Referee report on Bent Nielsen: "On the explosive nature of hyper-inflation data".

This paper analyzes the Serbian/Yogoslav hyperinflation from 1991-1994, using the "Co-explosive" framework from Nielsen (2005b). The main finding is that money, prices, and exchange rates are explosive processes that obey certain co-explosive restrictions. Some of these restrictions are inconsistent with the standard Cagan hyperinflation model. However, by redefining the cost of holding money in a particular way, an alternative model appears that satisfy the explosiveness and co-explosiveness properties of the data.

The econometric framework in Nielsen (2005b) for analyzing explosive processes within a multivariate model is very interesting, as is the application of this framework in the present paper. I also find the redefinition of the cost of holding money in the Cagan model quite interesting.

I think the paper is publishable, but only after various changes. Here are some points that I encourage the author to look at:

1) Regarding Section 2.2 on the I(2) approach:

a) Note that most of the early papers on the Cagan model (including the Sargent papers) add an error term to the model (to reflect money demand shocks or velocity shocks), and *assume that this error term is a random walk.* Basically, this reduces the empirical content of the model from the outset, as noted by Taylor (1991), and implies non-cointegration between real balances and inflation. (This error term corresponds to ζ_t in (2.8)).

b) As noted in the paper, Taylor (1991) derived the cointegrating implication between $m_t - p_t$ and $\Delta_1 p_t$, given that ζ_t is I(0). But note also that Engsted (1993) derived a similar cointegrating relationship in the Cagan model, namely that $m_t - p_t$ should cointegrate with $\Delta_1 m_t$, but only under the additional assumption that there are no rational bubbles in p_t. Taylor (1991) and Engsted (1993) found these cointegrating implications to be fulfilled in hyperinflation data, thus rejecting the random walk assumption for the error term made by Sargent and others, c.f. point a) above.

c) On page 5 some comments on Granger-causality are given. Note that if $\Delta_1 p^e_{t+1}$ in (2.8) is the *rational expectation* of future inflation, then statistically there should be Granger-causality from $m - p$ to $\Delta_1 p$ (and Granger-causality from $(m - p + \alpha\Delta_1 p)$ to $\Delta_1^2 p$, and from $(m - p + \alpha\Delta_1 m)$ to $\Delta_1^2 m$ if there are no bubbles). This is related to the exogeneity analysis in section 5.4.

2) Regarding Section 2.4 on the preliminary analysis: I don't understand what is done here. What exactly is $\widehat{u}_t$ in (2.11) ?

3) Regarding Section 3 on the VAR analysis:

a) The author goes straight to the 3-variable system (p_t, m_t, s_t). I would suggest to begin with the standard bi-variate systems (m_t, p_t) as in the standard Cagan model, and (m_t, s_t) as in Engsted (1996) and Petrovic and Mladenovic (2000), to be able to compare more directly with the existing studies. Then, after that, you can continue to the 3-variable system. One further advantage of also analyzing the bi-variate systems is that then you can directly compare the standard Cagan model with p_t, with the version using s_t. Figure 1 clearly shows that $m_t - p_t$ behaves strangely towards the end of the hyperinflation, which $m_t - s_t$ does not. Thus, using s_t will probably give "better" results than using p_t.

b) Three lags were chosen for the VAR. How was this lag-length selected?

c) It seems that a linear trend is included in the system, and that there is a linear trend in the cointegrating and co-explosive vectors, c.f. Table 5. What are the - statistical and economic - arguments for including a linear trend?

d) The explosive root of the system is estimated at 1.21. Can you put a standard error on this estimate? And test whether it is significantly larger than one?

e) Can you put standard errors (or $\sqrt{LR}$) on the parameter estimates in the co-explosive vector in Table 5?

f) I suppose that $\Delta_\rho X_{t-1}$ in the line just below the first equation in section 3.3 should be $\Delta_\rho X_t$ (?)

3) Regarding Section 4: I suppose that $-\alpha c_t^e$ in the third-to-last equation on page 14 should be $-\alpha c_{t+1}^e$ (?)

4) Regarding Section 5:

a) Just as in section 3, I would suggest to begin with analyzing the bi-variate systems ($m_t - p_t$, c_t) and ($m_t - s_t$, d_t) before going to the 3-variable system. Maybe you don't really need both c and d using your new definition of the cost of holding money.

b) Show a table, similar to Table 2, with the characteristic roots.

c) The largest unrestricted characteristic root is now 1.035. Is it insignificantly larger than 1 ?

d) It seems to me that $(d_t - c_t)$ is stationary, see Figure 2(c). So how does this variable appear in the cointegrating relation?

5) General comment: In the paper the explosiveness in the data is due to a *common* explosive trend in *all* the variables. However, it could be noted that an additional source of explosiveness in p_t (and s_t) is the presence of a rational price bubble. Such a bubble would generate an explosive root in p_t even without explosiveness in m_t, c.f. Diba and Grossman (1988a). Cointegration based methods can be used to discriminate between explosive bubbles and no bubbles in hyperinflation data (see Engsted, 2003), and to test for explosive bubbles in stock prices, see Diba and Grossman (1988b) and Engsted (2006), where the latter in fact uses the methodology from Nielsen (2005b).

References in this report to papers not listed in Nielsen's paper:

Diba, B. and H. Grossman (1988a): Rational inflationary bubbles. Journal of Monetary Economics 21, 35-46.

Diba, B. and H. Grossman (1988b): Explosive rational bubbles in stock prices. American Economic Review 78, 520-530.

Engsted, T. (1993): Cointegration and Cagan's model of hyperinflation under rational expectations. Journal of Money, Credit and Banking 25, 350-360.

Engsted, T. (2003): Misspecification versus bubbles in hyperinflation data: comment. Journal of International Money and Finance 22, 441-451.

Engsted, T. (2006): Explosive bubbles in the cointegrated VAR model. Finance Research Letters 3, 154-162.