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 24, 2017

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 with the aim of finding out whether Finland suffered from a balance sheet recession after the collaps of the housing bubble.

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 very 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). Thus, such models lack features 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 a well-known case of a house bubble that was followed by a long balance-sheet recession (Koo, 2010), 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. At the same time Finland was hit by a serious external shock when the former Sovjetunion collapsed and abolished the previous bilateral trade agreement with Finland. A severe banking crisis in Sweden, a main trading partner of Finland, contributed to the severness of the crisis after the house bubble burst in 1990. As Figure 1 shows house prices dropped by roughly 60% and unemployment rose from a record low 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, 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 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

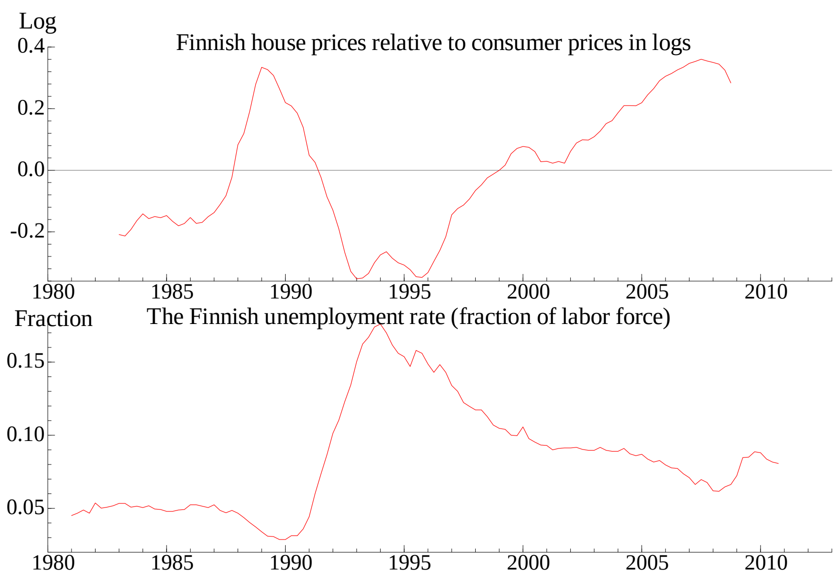

Figure 1: The development of real house prices and unemployment in Finland from 1983-2009.

are likely to be associated with financial market behavior [1]. Juselius (2013) 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.

The hypothesis that the Phillips curve has a unit root nonstationary natural rate is conveniently addressed in a Cointegration VAR (CVAR) analysis of inflation, unemployment and interest rates. 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 implies that inflation is negatively associated with unemployment. Friedman and Phelps (??) introduced the concept of a natural rate of unemployment which postulated that inflation is negatively related to the deviation from a constant natural rate. But in the seventies inflation and unemployment became positively co-moving in a so called stagflation relationship. This break-down of the previous 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 became a function of the domestic real interest rate. The structural slumps theory was, however, based on model consistent rational expectations and consequently real interest rates and real exchange rates were assumed stationary. This is contrary to empirical evidence that often finds that they are indistinguishable from a unit root process. Therefore, Juselius (2013) suggests that the structural slumps theory should be based on imperfect knowledge expectations to adequately explain the long persitent movements in the data. This is because in an Imperfect Knowledge Economy (IKE), financial behavior can be shown to drive assset prices persistently away from long-run benchmark values.

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

In an IKE economy the nominal exchange rate is primarily determined by financial speculation whereas prices of tradable goods, 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). Thus, relative prices would fluctuate much less than nominal exchange rates so that 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 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 (for example, as a result of an increase in the demand for capital) 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 thet real exchange rate keeps appreciating (a self reinforcing feed-back loop). In such a situation, we would expect the structural imbalances in the economy to be growing and so would the uncertainty premium. This would continue until the uncertianty premium has become large enough to cause a reversal in the exchange rate. Under this scenario we would expect the real interest rate differential and the real exchange rate to move in similar persistent swings (Frydman and Goldberg, 2007, Johansen et al., 2011). Under such conditions, one would expect enterprises to use customer market pricing (Phelps, 1994) or alternatively pricing to market (Krugman, 1993) as their pricing strategy rather constant mark-up pricing.

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. Under this scenario one would expect customer market pricing (Phelps, 1994) or alternatively pricing to market (Krugman, 1993) to replace constant mark-up pricing in a structural slumps economy with imperfect knowledge expectations. [2]

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

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

has a natural rate, $u^n = f(r)$, which is a function of the real interest rate, r.[3] Δp^e stands for expected inflation. How to properly measure expected inflation is not obvious. While model based rational expectations is a popular choice in the literature, such a choice is far from unproblematic as Castle et al. (2010) convincingly demonstrate. Under the assumption of imperfect knowledge the rational expections hypothesis is simply incorrect (Frydman and Goldberg, 2007, 2011). Because of this we have chosen to use the spread between the long and the short rate as a proxy for expected inflation.

Thus, the structural slumps theory in conjunction with IKE predicts that the unemployment rate and the real interest rate are co-moving both exhibiting similar persistent swings. If the two are cointegrated, then the unemployment gap $u^n - f(r)$ is likely to be less persistent than unemployment rate itself and Δp and $(u - u^n)$ 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

[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) and Juselius and Ordonez (2009).

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 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 Phelsian natural rate may not be an adequate description of inflation in a balance-sheet recession.

3 Empirical methodology[4]

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

3. The relationship among interest rates, unemployment and inflation will 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 (Johansen, 1995) for $x_t' = [\Delta p_t, u_t, rb_t, spr_t]$:

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

[4] All cointegration analyses have been done by CATS for RATS, Version 2.02, the STR analyses by the nonlinear least squares regression module in OxMetrics, partly by a program for calculating the Saikkonen and Choi estimator obtained by Choi. The graphs have been performed with OxMetrics.

where

- Δp_t is measured as $400(\Delta \log(CPI)_t)$,
- u_t as the percentage of the number of unemployed in the 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 interest rate spread as a proxy for inflationary expectations by the market as well as the central bank, with
  - s_t the short term interest rate,
- $Ds_{90,t}$ 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
  - $D_{p,90,t}$ accounts for the extraordinary shock in house prices at the onset of the crisis and
  - $D_{p94,t}$ accounts 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.

The sample consists of quarterly data 1982:2-2010:4. This period was to chosen to represent the In macroeconomic applications, the end of the seventies, beginning of the eighties typically represent a structural change from a more regulated to an increasingly deregulated world economy. Even though a major deregulation took place first in 1986 Finland as a small open economy was affected by this structural change. The choice of the first observation 1982:2 was based on the robustness in the results of adding one more observation in sensitivity. In retrospect 1986 might have been a more reasonable choice.

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

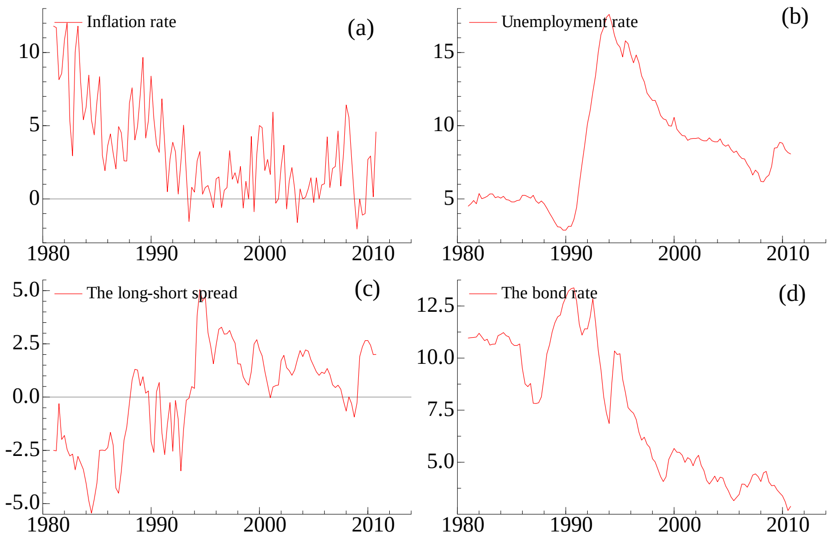

Figure 2: Panel (a) the annualized inflation rate, (b) the unemployment rate (c) the annual long-short interest rate spread and (d) the annual long-term bond rate. All in %.

fluctuations underways. 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 7 - 8 % which, albeit much lower than in the crisis years, was significantly higher than the pre-crisis level. This change in the unemployment level is the main reason for the 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 structural adjustments in the crisis years, she was fortunate to avoid the worst effects of this crisis. 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 consistent with a central bank policy rule of increasing its policy rate relative to the long-term rate as a result of inflation fear in the bubble period and lowering the rate when concerned about the high unemployment rates in the crisis and post crisis period.[5] 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.

3.2 Misspecification tests

With such dramatic changes over the 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 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. CVAR 1 can be said to represent the economist's approach: applying a constant parameter economic model to the data, whereas CVAR 2 the econometrician's approach: checking for structural change in the data.

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 but rather that there probably are 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.

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

[5] 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.

Table 1: Misspecification tests of the CVAR models for the period 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 [ ].

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 that are 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 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

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 [ ].

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:

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

where

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

The inflation rate is equilibrium correcting indicating that unemployment in excess of $u_t^n = 1.8(b_t - \Delta p_t) + 5.5$ 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

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**	**−1.10**	–	**−3.41**	
		[6.92]	[−4.97]		[−2.79]	
α_1	**−0.40**	−0.03	**0.43**	**−0.10**		
	[−5.09]	[−1.45]	[5.47]	[−2.46]		
β_2	–	**−0.70**	**0.82**	**1.00**	1.88	
		[−4.36]	[3.14]		[1.18]	
α_2	**−0.23**	0.01	**0.24**	**−0.17**		
	[−2.28]	[0.57]	[2.45]	[−3.46]		
CVAR 2						
β_1	**1.00**	0.15	**−0.52**	**0.63**	**−2.22**	–
		[1.53]	[−4.20]	[3.92]	[−2.66]	
α_1	**−0.54**	0.03	**0.57**	**−0.03**		
	[−6.16]	[1.36]	[6.57]	[−0.72]		
β_2	–	**1.00**	**−2.37**	**2.87**	**13.90**	**−17.85**
			[−6.14]	[4.77]	[4.70]	[−6.31]
α_2	**0.07**	**−0.04**	**−0.07**	−0.02		
	[2.36]	[−6.17]	[−2.43]	[−1.08]		

Note: t-values in [ ]

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 more persistent during the crisis period, still seem to be mean-reverting. Rather surprisingly the cointegration relations do not suggest that CVAR 1 is strikingly misspecified.

This visual check of cointegration properties needs to be complemented with a formal test of parameter constancy. The recursive test in Figure 4 of

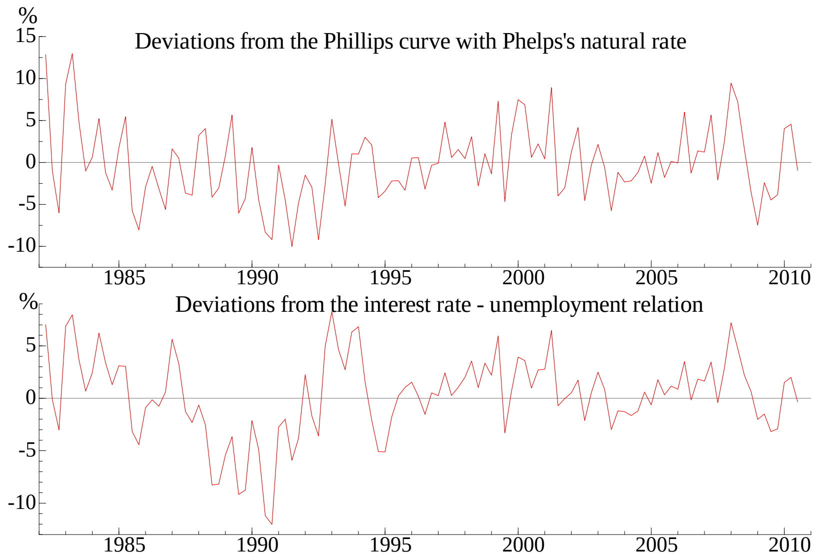

Figure 3: The two identified cointegration relations in CVAR 1.

parameter constancy of β is discussed in Hansen and Johansen (1999) and 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 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 CVAR 1, 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. Thus, the sample period is likely to define at least two regimes.

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 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, but

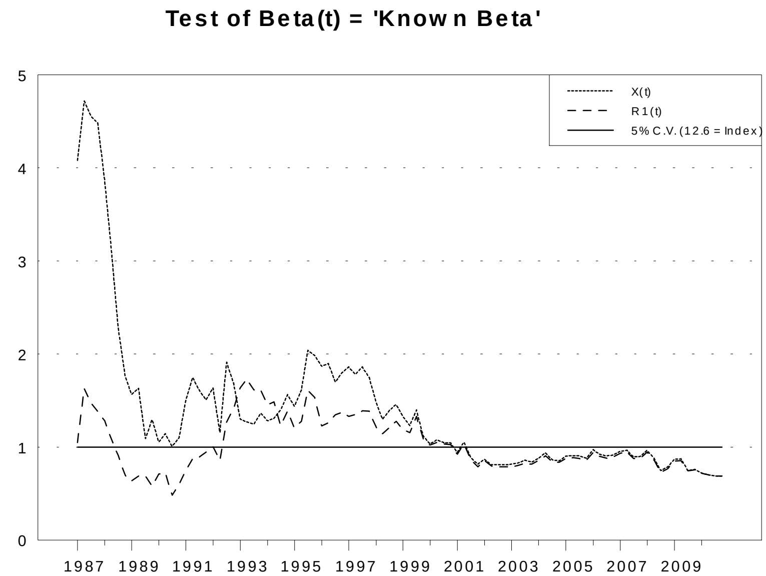

Figure 4: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ divided by its 95% quantile where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for Model 1.

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 consistent with a Phillips curve relationship. The graphs of the equilibrium errors in 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 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 short-term interest rate

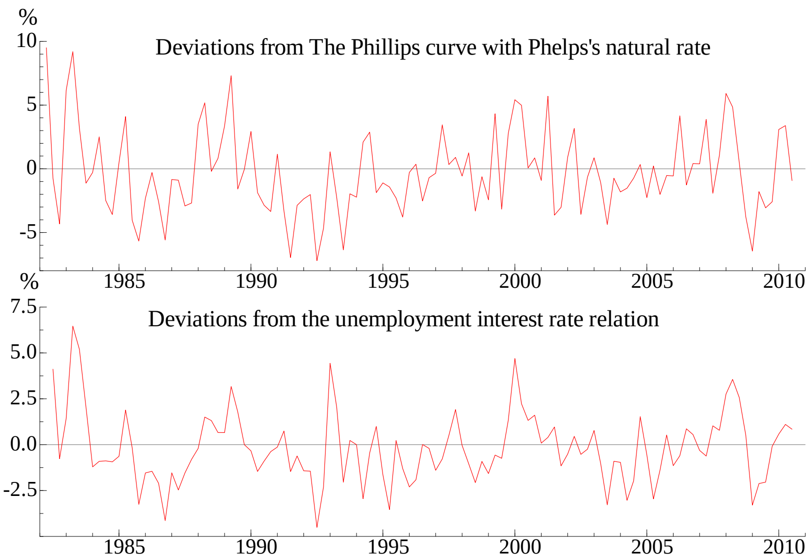

Figure 5: The two identified cointegration relations in CVAR Model 2.

may have helped to reduce unemployment rate. As for CVAR 1 the second relation is economically less unambiguously defined.

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 Phillips curve relationship with a Phelpsian natural rate (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)

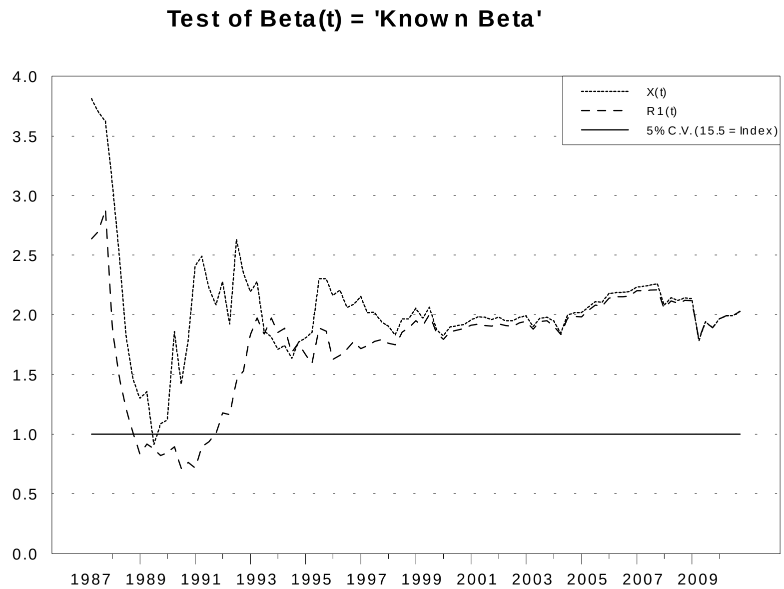

Figure 6: The recursively calculated tests of $\tilde{\beta} \subseteq sp(\beta_{t_1})$ divided by its 95% quantile, where $\tilde{\beta}$ is estimated for the subsample 1990:1-2010:1 for CVAR 2. Constancy is rejected when the test value is above the unit line.

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 Phelps 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.:

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

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 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 provided by Juselius and Upper (2013) defined as the households' real house debt relative to real disposable income:

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

with

- d_t^{HH} denoting household sector total debt,
- 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 in Section 4 were consistent with two equilibrium relations in the data: one describing a relation between the unemployment rate, 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.

Saikkonen and Choi (2004) show that a standard NLLS estimator for the paramters in (5) is consistent under fairly general conditions. However, when the residuals are correlated with the regressors, the NLLS estimator becomes

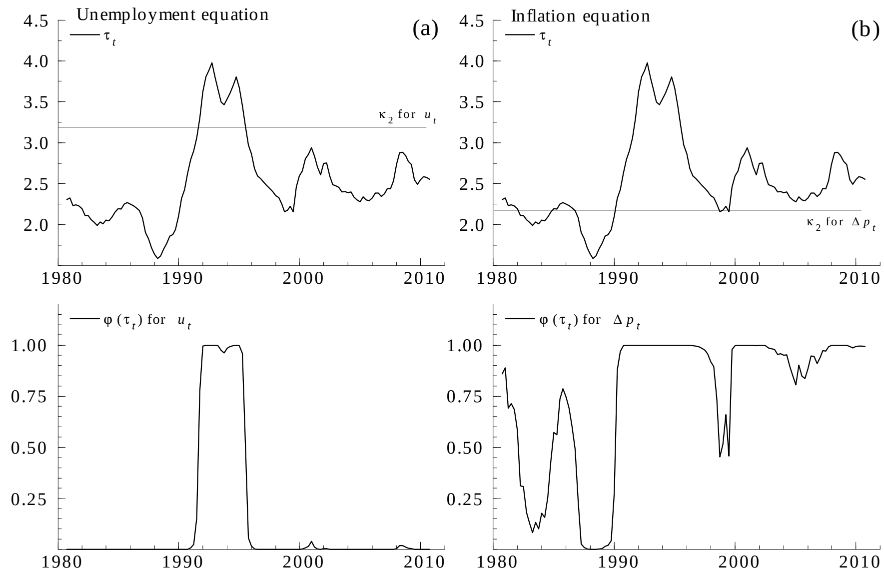

Figure 7: The transition variable and the transition function for unemployment and inflation rate.

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 also consider an efficient two-step Gauss-Newton estimator suggested by Saikkonen and Choi. This estimator corrects for the endogenity 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 $x_t' = (\Delta p_t, b_t, s_t) \equiv (b_t - \Delta p_t, b_t - s_t, b_t)$, where the latter 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 $x_t' = [(u - u^n)_t, s_t, b_t]$ where u^n is defined by (6) below. In addition we include a step dummy, $D_{s,94,t}$, in the unemployment model to allow for a permanent shift of the level unemployment rate after the EU referendum in 1994:1.

The transition variable and the transition function are depicted in Figure 7 for the two models. Table 4 reports the STR model estimates, Table 5

Table 4: Regime shift cointegration relationships for 1982:2-2010:4

STR model for unemployment rate

	κ_1	κ_2	D_{s94}		β_0	rb_t	spr_t	b_t
NLLS								
	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)
Gauss-Newton								
	12.34	3.20	5.41	Regime 1	1.92	0.58	–	–
	(1.4)	(22.4)	(6.4)		(6.6)	(2.4)		
				Regime 2	7.65	–	–	–
					(5.2)			

STR model for inflation rate

	κ_1	κ_2		β_0	$u_t - u_t^n$	b_t	s_t
NLLS							
	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)
Gauss-Newton							
	13.4	2.17	Regime 1	3.39	–	0.26	–
	(0.2)	(53.8)		(2.4)		(2.2)	
			Regime 2	0.18	−0.22	–	–
				(0.08)	(−1.90)		

Note: t-values in ( ).

some standard misspecification tests and Figure 8 illustrates the fit of the models and the residuals.

The models for equilibrium unemployment and inflation have been estimated both using the NLLS and the Gauss-Newton method. As it might be of som interest to see how sensitive the estimated results are to the choice of method we have reported both results in Table 4. A general finding is that the NLLS method is underestimating the standard error of estimates. As a consequence, some of the estimated coefficients by the NLLS method became insignificant by the G-N method. The joint test of setting insignificant coefficients to zero were tested with a Wald test. The five zero coefficients imposed on the unemployment model were accepted based on $\chi^2(5) = 4.37[0.50]$ whereas the four zero coefficients in the inflation model were only borderline acceptable based on $\chi^2(4) = 10.79[0.03]$. Because the G-N models are econo-

Table 5: Misspecification tests for the STR models

	Autocorr.	Norm.	ARCH
STR model for unemployment			
NLLS	F(5,98) = 63.5[0.00]	$\chi^2(2)$ = 5.0[0.08]	F(4,107) = 41.4[0.00]
G-N	F(5,105) = 38.2[0.00]	$\chi^2(2)$ = 13.1[0.00]	F(4,102) = 9.7[0.00]
STR model for inflation			
NLLS	F(5,98) = 2.5[0.03]	$\chi^2(2)$ = 2.6[0.27]	F(4,107) = 1.6[0.18]
G-N	F(5,105) = 9.1[0.00]	$\chi^2(2)$ = 0.5[0.77]	F(4,102) = 3.8[0.01]

Note: P-values in [ ].

metrically more correct with more interpretable and plausible results, the subsequent discussion will focus primarily on this method.

In the unemployment nodel there is evidence for a nonlinear regime shift of the smooth transition type but the estimated speed of adjustment coefficient, $\kappa_1 = 12.34$ is not strongly significant. The coefficient suggests that 90% of the transition takes place in the interval where $3.02 \leq \tau_t \leq 3.38$ with the half way point estimated at $\kappa_2 = 3.20$. Interestingly, the latter corresponds exactly to the onset of the banking crisis in 1991:3. The graph in Figure 7 panel, (a), shows that the crisis regime comprises only the three worst years of unemployment suggesting that they were truly anomalous years. Table 4 reports the estimates for unemployment based on the N-G method:

$$\begin{aligned} &\text{Regime 1:} \quad u^n = 1.92 + 0.58(b_t - \Delta p_t) + 5.41 D_{s94.1,t} \\ &\text{Regime 2} \ : \quad u^n = 7.65 \end{aligned} \tag{6}$$

In Regime 1 the estimated coefficient of the long-term real interest rate is consistent with the Phelps's natural rate hypothesis but with a rather small coefficient compared to the cointegration results of the previous section, whereas in Regime 2 there is no longer evidence of a significant interest rate effect. This result seems broadly consistent with the Koo hypothesis that the effect of the interest rates is completely different during a balance sheet recession. Figure 8, panel (a) depicts actual and fitted values and panel (c) the residuals. While the model seems to closely describe the Finnish unemployment, the residuals suggest that equilibrium unemployment is systematically either under or overestimated for much of the period. This is consistent with the test results in Table 5 which shows that the model suffers from residual autocorrelation. Thus, the significance of the estimated results may not be

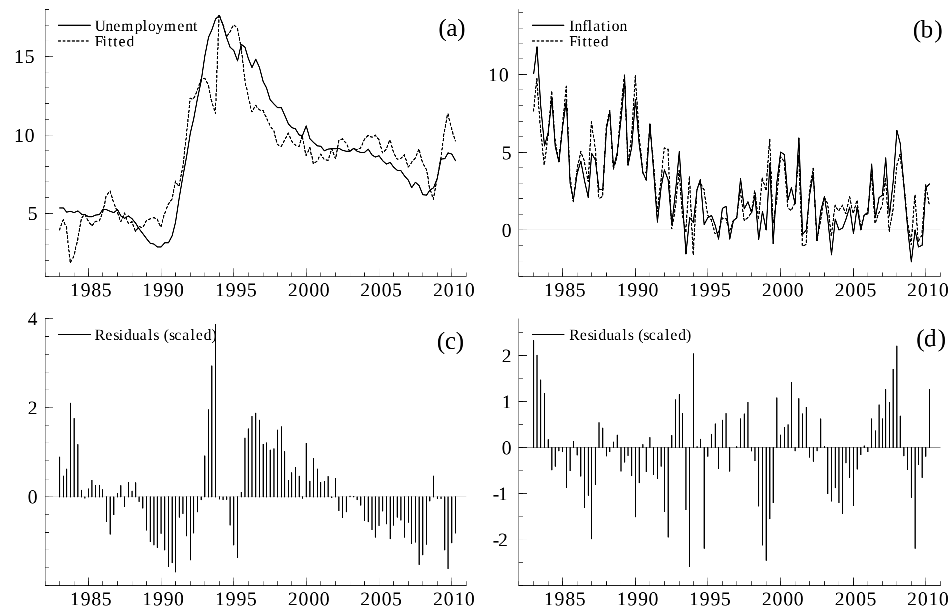

Figure 8: The graphs of fitted and actual unemployment the scaled residuals (left hand side panels) and of inflation rate (right hand side panels).

totally reliable and we shall, therefore, try to address this problem in the next section.

The lower part of Table 4 reports the estimated Phillips curve relationship for the inflation STR model

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

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 shows evidence in support of a Phelps Phillips curve relationship, but also here with a smaller coefficient than in the cointegration model of the previous section. This seems to suggest that the first regime is the "non-normal" one in contrast to the second regime which seems more normal. This may not be so surprising: The first regime covers both a period of financial regulation, 1982-1985, and a period of financial deregulation, 1986-1990, of which the latter was characterized by an accelerating housing bubble and an overheated economy. The speed of adjustment coefficient, $\kappa_1 = 13.4$, is completely insignificant and suggests a sharp shift between the two regimes rather than a smooth transition. In fact 9?% 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. Thus, the results suggest that the Finnish inflation rate was subject to a structural break 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 panel (d) that the residuals are moderately autocorrelated consistent with the test results in Table 5.

Altogether, the results can be interpreted to provide broad support for the Phelpsian natural rate hypothesis and for Koo's hypothesis of a weakening interest rate effect after the bursting of a real estate bubble. But the results also raise the question why the size of the coefficients differed so much between the CVAR and STR analyses. This will be addressed in the next section.

6 Addressing the autocorrelated residuals in unemployment

The CVAR results in Section 4 seemed broadly consistent with a Phillips curve with a Phelpsian natural rate relation, but were to some extent challenged by the STR results. The latter suggested a lower real interest rate effect in the natural rate effect and a lower unemployment gap effect in the inflation model.

Furthermore, the STR inflation model indicated that the beginning of the crisis period defined a break rather than a smooth transition to a new regime whereas the unemployment STR model showed that the period of of extremely high unemployment rates, 1991:3-1995:1, belongs to a different regime. But, while the inflation model was moderately well specified, the residuals of the unemployment model were strongly autocorrelated residuals casting doubts on the validity of the statistical inference in that model. Therefore, as a sensitivity check we re-estimated the unemployment STR

Table 6: Estimated regime shift cointegration relationships for the period 1982:2-2010:4

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 (2.6)	2.47 (23.0)	0.95 (56.4)		−0.79 (−4.2)	1.11 (4.4)	–	0.04 (1.5)	−0.10 (−4.9)
Steady-state solution:				−15.8	22.2		0.8	−2.0
			Regime 2					
		0.95 (56.4)		−0.79 (−4.2)	0.70 (2.3)	0.11 (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: $\chi^2(2) = 19.1$								

Note: t-values in ( ).

model (5) allowing for a lagged unemployment rate:

$$y_t = (1 - \varphi(\tau_t))(\beta_{10} + \beta'_{11}x_t) + \varphi(\tau_t)(\beta_{20} + \beta'_{21}x_t) + \rho y_{t-1} + \Gamma S_t + \varepsilon_t, \quad (7)$$

where ρ is a measure of unemployment persistence. Table 6 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, i.e. almost exactly the same regimes as for the inflation rate in Table 4. This should not be interpreted to mean that 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 6 shows that it is the effect of the interest rates on unemployment that distinguishes Regime 1 from Regime 2. In Regime 1 (characterized by capital deregulation, excessive spending, fast developing real estate prices and inflationary expectations) the effect of the real long-term bond rate was insignificant and set to zero, whereas the nominal bond rate had a significantly negative effect. As the bubble kept inflating the demand for labor kept increasing in spite of increasing long-term and short-term interest rates.

Similar behavior has been 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 compared to the STR estimate, 0.58, in Table 4 and it is much closer to the estimate,1.8, in (4). Thus, the divergence between the CVAR and the STR estimation results for the natural rate is likely 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. Altogether the results provide strong support for the Phelps natural rate of unemployment in the post bubble period.

7 Concluding discussion

Finland experienced a real estate bubble almost two decades before the burst of the more recent US real estate bubble in 2007 which was followed by a large number of other similar cases around the world. Can we learn anything useful from the Finnish experience? While every country has her own idiosyncracies, we still believe there are some general lessons to be learned from our results that can shed light on the dynamics of inflation, unemployment and interest rates in an econometrically very challenging period of post capital deregulation. With the caveat that some of the conclusions may not be robust to expanding the rather small information set, it is nonetheless the relationship between inflation and unemployment that is crucial for a balanced mix between fiscal and monetary policy.

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 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.

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.

8 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 trace test finds that the cointegration rank is three in the deregulation period rather than two for the full sample. *A priori* one would expect to find more cointegration in the absense of binding regulations. The upper part of Table 7 report the results for a just-identified structure of cointegration relations based on the period 1987:1-2010:4.

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 7: 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 its adjustment coefficient is only borderline significant. 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 term spread is equilibrium correcting. Unemployment is positively affected when the term 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.

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.)

9 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.

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”, J*ournal 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, Microfoundations for Modern Macroeconomics, Princeton University Press, Princeton.

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.

Miller, M. and J. Stiglitz (2010), "Leverage and Asset Bubbles: Averting Armageddon with Chapter 11?, *The Economic Journal,* 120, 500-518.

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.