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Measuring the importance of the uniform nonsynchronization hypothesis*

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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

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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

[1] Uniform 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,

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

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]

[2] By 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 $Var\left[\left(\theta_t-\theta\right)\delta_t\right]+2Cov\left[\theta\delta_t,\left(\theta_t-\theta\right)\delta_t\right]<0$, then $\alpha_{KK}>1$. In particular, $\alpha_{KK}=\infty$ for $Var\left[\pi_t\right]=0$. 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 $Var\left[\delta_t\right]>0$, 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 $Var\left[\left(\theta_t-\theta\right)\delta_t\right]+2Cov\left[\theta\delta_t,\left(\theta_t-\theta\right)\delta_t\right]=0$.

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 $Var\left[\theta_t\delta_t+\lambda\theta_t\right]$, which in general is different from $Var\left[\theta_t\delta_t\right]$

4. Finally, α_{KK} also depends on the variance of δ_t. Specifically, α_{KK} tends to 0 when $Var\left[\delta_t\right]$ passes to 0. In the limit, for constant δ_t, α_{KK} will be zero, whether or not UNS is important (as long as $Var\left[\theta_t\right]>0$). 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.

[3] Below, 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 by[4]

$$\theta_t = \alpha\theta_1 + (1-\alpha)\, s_t. \tag{2}$$

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.

[4] To 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.

[5] That 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 $\widehat{\alpha_U} = 1 - \max\left\{\hat{\theta}_t\right\} + \min\left\{\hat{\theta}_t\right\}$. 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.

[6]In 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 it[8]. In particular, despite being close to one in most cases, we cannot conclude that the time-dependent

[7] Notice 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.

[8] Notice, 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 $\widehat{\alpha_{FK}}$.

[9] During 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.

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