



EUROPEAN CENTRAL BANK

**EUROSYSTEM INFLATION
PERSISTENCE NETWORK**

WORKING PAPER SERIES

NO 606 / APRIL 2006

BCE ECB EZB EKT EKP

**MEASURING
THE IMPORTANCE
OF THE UNIFORM
NONSYNCHRONIZATION
HYPOTHESIS**

by Daniel A. Dias,
Carlos Robalo Marques
and João M. C. Santos Silva

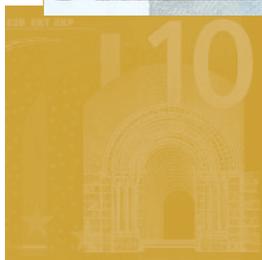




EUROPEAN CENTRAL BANK



In 2006 all ECB publications will feature a motif taken from the €5 banknote.



WORKING PAPER SERIES

NO 606 / APRIL 2006

**EUROSYSTEM INFLATION
PERSISTENCE NETWORK**

MEASURING THE IMPORTANCE OF THE UNIFORM NONSYNCHRONIZATION HYPOTHESIS¹

by Daniel A. Dias²,
Carlos Robalo Marques³
and João M. C. Santos Silva⁴

This paper can be downloaded without charge from
<http://www.ecb.int> or from the Social Science Research Network
electronic library at http://ssrn.com/abstract_id=890991

¹ We are indebted to Stephen Cecchetti, an anonymous referee and participants in the Eurosystem „Inflation Persistence Network“ for inspiring discussions and many useful suggestions. We also thank Pedro Duarte Neves for helpful discussions and suggestions. Pete Klenow kindly provided the U.S. data used in the examples. The usual disclaimer applies. João Santos Silva is thankful for the hospitality, working conditions and financial support provided by Banco de Portugal and gratefully acknowledges the partial financial support from Fundação para a Ciência e Tecnologia, program POCTI, partially funded by FEDER.

² Banco de Portugal and UCLA Anderson School of Management, Box 951481, Los Angeles, CA 90095-1481, USA;
e-mail: ddias@anderson.ucla.edu

³ Banco de Portugal, R. Francisco Ribeiro, 2, 1150-165 Lisboa, Portugal;
e-mail: cmrmarques@bportugal.pt

⁴ ISEG/Universidade Técnica de Lisboa, R. do Quelhas 6, 1200-781 Lisboa, Portugal;
e-mail: jmcass@iseg.utl.pt

The Eurosystem Inflation Persistence Network

This paper reflects research conducted within the Inflation Persistence Network (IPN), a team of Eurosystem economists undertaking joint research on inflation persistence in the euro area and in its member countries. The research of the IPN combines theoretical and empirical analyses using three data sources: individual consumer and producer prices; surveys on firms' price-setting practices; aggregated sectoral, national and area-wide price indices. Patterns, causes and policy implications of inflation persistence are addressed.

Since June 2005 the IPN is chaired by Frank Smets; Stephen Cecchetti (Brandeis University), Jordi Galí (CREI, Universitat Pompeu Fabra) and Andrew Levin (Board of Governors of the Federal Reserve System) act as external consultants and Gonzalo Camba-Méndez as Secretary.

The refereeing process is co-ordinated by a team composed of Günter Coenen (Chairman), Stephen Cecchetti, Silvia Fabiani, Jordi Galí, Andrew Levin, and Gonzalo Camba-Méndez. The paper is released in order to make the results of IPN research generally available, in preliminary form, to encourage comments and suggestions prior to final publication. The views expressed in the paper are the author's own and do not necessarily reflect those of the Eurosystem.

© European Central Bank, 2006

Address

Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address

Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone

+49 69 1344 0

Internet

<http://www.ecb.int>

Fax

+49 69 1344 6000

Telex

411 144 ecb d

All rights reserved.

Any reproduction, publication and reprint in the form of a different publication, whether printed or produced electronically, in whole or in part, is permitted only with the explicit written authorisation of the ECB or the author(s).

The views expressed in this paper do not necessarily reflect those of the European Central Bank.

The statement of purpose for the ECB Working Paper Series is available from the ECB website, <http://www.ecb.int>.

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

CONTENTS

Abstract	4
Non-technical summary	5
1. Introduction	7
2. Measuring UNS: the method of Klenow and Kryvtsov	8
3. Measuring UNS: other methods	11
3.1 The FK index	12
3.2 A nonparametric upper bound	13
4. Empirical results	14
4.1 The data	14
4.2 Results	15
5. Concluding remarks	17
References	18
European Central Bank Working Paper Series	19

Abstract

In this paper we critically reappraise some measures of the importance of time-dependent price setting rules and propose an alternative way to gauge the significance of this type of price setting behaviour. The merits of the proposed measure are highlighted in an application using micro-data. Our results suggest that a large proportion of price trajectories may be compatible with simple time-dependent price setting mechanisms but the strength of this evidence very much depends on the way that is used to evaluate the importance of this type of behaviour.

JEL classification codes: D40, E31, L11.

Key Words: Time-dependent price setting models, uniform staggering, perfect synchronization

NON TECHNICAL SUMMARY

Price rigidities are a condition for monetary policy to have real effects. Therefore, the study of price setting policies is critical to understand the importance of monetary policy.

Price setting models suggested in the literature are generally classified into two categories: time- and state-dependent. Time-dependent models, like those proposed by Taylor (1980) and Calvo (1983), assume that prices are kept unchanged during a period of time, whose length does not depend of the economic conditions. In its basic version, the model proposed by Taylor (1980) implies that the share of prices that changes each period is constant. Cecchetti (1985) termed this the uniform nonsynchronization (UNS) hypothesis. On the contrary, state-dependent models assume that firms decide whether or not to change their prices, based on the evaluation of the costs and benefits of a price change.

Although state-dependent price setting models may be a more realistic description of the price setting behaviour of many firms, time-dependent models are very popular in the literature, not only because they are simpler to work with, but also because in some circumstances they may provide an adequate description of the frequency of price changes. For example, with low and stable inflation, we may expect the fraction of prices that change every period to vary little over time. In this case, macroeconomic models based on the UNS hypothesis may lead to results that do not differ much from the ones obtained using state-dependent price setting schemes.

This idea is explored by Klenow and Kryvtsov (2005). These authors have suggested a statistic, which can be interpreted as a measure of the degree of UNS, and compared the results of a model using time-dependent price setting with the results of a state-dependent model calibrated to produce a value of their statistic similar to that found using the USA data. The results of Klenow and Kryvtsov (2005) suggest that the differences between the two models are negligible. Although the line of research pioneered by Klenow and Kryvtsov (2005) is potentially very fruitful, the results depend critically on the way the importance of time-dependent price setting schemes is measured.

In this paper we show that the interpretation of the statistic suggested in Klenow and Kryvtsov (2005) as a measure of the degree of UNS is marred by important difficulties, which ultimately make it uninterpretable. Moreover, we discuss two alternative ways to measure the significance of UNS in the economy. Particular attention is paid to a novel measure of UNS suggested in the paper, which is a non-parametric upper bound of the degree of UNS in the economy, and has important advantages over the statistic proposed by Klenow and Kryvtsov (2005).

The different measures of UNS are used to obtain empirical results, both for Portugal and the US. We conclude that, although there is evidence to suggest that time-dependent price setting schemes implying UNS may be quite important, the strength of this evidence very much depends on the measure of UNS that is used.

1. INTRODUCTION

The type of price setting mechanism to use is a major issue in the specification of any macroeconomic model. Time-dependent price setting mechanisms, like the ones proposed by Taylor (1980) and Calvo (1983), are often used due to their simplicity. In its basic version, the model proposed by Taylor (1980) implies that the share of prices that changes each period is constant. Cecchetti (1985, p. 940) termed this the uniform nonsynchronization (UNS) hypothesis.¹

Even if simple time-dependent price setting mechanisms characterized by UNS do not provide a valid description of the whole economy, it might be the case that the fraction of prices that change every period varies little over time. In this situation, macroeconomic models based on the UNS hypothesis may lead to results that do not differ much from the ones obtained using state-dependent price setting schemes.

This idea is explored by Klenow and Kryvtsov (2005). These authors have devised a statistic which can be interpreted as a measure of the degree of UNS, and compared the results of a model using time-dependent price setting with the results of a state-dependent model calibrated to produce a value of their statistic similar to that found using the USA data. The results of Klenow and Kryvtsov (2005) suggest that the differences between the two models are negligible.

Although the line of research pioneered by Klenow and Kryvtsov (2005) is potentially very fruitful, the results depend critically on the way the importance of time-dependent price setting schemes is measured. In this paper, we argue that some caution is needed in the use of the statistic proposed by Klenow and Kryvtsov (2005) as a measure of the degree of UNS. Furthermore, we build on the work of Dias, Marques, Neves and Santos Silva (2005) to propose an alternative way to measure the significance of UNS.

It is important to realize that all the statistics considered here measure only the importance of price-setting rules implying UNS. Therefore, they provide no information

¹Uniform nonsynchronization is also termed uniform staggering (see, for instance, Fisher and Konieczny, 2000), uniform price staggering (see, Dias et al., 2005) or perfect staggering (see, for instance, Aucremanne and Dhyne, 2004).

on the importance of other forms of time-dependent price setting rules. On the other hand, it is also important to point out that, even if these statistics indicate that UNS provides a good description of the price setting rules in the economy, that does not mean that indeed time-dependent rules are used. What matters is that, whatever the way prices are set, their behaviour mimics what happens in an economy where UNS is important.

The remainder of this paper is organized as follows. The next section critically reviews the way Klenow and Kryvtsov (2005) measure the significance of time-dependent price setting mechanisms. In Section 3 we use the results in Dias et al. (2005) to obtain a measure of the importance of time-dependent price setting mechanisms implying UNS, and suggest an alternative approach to this problem. Section 4 describes the data available to us and provides the empirical results obtained with the different measures. Finally, Section 5 concludes.

2. MEASURING UNS: THE METHOD OF KLENOW AND KRYVTSOV

Klenow and Kryvtsov (2005) proposed a simple and ingenious method to measure the importance of time-dependent price setting mechanisms. Their method is based on a decomposition of the variance of inflation into two components. The first, depends on the variance of the average magnitude of price changes and reflects changes in the intensive margin. The second, depends on the variance of the fraction of items changing price and on the covariance between the magnitude of price changes and the fraction of items changing price. Essentially, this second term captures changes in the extensive margin.

Specifically, let π_t be the inflation rate in period t and denote by δ_t the average rate of price changes across all firms in period t , conditional on a price change having occurred. Furthermore, define $E(\delta_t) = \delta$ and $E(\theta_t) = \theta$. Klenow and Kryvtsov (2005) notice that $Var[\pi_t] = Var[\theta_t \delta_t]$ and therefore

$$\begin{aligned} Var[\pi_t] &= Var[\theta \delta_t + (\theta_t - \theta) \delta_t] \\ &= \theta^2 Var[\delta_t] + Var[(\theta_t - \theta) \delta_t] + 2Cov[\theta \delta_t, (\theta_t - \theta) \delta_t]. \end{aligned}$$

Klenow and Kryvtsov (2005) define $\theta^2 Var [\delta_t]$ as the time-dependent component of the inflation variance because that would be the value of $Var [\pi_t]$ for $\theta_t = \theta$. Given this split of the variance of inflation, Klenow and Kryvtsov (2005) use the ratio between the time-dependent component of the inflation variance and the total variance of π_t , that is,

$$\alpha_{KK} = \frac{\theta^2 Var [\delta_t]}{Var [\pi_t]}, \quad (1)$$

as a measure of the importance of time-dependent price setting schemes. In practice, an estimator of α_{KK} , say $\widehat{\alpha_{KK}}$, can be obtained by replacing in (1) θ , $Var [\delta_t]$ and $Var [\pi_t]$ by the respective sample counterparts.

At this point, it is important to carefully consider the meaning of α_{KK} . Klenow and Kryvtsov (2005, p.11) state that $\theta^2 Var [\delta_t]$ captures changes in the intensive margin, which account for all of the variation in inflation in staggered time-dependent models. However, it is important to notice that the type staggering that implies $Var [\pi_t] = \theta^2 Var [\delta_t]$ is UNS, for which $\theta_t = \theta, \forall t$.

The authors go on to claim that the other two terms involve changes in the extensive margin, which only contribute in state-dependent models. However, time-dependent models *à la* Calvo (1983) also imply changes in the extensive margin because in these models θ_t varies randomly around θ . Therefore, these two other terms capture not only the importance of state-dependent rules, but also the contribution for the variance of the inflation from time-dependent rules that do not imply UNS.

Therefore, at best, α_{KK} is a measure of the importance (for the variance of the inflation) of time-dependent price setting rules that imply UNS, rather than a measure of the importance of time-dependent rules *tout court*. This view is in a way confirmed by Klenow and Kryvtsov (2005, pp. 11-12), who explicitly use this term in their variance decomposition to draw conclusions about the importance of fluctuation in θ_t , that is, about the degree of UNS. However, the interpretation of α_{KK} as a measure of the degree of UNS is marred by some difficulties, which we now enumerate.²

²By definition, the so-called time-dependent term in the variance decomposition of inflation measures the contribution of the variation in the average size of price changes (changes in the intensive margin) to the variance of inflation. Our criticism of α_{KK} only applies to its use as a measure of the importance

1. Perhaps the more obvious flaw of α_{KK} is that it is not constrained to be in the $[0; 1]$ interval. Indeed, if $Var[(\theta_t - \theta)\delta_t] + 2Cov[\theta\delta_t, (\theta_t - \theta)\delta_t] < 0$, then $\alpha_{KK} > 1$. In particular, $\alpha_{KK} = \infty$ for $Var[\pi_t] = 0$. Consequently, α_{KK} cannot be seen as a proportion.
2. A related problem is that values of α_{KK} close to 1 do not necessarily imply a high degree of UNS. Indeed, for $Var[\delta_t] > 0$, UNS implies $\alpha_{KK} = 1$ but the converse is not true. Indeed, all that is required for α_{KK} to be equal to 1 is that $Var[(\theta_t - \theta)\delta_t] + 2Cov[\theta\delta_t, (\theta_t - \theta)\delta_t] = 0$.
3. The value of α_{KK} depends on the mean of δ_t , which has little to do with the importance of UNS. In particular, if δ_t is shifted by a constant, say λ , the numerator of α_{KK} will remain constant, whereas the denominator becomes $Var[\theta_t\delta_t + \lambda\theta_t]$, which in general is different from $Var[\theta_t\delta_t]$.
4. Finally, α_{KK} also depends on the variance of δ_t . Specifically, α_{KK} tends to 0 when $Var[\delta_t]$ passes to 0. In the limit, for constant δ_t , α_{KK} will be zero, whether or not UNS is important (as long as $Var[\theta_t] > 0$). On the other hand, a pure state-dependent economy, where the degree of UNS is zero, will not be characterized by a value of α_{KK} equal to zero (unless δ_t is constant).

These facts make clear that, by itself, the estimated value of α_{KK} may have little to do with the importance of UNS in the economy. In the particular application considered by Klenow and Kryvtsov (2005), these pitfalls of α_{KK} are somewhat mitigated by the fact that the covariance term is generally small. Nevertheless, the authors report some values for their statistic which are higher than one, highlighting the difficulties with its interpretation.³ In other applications, there is no guarantee that the covariance term will be negligible and therefore the use of α_{KK} requires some caution.

The source of the problems with α_{KK} can be traced back to the fact that a ratio measuring the importance for the variance of inflation of changes in the intensive margin of the degree of UNS, and not to its use as a measure of the importance of changes in the intensive margin to the variance of inflation.

³Below, we provide an example in which $\widehat{\alpha_{KK}} = 1.30$.

is being interpreted as a measure of the importance of UNS. This makes α_{KK} dependent on characteristics of the economy (e.g., $Var[\delta_t]$) which are only indirectly related to the topic of interest, viz., the fluctuations in the fraction of items changing price. Given these limitations of α_{KK} as a measure of UNS, it is interesting to study alternative forms of gauging the importance of this type of price setting rules.

3. MEASURING UNS: OTHER METHODS

Rather than measuring the importance of UNS by its contribution to the variance of the inflation, here we follow Dias et al. (2005) and evaluate the importance of UNS by the proportion of prices in the economy that are set using time-dependent rules that imply UNS. Of course, these new statistics will not allow us to measure the contribution of UNS for the variance of inflation, but they have the advantage of depending only on the variability of θ_t .

As in Dias et al. (2005), suppose that the economy is characterized by a mixture of two types of firms. Firms of type 1 are characterized by UNS, with a fixed proportion of firms adjusting their prices every period (as in Taylor, 1980, p. 4). Let α denote the proportion of firms of type 1 in the economy and define θ_1 as the fraction of this type of firms that adjust their prices in a given period. For type 2 firms, UNS does not hold and therefore the share of these firms that adjusts their prices in period t varies. Let s_t denote the proportion of type 2 firms that change prices in period t . Under these circumstances, θ_t , the fraction of prices that change in period t for the whole economy is given by⁴

$$\theta_t = \alpha\theta_1 + (1 - \alpha) s_t. \quad (2)$$

This model for θ_t nests two polar cases. For $\alpha = 1$, the economy is characterised by UNS. On the other hand, for $\alpha = 0$, no price is set by time-dependent rules implying UNS. We take the value of α as a measure of the importance of price setting rules implying UNS and, in what follows, we discuss how to obtain information on this parameter.

⁴To provide a link with the results of Klenow and Kryvstov (2005), it is interesting to notice that if (2) is substituted into $Var[\pi_t]$, $\alpha = 1$ implies $\alpha_{KK} = 1$ for $Var[\delta_t] > 0$.



3.1 The FK index

Dias et al. (2005) have studied the case in which firms of type 2 have perfect price synchronization as defined by Fisher and Konieczny (2000).⁵ In this case, s_t is a Bernoulli random variable with $E(s_t) = \theta_2$, say. If, for simplicity, we assume that $\theta_1 = \theta_2 = \theta$, we have $E(\theta_t) = \theta$ and $Var[\theta_t] = \theta(1 - \theta)(1 - \alpha)^2$. Dias et al. (2005) show that under these assumptions the proportion of firms with perfect price synchronization can be estimated by the Fisher and Konieczny (2000) synchronization index defined as

$$FK = \sqrt{\frac{Var[\hat{\theta}_t]}{\bar{\theta}(1 - \bar{\theta})}},$$

with $\bar{\theta}$ and $Var[\hat{\theta}_t]$ denoting respectively the sample mean and the sample variance of $\hat{\theta}_t$ (see Dias et al., 2005). Consequently, in this economy, the proportion of firms whose price setting behaviour is characterized by UNS can be estimated by $\widehat{\alpha}_{FK} = 1 - FK$.

Clearly, $\widehat{\alpha}_{FK}$ has some important advantages over $\widehat{\alpha}_{KK}$ as a way of measuring the importance of time-dependent price setting mechanisms with UNS. Indeed, besides having a clear interpretation, it is restricted to the $[0; 1]$ interval. Moreover, unlike $\widehat{\alpha}_{KK}$, $\widehat{\alpha}_{FK}$ does not depend on the properties of δ_t , the average rate of price changes in period t , conditional on a price change having occurred.

Despite these attractive features, $\widehat{\alpha}_{FK}$ also has some drawbacks which are related to the fact that it is based on a statistics whose purpose is to measure the degree of perfect price synchronization rather than the degree of UNS. Indeed, if type 2 firms are not perfectly synchronized, s_t is a random variable with domain $[0, 1]$ rather than a Bernoulli variable with support in $\{0, 1\}$. In this case $\widehat{\alpha}_{FK}$ will be biased upwards because $Var[\theta_t]$ will be smaller than $\theta(1 - \theta)(1 - \alpha)^2$. Since this is generally the case, $\widehat{\alpha}_{FK}$ should be viewed as an upper bound on the proportion of firms of type 1, rather than as an estimator of this parameter. A related drawback is that, conditional on $Var[\theta_t]$, $\widehat{\alpha}_{FK}$ is a function of θ , whereas in the model α is independent of θ .

⁵That is, for firms of type 2, in a given period either no firm changes its price, or all firms do it.

3.2 A nonparametric upper bound

More appropriate estimators of α can be obtained if a more realistic hypothesis is made about the behaviour of type 2 firms. In particular, if the researcher is willing to assume a different distribution for s_t , α can be easily estimated. Identification of α , however, comes at a cost because the results are likely to be sensitive to the particular choice of distribution. Nevertheless, it is possible to obtain useful information on the degree of UNS without any further information on the distribution of s_t . Indeed, we now show that it is possible to establish a nonparametric upper bound for α which, besides requiring only very mild assumptions, provides an alternative and interesting way of measuring the degree of UNS.

If, in (2), s_t were indeed a Bernoulli variable, θ_t would only assume two values: $\alpha\theta_1$ and $\alpha\theta_1 + (1 - \alpha)$. In this case, α could be obtained directly from the difference between the two values assumed by θ_t . However, whatever the distribution of s_t , it must be the case that $0 \leq s_t \leq 1$. Consequently, θ_t can never be above $\alpha\theta_1 + (1 - \alpha)$ or below $\alpha\theta_1$, which implies that the range of θ_t must be smaller than the difference between these two limits. That is,

$$\begin{aligned}\max \{\theta_t\} - \min \{\theta_t\} &\leq \alpha\theta_1 + (1 - \alpha) - \alpha\theta_1 = (1 - \alpha) \\ 1 - \max \{\theta_t\} + \min \{\theta_t\} &\geq \alpha.\end{aligned}$$

This inequality leads to the following upper bound for α

$$\alpha_U = 1 - \max \{\theta_t\} + \min \{\theta_t\},$$

which can be estimated by its sample counterpart $\widehat{\alpha}_U = 1 - \max \{\hat{\theta}_t\} + \min \{\hat{\theta}_t\}$. Notice that this upper bound does not depend on the proportion of type 1 firms changing prices each period and, therefore, the assumption that $\theta_1 = \theta_2$ is not needed.

Although α_U is just an upper bound for the proportion of firms adopting time-dependent price setting methods, it has several interesting properties. Indeed, it is very simple to compute, it is restricted to the $[0; 1]$ interval and has a very clear interpretation. Moreover, it has the advantage of being based on very mild assumptions. Since

$\widehat{\alpha}_{FK}$ also provides an upper bound for α , it will be interesting to see, in practice, which of the methods provides a tighter bound and how they compare to $\widehat{\alpha}_{KK}$.

4 EMPIRICAL RESULTS

4.1 The data

In this section we use three micro datasets on consumer and producer prices, all collected by the Portuguese *Instituto Nacional de Estatística* (INE), to compare and evaluate the different measures of UNS discussed before. Two of these datasets were designed to produce the aggregate Consumer Price Index for Portugal and cover the periods from January 1993 to December 1997 and from January 1998 to December 2000. Hereafter, these two datasets will be referred to as CPI1 and CPI2, respectively. The third dataset has information on producer prices at the firm and product level, containing the raw data underlying the Portuguese Production Price Index. This dataset covers the period from January 1996 to December 2000 on a monthly basis and hereafter it will be referred to as the IPPI dataset.

The CPI1 and CPI2, datasets contain information on prices at the outlet and product level, covering outlets nationwide. The basic observation is that of a price of an item in a particular outlet at a given point in time. This item is followed over time within the same store. In both cases the sampling frequency is product-dependent, being either yearly, quarterly or monthly.⁶ We excluded items observed on a yearly basis because this information is too poor for our purposes. Furthermore, in order to use data on all remaining items, we have opted for transforming monthly data into quarterly data. This was done by randomly selecting one month (first, second or third) in the quarter for each monthly observed item and discarding the other two records for the entire observation period. Products for which price trajectories are incomplete were discarded from CPI1 or CPI2 for estimation purposes.

⁶In CPI1 yearly, quarterly and monthly observations represent 1%, 51% and 48% of the consumer bundle while in CPI2 these proportions are, respectively, 4%, 58% and 38%.

It is worth mentioning that CPI1 and CPI2 share a similar longitudinal structure, but are collected using different criteria. The composition of the datasets at the product level is determined using information on family expenditure patterns from the Portuguese Family Income and Expenditure Surveys. Two different surveys underlie CPI1 and CPI2, thus introducing differences in composition between CPI1 and CPI2.

The IPPI dataset reports prices in industry for different sectors but in this study we focus on the Manufacturing industry. As for the CPI datasets, each observation corresponds to the price of an item in a firm at a given moment in time. The price collected by INE is defined as the list price of industrial goods traded within the domestic market. Any discounts or subsidies are not deducted and taxes are not added. The relevant price is the one in force at the 15th of each month. The sample covers firms that produce in part or totally for the domestic market. As with the CPI datasets, incomplete price trajectories were discarded for estimation purposes.

4.2 Results

In order to obtain a rough estimate of the ability of models that imply UNS to describe the price setting behaviour in the Portuguese economy, the three indicators presented above were computed for the different datasets we have available. The results are presented in Tables 1 and 2.⁷

The results in Table 1 highlight the difficulties in interpreting $\widehat{\alpha_{KK}}$. As mentioned above, this estimator is not constrained to be in the $[0; 1]$ interval, and therefore it is hard to give a meaningful interpretation to the results obtained with it⁸. In particular, despite being close to one in most cases, we cannot conclude that the time-dependent

⁷Notice that in all empirical results presented in this paper $\hat{\theta}_t$ is computed as a weighted average of the frequency of price changes in each product. The weights used are based on the Consumer Expenditure Survey in the case of CPI and on the value of production in the case of IPPI. In the case of CPI, the weights are defined at the product×region level while in the case of IPPI the weights are defined at the NACE 3 digits level.

⁸Notice, for instance, that for the "non-food" sector in case of CPI2, $\widehat{\alpha_{kK}}$ is equal to 1.30

term dominates the inflation variance. Moreover, as argued in section 2, it is also not possible to draw any conclusion on the importance of UNS from the value $\widehat{\alpha_{KK}}$.

Table 1 - CPI results

	CPI1: 1993 - 1997			CPI2: 1998 - 2000				
	# of Obs.	$\widehat{\alpha_{KK}}$	$\widehat{\alpha_{FK}}$	$\widehat{\alpha_U}$	# of Obs.	$\widehat{\alpha_{KK}}$	$\widehat{\alpha_{FK}}$	$\widehat{\alpha_U}$
All goods	686520	0.74	0.90	0.78	570636	0.69	0.88	0.78
Food	309480	0.94	0.94	0.83	290076	1.02	0.92	0.85
Non-food	285960	0.62	0.86	0.70	201096	1.30	0.85	0.75
Services	91080	0.42	0.81	0.62	79464	0.62	0.80	0.68

Table 2 - IPPI results: 1996 - 2000

	# of Obs.	$\widehat{\alpha_{KK}}$	$\widehat{\alpha_{FK}}$	$\widehat{\alpha_U}$
All goods	478740	0.92	0.89	0.79
Intermediate	229080	0.74	0.84	0.72
Consumer	249180	0.95	0.89	0.80
Energy	480	0.84	0.57	0.13

The estimator for the upper-bound of the proportion of firms characterized by UNS based on the FK index suggests that UNS can be adequate to describe a large proportion of price-setting decisions, both for CPI1 and CPI2. However, comparisons between the values of $\widehat{\alpha_{FK}}$ for CPI1 and CPI2 are not very informative because, as noted above, α_{FK} is sensitive to the value of $\bar{\theta}$ and the average of $\hat{\theta}_t$ is not equal in the two datasets.

The first point to notice about the results obtained using α_U is that $\widehat{\alpha_U}$ is always smaller than $\widehat{\alpha_{FK}}$. Since both statistics are upper-bounds for the percentage of firms characterized by UNS, we conclude that in this example the bound provided by α_U is tighter than the one provided by $\widehat{\alpha_{FK}}$. The values of $\widehat{\alpha_U}$ provide further evidence suggesting that UNS may indeed be able to describe a large proportion of price-setting decisions in the Portuguese economy.

Turning now to the results in Table 2, we find that, again, $\widehat{\alpha_U}$ is always smaller than $\widehat{\alpha_{FK}}$. This difference is particularly noticeable for the case of Energy where the estimated

upper-bound for the fraction of firms following UNS is only 0.13.⁹ Despite the noticeable differences across the various sectors, these results also suggest that an important part of the price-setting decisions are compatible with UNS. Moreover, it is worth noticing that the overall results for $\widehat{\alpha}_{FK}$ and $\widehat{\alpha}_U$ are remarkably close in all data sets, whereas $\widehat{\alpha}_{KK}$ has some important fluctuations.

In short, we conclude that although there is evidence to suggest that time-dependent price setting schemes implying UNS may be quite important, the strength of this evidence very much depends on the measure of UNS that is used. These conclusions are not specific of the Portuguese economy. Using the data for the U.S. that was studied by Klenow and Kryvtsov (2005), the results of the three measures of UNS are as follows: $\widehat{\alpha}_{KK} = 0.96$, $\widehat{\alpha}_{FK} = 0.94$ and $\widehat{\alpha}_U = 0.80$.

The findings in this section suggest that UNS may adequately describe a large proportion of price setting decisions. However, using the test suggested by Dias et al. (2005), the hypothesis that uniform nonsynchronization provides an adequate description of price setting behaviour in the whole economy was clearly rejected (p-values smaller than 0.000) for all the 12 cases considered. Again, a similar result is found using the CPI data for the U.S. studied by Klenow and Kryvtsov (2005).

5. CONCLUDING REMARKS

For different reasons, the use of $\widehat{\alpha}_{KK}$ and $\widehat{\alpha}_{FK}$ to gauge the importance of UNS can be very misleading. Therefore, $\widehat{\alpha}_U$, the new measure of UNS proposed in Section 3, can be an interesting additional tool as it has a clear interpretation and is very easy to compute. Unlike $\widehat{\alpha}_{KK}$, $\widehat{\alpha}_U$ does not measure the contribution of time-dependent price setting rules characterized by UNS for the variance of inflation, but rather provides an upper bound for the proportion of prices that are set using rules leading to UNS. In the examples in section 4, $\widehat{\alpha}_U$ provides an upper bound for this proportion which is much tighter than the one given by $\widehat{\alpha}_{FK}$.

⁹During the period under analysis the prices of energetic goods in the producer were not subject to any form of regulation, being derived mainly by oil prices and exchange rate fluctuations.

In view of these results, it would be interesting to see how sensitive to the choice of UNS measure is the conclusion that models based on time-dependent price setting mechanisms and appropriately calibrated state-dependent models, lead to similar conclusions. This task is, however, beyond the scope of the present work.

REFERENCES

- Aucremanne, L. and Dhyne, E., (2004), “How frequently do prices change? Evidence based on the micro data underlying the Belgian CPI”, European Central Bank, Working Paper N. 331.
- Calvo, G.A. (1983), “Staggered Prices in a Utility-Maximizing Framework,” *Journal of Monetary Economics*, 12, 383-398.
- Cecchetti, S.G. (1985), “Staggered Contracts and the Frequency of Price Adjustment,” *The Quarterly Journal of Economics*, 100, 935-959.
- Dias, D., Marques, C.R., Neves, P.D. and Santos Silva, J.M.C. (2005), “On the Fisher-Konieczny Index of Price Changes Synchronization,” *Economics Letters*, 87, 279-283.
- Fisher, T. and Konieczny, J. (2000), “Synchronization of Price Changes by Multiproduct Firms: Evidence from Canadian Newspaper Prices,” *Economics Letters*, 68, 271-277.
- Klenow, P. and Kryvtsov, O. (2005), “State-Dependent or Time-Dependent Pricing: Does It Matter for Recent U.S. Inflation?,” Bank of Canada Working Paper 05-4.
- Taylor, J.B. (1980), “Aggregate Dynamics and Staggered Contracts,” *Journal of Political Economy*, 8, 1-23.

European Central Bank Working Paper Series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (<http://www.ecb.int>)

- 570 "Household debt sustainability: what explains household non-performing loans? An empirical analysis" by L. Rinaldi and A. Sanchis-Arellano, January 2006.
- 571 "Are emerging market currency crises predictable? A test" by T. A. Peltonen, January 2006.
- 572 "Information, habits, and consumption behavior: evidence from micro data" by M. Kuismanen and L. Pistaferri, January 2006.
- 573 "Credit chains and the propagation of financial distress" by F. Boissay, January 2006.
- 574 "Inflation convergence and divergence within the European Monetary Union" by F. Buseti, L. Forni, A. Harvey and F. Venditti, January 2006.
- 575 "Growth in euro area labour quality" by G. Schwerdt and J. Turunen, January 2006.
- 576 "Debt stabilizing fiscal rules" by P. Michel, L. von Thadden and J.-P. Vidal, January 2006.
- 577 "Distortionary taxation, debt, and the price level" by A. Schabert and L. von Thadden, January 2006.
- 578 "Forecasting ECB monetary policy: accuracy is (still) a matter of geography" by H. Berger, M. Ehrmann and M. Fratzscher, January 2006.
- 579 "A disaggregated framework for the analysis of structural developments in public finances" by J. Kremer, C. Rodrigues Braz, T. Brosens, G. Langenus, S. Momigliano and M. Spolander, January 2006.
- 580 "Bank interest rate pass-through in the euro area: a cross country comparison" by C. K. Sørensen and T. Werner, January 2006.
- 581 "Public sector efficiency for new EU Member States and emerging markets" by A. Afonso, L. Schuknecht and V. Tanzi, January 2006.
- 582 "What accounts for the changes in U.S. fiscal policy transmission?" by F. O. Bilbiie, A. Meier and G. J. Müller, January 2006.
- 583 "Back to square one: identification issues in DSGE models" by F. Canova and L. Sala, January 2006.
- 584 "A new theory of forecasting" by S. Manganelli, January 2006.
- 585 "Are specific skills an obstacle to labor market adjustment? Theory and an application to the EU enlargement" by A. Lamo, J. Messina and E. Wasmer, February 2006.
- 586 "A method to generate structural impulse-responses for measuring the effects of shocks in structural macro models" by A. Beyer and R. E. A. Farmer, February 2006.
- 587 "Determinants of business cycle synchronisation across euro area countries" by U. Böwer and C. Guillemineau, February 2006.

- 588 “Rational inattention, inflation developments and perceptions after the euro cash changeover” by M. Ehrmann, February 2006.
- 589 “Forecasting economic aggregates by disaggregates” by D. F. Hendry and K. Hubrich, February 2006.
- 590 “The pecking order of cross-border investment” by C. Daude and M. Fratzscher, February 2006.
- 591 “Cointegration in panel data with breaks and cross-section dependence” by A. Banerjee and J. L. Carrion-i-Silvestre, February 2006.
- 592 “Non-linear dynamics in the euro area demand for M1” by A. Calza and A. Zaghini, February 2006.
- 593 “Robustifying learnability” by R. J. Tetlow and P. von zur Muehlen, February 2006.
- 594 “The euro’s trade effects” by R. Baldwin, comments by J. A. Frankel and J. Melitz, March 2006.
- 595 “Trends and cycles in the euro area: how much heterogeneity and should we worry about it?” by D. Giannone and L. Reichlin, comments by B. E. Sørensen and M. McCarthy, March 2006.
- 596 “The effects of EMU on structural reforms in labour and product markets” by R. Duval and J. Elmeskov, comments by S. Nickell and J. F. Jimeno, March 2006.
- 597 “Price setting and inflation persistence: did EMU matter?” by I. Angeloni, L. Aucremanne, M. Ciccarelli, comments by W. T. Dickens and T. Yates, March 2006.
- 598 “The impact of the euro on financial markets” by L. Cappiello, P. Hördahl, A. Kadareja and S. Manganelli, comments by X. Vives and B. Gerard, March 2006.
- 599 “What effects is EMU having on the euro area and its Member Countries? An overview” by F. P. Mongelli and J. L. Vega, March 2006.
- 600 “A speed limit monetary policy rule for the euro area” by L. Stracca, April 2006.
- 601 “Excess burden and the cost of inefficiency in public services provision” by A. Afonso and V. Gaspar, April 2006.
- 602 “Job flow dynamics and firing restrictions: evidence from Europe” by J. Messina and G. Vallanti, April 2006.
- 603 “Estimating multi-country VAR models” by F. Canova and M. Ciccarelli, April 2006.
- 604 “A dynamic model of settlement” by T. Koepl, C. Monnet and T. Temzelides, April 2006.
- 605 “(Un)Predictability and macroeconomic stability” by A. D’Agostino, D. Giannone and P. Surico, April 2006.
- 606 “Measuring the importance of the uniform nonsynchronization hypothesis” by D. A. Dias, C. Robalo Marques and J. M. C. Santos Silva, April 2006.

ISSN 1561081-0



9 771561 081005