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Measurement of Inflation: Another Stochastic Approach

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Measurement of Inflation: Another Stochastic Approach

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Abstrakt

V této práci prezentujeme alternativní přístup k inflaci a k jejímu měření, založený na Mengerově vnitřní směnné hodnotě peněz a stochastickém přístupu k indexním číslům. Nejprve uvádíme běžné přístupy k inflaci a některé pojmy si pracovně upravujeme. Poté diskutujeme vážený a nevážený stochastický přístup k měření inflace, stručně také dopad Keynesovy kritiky. Krátce rovněž pojednáváme o charakteristice průřezových rozdělení cenových změn. Jako vhodný přístup k měření inflace navrhujeme výpočet Törnqvistova cenového indexu upraveného pomocí (a)symetrických trimmed means.

JEL: E31, C43
Klíčová slova: měření inflace, indexní teorie, jádrová inflace, trimmed means, medián, průřezové rozdělení cenových změn

Abstract

Measurement of Inflation: A stochastic approach

In this paper, we present an alternative approach to inflation and inflation measurement based on Menger's theory of inner exchange value of money and on the stochastic approach to index numbers. First, we review mainstream approach to inflation and redefine some terms. Then we discuss the unweighted and weighted stochastic approach to inflation measurement and the impact of Keynes' critique. We briefly describe the characteristics of the sample cross-section distribution of price changes. We propose a measure of inflation based on Törnqvist price index adjusted by the (a)symmetric trimmed means.

JEL: E31, C43
Keywords: inflation measurement, index theory, core inflation, Edgeworth, trimmed means, median, cross-section distribution of price changes

Contents

1 Introduction

Inflation is one of the most discussed issues in economics. Our opinion is that it is also the least understood and a very abused term in economic theory. The aim of this paper is to offer an alternative to defining and measuring inflation. Our main contribution is that we refuse to motivate measuring inflation by the cost-of-living theory or the pure price comparison.

In the first part we discuss the standard definitions of inflation and we introduce the concept of the inner exchange value of money. The main propositions of the stochastic approach to index numbers follow. All cited works we reinterpret according to the concept of the inner value of money.

This paper is based on the first theoretical part of a larger work Andrle (2002), where the measures proposed here are calculated for the Czech Republic.

2 The treatment of inflation in current economic theory

We can say –see Bryan (1997)– that the term „inflation“ was firstly linked to the quantity of paper money in the economy. Today, however this term is linked to prices in rather dangerous way. Modern economics treats its terminology quite liberally, in contrast to the *classics* who used much more precise terminology.

Inflation was linked to money and it was understood as a change in the ratio of „money to trade needs“. At the end of the 19^{th} century the difference between money and currency becomes more and more blured and all cirrculating media of exchange are called „money“. But how can we tell when there is more of the medium of exchange than trade needs? It became apparent that one of the plausible indicators may be the „general price level“. To indicate the evolving meaning of the term inflation we cite from Bryan (1997, pp. 4): „Inflation occurs when at a given price level, a country's circulating media (cash and deposit currency) increase relatively to trade needs. (E. W.Kemmer (1918)) “ and the later reference: „Inflation exists in a country whenever the supply of money and of circulating bank deposits... increases, relatively to demand for media of exchange, in such a way as to bring about a rise in a general price level. (E. W. Kemmer (1934))“

What used to be described as a monetary cause became described as

a „price effect“. John Maynard Keynes had a major influence on the concept of understanding inflation, in his *General Theory* he separated the price level from money stock, in the case when the economy has continually underutilized resources, and the term inflation was used more and more without refference to money and became used to describe just the movements in prices, or, became synonymum for whatever price increase! We can see this everyday in the newspapers. Sometimes some economists talk about the „segments of inflation“, meaning the subindices of the consumer price index. Some economists even claim, that the emphasis put on money (i.e. monetary inflation) is too specific and narrow treatment of inflation. In this paper we want to present an idea that it is crucial, for methodological reasons, to strictly draw a distinction between the definition of the phenomenon (inflation) and measuring the phenomenon (measure, rate of inflation).

3 Defining inflation

The definition of inflation is of crucial importance –both for economic theory and the application of economics. But even definitions which do not describe inflation as whatever price increase are not unified. The problem might by that these definitions use rather dangerous term *general price level*, which is ambiguous and according to us misleading. We think that the concept of an aggregate level of prices is not suitable for defining, nor for measuring inflation.

With reference to inflation there exists a vast literature on „core inflation“, but in using this term there is even more ambiguity than in the case of inflation itself. Our opinion is that we should understand by the core inflation and inflation (the true inflation) the same phenomenon. We claim that the unsatisfactory theoretical definition of inflation and practical problem to measure the true inflation caused this terminological dichotomy. We think that economists use the term core inflation when trying to talk about the „true“ inflation as a theoretical ideal.

One of the most frequent approaches to defining inflation is to put emphasis on the persistence in price movement. This is done e.g. by Friedman (1963, pp. 1), who defines inflation as: „*. . . steady and sustained increase in the general price level.*“ This concept is well known and probably the most used one. In the long-run according to M. Friedman, (and the majority of school of economic thoughts) money is neutral, i.e. inflation does not influence output and the Phillips curve is vertical in the long-run. The reasons why it might be different in the short-run are numerous and can

be found e.g. in (Fischer 1981a, Romer 1998, Barro 1993).

Another interesting and similar definition of inflation is given by Laidler and Parkin (1975, pp. 741), who define inflation as a „*process of continuously rising prices, or, equivalently, of continuously falling value of money.* " This definition is much more interesting, because it uses another term – *value of money.*

However, another approach to defining inflation can be found. This approach puts emphasis on the generality in price movements, not on the persistence in time. We can quote the definition of Flemming (1976, pp. 2), that the rate of inflation is „*the rate at which the general level of prices in the economy is changing.* "

We claim that there are two main approaches to understanding inflation, understanding it as a (i) *persistent increase in the general price level* and (ii) *general incrase in prices*. In the work of Roger (1998), which –one of the few– investigates the core inflation, can be seen that Roger distinguishes two approaches to core inflation: persistent inflation and generalised inflation.

We consider this terminology as a consequence of the fact that the definitions of inflation mentioned above are based on the *measured inflation*, better to say, based on the movement of a (somehow measured) general price level. We think that a definition based on the already measured variable may be problematic. Inflation is then defined by means of its consequence, the price effect without any reference to what we consider important: money. The above mentioned definitions are trying to identify the inflation from measured variables (price movement), and therefore they adopt identifying conditions (each one adopts a different one) to obtain inflation from the measured price indices. For some economists the identifying condition is the persistent movement of the price index in time, when at some rate there is no doubt that part of the movement of the index may be assigned to inflation, for others the identifying condition is the generality in the price movement.

We think that these approaches may be useful for measuring inflation, when we try to „discover" inflation using price data and statistical tools available. *But we think that the definition of inflation (as a monetary phenomenon) should not be based on the measured price effect.* Our idea is that the price effect should be used (and is used) to obtain an approximation of the theoretical ideal of inflation, i.e. it should be used for measuring the inflation phenomenon. If we base the definition of the phenomenon itself on the measurement, it is neccessary to use the term core inflation to describe the theoretical ideal, which substract the changes in

relative prices, etc. The basic idea is that the measurement of the phenomenon has to be motivated by the definition of it, which is problematic if the definiton of the phenomenon is based on the measurement!

4 Inflation as a change in the inner value of money

At the end of the 19^{th} century Carl Manger introduced an original theory of the outer and inner value of goods,[1] and of the money also. The exposition of Menger's theory is based on Menger (1976), Mises (1953) and the work of (Fase and Folkertsma 1997, pp. 1-4).[2] This theory may be close to austrian economists to which Menger belongs. By outer value of good Menger defined the price of a good, i.e. the quantity of unit of exchange (money) per unit neccessary for the exchange itself (in equilibrium). In the same way the outer value of money is its purchasing power, i.e. the bundle of goods attainable on the market for the unit of money (unit of exchange). In Menger's terminology then the consumer price index as we know it is just a measure of the outer value of money.

The ratio at which the goods are exchanged is naturally fully determined by the marginal utility of the goods. Menger refuses that the change in that ratio can be caused by a change affecting only one good. He calls these changes the movements in the inner value of good. Then the changes in the inner (exchange) value of money are those price changes caused only by the monetary factors. Accoording to Menger a change in the inner value of money should manifest itself in proportional increase of the nominal prices of all the goods, so there is no movement in the relative prices, they remain constant. Of course even Menger himself claims, that the proportional movement in all prices doesn't necessarily mean that the inner value of money changed, because it may be caused by the simultanneous effect of the real effect. Menger is therefore very sceptical about the possibility of measuring the changes in the inner value of money.

We find this concept very useful from the theoretical point of view and therefore we define inflation as a change (fall) in the inner (exchange) value of money. Implicitly we draw a distinction between the definition of the phenomenon and its measurement. If we would not take the definition of Friedman just as an identyfing condition for measuring inflation (the

[1] Innerer Tauschwert, Ausserer Tauschwert – Innerer Tauschwert des Geldes

[2] Note: Fase and Folkertsma (1997) followed adifferent approach to measuremet of inflation than presented in this paper.

signal extraction) then the changes in the price level caused purely by monetary factors which were not persistent could not be called inflation. But from the theoretical point of view, for the monetary authority is highly relevant to measure any changes stemming from monetary factors.

We think that a phenomenon defined in this way is not directly observable and directly measurable. We understand it as an existing phenomenon, but unobservable. Therefore our effort is to measure, i.e. identify or approximate this phonomenon as an unobserved variable.

In a similar way to Carl Menger, Ludwig von Mises (1953) also distinguishes the changes in the exchange value of money stemming from monetary factors and stemming from real factors. There is not necessary to look for the quantity theory of money behind it, which was refused by Mises. Mises also explicitly draws a distinction between the inner and outer exchange value of money. The theoretical ideal of Mises then is money with a constant inner value, but with a varying exchange value derived from changes in the real sector.

We think that one advantage of this approach (not the only one) to inflation is that we do not operate with the general price level, so the definition is not based on its price effect. If we talk about general price level, we mean some average price, which does not exist in fact, or, equivalently there exists a continuum of ways how to construct this average price. It is just the mapping of the set of prices to scalar and therefore it is influenced by every change in the set of prices with no regard whether the change in the price is caued by the change in relative price or not.

But right at the beginning of this essay we have to admit that inflation, defined as above, cannot be measured exactly, because it is impossible to destinguish using price data only if the change in prices is caused just by the inner value of money or by the change in relative prices. Both Menger and Mises were sceptical about measuring the inner value of money, but Menger admitted the usefulness of the effort to approximate the phenomenon.

To support our claims we may quote from Mises (1953, p. 189) a passage, which we label in this text as a *Mises critique*:

„Nearly all the attempts that have hitherto been made to solve the problem of measuring the objective exchange-value of money have started from the idea that if the price-movements of a large number of commodities were combined by a particular method of calculation, the effects of those determinants of the price-movements which lie on the side of the commodities would largely cancel one another out, and consequently, that

such calculations would make it possible to discover the direction and extent of the effects of those determinants of price movements that lie on the monetary side. This assumption would prove correct, and the inquiries instituted with its help could lead to the desired results, if the exchange-ratios between the other economic goods were constant among themselves. Since this assumption does not hold good, refuge must be taken in all orts of artifical hypothesis in order to obtain at least some sort of an idea of the significance of the results gained. But to do this is to abandon the safe ground of statistics and enter into a territory in which, in the absence of any reliable guidance (such could be provided only by a complete understanding of all the laws governing the value of money), we must necessarily go astray. ... All determinants of prices have their effect only through the medium of the subjective estimates of individuals; and the extent to which any given factor influences these subjective estimates can never be predicted. "

We fully agree with this statement, but we believe that the effort to extract the inflation signal more or less precise is the only way how to measure inflation, the inner value of money. We believe that for making economic policy it is crucial.

Let's express the problem in a bit more formalised way. Let $\pi_{i,t}$ be the relative change of the nominal price of the good i at time t. Following Menger (1976) and Fase and Folkertsma (1997) we define this expression:

$$\pi_{i,t} = \alpha_t^M + \alpha_{i,t}^M + \beta_{i,t} + \lambda_{i,t} \tag{1}$$

We claim that an observed (relative) change in the price of the i-th good is the result of the change in the relative prices due to real factors ($\beta_{i,t}$) and also change in price due to monetary factors ($\alpha_t^M + \alpha_{i,t}^M$). The term $\lambda_{i,t}$ stands for the error of observation. The effect of monetary expansion may be decomposed into the $\alpha_{i,t}^M$, i.e. the change in relative price due to monetary factors in the short run, and α_t^M, which is the change in the inner value of money common to all goods. We consider (1) to be an identity. The concept is relatively modern, becuase it allows for the short-run effect of monetary expansion on relative prices.

We do not conclude that the monetary expansion has to force all nominal prices to increase in the same rate, because we are aware of the microeconomic complexity of monetary expansion due to its decentralised form as to persons and regions and therefore also to some extent *hidden form* for some individuals, with consequences on their subjective evaluations of market and arbitrage trading. Reasons why the non-administred prices may not adjust in a flexible way are numerous, an overview can be found in Fischer (1981a) or Romer (1998).

We also think that the way we have defined the terms, we can expose in an interesting way Lucas' model of imprecise distinction between the change in the relative prices and the inner value of money. The change in the inner value of money is not directly observed until it manifest itself in time as to its persistence or strength. In addition considering the imperfect information on markets this imprecise destinction has to occur. And even if the standard CPI is published it may not help because the CPI is flawed measure, it is the measure of the cost-of-living, not the measure of the change in the inner value of money (we may measure only the change, not the level, but then the level can be normalised).

The change in the inner value of money happens to be continuous in time with regards to relation of „money" to the „trade needs". It is natural that endogenous money creation changes the inner value of money, the presented concept is not based on exogenous money. But this unobservable phonomenon often manifest itself in prices after reaching some treshold value. Then with the reference to decentralisation of money creation the relationship (1) holds and the relative prices are changing. Some subjects, however do not realise immediately and then correct their behaviour and the prices adjust (abstracting from the costs of adjustment).

The price change of a good is then composed by the change in relative price and the change in the inner value of money. If we omit the cause of the change in relative price (real or monetary factor), we can rewrite (1) as

$$\pi_{it} = \Pi_t + \epsilon_{i,t} \tag{2}$$

where $\Pi_t = \alpha_t^M$ and $\epsilon_{i,t} = \alpha_{i,t}^M + \beta_{i,t} + \lambda_{i,t}$. Expression (2) is consistent with the definition of inflation as a change in the inner value of money.

With regard to Roger (1998) or Wynne (1999) we may say that some authors understand by core inflation term Π_t, nevertheless this statement is not precise, because core inflation is not unambigously defined term.

Using (2) and the available information on individual price movements we will discuss how to identify component Π_t. Our aim is to construct such a measure of inflation (or model) which is as close as possible approximation of the inner value of money. Having the Mises critique in mind we interpret it that Mises agrees with (1) or (2), but is highly sceptical about an identification (isolation or extraction) of the component Π_t.

It may be questioned whether we find plausible approximation of the inner value of money, but the important aspect is the approach we follow. We try to measure inflation as everywhere and everytime monetary phenomenon (Friedman 1963). We do not care about the measuring of the

fact how the expenditure of a representative consumer must change to attain the same bundle of good (pure price level comparison), or to attain the same level of utility (cost-of-living approach). By these two approaches the „measuring inflation“ is motivated most and we strictly refuse this motivation for measuring inflation.

We consider then, that the consumer price index motivated by the cost-of-living theory or pure price level comparison a conceptually inappropriate measure of the inflation.

If measurement of some variable (phenomenon) is done, the reason for measuring, the motivation is crucial. In the case of inflation and its measurement the role of some measure (index, indicator) is different than in the case of the cost-of-living theory, even if the measure would be formally written in the same way! This measure has a different interpretation and interpretation is strictly inseparable from the measurement.

5 Measuring inflation: a stochastic approach

5.1 Motives for adopting the stochastic approach

The stochastic approach to measuring inflation is a bit of a reinvented approach today, originated mainly by[3] W. S. Jevons and F. Y. Edgeworth. Today the main propagators of the stochastic approach to index numbers generally are K. W. Clements, H. Y. Izahn, E. A. Selvanathan or D. S. Prasada Rao. An important contribution to the stochastic perspective on inflation was brought by Michael F. Bryan with Stephen G. Cecchetti.

In previous part of the paper we adopted another definition of inflation in the tradition of the inner value of money. Now we have to make a second step – choose an approach to measuring inflation. *As an identifying condition of inflation we adopt the generality in price changes.*

As already noted Carl Menger was sceptical about precise measurement of the change in the inner value of money, but still admitted the usefulness of approximation. He claimed that if we observe the growth of all prices in the same direction and of the same magnitude, then the hypothesis of change in the inner value of money is *more probable* then the hypothesis of simultanneous increase in inner value of all goods observed. If the prices are not moving in the same magnitude, then a possible approximation, according to Menger, is to look at the mode of cross-section distribution of price changes $\pi_{i,t}$. But Menger immediately continues that

[3] see (Aldrich 1992)

this method is much less reliable the more the price changes vary.[4] Next we will try to operationalize adopted theoretical approach.

The last paragraph is actually nearly all what we need to motivate stochastic approach to measuring inflation. We see a great probabilistic foundation of Menger's theory – an invitation to the world of probabilities. We will try to increase probability that the extracted signal (from the price data) is the best approximation to the change in the inner value of money. The second probabilistic aspect of the problem is the fact that we treat the available price data as a draw from the population distribution.[5]

5.2 Early attempts to measure inflation

By measurement we understand attribution of quantitative value to conceptually quantifiable variable on the base of empirical data. It is a question to what extent we should distinguish measurement from inferrence here, therefore we treat it as synonyma.

It is interesting, that before the CPI motivated on the basis of pure price level comparison of cost-of-living theory, several economists attempted to measure inflation. Although their theoretical motivations were different, we can relate some of their works to the concept adopted in this paper. To give an example, Adam Smith in his *Wealth of Nations* attempts do distinguish change in the market price of the good because of silver and because of other factors. Thomas Tooke in his six volume book *History of prices* investigates the changes in the „value of money" with reference to monetary policy.

These authors together with many others adopted the *method of residual*.[6] The basic principle of this method is that the scientist tries to exclude the maximum possible price movements which may be directly attributed to certain real factors to be able then better idenfity the monetary cause. We can say that we try to increase the probability that the residual contains only such movements caused by the change in the inner value of money. Tooke and Smith, however have not explicitely used the used the probabilistic terms.

[4] E.g. Hayek (1934, pp. xxxi) notes that the approach of Menger is extraordinaly modern, however the terminology used may be misleading for today's economist.

[5] This fact has important implication for test and economic approach to index numbers (Diewert 1995b).

[6] According to Hoover (2000) J. S. Mill describes this method as follows: „Subduct from any phenomenon such part as is known by previous inductions to be effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

Why is the measurement using the method of residual defined in a negative way? It is because the change in the inner value of money is directly unobservable variable and therefore it is easier to measure things which are certainly not the change in the inner value of money. Tooke (and others) then extract the signal by reducing the noise caused by the changes in relative prices, coming from the dynamic interaction of the supply and demand of/for individual goods.

5.3 Beginning of the stochastic approach to measuring inflation

W. S. Jevons together with F. Y. Edgeworth are most outstanding individuals who worked on the stochastic perspective with reference to inflation. Jevos in his work *A Serious Fall in the Value of Gold Ascertained and Its Social Effects Set Forth* (1863) has described the history of prices, where he used the index numbers as a form of reduction.

The pure method of residual is based on the measurement which attempts to find causes, because the excluded shocks (noise) has to be identified exactly. We stress the exactness of identification here. That is because Jevons (1863, pp. 58) review this method very critically especially due to exact identification. Jevons concludes that it is impossible to investigate the context of supply and demand of/for every good. Eventually the researcher would have to exclude all items and changes, because by extracting particular items he would more and more corrupt the mutually offsetting changes in the system of relative prices. It is important to realise that there is no exact system of general equilibrium at our disposal. That is why we consider and treat the available price changes (used for computations) only as a draw from the underlying population.

Jevons concluded that by averaging he can neutralise all specific shocks and factors of price changes. Jevons therefore decided to choose his „wide averages“, i.e. he tried to include as many items as possible in his computations. Although we have a different theoretical motivation, we may reinterpret and use several parts of Jevons work.

Now the expression $\pi_{it} = \Pi_t + \epsilon_{it}$ is not meant to represent an identity, because we make assumptions about Π_t and ϵ_{it}, which may help us to identify both components.

When using the „wide averages“ Jevons decided to construct unweighted geometric mean. He believed that the changes in relative prices will mutually offset and neutralised. But this is sipmply not true, because we do not work with the population, but only with the draw from it. Thus

Jevons assumes constant relative prices and that the price changes are independet observations. Unfortunately this is too strong assumption.

We may add a bit of formalism to clarify the problem. Assuming simple model

$$\pi_{i,t} = \Pi_t + \epsilon_{i,t} \tag{3}$$

where $t = 1, 2, \ldots, T$ and $i = 1, 2, \ldots, N$, with $\pi_{i,t} = \ln(p_{i,t}/p_{i,t-1})$. It is actually the expression we are familiar with, but now we adopt identifying conditions (assumptions) to be able to isolate the components. We assume that $\epsilon_{i,t}$ is an independently distributed random variable with zero mean $E(\epsilon_{i,t}) = 0$. We also assume that changes in relative prices are independent through commodities, i.e. $cov(\epsilon_{it,}, \epsilon_{j,t}) = 0$ for $i \neq j$ and have common variance var $\epsilon_{i,t} = \sigma_t^2$.

Under these assumptions the (BLUE) estimate of Π_t by the maximum likelihood and least squares is the simple unweighted arithmetic average of N logarithms (natural) of price changes ($\pi_{i,t}$)

$$\hat{\Pi}_t = \frac{1}{N}\sum_{i=1}^{N} \pi_{i,t} \qquad \hat{\sigma}_t^2 = \frac{1}{N-1}\sum_{i=1}^{N}(\pi_{i,t} - \hat{\Pi}_t)^2. \tag{4}$$

If we realise that $\epsilon_{i,t} = \pi_{i,t} - \Pi_t$ is the change in the relative price (we may also interpret the expression as a price change deflated by Π_t), then we acknowledge Menger's and Jevons' intuitive conclusion that the larger is the variance of changes in relative prices, the less precise we can estimate the component Π_t, which can be interpreted as the change in the inner value of money. It is equivalent to saying that for extracting the right signal the shape of distribution of cross-section price changes is crucial.

Let's go back to Jevons and exponentiate $\hat{\Pi}_t$, obtaining

$$\exp\left(\hat{\Pi}_t\right) = \prod_{i=1}^{N}\left(\frac{p_{i,t}}{p_{i,t-1}}\right), \tag{5}$$

an unweighted geometric average, which is called *Jevons index.* Jevons' initial derivation of (5) was a bit different, but using explicitly or implicitly the same assumptions. Later he applied on (3) the least squares method and calculated the „probable error" – i.e. confidence interval as we say today. With regard to test approach to index numbers we may note that this index satisfies e.g. the time-reversal condition.[7]

[7] If we formulated the model above without using logarithmic transformation, then the BLUE estimator is Carli index. Both models are closely related through the logarithmic transformation.

This approach to measurement is a very attractive concept, its main idea. But the problem is that we assume the cross-section of price changes to be independently distributed and the relative prices to be constant. Jevons *believed* that using huge number of items the changes in relative prices will be neutralised. The second question is whether to treat all price changes (of individal commodities) as if thery are of the same importance. The third problem –Jevonsdid consider– is the reflection of the whole set of charasteristics of the distribution of the cross-section distribution of prices.

Thus we may outline three problem sets: (i) *assumptions about the behaviour of relative prices*, (ii) *whether and how the price changes should be weighted* and (iii) *the feasibility of a chosen estimator with regard to the character of the cross-section distributions of price changes.*

These problem sets are actually the problem how to weight the individual price changes, i.e. we want to find the weights in the estimator of the general form $\hat{\Pi}_t = \sum_{i=1}^{N} w_{i,t}\pi_{i,t}$, where $w_{i,t}$ is nonrandom weights at time t for commodity i. Jevons then derived special case when for all weights $w_{i,t} = 1$ holds, so all price changes (and therefore all commodities) are treated equally important. This episode in theory may be labeled as unweighted approach to index numbers and has been subject to sever criticism.

6 Keynes critique

There are mainly two critics of Jevons – correa M. Walsh and J. M. Keynes. The so called *Keynes critique* concerns especially the first two problem sets we outlined above. Now we lay down the basic features of Keynes critique, for more detailed discussion with Keynes see Andrle (2002).

Keynes admits that it may be valuable to isolate that part of the fluctuations in prices caused purely by monetary factors. I.e. Keynes admits the usefulness of distinguishing α_t^M from $\beta_{i,t}$ – by monetary causes we do not understand at this moment $\alpha_{i,t}^M$, which is the change in relative prices due to the monetary expansion.

Keynes (1930) states that the concept of the price level is false and misleading and inflation (change in the inner value of money in our view) can not be measured as a change in the price level, becauase the price level itself is affected by the changes in relative prices. We fully agree and more than that –we think that this critique supports our attack on current measurement practices of inflation and the ambiguous use of the term general price level.

But we have not interpreted Π_t in (2) –in contrast to several other authors– as a change in the general price level, i.e. we do not make use of expression $\Pi_t = \ln(P_t/P_{t-1})$. That would be flawed and we could not then consider (2) as an identity. Although one might view this as a rather unimportant detail, it is not the case. Doing that we would refer already in definition to very problematic variable (measured one) and we would make rather restrictive assumptions about behaviour of relative prices.

As we have already noted, we have to distinguish between the definition and measurement. Those who decide to use the term price level right from the start, in the definition, then have to come up with identifying conditions to *identify inflation*, not only to *measure inflation*. Although we use the same price data, we do not use the *two step method of measuring*. Instead of this we consider more plausible to work with the *cross-section distribution of price changes* instead of the price level, because it objectively exists.

Keynes also makes a criticism of the assumption of relative prices independence. That is true, in measuring we construct models having a simplifying assumption and dependent upon the cross-section distribution of prices we choose those statistical methods which increase the probability of getting the right signal. Keynes critique then relates to our measurement, but at least it is not related to our theoretical background.

We also do not believe that relative prices are constant, nor independently distributed. But that is why we can only approximate the inflation! The results are obtained at certain costs. But we think that if our approach is flawed, then it should not be flawed more then than other approaches based on conceptually inappropriate theoretical motivation (cost-of-living etc.).

However, Keynes continues his attack on the approach to measurement we adopted here Keynes (1930, pp. 77). He notes that price changes are not independently distributed and it is not possible to work with them without reference to the underlying quantities of the goods. He also implicitly suggests that the only plausible tool to handle the problem is general equilibrium model. Here and in other works Kenyes then points out that the price changes ought to be weighted according to their respective *economic importance*. i.e. to quantities or expenditures on the goods.[8]

We have to agree with this criticism and we are aware of it. And the problem is rather serious. But also we have to mention that Keynes has

[8]Acoording to (Andrle 2002) it can be traced in (Keynes 1930, pp. 76 – 77) that Keynes claims that there is nothing as „the“ rate of inflation. This interpretation is also suggested by (Diewert 2001).

never proposed anything more than the statement that the price changes should be weighted, which doesn't solve the problem. As Keynes was strictly against the (with respect to economic importance) unweighted approach applied by Jevons and Edgeworth, the economic statistitians decided to weight the price changes with reference to the importance for the consumer.

Today, there are attempts to answer Keynes last criticism, but we consider the answers partly unsatisfactory. One branch of the stochastic approach to index numbers (Clements and Izahn 1981, Clements and Izahn 1987, Prasada Rao and Selvanathan 1992) adopts additional assumptions about the structure of the model to allow for trend in relative prices, etc. but the assumptions are strongly defeated by the observed reality. Based on these assumptions it is possible to derive e.g. Törnqvist-Theil, Lespeyres or Paasche price index (Selvanathan 1991, Crompton 2000).

7 A weighted stochastic approach to index numbers

It goes without saying that Jevons also considered weighting. He asked himself whether to weight the price changes of the good with respect to the variability of its price change or with respect to the economic importance of the good. Also he knew that treating price changes as independent observations is problematic. Eventually, he decided just for his unweighted wide averages. F. Y. Edgeworth went much further and investigated more the statistic and economic theory underlying particular index number. Rather than economic importance of the good he was interested in statistical arguments (with links to economic theory).

Edgeworth claimed that the particular formula of an index number should correspond with the shape of the cross-section distribution of prices. Today the literature shows (almost as stylised fact) that this distribution is chronically non-Normal – a fact Edgeworth knew. That is why he did not agree with Jevons model and proposed using the *unweighted median* instead. Egeworth, however continued to use the unweighted approach with reference to economic importance of the goods.[9] He emphasised that some commodities are highly volatile and their relative prices change very often.

Edgeworth continues saying that the price changes of the item should

[9]Note that the median may be described as a weighted average where all but the particular percentiles are zero-weighted.

be weighted with respect to the volatility of price changes, so the index number formulla is significantly influenced by the *sample cross-section distribution of price changes*. Frequent changes in relative prices make the inflation signal extraction much harder. This whole set of arguments is carefully elaborated in (Edgeworth 1887, Edgeworth 1901, Edgeworth 1923b, Edgeworth 1925a) and other outstanding works of Edgeworth. But he strictly and explicitely refuses weightening with reference to (representative) consumer and a link to the cost-of-living theory.

In our view, however Edgeworth in his brillant argumentation underestimated the great importance of the economic importance, i.e. the importance for transaction in the economy. We are conviced that we must to combine economic (transaction) weights and edgeworth-like weights somehow to obtain the weight $w_{i,t}$. We claim that mainly due to the fact that the price changes data are only a draw from the population, we may incorporate the transaction weigthning in the measure together with edgeworth weights. It is not a surprise that we shall use probabilistic motivation again.

The reflection of transation importance we may support by a very simple idea, also considered and used by Theil (1967, pp.136 – 137). Assume we make a random draw from the population of items in first period in the way that each Dollar of expenditures has the same probability to be chosen. The probability that we choose the price change of the i-th good is

$$s_i^0 = \frac{p_i^0 q_i^0}{\sum_{k=1}^N p_i^0 q_i^0}, \tag{6}$$

where p_i^0 denotes the price of the i-th good in the first period and q_i^0 denotes the quantity of that good. Then the average with corresponding weights may be expressed as

$$\sum_{i=1}^N s_{i,t-1} \ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right) = \sum_{i=1}^N s_{i,t-1}\pi_{i,t}. \tag{7}$$

Now we will repeat the mental experiment again using the same procedure we adopted in time $t-1$, but now for the period t. We obtain

$$\sum_{i=1}^N s_{i,t} \ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right) = \sum_{i=1}^N s_{i,t}\pi_{i,t}. \tag{8}$$

Then (7) is in fact logarithmic Lespeyres price index and (8) is the logarithmic Paasche price index. Each of these indices has the importance of the same strength.

It is dated back to Correa Moylan Walsh that we may obtain the weights for two periods in time, but if we treat the price change whichs happens between this two time periods –which weight is more plausible then? Walsh and Theil also adopt arithmetic mean of the weights of the two consecutive periods.[10] Thus we construct an index

$$\ln P_T = \sum_{i=1}^{N} \frac{1}{2}(s_{i,t} + s_{i,t-1}) \ln \left(\frac{p_{i,t}}{p_{i,t-1}} \right), \tag{9}$$

or, equivalently,

$$\ln P_T = \sum_{i=1}^{N} \rho_{i,t} \pi_{i,t} \qquad \text{kde} \qquad \rho_{i,t} = \frac{1}{2}(s_{i,t} + s_{i,t-1}), \tag{10}$$

which is the Törnqvist index. Avoiding the logaritms we obtain so called Törnqvist-Theil index. [11]

In the absence of the genaral equilibrium system we continue with these weights, motivated by probabilities, reflecting the transaction importance of various commodities. Now we also have to incorporate the second type of weights (Edgeworth's weights).

8 Behaviour of prices

We have already noted that the prices of commodities do not evolve in correspondance with inflation (Π_t), even in the absence of real shocks. There are numerous reasons why the non-administred prices behave in this way, starting from the cost of adjustments, menu cots –see Sheshinski and Weiss (1977), Ball and Mankiw (1994) or Ball and Mankiw (1995)– to difficulties in distinguishing the changes in relative prices and the inflation Lucas (1973). We may also work with other state-dependent or time-dependent pricing models, see Caplin and Leahy (1991), Fischer (1981b), or (Barro 1976).

A significant feature of the price behaviour is also the seasonality. It may be induced by both demand and supply shock, when the structure of relative prices is changing. Seasonality not only affects prices, but also the quantities available (or produced). Then, if we compute the price change between the periods, the prices do not follow Π_t, because the ϵ_{it} is much

[10] To be precise, Walsh used the geometric mean.

[11] The fact we obtain a Törnqvist index is rather interesting, because e.g. the cost-of-living theory considers this index as a „superlative index".

more significant. These commodities are also very volatile. We consider the commodity unavailable at certain season to be seasonal as well –a fact that may also complicate the computations.

Another interesting issue concerns administrated prices, either directly set or just partially influenced (price cielings, etc.) These prices are usually very disconneted with Π_t. They are either kept away from the Π_t, or they are adjusted in jumps to reach the price level considered by the regulator as optimal.

Another source of variations in prices –with reference to measurement only– is the error of observation, stemming from uncorrectly made sampling and imputed values, inappropriate geographic aggregation (Shapiro and Wilcox 1997), etc. These issues we attribute to the component $\lambda_{i,t}$ in (1).

Thus we may conclude – important reasons why prices do not have to evolve according to Π_t are the changes in relative prices due to (i) *real or nominal shocks – nonadjustment to the shocks because of the menu-costs, imperfect information, implicit or explicits contracts,...*, (ii) *seasonality* , (iii) *administrated prices* and (iv) *error of observation*. This classification is rather arbitrary and individual groups may be subgroups of others. Even if the economic theory is concerned more by the (i), we emphasise the effects of the (ii) to (iv), which are not issue of such a deep investigation.

To show some „patterns“ of the price behavior we present Fig. 1, which may illustrate the main price changes patterns we may observe.

As our main concern is as close as possible approximation of inflation signal Π_t incorporated in these price changes, we should look at monthly price changes at Fig. 2. Here we want to show that it may be rather difficult the common signal encoded in the data and that not only the quantity of the goods.

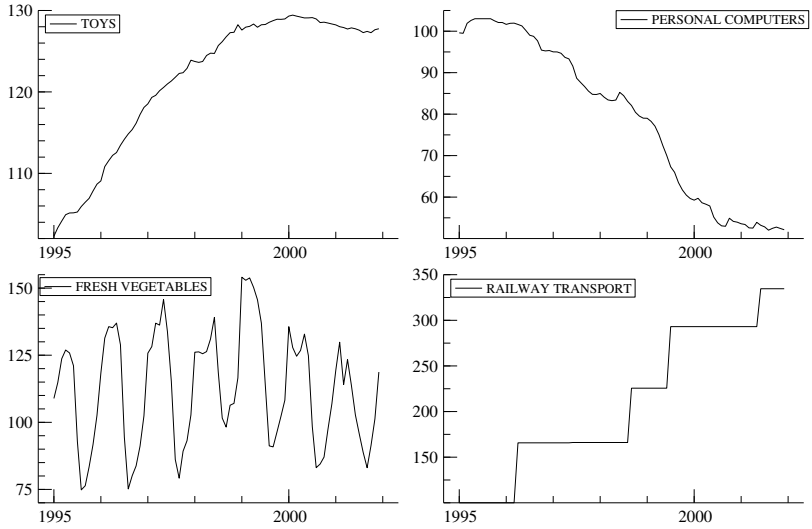
9 Constructing a measure of inflation

9.1 L-estimators

The pattern suggested above has to be incorporated in $w_{i,t}$. With reference to Edgeworth we may do it in two ways. The first way is the usage of so called neo-edgeworth indices (Diewert 1995b, Wynne 1997).[12] The second one is what we have adopted in this paper – we directly take into

[12]Generally, this approach is based on the idea that the weights $w_{i,t}$ are functions of the price variability of item in relation to overall variability of prices. For advantages and disadvantages see e.g. Andrle (2002).

Fig. 1: Behaviour of representative prices – levels (SKP4, CR)



Source: Czech Statistical Office, own computations

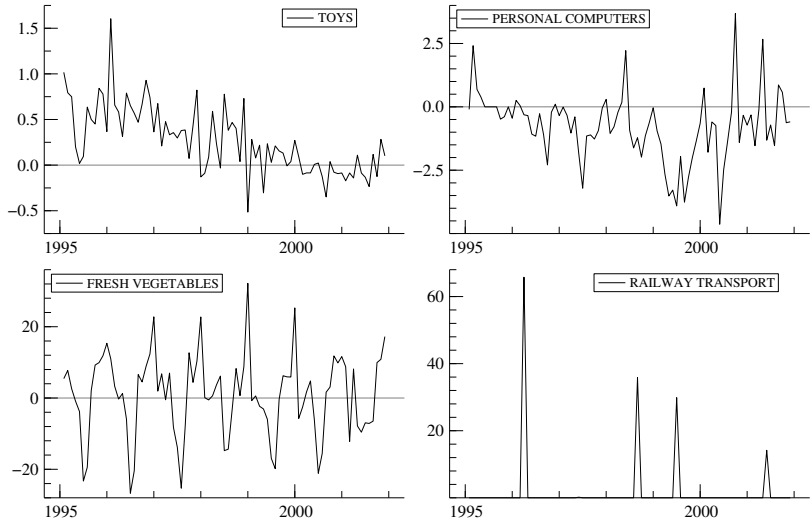
consideration the shape of cross-section distribution of prices. Although the computational method is different, the main theoretical motivation remains.

Let us remind ourselves of the overall concept we present here. The price changes used for construction the estimator (index) are treated as a *sample* from the population of price changes. Our aim is to find the central tendency of that population as –in our view– the best approximation of the change in the inner value of money. In each period we have at our disposal only a draw from the population and some drawn price changes may be quite unrepresentative for estimating of the central tendence of the population.[13]

Our goal is to find a suitable estimator of the central tendency of the population distribution. The feasibility of estimators is dependent upon the characteristics of the population distribution of price changes. With reference to the text above we look for an estimator which will properly treat the extreme, or, unrepresentative price changes. A simple example may be the sudden hike in oil prices or railway transport. It is

[13]In addition, the population distribution is unknown and also varying in time.

Fig. 2: Behaviour of representative prices – m/m, (SKP4, CR)



Source: Czech Statistical Office, own computations

very probable that this price movement is caused by the change in relative price, not by inflation and therefore this price movement is not relevant for information to determine the change in the inner value of money in the current period. We may treat this price movement as a „bad draw“ from the population. If this shock is not transitive and the money creation follows, it may lead to the change in the inner value of money, but only at that time we want to measure the change in the inner value of money, inflation, not in the period of shock.

We seek an estimator which is an (i) unbiased, (ii) efficient and (iii) robust estimator of the population central tendency. It is often wrongly assumed that the sample mean is the best estimator of population central tendency for all types of distributions, but this is not true. Even a very small departure from Normality and the sample mean is still an unbiased estimator, but much less efficient estimator of central tendency. Although the population distribution is unknown, the empirical facts surveyd in the literature allow us to suppose (based on the huge evidence from sample data) that the pouplation is not Normal!

The relative efficiency of various estimators is very sensitive to kurtosis

of the distribution, when considering biasedness the skewness is important. With reference to prices we may construct the coefficient of skewness and kurtosis based on weighted moments (Theil 1967). The moments are weighted by the transaction weights.

The skewness coefficient (S) is standardized third central moment. For symmetric distribution the coefficient is zero, the reverse does not hold. This coefficient can differentiate the symmetric and asymmetric distributions, but can not tell two different symmetric distributions. For this purpose we use the kurtosis coefficient (K), standardizedn fourth central moment.

If we denote by $m^h_{r,t}$ the r-th central moment then

$$m^h_{r,t} = \sum_{i=1}^{N} w^h_{i,t} \left(\pi^h_{it} - \bar{\Pi}^h_t\right)^r, \tag{11}$$

where w_{it} are corresponding nonrandom transaction weights, N is the number of commodities, $\bar{\Pi}_t = \sum_{i=1}^{N} w_{it}\pi_{it}$ and $\pi^h_{it} = \ln p_{i,t} - \ln p_{i,t-h}$.

The second moment ($r = 2$) is the variance; the square root of it we denote σ_t and define the skewness S_t and kurtosis K_t coefficients as:

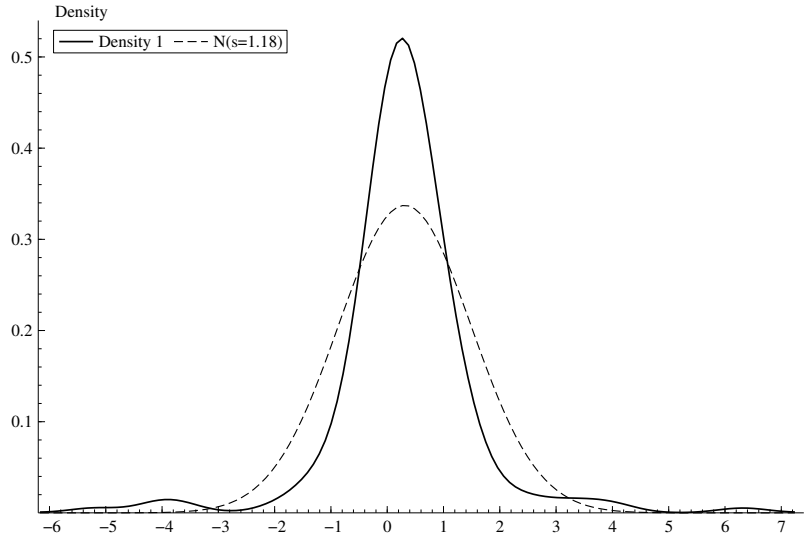
$$S^h_t = \frac{m^h_3}{(\sigma^h_t)^3} \qquad K^h_t = \frac{m^h_{4,t}}{(\sigma^h_t)^4}. \tag{12}$$

Based on a survey of literature we may claim in the manner of „stylised fact“ that the distribution of price changes is often (i) extremely kurtotic and (ii) asymmetric – with tendency to right-skewness. Also the more the data are aggregated in time or cross-commodities the smaller is the sample skewness and kurtosis. These facts may be observed for majority of european countries, New Zealand, Australie and also for the Czech republic (Andrle 2002).

As presented in illustration on Fig. 3 where the „typical“ sample distribution of price changes is depicted for the Czech Republic compared to Normal distribution. We may observe that the distribution of price changes is much more kurtotic. But the distribution has not „fat tails“ as usually described with reference to kurtosis, but it has „long tails“. The distribution contains rather few numbers of very large extremes.

We may also observe positive (right) skewness of the distribution, i.e. there are more postive price changes than negative ones. But we have to interpret the volatile skewness and kurtosis coefficent very carefully. If the average skewness over a large period of time indicates positive skewness, we may judge the population also positively skewed. E.g. Roger (1997)

Fig. 3: Example of distribution of price changes in the CR



Source: Czech Statistical Office, own calculations

finds chronic righ-skewness for quarterly data of New Zealand, in contrast to Bryan and Cecchetti (1998) who find for USA producer prices the distribution symmetric in average. The results of Andrle (2002) indicate that in the Czech republic there is tendency to right-skewness (positive).

But it is neccessary to realise that even from a symmetric population distribution it is easy to obtain an asymmetric sample – but in average the drawn should be symmetric. The more kurtotic the population distribution is larger the probability of obtaining an extreme observation which is not offset by similar one on the other tail of distribution.[14] I.e. with increasing kurtosis of the population distribution, the probability of getting skewed sample distributin is also increasing.

These facts alone are, in our view, solid motivation to seek for an estimator of central tendency other than the sample mean. However, can we support these arguments even more by economic theory?

We think that there is also support by the economic theory. Andrle (2002, pp. 59 – 63) discuss the main issues affecting the shape of distribution of price chagnes – (i) administrated prices, (ii) seasonality, (iii)

[14]Note that also the transaction weights influence the shape of the distribution.

unadjustment because of the menu-costs, imperfect information and naturally (iv) real shocks. After minor adjustments the models in Ball and Mankiw (1995) and Ball and Mankiw (1994) may be well related to our approach. These models are based on the menu-costs. If we introduce a monetary (nominal) shock to the model in (Ball and Mankiw 1995) it should not (in the case of perfect information and flexible prices) affect relative prices. So we work with α_t^M, which affect all prices in the same ratio. In the model, however due to the menu-costs existence the positive nominal shock does not affect all prices equally and the shock increases the „general price level" and the authors interpret that as rise in „aggregate inflation". Yes, the inner value of money is changing by α_t^M, but due to the menu-costs there is also non-zero term α_{it}^M, which will after adjustment return to zero value. In opposition to the authors we think that in reality the main reason for change in α_{it}^M might come from the existence of imperfect information about the true α_t^M. This model also shows the causality running from the monetary shocks to the change (skewness) in the shape of the distribution of price changes.

However, these models indicate possible problems with our approach in „measuring" inflation. If we filter out extreme changes in prices (as they might represent bad draws), we may also discard highly important information. Imagine that α_t^M increases when there are no real shocks (i.e. $\beta_{it} = 0$). Due to existence of menu-costs (etc.) not all prices adjust to a shocks, but only part. If the costs of adjustments are high, then only small part of prices adjusts and if we exclude them, then we exclude the only relevant information about α_t^M available in the price data. It is because with regard to other price changes these ones are treated as extreme changes – the statistical measure will not look for causalities. For more examples see Andrle (2002) or Bakhshi and Yates (1997).

9.2 Constructing a robust and efficient measure

Estimation from a symmetric population Assume that the population distribution is symmetric. The most feasible estimator of central tendency depends then largely on the kurtosis of the distribution. Here we assume that the distribution is rather kurtotic, so the sample mean is not an efficient estimate of the central tendency – the sample median is much more efficient in this case. That is also the logic of Edgeworth propagation of (unweighted) median.

But we do not seek just an efficient measure of the central tendency, but also a „robust" one. It comes from the fact that we do not know the

population distribution. If we knew it we could find the most efficient estimator and use it. But because we do not know the distribution, we need the estimator to be robust, i.e. the estimator should not be too sensitive to changes in distribution, it should be feasible for some „family of distributions“, which we can define thanks to the (rather good) information we have from the sample distributions.[15] The estimator chosen then may not be the best one for every population, but is rather good for all considered ones (from the family).

The theory of robust statistics offers many possibilities, but we will concentrate on „L-estimators“. These estimators are linear combination of order statistics. The typical representant of L-estimators are so called α-trimmed means.

L-estimators are constructed as follows. First we order the (weighted) observations and then we reweight the observations according to their relative position. The reweighted observations are averaged. Trimmed means then attribute to α percent of observations zero weight at each tail of the distribution (i.e. an ordered sample). Thus the biggest extremes are eliminated on both tails. Attractive property of this measure is the fact that the sample mean ($\alpha = 0$) and sample median ($\alpha \to 50$) are subset of this measure.

These measures were applied by Bryan and Pike (1991), who analyse and recommend the median as a (core) inflation measure and then applied by Bryan and Cecchetti (1998) who already concentrated on finding of the most suitable α-trimmed mean. This is all done without explicit reference to Edgeworth and his work, however Edgeworth was the first one who applied the L-estimator to measure inflation – see outstanding essay Edgeworth (1888).

Following Bryan, Cecchetti and Wiggins II (1997) we construct the α-trimmed mean TM(α) in this way: First we order all available observations $\{\pi_{1,t}, \ldots, \pi_{N,t}\}$ and attribute the corresponding weights (transaction weights) $\{w_{1t}, \ldots, w_{N,t}\}$. Then we define W_{it} as a cumulative weight $W_{it} = \sum_{i=1}^{j} w_{it}$. We identify the set of observations which will be centered as follows: $\frac{\alpha}{100} < W_i < (1 - \frac{\alpha}{100})$, and we denote this interval I_α. Then we construct

$$\mathrm{TM}_\alpha = \frac{1}{1 - 2\frac{\alpha}{100}} \sum_{i \in I_\alpha} w_{it}\pi_{it}, \tag{13}$$

where $\pi_{i,t} = \ln(p_{i,t}/p_{i,t-1})$ and w_{it} are non-random time varying transaction weights motivated above.

[15] For reference to robust statistics see (Huber 1981, Huber 1964, Blatna 2000, Pawitan 2001, Spanos 1999, Lehman 1991, Roger 2000).

Of course a more detailed (or sophisticated) weighting scheme might seem better, e.g. the weights inversly related to the relative distance from the central tendency of the population distribution. But the snag is that we do not know the central tendency – all the things discussed above is done just to find it! However, we agree with Bakhshi and Yates (1997), who note that it is possible to improve the „binary“ weighting scheme. The question is then to find a proper and solid motivation for the new scheme.

Another interesting problem with measuring inflation is how to choose the optimal size of α, i.e. how large part of the tails to discard. An intuitive and correct reaction is that the α should depend on the kurtosis of the population distribution. Again – we do not know it. But we might obtain rather good information from the sample distribution. As far as we know only Aucremanne (2000) adopted this approach and uses the deviation from Normality (on the basis of the Jarque-Berra test). Aucremanne (2000) construct two types of mesures – JB-estimators. The first one has a constant trimming percentage based on the JB test for some period (average results), the second one is time-varying and the trimming procedure stops when it can not refuse the hypothesis of Normality of the remaining observations. The time-varying trimm has the great advantage that it is not so prone to discard too much and sometimes too little of the information necessary to obtain the central tendency. The average measures (calibrated for an chosen time period) are always just and average.

Usually the method of calibrating the optimal trimm to a certain time period is adopted, where the use of a trend of some measured price index is used (Bryan et al. 1997). However, this method has many drawbacks (Andrle 2002, Aucremanne 2000). The first one is that the trimming percentage is calibrated to the history, the second is that it does not vary over time and thus it may not be optimal at each period and third, the calibration is very sensitive to chosen period as a benchmark. The main problem, especially in our view is the use of the trend of the price changes index (weigted or unweighted) as a proxy for past „true inflation“, i.e. adjusting from the noise of the relative prices. When choosing the right trimming percentage it is also crucial which use of the fit is used (RMSE vs. MAD), becuase they provide sometimes rather different results. RMSE more heavily weights the larger deviations from the benchmark.

Estimation from an assymetric population When we face an assymetric population distribution, then the mean and median coincide no more. If the distribution is positively skewed –as it usually is–, then the

median is biased (in relation to the mean) in a systemic way. The reasons for assymetry are the above mentioned menu-costs or administrated prices, which generate large assymetry.

If we applied symmetric trimmed means to assymetric population distribution, then this measures are systematically biased. In the case of an assymetric distribution the population mean is larger than the 50^{th} percentile. If we can identify this percentile, we can consider it as an estimate of the mean of the population distribution (Roger 2000).

If the population distribution is right-skewed (positive skewed) the observations on the right tail of the distribution are more distant from the population central tendency than the left-tail observations. Applying symmetric trim result in biased (lower) estimates of the central tendency. Thus to adjust for this skewness we have to apply assymetric trimmed mean, which symmetric trimmed means which proves to be superior to symmetric trimmed means in the case of Czech Republic (Andrle 2002).

10 Conclusion

In this paper we introduced an alternative approach to defining and measuring inflation. We based our paper on the theory of the inner value of money and a probabilistic treatment of inflation. Thus we present an extraction of the inflation signal using (a)symmetric trimmed means applied to the Törnqvist price index. Although this approach has many (especially computational) drawbacks it is motivated by the theory relevant to inflation, not by the cost-of-living theory.

The resufal of the cost-of-living theory as a motivation for measurement of inflation is the main idea of this paper. We want to discuss the measurement of inflation, not the construction of an cost-of-living index.

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