E C O N O M I C S B U L L E T I N

A note on measuring the importance of the uniform nonsynchronization hypothesis

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Abstract

In this note we reappraise the measure of the importance of time-dependent price setting rules suggested by Klenow and Kryvtsov (2005, "State-Dependent or Time-Dependent Pricing: Does It Matter for Recent U.S. Inflation?," Bank of Canada Working Paper 05-4). Furthermore, we propose an alternative way to gauge the significance of this type of price setting behavior, which can be interpreted as an upper bound for the proportion of price trajectories which are compatible with the uniform nonsynchronization hypothesis. 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 behavior.

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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 U.S. data. The results of Klenow and Kryvtsov (2005) suggest that the differences between the implications of 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) and, building on the work of Dias, Marques, Neves and Santos Silva (2005), we propose an alternative way to measure the significance of UNS.

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 an alternative measure of the importance of time-dependent price setting mechanisms implying UNS. 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 non-zero 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 non-zero price changes and the fraction of items changing price. Essentially, this second term captures changes in the extensive margin.

[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).

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, let θ_t be the fraction of prices that change in period t, and 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.

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 of staggering that implies $Var[\pi_t] = \theta^2 Var[\delta_t]$ is UNS, for which $\theta_t = \theta$, $\forall t$. Therefore, 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.[2] In particular, we note that:

1. α_{KK} 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 $\alpha_{KK} > 1$. Consequently, α_{KK} cannot be seen as a proportion.
2. 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 $Var[(\theta_t - \theta)\delta_t] + 2Cov[\theta\delta_t, (\theta_t - \theta)\delta_t] = 0$.

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

[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. So, the time-dependent term is important in accounting for fluctuations in inflation. Our criticism of α_{KK} only applies to its use as a measure of the importance 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.

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. 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 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: An alternative method

Rather than measuring the importance of UNS by its contribution to the variance of the inflation, we suggest evaluating the importance of UNS by the proportion of prices in the economy that are set using time-dependent rules that imply UNS. Of course, statistics constructed with this objective 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[3]

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

This model for θ_t nests two polar cases. For $\alpha = 1$, the economy is characterized 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.

If the researcher is willing to assume a distribution for s_t, α can be easily estimated.[4] 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. Notice that, whatever the distribution of s_t, it must be the case that $0 \leq s_t \leq 1$.

[3] 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 $Var[\delta_t] > 0$.

[4] For instance, Dias, Marques and Santos Silva (2006) show that if type 2 firms are perfectly synchronized and $E(s_t) = \theta_1$, then the estimate of α is given by 1 minus the Fisher and Konieczny (2000) synchronization index.

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 non-parametric upper bound for α

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

which can be estimated by its sample counterpart $\widehat{\alpha_U} = 1 - \max\left\{\hat{\theta}_t\right\} + \min\left\{\hat{\theta}_t\right\}$.

Although α_U is just an upper bound for the proportion of firms adopting time-dependent price setting methods that imply UNS, 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.

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 two 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. We excluded items observed on a yearly basis because this information is too poor for our purposes.[5] 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.

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

[5] In CPI1 and CPI2, these items represent, respectively, 1% and 4% of the consumer bundle.

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 behavior in the Portuguese economy, the two indicators presented above were computed for the different datasets we have available. The results are presented in Tables 1 and 2.[6]

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.[7] In particular, despite being close to one in most cases, we cannot conclude that the time-dependent term dominates the inflation variance.

To illustrate the difficulties in interpreting $\widehat{\alpha_{KK}}$, consider the results for the "Food" products in the CPI2 dataset. The value of $\widehat{\alpha_{KK}}$ is very close to one, suggesting that in this sector θ_t is essentially constant. However, $\widehat{\alpha_U}$ indicates that the variability of θ_t is such that at most 85 percent of the prices are set using models that imply UNS. A similar results is found using the CPI data for the U.S. that was studied by Klenow and Kryvtsov (2005), for which we obtained $\widehat{\alpha_{KK}} = 0.96$ and $\widehat{\alpha_U} = 0.80$. Therefore, although $\widehat{\alpha_{KK}}$ suggests that UNS adequately describes the price setting behavior of the vast majority of U.S. firms, this result is not corroborated by the value of $\widehat{\alpha_U}$.

TABLES 1 & 2 ABOUT HERE

The results for the "Energy" sub-sector in Table 2 also deserve some attention as, in this case, the difference between $\widehat{\alpha_{KK}}$ and $\widehat{\alpha_U}$ is particularly noticeable. During this period, the prices of energetic goods in the producer were not subject to any form of regulation, being frequently updated in reaction to fluctuations in oil prices and exchange rates. The high value of $\widehat{\alpha_{KK}}$ is clearly at odds with these facts, while the estimate of $\widehat{\alpha_U}$ seems more in line with the expected low degree of UNS.

It is also interesting to note that, despite the noticeable differences across the various sectors, the overall results for $\widehat{\alpha_U}$ are remarkably close in all datasets. This contrasts with $\widehat{\alpha_{KK}}$, which has some important fluctuations across datasets.

Finally, it is important to point out that, although $\widehat{\alpha_U}$ suggests that UNS may adequately describe a large proportion of price setting decisions, the hypothesis that uniform nonsynchronization provides an adequate description of price setting behavior in the whole economy is clearly rejected. Indeed, the test suggested by Dias et al. (2005) leads to 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).

[6] 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.

[7] Notice, for instance, that for the "non-food" goods in case of CPI2, $\widehat{\alpha_{KK}}$ is equal to 1.30.

5. Concluding remarks

We have found 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. Moreover, as argued in section 2, it is not possible to draw any conclusion on the importance of UNS from the value α_{KK}. Indeed, for different reasons, the use of α_{KK} to gauge the importance of UNS can be very misleading. Therefore, α_U, the new measure of UNS proposed in Section 3, can be an interesting additional tool because it has a clear interpretation and is very easy to compute.

It is important to realize that, like α_{KK}, α_U only measures the importance of price-setting rules implying UNS. Therefore, α_{KK} and α_U provide no information on the importance of other forms of time-dependent price setting rules. On the other hand, 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 behavior mimics what happens in an economy where UNS is important.

Naturally, 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 note.

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Table 1 - CPI results

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

Table 2 - IPPI results: 1996 - 2000

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