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

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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. This proposition usually works well in normal times but is likely to break down during a balance sheet recession (Koo, 2010) 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 normal and nonnormal periods.

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 more devastating debt crisis. The mere scope of the crisis has shaken the foundations of the world economy and has started a debate about the realism of standard economic models as they were not able to foresee the problems ahead (see eg. Colander et al. 2008). Obviously such models lack features

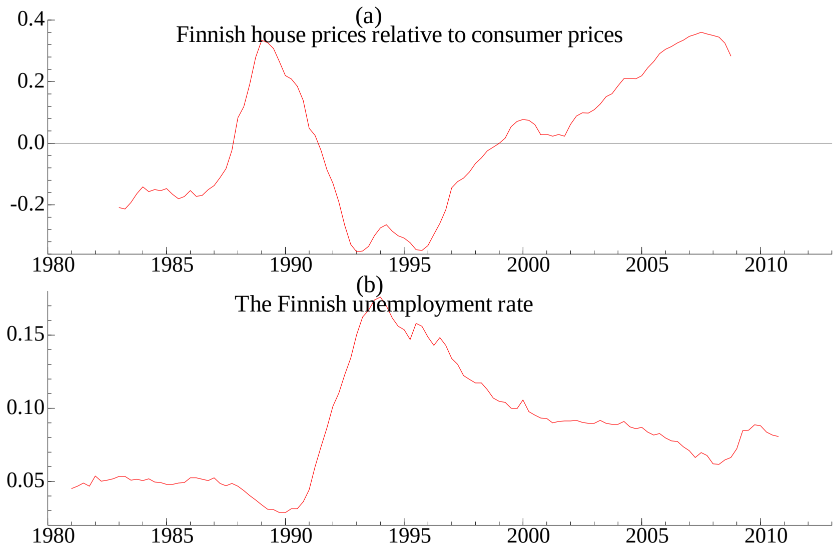

Figure 1: The development of real house prices and unemployment in Finland from 1983-2009.

that otherwise could have warned us about the approaching disaster and possibly prevented it. These deficiencies may render them unable to provide the necessary policy guidelines for dealing with the still ongoing crises. The question we raise in this paper is whether there are useful lessons to be learnt by studying the dynamics of a previous real estate bubble.

While Japan in the mid-nineties is the most well-known case of a house bubble to be followed by a long balance sheet recession, Finland also went through a similar crisis a few years before the Japanese one. Deregulation of the Finnish credit market in 1986 resulted in a booming house market and the build-up of a serious house price bubble. When the bubble burst in 1990 house prices collapsed (see Figure 1, panel a) and unemployment rose rapidly from a low 2% to almost 20% (see panel b). These are huge fluctuations which beg 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 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, 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 in 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 theory the natural rate is a function of a stationary real interest rate (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 speculative behavior in financial markets[1]. Juselius (2012) argues that IKE combined with Phelps Structural Slumps theory can give the rationale for why the nominal interest rate exhibit much more persistence than the inflation rate and, hence, why the ex post real interest rates often move in a nonstationary manner.

Thus, an econometric analysis based on cointegration techniques seems to be relevant for learning about the relationship between inflation, unemployment and interest rates. properties of the Phelps Phillips curve. But, as argued by Koo (2010) we should also 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.

[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.

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 predicts that inflation would be negatively associated with the deviation of unemployment from a constant natural rate. But then the in the seventies stagflation replaced the standard Phillips curve with inflation and unemployment rates positively co-moving. This break-down of the previously accepted empirical regularity seemed to be caused by the increasingly important role of inflationary expectations. As a result, 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, rather than being a constant, became a function of the domestic real interest rate.

The intuition behind the Phelps natural rate with a nonstationary real interest rate is broadly as follows.

When prices of tradable goods are primarily determined in very competitive customer markets, they are not likely to be affected by speculation (energy, precious metals and, recently, grain may be exceptions in this respect) and, therefore, should not exhibit persistent swings around long-run benchmark values. On the other hand, nominal interest rates are likely to be affected by speculation, for example through international capital flows. This implies that the inflation rate will be more stable than the nominal interest rate and, thus, that the real interest rate will inherit the persistent long swings of the latter.

A shock to the long-term interest rate (for example, as a result of an increase in sovereign debt) 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 and keep increasing as long as the structural imbalances are growing and we would expect to see the real interest rate and the real exchange rate moving in similar persistent swings. 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 an Imperfect Knowledge Economy the nominal exchange rate is primarily determined by speculation. Therefore, after a permanent shock to relative costs, enterprises cannot in general count on exchange rates to restore competitiveness. Unless they are prepared to loose market shares, they cannot use constant mark-up pricing as their pricing strategy. To preserve market shares, they would have to adjust productivity or profits rather than to increase their product price. This implies that one would expect customer market pricing (Phelps, 1994) or alternatively pricing to market (Krugman, 1993) to replace constant mark-up pricing in an Imperfect Knowledge economy. Hence, profits are squeezed in periods of persistent appreciation and increased in periods of depreciation.[2]

In such an economy, 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 to increase 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).

Unemployment above or below its time-varying natural rate generally

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

affect nominal wage claims negatively and, hence, price inflation, Δp. In this set-up, the expectations augmented Phillips Curve:

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

has a natural rate, $u^* = f(r)$, which is a function of the real interest rate, r[3]. Δp^e stands for an inflationary expectation.

Thus, the structural slumps theory in conjunction with IKE predicts that the unemployment rate and the real interest rates are co-moving both exhibiting similar persistent swings. This means that the unemployment gap $u^* - f(r)$ is likely to be less persistent than unemployment rate itself and that Δp and $(u - u^*)$ can be cointegrated even though Δp and u might seem unrelated. This can explain the general failure to find empirical support for the Phillips curve in recent decades.

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, Miller and Stiglitz, 2010). This is because when numerous balance sheets in the economy are 'under water', 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 Phelps Phillips curve may not be an adequate description of inflation in a balance sheet recession.

3 Empirical methodology

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

1. The same constant parameter CVAR model can approximately describe normal and crisis periods.

2. The main effect of the crisis is a change in the equilibrium mean of the cointegration relations implying that the crisis which erupted in the early nineties caused the natural rate of unemployment to move to a

[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) and Juselius and Ordonez (2009).

higher level. It involves re-estimating the model with a step-dummy restricted to the cointegration relations.

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

3.1 Specification of CVAR model

We consider the following linear cointegrated VAR model for Finnish quarterly data from 1982:2 to 2010:4:

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

where, for $x_t' = [\Delta p_t, u_t, rb_t, spr_t]$, Δp_t is measured as $400(\Delta \log(CPI)_t)$, u_t as the percentage of the number of unemployed in workforce, $rb_t = b_t - \Delta p_t$ with b_t the annual long-term bond rate, $spr_t = b_t - s_t$ is the spread between the long and the short term interest rate as a proxy for inflationary expectations by the market as well as the central bank, $Ds_{90,t}$ is a step dummy defined 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 and S_t is a vector of three seasonal dummies.

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. Panel (b) shows that the unemployment rate rose 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, it started slowly to come down and reached a new stable level of approximately 6% which, albeit much lower than in the crisis years, was significantly higher than the pre-crisis level. 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 she was fortunate to avoid the worst effects of this crisis. Panel (c) shows that the interest rate spread was systematically negative in the period up to the crisis and systematically positive after the crisis. In the bubble period high inflationary expectations resulted in relatively high short-term interest

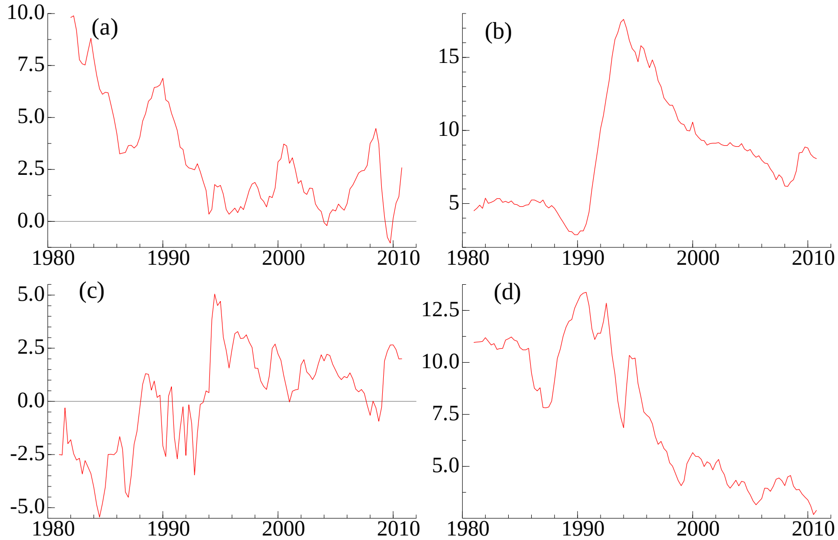

Figure 2: The graphs of inflation rate (a), unemployment rate (b), the long-short interest rate spread (c), and the long-term bond rate (d) in Finland from 1981-2010.

rates.[4] In the second period with the high unemployment rates, the central bank interest rate remained on a low level relative to the long-term bond rate. From Panel (d) it appears that the long-term bond rate dropped somewhat after 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.

[4]In the bubble period, the Finnish markka was experiencing a continuous real appreciation which, after the bubble burst, became a growing pressure to depreciate. When allowed to float the markka lost approximately 30 % of its value.

4 Misspecification tests and rank determination

With such dramatic changes over the sample period, it might seem overoptimistic 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 misspecification analysis of the linear CVAR 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. Even though Table 1 shows that CVAR 1 fails on multivariate residual autocorrelation we do not interpret this to mean that more lags should be added but rather that there are non-modelled nonlinear effects in the model. A similar argument applies to the failure of multivariate normality and ARCH. Nevertheless, the signs of misspecification mean that standard distributional results do not hold and the reported significance tests are, therefore, only indicative.

Figure 2 showed that the level of unemployment rate was lower in the precrisis 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 multivariate 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.

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 that may make the trace test less reliable. This can probably explain why three unit roots cannot be rejected with a p-value of 0.09, whereas two unit roots with a p-value of

Table 1: Misspecification tests

	Multivariate tests			
	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
	Univariate tests			
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

Table 2: Rank determination

CVAR 1						**CVAR 2**			
$p-r$	r	λ_i	*Trace[p-val]*	$Q_{.95}$		λ_i	*Trace[p-val]*	$Q_{.95}$	
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

Table 3: The estimated cointegration relations

	Δp	u	rb	spr	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]		

only 0.05 can. 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 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, we continue with $r = 2$ in both models to improve comparability.

4.1 Estimated cointegration relationships

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

$$\Delta p_t = -0.62(u_t - u_t^*) \tag{3}$$

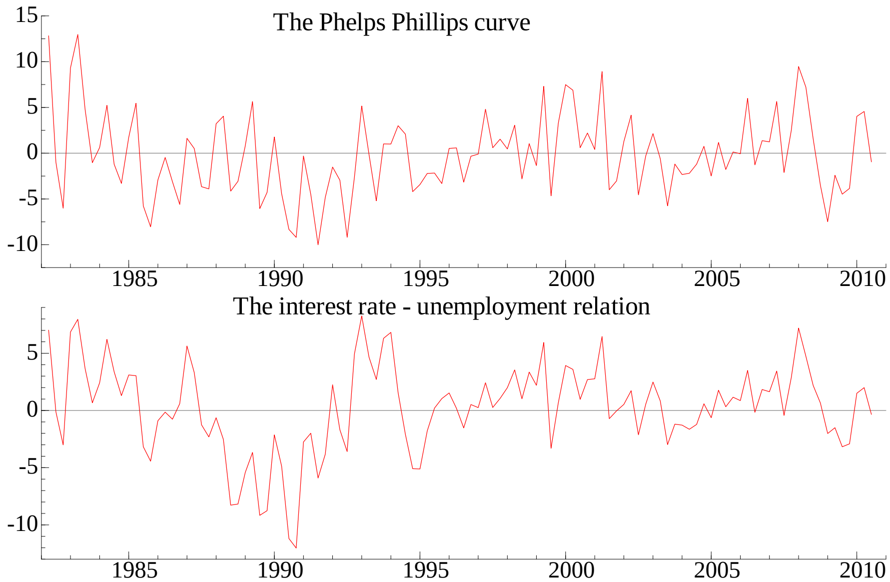

Figure 3: The graphs of the identified cointegration relations in CVAR 1.

where

$$u_t^* = 1.8(b_t - \Delta p_t) + 5.5 \tag{4}$$

The inflation rate is equilibrium correcting indicating that unemployment in excess of $u_t^* = 1.8(b_t - \Delta p_t) + 5.5$ 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 suggests 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. As the graph

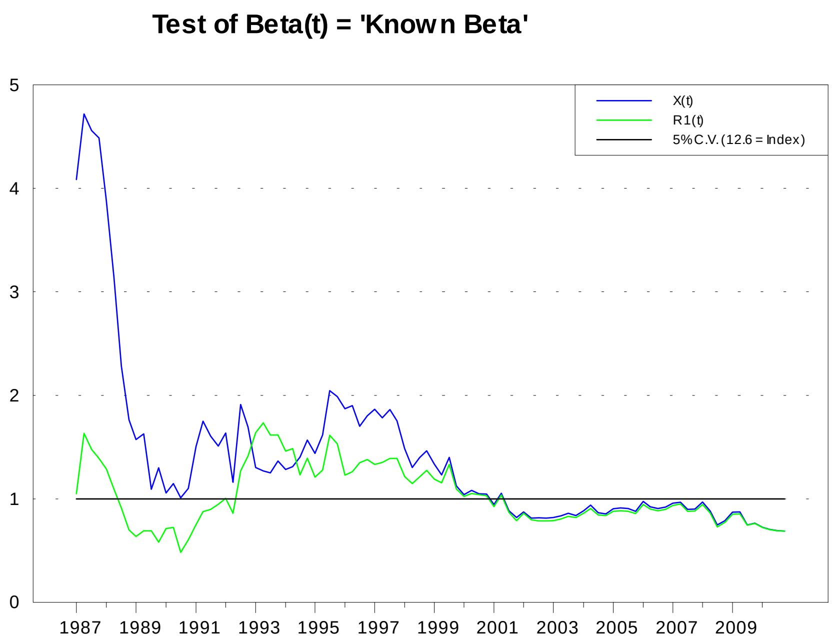

Figure 4: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for Model 1.

of the equilibrium errors in Figure 3 demonstrates, the deviations from (4) do not suggest fundamentally changing cointegration properties. While the second relation is slightly more volatile during the crisis period, it does not seem strikingly misspecified.

This visual check of cointegration properties needs to be complemented with a formal test of parameter constancy. The recursive tests in Figure 4, of parameter constancy of β is based on testing 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 and then recursively extending the sample period with $t_1 = 1, 2, 3$ until the full sample is covered. The test statistic is divided by the 95% quantile so parameter constancy is rejected on a 5% level when the graph is above the unit line. The $X(t)$ graph corresponds to the full CVAR 2, whereas the $R1(t)$ graph corresponds to the same model where $\Gamma_1 \Delta x$ has been concentrated out. The

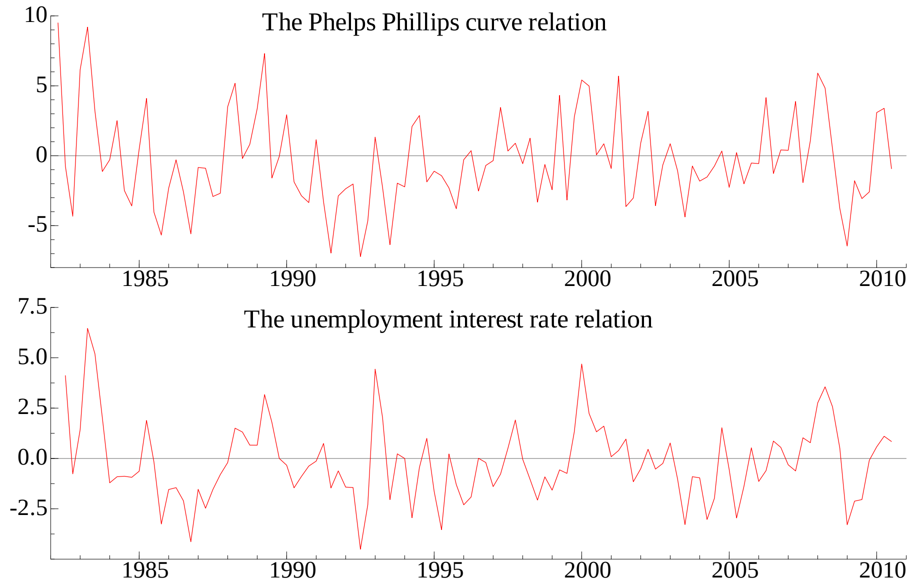

Figure 5: The graphs of the identified cointegration relations in CVAR Model 2.

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. Thus, the sample period is likely to define at least two regimes.

The CVAR 2 is specified with an equilibrium mean shift in the cointegration relation. This shift is found strongly significant based on $\chi^2(2) = 24.03[0.00]$. The two cointegration relations contain one just-identifying restriction each.

The first relation has the property of a Phillips curve relation with the natural rate being a function of the real interest rate, but the coefficient to the unemployment rate is insignificant. Thus, allowing for an equilibrium mean shift seems to make the Phillips curve less visible in the data. Inflation is significantly equilibrium correcting and the graph in Figure 5 suggests 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-

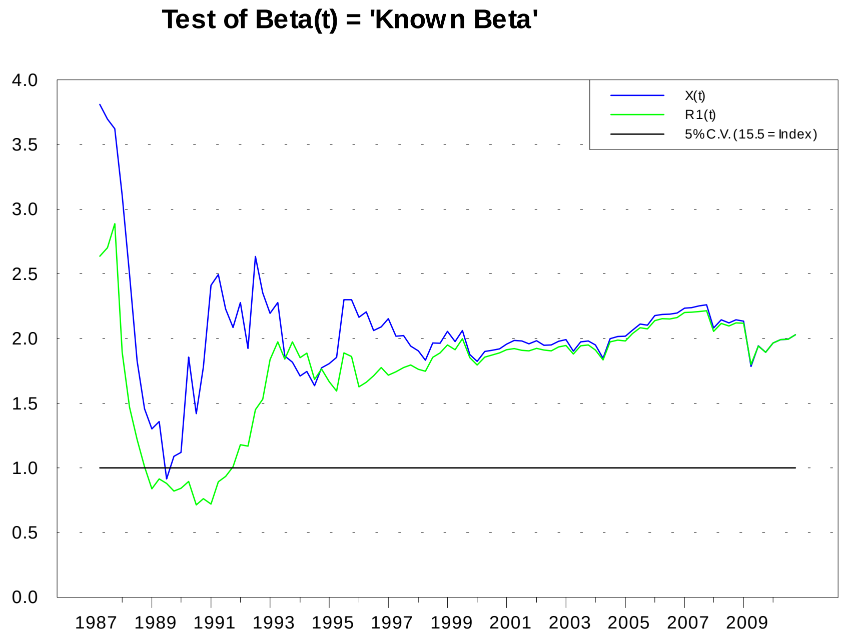

Figure 6: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for CVAR 2. Constancy is rejected when the test value is above the unit line.

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 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 may also be interpreted as a monetary policy reaction rule and that lowering the short-term 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 period 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 Phelps Phillips curve relationship (3) has not been completely stable over the entire sample period. Such a change in cointegration properties might be a signal that the Phillips curve relationship changed after the Finnish real estate bubble burst and the economy moved into a balance sheet recession 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) which extends the STR framework to the case of stochastically trending regressors. In line with Koo (2010), we assume that there are two regimes: one describing normal periods during which a standard Phelps Phillips curve prevails and the other balance sheet recession periods 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 gives us a transition function of the logistic form with symmetric weights attached to the regimes around the half way point, i.e.:

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

and

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

where 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 main difficulty lies in finding a suitable transition variable (τ_t) that is able to capture periods in which the private sector experiences balance sheet problems. For this purpose, we adopt a measure provided by Juselius and Upper (2012) defined as

$$\tau_t = \frac{d_t^{HH} \cdot p_t^Y}{w_t^{HH} \cdot p_t^H}$$

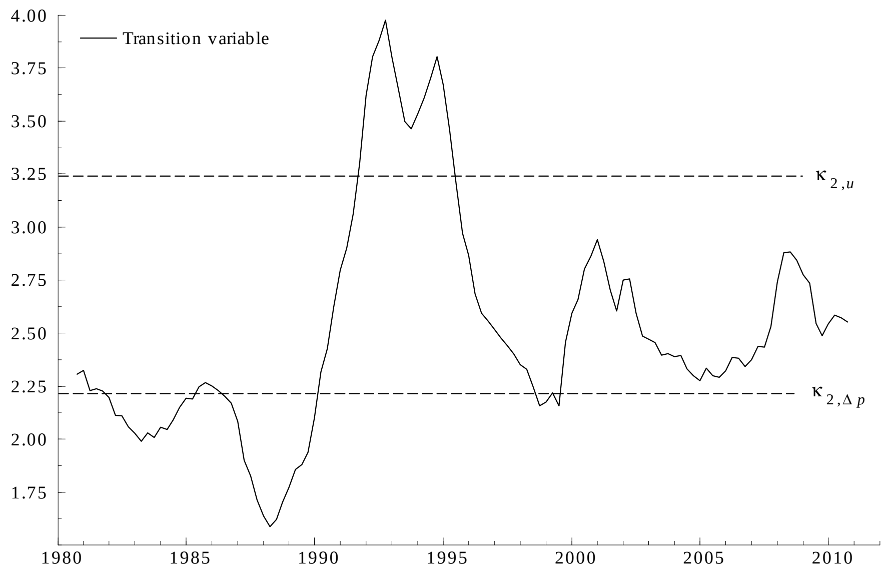

Figure 7: The transition variable

with d_t^{HH} denoting household sector total credit, p_t^Y the GDP deflator, p_t^H a house price index, and w_t^{HH} household sector disposable income. 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 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. 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 suggested that there are two equilibrium relations in the data: one describing a relation between the unemployment rate and the real and nominal interest rates that could be interpreted as the gap between unemployment and its natural rate or alternatively as a monetary policy rule; the other describing a relation between inflation rate and the unemployment gap. Accordingly we specify two STR models one for the unemployment rate and the other for the inflation rate.

For equilibrium unemployment $y_t = u_t$, $x_t' = (u, \Delta p_t, b_t, s_t) \Leftrightarrow (b_t -$

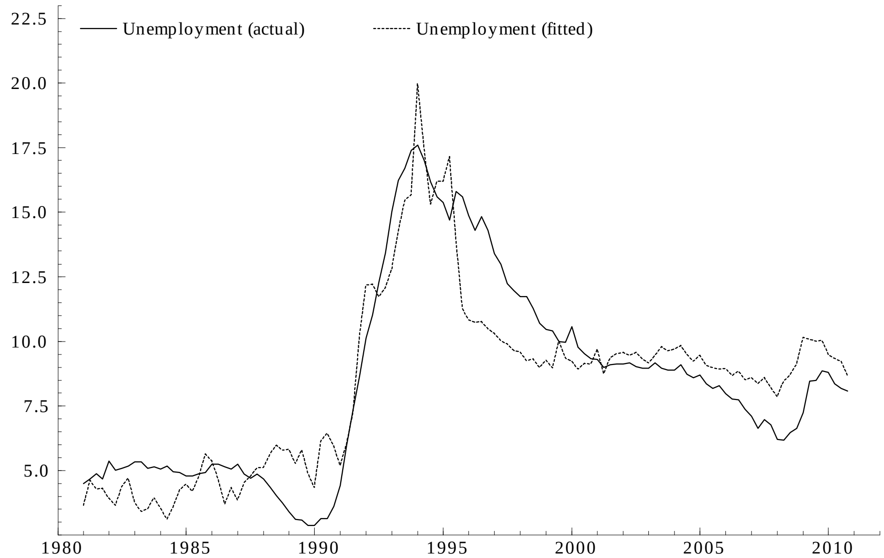

Figure 8: Actual and fitted unemployment

$\Delta p_t, b_t - s_t, b_t)$ where the latter formulation is just a linear transformation of the original data. In addition we include a step dummy variable, $D_{s,94,t}$, to allow for a permanent shift of the level unemployment rate in 1994:1, capturing a rise in long-term structural unemployment in the wake of the crisis.

The results for both models are reported in Table 4. The model for unemployment provides clear evidence of a nonlinear regime shift of the smooth transition type. The estimated coefficient of the speed of adjustment, $\kappa_1 = 9.45$, suggests that 90% of the transition takes place in the interval where $3.01 \leq \tau_t \leq 3.47$, with the half way point estimated at $\kappa_2 = 3.24$. Interestingly, the latter corresponds exactly to the onset of the banking crisis in 1991:3. The zero coefficients on the bond rate in the first regime and the real bond rate in the second regime were accepted with $\chi^2(2) = 1.3[0.60]$. Figure 7 shows that the crisis regime only comprises the three worst years of unemployment suggesting that they were truly anomalous years.

For the first regime, the estimated coefficient of the long-term real interest rates is consistent with the Phelps hypothesis but with a rather small coefficient. In the second regime the coefficient of the spread is not statis-

Table 4: Estimated regime shift cointegration relationships

STR model for unemployment rate							
κ_1	κ_2	D_{s94}		β_0	rb_t	spr_t	b_t
9.45	3.24	3.63	Regime 1	4.48	0.19	0.40	–
(2.5)	(42.2)	(5.2)		(6.6)	(2.2)	(2.8)	
			Regime 2	25.8	–	−0.33	−1.18
				(5.2)		(−1.1)	(−2.7)
STR model for inflation rate							
κ_1	κ_2			β_0	$u_t - u_t^*$	b_t	s_t
42.9	2.22		Regime 1	−7.70	1.51	1.43	–
(1.2)	(68.4)			(−4.7)	(4.7)	(8.1)	
			Regime 2	1.00	−0.14	–	0.21
				(3.4)	(2.7)		(4.4)

tically significant and the bond rate is negative but significant. Although the interpretation of the coefficients is not straightforward, the results seem to confirm the Koo hypothesis that the effect of the interest rates changes completely during a balance sheet recession. Figure 8 reports the actual and fitted values from the unemployment STR model. While equilibrium unemployment closely follows actual unemployment, it is nonetheless systematically either under or overestimated for much of the period and the model suffers from strong residual autocorrelation. The significance tests results should, therefore, only be considered indicative.

Table 4 reports the estimated Phillips curve relationship from the inflation STR model with $x_t' = [(u - u^*)_t, s_t, b_t]$ where

$$u_t^* = 4.48 + 0.19 rb_t + 3.63 * D_{s94.1,t}.$$

The estimated value for the speed of adjustment, $\kappa_1 = 42.9$, suggests that 90% of the transition takes place in the interval where $2.17 \leq \tau_t \leq 2.27$, with the half way point estimated at $\kappa_2 = 2.22$. Interestingly, the latter value corresponds exactly to the burst of the housing bubble in 1990:1. Contrary to the unemployment rate, there is now much stronger evidence for a sharp shift between the two regimes and the second regime essentially continues for the rest of the sample period (see Figure 7). Thus, there might have been a structural break in the determination of inflation rate rather than a smooth transition of the STR-type. Figure 9 shows actual and fitted inflation rates. It does not suggest any systematic deviations between the two which was confirmed by standard misspecification tests.

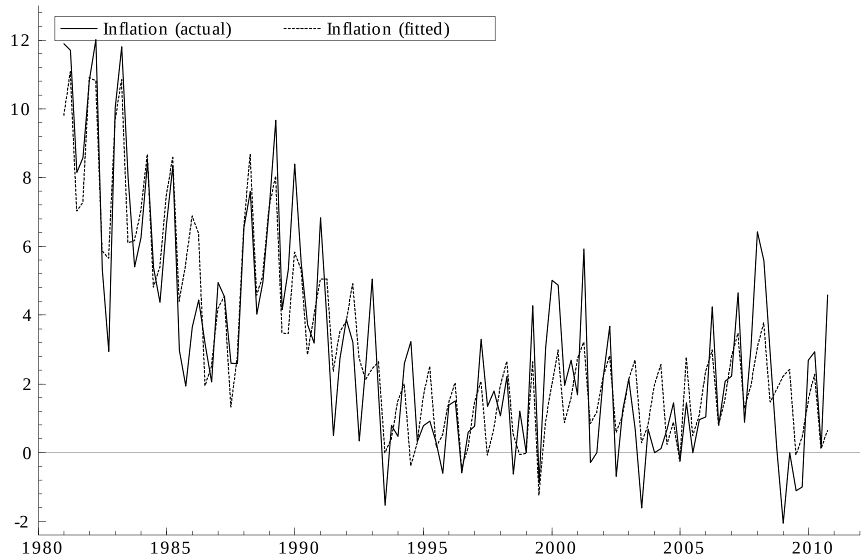

Figure 9: Actual and fitted inflation

In the first regime the short-term interest rate was insignificant, in the second regime this was the case with the long-term bond rate. They were jointly accepted based on $\chi^2(2) = 4.3[0.12]$. For the first regime the coefficient to the unemployment gap has the wrong sign, whereas for the second regime there are evidence in support of a Phelps Phillips curve relationship. Thus, the results seem to suggest that the first regime is a "non-normal" regime whereas the second regime seems more normal. This may not be too surprising: The first regime covers both a period of financial regulation, 1982-1985 and a period of financial deregulation, 1986-1990. The latter period is, however, far from normal in the sense that it was characterized by an accelerating housing bubble and an overheated economy.

While the results were not completely unambiguous, they can nonetheless be interpreted as broad empirical support for Phelps natural rate hypothesis and for Koo's hypothesis of a weakening interest rate effect after the bursting of a real estate bubble. The results from the CVAR and STR analyses raise the question why the size of the coefficients differed so much. This and the question of a structral break in inflation rate will be addressed in the next section.

6 Discussing the results

The CVAR results in Section 4 provided some broad support for a Phillips curve augmented with a Phelpsian natural rate relation, but they were to some extent challenged by the STR results. The latter suggested a much lower effect of the real interest rate in the unemployment model and of the unemployment gap in the inflation model.

Furthermore, the STR inflation model suggested that the end of the bubble define a structural break rather than a smooth transition to a new regime. Accordingly, the CVAR needs to be re-estimated for the post-bubble period. The unemployment STR model showed that the period 1991:3-1995:1, comprising a period of extremely high unemployment rates, should be considered a different regime. But, while the inflation model was statistically well specified, the unemployment model showed strong evidence of autocorrelated residuals[5] casting doubts on the validity of the statistical inference in that model. Therefore, as a sensitivity check we re-estimated the unemployment STR model (5) allowing for a lagged unemployment rate:

$$y_t = (1 - \varphi(\tau_t))(\beta_{10} + \beta'_{11} x_t) + \varphi(\tau_t)(\beta_{20} + \beta'_{21} x_t) + \rho y_{t-1} + \Gamma S_t + \varepsilon_t, \quad (6)$$

where ρ is a measure of unemployment persistence. Table 5 reports the results:

With this change in specification, the autocorrelation test is now acceptable, as is the ARCH test, while normality is still rejected. It is quite interesting that the unemployment model now suggests two new regimes, one from 1982:2-1990:1, the other from 1990:2-2010:4. These are almost exactly coinciding with the previous inflation rate regimes. Of course, this does not imply that the extreme unemployment years have become more "normal", only that the high autocorrelation coefficient (0.95) makes it easier to explain the persistent movements in unemployment rate and, therefore, easier to detect other changes in the cointegration properties.

Table 5 shows that the distinguishing feature between regime 1 and 2 is the way interest rates affect unemployment. In regime 1 (characterized by capital deregulation, excessive spending, a fast developing real estate bubble and inflationary expectations) the real long-term bond rate had an insignificant effect on unemployment and was set to zero, whereas the nominal rate

[5] As already discussed, it is the pronounced persistence in unemployment but not in inflation that explains the different outcomes.

Table 5: Estimated regime shift cointegration relationships

STR model for unemployment rate with a lag

κ_1	κ_2	ρ	D_{s94}	β_0	rb_t	spr_t	b_t
Regime 1							
3.64	2.47	0.95	-0.79	1.11	–	0.04	-0.10
(2.6)	(23.0)	(56.4)	(-4.2)	(4.4)		(1.5)	(-4.9)
Steady-state solution:			-15.8	22.2		0.8	-2.0
Regime 2							
		0.95	-0.79	0.70	0.11	–	–
		(56.4)	(-4.2)	(2.3)	(4.81)		
Steady-state solution:			-15.8	14.0	2.2		
AR 1-5: $F(5,98) = 1.22$		ARCH 1-4: $F(4,107) = 1.32$					
Normality: $\chi^2(2) = 19.1$							

had a negative and significant effect. Obviously, the demand for labor had kept increasing as the bubble kept inflating in spite of increasing long-term and short-term interest rates. Similar behavior has seen in many of the more recent bubble economies.

In regime 2 (characterized by very high unemployment rates, re-consolidation of balance sheets both in the private and business sector, and relatively low central bank interest rate) the real long-term bond rate is positively related to the unemployment rate, whereas both the spread and the nominal bond rate were found insignificant and set to zero. The steady-state solution gives a much higher coefficient (2.2) to the real long-term bond rate. It is now much closer to the estimate in (4). Thus, the divergence between the CVAR and the STR natural rate results seemed to be due to missing unemployment dynamics in the STR model.

The new results suggest that the bubble period preceding the crisis was indeed exceptional: standard economic mechanisms did not seem to be at work at all. The euphoria of the bubble period stands in harsh contrast to the painful adjustment back to more sustainable conditions characterizing the second period where the results emphasize the strong relationship between the unemployment rate and the real long-term bond rate. The results provide strong support for the Phelps natural rate of unemployment theory.

7 Inflation, unemployment and interest rate dynamics in the period of credit deregulation

According to the STR results the second regime starts in 1990:1 and continues until the end of the sample in 2010:4. However, the CVAR results based on this sample were strongly influenced by the fact that the sample starts at a point when the economy is very far from equilibrium. We have addressed this problem by first estimating the CVAR for a sample that starts three years before the crisis erupted and then compare the results based on a sample that starts after the extreme unemployment years. The first model analysis is based on the assumption that the significant change in the Finnish economy was due to the deregulation of credit, the second analysis is based on the STR results in Table 4 which suggested that the whole period up to 1995 was exceptional either for inflation or unemployment.

The upper part of Table 6 report the results for the period 1987:1-2010:4. Based on the trace test, the cointegration rank was found to be three rather than two in the full sample. The fact that the full sample was a mixture of a credit regulated and a deregulated period is likely to explain the difference in cointegration rank.

The estimated cointegration relations together with the estimated adjustment coefficients tell the following story of inflation, unemployment, and interest rate dynamics in the period after credit regulation:

1. The first relation shows that inflation rate and the interest rate spread have been positively co-moving over the sample period. Inflation has been equilibrium correcting and the real long-term bond rate has reacted positively to this relation.

2. The second relation shows that the unemployment rate and the real long-term bond rate have been positively co-moving describing a Phelpsian natural rate of unemployment. Inflation rate is negatively affected by the unemployment gap consistent with a Phillips curve effect, the unemployment rate is equilibrium correcting, and the real long-term bond rate is positively affected by the gap.

3. The third relation has the property of a central bank policy rule: the long–short spread has been positively co-moving with the unemploy-

Table 6: The estimated cointegration relations

	Δp	u	rb	spr	μ_0
The CVAR for 1987:1-2010:4					
β_1	**1.00**	0.00	0.00	**−0.69** [−3.07]	**−2.06** [−3.55]
α_1	**−0.39** [−5.26]	−0.01 [−0.46]	**0.42** [5.82]	0.03 [0.65]	
β_2	0.00	**1.00**	**−1.20** [−5.53]	0.00	**−3.25** [−2.53]
α_2	**−0.19** [−3.78]	**−0.05** [−3.67]	**0.19** [3.93]	0.02 [0.58]	
β_3	**0.29** [3.80]	**−0.19** [−7.72]	0.00	**1.00**	0.00
α_3	**−0.39** [−3.06]	−0.05 [−1.45]	**0.35** [2.81]	**−0.33** [−4.76]	
The CVAR for 1995:1-2010:4					
β_1	0.00	0.00	0.00	**1.00**	**−0.82** [−4.35]
α_1	0.29 [1.61]	**−0.11** [−3.08]	**−0.40** [−2.33]	**−0.24** [−5.65]	
β_2	0.00	**1.00**	**−1.80** [−13.43]	0.00	**−3.96** [−8.98]
α_2	**−0.31** [−2.17]	**−0.18** [−6.03]	**0.32** [2.37]	0.01 [0.37]	
β_3	**1.22** [7.47]	**−0.43** [−10.40]	0.00	**1.00**	0.00
α_3	−0.11 [−0.66]	**0.18** [4.98]	0.09 [0.53]	**−0.13** [−3.12]	

ment rate and negatively with the inflation rate. The spread is equilibrium correcting, inflation has gone down when the spread relation has been above its steady-state level and so has unemployment rate, albeit not very significantly so, whereas the real bond rate has gone up.

These are all economically plausible results which are broadly consistent with the STR results. The estimate of the unemployment gap effect in the inflation STR model was -0.14 and -0.19 in the CVAR. The estimate of the real bond rate effect in the natural rate relation was 2.2 in the STR model and 1.2 in the CVAR.

For the second period the rank test again suggested three cointegration relations. The structure has one overidentifying restriction which was accepted based on $\chi^2(1) = 0.05[0.82]$. Together with the adjustment coefficients they describe the following mechanisms:

1. The first relation shows that the interest rate spread can be considered a unit vector in the space spanned by β for this period. It is autoregressive in itself and has a positive effect on the real bond rate.

2. The second relation describes the Phelps unemployment gap relation where the coefficient to the real long-term bond rate in the natural rate relation is now somewhat higher than for the longer sample and closer to the STR results. Unemployment is equilibrium correcting. A positive unemployment gap has a negative effect on inflation consistent with a Phillips curve effect, but with a borderline significant adjustment coefficient. The real bond rate is positively affected by the unemployment gap.

3. The third relation has the property of a central bank policy rule describing the spread as a positive function of unemployment rate and a negative function of inflation. It resembles the third relation of the longer period but the size of the coefficients has increased. This may suggest that the central bank has reacted more strongly to unemployment and inflation when the worst of the crisis is over. The spread is equilibrium correcting. Unemployment is positively affected when the spread is above its steady-state value, whereas inflation rate is not significantly affected.

Qualitatively the results are similar for the two periods. The largest difference is associated with the implied monetary policy rule and its effect on the system. In the post credit deregulation period, which includes the crisis years, unemployment is not significantly reacting to changes in the policy rule, whereas inflation is. In the second period, which does not include the worst crisis years, unemployment rate is again significantly reacting to the central bank policy rule, whereas inflation rate is not. This can be interpreted as some evidence of a Koo effect: In a period of balance sheet re-consolidation, economic activity is likely to be low independently of the level of the central bank interest rate.

8 Concluding discussion

Finland experienced a real estate bubble almost two decades before the more recent US real estate bubble burst in 2007 followed by a large number of other similar cases around the world. Can we learn anything useful from the Finnish experience? Even though this paper focuses only on a small part of the ongoing policy debate, it is the relationship between inflation and unemployment that is crucial for a balanced mix between fiscal and monetary policy. With the caveat that some of the conclusions may not be robust to expanding the information set, we believe our results may help to shed light on inflation, unemployment and interest rate dynamics in the period after the abolishment of most of previous restrictions on credit and capital.

Our approach was first to learn about the basic mechanisms based on a linear CVAR. Provided the correct mechanism is non-linear, the CVAR approach will of course only deliver average effects over the sample period. While it is hard to know a priori whether such results make economic sense, the first CVAR results turned out to be quite good: the estimates of the constant and the real interest rate effect in the natural unemployment rate relationship were plausible; inflation and the natural rate gap were negatively related, and the adjustment took place in the inflation rate equation as expected. Nevertheless, there were quite large differences between the estimates from the linear CVAR and the two-regime STR models for unemployment and inflation, respectively.

The STR results also showed that the bursting of the bubble defined a structural break for inflation rate rather than just a regime shift. When the STR model for the unemployment rate was respecified by including lagged unemployment, the results suggested a similar regime shift at the time when the bubble burst. This turned out to be the reason why the CVAR and the

STR results differed so much: the CVAR estimates were basically average effects from two different structural regimes. As the most significant structural change in this period is likely to be associated with a major deregulation of credit and capital movements in 1986, the CVAR was re-estimated for the period characterized by credit deregulation. The new results from the CVAR and the STR models became now much more aligned to each other.

By combining the CVAR and STR analyses the paper was able to provide a plausible description of the dynamics of inflation, unemployment and interest rates in an econometrically and economically very difficult and demanding period. We found that (1) inflation and the interest rate spread was co-moving, describing a relation between actual and expected inflation, (2) unemployment and the real long-term bond rate were positively co-moving, describing a Phelpsian natural unemployment rate, and (3) the short-term interest rate relative to the long-term bond rate was negatively co-moving with unemployment rate and positively with the inflation rate, describing elements of a Taylor type monetary policy rule. The adjustment dynamics were generally plausible and interpretable.

Altogether, the results provide empirical support both for the Phelps Phillips curve with the natural rate being a function of the long-term real interest rate, for the Frydman and Goldberg IKE hypothesis of pronounced persistence of the real interest rate and the interest rate spread as a result of financial speculation, and for the Koo hypothesis of the weakening effect of central bank interest rates for economic activity in a balance sheet recession.

Interestingly the results also suggested that CPI inflation, contrary to unemployment, has not reacted in any significant way to changes in the central bank policy rule. One interpretation is that the determination of consumer price inflation after financial deregulation has been more strongly affected by the pressure to be internationally competitive rather than by excess domestic demand. This would be consistent with the hypothesis in Section 2 that in an IKE world where financial speculation drive the nominal exchange rates away from their fundamental values, enterprises are forced to use a pricing to market strategy to preserve market shares. In such a world, CPI inflation is likely to be determined in a Phelpsian customer market in which labor productivity and profit shares are adjusting much more than prices. The fact that unemployment but not CPI inflation was shown to react strongly to the estimated gaps in the model supports such an interpretation.

Taken together, the results suggest that an adequate empirical understanding of inflation, unemployment and interest rate dynamics in a world of credit and capital deregulation is crucial for understanding the scope of economic policy. What works well when capital markets are regulated may be counter-productive and risky when they are unregulated.

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