFPR. A decrease is more probable, as some other developed countries demonstrate.

The rate of labor force growth was very low in Austria during the last 10 years, as Figure 4 demonstrates. There are three labor force time series displayed, as estimated by the OECD, Eurostat, and NAC. The Eurostat series is represented by civilian labor force. Prior to 1994, armed forces were included in the civilian labor force (CLF), in services. The NAC readings include the estimates of employment made according to the HSV definition and those of unemployment level made by AMS (Statistik Austria, 2005). Both agencies base their estimates on administrative records. Thus, their approach has been undergoing weaker changes in definitions and procedures since the 1960s compared to that adopted by the OECD and Eurostat.

The curves in Figure 4 have inherited the features, which are demonstrated by corresponding working age populations in Figure 2. The OECD curve is characterized by several spikes of artificial character, as discussed above. The Eurostat curve is similar to that reported by the OECD with minor deviations probably associated with differences between LF and CLF. The NAC LF curve is smoother. It demonstrates a period of a slow growth with a high volatility in the 1970s, a period with an elevated growth with a high volatility between 1981 and 1995, and again a slow growth period with a low volatility during the last ten years (from 1995 to 2005). The second period is characterized by significant changes in the labor force definition - both for employment and unemployment (OECD, 2005):

- "In 1982, re-weighting of the sample was made, due to an underestimation of persons aged 15 to 29 years.
- In 1984, the sample was revised and a change occurred in the classification of women on maternity leave**:** they were classified as unemployed before 1984 and as employed thereafter.
- In 1987, a change occurred in the definition of the unemployed where non-registered jobseekers were classified as unemployed if they had been seeking work in the last four weeks and if they were available for work within four weeks. In previous surveys, the unemployment concept excluded most unemployed persons not previously employed and most persons re-entering the labor market.
- Employment data from 1994 are compatible with ILO guidelines and the time criterion applied to classify persons as employed is reduced to 1 hour. "

Therefore, one can expect some measurable changes in the units of the labor force measurements during the period between 1982 and 1987 and in 1994. The latter change is potentially the largest since the time criterion dropped from 13 hours, as had been defined in 1974, to 1 hour. For the sake of consistency in definitions and procedures, the NAC labor force is used as a predictor in this study. The OECD labor force time series is also used in few cases to illustrate that the definitions provide similar results. For the labor force series, quantitative statistical estimates of similarity (such as correlation) are worthless due to the spikes in the OECD time series.

There are three curves associated with unemployment estimates for Austria shown in Figure 5, as defined by the national statistics approach (AMS), Eurostat, and OECD. It is illustrative to trace changes in the definitions used by the institutions over time. Currently, OECD and Eurostat use very similar approaches. There was a period between 1977 and 1983 when OECD adopted the national definition, which was different from the one used by Eurostat. During a short period between 1973 and 1977, the three time series were very close to each other. A major change in all three series occurred between 1982 1987 according to the changes in definitions, as described above. Therefore, the unemployment curves in Figure 5 are characterized by two distinct branches: a low (~2%) unemployment period between 1960 and 1982 and a period of an elevated unemployment (~4% for the OECD and Eurostat, and ~6.5% for the AMS) since 1983.

The switches between various definitions, as adopted by the OECD, also do not facilitate obtaining of a unique relationship between labor force change and unemployment. The AMS definition based on administrative records might be the most consistent among the three, but it definitely differs from the definition recommended by the International Labor Organization, as adopted in European countries (Statistik Austria, 2005). We use the national and OECD time series to represent unemployment in the linear relationship linking it to labor force.

The above discussion explains why one cannot model the whole period by a unique linear relationship. There was a period of substantial changes in units of measurement between 1982 and 1987. Therefore, we model the Austrian unemployment (*UE*) during the periods before 1982 and after 1986 separately. The period between 1982 and 1987 is hardly to be matched by a linear relationship. Results of the modeling are presented in Figure 6, where the AMS unemployment curve is matched by the following relationships:

$$UE(t)=0.35*dLF(t)/LF(t)+0.0260 \; (t<1982) \quad (4)$$

$$UE(t)=0.70*dLF(t)/LF(t)+0.0705 \; (t>1986) \quad (5)$$

The NAC labor force time series is used for the prediction with no time lead ahead of the unemployment. The absence of any lag might be presumed as a natural behavior of labor force and unemployment as one of the labor force components, but labor force change in the US leads unemployment by 5 years. Hence, processes behind labor force change and unemployment growth are different. Coefficients in relationships (4) and (5) provide the best visible fit between the observed and predicted curves. From the Figure and the relationships, one can conclude that there was a step change in the unemployment average level from approximately 0.03 during the years before 1982 to 0.07 for the period after 1986. In addition, the linear coefficient has doubled indicating a higher sensitivity of the unemployment to the labor force change under the new definitions introduced between 1982 and 1987.

The annual OECD unemployment readings presented in Figure 7 vary by less than 1%, if to exclude a short period between 1980 and 1983, when changes in definitions resulted in a step-like unemployment increase. Duration of this period of changing definitions is different from that related to the NAC unemployment according to the timing of the changes as adopted by AMS and OECD. This jump in the unemployment rate from 2% to 4% during the two years between 1981 and 1983 is not well modeled. Otherwise, the following relationships are used to match the observed unemployment readings:

$$UE(t)=0.35*dLF(t)/LF(t)+0.0405\ (t\geq 1983) \quad (6)$$

$$UE(t)=0.30*dLF(t)/LF(t)+0.020\ (t\leq 1980) \quad (7)$$

For the period before 1980, the NAC labor force readings are used, and the OECD labor force is used after 1981. We combined the labor force data sets in order to demonstrate their exchangeability in the description of the unemployment. Cumulative curves in the lower panel of Figure 7 illustrate the quality of the overall match between the measured and predicted values. The cumulative curves are very sensitive to the intercepts in relationships (6) and (7) as they are summed through time. Therefore, the intercepts 0.0405 and 0.020 are significant to the last digits. Potential variation in the linear coefficients in (6) and (7) is not so well resolved.

Amplitude of the variations in the unemployment during the entire period except the short period between 1980 and 1983 is so low that makes the prediction according to (6) and (7) of a limited reliability. To obtain a more reliable prediction, the unemployment has to undergo an actual (not definition related) change at an annual rate of several percent, what would have been a big surprise for Austria with its stable socio-economic conditions and demographic structure. The agreement observed between the cumulative curves also is not statistically significant since it just reflects the unchanging unemployment and labor force growth rates during the two separately modeled periods.

These results can be interpreted, however, as an indication of a weak dependence of the unemployment on the labor force change. The latter is transmitted only by one third into the unemployment as the linear coefficients 0.30 and 0.35 indicate. These transmission coefficients are an order of magnitude smaller than that for the USA (Kitov, 2006a). The difference is of a potential importance because labor force participation rate and unemployment in both countries are close.

Table 1 consistently lists results of linear regression analysis carried out in the study for various measures of unemployment and inflation with labor force as a predictor, as obtained for Austria. First row of the Table presents standard deviation (stdev) as obtained for the OECD readings of unemployment in Austria during the period between 1983 and 2003. The standard deviation is 0.0036. Second and third rows present regression coefficients with their standard errors, R^2, and stdev as obtained for the OECD unemployment between 1983 and 2003 with a predictor computed by relationship (6) with the OECD labor force readings. (A linear regression analysis for the whole period between 1969 and 2003 would be meaningless because of the artificial change in the predicted curve around 1982.) For the annual *UE* readings after 1983, R^2 is very low (0.11) and stdev=0.0035, i.e. marginally lower than stdev for the *UE* series itself. For the cumulative curves during the same period, R^2=0.999 and stdev=0.007. Therefore, relationships (4) through (7) are accurate one but not reliable. In fact, only large and synchronized in time and amplitude actual changes can provide a more reliable evidence for the model. Inflation in Austria provides a variable with higher fluctuations to predict.

Figure 8 depicts observed and predicted, annual and cumulative, inflation values in Austria for the period between 1960 and 2003. As mentioned above, there was a significant change in the labor force (employment and unemployment separately) statistics in the 1980s. Thus, the two different periods are described by two different linear relationships without any time lag between variables. The GDP deflator, as determined by the national statistics approach, represents inflation. Labor force is also taken according to the NAC (AMS+HSV) definition. The relationships predicting inflation are as follows:

$$\pi(t)=2.0*dLF(t)/LF(t)+0.033 \quad (1960\leq t \leq 1985) \qquad (8)$$

$$\pi(t)=1.25*dLF(t)/LF(t)+0.0075 \quad (t \geq 1986) \qquad (9)$$

Coefficients in the relationships are obtained by fitting the cumulative curves over the entire period, with 1986 being the point where relationship (8) is replaced by relationship (9). Ratio of the linear coefficients in (8) and (9) is 2/1.25=1.6 and the intercept dropped from 0.033 to 0.0075. The change in the linear coefficients is consistent with the changes in the definition of labor force in between 1982 and 1987 – gradually more and more persons were counted in as employed and unemployed with a substantial increase in the labor force level. The increase resulted in corresponding growth in annual increments and the decrease in the linear coefficient (or sensitivity) in relationship (9). Thus, the sensitivity of the inflation to the new measure of labor force (or new units of measurement) in Austria decreased. This does not mean that the observed inflation path has changed, but, if to use relationship (8) for the second period, the inflation would be overestimated, as shown in Figure 8. The deviation between the two predicted curves after 1986 demonstrates the importance of the changes in definition for quantitative modeling of economic parameters.

The two predicted curves are in a good agreement with the actual inflation readings within relevant periods. A prominent feature is an almost complete coincidence between 1968 and 1975, when the highest changes in the inflation rate were observed: from 0.027 in 1968 to 0.095 in 1973, and back to 0.056 in 1975. Conventional inflation models, including the Phillips curve, the NKPC or any other model using autoregressive properties of inflation, fail to describe such a dynamic behavior as a rule. They require introduction of some artificial, i.e. based on various invalidated assumptions, features such as structural breaks. Another opportunity used in conventional models is to split corresponding time series into two segments before and after such inflation peak, as was observed in Austria in 1973. Our model describes the whole period without any difficulty and the best description of the inflation is achieved during the period of the largest changes. This provides the best evidence of an adequate modeling by relationship (8).

Similar conclusion is valid for the period after 1987, where an excellent timing and amplitude correspondence is observed between the measured inflation and that predicted according relationship (9). In addition, there is a transition period between 1982 and 1987, where neither of relationships (8) and (9) is expected to be accurate due to the reported changes in the labor force definition.

A quantitative measure of the agreement between the observed and predicted curves is provided by a linear regression analysis. Table 1 lists standard deviation for the NAC GDP deflator time series between 1965 and 2003, stdev=0.022 (2.2%). The inflation computed according to (8) and (9) is used as a predictor and results in R^2= 0.81

and stdev=0.01 (1%). Hence, the prediction based on the labor force explains 81% of variation in the original inflation series. Standard deviation could be considered as an equivalent of root mean square forecasting error (RMSFE) – for "in-sample" forecasts in the case of Austria. For the USA, R^2=0.62 and stdev=0.014 for the original annual readings of GDP deflator and labor force covering the same period (Kitov, 2006d). Perhaps, the Austrian labor force and inflation measurements are characterized by a higher accuracy.

A number of simple measures is proposed by Kitov (2006d) in order to improve the quality of labor force measurements and to obtain more reliable statistical estimates. Due to the lack of information on quantitative characteristics of the revisions applied to the Austrian labor force series, similar to that available for the USA, we cannot correct for probable step revisions. Thus, a natural next step is to apply a moving average technique. A two-year moving average suppresses the noise associated with the labor force measurements and also removes the shift in timing between the inflation and labor force readings - by definition, annual values of labor force correspond rather to July than to December. Averaging over two years effectively moves the center of the measurement period to December. Table 1 represents the results of a linear regression when two-year moving average is applied to the labor force and inflation. Averaging of the labor force solely before usage in relationships (8) and (9), results in R^2=0.85 and stdev=0.009. When both variables are averaged in two-year windows, R^2=0.88 and stdev=0.007. These results quantitatively evidence an excellent predictive power of relationship (8) and (9) over the entire period between 1965 and 2003. If to recall that the period between 1983 and 1986 is poorly modeled due to the turbulence in the labor force definitions, one can expect that further improvements in the accuracy of the labor force measurements are possible, which might lead to a higher confidence as presented by statistical estimates.

Regression of the cumulative curves is characterized by R^2=0.999 and stdev=0.0011. Thus, one can precisely replace the inflation cumulative curve or, in other words, inflation index with that obtained from the labor force measurements. This substitution is a reciprocal one– it is possible to exactly estimate the total increase in the labor force between 1965 and 2003 by measuring the GDP inflation.

Currently, inflation is Austria, as represented by the NAC GDP deflator, is close to

2%, as explicitly defined by the monetary policy adopted by the European System of Central Banks (ECB, 2004) and correspondingly by the Austrian National Bank (OeNB, 2005). The inflation obeys the revealed dependence on the labor force change as well. Hence, the new monetary policy oriented to price stability does not disturb the relationship describing the last 40 years of the Austrian inflation.

Linear relationship (9) obtained for the current period implies that one per cent of the labor force change produces inflation of 2%=1.25%+0.75%, where 0.75% is the persistent inflation level, i.e. the inflation existing even when no labor force change is observed. Thus, an annual change in labor force of +1% produces the OeNB's target inflation.

Obviously, labor force change in Austria is affected not only by the OeNB's monetary policy. There are demographic, social, political, economic processes behind the change. Therefore, it is probable that the labor force will change in future in a way not matching the target inflation. In the case of a decrease in the labor force, a deflationary period is probable starting from -0.6% annual labor force change rate, as relationship (9) defines: 1.25*(-0.006) +0.0075=0.

Labor force participation rate is stable in Austria during the last ten years and close to 59% (the OECD definition). If this tendency holds in future, the labor force will be defined by the level of the population of 15 years of age and above. Statistics Austria (2006) provides a good population projection and corresponding approximation for this variable as a sum of the population aged between 15 and 60 years and that above 60 years as presented separately:

Year	From 15 to 60 years of age	>60 years of age	Total
2004	5059	1789	6848
2010	5112	1928	7040
2015	5120	2053	7173

The population above 15 years of age will grow by 2.8% between 2004 and 2010 and by another 1.9% during the following five years. The mean growth rate of 0.4% per year provides a 1.2% inflation growth rate during the next ten years. The value is below the

2% target and the Austrian monetary authorities have to provide an approximately 0.8% average annual growth in the participation rate, i.e. from 59% in 2005 to 67% in 2015. Otherwise, the target inflation rate will not be matched.

Figures 9 and 10 show the results of a similar analysis for the other two measures of inflation: the NAC CPI and the GDP deflator calculated at the exchange rate to Euro. The NAC CPI readings are very close to those obtained for the NAC GDP deflator. Therefore, coefficients in relationship (1) are also close: A_1=2, A_2=0.0315 before 1986, A_1=1.35, A_2=0.0095 after 1986. The linear relationships for the EUR GDP deflator readings are characterized by larger coefficients: A_1=4, A_2=0.047 before 1986, A_1=2.5, A_2=0.00 after 1986. Results of the regression analysis are presented in Table 1.

The CPI time series is characterized by stdev=0.022 for the period between 1965 and 2003, which is equal to the standard deviation related to the NAC GDP deflator series. At the same time, a linear regression of the CPI NAC against the predicted inflation results in a lower R^2=0.60 and larger stdev=0.014. Therefore, even small differences between the GDP deflator and CPI, as defined by correlation coefficient 0.92, result in a large difference in statistical estimates.

The Eurostat GDP deflator demonstrates a higher scattering: stdev=0.046 for the period between 1965 and 2003. Correspondingly, R^2=0.66 and stdev=0.027, i.e. much poorer than the results shown by the NAC GDP deflator. Especially, it concerns the high standard deviation, which is by a factor of 2.5 larger than that for the NAC GDP deflator. However, if normalized to standard deviation of corresponding inflation series, i.e. to 0.014/0.022=0.64 and 0.027/0.046=0.59, the relative volatility does not differ much in the cases of the NAC and Eurostat GDP deflators. The two-year moving average technique provides a gradual improvement on the results of the regression of the annual values, as presented in Table 1.

It is confirmed above that both inflation and unemployment in Austria are linear functions of labor force change rate with no time lag. There is no need to apply generalized relationship (3) to the data in order to balance some potential disturbances, which might be induced by the ESCB fixed inflation rate. Relationships (1) and (2) work excellent separately and its sum should also work well. There is another issue associated with usage of (3), however. Measurement errors make prediction of the annual time series unreliable during the periods of weak changes in defining parameters, i.e. when the change in labor force is lower than the accuracy of the labor force measurements. In such a situation, the observed change is statistically insignificant, as we have obtained for the unemployment. Relationship (3) provides a potential way to improve the match. All the involved variables have almost independent measurement errors. Thus, one can expect an additional destructive interference of the errors when the variables are used together, such as relationship (3) defines.

Figure 11 displays the observed and predicted inflation. The former is presented by the NAC GDP deflator. The latter is obtained using relationship (3) with coefficients computed for the case of the predictor based on the NAC (AMS+HSV) labor force and the AMS unemployment. This representation of inflation is less sensitive to the changes in the unemployment and labor force definitions. In fact, the unemployment is a part of the labor force and any change in unemployment is automatically included into the labor force change, but the changes in the unemployment and employment definitions are not synchronized. The latter observation makes the changes in the labor force and unemployment also to be asynchronous. In any case, the agreement between the predicted and observed curves is remarkable over the whole interval between 1965 and 2003.

There is a small deviation starting in 1994, however, as the cumulative curves in Figure 11 show. One can explain the discrepancy as associated with the change in the employment definition in 1994 - the time criterion was decreased to 1 hour, as mentioned above. Obviously, the change resulted in the increase of the overall labor force level and corresponding change rate. In addition, the labor force survey procedures, including population coverage and timing, were changed and Statistik Austria became responsible for the labor force estimates in line with the Eurostat and ILO definitions since 1994 (Statistik Austria, 2004). These modifications could result in the observed change of the inflation sensitivity to the labor force change due to the introduction of new units of measurements. So far, the inflation in Austria (in all the three representations) was modeled for the period after 1986 separately. The difference between units of measurement in the 7-year long interval between 1987 and 1994 and during the nine years after 1994 was so weak that is could not be resolved using the short intervals. The difference was balanced in (9), i.e. a small overestimation of inflation in the first interval was compensated by a small underestimation during the second period. The generalized approach has a higher resolution because of longer baselines: 29 years between 1965 and 1994 and 9 years between 1994 and 2003. Therefore, the deviation between two branches has been revealed and successfully modeled by the introduction of new coefficients in the generalized linear relationships after 1994:

$$\pi(t)=1.2*dLF(t)/LF(t)-UE(t)+0.066 \quad (1965\leq t \leq 1994) \qquad (10)$$

$$\pi(t)=0.9*dLF(t)/LF(t)-UE(t)+0.0074 \quad (t \geq 1995) \qquad (11)$$

The predicted values of inflation according to relationships (10) and (11) with the NAC labor force and the AMS unemployment are used as a predictor for a linear regression of the NAC GDP readings. For the annual readings between 1965 and 2003, Table 1 lists the following values: R^2=0.86 and stdev=0.008. This is an outstanding result considering the uncertainty associated with the measurement of the inflation, labor force, and unemployment. The predictor explains 86% of inflation variation including the periods of high and low inflation, and the periods of intensive growth and decrease of the inflation, as presented in Figure 11. The choice of 1965 is arbitrary and an extension of the period to 1960 does not change R^2 much - it drops to 0.84. Standard error of the regression is only 0.008. The slight improvement in statistical description related to usage of (3) instead of (1), as expressed by R^2 increase from 0.81 to 0.86 for the annual readings, is apparently related to a stabilizing role of the unemployment readings. Averaging in two-year moving windows provides almost no additional improvement in statistical estimates. When the predicted values are averaged, R^2=0.87 and stdev=0.008. When both observed and predicted readings are averaged, R^2=0.91 and stdev=0.007. In any case, generalized relationship (3) provides a very accurate description of inflation in Austria between 1960 and present.

In this Section, we have scrupulously considered details of the procedures related to measurements in order to obtain the best agreement between the observed and predicted values. As a result we have obtained a very accurate, in statistical sense, description of unemployment and inflation in Austria during the last 45 years. In addition, a prediction of inflation for the next ten years has been computed using population projections provided by Statistik Austria. We have also learned several important lessons for future investigations:

- Data related to labor force and unemployment needs special consideration because of numerous revisions of definitions and procedures.
- There is not break or any other discontinuity in inflation behavior around its peak and trough values. Linear dependence of inflation and unemployment on labor force change is very consistent and reliable over time.
- The larger is the amplitude of inflation (unemployment) change the better is its prediction based on labor force change. An alternative opportunity to increase resolution is to improve accuracy of corresponding measurements.
- The GDP deflator is the best representation of inflation, at least in Austria and the USA.
- The generalized linear relationship linking together inflation, unemployment, and labor force potentially provides an additional improvement in prediction of inflation.
- Quantitatively, the best fit model of inflation in Austria is characterized by R^2=0.86 and RMSFE=0.008, as obtained for the period between 1965 and 2003.

Concluding this Section, it is worth noting that Austria provides a good opportunity not only to model the dependence between inflation, unemployment, and labor force change, but also evaluate consistency of various definitions of the studied variables. Despite the documented changes in units of measurements, the variables do not lose their intrinsic links persistent through the last 45 years. There is no reason to think that these bounds will disappear in the near future.

3. France

France is characterized by an outstanding productivity and has the largest GDP per working hour among large developed economies, as presented by the Groningen Growth and Development Center and Conference Board (2006). At the same time, real economic performance in France is far from a stellar one during the last twenty-five years with the mean annual real GDP growth of 2%. Therefore, France is an example of an economy different in many aspects from those in the USA, Japan, and Austria. This is especially important for the concept we examine. Linear relationships (1) and (2) with country specific coefficients are supposed to be intrinsic ones to any developed economy and to express deep socio-economic bounds between people. In turn, the linear relationship for inflation does not depend on such parameters of real economy as output gap, marginal labor cost, and so on.

OECD (2005) provides relatively long time series for the variables involved in the study: GDP deflator (between 1971 and 2004), CPI based on the national currency (between 1956 and 2004), labor force level (between 1956 and 2004), unemployment rate (between 1960 and 2004), working age population (between 1960 and 2004), and labor force participation rate (from 1960 to 2004). Inflation estimates are also available at the web-sites of Eurostat- the Euro based CPI between 1979 and 2005, and at the National Institute for Statistics and Economic Studies (INSEE)- http://www.incee.fr.

There are three different measures of inflation in France shown in Figure 12: the OECD CPI, the CPI based on the Euro, and the OECD GDP deflator. The time series for CPI and GDP deflator published by the INSEE (2006) almost coincide with those provided by OECD and Eurostat and start from 1983 as a rule. Therefore, they are not presented in the Figure. The OECD GDP deflator and CPI inflation are very similar with only relatively small discrepancies during some short intervals. These curves show a high inflation rate between 1975 and 1985 and a gradual decrease to the current level close to 2%.

Only two measures of inflation from the three available are modeled in the study. The Eurostat CPI based on the Euro is limited in time and volatile due to the exchange rate fluctuations. So, this time series is neglected. GDP deflator is probably the best variable reflecting inherent links between inflation and labor force change, as found for the USA, Japan, and Austria. So, our primary goal is to model the GDP deflator provided by the OECD. The OECD CPI time series is also predicted for a comparison. CPI is of a lower interest for our study because it hardly represents a valid economic parameter to model in our framework.

Figure 13 displays the principal variable of the model – labor force change rate, *dLF/LF*, in France for the period between 1956 and 2004. The Eurostat web-site also publishes time series for the number of unemployed (1983 through 2004) and employed (1978 through 2004) separately. The sum of the two series gives a labor force estimate between 1983 and 2004 also presented in Figure 13. Because of the limited interval spanned by the Eurostat labor force series and its high volatility of unknown origin only the OECD labor force readings are used to predict unemployment and inflation rate.

The OECD labor force series can be split into several distinct periods. From 1958 to 1963, a very low and even negative change rate was observed, which is potentially associated with statistical definitions or methodology of measurements in the past. From 1963 through 1981, a strong labor force growth was measured with the mean annual rate of +0.94%. A relatively slow growth between 1982 and 1995 with the mean annual rate of +0.48% is followed by a new period of a strong growth started in 1996 with the mean annual rate of +0.84%. According to the linear relationships under study, inflation and unemployment have to evolve in the same way. It is interesting that the recent increase in the labor force has not been accompanied by any visible change in the inflation, as Figure 12 evidences.

Taking into consideration a gradual decrease in the rate of working-age population growth in France (OECD, 2006), one can expect an intensive growth of labor force participation rate (LFPR) started in 1996 to be responsible for the rapid increase in the labor force. Figure 14 proves that the expected strong growth in the LFPR has been an actual and consistent one since 1996. During the previous forty years, the participation rate in France was as low as 55% compared to 59% in the USA and above 60% in Japan. So, it is natural that the participation rate in France has started to grow at some point.

The current period of the labor force growth almost coincides with the establishment of a new entity of the French national bank, Banque de France, as an independent monetary authority having a fixed target value of inflation rate. In 1993, the European System of Central Banks (ESCB) cardinally changed its approach to inflation managing – the main target is currently to reach price stability at a level near 2% of annual growth (ECB, 2004). Whatever reasons are put forth to justify the new approach they are not theoretically and empirically sound, i.e. there are no reliable evidences for the assumptions underlying the current concepts of inflation to be valid. The most recent models rely on exogenous shocks as the driving force behind inflation (Rudd and Whelan, 2005; GG (1999); Gali *at al.*, 2002, 2005; Hall, 2005). Such shocks are inherently unpredictable and uncontrollable in time and amplitude. So, the approach based on an aggregated opinion of central bankers and economists is barely valid in view of unpredictable exogenous shocks. Our concept provides a clear understanding of the nature of these exogenous forces and thus a control over unemployment and inflation.

For France, as for the US, Japan, and Austria we use the same procedure to fit annual and cumulative inflation and unemployment readings by linear functions of labor force change rate. The most sensitive to coefficients in relationship (1) is a cumulative curve. Even a small systematic error in predicted amplitude cumulates to a high value when aggregated over thirty-five years. Predicted and measured annual and cumulative curves for the OECD unemployment rate between 1970 and 2004 are presented in Figure 15.

The predicted curve in Figure 15a is obtained from the OECD labor force change rate and shows large-amplitude fluctuations around the measured unemployment curve. This is a result of a very large coefficient in the relationship between *UE(t)* and *dLF(t)/LF(t)*:

$$UE(t)=0.165-13*dLF(t)/LF(t) \quad (12)$$

Linear coefficient in (12) amplifies labor force change and any measurement error in the labor force by a factor of 13. This coefficient is also a negative one, i.e. any increase in labor force is converted in a synchronized (no time lag between the labor force and the unemployment change) and 13-time amplified drop of the unemployment rate in France. On the other hand, in the absence of any growth in the labor force the unemployment rate reaches a 16.5% level. (The high sensitivity of the unemployment to the labor force change provides a good opportunity to control the unemployment through a reasonable labor market policy. At the same time, the high sensitivity demands any such a policy to be thoroughly and deeply discussed before implementation.) From 1970 through 1995, there is a good agreement between the observed and predicted curves. The period before 1970 is neglected in the study. As we have learned from the case of Austria, the earlier period is characterized by some changes in the methodology of labor force survey and/or the definitions of labor force itself. The model period after 1970 is also in line with many other studies devoted to the modeling of various Phillips curves in European countries, where the period before 1970 is rarely covered (see Angelini *et al.* (2001); Canova, F., (2002), Cristadoro *et al.* (2001); Espasa *et al.* (2002); Gali *et al.* (2001), Ihrig and Marquez (2003); Marcellino *et al.* (2001); Hubrich (2005), among others).

The observed unemployment curve gradually elevates from 3% in 1970 to almost 10% in 2004, with the predicted curve fluctuating around the observed one with an amplitude reaching 0.1. In 1996, a sudden drop in the predicted curve started a major deviation from the measured curve. The predicted curve falls from 10% in 1996 to 4% in 2003. It is possible to compute the total number of unemployed people who could get paid jobs under the theoretical curve in excess of the measured number: 4%*27,000,000~1,000,000 per year. Thus, approximately one million less than expected persons have job in France every year since 1996.

There are three potential explanations of the deviation. The first one is associated with a probable change in unit of measurements, as has been found for Austria. There is no documented change in the labor force and unemployment definitions in the 1990s in France, however. Therefore, this explanation is not working for France. The second possibility is that coefficients in relationship (12) were changed in 1996 by some external forces to new values, but the linear link to labor force is retained. We have discussed such a situation is Section 1 and suggested that generalized relationship (3) has to replace individual relationships (1) and (2). We will examine this assumption in detail later on. The third explanation is that there is no linear relationship between unemployment, inflation, and labor force and the deviation started in 1996 is unpredictable and spontaneous.

A standard linear regression analysis is carried out for the period between 1970 and 1995. The OECD unemployment rate is a dependent variable and the theoretical curve is used as a predictor. Table 2 lists some results of the analysis. The measured time series is characterized by stdev=0.032. As expected from the high volatility in the annual readings of the predictor (see Figure 15a) corresponding regression gives R^2=0.48 with stdev=0.023. Hence, the annual time series is poorly predicted.

Figure 15b represents a cumulative view on the predicted and observed unemployment in France. This view emphasizes the deviation started in 1996. The cumulative curves provide a good way to demonstrate that the oscillations in the predicted curve are induced by some uncorrelated measurement errors, not by actual change. At the same time, the curves definitely show some problematic years in the beginning of the period. Overall, the curves almost coincide and confirm the reliability of the linear relationship between *UE(t)* and *dLF(t)/LF(t)*. A linear regression of the cumulative curves gives R^2=0.998 and stdev=0.028.

Moving average is thoroughly used in this study in order to obtain a better agreement between the observed and predicted curves. This technique effectively suppresses the noise associated with measurement errors. Figure 16 displays the annual measured curve and that obtained by a 2-year moving average as applied to the predictor. There is a significant improvement in the predictive power of relationship (12), especially between 1978 and 1995 - the curves practically coincide. The improved overall agreement is also reflected in a higher R^2=0.75 and lower stdev=0.016, as presented in Table 2. When a 5-year moving average is applied to the predictor, R^2 increases to 0.90 and stdev falls to 0.010. Hence, moving average is very efficient in noise suppression and provides an explanation of about 90% of variation in the unemployment rate. One can not expect any further improvement beyond the level associated with some intrinsic measurement uncertainty, however. More accurate measurements of the labor force are necessary for obtaining a higher correlation between the observed and predicted time series.

According to relationship (2), inflation is also a linear function of labor force change. Figure 17 illustrates the fit between observed (the OECD GDP deflator) and predicted inflation. Figure 17a compares the measured annual values to those obtained according to the following relationship:

$$\pi(t)=17*dLF(t-4)/LF(t-4)-0.063 \qquad (13)$$

where $\pi(t)$ is the inflation at time *t*, *LF(t-4)* is the labor force four years before. Thus, there is a four years lag in France between the labor force change and corresponding reaction of the inflation. The linear coefficient 17 indicates that the inflation is aslo very sensitive to the labor forced change. The intercept -0.063 means that a positive labor force change rate has to be retained in order to avoid deflation. The threshold for a deflationary period is a labor force change rate of 0.0037(=0.063/17) per year. Actual change rate was consistently higher than the threshold value over the studied period, as Figure 13 demonstrates.

The predicted inflation has been rapidly increasing since 2000 according to the labor force increase started in 1996 and the four-year lag. The observed inflation has been fluctuating near 2% since 1995, however. This inflation rate is the one defined by the ECB (2004) and Banque de France (2005) as the target of monetary policy. Therefore, one might suppose that the observed inflation is fixed by some special measures applied by the ESCB such as a monetary supply constrained to real GDP growth plus 2%. The effect of the inflation rate fixed by force is expressed in the observed deviation of the predicted unemployment and inflation from those measured in France. The unemployment reacts immediately to the labor force increase started in 1996. The inflation reacts four years later. In the absence of the fixed inflation rate or price stability, the observed inflation and unemployment would follow their predicted paths: in 2004, 9% inflation would be accompanied by 4% unemployment.

Since the discrepancy between the observed and measured inflation starts in 2000, a linear regression analysis is carried out for the period between 1971 and 1999. The GDP deflator is a dependent variable and a predictor is obtained according to relationship (13). Some results of the analysis are presented in Table 2. Standard deviation of the actual time series for the studied period is 0.042. The regression of the annual readings is characterized by R^2=0.47 and stdev=0.031. R^2 is a low one and close to that obtained for the unemployment. In both cases, the reason for the low correlation is low accuracy of labor force measurements accompanied by the high sensitivity of the predicted values to the labor force change rate.

Moving average provides a more accurate representation of the labor force change rate. For the four-year lag, as observed in France, even a 7-year moving window applied to the predictor does not include the labor force readings contemporaneous to the predicted inflation. Therefore, the lag guarantees a natural "out-of-sample" inflation forecast at various time horizons - from 1 year to 4 years. Table 2 lists standard errors (deviations) and R^2, which are obtained by linear regressions with various moving averages. Obviously, the larger is forecasting horizon, i.e. the shorter is corresponding averaging window, the larger is the forecast uncertainty. On the other hand, there must be some optimal width of moving windows. For a very wide window, the readings at the left (early) side of the window introduce some additional noise rather than improve the modeled leading value. In fact, for a 2-year moving average applied to the predicted inflation R^2=0.74 and stdev=0.022, for a 3-year window R^2=0.91 and stdev=0.013, and for a 7-year window R^2=0.89 with stdev=0.014. So, the best result is obtained for the 3-year moving average, which explains 91% of variation in the original inflation time for the period between 1971 and 1999. Figure 17b demonstrates the outstanding predictive power of the 3-year moving average.

One can potentially reach an additional improvement on the results obtained with the 3-year moving average by using more powerful techniques for noise suppression. This is not the purpose of this study, however. We just reveal inherent links between unemployment, inflation, and labor force at a high level of confidence, as represented by R^2. Further improvements in R^2 related to the annual readings above 0.91 hardly deserve any additional effort and potentially fall into a conflict with the level of uncertainty in the inflation and labor force measurements.

In our framework, the residual difference between the observed and predicted readings is related solely to measurement errors. In France, labor force is measured with an uncertainty, which is not appropriate to the modeling of the more accurately measured unemployment and inflation. One-year long measuring baseline is not enough for obtaining a reliable estimate of labor force change rate. Moving average takes an advantage of a longer baseline for the calculation of the change rate and provides a substantial increase in the predictive power of relationships (12) and (13). Therefore, a longer basic time unit will potentially result in a higher accuracy of corresponding measurements and in a better correlation between the modeled variables. Table 2 supports this assumption by an example of a regression of 7-year moving averages of the observed and predicted inflation: R^2=0.97 and stdev=0.006. Hence, if to replace the current one-year basic interval with a seven-year long one, the inflation prediction would be as accurate as 0.006 for the period between 1971 and 1999. The same effect might be obtained by improvements in the current measuring procedures, however. There is a direct trade-off between the efforts invested in such improvements and the accuracy of predicted inflation and unemployment. Since the problem of low measurement accuracy is a resolvable one we leave it to appropriate agencies.

Figure 17c compares two cumulative curves as obtained for the measured and predicted inflation. There is a good agreement during the years between 1971 and 1999. We do not provide in Table 2 statistical estimates for the cumulative curves of inflation in France. Obviously, R^2 has to be very close to 1.0 and standard deviation is similar to that for the case of the annual readings. The cumulative curves evidence that the labor force cumulative change provides a precise measure of the inflation index growth and vice versa.

Figure 18 and Table 2 represent results of a similar analysis as applied to the OECD CPI inflation. The actual time series is characterized by standard deviation of 0.043 for the period between 1971 and 1999, which is just marginally higher than that for the OECD deflator during the same period. The best predictor for the annual readings is also obtained with a 3-year moving average: R^2=0.85 and stdev=0.017. These values indicate a slightly lower predictive power of the labor force change rate compared to that obtained for the GDP deflator. This is a common situation for the countries studied so far. GDP deflator is a consistently better measure of inflation as related to labor force change rate. Caveats in CPI definition and measuring procedures are well known and have been actively discussed since the Boskin's report (1998). Obviously, the problems associated with the uncertainty in CPI measurement lead to the poorer performance of the labor force as a predictor.

Having discussed the potentially resolvable problems associated with the uncertainty in labor force measurements, we start to tackle the problem associated with the discrepancy between the observed and predicted curves. This problem is a critical one for the concept. Potentially, the discrepancy is associated with the new monetary policy first applied by the Banque de France in the beginning of the 1990s. The policy of a constrained money supply, if applied, could obviously disturb relationships (12) and (13). New coefficients in the linear relationships are computed and presented in relevant Figures for the periods after 1995 for the unemployment after 1999 for the inflation, respectively. The coefficients are unreliable, however, due to the shortness of observations, but definitely different from the old ones. Probably, one could conclude that the Banque de France has created some new links between the unemployment, inflation, and labor force.

Our assumption is a different one. Money supply in excess of that related to real GDP growth is completely controlled by the demand of growing labor force because the excess is always accommodated in a developed economy through employment growth, which causes inflation. The latter serves as a mechanism which effectively returns personal income distribution (normalized to total population and nominal GDP growth) in the economy to its original shape (Kitov, 2006a,d). The relative amount of money that the economy needs to accommodate a given relative labor force increase through employment is constant through time in corresponding country but varies among developed countries. This amount has to be supplied to the economy, however. Central banks are responsible for this process. In the USA and Japan, central banks provide adequate procedures for money supply and individual dependence on labor force change does not vary with time both for inflation and unemployment. The ESCB limits money supply to achieve price stability. In Austria, it does not affect the individual linear relationships because actual money supply almost equals the amount required by the observed labor force growth. For France, the labor force growth is so intensive that demands a much larger money input for creation of an appropriate number of new jobs. The 2% artificial constraint on inflation (and thus money supply) disturbs relationships (12) and (13). The labor force growth induces only an increase in employment, which accommodates the given 2% inflation instead of the 9% predicted inflation. Those people who enter the labor force in France in excess of that allowed by the target inflation have no choice except to join "the army of unemployed". Hence, when inflation is fixed, the difference between observed and predicted change in the inflation must be completely compensated by an equivalent change in unemployment in excess of the predicted one. Generalized relationship (3) mathematically describes this assumption.

For France, generalized relationship is obtained as a sum of (12) and (13), which gives the following equation:

$$\pi(t) = 4*dLF(t-4)/LF(t-4) - UE(t-4) + 0.095 \qquad (1971<t<2004) \qquad (14)$$

where the intercept 0.095 is slightly different from that obtained as a straight sum of corresponding free terms: 0.165-0.063=0.102. The difference is dictated by the fit of the cumulative curves presented in Figure 19, which illustrates results of the generalized approach. It is important to emphasize that relationship (14) is valid for the entire interval where the OECD GDP deflator readings are available.

Annual readings are presented in Figure 19a. A linear regression of the observed inflation against that predicted according to (14) is characterized by an outstanding for annual curves R^2=0.88 and stdev=0.014. Moving averages of the predictor provide an additional improvement on the annual results: for a 2-year moving average R^2=0.89 and stdev=0.015, for a 3-year moving average R^2=0.93 and stdev=0.011, and for a 7-year moving average R^2=0.93 and stdev=0.011 as well. These values are the best we have obtained for France so far. They explain the inflation to the extent beyond which measurement uncertainty should play a key role. Practically, there is no room for any further improvements in R^2 given the current time series. The regression results also undoubtedly prove the success of the generalized approach.

The 7-year averages displayed in Figure 19b give an additional visual evidence of the excellent predictive power of relationship (14). A linear regression of these averages during the period between 1977 and 2004 is characterized by R^2=0.99 and stdev=0.004. We have already discussed the importance of a substantial reduction in the uncertainty of the labor force measurements. The 7-year moving averages provide a good approximation of the results one can potentially obtain from the improved labor force measurements. A standard error of prediction of 0.004 and even lower might be obtained at a four-year horizon for inflation forecasts in France. Figure 19c shows cumulative curves and provide a prediction of the GDP deflator index four years beyond 2004. One can expect a slight increase in the inflation during the years if labor force estimates for the years between 2001 and 2004 are accurate. Unfortunately, the estimates are prone to potential adjustments in future than new data from the next census will be available.

In this Section, we have successfully modeled unemployment and inflation in France as a linear and lagged function of labor force change rate for a relatively long period. The unemployment is characterized by a very high and negative sensitivity to the labor force change rate, i.e. even a small increase in the labor force level leads to a substantial drop of the unemployment rate. Both variables evolve synchronously. The inflation lags four years behind the labor force change and also is very sensitive to it. This lag provides a basis for an out-of-sample inflation forecast at a four-year horizon with an accuracy of 1.0% for the whole period between 1971 and 2004. (A detailed study of the properties of GDP deflator and CPI forecast in France at various time horizons will be presented in a paper, which is currently under preparation.)

The lags and sensitivities found for the unemployment and inflation in France are quite different from those obtained for the USA, Japan, and Austria. The latter two countries are characterized by the absence of any time lags and low sensitivities. In the USA, inflation lags by two and unemployment by five years behind labor force change, with sensitivities much lower than those in France. Apparently, the variety of lags is the source of the problems with Phillips curves of various kinds. In France, inflation lags by four years behind unemployment, and in the USA - leads by three years. Nevertheless, the Phillips curve in its original form does exist because both variables are linear functions of labor force change and thus also can be linked by a linear dependence.

The high sensitivities of the inflation and unemployment to the labor force change in France require very accurate labor force measurements for a reliable modeling. Unfortunately, the OECD labor force time series does not meet this requirement and only poor statistical results are obtained for annual readings. The best agreement between observed and predicted time series is obtained with a moving average technique applied to the labor force values. For the period between 1971 and 1996, linear regression analysis provides as high values of R^2 as 0.9 for the unemployment and 0.91 for the GDP deflator for 5-year and 3-year moving average of the labor force, respectively. Corresponding standard deviations (errors) are as low as 0.010 and 0.013, respectively

As a result we have obtained a very accurate description of unemployment and inflation in France during the last 35 years. In contrast to Austria, a prediction of inflation for the next four years has been computed using only past readings of the labor force. No population projections are necessary for the inflation forecast at a four-year horizon. At longer horizons, one can use labor force forecasts. Accuracy of such long-term unemployment and inflation forecasts is proportional to the accuracy of the labor force predictions. Monetary policy of the ECB is also an important factor for the forecast because of its influence on the partition of the labor force growth between inflation and unemployment. The sum of these two variables is always a linear function of the labor force change, however. Therefore, it is for the ECB and Banque de France to decide on the partition of the labor force growth into unemployment and inflation. There is no opportunity to compensate the past high unemployment by freeing monetary supply. To achieve the predicted 4% unemployment rate a further intensive growth in labor force is necessary. Otherwise, the unemployment will be retained at its current level.

4. Conclusion

It is demonstrated at a very high level of confidence that Austria and France are characterized by linear relationships between inflation and unemployment from one side and labor force change from the other side. The best predictions explain more than 90% of observed variation in unemployment and inflation in both countries. The residual variation is hardly to be explained using the data available due to intrinsic uncertainty in corresponding measurements. The relationships contain lags associated with some dynamic processes of internal transformations induced by labor force change. These lags are large and distinct in France and in the USA to represent strong evidences in favor of the assumption that labor force change is the only driving force behind inflation and unemployment. This linear dependence on labor force provides a new approach to the conventional Phillips curve linking inflation and unemployment. The relationship between inflation and unemployment does exist, but the unemployment in many cases lags or leads the inflation by several years, introducing confusion in standard econometric analysis. The conventional Phillips curve does not allow inflation to lead unemployment, how it happens in the USA.

Among economic and econometric models explaining behavior of inflation and linking it to various economic parameters, including those related to behavioral characteristics of human beings, there is no one which would explain the whole variety of empirical facts. What the models lack is first principles when a simple and measurable variable drives other economic parameters. In such a case the whole set of observations aligns in a clear pattern with obvious links. In hard sciences, this is a standard situation. In economics, such first principles connecting measurable economic variables are absent so far. The new concept fills this lacuna putting forth population characteristics as the only parameter defining all the studied macro and microeconomic characteristics.

Other concepts meet inevitable obstacles due to misspecification of actual relationships: measurable variables are substituted with unobserved or immeasurable variables. For inflation, the NKPC ends with a marginal cost which is unobservable, accelerationists rely on some natural (but theoretically undefined and empirically unobservable) level of unemployment, and "behaviorists" demand some mechanism of imperfect information processing. In fact, marginal cost, which in practice is often represented by a unit labor cost, not only unobservable but also unpredictable in the NKPC framework as associated with exogenous productivity and supply shocks. Natural level of unemployment, which can also vary through time, seems to be rather an additional degree of freedom in the Phillips curve than a measurable parameter.

Similar problems arise in the real business cycle where real economic growth is determined mostly by exogenous productivity and supply shocks. The only positive features known about the shocks are that they are random, persistent in time and characterized by decaying amplitude during the last 25 years. No explanation of the shocks' nature is given what actually leaves the question of the real growth driving force open.

All these problems have been successfully overcome in the population related models. At the same time, the developed concept does not contradict to the conventional consideration. Let us try to reverse some statements of the NKPC approach and assume that inflation is driven by some exogenous force and evolves according to some strict relationships (for example, according to the linear lagged equations obtained in this study). In a given developed country, which undergoes a permanent real and nominal economic growth, firms creation and extinction, change in labor force quantity and age structure, one can always distinguish in the set of existing firms a subset of firms, which can set new prices according to some "expected" inflation change, some firms, which are able only to match previous inflation values, and some firms, which can not change price at all. In practice, more than three groups can be distinguished and the distribution of the firms against price setting capabilities is more or less continuous. The distribution may have various shapes with only one requirement that the integral price change over the firms has to give the observed inflation value (for the sake of simplicity we presume here real economic growth to be zero). In other words, the firms are allowed to change the prices according to the inflation rate driven by the exogenous force represented by labor force change and do that through a "monopolistic competition process" whatever it means. In the framework of the NKPC, the distribution is used to estimate rigidity of nominal marginal cost. If the distribution does not change fast in time, the rigidity might be close to a constant one and the NKPC model fits the observations to the extent nominal marginal cost is represented by unit labor cost. Same is valid for sticky prices, sticky information, labor market imperfectness, etc. Corresponding characteristics can be easily obtained from the observed behavior but are only derivatives not the driving forces.

Advantages of the labor force change as the driving force for inflation are as follows:

1. It is measurable, what guarantees increasing accuracy of fit with development of more accurate methodology and procedures.
2. Meets requirement of the fixed personal income distribution because directly follows from the internal redistribution in the PID.
3. Represents a part of a broader economic concept based on population characteristics.

There is a standard scientific problem associated with the applicability of some empirical relationship to a broader set of problems both in logical and historical sense. In philosophy of science, this area of applicability can be reformulated in the principle of falsifiability, i.e. a possibility to find an example when a given relationship does not hold. In other words, this principle confines the area of applicability, where the relationship can be verified and validated. A fame example in physics is the Newton's second law, which needs to be reformulated for speeds approaching the light speed.

In economics, such a distinct point in time between periods where a given relationship holds and not applicable is usually absent due to unidirectional evolution in time. There is no possibility to repeat the past events and to re-measure economic variables of interest if they were not measured at proper time. Thus, empirical relationships in economics lack the beginning time, as a rule. Actually, necessary observations are not conducted in a methodologically appropriate manner due to the absence of contemporaneous demand. Despite a huge amount of economic information both qualitative and quantitative accurate measurements of some fundamental economic variables are very limited in time and accuracy.

France is currently enjoying a low inflation rate due to the limitations induced by the European Monetary Union in the field of monetary policy. Due to the strict rules France does not allow people to get into employment and occupy their otherwise available positions in the personal income distribution. Money supply in the country does not meet the requirements of the natural employment growth associated with the observed labor force growth. The people entering the French labor force are forced to become unemployed. The principal question is – does it affect real economic growth? In the case of a natural behavior, i.e. the one not restricted by external non-economic rules similar to those superimposed on economies of socialist countries, real growth of an economy does not depend on inflation and vise versa. When monetary authorities artificially suppress inflation by a restricted money input one can expect a diminishing real economic growth due to the increase in unemployment above its natural level and corresponding decrease in labor force. If the labor force growth is independent, less people obtain paid job. Total production suffers, the economy slows down, and the personal income distribution is disturbed. All these effects are obviously country-dependent due to variation in sensitivity of inflation and unemployment to labor force change. The driving force behind the sensitivities is apparently personal income distribution.

There are four countries studied so far - the USA, Japan, Austria, and France. The results obtained in the study indicate the existence of a linear link between principal economic parameters: inflation, unemployment, and labor force. There are many developed countries not studied yet, however. As we have learned already, every country potentially represents a unique case with specific sensitivities and lags to be determined empirically. Problems related to measurement uncertainty, especially in labor force, raise additional difficulties for the study. Therefore, future work will be focused on the largest economies such as the UK, Germany, Italy, Switzerland, Canada, etc. Results of individual cases should provide an extended basis for a comparative analysis, which may potentially help to understand the mechanisms responsible for varying sensitivities and lags.

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Tables

Table 1. Results of linear regression analysis for Austria

Period	Dependent variable	Predictor	A	B	R^2	stdev
1983-2003	annual UE (OECD)					**0.0036**
1983-2003	annual UE (OECD)	annual dLF(t)/LF(t) (OECD)	1.03 (0.020)	0.026 (0.007)	0.11	0.0035
1983-2003	cumulative UE (OECD)	cumulative dLF(t)/LF(t) (OECD)	1.00 (0.006)	0.010 (0.003)	0.999	0.007
1965-2003	annual GDP deflator (NAC)					**0.022**
1965-2003	annual GDP deflator (NAC)	annual dLF(t)/LF(t) (NAC)	0.880 (007)	0.005 (0.003)	0.81	0.010
1965-2003	annual GDP deflator (NAC)	2-year moving average dLF(t)/LF(t) (NAC)	0.95 (0.07)	0.003 (0.003)	0.85	0.009
1965-2003	2-year moving average GDP deflator (NAC)	2-year moving average dLF(t)/LF(t) (NAC)	0.93 (0.06)	0.003 (0.002)	0.88	0.007
1960-2003	cumulative GDP deflator (NAC)	cumulative dLF(t)/LF(t) (NAC)	1.03 (0.004)	0.003 (0.005)	0.999	0.011
1965-2003	annual CPI (NAC)					**0.022**
1965-2003	annual CPI (NAC)	annual dLF(t)/LF(t) (NAC)	0.76 (0.10)	0.010 (0.004)	0.60	0.014
1965-2003	annual CPI (NAC)	2-year moving average dLF(t)/LF(t) (NAC)	0.85 (0.10)	0.006 (0.004)	0.64	0.013
1965-2003	2-year moving average CPI (NAC)	2-year moving average dLF(t)/LF(t) (NAC)	0.83 (0.09)	0.007 (0.004)	0.72	0.011
1965-2003	annual GDP deflator (Eurostat)					**0.046**
1965-2003	annual GDP deflator (Eurostat)	annual dLF(t)/LF(t) (NAC)	0.82 (0.10)	0.010 (0.007)	0.66	0.027
1965-2003	annual GDP deflator (Eurostat)	2-year moving average dLF(t)/LF(t) (NAC)	0.88 (0.10)	0.008 (0.007)	0.68	0.027
1965-2003	2-year moving average GDP deflator (Eurostat)	2-year moving average dLF(t)/LF(t) (NAC)	0.87 (0.07)	0.008 (0.005)	0.78	0.02
1965-2003	annual GDP deflator (NAC)					**0.022**
1965-2003	annual GDP deflator (NAC)	annual dLF(t)/LF(t)-UE(t) (NAC)	0.89 (0.06)	0.04 (0.03)	0.86	0.008
1965-2003	annual GDP deflator (NAC)	2-year moving average dLF(t)/LF(t)-UE(t) (NAC)	0.89 (0.06)	0.004 (0.003)	0.86	0.008
1965-2003	2-year moving average GDP deflator (NAC)	2-year moving average dLF(t)/LF(t)-UE(t) (NAC)	0.91 (0.05)	0.003 (0.002)	0.91	0.007

Table 2. Results of linear regression analysis for France

Period	Dependent variable	Predictor	A	B	R^2	stdev
1970-1995	annual unemployment (OECD)					0.032
1970-1995	annual unemployment (OECD)	annual dLF(t)/LF(t) (OECD)	0.45 (0.10)	0.04 (0.008)	0.48	0.023
1970-1995	annual unemployment (OECD)	2-year moving average dLF(t)/LF(t) (OECD)	0.71 (0.08)	0.02 (0.006)	0.75	0.016
1970-1995	annual unemployment (OECD)	5-year moving average dLF(t)/LF(t) (OECD)	1.00 (0.07)	0.000 (0.005)	0.90	0.010
1970-1995	cumulative unemployment (OECD)	cumulative dLF(t)/LF(t) (OECD)	1.01 (0.009)	0.04 (0.001)	0.998	0.028
1971-1999	GDP deflator (OECD)					0.042
1971-1999	annual GDP deflator (OECD)	annual dLF(t-4)/LF(t-4) (OECD)	0.48 (010)	0.03 (0.008)	0.47	0.031
1971-1999	annual GDP deflator (OECD)	2-year moving average dLF(t-4)/LF(t-4) (OECD)	0.74 (0.08)	0.01 (0.006)	0.74	0.022
1971-1999	annual GDP deflator (OECD)	3-year moving average dLF(t-4)/LF(t-4) (OECD)	0.94 (0.06)	0.001 (0.004)	0.91	0.013
1971-1999	annual GDP deflator (OECD)	7-year moving average dLF(t-4)/LF(t-4) (OECD)	1.09 (0.07)	0.01 (0.005)	0.89	0.014
1977-1999	7-year moving average GDP deflator (OECD)	7-year moving average dLF(t-4)/LF(t-4) (OECD)	0.97 (0.03)	0.001 (0.003)	0.97	0.006
1970-1999	CPI inflation (OECD)					0.043
1970-1999	annual CPI inflation (OECD)	annual dLF(t-4)/LF(t-4) (OECD)	0.50 (010)	0.03 (0.008)	0.48	0.031
1970-1999	annual CPI inflation (OECD)	2-year moving average dLF(t-4)/LF(t-4) (OECD)	0.81 (0.09)	0.01 (0.007)	0.74	0.022
1970-1999	annual CPI inflation (OECD)	3-year moving average dLF(t-4)/LF(t-4) (OECD)	1.00 (0.08)	0.000 (0.006)	0.85	0.017
1977-1999	annual CPI inflation (OECD)	7-year moving average dLF(t-4)/LF(t-4) (OECD)	1.15 (0.09)	0.01 (0.007)	0.83	0.018
1971-1999	GDP deflator (OECD)					0.042
1971-2004	annual GDP deflator (OECD)	annual dLF(t-4)/LF(t-4)-UE(t-4) (OECD)	0.89 (0.06)	0.004 (0.004)	0.88	0.014
1971-2004	annual GDP deflator (OECD)	2-year moving average dLF(t-4)/LF(t-4)-UE(t-4) (OECD)	0.91 (0.06)	0.003 (0.004)	0.87	0.015
1971-2004	annual GDP deflator (OECD)	3-year moving average dLF(t-4)/LF(t-4)-UE(t-4) (OECD)	0.97 (0.05)	0.000 (0.003)	0.93	0.011
1971-2004	annual GDP deflator (OECD)	7-year moving average dLF(t-4)/LF(t-4)-UE(t-4) (OECD)	1.03 (0.05)	0.003 (0.004)	0.93	0.011
1977-2004	7-year moving average GDP deflator (OECD)	7-year moving average dLF(t-4)/LF(t-4)-UE(t-4) (OECD)	0.99 (0.02)	0.000 (0.001)	0.99	0.004

Figures

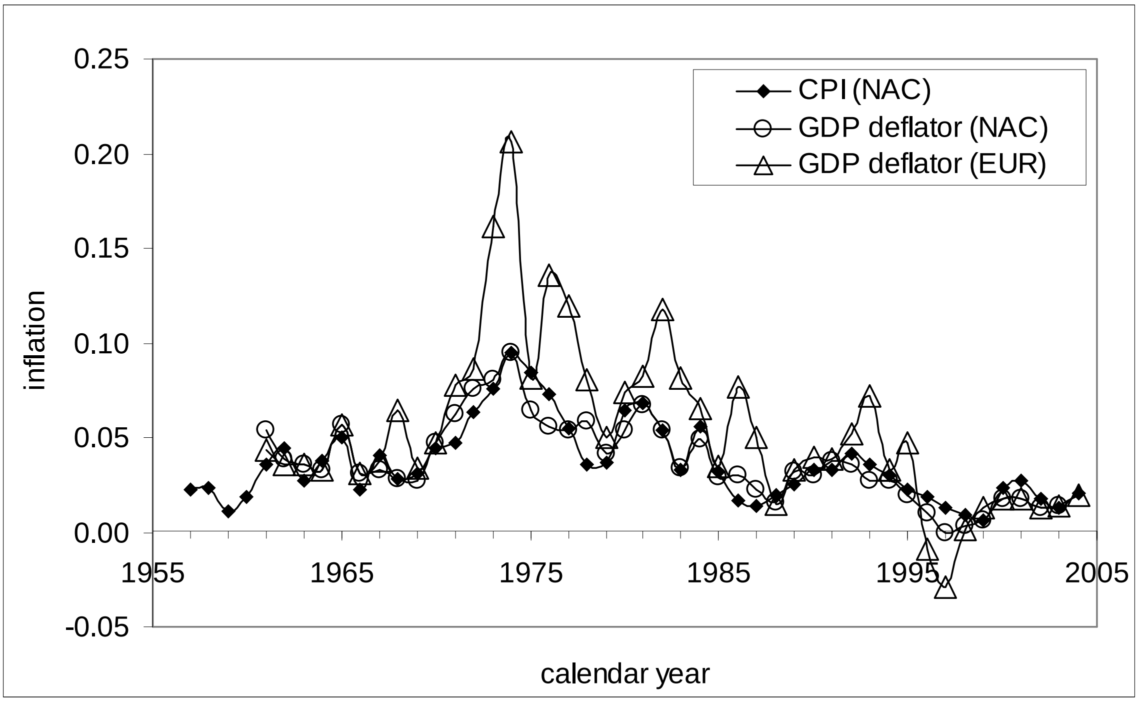


Fig. 1. Comparison of three variables representing inflation in Austria: GDP deflator determined using national currency (NAC) and Euro (EUR), and CPI determined by using national currency. The GDP deflator curves coincide since 2000. Inflation volatility is much lower when it is represented in national currency. Correlation coefficients for the period between 1961 and 2004: CPI NAC/GDP deflator NAC - 0.92; CPI NAC/GDP deflator EUR - 0.82; GDP deflator NAC/GDP deflator EUR - 0.86.

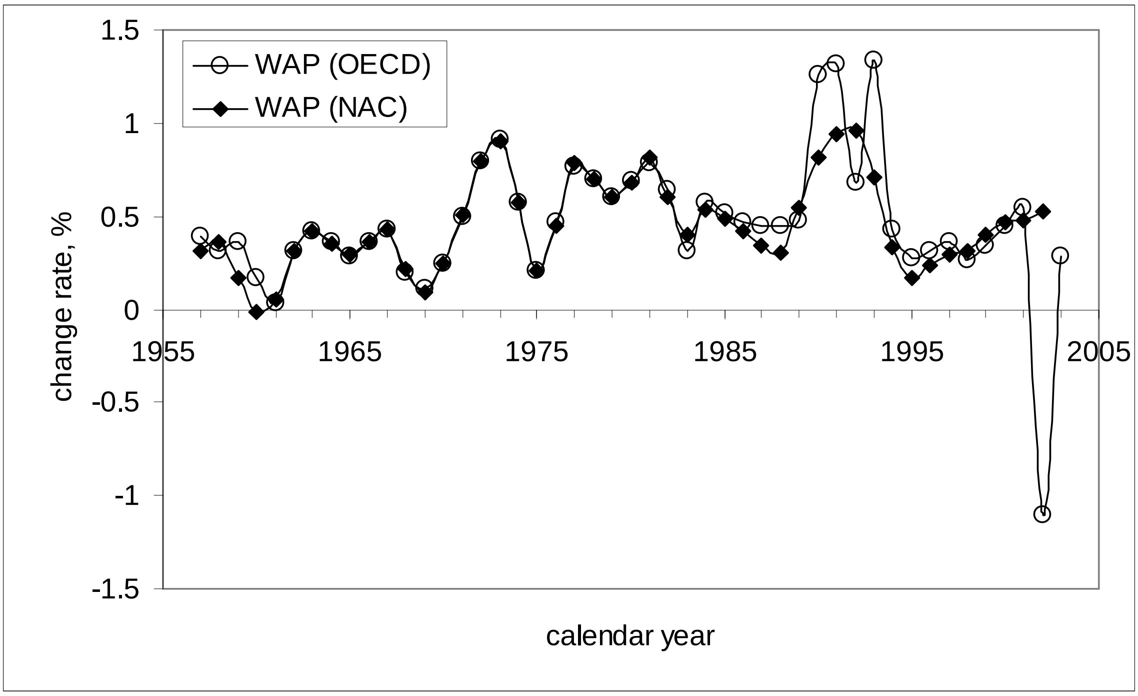


Fig. 2. Comparison of the rate of change in working age population (aged 15 and over) in Austria as determined by the OECD and national statistics (NAC). Notice the spikes in the OECD curve related to step adjustments according to population surveys.

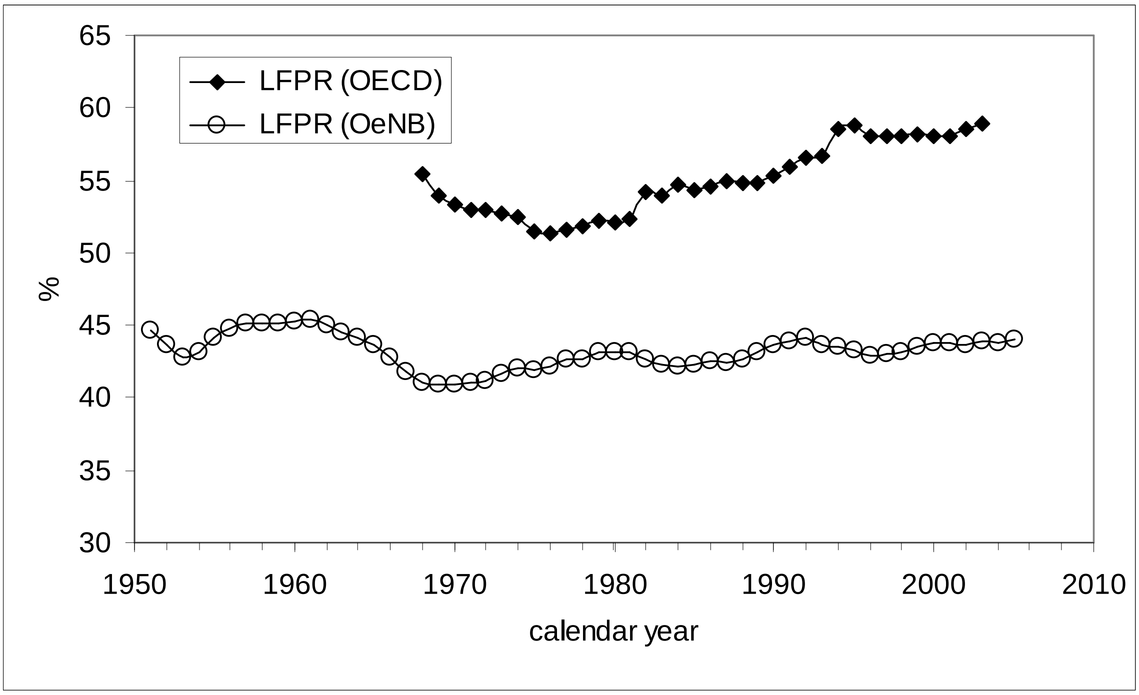


Fig. 3. Labor force participation rate (LFPR) in Austria as determined by OECD and obtained from the OeNB. A weak tendency to growth was observed in the beginning of the 2000s.

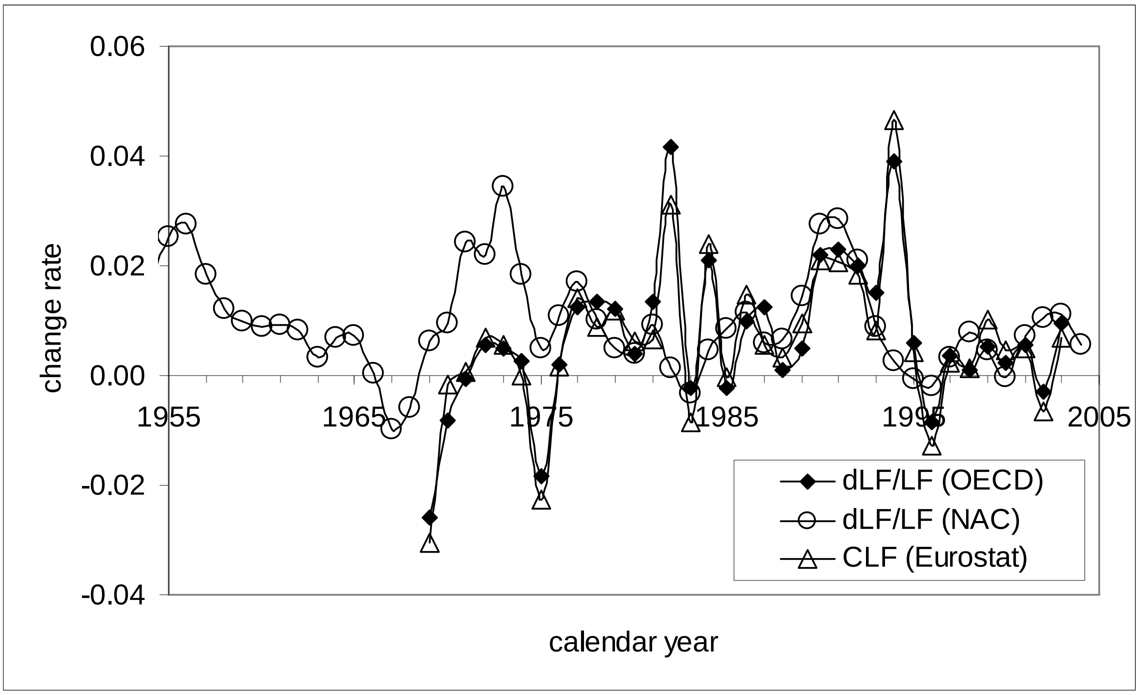


Fig. 4. Comparison of labor force change rate estimates as reported by OECD, NAC, and Eurostat. Notice the smoothness of the NAC curve.

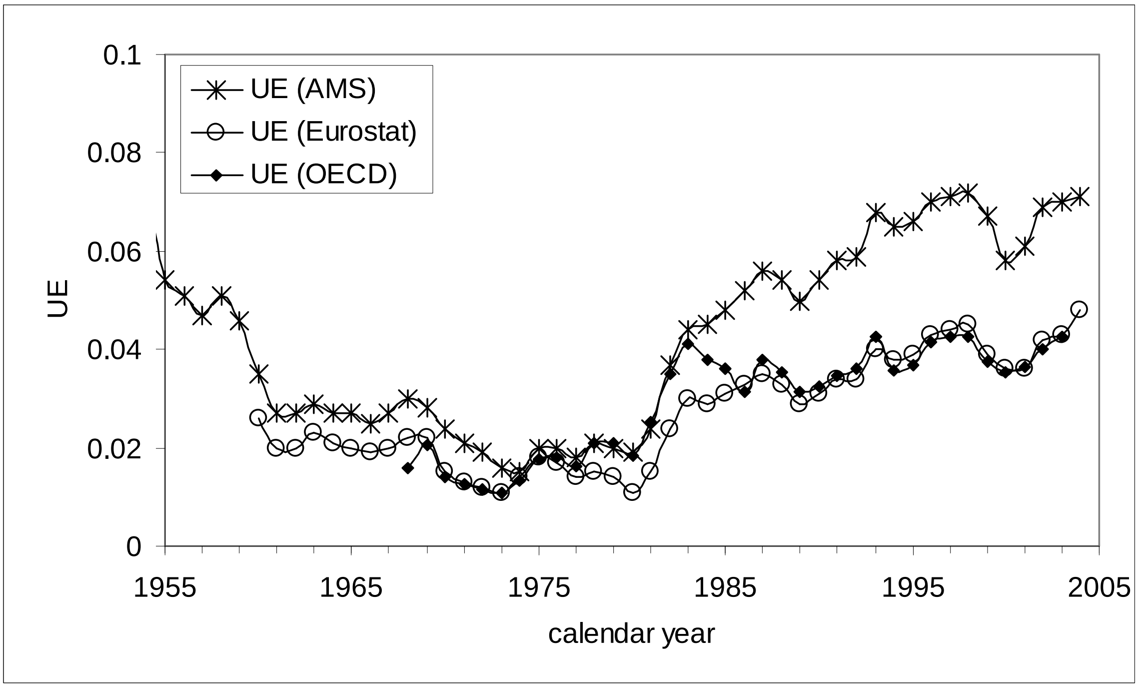


Fig. 5. Estimates of unemployment rate in Austria according to definitions given by the AMS, Eurostat, and OECD.

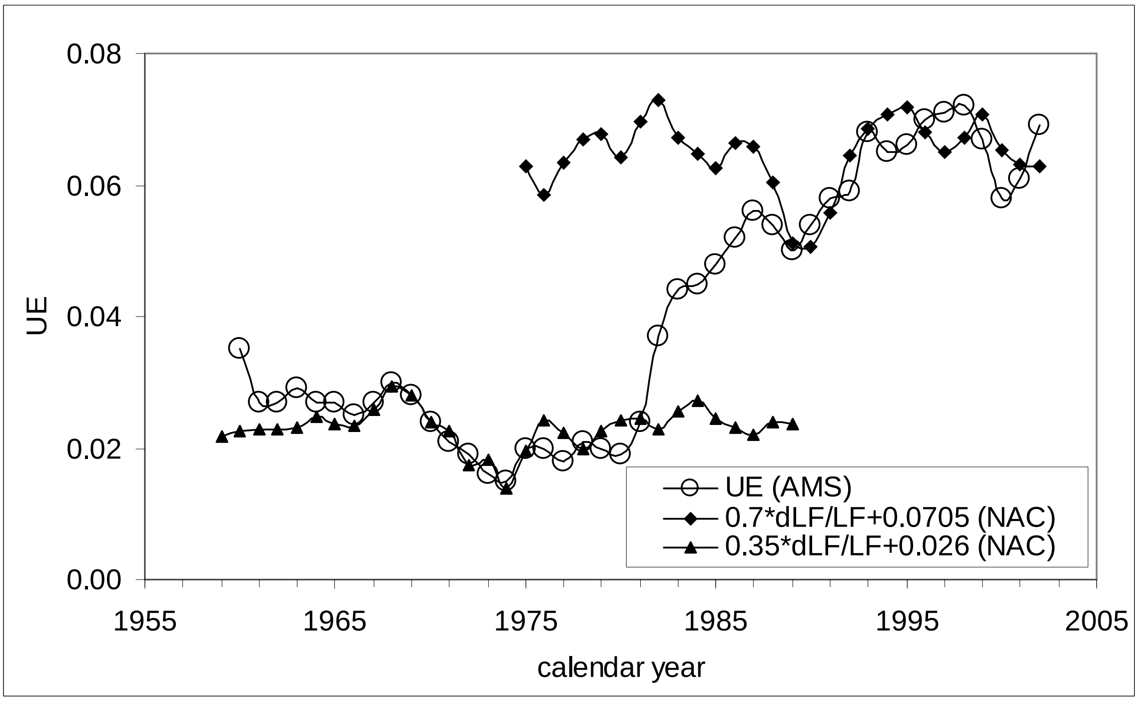
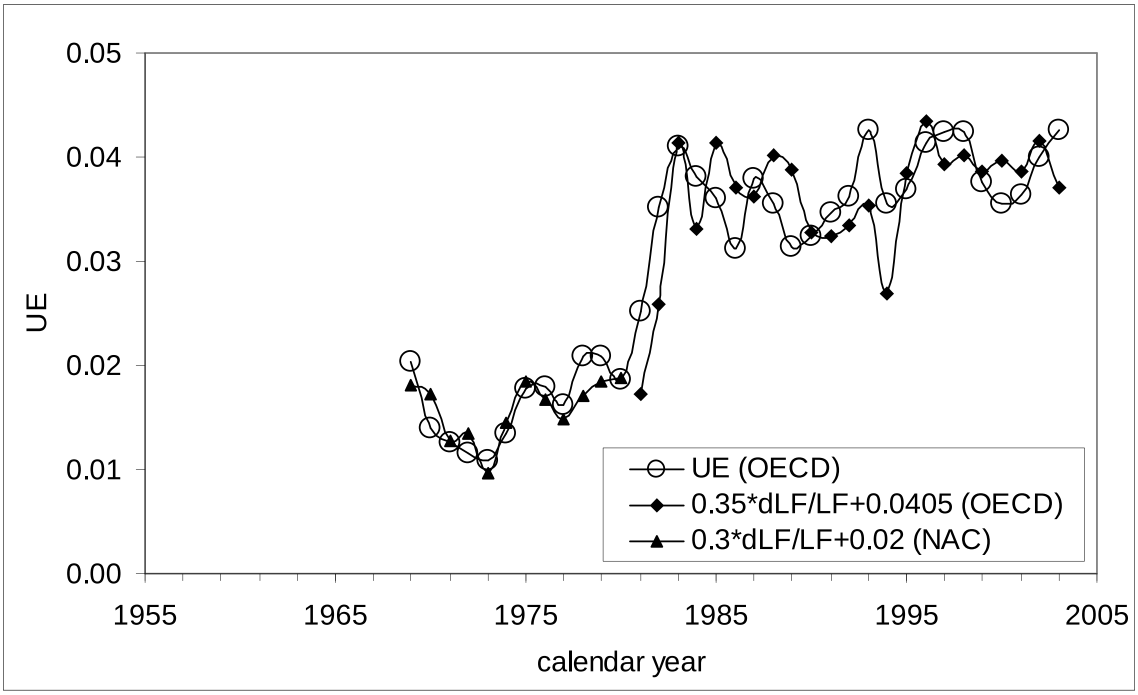


Fig. 6. Comparison of the observed (AMS) and predicted by the linear relationships (shown in lower right corner of the panel) using the NAC (AMS+HSV) labor force and the AMS unemployment rate. Changes in the unemployment and labor force definitions between 1983 and 1987 make it impossible to fit the unemployment curve during this period. Otherwise, the predicted curve is in a good agreement with the measured one.



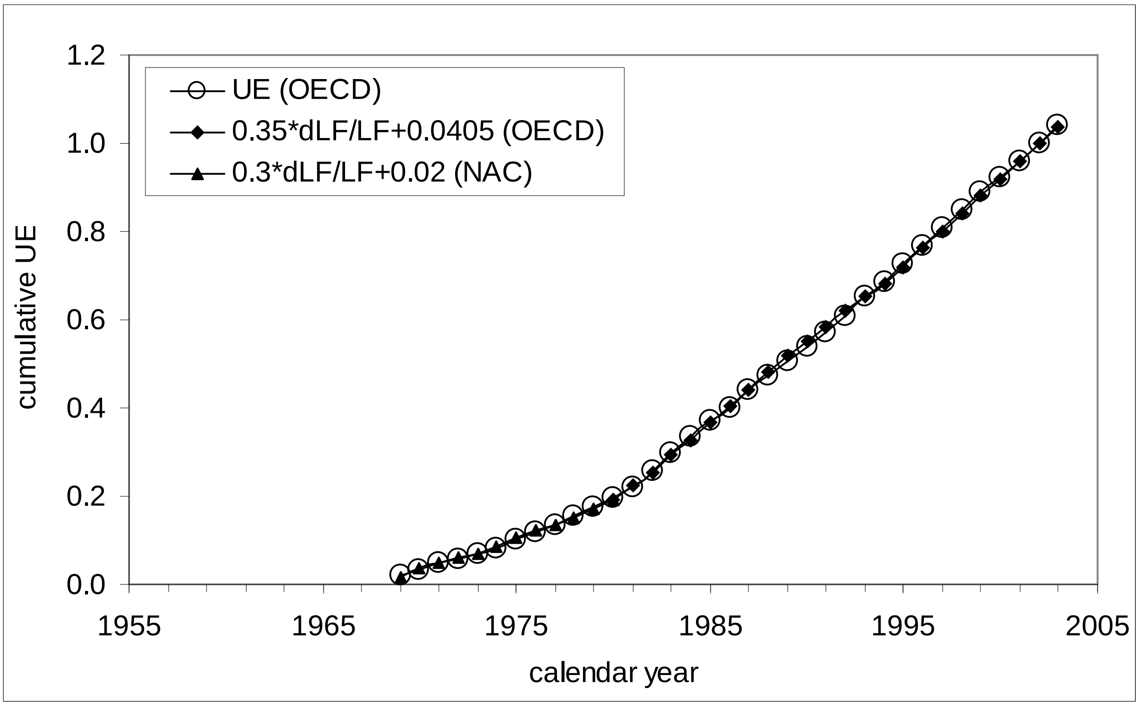


Fig. 7. Comparison of the observed (OECD) and predicted (AMS before 1980 and OECD after 1980) unemployment rate in Austria. The upper frame displays annual readings and the lower one – cumulative unemployment since 1968. Notice a major change in unemployment definition between 1981 and 1984 (OECD, 2005)

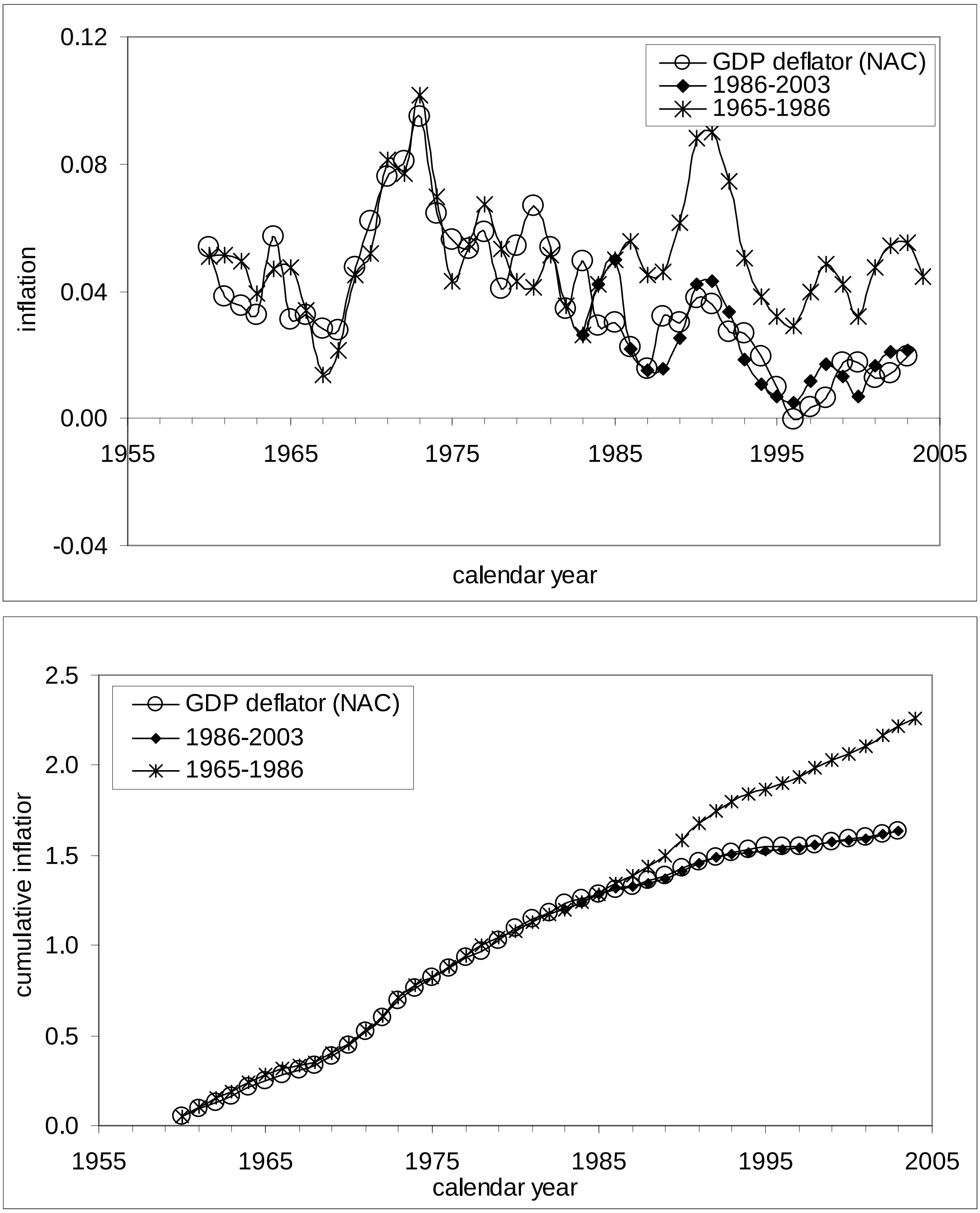


Fig. 8. Comparison of the observed (NAC GDP deflator) and predicted inflation in Austria. The upper frame displays annual readings and the lower one – cumulative inflation since 1960. Notice a major change in labor force definition between 1981 and 1987 (OECD, 2005). The periods before and after 1986 are described separately.

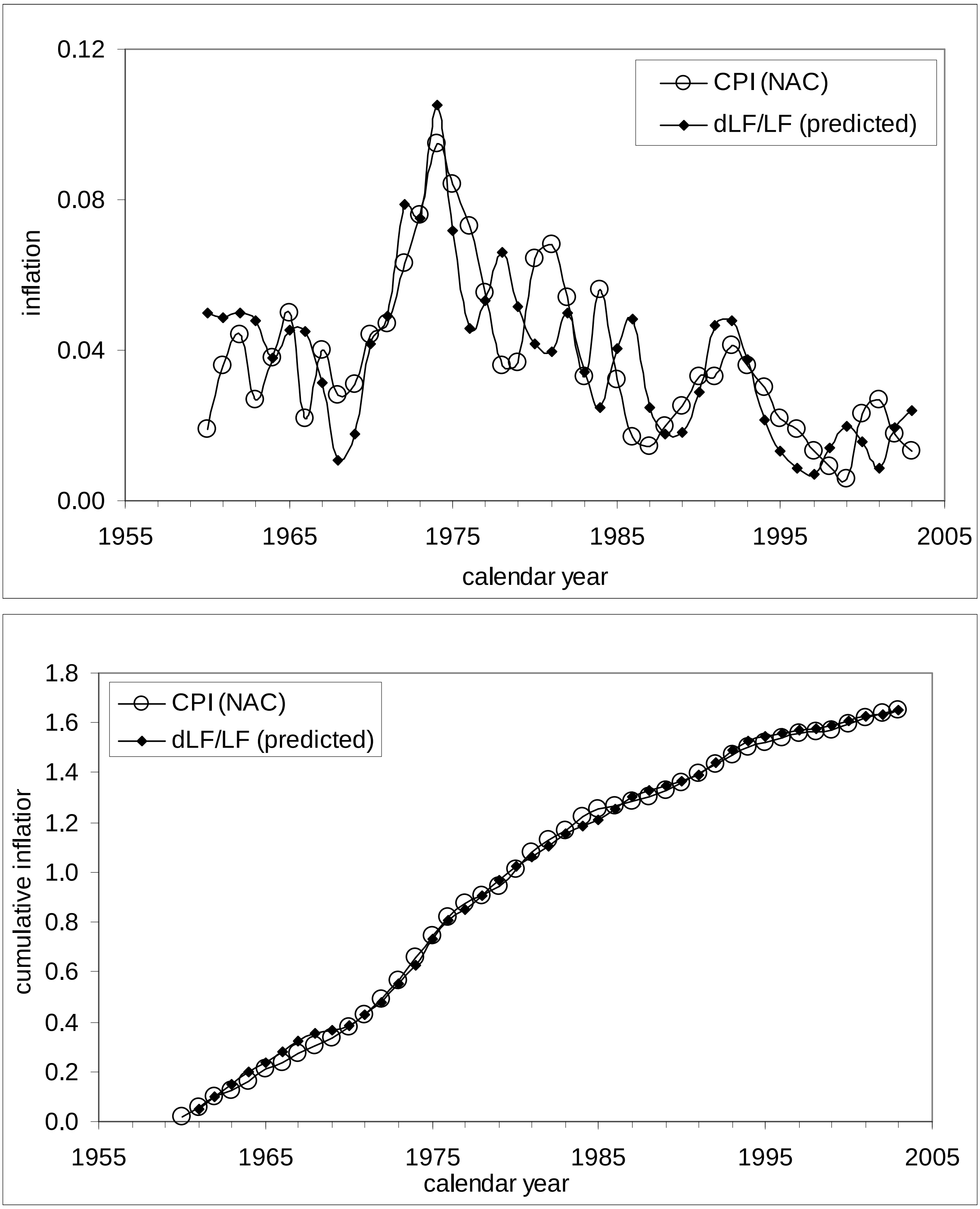


Fig. 9. Comparison of the observed (NAC CPI) and predicted inflation in Austria. The upper frame displays annual readings and the lower one – cumulative inflation since 1960. Notice a major change in labor force definition between 1981 and 1987 (OECD, 2005). The periods before and after 1986 are described separately.

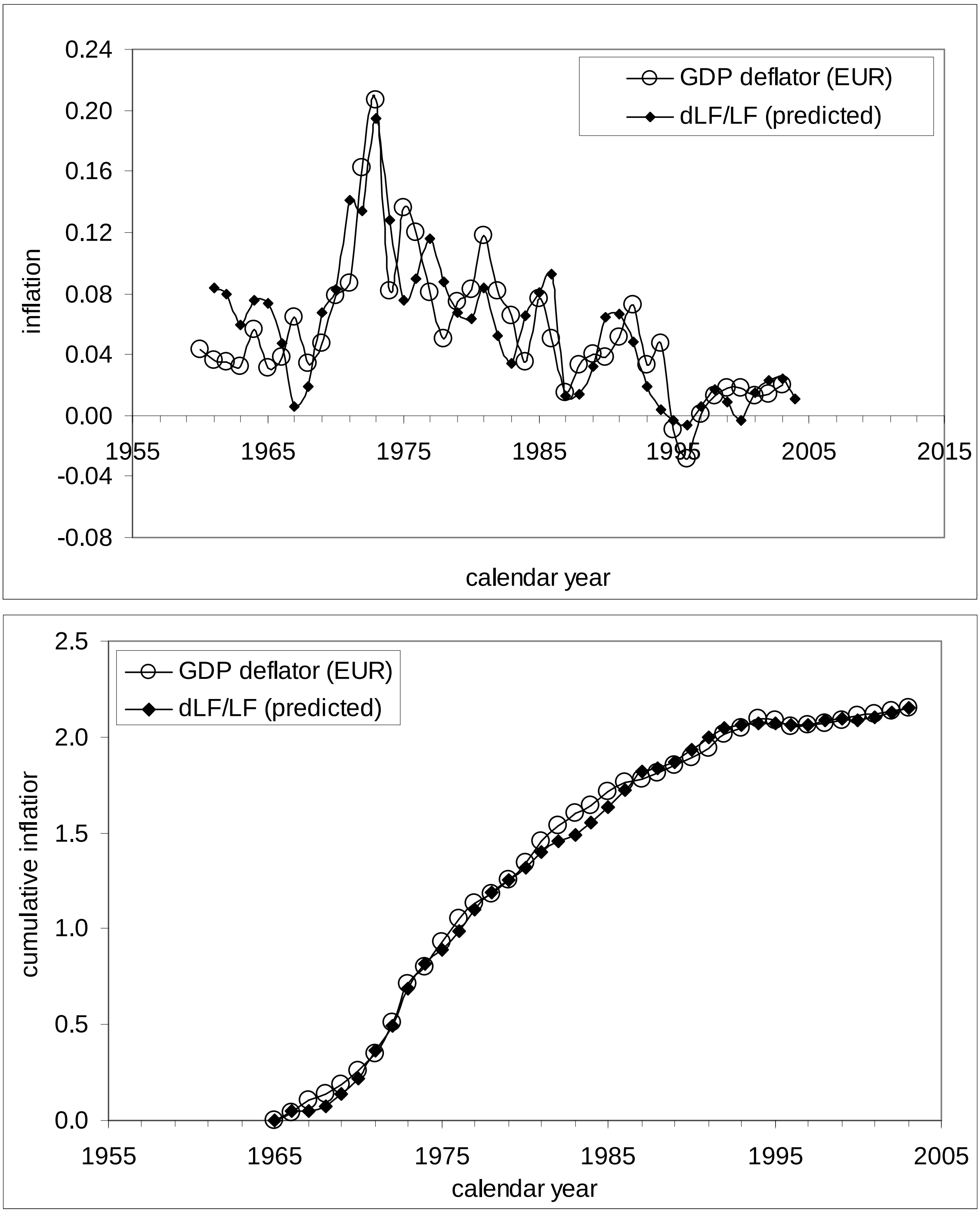
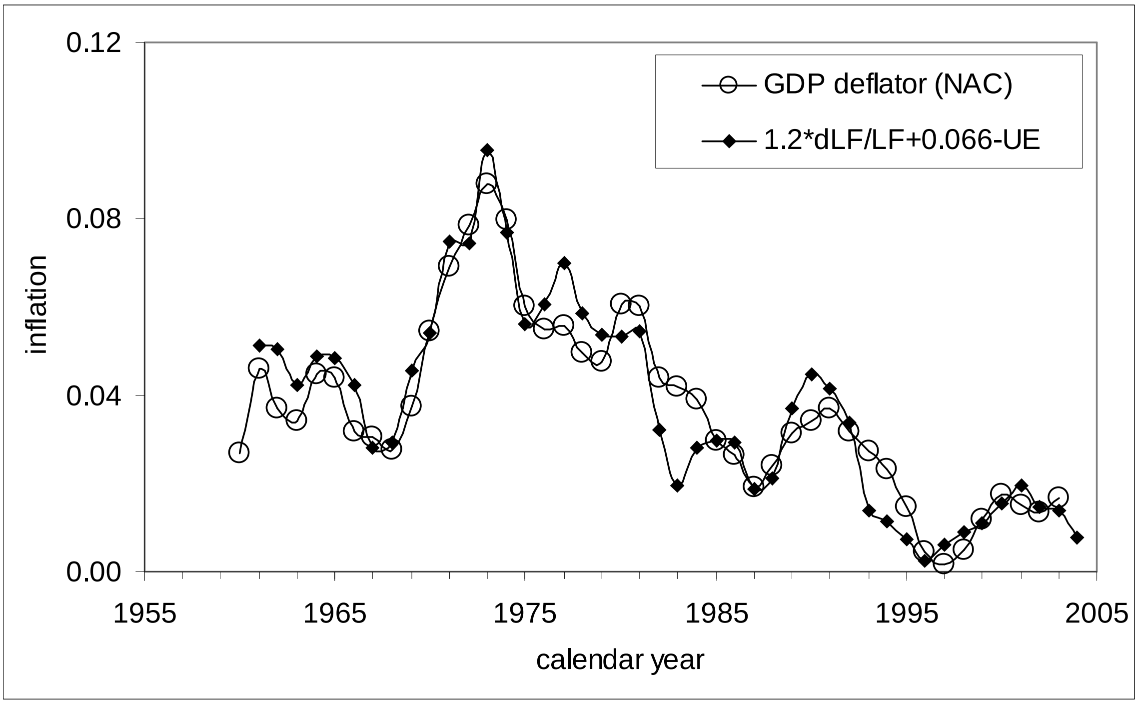


Fig. 10. Comparison of the observed (EUR GDP deflator) and predicted inflation in Austria. The upper frame displays annual readings and the lower one – cumulative inflation since 1965. Notice a major change in labor force definition between 1981 and 1987 (OECD, 2005). The periods before and after 1986 are described separately.



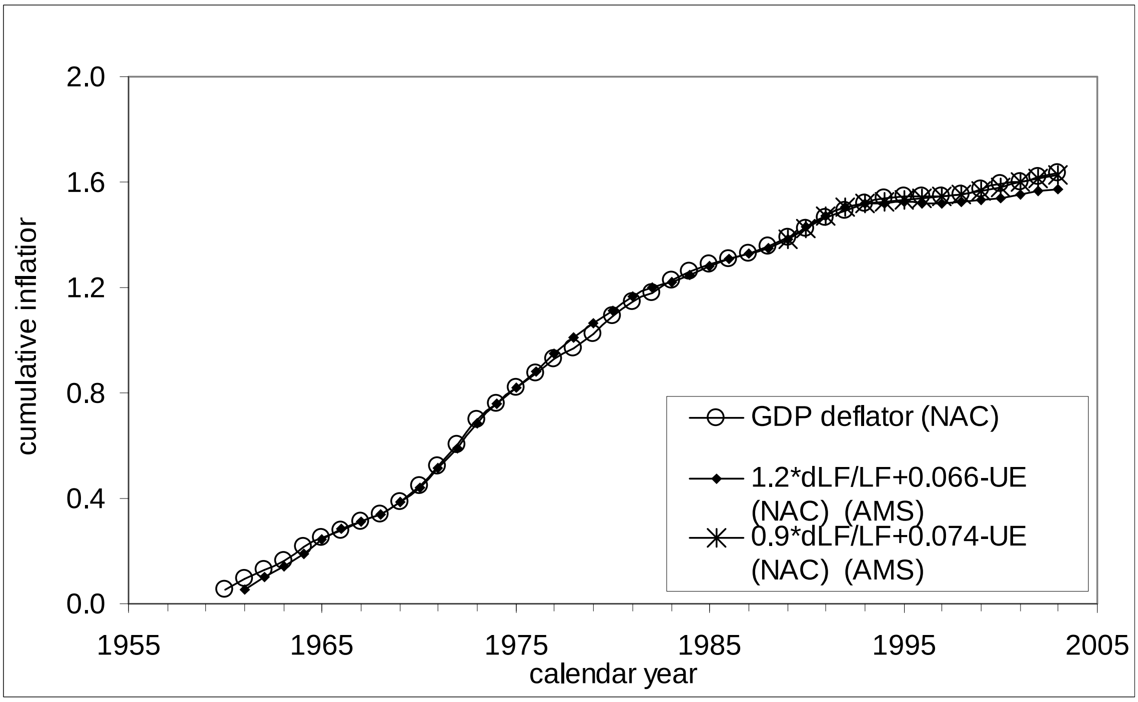


Fig. 11. Comparison of the observed (NAC GDP deflator) and predicted inflation in Austria. The upper frame displays annual readings and the lower one – cumulative inflation since 1960. The predicted inflation is a linear function of the labor force change and unemployment as defined by relationship (3). Notice the absence of the major change in 1986 due to effective compensation of the labor force change by the unemployment. There is a slight discrepancy started in 1994 with corresponding change in linear coefficient and intercept, as described by the relationships in the lower right corner of the lower frame.

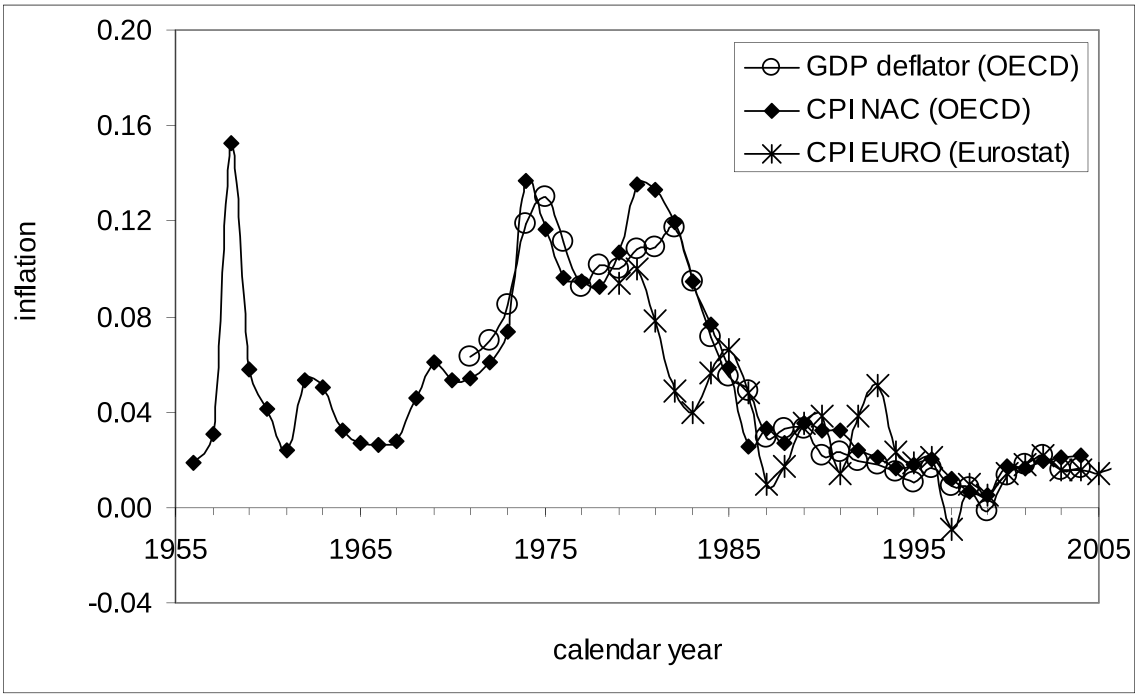


Fig. 12. Comparison of various measures of inflation in France. There are three time series: GDP deflator and CPI based on national currency obtained from the OECD web-site and CPI inflation based on the exchange rate to Euro, as given by Eurostat. The GDP deflator and CPI NAC time series start from 1971 and 1956, respectively. The CPI EURO starts from 1979.

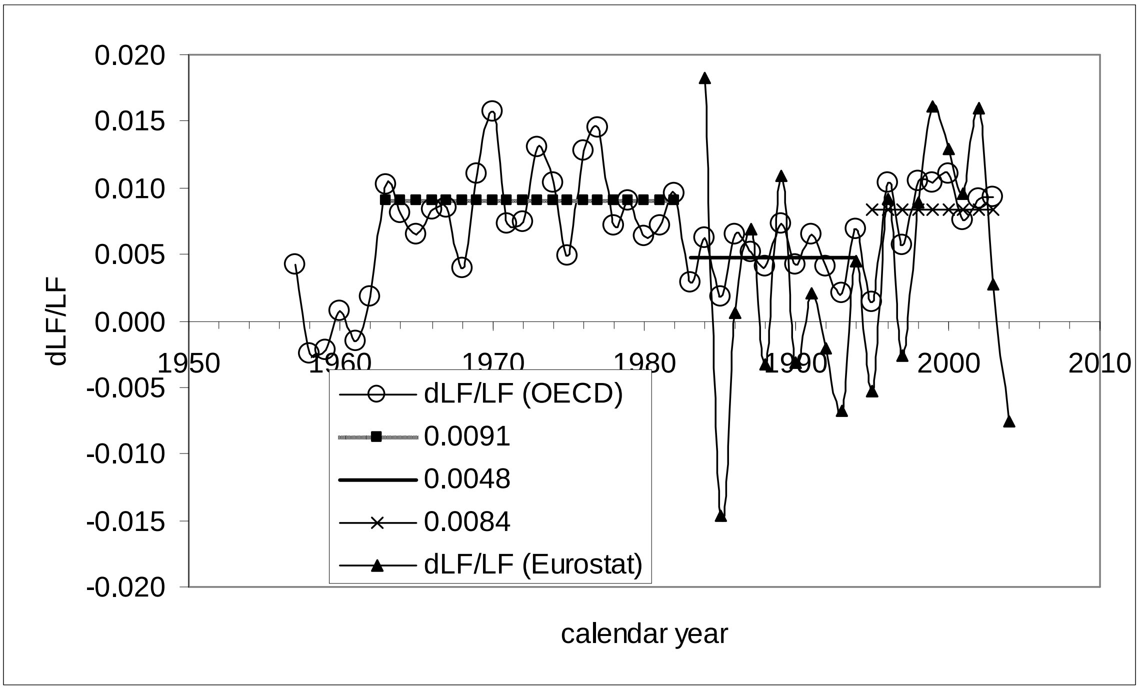


Fig. 13. Labor force change rate in France as given by the OECD and Eurostat. The OECD time series starts from 1956 and the Eurostat's one - in 1983. The latter curve is characterized by higher fluctuations. The mean growth rates of the OECD labor force are also shown for three different periods as defined in the text. Notice a period of strong growth started in 1996.

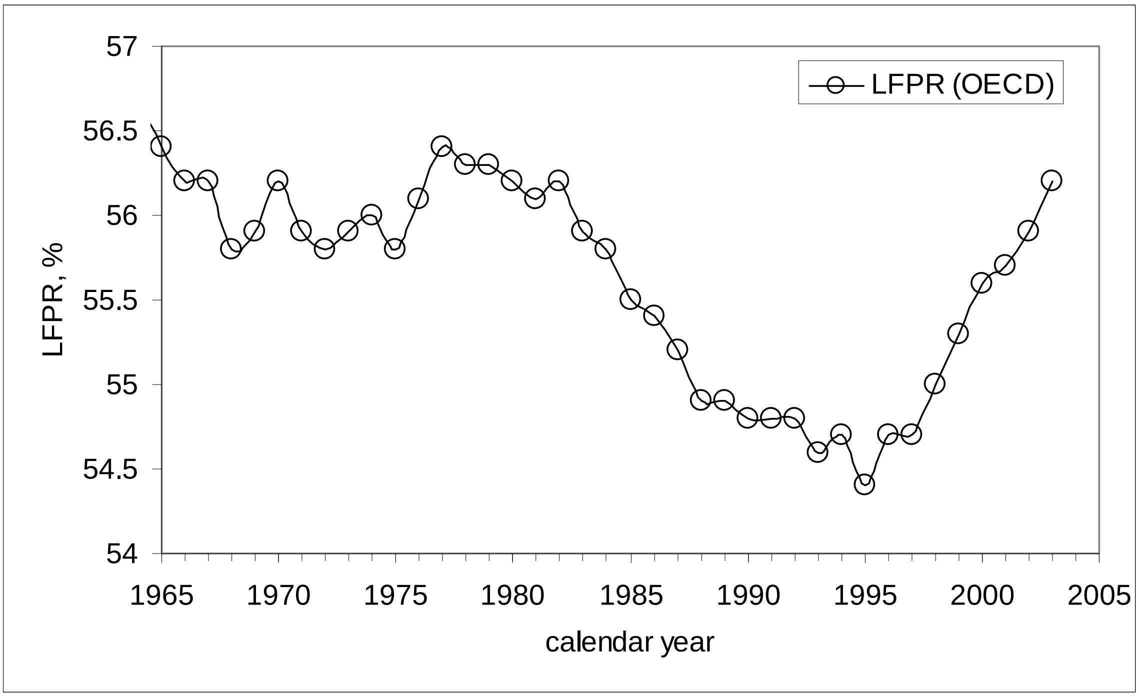


Fig. 14. Labor force participation rate in France as defined by OECD for the population above 15 years of age. There was a long period of a gradual decrease in LFPR between 1975 and 1995 when the lowermost level was measured -54.4%. In 1996, a period of strong growth started with the average annual increment of ~0.2%. In 2004, the LFPR reached 55.7%.

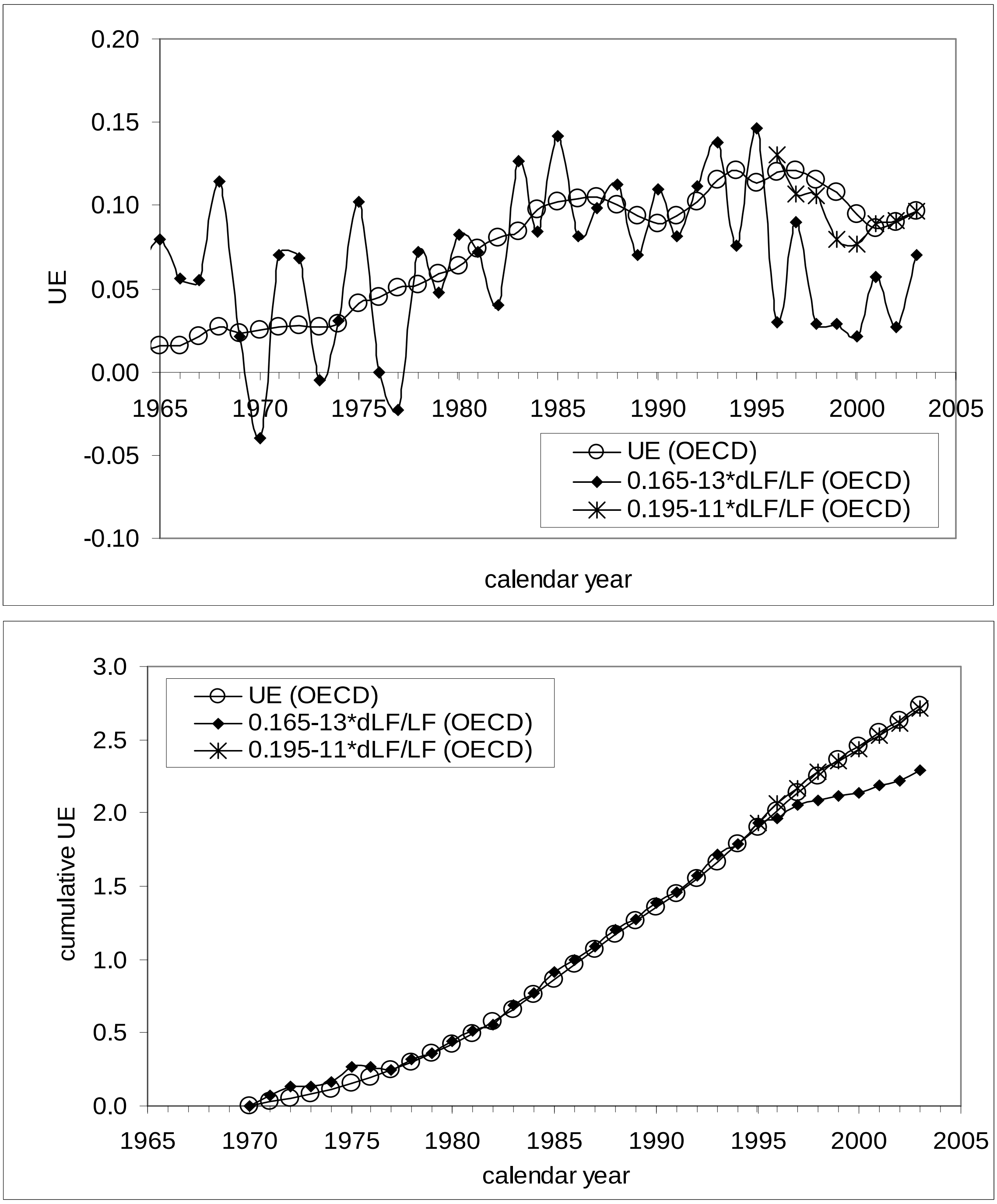


Fig. 15. Comparison of the observed and predicted unemployment in France: the upper frame for the annual readings and the lower for the cumulative values of the unemployment since 1970. There is no time lag between the unemployment and labor force change. Notice the discrepancy started in 1996 – the year when the labor force participation rate started to grow fast, and two years after the Banque de France obtained a new status and introduced a new monetary policy - price stability. The predicted unemployment is about twice as low as the observed one, as presented in the upper panel. The period after 1996 can be described by a different dependence of the unemployment on the labor force with a higher intercept (0.195) and a lower (in absolute value) linear coefficient (-11), as given in the legend. Results of corresponding regression analysis are given in Table 2.

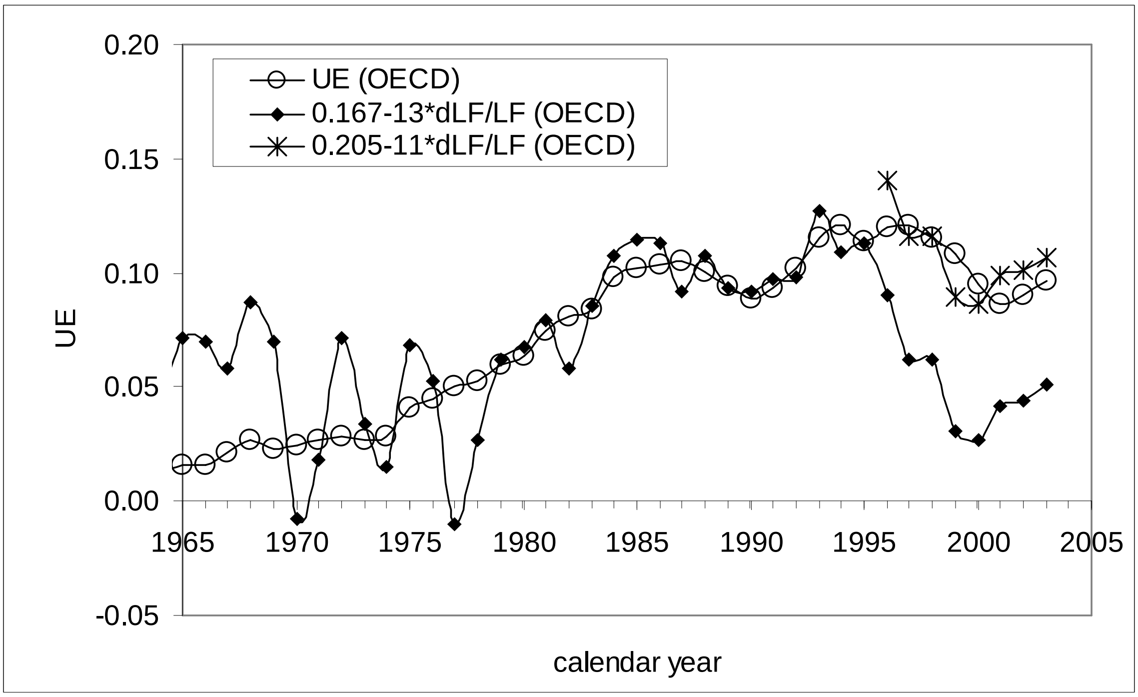
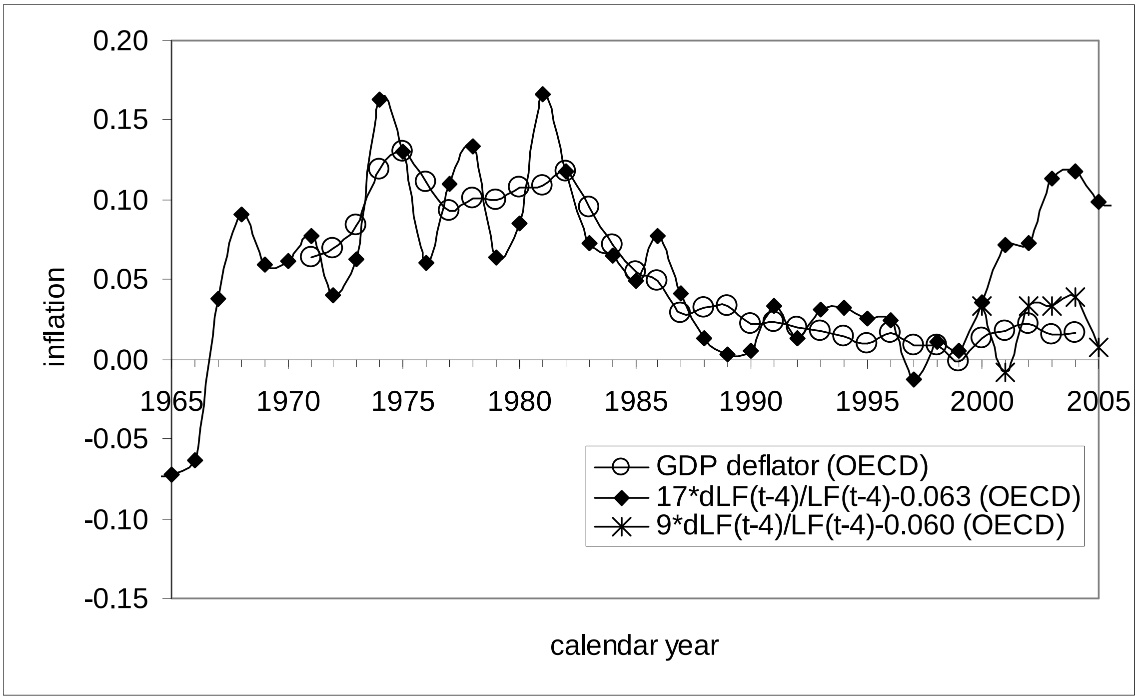


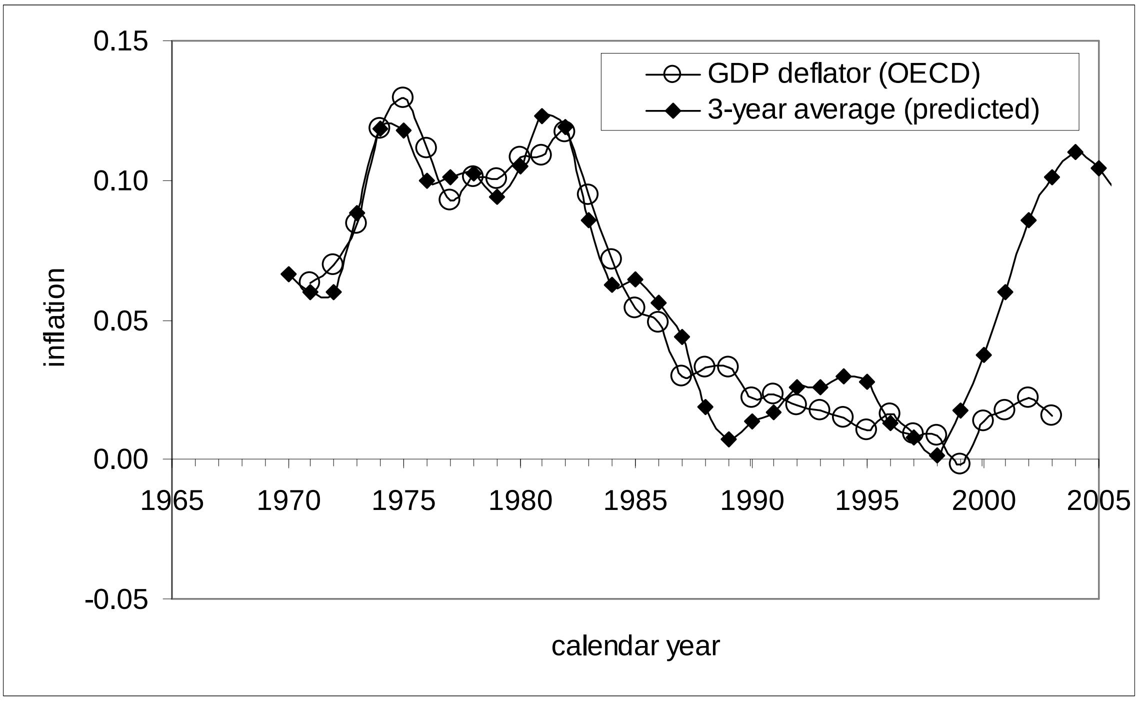
Fig. 16. Same as in Fig. 15a, but with the predicted curve smoothed by a 2-year moving average. There is a better agreement between the observed and predicted time series, especially between 1978 and 1995. Notice a slightly higher intercept 0.167 instead of 0.165 for the annual readings in Fig. 15.

a)



0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
inflation
1965
1970
1975
1980
1985
1990
1995
2000
2005
GDP deflator (OECD)
17*dLF(t-4)/LF(t-4)-0.063 (OECD)
9*dLF(t-4)/LF(t-4)-0.060 (OECD)
calendar year

b)



0.15
0.10
0.05
0.00
-0.05
inflation
GDP deflator (OECD)
3-year average (predicted)
1965
1970
1975
1980
1985
1990
1995
2000
2005
calendar year

c)

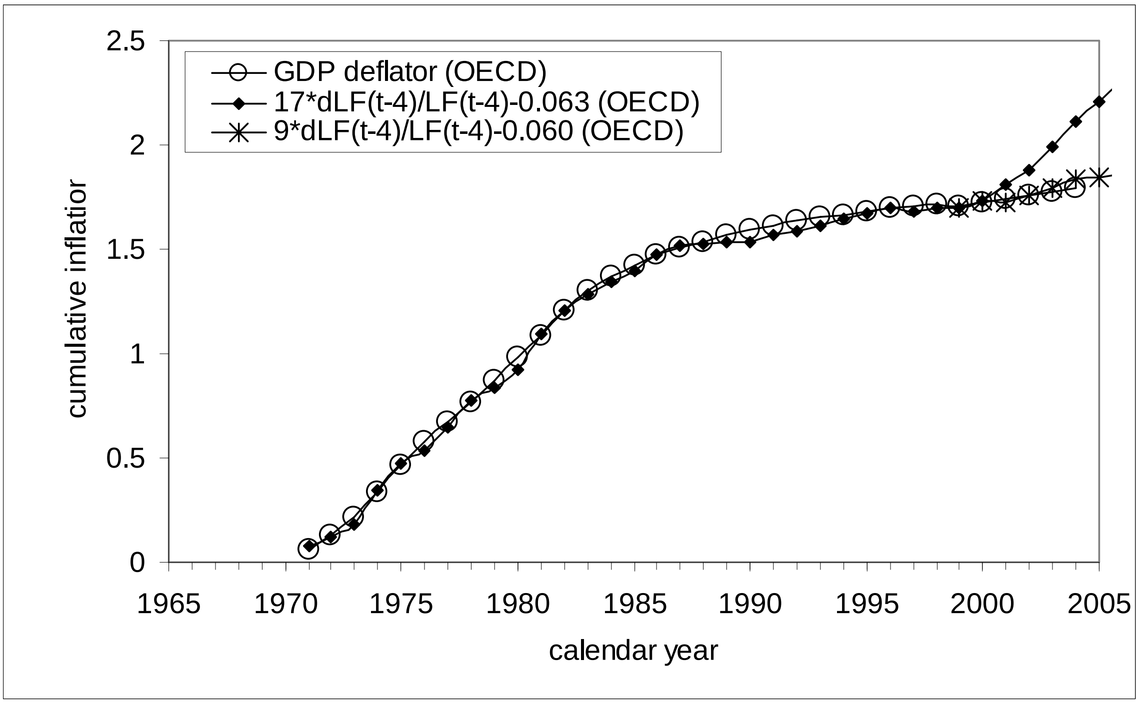
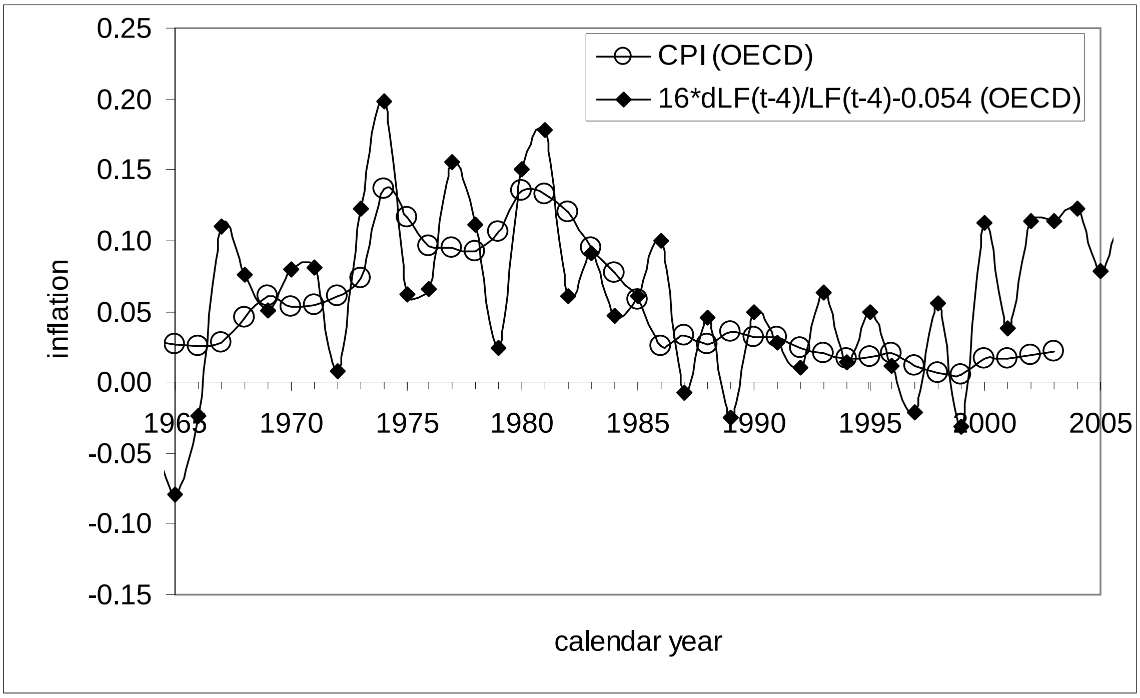
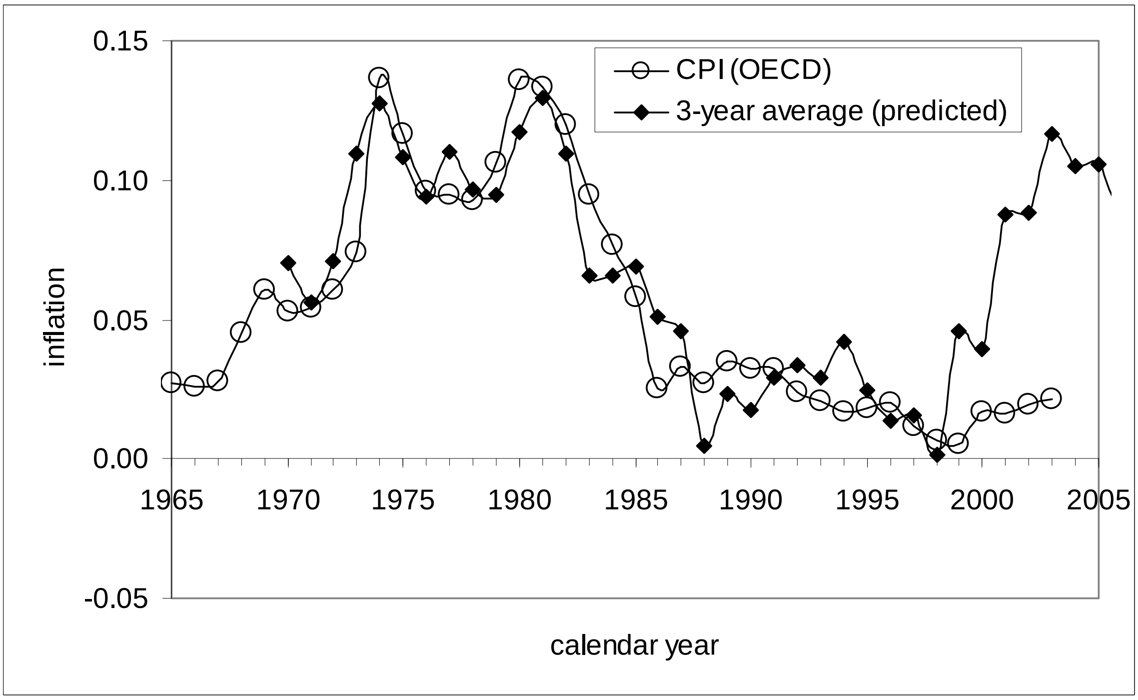


Fig. 17. Comparison of the observed and predicted inflation, as defined by the relationship given in the text and in the legend (OECD GDP deflator) in France: a) annual readings, b) real annual readings and predicted readings smoothed by a 3-year moving average, c) cumulative inflation since 1970. The inflation lags by four years behind the labor force change. Notice the discrepancy started in 2000 – four years after the start of the labor force. The predicted inflation oscillates around 10% after 2000. The period after 1999 can be described by a different dependence of the GDP deflator on the labor force with a slightly larger intercept (-0.060 instead of -0.063) and a much lower linear coefficient (9 instead of 17), as given in the legend.

a)


CPI (OECD)
16*dLF(t-4)/LF(t-4)-0.054 (OECD)
inflation
calendar year
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
1965
1970
1975
1980
1985
1990
1995
2000
2005

b)


CPI (OECD)
3-year average (predicted)
inflation
calendar year
0.15
0.10
0.05
0.00
-0.05
1965
1970
1975
1980
1985
1990
1995
2000
2005

c)

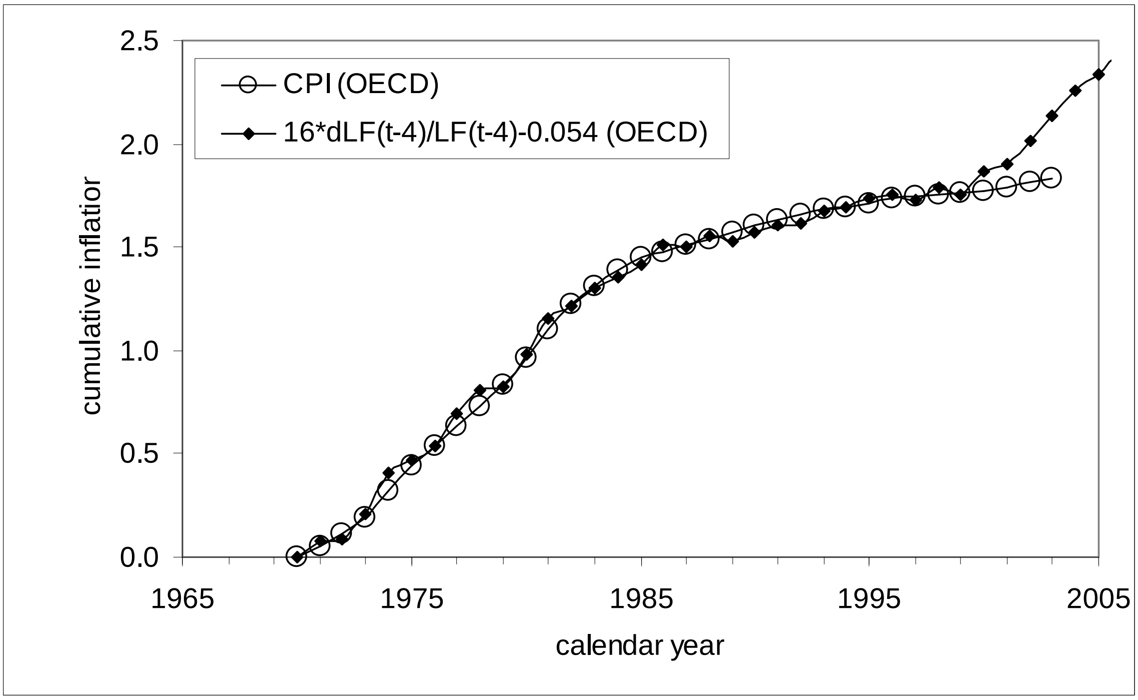
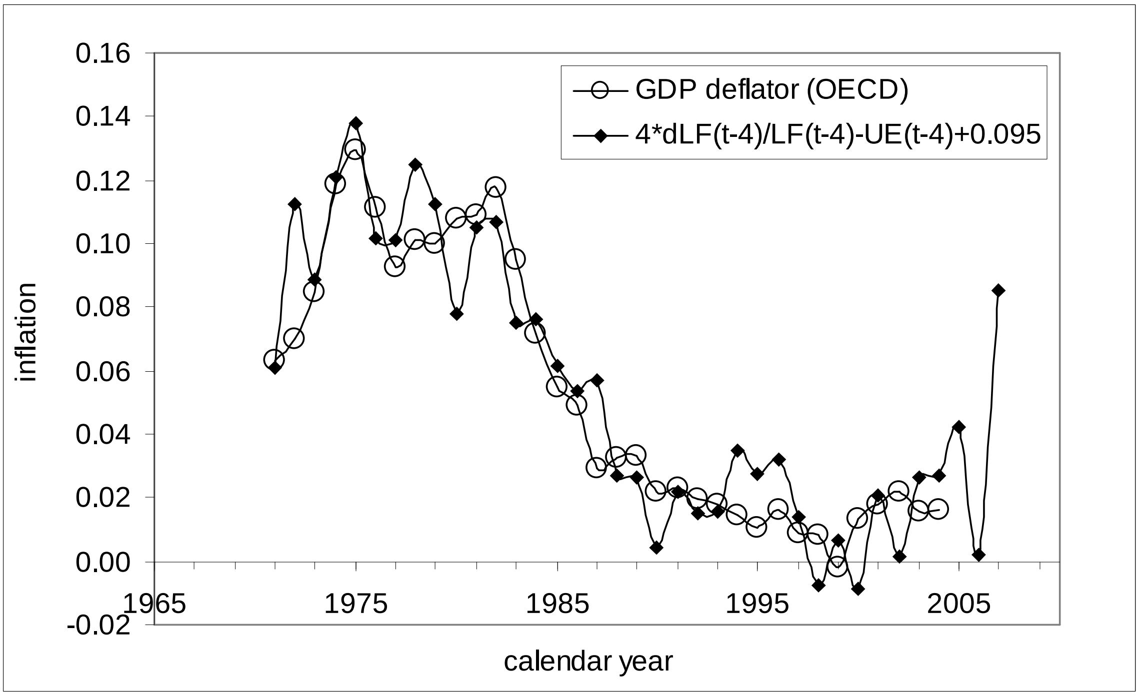
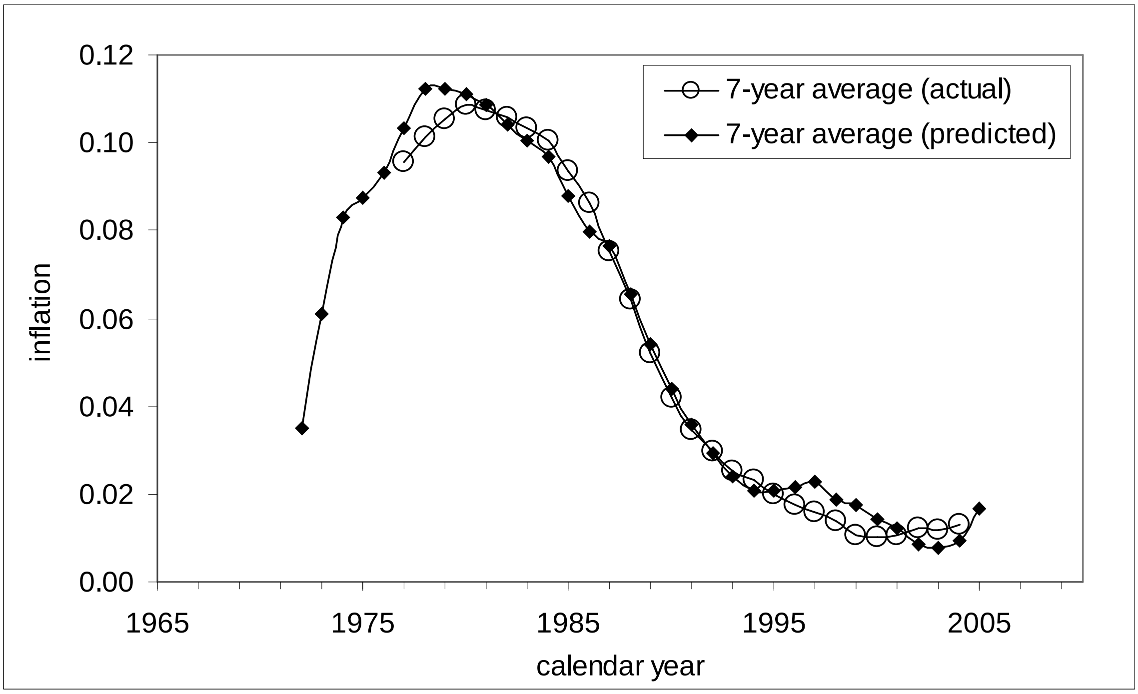


Figure 18. Same as in Figure 17, for the observed inflation expressed by the OECD CPI.

a)


0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
inflation
1965
1975
1985
1995
2005
calendar year
GDP deflator (OECD)
4*dLF(t-4)/LF(t-4)-UE(t-4)+0.095

b)


0.12
0.10
0.08
0.06
0.04
0.02
0.00
inflation
1965
1975
1985
1995
2005
calendar year
7-year average (actual)
7-year average (predicted)

c)

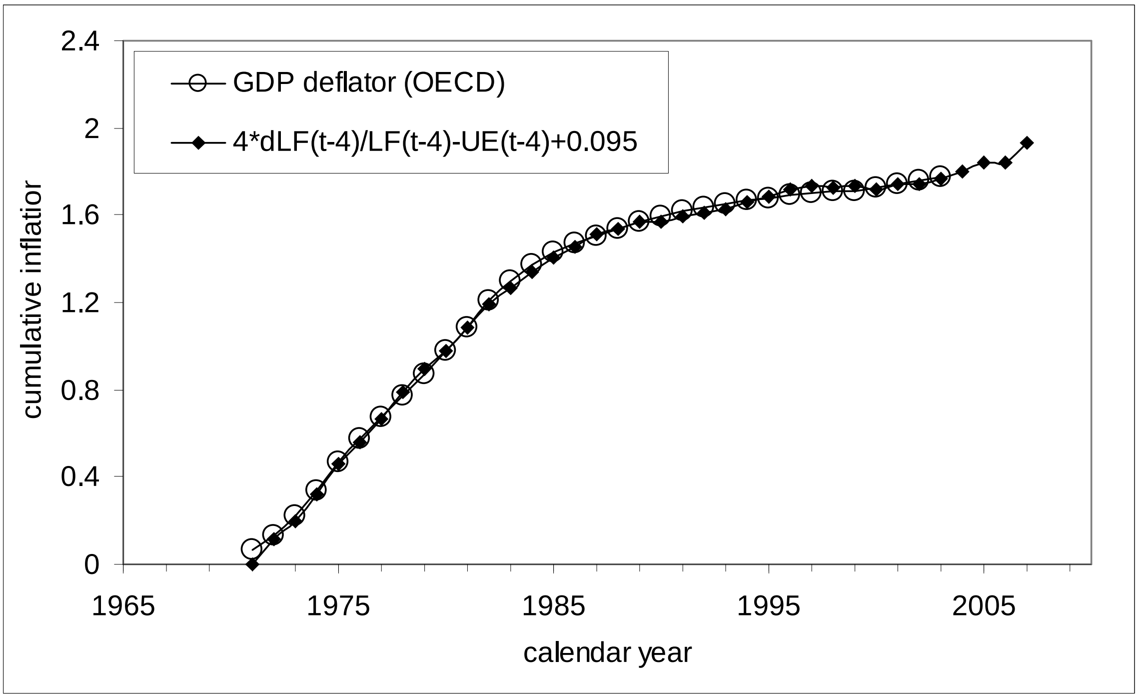


Fig. 19. Comparison of the observed and predicted inflation in France a) annual readings, b) real annual readings and predicted readings smoothed by a 7-year moving average, c) cumulative inflation since 1970. The predicted inflation is a linear function of the labor force change and unemployment. There is no discrepancy starting in 2000.