

AGGREGATES EXTRACTION IN SERBIA-MULTIPLE STRUCTURAL BREAKS ANALYSIS

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ABSTRACT

This short letter investigates the dynamics of aggregates extraction in Serbia between 1973 and 2015. The change point analysis identifies 5 structural breaks in the intercept and linear time trend of aggregates extraction: 1980, 1989, 1995, 2003 and 2009. The estimated break dates correspond to the major business cycle turning points of the Serbian economy in the last 40 years. These findings suggest how aggregates extraction industry in Serbia was largely affected by the overall economic activity between 1973 and 2015.

Key words; aggregates, mineral economics, Serbia, change point regression, structural breaks.

4 INTRODUCTION

Aggregates, i.e., crushed stone, sand and gravel, represent the most valuable nonfuel mineral in the world. Menegaki and Kaliampakos (2010) document how aggregates represent the biggest branch of mining by production volume, and the second biggest branch of mining by production value. Bleischwitz and Bahn-Walkowiak (2007) report how the global demand for aggregates rose approximately by 4.7% annually through 2007. Andrić et al. (2017) obtain the same estimate in the case of Serbia between 1973 and 2015, while Menegaki and Kaliampakos (2010) find similar results in the case of 26 European economies between 1997 and 2006. Finally, Krausmann et al. (2009) report how the total aggregates extraction in the XXth century has increased by a factor of 34.

This short letter investigates the dynamics of aggregates extraction in Serbia between 1973 and 2015. The change point analysis identifies 5 structural breaks in the intercept and linear time trend of aggregates extraction: 1980, 1989, 1995, 2003 and 2009. The estimated break dates correspond to the major business cycle turning points of the Serbian economy in the last 40 years. These preliminary findings suggest how aggregates extraction industry in Serbia was largely affected by the overall economic activity between 1973 and 2015.

The rest of the paper is organized as follows. Section II provides theoretical background for our empirical estimates. Section III outlines major trends in aggregates extraction and presents the results of multiple structural breaks tests. Section IV concludes.

THEORETICAL BACKGROUND

Bai and Perron (1998, 2003a, 2003b) consider a standard multiple linear regression model with T periods and m potential structural breaks. For the observations in regime j they estimate the following ordinary least squares (OLS) regression model

$$y_t = X_t' \beta + Z_t' \delta_j + \varepsilon_t \quad (1)$$

for the regime $j=0,1,2\dots m$. Bai and Perron (1998, 2003a, 2003b) describe global optimization procedures for identifying the m multiple breaks and associated coefficients which minimize the sum of squared residuals of the regression model defined in Equation (1). These global breakpoint estimates are then used as the basis for several breakpoint tests.

For a test of the null of no breaks against an alternative of l specified breaks, Bai and Perron [4, 5, 6] construct the F-statistic to evaluate the null hypothesis that $\delta_0 = \delta_1 = \dots = \delta_{l+1}$. In cases in which l is not known, Bai and Perron (1998, 2003a, 2003b) test the null of no structural change against an unknown number of breaks up to some upper bound M . The test of l versus no breaks procedure may be applied sequentially (sequential F-statistic) beginning with a single break until the null is not rejected. Alternatively, it may be applied to all breaks with the selected break being the highest statistically significant number of breaks (significant F-statistic), or it may employ double maximum tests, UDmax and WDmax. Double maximum tests involve maximization both for a given l and across various values of the test statistic for l . The equal weighted version of the test UDmax chooses the alternative that maximizes the statistics across the number of breakpoints, while WDmax test applies weights to the individual statistics so that the implied marginal p-values are equal prior to maximization. In both tests, the upper bound M for the number of breaks is inversely proportional to the size of trimming percentage ϵ , $\epsilon = h/T$, in which h represents the minimal length of each subregime.

EMPIRICAL EVIDENCE

This section consists of two subsections. Subsection 3.1 depicts major trends in the dynamics of aggregates extraction in Serbia between 1973 and 2015. Subsection 3.2 detects the most important structural breaks in the dynamics of aggregates extraction between 1973 and 2015.

Trends

The analysis in this subsection relies heavily on Andrić et al. (2017). We instruct the reader to refer to the aforementioned reference for a more detailed analysis, while here we only outline the most important trends in the dynamics of aggregates extraction.

We focus on the levels of domestic aggregates extraction measured in 000 of m^3 for the period 1973-2015. Between 1973 and 2002, aggregates encompass broken stone from silicate rocks, sand and gravel. Between 2003 and 2015 aggregates include crushed and broken stone, round pebbles, natural sand and gravel. Our data set comes from official statistical Yearbooks of the Republic of Serbia between 1978 and 2016 published by the Statistical Office of the Republic of Serbia.¹

Figure 1 depicts the levels of aggregates extraction in Serbia between 1973 and 2015. Shaded areas outline potential structural breaks in the dynamics of aggregates extraction. In particular, the Figure 1 points to 5 potential structural breaks, i.e., to 6 distinctive subregimes in the dynamics of aggregates extraction. The potential subregimes are as follows: 1) 1973-1979; 2) 1980-1988; 3) 1989-1994; 4) 1995-2002; 5) 2003-2008 and 6) 2009-2015.

The *first subperiod* from 1973 to 1979 exhibited a rapid increase in levels of aggregates extraction. In 1979, the aggregates extraction reached its maximum level of approximately 18 million m^3 . The upward trend in aggregates extraction is consistent with fast economic growth in Serbia between 1973 and 1979, as documented in Bićanić et al. (2016)

The *second subperiod* between 1980 and 1988 exhibited a rapid decrease in the levels of aggregates extraction. The average level of extraction of around 13 million m^3 was far below the 1979 maximum level of extraction. The downward trend in aggregates extraction is consistent with the stagnation of

¹ The Statistical Yearbooks of the Republic of Serbia are available from electronic library of the Statistical Office of the Republic of Serbia at <http://www.stat.gov.rs/WebSite/Public/PageView.aspx?pKey=452>.

Serbian economy during the 1980s. In particular, Bićanić et al. (2016) report the average annual growth rate of Serbian economy of only 0.4% between 1980 and 1989.

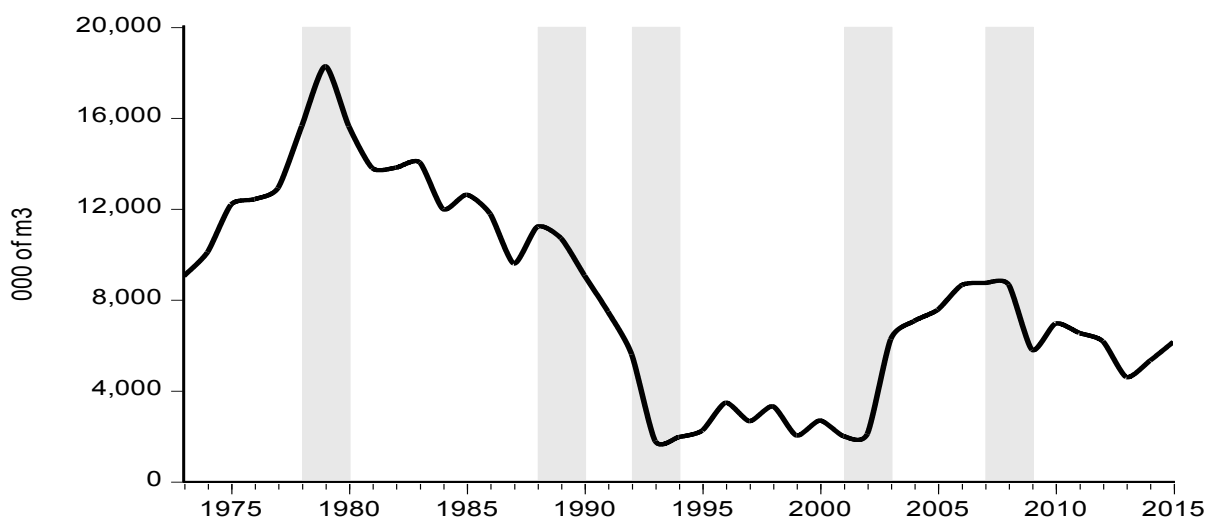


Figure 1. The extraction of Aggregates in Serbia, 1973-2015

The *third subperiod* between 1989 and 1994 exhibited an even faster decrease in the levels of aggregates extraction than the second subperiod between 1980 and 1988. In 1993, the level of aggregates extraction reached historical minimum of approximately 2 million m³. The economic effects of international sanctions, the Yugoslav wars and the hyperinflation between 1992 and 1994 destroyed any potential for the revival of construction and aggregates industry in Serbia.

The *fourth subperiod* between 1995 and 2002 exhibited a slow recovery of aggregates extraction in Serbia. The Kosovo War and the overthrown of Milošević regime, however, stifled a more robust and faster recovery of the construction and aggregates industry in Serbia between 1995 and 2002.

The *fifth subperiod* between 2003 and 2008 exhibited a sharp recovery of aggregates extraction industry in Serbia. In 2003, the average annual growth rate of aggregates extraction reached its historical maximum of 200% due to the privatization of the 3 biggest cement plants in Serbia. The revival of Serbian construction and aggregates extraction industry is a direct consequence of macroeconomic and political reforms after the year 2000.

The *sixth subperiod* between 2009 and 2015 exhibited a decrease in the levels of aggregates extraction in Serbia. In 2009, a year in which the Great Recession hit the Serbian economy, the average annual growth rate of aggregates extraction equalled -33%.² After the arrival of the Great Recession to Serbia, the overall economic slowdown affected construction industry and, consequently, spilled over to aggregates extraction industry.

Results

We begin our empirical analysis by regressing the levels of aggregates extraction on a constant and linear time trend. The estimation via OLS is statistically sound, since the time series for levels of

² For the spillover effects of the Great Recession on the overall economic activity in Serbia, see Andrić et al. (2017, 2016a, 2016b).

aggregates extraction does not contain a unit root.³ Figure 2 shows the actual, estimated and residual values of aggregates extraction in Serbia from linear OLS model for the period 1973-2015. The right axis measures the actual and model fitted values, while the left axis measures the residual values.

Figure 2 shows how linear time trend is a poor approximation for the combined influence of all relevant economic factors on aggregates extraction in Serbia between 1973 and 2015. In particular, the linear time trend fails to capture structural breaks depicted with shaded areas on both Figure 1 and Figure 2.

Table 1 presents the results of the Bai-Perron M globally optimized breaks against the null of no structural break. The upper panel in Table 1 shows the results of different test statistics in determining the number of structural breaks. The Sequential F-statistic chooses the last significant number of breaks determined sequentially. The Significant F-statistic chooses the number of breaks by choosing the largest statistically significant breakpoint. The UDmax and WDmax statistics show the number of breakpoints as determined by application of the unweighted and weighted maximized statistics. All aforementioned test statistics detect 5 structural breaks.

The middle panel in Table 1 shows the values of original, scaled and weighted F-statistics along with the critical values for the scaled F-statistic. The bottom panel shows the values of double maximum test statistics along with its critical values. All test statistics point to 5 statistically significant structural breaks at 10% level. The breaks occurred in 1980, 1989, 1995, 2003 and 2009. The estimated break dates correspond to the major business cycle turning points of the Serbian economy in the last 40 years. In obtaining the values of test statistics from Table 1, we have used 15% sample trimming percentage along with the heterogeneous errors across breaks. We modelled the autocorrelation in disturbances by specifying a quadratic spectral kernel with Andrews automatic bandwidth and AR (1) prewhitened residuals, as in Bai and Perron (1998, 2003a, 2003b).

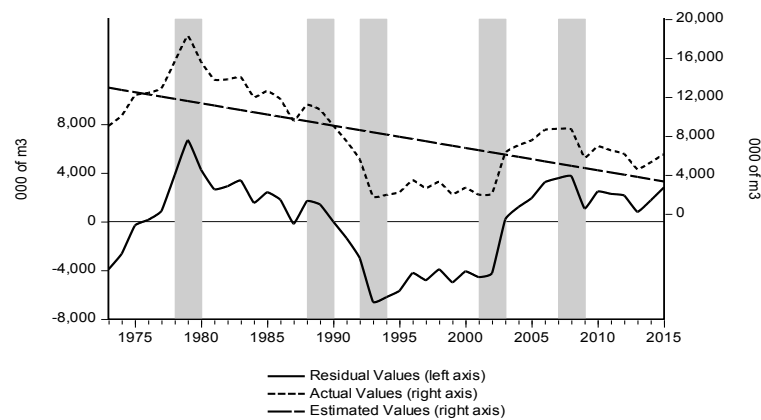


Figure 2. The Actual, Estimated and Residual Values of Aggregates Extraction in Serbia from Linear OLS Model, 1973-2015

³ Unit root tests proposed in Elliott et al. (1996) and Ng and Perron (2001) reject the unit root hypothesis. We do not report these results in order to save space. These results are, however, available from authors upon request.

Table 1. Structural Breaks for Aggregates Extraction in Serbia, 1973-2015

Sequential F-statistic determined breaks:				5
Significant F-statistic largest breaks:				5
UDmax determined breaks:				5
WDmax determined breaks:				5
Breaks	F-statistic	Scaled F-statistic	Weighted F-statistic	Critical Values
1 *	20.85	41.71	41.71	9.81
2 *	34.36	68.73	78.13	8.63
3 *	138.42	276.83	360.18	7.54
4 *	121.36	242.72	365.76	6.51
5 *	274.32	548.63	1021.27	5.27
UDmax statistic*		548.63	UDmax critical value	10.16
WDmax statistic*		1021.27	WDmax critical value	11.15

Estimated break dates: 1980, 1989, 1995, 2003, 2009

Notes: *dependent variable*-levels of aggregates (000 of m³); *breaking variables*-intercept and linear time trend; *break type*-Bai-Perron tests of 1 to M globally determined breaks with 15% sample trimming percentage and heterogeneous errors across breaks; *covariance matrix specification*: HAC standard errors with quadratic-spectral kernel and Andrews automatic bandwidth with single prewhitening lag. *-10% significance level.

CONCLUSION

In this short letter, we investigate the dynamics of aggregates extraction in Serbia between 1973 and 2015. We identify 5 structural breaks in the intercept and linear time trend of aggregates extraction dynamics in the aforementioned period. The breaks occurred in the following years: 1980, 1989, 1995, 2003 and 2009. The estimated break dates are in great accordance with the major turning points of the business cycle fluctuations in Serbia between 1973 and 2015. These findings suggest how aggregates extraction industry in Serbia was largely driven by the overall economic activity in the last 40 years.

ACKNOWLEDGEMENTS

We wish to express our deepest gratitude to Georgios N. Anastassakis, Professor of National Technical University of Athens [NTUA], School of Mining, Engineering and Metallurgy, for several constructive discussions which led to the writing of this paper. The paper was supported by funds from projects OI 179015, TR 34013 and TR 34006 financed by the Ministry of Education, Science and Technological Development of Republic of Serbia.

REFERENCES

- Andrić, V., Andrić, Lj., Radulović, D., 2017. The Extraction of Aggregates in Serbia, 1973-2015-A Statistical Exploration. Under review at *Mining and Metallurgy Engineering Bor*.
- Andrić, V., Arsić, M., Nojković, A., 2016a. Public Debt Sustainability in Serbia Before and During the Global Financial Crisis. *Economic Annals*, XVI (210): 47-78. DOI: 10.2298/EKA1610047A.
- Andrić, V., Arsić, M., Nojković, A., 2016b. Fiscal Reaction to Interest Payments-The Case of Serbia. *Industrija*, 44 (3): 117-144. DOI: 10.5937/industrija44-12031.
- Bai, J., Perron, P., 1998. Estimating and Testing Linear Models with Multiple Structural Changes. *Econometrica*, 66 (1): 47-78. DOI: 10.2307/2998540.
- Bai, J., Perron, P., 2003a. Computation and Analysis of Multiple Structural Change Models. *Journal of Applied Econometrics*, 18 (1): 1-22. DOI: 10.1002/jae.659.
- Bai, J., Perron, P., 2003b. Critical Values for Multiple Structural Change Tests. *Econometrics Journal*, 6 (1): 72-78. DOI: 10.1111/1368-423X.00102.
- Bićanić, I., Deskar-Škrbić, M., Zrnc, J., 2016. A Narrative Explanation of Breakpoints and Convergence Patterns in Yugoslavia and its Successor States 1952-2015. *WIIW Balkan Observatory Working Paper No. 122*, Vienna: The Vienna Institute for International Economic Studies.
- Bleischwitz, R., Bahn-Walkowiak, B., 2007. Aggregates and Construction Markets in Europe: Towards a Sectoral Action Plan on Sustainable Resource Management. *Minerals & Energy*, 22 (3-4): 159-176. DOI: 10.1080/14041040701683664.
- Elliott, G., Rothenberg, T.J., Stock, J.H., 1996. Efficient Tests for an Autoregressive Unit Root. *Econometrica*, 64 (4): 813-836. DOI: 10.2307/2171846.
- Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K-H., Haberl, H., Fischer-Kowalski, M., 2009. Growth in global materials use, GDP and population during the 20th century. *Ecological Economics*, 68 (10): 2696-2705. DOI: 10.1016/j.ecolecon.2009.05.007.
- Menegaki, M.E., Kaliampakos, D.C., 2010. European aggregates production: Drivers, correlations and trends. *Resources Policy*, 35 (3): 235-244. DOI: 10.1016/j.resourpol.2010.01.003.
- Ng, S., Perron, P., 2001. Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power. *Econometrica*, 69 (6): 1519-1554. DOI: 10.1111/1468-0262.00256.