EFRI Exclusive Working Papers 2016-002

Spectral Analysis in Modelling and Forecasting Changes in the Unemployment in Croatia

Vesna Buterin*

* Faculty of Economics, University of Rijeka, Croatia

This research was supported by the
Faculty of Economics, University of Rijeka
https://www.efri.uniri.hr/en
ISSN:

Faculty of Economics, University of Rijeka
I. Filipovića 4, 51000 Rijeka, Croatia

EFRI WORKING PAPER SERIES

SPECTRAL ANALYSIS IN MODELLING AND FORECASTING CHANGES IN THE UNEMPLOYMENT IN CROATIA[1]

Marinko Škare
Department of Theoretical Economy, Juraj Dobrila University of Pula, Faculty of Economics and Tourism "Dr. Mijo Mirković", Pula, Croatia
E-mail: mskare@unipu.hr

Vesna Buterin[2]
Department of Theoretical Economy, University of Rijeka Faculty of Economics, Rijeka, Croatia
E-mail: vesna.buterin@efri.hr

ABSTRACT

Changes in the unemployment in Croatia are largely permanent. Unemployment behaviour in Croatia shows evidence of cyclo-stationarity caused by seasonal employment effects. However, transitory movements account for most of the unemployment dynamics after 2008. Unemployment series is non-stationary but mean-reversing, non-linear with structural breaks and significant white and red-noise in the data. This paper estimates Multivariate singular spectrum model (MSSA) to explain overall fluctuations in unemployment registered during 1998 – 2013. We use 88 time series (variable) to explain observed fluctuations with our MSSA model explaining 76% of the total unemployment variance comprehensively. Evidence of this study demonstrates that unemployment phenomena should be modelled by using a non-linear model with multivariate singular spectrum models giving more robust and empirically valid results in relation to standard modelling techniques. A 5-6 years limit cycle for unemployment is isolated dominating unemployment behaviour in Croatia over the last two decades.

[1] When citing this paper please refer to altered and modified version of this paper: Škare, M., Buterin, V. (2015). Modelling and Forecasting Unemployment Nonlinear Dynamics Using Spectral Analysis*,* Inzinerine Ekonomika-Engineering Economics, Vol. 26, No. 4, pp. 373-383.

[2] The financial support from the Faculty of Economics, University of Rijeka, Rijeka, Croatia is gratefully acknowledged.

Keywords: Multivariate singular spectrum analysis, Unemployment, Non-linear, Persistence, Causality, Croatian disease, Partial Hysteresis, Spectral methods

1. INTRODUCTION

This paper is the first to explore unemployment nature and determinants in Croatia in a comprehensive way (88 time series/variables analysed) and using non-linear multivariate singular spectrum modelling. Empirical findings from the study both contribute significantly to the body of literature on unemployment in Croatia and offer valuable practical knowledge to policy makers to address one of the biggest issues Croatian economy has been facing over 24 years. Unemployment causes persistent and pronounced adverse effects on the economy. Economic policy designed to address the issue of unemployment is often inadequate and inefficient. To deal efficiently with unemployment, one must know the true nature of unemployment, i.e. what causes unemployment and its determinants behind. Without this empirical knowledge, policy makers design economic policies having adverse effects on the economy. The biggest issue from the last economic crisis is sluggish fall of unemployment despite the economy's slow recovery. This raises several questions on the nature of unemployment such as: Is unemployment following a random walk (Hysteresis theory) or natural rate of unemployment? What drives natural rate of unemployment rise and are cyclical or structural components of unemployment responsible?

Unemployment has hit hard transition economies. A hit has been particularly hard for the Croatian economy with unemployment rates among the highest in the EU making unemployment the biggest issue for Croatia right now. The economy is still falling with stagnating unemployment mostly because of the favourable seasonal effect coming from the tourism industry. Several constraints do arise when one investigate the nature and determinants of unemployment in Croatia. Short time series and noisy data are at the top followed by stationarity (Furuoka, 2014) and non-linearity. Our study results show that unemployment in Croatia is non-stationary and non-linear with a long memory and adverse effects lasting in the long run. Empirical results of this study point to the possibility that unemployment in Croatia is a cyclo-stationary process because of strong seasonal effects spreading from the tourism industry. With a time series with such statistical characteristics, appropriate empirical modelling is not an easy task. Previous studies in Croatia on unemployment followed the premise of that unemployment is either I(0) or I(1). Investigations in earlier articles show unemployment in Croatia is neither I(0) nor I(1) but fractionally integrated (Škare, Stjepanović 2013). In fact, unemployment is non-stationary and means reverting but mean reversion acts in the very long run (long range dependence or long memory). We find evidence also unemployment having dual long memory – both in the conditional mean and conditional variance. All evidence points to a single conclusion – unemployment in Croatia is a process with complex behaviour having long-lasting, although not permanent effects. This finding is rather important, and it is not falling within standard theory notion of unemployment being transitory or permanent in nature. From this notion itself, i.e. unemployment having permanent or transitory behaviour, policy makers design what they think is the appropriate policy action. For example, if unemployment in Croatia is transitory, monetary and fiscal policy in place now is acting pro-cyclically. Our study results offer strong empirical evidence to resolve this issue.

In fact, factors behind unemployment dynamics in Croatia are both structural and cyclical in nature. Unemployment has long lasting but not permanent effects on the economy with unemployment negative impact lasting over 20 years before reverting to the natural unemployment rate. This means that active monetary and fiscal policy is needed to restore the initial equilibrium level. No policy action is also an option, but, in that case, negative effects of the unemployment will keep pounding the economy over 20 years.

Another critical empirical finding of this study is the cyclical nature of unemployment. Unemployment in Croatia exhibits quite remarkably precise 5-6 years business cycles recurring timely. This is indeed very important since a theory of unemployment having cyclical behaviour has been widely ignored. Unemployment in Croatia is indeed cyclical in nature following a 5-6 years cycle having five such episodes in the last 24 years. Our model suggests that unemployment in Croatia us settling down (stagnating) and the current cycle is showing signs of its end. This cyclical behaviour of unemployment is both important from theoretical and practical point of view. If empirical results of this paper are validated by other studies and researchers, then a ‘partial Hysteresis’ hypothesis should be recognized with unemployment since both Hysteresis and the natural rate of unemployment hypothesis in Croatia are true. Both Hysteresis and the natural rate of unemployment govern unemployment dynamics in Croatia causing cyclical behaviour and observed 5-6 years cycles.

A new issue is the possible negative effect of Croatian disease[3], i.e. cyclo-stationarity in unemployment caused by strong seasonal effects in the tourism industry. In the short run, seasonal unemployment effects can alleviate high unemployment issue but in the long run it can be rather a cause of high unemployment and not the solution (possible de-industrialization, jobless growth, net employment change threshold effect).

This paper seeks to encourage further research on phenomena of unemployment in Croatia, in particular, non-linear studies and studies addressing Hysteresis and the natural rate of unemployment issues. This means that cyclical unemployment behaviour is not essentially linked only to economic cycles, but a part of its cyclical behaviour is caused by its permanent/transitory components (Hysteresis and the natural rate of unemployment dynamics).

This study extends previous research of both theory and methodology on unemployment in Croatia. Earlier studies do not address the long memory issues in the unemployment or ‘partial Hysteresis’. This is not the case only for the existing literature on unemployment in Croatia. To the best of our knowledge, only a few papers explore unemployment dynamics using singular spectrum analysis and possibly none in Croatia.

[3] Croatian disease – cyclical and seasonal effects in the tourism industry as the main sector in the economy leading to cyclical effects in the total economy.

The paper is structured as follows. While section 2 provides a literature review on different unemployment theories; the methodology of the paper is described in section 3. Section 4 offer analysis and empirical findings of the paper by using MSSA modelling with concluding remarks and discussion on the findings in section 5.

2. LITERATURE REVIEW OF UNEMPLOYMENT FLUCTUATIONS

In this section, we provide a review only of those studies that are closely connected to the subject of this paper and that of the studies investigating unemployment in Croatia. The Hysteresis issue has been thoroughly addressed by Blanchard et al. (1987) and Jaeger and Parkinson (1994). Empirical findings are mixed with unemployment time series having random walk properties and others fractional integration with Hysteresis remaining an open discussion. Unemployment dynamics has often been linked to the natural rate of unemployment and its transitory/permanent behaviour. Well known are the studies on the subject by Blanchard et al. (1986, 1996), Sargent (1973), Juhn et al. (1991), Staiger et al. (1997), Stiglitz (1997), Friedman (1968), and Phelps (1998; 1968; 1967; 1994). Different views on the theory of the natural rate of unemployment are known in the body of economic literature but the unique equilibrium value of unemployment can hardly be observed if we do not possess sufficeint quantitative knowledge on the natural rate permanent/transitory components. A known non-linear long memory model for the US unemployment developed by van Dijk et al. (2002) shows non-linear modelling that outperforms the related standard various models in fitting unemployment. Fractionally integrated approach to the subject of long memory unemployment has been extensively covered by Gil-Alana (2003) and Caporale (2008; 2007; 2009).

The possibility of fractional integration in macroeconomic variables for Croatia is studied in Škare and Stjepanović (2013). Studies on unemployment in Croatia investigate labour market mismatch as in Tomić and Domadenik (2012), Tomić (2014) and Obadić (2006), long-term unemployment Botrić (2009) and labour market differences Botrić (2004). Unemployment determinants in Croatia have been investigated in Škare (2001) and structural unemployment in Botrić (2011). The impact of regional differences on self-employment in Croatia is analysed in Botrić (2012). The active labour market policy impact has been investigated in Babić (2003) and labour market structure in Rutkowski (2003). The impact of education on the labour market and long run unemployment consequences have been thoroughly investigated in Bejaković (2003; 2006). Empirical econometric papers dealing with fractional integration and non-linearity in the unemployment series in Croatia as well empirical econometrics paper are missing and one close to the issue we address here can be found on natural rate of unemployment in Croatia is Šergo et al. (2009). Inflation – unemployment relationship in the Phillips curve framework for Croatia is studied in Šergo et al. (2012). Blažević (2013) studies the impact of minimum wages on employment in Croatia finding weak evidence to support the trade-off hypothesis.

3. DATA AND MULTIVARIATE SINGULAR SPECTRUM ANALYSIS METHODOLOGY

In this paper, we construct a set of a large database including 88 time series variables (see table A1) covering the monthly data from 1990 to 2013. Data were collected from the Croatian national bank online and published databases, IFS financial statistics, Croatian statistical office online and published databases covering the period 1990-2013.

Because of the monthly data constraints, instead of using GDP we use the index of industrial production facing the problem of missing data in the time series. To resolve the problem of missing data (particularly from 1990-1992 and 1998-2000), we reconstruct data using SSA Reconstruction/Prediction filter (Kspectra program 3.4) following (Harvey 1990), (Hamilton 1994), (Priestley 1981). Time series data (variables) used in this study are listed in the appendix (see table A1). Following standard multivariate singular spectrum analysis procedure to identify statistically relevant oscillations and limit cycles, from a set of 88 time series 21 time series (variables) were selected backed by data availability, theoretical prior research (theory) and the pre-processing analysis

(PCA-MSSA screening) as limit cycle (oscillations) candidate for the MSSA study of unemployment dynamics in Croatia over 1990-2013 time period.

3.1. Spectral Analysis Techniques

Spectral techniques are used in this study to analyse, explain and capture the unemployment trajectory in Croatia over the observed period. Since too many missing data were for the sample from 1990-2013 we decide to use a sample with only a few missing data in the time series, i.e. monthly data sample from 1998-2013. The spectral analysis technique is used to decompose unemployment series into different frequency band paths over the phase space. Capturing different frequency bands spectrum overall variance in the unemployment behaviour the nature of unemployment can be explained, and unemployment primary sources and determinants isolated. The evaluated spectrum shows periodicity and large oscillations in the unemployment series behaviour over the sample. In this paper, we use Squared Coherency (same as R^2 in a linear time domain).

3.2. Choice of Modelling Techniques

Coherency measure captures the proportion of the variance in the unemployment in a given frequency point explicated by the variance in the 88 selected individual time series (variables). Standard spectral analysis models usually refer to coherency spectrum as the R^2 exposing the proportion of variance in unemployment that can be explicated by the variance in another individual time series (bivariate spectral analysis). The rule of thumb is to considerate coherence measure around 0.50 is moderate and > 0.75 as statistically significant. Empirical results from the coherency analysis were used to select potential candidates for the MSSA model from a set of 88 time series. Results of the coherency spectrum analysis due to space constraint are not presented here.

Building an MSSA of unemployment for Croatia involves: decomposition and reconstruction. Decomposition is carried by embedding the original time series (88) into lagged vector sequences of the form (trajectory matrix) following Golyandina et al. (2013) and Ghil et al.(1997; 2002; 1996), Kimoto and Ghil (1993).

Original unemployment series is first decomposed into reconstructed series, to isolate the trend, periodic components and oscillatory components. SSA is extended to the multivariate singular spectrum (multivariate input channels – time series/variables) analysis of unemployment to get more robust empirical results due to unemployment complex behaviour failed to capture with singular spectrum analysis.

To test for the statistical significance of the identified oscillatory channels (extracted spectral components) we use a Monte Carlo test (MC-SSA) Allen et al. (1996) against red noise null hypothesis following AR(1). (For more details see Ghil et al. (1996; 1997; 2002).

We also check the robustness of MSSA results (statistical significance of isolated oscillations), with a comprehensive causality test based on singular spectrum analysis following Hassani et al. (2010).

Granger causality test (based on SSA) takes the form

$$F_{X|Y}^{(h,d)} = \frac{\Delta_{X_{K+H_x}|Y_{K+H_y}}}{\Delta_{X_{K+H_x}}} \qquad (1)$$

where $\Delta_{X_{K+H_x}} \equiv \mathcal{L}(X_{K+H_x} - \hat{X}_{K+H_x})$ representing mean square forecast error from univariate SSA, $\Delta_{X_{K+H_x}|Y_{K+H_y}} \equiv \mathcal{L}(X_{K+H_x} - \tilde{X}_{K+H_x})$ having X_T and Y_{T+1} (lagged differenced series) being a mean square forecast error from MSSA. The rule of thumb is $F_{X|Y}^{(h,d)} < 1$, Y_{T+1} Granger cause (better forecast) X_T and if $F_{X|Y}^{(h,d)} > 1$ no association between X_T and Y_{T+1} exists. A bivariate Granger causality (forecasting feedback) exists if both $F_{X|Y}^{(h,d)} < 1$ and $F_{Y|X}^{(h,d)} < 1$. To check forecasting statistical significance between SSA and MSSA forecasting techniques, Mariano and Diebold (1995) test of the form

$$S = \bar{D}\sqrt{\frac{n+1-2h+h(h-1)/n}{n\widehat{\text{var}}(\bar{D})}} \quad (2)$$

following Hassani et al. (2010) with $(\bar{D})$ being the sample mean of the vector D_t and $\widehat{\text{var}}(\bar{D})$ autocovariance of D_t is performed.

3.3. Methodological Issues

Developing a MSSA model for unemployment in Croatia demands that several methodological issues are addressed to deal efficiently the problem of oscillation-like fluctuations and noisy observation (background) noise. Few major issues are briefly considered here.

Groth et al. (2011) forward the problem of poor oscillation pattern identification under the condition of corresponding Eigen values similar in size. VARIMAX rotation for MSSA algorithm is used to address this issue. For further discussion on VARIMAX procedure Groth and Ghil (2011).

The number of observations (*n*) for all series n = 192 satisfying Granger and Hatanaka (1964) conditions for minimum *n*. All data are seasonally adjusted following Census X-13 ARIMA, detrended using Hodrick and Prescott (1997) and non-dimensionalized by dividing HP residuals with HP trend. To make comparison and impulse response analysis more flexible, all time series were divided by their standard deviations (normalised). Following Granger and Hatanaka (1964), Elsner and Tonis (1996), Golyandina et al. (2010) an optimal window length (temporal lag) was chosen considering a general rule m = $N_t/2$, $N_t/3$, $N_t/4$. Maximum m = 96 lag was selected and has been used in the analysis for Monte Carlo tests (1000 noise realisations) to trace statistically significant deterministic behaviour.

4. SPECTRAL DECOMPOSITION OF UNEMPLOYMENT – EMPIRICAL RESULTS

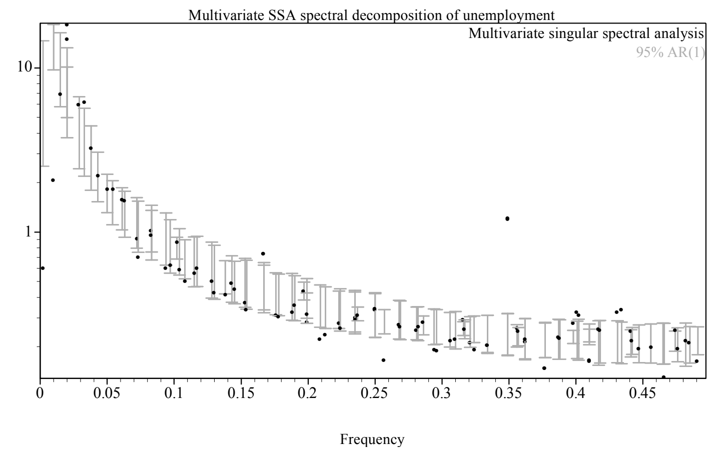
This section explains the results of the univariate SSA and multivariate MSSA spectral decomposition of unemployment in Croatia over 1990-2013. As expected, unemployment time series show a high level of persistence and long memory in the Granger (1966) sense. Trend component in the series is strong, with four SSA components explaining almost 92% of the variance in the unemployment series.

Deviations of the original unemployment series from SSA trend reconstructed show the impact of transitory shocks resulting from within and outside Croatian economy. First significant deviation (0-50 months) is a consequence of the war condition during 1990-1995. A substantial deviation from the trend occurred after the VAT introduction in 1998. Sharp deviation from the trend repapered in 2005 with continuous deepening after the crisis of 2008. The reconstructed trend shows evidence of high persistence in the unemployment series. Evidence is that shocks (cyclical effects) have a strong and persistent (long lasting) impact on the unemployment dynamics in Croatia. The structural break in the unemployment series resulting from the VAT introduction in 1998 was long lasting with shocks in the unemployment disappearing only after three years (mean reversion). Fiscal austerity policies in place after 2009 have a large impact on the unemployment dynamics. Because of the fiscal austerity measures, unemployment in Croatia has significantly shifted from its trend showing no sign of mean reversion soon. Seasonal effect on the unemployment is also present having persistent effects on the unemployment dynamics. During 1995-1998, unemployment had had a trend-in-mean dynamics with cyclical and seasonal effects being neutral to the movements on the labour market. This condition drastically changes after the VAT introduction and after being driven by public debt expansion. The crisis of 2008 completely changed the deficit spending policy resulting in sharp trend deviation in the unemployment series. Unemployment in Croatia during 1990's was mainly a consequence of structural changes in the economy (structural factors) with cyclical factors (shocks) dominating unemployment after 2005. Technology and sectoral shifts, diminishing importance of industry and rising service sector's (tourism) share in aggregate output tightened-up unemployment. This in turn made unemployment much more vulnerable to the seasonal and cyclical effects than ever before in history. Unemployment from structural phenomenon in 1990's shifted to the seasonal/cyclical phenomenon in the 2000's.

4.1. Multivariate (MSSA) Model of Unemployment

Previous section shows spectral decomposition for the unemployment series in Croatia using univariate SSA (unemployment time series alone) identifying statistically relevant oscillations between 12 and 20-month cycles. Since unemployment as a phenomena is a complex one, to study its true nature, another time series (that of aggregates) must also be addressed. This means that standard univariate SSA decomposition of the previous section should be extended to include several other time series variables (aggregates) that are expected to offer an explanation for the oscillations in the unemployment dynamics. In order to do that, multivariate SSA (MSSA) decomposition is used here. Using time series data for other 87 variables (see table A1), i.e. multichannel time series an MSSA model is used to study oscillations and co-movements between unemployment and various variables (time series). To detect important oscillations in the unemployment dynamics (Eigen value pairs), multichannel singular spectrum analysis (reduced covariance) of the unemployment series is applied. Results of the MSSA analysis are shown in figure 1.

Figure 1 Multivariate Singular Spectrum Analysis of Unemployment



Source: Author's calculation

Figure 1 show several signals (variables) that are possible candidates to explain the oscillatory behaviour of the unemployment series. Eigen value pairs that do not fall in the 95% Monte Carlo error band (from 1000 surrogate series), i.e. that are outside error band, pass the test as statistically significant oscillations. The red noise hypothesis (oscillations being background red noise) is rejected for Eigen value pairs (EOF's) 1-16, 19-20, 38-41, 43-47. To check that identified Eigen value pairs are statistically significant we check their phase dynamics (phase quadrature). Since the identified Eigen value pairs meet the phase quadrature test (not displayed here), there is indeed a statistically significant relation between unemployment and identified oscillatory components. The relation between unemployment dynamics and identified MSSA components (time series oscillators) is not a consequence of random shocks but related co-movements in the phase space (phase difference). Identified time series (statistically significant at 5% significance level) related to the shocks in the unemployment dynamics, i.e. oscillatory components related to changes in unemployment dynamics are:

Industrial production (energy) AE
Industrial production (intermediate goods) AI
Industrial production (capital goods) BB
Industrial production (durable consumer goods) CD

Industrial production (non-durable consumer goods) CN

Indices of stock (energy) AES

Indices of stock (intermediate goods) AIS

Indices of stock (capital goods) BBS

Indices of stock (durable consumer goods) CDS

Indices of stock (non-durable consumer goods) CNS

Croatian disease (share of employment in tourism in total employment) CD's(CD01)

Croatian national bank (international reserves) CBR

Core inflation CIP

Consumer price index CPI

Budget/surplus deficit BP

CNB discount rate DR

Industrial production (total industry Euro area 18 countries) EU

New entrants to the register - 4 (or more)-year vocational secondary school and grammar school NER4

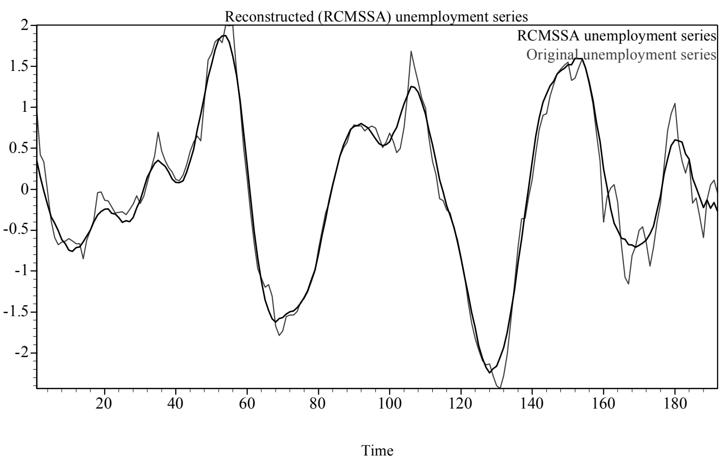
Loans to businesses (% share in total credits) CTE

New entrants to unemployment (first-time job seekers) NERFT

Nominal net wage NNW

Identified statistically significant oscillatory components (time series) explain 75.98% of the total variance in the unemployment dynamics in Croatia over the 1998-2013 period. Therefore, changes (shocks) in this time series can explain most of the changes in the unemployment dynamics that is visible from the figure 2.

Figure 2 Original and MSSA reconstructed unemployment series 1998-2013



Source: Author's calculation

Reconstructed unemployment series (black) using identified MSSA components (multivariate time series) fit the original unemployment series (grey) quite well. This is not surprising at all since changes identified multivariate components explain almost 76% of the total variance in the unemployment dynamics. Consequently, we can conclude that unemployment changes in Croatia during 1998-2013 can well be explained by movements (shocks) in identified 21 time series (multivariate components). Unemployment persistence (hysteresis) accounts for the most of the change in unemployment dynamics (18.92%). Multivariate SSA spectral decomposition of statistically significant time series components (oscillations) is visible from the table 1.

Table 1 Multivariate SSA decomposition of unemployment

Series	Frequency	Power	% of variance explained	% of cumulative variance Explained
UN	0.005	0.624	18.92	18.92
AE	0.01	2.462	15.46	34.38
AES	0.015	10.973	7.08	41.46
AI	0.02	18.975	6.37	47.83
AIS	0.025	10.342	6.1	53.93

BP	0.03	6.370	3.34	57.27
BB	0.035	6.046	2.26	59.53
BBS	0.04	3.127	2.13	61.66
CBR	0.045	2.302	1.87	63.53
CD	0.05	1.748	1.87	65.40
CD's (CD01)	0.055	2.103	1.61	67.01
CDS	0.06	1.918	1.58	68.59
CIP	0.065	1.415	1.25	69.84
CN	0.07	1.145	1.24	71.08
CNS	0.075	0.741	1.06	72.14
CPI	0.08	0.916	0.98	73.12
CTE	0.09	0.726	0.76	73.88
DR	0.101	0.735	0.76	74.64
EU	0.194	0.381	0.35	74.99
NER4	0.209	0.240	0.35	75.34
NERFT	0.22	0.273	0.33	75.67
NNW	0.24	0.234	0.32	75.99

Source: Author's calculation

When compared to the natural rate of unemployment series, we can conclude that hysteresis hypothesis is, in fact, true for Croatia. There is a large gap between actual unemployment and the natural rate of unemployment dynamics. Consequently, unemployment in Croatia is not following or converging to the natural unemployment path and show no sign of mean reversion. Under such conditions, an active economic policy is required since new equilibrium on the labour market can be reached only under high unemployment levels. At this point, unemployment becomes a significant issue in the long run with negative effects on the unemployment dragging economy and production down.

Industrial production (energy) accounts for 15.46% of the total variance in the unemployment dynamics. Businesses in Croatia on an average spend about 60% of their annual expenses on costs of goods and services and repeated change in the cost of energy have adverse effects on their business position on the market. When compared to the competition, firms in Croatia face much larger energy costs and low energy efficiency. After the start of 2008 crisis, electricity and natural gas prices increased significantly. This has caused adverse effects for a business that cut hiring resulting in job creation rate drop. Large fluctuations in the energy prices on industry after 2008 had a large negative impact on unemployment dynamics in Croatia.

4.2. Spectral Granger Causality analysis of unemployment

In this section spectral Granger causality is performed on the MSSA components (series) that we have identified previously as statistically significant and having an impact on unemployment dynamics. Granger causality results (see Table 2) confirm the results obtained from the MSSA analysis. Identified limit cycles (oscillatory pairs) thus in Granger sense have a significant impact on the unemployment trajectory path. Residual forecasting mean square errors are particularly low (meaning attractor skeleton reconstructed with MSSA model fits original unemployment series quite well) for industrial production of durable consumer goods *(CD)*, stocks of consumer durable goods *(CDS)*, consumer price index *(CPI)*, central bank discount rate *(DR)*, EU industrial production *(EU)* and nominal net wage *(NNW)*. Time series (variables) we identify as statistically significant affect unemployment trajectory path both in the short and the long run. Evidently, there is a strong Granger causality between them and the unemployment. Accordingly, we conclude that identified variables affect unemployment causing a shift (deviation) in the unemployment equilibrium trajectory when shocks do occur. No Granger causality is found for industrial production of intermediate goods, and weak Granger causality exists between unemployment and industrial production of consumer durable goods, industrial production of non-durable consumer goods. Spectral Granger causality in relation to standard (linear) Granger causality is quite robust, low noise level in the analysis (noise is removed using MSSA), causality is not previously fixed, test statistics not sensitive to model deviations. Further discussions on advantages of spectral

Granger causality analysis over standard linear Granger causality can be found in the research of Hassani et al. (2010; 2009; 2013a; 2013b) and Patterson et al. (2011). By using multivariate series in forecasting unemployment dynamics in Croatia we can significantly improve forecasting accuracy in relation to the univariate SSA forecasting of unemployment.

Table 2 Spectral Granger causality analysis between unemployment and identified series

Granger Causality Relation	Short run	Long run
MSSA forecast MSE of UN (AE as second series)	(AE $\rightarrow$ UN) 0.6181*	(AE $\rightarrow$ UN) 0.6359*
MSSA forecast MSE of *UN* (AES as second series)	(*AES* $\rightarrow$ *UN*) 0.6695*	(*AES* $\rightarrow$ *UN*) 0.5876*
MSSA forecast MSE of UN (AI as second series)	(AI $\rightarrow$ UN) 1.0734	(AI $\rightarrow$ UN) 1.3208
MSSA forecast MSE of *UN* (*AIS* as second series)	(*AIS* $\rightarrow$ *UN*) 0.6085*	(*AIS* $\rightarrow$ *UN*) 0.6224*
MSSA forecast MSE of UN (BP as second series)	(BP $\rightarrow$ UN) 0.6304*	(BP $\rightarrow$ UN) 00.7880*
MSSA forecast MSE of *UN* (*BB* as second series)	(*BB* $\rightarrow$ *UN*) 0.6403*	(*BB* $\rightarrow$ *UN*) 0.7879*
MSSA forecast MSE of UN (BBS as second series)	(BBS $\rightarrow$ UN) 0.7534*	(BBS $\rightarrow$ UN) 0.8743**
MSSA forecast MSE of *UN* (*CBR* as second series)	(*CBR* $\rightarrow$ *UN*) 0.5091*	(*CBR* $\rightarrow$ *UN*) 0.4671*
MSSA forecast MSE of *UN* (*CD* as second series)	(*CD* $\rightarrow$ *UN*) 0.9909**	(*CD* $\rightarrow$ *UN*) 0.9135*
MSSA forecast MSE of *UN* (*CD's* as second series)	(*CD's* $\rightarrow$ *UN*) 0.6327*	(*CD's* $\rightarrow$ *UN*) 0.6289*
MSSA forecast MSE of *UN* (*CDS* as second series)	(*CDS* $\rightarrow$ *UN*) 0.5395*	(*CDS* $\rightarrow$ *UN*) 0.5492*
MSSA forecast MSE of *UN* (*CIP*	(*CIP* $\rightarrow$ *UN*) 0.9621**	(*CIP* $\rightarrow$ *UN*) 0.9265**

as second series)		
MSSA forecast MSE of *UN* (*CN* as second series)	$(CN \rightarrow UN)$ 1.0079*	$(CN \rightarrow UN)$ 0.9922**
MSSA forecast MSE of *UN* (*CNS* as second series)	$(CPS \rightarrow UN)$ 0.9232**	$(CPS \rightarrow UN)$ 0.8801**
MSSA forecast MSE of *UN* (*CPI* as second series)	$(CPI \rightarrow UN)$ 0.5743*	$(CPI \rightarrow UN)$ 0.6542*
MSSA forecast MSE of *UN* (*CTE* as second series)	$(CTE \rightarrow UN)$ 0.8091**	$(CTE \rightarrow UN)$ 0.7276*
MSSA forecast MSE of *UN* (*DR* as second series)	$(DR \rightarrow UN)$ 0.5770*	$(DR \rightarrow UN)$ 0.5052*
MSSA forecast MSE of *UN* (*EU* as second series)	$(EU \rightarrow UN)$ 0.5977*	$(EU \rightarrow UN)$ 0.6288*
MSSA forecast MSE of *UN* (*NER4* as second series)	$(NER4 \rightarrow UN)$ 0.9162**	$(NER4 \rightarrow UN)$ 0.9056**
MSSA forecast MSE of *UN* (*NERFT* as second series)	$(NERFT \rightarrow UN)$ 0.8751**	$(NERFT \rightarrow UN)$ 0.9084**
MSSA forecast MSE of *UN* (*NNW* as second series)	$(NNW \rightarrow UN)$ 0.5356*	$(NNW \rightarrow UN)$ 0.5320*

Source: Author's calculation

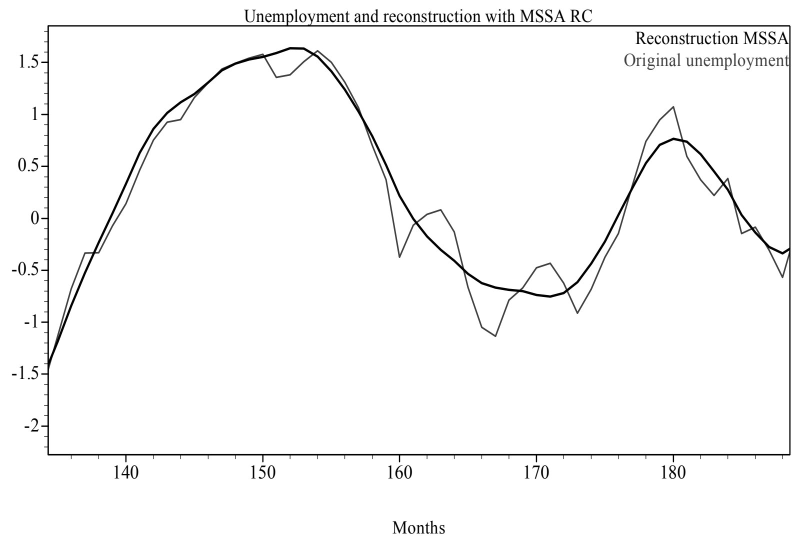
Notes. $(X \rightarrow Y)$ X Granger cause *Y* and $(Y \rightarrow X)$ Y Granger cause X

MSE – mean squared forecast error, $F^{(h,d)}_{X|Y}$ Granger causality multivariate spectral criterion, **,* *X* Granger cause *Y* at 1%, 5% significance level

Overall Granger causality test results show the existence of Granger causality between unemployment dynamics and time series we have used for the multivariate forecasting (MSSA model). Including considered multivariate series in attempt to understand non-linear and complex unemployment behaviour in Croatia is thus essential.

Using all identified oscillatory modes gives us a very good fit of the dynamic behaviour in the unemployment as it is visible from figure 3.

Figure 3 Unemployment and reconstruction with MSSA model RC



Source: Author’s calculation

Robustness of our MSSA model is checked by doing in-sample and out-of-sample test. In sample test displayed in the figure above show MSSA model with selected RC pass the in-sample test (RMSE and RRMSE values) capturing local variance and co-movements important for understanding unemployment dynamic behaviour. We also check the MSSA model with the out-of-sample test forecasting unemployment using our MSSA model.

RMSE, RRMSE forecast error values for a 12 step ahead forecasting for unemployment shows a high accuracy of the forecast compared to the actual unemployment data. Forecast errors are small with forecast values close to the real data. Forecast accuracy of our MSSA model is quite remarkable with identified limit cycles capturing 76% of the unemployment dynamic behaviour. Forecasting accuracy remains quite high even for a 24 step ahead forecast. After a 24 step ahead forecast, forecasting accuracy drops with MSSA model failing to capture the second cycle in the unemployment dynamics that reappeared in 2012. Our MSSA model fails to capture out-of-sample a 36 step ahead forecast's fluctuations registered in the unemployment behaviour during 2012 well capturing the dynamics in 2013. This could be due to other factors behind the fluctuations that our model did not capture using 88 time series variables, i.e. the remaining unexplained 24% of fluctuations in the unemployment over the 1998-2013 period. More likely, since the MSSA model capture extremely well the period from 1998-2012, large transitory shocks (seasonal effects) in 2012 drove unemployment away from its limits cycles and identified attractors. One possible explanation could be the increasing seasonal effects from the tourism with the tourism sector growing and capturing a larger share of aggregate output with the steady decline of manufacturing share (advancing Croatian disease).

Finally, empirical results of the built MSSA model including in-sample and out-of-sample test show that multivariate singular spectrum analysis can explain most of the dynamic behaviour in the unemployment series. Our MSSA model captures 76% of the total variance in the unemployment lifting the constraints (short time series, background noise, normality, stationarity and non-linearity) that other modelling technique fail to overcome.

5. CONCLUSION

Unemployment in Croatia shows a pattern of a complex system i.e. non-linearity, long memory and persistence − 'partial Hysteresis'. Modelling unemployment, therefore, demands a complex model including all above variables. Research on unemployment in Croatia range from one assuming unemployment to be I(0) and others to be I(1). This paper offer an evidence on unemployment that is being fractionally integrated, i.e. non-stationary and with long memory in the conditional mean, variance. Thus unemployment series possess dual memory, both in mean and variance and this must be considered when modelling unemployment. Unemployment series in level is close to random walk but still not posses all properties to be declared as a random walk (Hysteresis). Empirical evidence offered in this study, therefore, calls for investigating what we call “partial Hysteresis” with unemployment having some properties of the random walk (non-stationarity) as well as of stationary series (mean reversion). Because of the evidence of fractional integration in the unemployment, stationarity and non-linearity issues (background noise) an multivariate singular spectrum model (MSSA) for modelling unemployment in Croatia is presented in this paper. Developed MSSA model offers a very good fit of the unemployment series explaining 76% of the total variance in the unemployment series over the 1998-2013 period. From a pool of 88 variables under investigation 21 time series were selected as statistically important in explaining unemployment dynamic behaviour. Considered time series has passed all statistical testing (red noise Monte Carlo test, spectral Granger causality test, Diebold-Mariano test) fitting unemployment data in Croatia quite remarkably.

Using developed MSSA model, this paper presents empirical findings being significant both to the body of literature in economics and policy makers (having practical policy implications for the successful unemployment management). Unemployment in Croatia is caused by continuously shifting natural rate of unemployment and 'partial hysteresis'. A wide unemployment gap is evidenced. This is a consequence of both structural and cyclical component of unemployment. Macro mismanagement particularly present during the first decade of transition (1990-2000) led to a sharp increase in the natural rate of unemployment in Croatia. This sharp rise was the result of an inefficient privatization, war damages, building anemic labour market (job creation and destruction rates, job finding and separation rates, job turnover, labour mismatch) real economy sector oriented to simple reproduction cycles, insufficient capital funds and poor state support for building SME's, low rate of absorption from public to private sector during privatization, inadequate (too heavy) monetary anchors, hidden unemployment. During this period natural rate of unemployment increased from 3% to 5% in 2001. Therefore, empirical results show structural (permanent) unemployment components led natural unemployment rate and thus unemployment dynamics during the 1990-2001 period. After 2001, the natural rate of unemployment becomes sluggish driven by a small cyclical component of unemployment. The natural rate of unemployment during 2002-2006 lingered between 5-6%. Labour-market during this period show signs of activity with job creation and destruction rates settling down around 2% and almost virtually no gap between the two. De-industrialization during this phase remained low accompanied by rising tourism sector driving seasonal employment up building favourable labour market conditions. Structural (permanent) components of unemployment had a small impact on the unemployment dynamics at the time. The number of unemployed persons dropped sharply reaching levels below 250.000. Third unemployment dynamics phase started with the financial crisis in 2008, and this phase (cycle) is still continuing. Unemployment trajectory in this period is driven by a large increase in the natural unemployment rate led mostly by cyclical components of unemployment − fall in aggregate demand, building stocks, sluggish and inefficient labour market, fiscal austerity, monetary conservatism, small production capacity of the real sector, damaging inflation targeting, EU crisis and the 'Croatian disease'. This last is of particular importance since it causes considerable fluctuation in the unemployment dynamic during the second unemployment cycle. After allowing us to derive a deterministic unemployment cycle by identifying fixed point in the phase space (natural rate of unemployment) and limit cycles turning to ghost cycles behind the deterministic cycle, developed unemployment MSSA model isolate a 5-6 years cycle. To be exact, our deterministic 5 year cycle can explain 76% of the total variance in the unemployment. Somehow, we have failed to identify correctly remaining 24% that obviously remains outside the pool of 88 time series we used to build an MSSA model. If our model is correct, current unemployment cycle is coming to its endpoint, and a deceleration in the unemployment is expected on the annual level in 2014. Another important finding of our MSSA model is that the economic recovery is essential but not sufficient for unemployment drop. For a significant decrease in the unemployment dynamics, sympathetic movements in the 21 oscillatory series are needed, and the economic recovery is just one among them. Not taking into account remaining 20 limit cycles will result in having economic recovery accompanied by sluggish labour market recovery (persisting unemployment). This study is our modest contribution to encouraging the further use of univariate and multivariate singular spectrum analysis for modelling unemployment and other macroeconomic aggregates particularly in transitional countries facing data constraints and short time series. Unemployment is one of three (together with inflation and output) essential economy equilibrium (alignment) points having long lasting and persisting negative effects on the economy. The solution to the unemployment problem in Croatia is not in the cyclical behaviour of the unemployment (5-year unemployment cycle), but fiscal and monetary policy must be redesigned to fight both structural and cyclical components of unemployment. If this is not the case, then with a cyclical component of unemployment slowing down, unemployment in Croatia will remain high with a large gap. Without fiscal and monetary policy redesigned to deal with the structural component of unemployment in Croatia, unemployment rates will continue to remain above 9%, i.e. the natural rate of unemployment for Croatian economy in the long run. Empirical results of our study are constrained by the remaining 24% of the total variance in the unemployment that cannot be explained by our MSSA model. This study aspires to encourage further research in cyclical character of unemployment if cyclical unemployment is produced by economic cycle or a consequence of structural/transitory components within unemployment.

REFERENCES

Allen, M.R, Smith, L. A. (1996). Monte Carlo SSA: Detecting Irregular Oscillations in the Presence of Colored Noise. *Journal of Climate* 9(1): 3373–3404. doi:10.1175/1520-0442(1996)009<3373:MCSDIO>2.0.CO;2.

Babić, Z. (2003). Active Labor Policy Role on the Labor Market in Croatia. *Financial Theory and Practice* 27(4), 547–566.

Bejaković, P. (2003). Long Term Unemployment Shrinking in Croatia. *Financial Theory and Practice* 27(4), 581–607.

Bejaković, P. (2006). The Role of the Educational System in Employability and Competitiveness of the Workforce in Croatia. *Social Inquiry - Journal for Sociological Issues* (3), 401–25.

Blanchard, O. J., Summers, L.H. (1986). Hysteresis and the European Unemployment Problem. in *NBER Macroeconomics Annual, Volume 1*, 15–90.

Blanchard, Olivier J, and Lawrence H Summers. 1987. "Hysteresis in Unemployment." *European Economic Review* 31 (1). Elsevier: 288–95.

Blanchard, O., Katz, L.F. (1996). What We Know and Do Not Know About the Natural Rate of Unemployment. *The Journal of Economic Perspectives, Vol. 11(1), 51-72.*

Blažević, S. (2013). Is Employment Decreasing Due to Minimum Wage Increase?" *Ekonomska istraživanja - Economic Research*, 26(1), 69-100.

Botrić, V. (2004). Regional Aspects of Unemployment in Croatia. *Croatian Economic Survey* (6), 77–95.

Botrić, V. (2009). Unemployed and Long-Term Unemployed in Croatia: Evidence From Labour Force Survey. *Social Politics Review* 16(1), 25–44.

Botrić, V. (2011). Structural Unemployment and Its Determinants in Southeast Europe. *Economic Thought and Practice* (1), 81–100.

Botrić, V. (2012). Regional Differences in Self-Employment: Evidence from Croatia. *Ekonomska istraživanja - Economic Research,* Special Issue 25(1), 243-266.

Caporale, G. M., Gil-Alana, L.A. (2007). Non-linearities and Fractional Integration in the US Unemployment Rate. *Oxford Bulletin of Economics and Statistics* 69(4), 521–44.

Caporale, G. M., Gil-Alana, L.A. (2008). Modelling the US, UK and Japanese Unemployment Rates: Fractional Integration and Structural Breaks. *Computational Statistics & Data Analysis* 52(11), 4998–5013. doi:10.1016/j.csda.2008.04.023.

Caporale, G. M., Gil-Alana, L.A. (2009). A Multivariate Long-Memory Model with Structural Breaks. *Journal of Statistical Computation and Simulation* 79(8), : 1001–13. doi:10.1080/00949650802087011.

Croatian National Bank Publications, Annuals reports 1997-2014, available at http://www.hnb.hr/publikac/hpublikac.htm.

Croatian Statistical Office and Databases Publications available at www.dzs.hr.

Elsner, J. B., Tsonis, A.A. (1996). Singular Spectrum Analysis: a New Tool in Time Series Analysis. Springer.

European Commission (2013). Directorate-General for Economic and Financial Affairs. Labour Market Developments in Europe. European economy, 6/2013.

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

Furuoka, F. (2014). Are unemployment rates stationary in Asia-Pacific countries? New findings from Fourier ADF test
Economic Research-Ekonomska Istraživanja Vol. 27, Iss. 1, pp. 34-45.

Ghil, M., Taricco, C. (1997). Advanced Spectral Analysis Methods in Past and Present Variability of the Solar-Terrestrial System: Measurement, Data Analysis and Theoretical Models. G. Cini Castagnoli and A. Provenzale (Eds.), Amsterdam, pp. 137-159.

Ghil, M., Yiou, P. (1996). Spectral Methods: What They Can and Cannot Do for Climatic Time Series. Decadal Climate Variability: Dynamics and Predictability, D. Anderson and J. Willebrand (Eds.), Elsevier, pp. 446-482.

Ghil, M., Allen, M.R., Dettinger, M.D., Ide, K., Kondrashov, D., Mann, M.E., Robertson, A.W. (2002). Advanced Spectral Methods for Climatic Time Series. *Reviews of Geophysics* 40(1),1003. doi:10.1029/2000RG000092.

Gil-Alana, L. A., Brian Henry, S.G. (2003). Fractional Integration and the Dynamics of UK Unemployment. *Bulletin of the Oxford University Institute of Economics & Statistics* 65(2),221–39. doi:10.1111/1468-0084.t01-1-00047.

Golyandina, N., Zhigljavsky, A.A. (2013). *Singular Spectrum Analysis for Time Series*. Springer.

Golyandina, N., Nekrutkin, V., Zhigljavsky, A.A. (2010). *Analysis of Time Series Structure: SSA and Related Techniques*. CRC Press.

Granger, C.W.J., Hatanaka, M. (1964). Spectral Analysis of Economic Time Series. *Spectral Analysis of Economic Time Series.* Princeton: Univ. Press.

Granger, C.W.J. (1966). The Typical Spectral Shape of an Economic Variable. *Econometrica: Journal of the Econometric Society* 34(1), 150-161.

Groth, A.A., Ghil, M.M. (2011). Multivariate Singular Spectrum Analysis and the Road to Phase Synchronization. *Physical Review E* 84 (3 Pt 2), 036206–6.

Hamilton, J. D. (1994). *Time Series Analysis*. Vol. 2. Cambridge Univ Press.

Harvey, A. C. (1990). Forecasting, Structural Time Series Models and the Kalman Filter. Cambridge University Press.

Hassani, H., Soofi, S.A., Zhigljavsky, A.A. (2013a). Predicting Inflation Dynamics with Singular Spectrum Analysis. *Journal of the Royal Statistical Society: Series a (Statistics in Society)* 176(3),743–60.

Hassani, H., Zhigljavsky, A.A., Patterson, K., Soofi, S.A. (2010). A Comprehensive Causality Test Based on the Singular Spectrum Analysis. in *Causality in Science Phyllis McKay Illari, Federica Russo, and Jon Williamson*
(eds). Oxford Press.

Hassani, H., Saeed H., Zhigljavsky, A.A. (2009). Forecasting European Industrial Production with Singular Spectrum Analysis. *International Journal of Forecasting* 25(1),103–18.

Hassani, H., Heravi, S., Zhigljavsky, A.A. (2013b). Forecasting UK Industrial Production with Multivariate Singular Spectrum Analysis. *Journal of Forecasting* 32(5), 395–408.

Hodrick, R.J, Prescott, E.C. (1997). Postwar US Business Cycles: an Empirical Investigation. *Journal of Money, Credit and Banking*. 29(1), 1–16.

International Financial Statistics CD ROM, February 2014.

Jaeger, A., Parkinson, M. (1994). Some Evidence on Hysteresis in Unemployment Rates. *European Economic Review* 38(2), 329–42.

Juhn, C., Murphy, K.M., Topel, R.H., Yellen, J.L., Baily, M.N. (1991). Why Has the Natural Rate of Unemployment Increased Over Time? *Brookings Papers on Economic Activity*. JSTOR: 75–142.

Kimoto, M., Ghil, M. (1993). Multiple Flow Regimes in the Northern Hemisphere Winter. Part I: Methodology and Hemispheric Regimes. *Journal of the Atmospheric Sciences* 50 (16), 2625–44.

Mariano, R. S,, Diebold, F.X. (1995). Comparing Predictive Accuracy. *Journal of Business & Economic Statistics* 13, 253–65.

Obadić, A. (2006). Theoretical and Empirical Framework of Measuring Mismatch on a Labour Market. *Journal of Conference Proceedings Rijeka* 24 (1), 55–80.

Patterson, K., Hassani, H., Saeed H., Zhigljavsky, A.A. (2011). Multivariate Singular Spectrum Analysis for Forecasting Revisions to Real-Time Data. *Journal of Applied Statistics* 38 (10), 2183–2211.

Phelps, E. S. (1967). Phillips Curves, Expectations of Inflation and Optimal Unemployment Over Time. *Economica*: Vo. 35, 254–81.

Phelps, E S. (1994). Structural Slumps: the Modern Equilibrium Theory of Unemployment, Interest, and Assets. Harvard Univ Press.

Phelps, E. S., Zoega, G. (1998). Natural Rate Theory and OECD Unemployment. *The Economic Journal* 108 (448),782–801.

Phelps, E. S. (1968). Money-Wage Dynamics and Labor-Market Equilibrium. *The Journal of Political Economy* 76 (4)678–7, 11.

Priestley, M. B. (1981). *Spectral Analysis and Time Series*. Academic Press.

Rutkowski, J. (2003). The Analysis and Suggestions for Improvement of the Labor Market in Croatia." *Financial Theory and Practice* 27 (4), 495–513.

Sargent, T. J. (1973). Rational Expectations, the Real Rate of Interest, and the Natural Rate of Unemployment. *Brookings Papers on Economic Activity* 2, 429-472.

Staiger, D.O., Stock, J.H., Watson, M.W. (1997). How Precise Are Estimates of the Natural Rate of Unemployment? In *Reducing Inflation: Motivation and Strategy*, 195–246. University of Chicago Press.

Stiglitz, J. E. (1997). Reflections on the Natural Rate Hypothesis. *Journal of Economic Perspectives* 11(1), 3–10.

Šergo, Z., Poropat, A.,, Gržinić, J. (2009). Croatia's Beveridge Curve and Estimation of Natural Rate of Unemployment: 1990-2008. *Ekonomska Istraživanja-Economic Research* 22 (3), 29–47.

Šergo, Z., Saftić, D., Težak, A. (2012). Stability of the Phillips Curve: The Case of Croatia. *Ekonomska Istraživanja - Economic Research* 25 (SE1), 65-85.

Škare, M. (2001). Unemployment and Labor Demand Determinants in Croatia. *Social Policy Review* 8 (1),19–34.

Škare, M., Stjepanović, S. (2013). A fractionally integrated model for the Croatian aggregate output (GDP) series, *Ekonomska istraživanja – Economic Research* 26(2):289-330.

Tomić, I., Domadenik, P. (2012). Matching, Adverse Selection and Labour Market Flows in a (Post) Transition Setting: the Case of Croatia. *Post-Communist Economies* 24 (1), 39–72.

Tomić, I. (2014). Structural unemployment in Croatia – How important is the occupational mismatch? *Economic Research-Ekonomska Istraživanja* Vol. 27, Iss. 1, pp. 346-365.

van Dijk, D., Franses, P.H., Paap, R. (2002). A Non-linear Long Memory Model, with an Application to US Unemployment. *Journal of Econometrics* 110(2), 35–65. doi:10.1016/S0304-4076(02)00090-8.

APPENDIX

Table A1 List of time series variables

Series
UN – Number of persons unemployed
AE – Industrial production index (energy) 2010=100
AES – Indices of stock (energy) 2010=100
AI - Industrial production index (intermediate goods) 2010=100
AIS - Indices of stock (intermediate goods) 2010=100
B – budget surplus/deficit in millions of Kuna
BB - Industrial production index (capital goods) 2010=100
BBS - Indices of stock (capital goods) 2010=100
CBR – Central bank reserves in millions of Eur
CD - Industrial production index (durable consumer goods) 2010=100
CDS - Indices of stock (durable consumer goods) 2010=100
CD's – Proxy for Croatian disease (employment in tourism/total employment)
CIP – Core inflation 2010=100
CN - Industrial production index (non durable consumer goods) 2010=100
CNS - Indices of stock (non durable consumer goods) 2010=100
CPI – Consumer price index 2010=100
CTE – Loans to enterprises (share in total loans)
CW – Construction work indices 2010=100
DR – Croatian national bank discount rate
EUR – Industrial production index EU area 2010=100
FTD – Foreign trade deficit in millions of Eur
HNB – Foreign exchange reserves in Central bank in millions of Eur
IIP – Industrial production index (industry), seasonally adjusted Euro area 18 countries
IP – Industrial production index 2010=100
JCR – Job creation rate
JDR – Job destruction rate
JFR – Job finding rate

JLR – Job losing rate

LADDER – Ladder effect

LCP – Unit labor costs

M1 – Monthly rates of growth in money supply (M1)

M4 – Monthly rates of growth in money supply (M4)

MM – Labor mismatch index

NEC – Net employment change

NER – New entrants to the register (total)

NER1 – New entrants to the register (no schooling and uncompleted basic school)

NER2 – New entrants to the register (basic school)

NER3 – New entrants to the register (1-3 years vocational school)

NER4– New entrants to the register (4 (or more)-year vocational secondary school and grammar school)

NER5 – New entrants to the register (non-university college)

NER6 – New entrants to the register (university and postgraduate degree)

NERBC – New entrant to the register by business closure

NERD – New entrant to the register by reduction in demand

NERFT – New entrant to the register (first time job seeker)

NERPE – New entrants to the register (previously employed)

NERTC – New entrant to the register by end of temporary contracts

NERXP – New entrants to the register (no working experience)

NNW – Nominal net wage in Kuna

NW – Nominal gross wage in Kuna

PLR – Primary liquidity ratio (banking system)

PPI – Producer price index (chain)

RES – Weighted average Central bank reserve requirements (in % of res. Base)

RW – Real gross wage

SEI – Total employed in tourism

TSHIFT – Employed in manufacturing (share) proxy for technological shift

UN1 - Unemployed persons no schooling and uncompleted basic school total

UN15 – Unemployed persons age 15-19 total

UN1W - Unemployed persons no schooling and uncompleted basic school woman

UN2 - Unemployed persons basic school total

UN20 - Unemployed persons age 20-24 total

UN25 - Unemployed persons age 25-29 total

UN2W - Unemployed persons basic school woman

UN3 - Unemployed persons 1-3 years vocational school total

UN30 - Unemployed persons age 30-34 total

UN35 - Unemployed persons age 35-39 total

UN3W - Unemployed persons 1-3 years vocational school woman

UN4 - Unemployed persons 4 (or more)-year vocational secondary school and grammar school total

UN40 - Unemployed persons age 40-45 total

UN45 - Unemployed persons age 40-45 total

UN4W - Unemployed persons 4 (or more)-year vocational secondary school and grammar school woman

UN5 - Unemployed persons non university total

UN50 - Unemployed persons age 50-55 total

UN55 - Unemployed persons age 55-60 total

UN5W - Unemployed persons 4 (or more)-year vocational secondary school and grammar school woman

UN6 - Unemployed persons university and postgraduate degree total

UN60 - Unemployed persons age 60 and more total

UN6W - Unemployed persons university and postgraduate degree total woman

UNB – Unemployment benefits recipients

UNW15 - Unemployed persons 15-19 age woman

UNW20 - Unemployed persons 20 - 24 age woman

UNW25 - Unemployed persons 25-29 age woman

UNW30 - Unemployed persons 30-34 age woman

UNW35 - Unemployed persons 35-39 age woman

UNW40 - Unemployed persons 40-44 age woman

UNW45 - Unemployed persons 45-49 age woman

UNW50 - Unemployed persons 50-54 age woman

UNW55 - Unemployed persons 55-59 age woman

UNW60 - Unemployed persons 60 and more age woman

Source: Croatian national bank on line and published database, IFS financial statistics, Croatian statistical office database and publications