Balance sheet recessions and time-varying coefficients in a Phillips curve relationship: An application to Finnish data*

Katarina Juselius and Mikael Juselius
University of Copenhagen and
the Bank for International Settlements

March 2, 2013

Abstract

Edmund Phelps (1994) introduced a modified Phillips curve where the natural rate of unemployment is a function of the real interest rate instead of a constant. Koo (2010) argues that the effect of the interest rate on the macro economy is likely to be diluted during a balance sheet recession such as the ones recently seen in many countries. In the late eighties, after having deregulated credit and capital movements, Finland experienced a housing boom which subsequently developed into a serious economic crisis similar to the recent ones. To learn from the Finnish experience we estimate the Phelps modified Phillips curve and use a Smooth Transition (STR) model to distinguish between ordinary periods and balance sheet recessions.

1 Introduction

The present financial crisis, triggered off in 2007 by a housing boom in the USA, quickly developed into a serious economic crisis and then into an even

*Very useful and detailed comments from two anonymous referees and Niels Haldrup are gratefully acknowledged. In Choi kindly provided us with his computer code for the Saikkonen-Choi estimator for which we are thankful. K. Juselius is grateful for generous financial support from the Institute of New Economic Thinking.

more devastating debt crisis. The very scope of the crisis has shaken the foundations of the world economy and started a debate about the realism of standard economic models as they were not able to foresee the problems ahead (see e.g. Colander et al. 2009). Therefore, it seems likely that these models lack features that otherwise could have warned us about the approaching disaster and possibly prevented it. Even more worrying, they may not be appropriate to provide us with the necessary policy guidelines for dealing with the still ongoing crises.

The over-arching question we raise in this paper is whether there are useful lessons to be learnt in this respect by studying the dynamics of a previous real estate bubble.

Japan in the mid-nineties is a well-known case of a real estate bubble that was followed by a long balance-sheet recession (Koo 2010). A less well-known case is Finland who also went through a similar crisis even a few years before the Japanese one. Deregulation of the Finnish credit market in 1986 resulted in a booming housing market and the build-up of a serious house price bubble. At the same time Finland was hit by a serious external shock when the former Soviet Union collapsed and thereby abolished the previous bilateral trade agreement with Finland. A severe banking crisis in Sweden, one of the main trading partners of Finland, contributed to the severeness of the post-bubble crisis. As Figure 1 shows house prices dropped by roughly 60% and unemployment rose from a record low of 2% to almost 20%. These are huge fluctuations which raise the question whether the scope for macroeconomic policy changed when Finland entered a balance sheet recession and if so, how?

In a recent book Koo (2010) argues that the interest rate is likely to become impotent as an instrument for monetary policy during a balance-sheet recession. This is because private firms and individuals, that have become insolvent due to collapsing real estate prices, are forced to spend any gains from lower interest rates on deleveraging rather than on investment and consumption. In such a situation, low interest rates are not likely to lead to a boom in economic activity and, hence, to inflationary pressure. Thus, when the economy moves into a balance-sheet recession, one would expect the relationship between interest rates and the unemployment rate to change.

The structural slumps theory of Phelps (1994) predicts that the natural rate of unemployment is a function of the real interest rate and, hence, provides a rationale for why the two should be related. However, in Phelps's

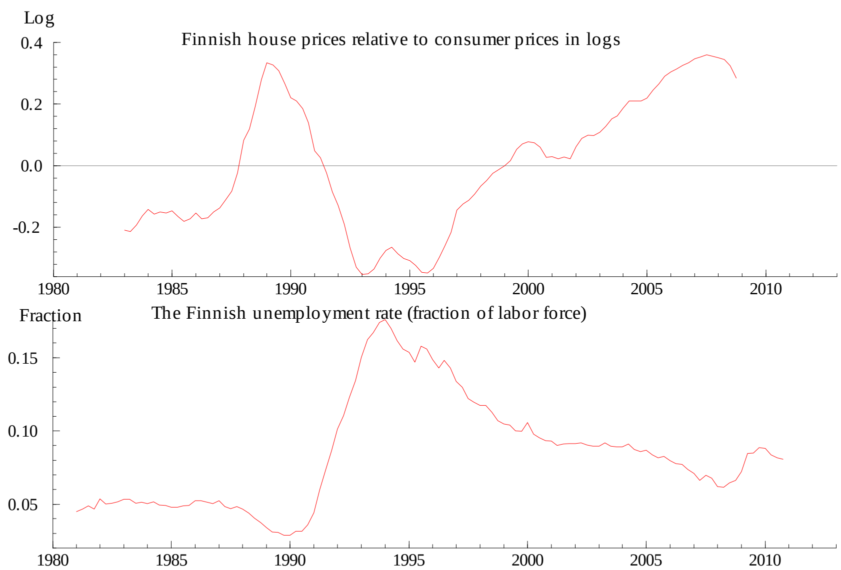

Figure 1: The development of real house prices and unemployment in Finland from 1983-2009.

1994 theory the natural rate is a function of a stationary real interest rate as a consequence of the rational expectations hypothesis. Econometrically this is difficult to reconcile with the empirical finding that real interest rates typically exhibit long persistent swings which are difficult to distinguish from a unit root process.

Based on the theory of Imperfect Knowledge Economics (IKE) Frydman and Goldberg (2007) show that such persistent swings in real interest rates are likely to be associated with financial market behavior.[1] Juselius (2013) argues that Imperfect Knowledge Economics combined with Phelps's Structural Slumps theory can give the rationale for why the nominal interest rate exhibits much more persistence than the inflation rate and, hence, why *ex post* real interest rates often move in a nonstationary manner.

The hypothesis that the Phillips curve has a unit root nonstationary natural rate is conveniently addressed in a Cointegrated VAR (CVAR) analysis

[1]The theory of IKE predicts that speculation tends to drive the nominal exchange rate away from long-term Purchasing Power Parity (PPP) values and that this causes a compensating movement in the real interest rate differential. Thus, according to IKE, the long swings of the real exchange rate are primarily due to speculation in foreign currency.

of inflation, unemployment and interest rates. But, as argued by Koo (2010) we should expect to see a change in these properties when the economy enters a balance sheet recession. To test this possibility we apply the Smooth Transition (STR) model suggested by Teräsvirta (1994) and others to study the cointegration properties of the Phillips curve for Finnish data and how they might have changed after the bubble burst in 1990:1.

2 The natural rate of unemployment and the Phillips curve

The Phillip's curve was historically established as an empirical regularity that seemed to work well in the fifties and the sixties. The relationship implies that inflation is negatively associated with unemployment. Friedman (1968) and Phelps (1968) further developed the Phillips curve by postulating that inflation is negatively related not just to unemployment as such, but to its deviation from a constant natural rate. However, in the seventies the previously negative relationship between inflation and unemployment broke down and inflation became positively related to unemployment; the so called stagflation period. This seemed to be caused by increasingly important inflationary expectations and the expectations' augmented Phillips curve became the new standard. But, starting from the eighties, inflation rate kept steadily declining whereas unemployment continued to exhibit long persistent swings. In particular many European countries experienced this kind of pattern which suggested that the Phillip's curve had again ceased to be empirically relevant.

The structural slumps theory, developed by Edmund Phelps in the early nineties, was an impressive attempt to address this problem. The aim was to explain how open economies connected by the world real interest rate (set in a global capital market) and the real exchange rate (determined in a global customers market for tradables) can be hit by long spells of unemployment. According to the structural slumps theory, fluctuations in the real interest rates and real exchange rates play an important role in explaining the persistent long swings in the observed unemployment rates. The theoretical implication for the Phillips curve was that the natural rate of unemployment became a function of the domestic real interest rate. However, real interest rates and real exchange rates were assumed stationary as Phelps's theory was based on model consistent rational expectations. This is in contrast to empirical evidence that often finds that they are indistinguishable from a unit root process. Frydman and Goldberg (2007) shows that financial behavior under imperfect knowledge can drive asset prices, such as nominal exchange rates and long-term bond rates, persistently away from long-run benchmark values. Juselius (2013) therefore argued that the structural slumps theory based on imperfect knowledge expectations would be a more adequate way to explain the long persistent movements in the data. The intuition behind the Phelps natural rate with a nonstationary real interest rate is broadly as follows.

Under Imperfect Knowledge, the nominal exchange rate is primarily determined by financial speculation whereas prices of tradable goods, being determined in very competitive customer markets, are not likely to be affected by speculation (energy, precious metals and, recently, grain may be exceptions in this respect). Hence, relative prices would fluctuate much less than nominal exchange rates and real exchange rates would inherit the persistent swings of nominal exchange rates.

Nominal interest rates are also likely to be affected by financial behavior, for example through international capital flows, and therefore likely to fluctuate much more that price inflation. Thus, the real interest rate will inherit the persistent long swings of the nominal interest rate. A shock to the long-term interest rate without a corresponding increase in the inflation rate, is likely to increase the amount of speculative capital moving into the economy. The exchange rate would appreciate, jeopardizing competitiveness in the tradable sector and the trade balance would worsen. The interest rate would start increasing as long as the real exchange rate keeps appreciating (a self reinforcing feed-back loop). In such a situation, we would expect structural imbalances in the economy to be growing and so would the uncertainty premium. This would continue until the premium has become large enough to cause a reversal in the exchange rate.

The tendency of the domestic real interest rate to increase and the real exchange rate to appreciate at the same time is likely to aggravate domestic competitiveness in the tradable sector. In this set-up, enterprises cannot in general count on exchange rates to restore competitiveness after a permanent shock to relative costs. To preserve market shares, they would have to adjust productivity or profits rather than increasing their product price and one would expect profits to be squeezed in periods of persistent appreciation and increased in periods of depreciation[2]. In a structural slumps economy with imperfect knowledge expectations one would expect customer market pricing (Phelps,1994) or alternatively pricing to market (Krugman 1993) to replace constant mark-up pricing.

A customer market firm, facing an increase in the domestic wage cost in excess of the foreign one, is likely to improve labor productivity rather than increase its product price. Labor productivity can be achieved by new technology or by producing the same output with less labor i.e. by laying off the least productive part of the labor force. In the latter case, the increase in productivity would be achieved at the cost of rising unemployment. Therefore, labor productivity and unemployment is expected to rise in periods of real currency appreciation and increasing real interest rates. Evidence of unemployment co-moving with trend-adjusted productivity and the real interest rate has been found, among others, in Juselius, K. (2006, Table 20.5).

Unemployment above or below a time-varying natural rate being a function of the real interest rate, r, generally affect nominal wage claims negatively and, hence, price inflation, Δp. In this set-up, the expectations augmented Phillips Curve becomes:

$$\Delta p = -b_1(u - u^n) + \Delta p^e \tag{1}$$

where $u^n = f(r)$ is the natural rate being a function of the real interest rate and Δp^e stands for expected inflation. How to adequately measure an unobserved expected inflation is not obvious. While model based rational expectations is a popular choice in the literature, such a choice can be empirically problematic as Castle et al. (2010) convincingly demonstrate. This is in line with Imperfect Knowledge Economics under which so called "rational expectations" are irrational (Frydman and Goldberg 2007, 2011). For this reason we have chosen to use the spread between the long and the short rate as a proxy for expected inflation.

The structural slumps theory in conjunction with Imperfect Knowledge Economics predicts that the unemployment rate and the real interest rate are co-moving both exhibiting similar persistent swings[3]. If the two are cointegrated, then the unemployment gap, $u-u^n$, is likely to be less persistent

[2] Evidence of a nonstationary profit share co-moving with the real exchange rate has for instance been found in Juselius (2006: Chapter 20, Table 20.5).

[3] Evidence of a non-stationary natural rate as a function of the long-term real interest rate has been found among others in Juselius (2006, Table 20.5) and Juselius and Ordonez (2009).

than unemployment rate itself. Thus, Δp and $(u - u^n)$ can be cointegrated even though Δp and u might seem unrelated. This can explain why it has been so difficult in recent decades to find empirical support for the Phillips curve.

While the structural slumps mechanism is likely to work well when the major driver underlying the fluctuations in aggregate activity is the long swings in real exchange rates, it is less likely to work well in the wake of a fundamental financial crises as the present one (Koo 2010). This is because when numerous balance sheets in the economy are in the negative, savings will primarily be used for financial consolidation rather than for investment and consumption. Not even a zero interest rate may have the intended effect in such a situation as the Japanese experience in the nineties showed. Hence, the Phillips curve with a Phelpsian natural rate may not be an adequate description of an inflation unemployment trade-off in a balance-sheet recession.

3 Empirical methodology[4]

The idea here is to test three different hypotheses about inflation and unemployment dynamics and compare the results.

H1. The same constant parameter CVAR model can approximately describe ordinary and crisis periods.

H2. The main effect of the crisis is a change in the equilibrium mean of the cointegration relations implying that the Finnish crisis which erupted in the early nineties caused the natural rate of unemployment to move to a higher level. It involves re-estimating the model with a step-dummy restricted to the cointegration relations.

H3. The relationship among interest rates, unemployment and inflation changes when the economy moves into a balance sheet recession. This will be tested with a two regime STR model for unemployment and inflation rate.

[4] All cointegration analyses have been done by CATS for RATS (Dennis et. al, 2006), the STR analyses partly by the nonlinear least squares regression module in GiveWin (Doornik and Hendry, 2001), partly by a program for calculating the Saikkonen and Choi estimator obtained by In Choi. The graphs have been performed in GiveWin.

3.1 Specification of CVAR model

We consider the following linear cointegrated VAR model (Johansen, 1995) for $x_t' = [\Delta p_t, u_t, rb_t, spr_t]$:

$$\Delta x_t = \alpha\beta' x_{t-1} + \alpha\beta_0 + \alpha\beta_{01} Ds_{90,t} + \Gamma_1 \Delta x_{t-1} + \phi_1 D_{p,90,t} + \phi_2 D_{p,94,t} + \Phi S_t + \varepsilon_t, \tag{2}$$

where

- $\varepsilon_t \sim Nid(0, \Omega)$
- Δp_t is inflation measured as $400(\Delta \log(CPI)_t)$, source OECD, economic outlook,
- u_t is unemployment measured as as a percentage of the number of unemployed in the workforce, source OECD, economic outlook,
- $rb_t = b_t - \Delta p_t$ is the real long-term bond rate measured as
  - b_t the annual 10 year long-term bond rate, source OECD, economic outlook,,
- $spr_t = b_t - s_t$ is the interest rate spread used as a proxy for inflation expectations by the market as well as the central bank, with
  - s_t the the 3 months short term interest rate, source OECD, economic outlook,
- $Ds_{90,t}$ is a step dummy defining the onset of the crisis measured as $Ds_{90,t} = 1$ from 1990:1-2010:4, 0 otherwise,
- $D_{p,90,t}$ and $D_{p94,t}$, are impulse dummies defined as 1 in 1990:1 and 1994:2, respectively, 0 otherwise, where
  - $D_{p,90,t}$ controls for the extraordinary shock in house prices at the onset of the crisis and
  - $D_{p94,t}$ controls for the referendum in 1994 when Finland voted in favor of joining the EU and subsequently the EMU,
- S_t is a vector of three seasonal dummies.

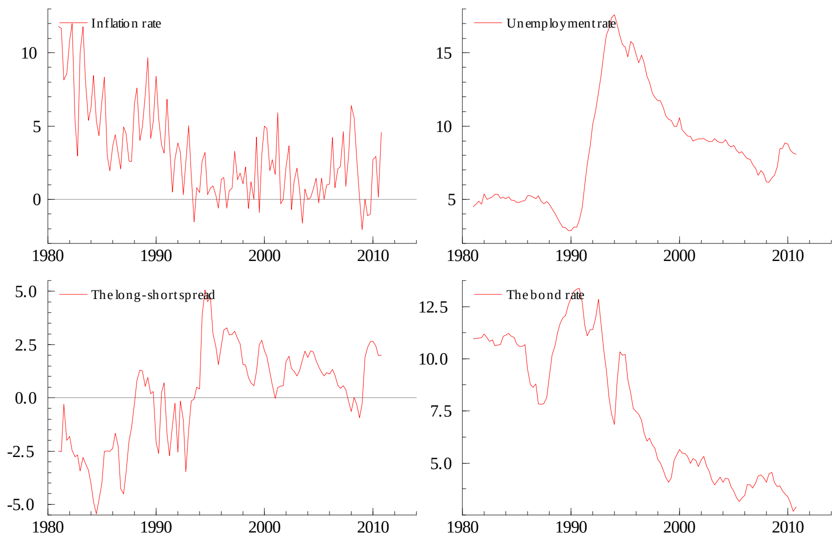

Figure 2: Panel (a) the annualized inflation rate, (b) the unemployment rate (c) the annual long-short interest rate spread and (d) the annual long-term bond rate. All variables are in %.

The end of the seventies, beginning of the eighties, represent a change in the world economy from more regulated to increasingly deregulated countries. This typically manifests itself as a structural change in the econometric models (see for example Juselius and Franchi 2007). The sample period, 1982:2-2010:4, was partly chosen to avoid mixing these different regimes, partly because of data availability.

Figure 2, panel (a) shows the general decline in inflation rate from a high 10% annual rate to roughly 2% at the end of the sample, albeit with some fluctuations under ways. Panel (b) shows unemployment rate rising from a record low of 2.9% in 1990:1 to the record high level of 17.6% only four years later. It illustrates the force with which the crisis struck the Finnish economy. After topping in 1994, unemployment started slowly to come down and reached a new stable level of 7 - 8 % which, albeit much lower than in the crisis years, was significantly higher than the pre-crisis level, i.e. the recovery was to some extent a jobless one. This change in the unemployment level is the main reason for including a step dummy at 1990:1. At the outbreak of the recent crisis in 2007, the Finnish unemployment started to rise again. But, since Finland had already made the necessary structural adjustments in the crisis years, she was fortunate to avoid the worst effects this time. Panel (c) shows that the long-short interest rate spread was systematically negative in the period up to the crisis and systematically positive after the crisis. This is likely to reflect standard policy behavior by the central bank policy, i.e. to increase its policy rate relative to the long-term rate when the fear of inflation is high in the bubble period and to lower the rate when the high unemployment rates in the crisis and post crisis period are the major concern. From Panel (d) it appears that the long-term bond rate dropped somewhat after the financial deregulation in 1986 but, as the economy became increasingly overheated, it started to increase again. When the real estate bubble burst and the crisis struck with unprecedented suddenness and force, the long-term interest rate started to decline and continued to do so until today's present low level.

3.2 Misspecification tests

With such dramatic changes in the data over the chosen sample period, it might seem overly optimistic to apply the standard linear VAR model to the data. However, the primary idea of the CVAR analysis is to obtain a first order linear approximation of what is considered to be an inherently nonlinear model. A preliminary analysis of the linear CVAR combined with misspecification tests may provide useful insights about the form of the nonlinearities, about the number of cointegration relations and their adjustment dynamics, etc. Such features are often difficult to specify on *a priori* grounds. In this vein, the subsequent misspecification tests are foremost interpreted as evidence of nonlinearities rather than as a signal for improving the linear specification.

We distinguish between two versions of the model: CVAR 1, defined by setting $Ds_{90,t} = 0$ and $D_{p,90,t} = 0$ in (2) and CVAR 2 which corresponds to the full specification. In terms of misspecification, Table 1 shows that CVAR 1 fails on multivariate residual autocorrelation. We do not, however, interpret this to mean that more lags should be added to the VAR but rather as evidence of non-modelled nonlinear effects in the model. A similar argument applies to the rejection of multivariate normality and no ARCH. Nevertheless, the signs of misspecification mean that standard distributional results do not hold and the reported significance tests are, therefore, only suggestive.

Table 1: Misspecification tests of the CVAR models for 1982:2-2010:4

	Multivariate specification tests of the full system			
	Autocorr. $\chi^2(16)$	Norm. $\chi^2(8)$	ARCH $\chi^2(100)$	Trace corr.
CVAR 1:	32.8[0.01]	25.9[0.00]	196.8[0.00]	0.47
CVAR 2:	18.1[0.32]	34.4[0.00]	]160.2[0.00]	0.48
	Specification tests of each equation in the system			
CVAR 1:	$\Delta\pi_t$	Δu_t	Δrb_t	Δspr_t
ARCH: $\chi^2(2)$	13.3[0.00]	15.6[0.00]	11.1[0.00]	17.8[0.00]
Skewness	0.28	0.22	-0.25	0.20
Kurtosis	3.37	3.22	3.48	5.07
CVAR 2:	$\Delta\pi_t$	Δu_t	Δrb_t	Δspr_t
ARCH: $\chi^2(2)$	9.0[0.02]	6.3[0.04]	4.9[0.09]	15.9[0.00]
Skewness	0.38	0.26	-0.34	-0.21
Exc.kurt.	3.30	4.10	3.45	5.41

Note: p-values in [ ].

Figure 2 showed that the level of unemployment rate was lower in the pre-crisis period suggesting that the mean of the natural rate in the Phillip's curve may have shifted to a higher level after the crisis erupted. CVAR 2 is specified to account for this possibility by allowing for an equilibrium mean shift in the cointegration relations starting from 1990:1. Table 1 shows that multivariate autocorrelation has improved with this change, but also that the multivariate test of no ARCH and normality are still rejected. Based on the univariate tests it appears that normality is primarily a problem because of excess kurtosis in the interest rate spread whereas ARCH is rejected in the interest rate spread and inflation rate equations.

3.3 Rank determination

Table 2 reports the eigenvalues, λ_i, and the Bartlett corrected trace tests with p-values in brackets. For CVAR 1, we expect unmodelled nonlinearities to produce additional persistence in the model which is likely to make the trace test less reliable. This may explain why three unit roots cannot be rejected with a p-value of 0.09, whereas two unit roots can be rejected with a p-value of 0.05. For the choice of $r = 1$ the largest unrestricted root is 0.72, whereas for $r = 2$ it is 0.79. Furthermore, the first two cointegration relations look

Table 2: Rank determination for CVAR 1 and CVAr 2

CVAR 1						**CVAR 2**			
$p-r$	r	λ_i	*Trace*	$Q_{.95}$		λ_i	*Trace*	$Q_{.95}$	
4	0	0.34	76.1 [0.00]	53.9		0.36	64.1 [0.00]	64.1	
3	1	0.12	32.6 [0.09]	35.1		0.27	43.3 [0.00]	43.3	
2	2	0.11	20.1 [0.05]	20.2		0.11	26.2 [0.18]	26.2	
1	3	0.07	9.1 [0.23]	9.2		0.09	12.7 [0.12]	12.7	
The four largest characteristic roots									
3	1	**1.0**	**1.0**	**1.0**	0.72	**1.0**	**1.0**	**1.0**	0.76
2	*2*	**1.0**	**1.0**	0.79	0.79	**1.0**	**1.0**	0.80	0.80
1	*3*	**1.0**	**0.97**	0.76	0.76	**1.0**	**0.92**	**0.92**	0.62
0	*4*	**0.98**	**0.98**	0.73	0.73	**0.94**	**0.94**	0.71	0.71

Note: p-values in [ ], roots >0.9 in bold face .

reasonably stationary as Figure 3 shows. The third cointegration relation, while not reported here, is clearly trending. For CVAR 2, the trace test suggests $r = 2$ (p-value 0.18). For this choice, the largest characteristic root is 0.80 and the the first two cointegration relations look convincingly stationary. Because the rank test has been shown to be quite robust to moderate ARCH (Rahbek et al. 2002) and excess kurtosis (Gonzalo 1994), we consider the determination of cointegration rank more reliable in CVAR 2. While admitting that the choice of rank is less clear in CVAR 1, to improve comparability we continue with $r = 2$ in both models.

4 Estimated cointegration relationships

Table 3 reports the cointegration results for both models where we have imposed one just-identifying restriction on each relation. In CVAR 1 the first relation has the properties of a Phillips curve with a Phelpsian natural rate:

$$\Delta p_t = -0.62(u_t - u_t^n) \quad (3)$$

where

$$u_t^n = 1.8(b_t - \Delta p_t) + 5.5. \quad (4)$$

Table 3: The estimated cointegration relations for the period 1982:2-2010:4

	Δp	u	$b - \Delta p$	$b - s$	μ_0	μ_{01}
CVAR 1						
β_1	**1.00**	**0.62** [6.92]	**−1.10** [−4.97]	−	**−3.41** [−2.79]	
α_1	**−0.40** [−5.09]	−0.03 [−1.45]	**0.43** [5.47]	**−0.10** [−2.46]		
β_2	−	**−0.70** [−4.36]	**0.82** [3.14]	**1.00**	1.88 [1.18]	
α_2	**−0.23** [−2.28]	0.01 [0.57]	**0.24** [2.45]	**−0.17** [−3.46]		
CVAR 2						
β_1	**1.00**	0.15 [1.53]	**−0.52** [−4.20]	**0.63** [3.92]	**−2.22** [−2.66]	−
α_1	**−0.54** [−6.16]	0.03 [1.36]	**0.57** [6.57]	**−0.03** [−0.72]		
β_2	−	**1.00**	**−2.37** [−6.14]	**2.87** [4.77]	**13.90** [4.70]	**−17.85** [−6.31]
α_2	**0.07** [2.36]	**−0.04** [−6.17]	**−0.07** [−2.43]	−0.02 [−1.08]		

Note: t-values in [ ], significant coefficients ($t \geq 2$) in bold face.

The inflation rate is equilibrium correcting indicating that unemployment in excess of $u_t^n = 1.8(b_t - \Delta p_t) + 5.5$ would lead to a downward pressure on inflation rate. The adjustment coefficient -0.40 corresponds roughly to a mean adjustment time of 1.5 quarters. Unemployment is not significantly correcting, but interest rates are reacting to deviations from the Phillips curve consistent with prior expectations. Figure 3 shows that the relation looks acceptable in terms of stationarity. The second relation describes that the short-term interest rate has been positively co-moving with the long-term bond rate and negatively with the unemployment rate. As the interest rate spread (rather than unemployment) is significantly equilibrium correcting to this relation, it is likely to capture features of a central bank reaction rule.

Thus, somewhat surprisingly, CVAR 1 provides fairly plausible estimates of a Phillips curve with the natural rate being a function of the real long-term interest rate. It has correctly signed coefficients toward which inflation rate is adjusting and elements of a central bank reaction rule. The graph of the deviations from (4) in Figure 3 does not seem to suggest fundamentally changing cointegration properties. The same can be said about the deviations from the second relation which, though quite persistent during the crisis

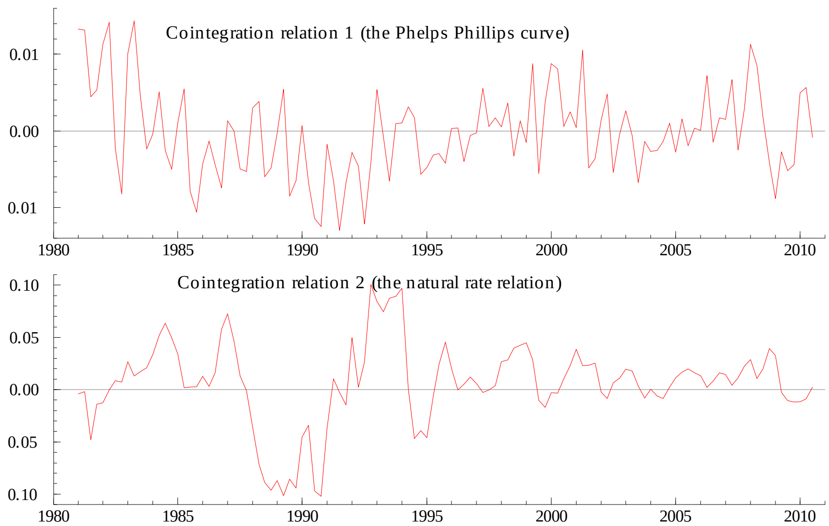

Figure 3: The two identified cointegration relations in CVAR 1.

period, still seem to be mean-reverting. To our surprise the CVAR 1 does not seem strikingly misspecified in terms of cointegration relations.

This visual check of cointegration properties needs to be complemented with a formal test of parameter constancy. The recursive test of parameter constancy of β in Figure 4 is discussed in Hansen and Johansen (1999). They are based on the hypothesis $\tilde{\beta} \subseteq sp(\beta_{t_1})$ where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 and β_{t_1} is recursively estimated starting from the baseline sample 1982:1-1986:1 which is then recursively extended by adding $t_1 = 1, 2, 3$ observations until the full sample is covered. The test statistic is divided by the 95% quantile so parameter constancy is rejected at the 5% level when the graph is above the unit line. The $X(t)$ graph corresponds to the CVAR 1 in (2), whereas the $R1(t)$ graph corresponds to the same model where the effects of the short-run dynamics ($\Gamma_1 \Delta x$) have been concentrated out. For more details, see Juselius (2006) and Dennis et al. (2007). The recursive tests reject constancy of β suggesting that the cointegration properties of the pre-crisis period are different from the ones in post-crisis period.

The CVAR 2 is specified with an equilibrium mean shift, μ_{01}, in the cointegration relations at the start of the crisis period. It was found to be strongly significant based on $\chi^2(2) = 24.03[0.00]$. The two cointegration relations are

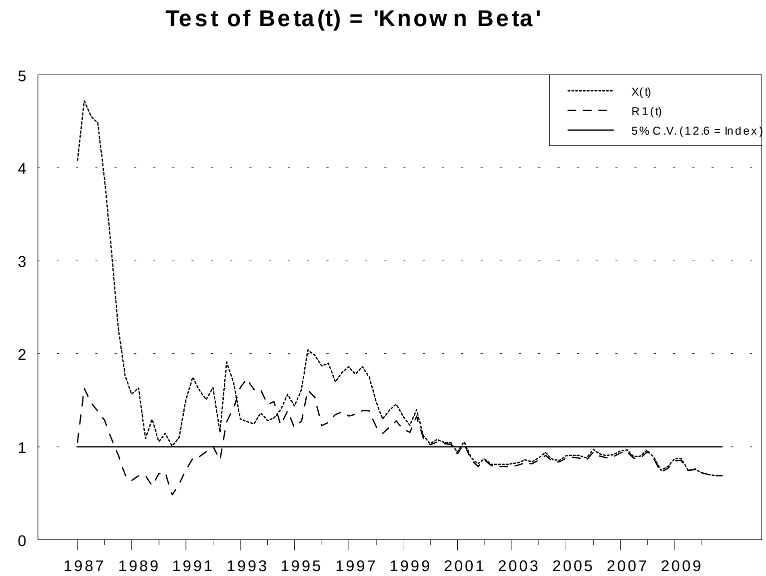

Figure 4: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ divided by its 95% quantile where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for Model 1.

identified by one just-identifying restriction each. Table 3 shows that the first relation has the property of a Phillips curve relation with the natural rate being a function of the real interest rate. However, the coefficient to the unemployment rate is now insignificant. Thus, allowing for an equilibrium mean shift seems to make the Phillips curve less visible in the data. Inflation is significantly equilibrium correcting consistent with a Phillips curve relationship. The graphs of the equilibrium errors in Figure 5 suggest that the mean shift has been able to remove most of the persistent movements which were visible in CVAR 1.

The second relation is essentially describing a natural rate relation between unemployment rate and the real long-term bond rate and the long-short interest rates spread. The fact that the coefficients to the bond rate and the spread are almost equal with opposite signs suggests, however, that it is the short-term interest rate rather than the long-term that have been important for the natural rate. The equilibrium mean exhibits a very significant shift to a higher unemployment level in 1990:1 consistent with the

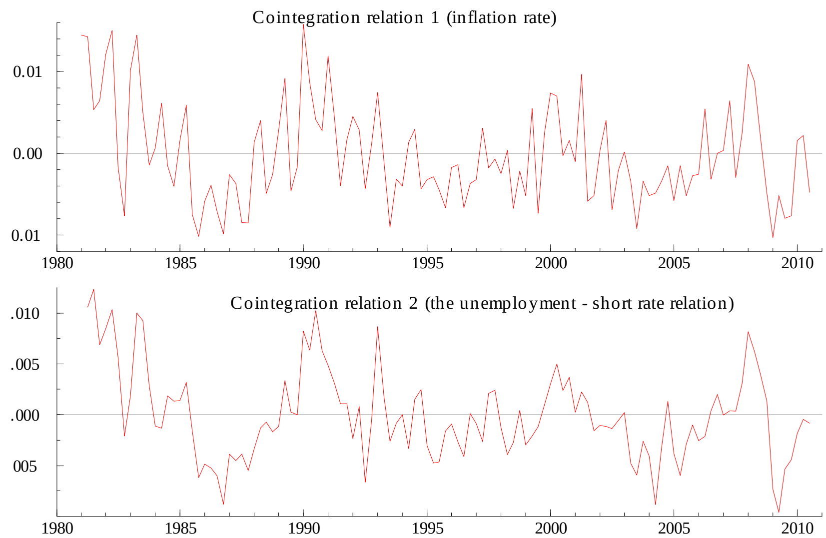

Figure 5: The two identified cointegration relations in CVAR Model 2.

graph in Figure 2, panel (b). The unemployment rate is significantly adjusting to this relation as is the interest rate spread, albeit less significantly so. The latter suggests that the second relation could also be interpreted as a monetary policy reaction rule and that lowering the central bank interest rate may have helped to reduce unemployment rate.

While the graphs of the cointegration relations do not signal misspecification, the recursive tests of constant β in Figure 6, suggest that the cointegration properties in the pre and post 1990 crisis periods are not the same. Thus, allowing for an equilibrium mean shift in the cointegration relations does not seem sufficient to capture the changes between the two periods. The next section will ask whether the cointegration properties have changed in a way predicted by Koo (2010).

5 Specifying the Phillips curve as a STR model

The above rejection of cointegration parameter constancy suggests that the Phillips curve relationship with a Phelpsian natural rate (3) has not been completely stable over the entire sample period. This is in line with the

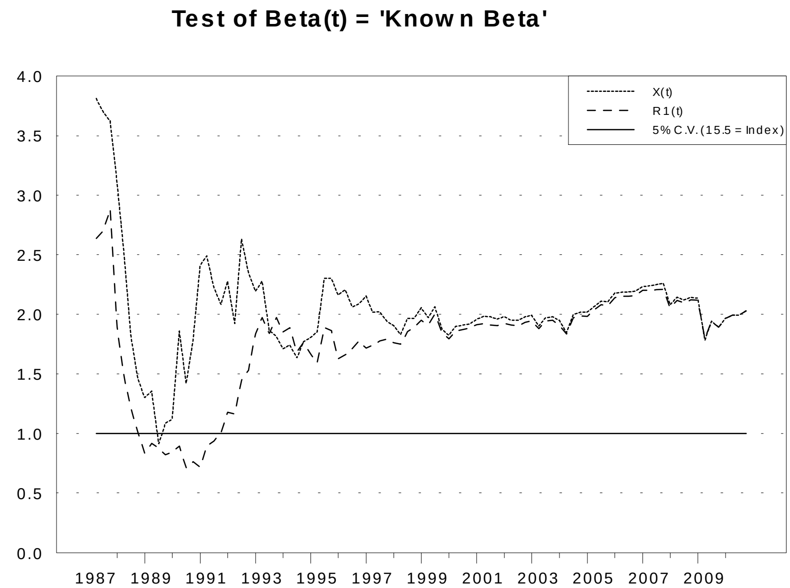

Figure 6: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ divided by its 95% quantile, where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for CVAR 2. Constancy is rejected when the test value is above the unit line.

hypothesis of the effect balance sheet recession that the Phillips curve relationship changed after the Finnish real estate bubble burst and that the economy moved into a of the type hypothesized by Koo (2010).

To test this hypothesis we adopt the smooth transition regression (STR) framework pioneered by Teräsvirta (1994). More specifically, we follow the approach by Saikkonen and Choi (2004) who extend the STR framework to the case of stochastically trending regressors. In line with Koo (2010), we assume that there are two regimes: one describing a standard period during which the Phillips curve with a Phelpsian natural rate prevails and the other a balance sheet recession period in which the interest rate effect is expected to be diluted. At any given point of time, the economy is assumed to move smoothly between these two states. This can be described by a transition function of the logistic form with symmetric weights attached to the regimes around the half way point, i.e.:

$$y_t = (1 - \varphi(\tau_t))(\beta_{10} + \beta_{11}' x_t) + \varphi(\tau_t)(\beta_{20} + \beta_{21}' x_t) + \Gamma S_t + \varepsilon_t \tag{5}$$

where ε_t is a zero-mean stationary error which is assumed to satisfy the mixing condition of Assumption 2 in Saikkonen and Choi (2004), and

$$\varphi(\tau_t) = \frac{1}{1 + e^{-\kappa_1(\tau_t - \kappa_2)}}. \tag{6}$$

In (5) x_t is the vector of explanatory variables, β_{i0}, β_{i1} are parameters in regime $i = 1, 2$ respectively, τ_t is the transition variable and S_t contains three centered seasonal dummies. The effect of x_t varies between β_{11} in regime 1 and β_{21} in regime 2. The half way point is measured by κ_2 and the degree of smoothness of the transition is measured by the parameter κ_1.

The main difficulty lies in finding a suitable transition variable that is able to capture periods in which the private sector experiences balance sheet problems. For this purpose, we adopt a measure discussed by Dynan (2012) and used by Juselius and Upper (2013) describing the households' real house debt relative to real disposable income:

$$\tau_t = \frac{d_t^{HH}/p_t^H}{w_t^{HH}/p_t^Y} \tag{7}$$

where

- d_t^{HH} is the Finnish household sector total debt defined in Dembiermont et.al (2013),
- p_t^Y is the Finnish GDP deflator, source OECD,
- p_t^H a Finnish house price index, defined as total residential property prices of existing dwellings, source BIS,
- w_t^{HH} household sector disposable income, Source Statistics Finland.

The reason why we focus on the household sector rather than the business sector, is because of the crucial role house prices played for the collapse of bubble and for the depth and the length of the subsequent crisis. The transition variable, τ_t, depicted in Figure 7, is designed to capture household sector leverage adjusted for movements in the value of the housing collateral.

Table 4: Gauss-Newton estimates of the two-regime STR models

κ_1	κ_2	D_{s94}		β_0	rb_t	b_t	s_t
Unemployment rate model							
11.03 (1.6)	3.20 (22.3)	5.40 (6.3)	Regime 1	1.98 (1.6)	0.57 (2.5)	–	–
			Regime 2	10.56 (2.1)	0.24 (0.4)	–	–
Inflation rate model							
13.4 (0.2)	2.17 (53.8)		Regime 1	3.39 (2.4)	–	0.26 (2.2)	–
			Regime 2	0.18 (0.08)	−0.22 (−1.90)	0.26 (2.2)	–

Note: t-values in ( ).

As long as house prices remain high, leverage is less of a problem but as prices fall the housing debt can exceed the value of the collateral aggravating the effect of leverage.

The linear CVAR results in Section 4 were consistent with two equilibrium relations in the data. The first described a relation between the unemployment rate and the real and nominal interest rates which could be interpreted as the gap between unemployment and its natural rate. The second described a relation between inflation rate and the unemployment gap interpreted as a Phelpsian Phillips cure. Accordingly we specify two STR models, one for the unemployment rate and the other for the inflation rate.

Saikkonen and Choi (2004) show that a standard NLLS estimator for the parameters in (5) is consistent under fairly general conditions. However, when the residuals are correlated with the regressors, the NLLS estimator becomes both inefficient and biased. The results from the linear CVAR model above suggest that this is likely to be the case in the present context. Therefore we use the efficient two-step Gauss-Newton estimator suggested by Saikkonen and Choi. This estimator corrects for the endogeneity bias in the NLLS estimator by adding lags and leads of the first differenced regressors. Conventional tests on the parameters have standard limiting distributions and require an estimate of the long run variance of the residual from the second stage regression. To estimate the long-run variance, we use the QS kernel coupled with an AR approximation for the bandwidth.

In the unemployment model the dependent variable is u_t and the explanatory variables are $x_t' = (\Delta p_t, b_t, s_t) \equiv (b_t - \Delta p_t, b_t, s_t)$, where the latter

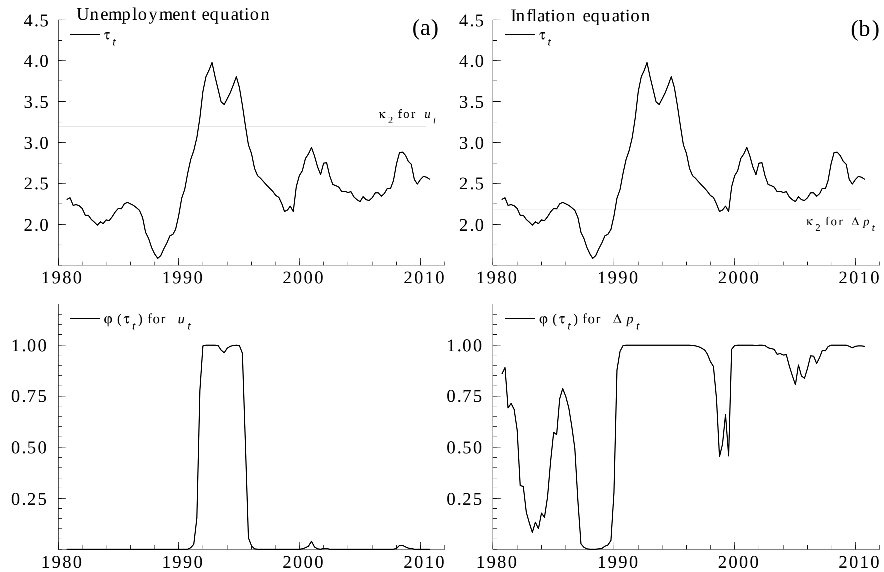

Figure 7: The transition variable and the transition function for unemployment and inflation rate.

formulation is just a linear transformation of the original data. In the inflation model the dependent variable is Δp_t and the explanatory variables are $x_t' = [(u - u^n)_t, b_t, s_t]$ where u^n is defined by (8) below with the caveat that the natural rate may not be well defined in a balance sheet recession. In addition we include a step dummy, $D_{s,94,t}$, to allow for a shift in the level of unemployment in 1994:1 capturing the rise in long-term structural unemployment in the wake of the crisis.

The transition variable and the transition function are depicted in Figure 7 for the two models and Table 4 reports the STR model estimates. Both models are based on a specification with two leads and laggs of Δx_t. However, the results in Table 4 are both qualitatively and quantitatively similar if three (or even four) lags and leads are used, and if lags and leads of $\Delta \tau_t$ are included. Insignificant coefficients in the Table have been set to zero and unchanging coefficients are restricted to take the same value in both regimes. The joint tests of these restriction were tested with a Wald test and accepted in the unemployment model based on test value of $\chi^2(4) = 4.36[0.36]$. In the inflation model the corresponding test value was $\chi^2(4) = 10.79[0.03]$.

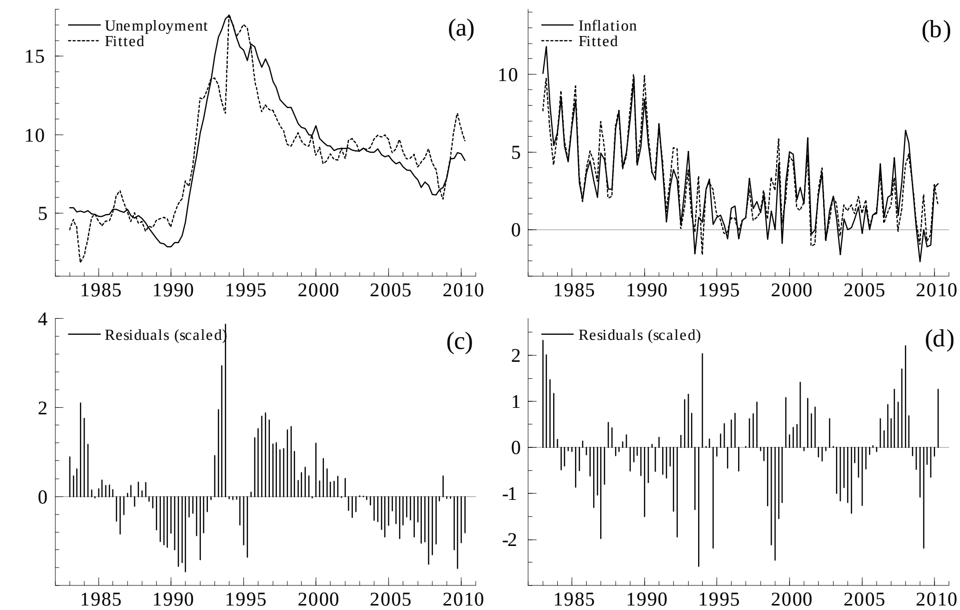

Figure 8: The graphs of (a) the fitted and actual unemployment rate, (b) the fitted and actual inflation rate, (c) the scaled unemployment residuals and, (d) the inflation residuals.

The model for the unemployment rate seems to indicate a nonlinear regime shift of the smooth transition type, with the caveat that the estimated speed of adjustment coefficient, $\kappa_1 = 11.03$ may not deviate significantly from zero. As $\kappa_1 = 0$ follows a nonstandard distribution, the Students t-ratio (1.6) cannot be used to test this hypothesis. But, whatever the case, the result clearly indicates that the transition function is quite steep. For example, the estimates suggest that 90% of the transition takes place in the interval $3.02 \leq \tau_t \leq 3.38$ with the half way point estimated at $\kappa_2 = 3.20$, implying that most of the transition is done in a quarter. Because of this, the coefficients in Table 4 might be imprecisely estimated. Interestingly, the half way point corresponds exactly to the onset of the banking crisis in 1991:3. The graph in Figure 7 panel, (a), shows that the crisis regime is restricted to the three worst years of unemployment suggesting that they were truly anomalous years. Table 4 reports the equilibrium relationships for unemployment in the two regimes. The results are reproduced below:

$$\begin{aligned} \text{Regime 1:} \quad & u^n = 1.98 + 0.57(b_t - \Delta p_t) + 5.40 D_{s94.1,t} \\ \text{Regime 2} \; : \quad & u^{bsr} = 10.56 + 0.24(b_t - \Delta p_t) + 5.40 D_{s94.1,t} \end{aligned} \tag{8}$$

where the superscript bsr denotes the balance sheet recession period. In regime 1 the estimated coefficient of the long-term real interest rate is consistent with Phelps's natural rate hypothesis but with a rather small coefficient compared to the cointegration results of the previous section. In regime 2 there is no longer a significant interest rate effect. This result seems broadly consistent with the Koo hypothesis that the effect of the interest rates is diluted in a balance sheet recession. Figure 8, panel (a) depicts actual and fitted values and panel (c) the residuals. In spite of the apparently good fit in panel (a), the residuals in panel (b) are clearly strongly auto-correlated. Nevertheless, the standrad errors of the coefficients in Table 4 remain valid as these are based on estimates of the long-run variance.

The lower part of Table 4 reports the estimates of the Phillips curve with a Phelpsian natural rate. The results for the two regimes are reproduced below:

$$\begin{aligned} \text{Regime 1:} \quad & \Delta p_t = 3.39 + 0.26 b_t \\ \text{Regime 2} \; : \quad & \Delta p_t = 0.18 - 0.22(u_t - u_t^n) + 0.26 b_t \end{aligned}$$

In regime 1, the gap effect of the Phillips curve could be omitted altogether, whereas in regime 2 it is significant. Thus, only in the second regime is there evidence in favor of a Phelpsian Phillips curve relationship, but also here with a smaller coefficient than in the cointegration model of the previous section. This suggests that it is the first regime that is "extraordinary" in contrast to the second regime which seems to represent a more standard mechanism.

The first regime covers both a period of financial regulation, 1982-1985, and a period of financial deregulation, 1986-1990, characterized by an accelerating housing bubble and an overheated economy. As the speed of adjustment coefficient, $\kappa_1 = 13.4$, is completely insignificant, it suggests a sharp shift between the two regimes rather than a smooth transition. In fact 90% of the transition takes place in the interval where $2.01 \leq \tau_t \leq 2.33$ with the half way point estimated at $\kappa_2 = 2.17$. Interestingly, the latter value corresponds exactly to the burst of the housing bubble in 1990:1. As Figure 7 panel (a) shows, the second regime essentially continues for the rest of the sample period, suggesting a structural break in the Finnish inflation rate in connection with the burst of the housing bubble in 1990:1. Figure 8 panel (b) shows that actual and fitted inflation rates follow each other quite closely and that the residuals are not strongly autocorrelated.

Altogether, the results can be interpreted as broadly supporting the Phelps hypothesis of a Phillips curve where the natural rate is a function of the real interest rate and the Koo hypothesis of a weakening interest rate effect in the balance sheet recession following the burst of the Finnish real estate bubble.

6 Concluding discussion

Finland experienced a bursting real estate bubble almost two decades before the bursting of the 2007 US one which was followed by a large number of other similar cases around the world. Can we learn anything useful from the Finnish experience? With the caveat that the real estate boom in Finland coincided with a number of other specific events which may have aggregated the severity of the subsequent crisis, we find that the Finnish results can shed light on the determination of inflation, unemployment and interest rates in the period preceding and succeeding a house price bubble.

Our approach was first to learn about the basic dynamic mechanisms based on a linear CVAR, while recognizing that this approach will only deliver average effects over the sample period if the correct mechanism is a non-linear two regime model. However, the first CVAR results turned out to be surprisingly good: the estimates of the Phelpsian natural unemployment rate were plausible, the inflation and the natural rate gap were negatively related in accordance with a plausible Phillips curve, and the adjustment took place in the inflation rate equation as theory would suggest. But parameter constancy was rejected for the full period and we turned to the STR model by Teräsvirta to investigate the possibility of a different crisis regime.

The STR results for the unemployment model showed that the period from the end of 1993 to 1995, comprising the most extreme unemployment rates, was a different regime where the interest rates had no significant effects on unemployment as predicted by Koo (2010). For the inflation model the STR results showed that the bursting of the bubble in 1990:1 defined a structural break rather than just a regime shift. In the post bubble period, the Phillips curve with a Phelpsian natural rate seemed to work well.

Altogether, the results provide empirical support both for Phelps' hypothesis of a Phillips curve where the natural rate is a function of the real interest rate, for the Frydman and Goldberg Imperfect Knowledge hypothesis of pronounced persistence in the real interest rate, and for the Koo hypothesis of the weakening effect of the interest rates for economic activity in a balance sheet recession. Thus, our results suggest that many standard economic models are not likely to work well in the wake of a fundamental financial and economic crisis like the present one.

7 References

Castle, J. L., Doornik, J. A., Hendry, D. F., and Nymoen, R. (2010). "Testing the invariance of expectations models of inflation". Working paper no. 510, Economics Department, University of Oxford.

Colander, D, M. Goldberg, A. Haas, K. Juselius, A. Kirman, T. Lux, B. Sloth (2009). "The Financial Crisis and the Systemic Failure of the Economics Profession". *Critical Review*, 21, 3.

Dennis, J. G., H. Hansen, S. Johansen, and K. Juselius (2006). *CATS in RATS. Cointegration Analysis of Time Series*, Version 2. Estima: Evanston, Illinois, USA.

Dembiermont, C., M. Drehmann, and S. Muksakunratana (2013): "How much do they borrow - a new database for total debt of the private non-financial sector", *BIS Quarterly Review*, March (forthcoming).

Doornik, J. A. and D. F. Hendry (2001). *GiveWin. An Interface to Empirical Modelling* (3rd edn.). Timberlake Consultants Press: London.

Dynan, K. (2012). "Is A Household Debt Overhang Holding Back Consumption?", Unpublished paper at the Brookings Institution.

Friedman, M. (1968). "The Role of Monetary Policy." *American Economic Review* 58, 1, 1–17.

Frydman, R. and M. Goldberg (2007). *Imperfect Knowledge Economics: Exchange rates and Risk, Princeton.* NJ: Princeton University Press.

Frydman, R. and M. Goldberg (2011). *Beyond Mechanical Markets: Risk and the Role of Asset Price Swings*, Princeton University Press.

Gonzalo, J. (1994). "Five alternative methods of estimating long-run equilibrium relationships", *Journal of Econometrics*, 60(1-2), pp. 203-233

Hansen, H.and S. Johansen (1999). Some test for parameter constancy in cointegrated VAR-models. *The Econometrics Journal*, 2(2), 306–333.

Johansen, S. (1995). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models, Oxford*. Oxford University Press.

Johansen, S., K. Juselius, R. Frydman, and M. Goldberg (2010). **"**Testing Hypotheses in an $I(2)$ Model With Piecewise Linear Trends. An Analysis of the Persistent Long Swings in the Dmk/$ Rate,**"** *Journal of Econometrics*.

Juselius, K. (2006). *The Cointegrated VAR Model: Methodology and Applications*. Oxford: Oxford University Press.

Juselius, K. (2013). "Imperfect Knowledge, Asset Price Swings and Structural Slumps: A Cointegrated VAR Analysis of Their Interdependence", (eds.) E. Phelps and R. Frydman, *Rethinking Expectations: The Way Forward for Macroeconomics*, Princeton University Press, Princeton.

Juselius, K. and Franchi, M. (2007). Taking a DSGE Model to the Data Meaningfully, *Economics*, **??** , 1, 4, http://dx.doi.org/10.5018/economics-ejournal.ja.2007-4

Juselius, K., and J. Ordóñez (2009). **"**Balassa-Samuelson and Wage, Price and Unemployment Dynamics in the Spanish Transition to EMU Membership**"**. *Economics: The Open-Access, Open-Assessment E-Journal*, 3, 4, http://dx.doi.org/10.5018/economics-ejournal.ja.2009-4

Juselius, M. and C. Upper (2013). "The effect of collateral prices and debt service costs on deleveraging, consumption and investment". Unpublished manuscript

Koo, R. (2010). "*The Holy Grail of Macroeconomics: Lessons from Japan's Great Recession*", John Wiley & Sons, Hoboken, USA.

Krugman, P. (1993). *Exchange Rate Instability*. The MIT Press, Cambridge Mass.

Phelps, E., S. (1968). "Phillips Curves, Expectations of Inflation and Optimal Employment over Time." *Economica*, n.s., 34, no. 3 (1967): 254–281.

Phelps, E. (1994). *Structural Slumps*, Princeton University Press, Princeton.

Rahbek, A., E. Hansen, and J. Dennis (2002). "ARCH innovations and their impact on cointegration rank testing", The Department for Mathematical Statistics, University of Copenhagen.

Saikkonen, P., Choi, I. (2004). "Cointegration smooth transition regressions" *Econometric Theory* 20, 301-340.

Teräsvirta, T. (1994). "Specification, Estimation, and Evaluation of Smooth Transition Autoregressive Models", *Journal of the American Statistical Association*, Vol. 89, No. 425, pp. 208-218.