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FOREWORD

Mineral processing is an art of treating raw ores in order to separate valuable minerals from the waste rock as well as preparing mineral products for specific needs. It is the first process that most ores undergo after mining in order to provide concentrated material for the downstream metallurgical processes. The primary operations are comminution and concentration, but there are other important operations in a modern mineral processing plant, including sampling and analysis and dewatering. In mineral processing, a number of unit operations are required to prepare and classify ores before the valuable constituents can be separated or concentrated and then forwarded on for use or further treatment. Mineral processing education at the Istanbul Technical University has started as a division of the "Mining Engineering Department" which was founded as a part of the Mining Faculty in 1953. The division was re-organized as a Mineral Processing Engineering Department of the same faculty in 2007, in order to meet the requirements of engineering education. It is the first and only one in Turkey.

The first Balkan Mineral Processing Congress was held in Varna, Bulgaria in 1973. The “XVIIth Balkan Mineral Processing Congress – BMPC 2017” is organized by ITU Mineral Processing Engineering Department and the Turkish Mining Development Foundation between November 1 and 3, 2017, in Antalya-Turkey. “BMPC 2017” will bring together a large number of academicians from Turkey and many other countries as well as the authorities from the companies that are operating in the mining, mineral processing, and extractive metallurgy industries in order to create an opportunity to evaluate the future of the sector. In this context, BMPC represents a technical platform for the safe and sustainable future of the mining and mineral processing industries in Balkan Countries. We are inviting you to become a part of this global challenge by attending our congress through participation, presentation, exhibition and supporting our activities. In this respect, Antalya with its dynamism and diversity presents a unique opportunity for the attendees. We assure you that we will provide all means to make you enjoy and benefit from this extraordinary event.

The Congress will gather over one hundred professionals and academics from all over the world to exchange knowledge and experience, to present the results of scientific research and to discuss innovations in the mineral processing industry. Universities specializing in mineral processing, a number of important mining companies, major leading providers of services and technologies will participate in the Congress.

We are very pleased to welcome you to attend and we are sure you will enjoy the Congress from both scientific and social points of view. Looking forward to meeting you in Antalya!

Prof. Dr. Fatma Arslan | Prof. Dr. Ayhan Ali Sirkeci

FOUNDATION'S FOREWORD

As Turkish Mining Development Foundation, we are happy to be organizer of 17. Balkan Mineral Processing Congress. I would like to express my sincere thanks to the Balkan Scientific Committee, Turkish Organization Committee, to the Sponsors, exhibitors and all the attendees. Our special gradidute to Istanbul Technical University, Mining Faculty and Mineral Processing Department.

We wish successful and fruitful congress and sunny days in Antalya.

With kind regards,

Prof. Dr. Güven Önal

President of Turkish Mining Development Foundation

Balkan Scientific Committee Member

Index **Page**

The Past, The Present And The Future Of The Hydrometallurgical Treatment Of Refractory Gold Ores 1
J. Hendrix

Mechanochemistry Of Solids: From Minerals To Nanomaterials And Drugs 9
P. Baláž, M. Tešinský

Flotation 100 Years In Mineral Processing 19
S.Atak

Process Development Metallurgical Studies For Gold Cyanidation Process 25
S. Acar

Underground Coal Gasification Studies On Turkish Lignites 27
H. Okutan,, M. Gür, N. Eskin, A. Arisoy, E. Böke

Substitution Of Additive Sand By Slag And Optimization Of Its Content For Improving Cement Production And Environment Production 41
H. Fatmi, M. Chettibi, K. Chraita, Z. Mekti, A. Chaib, A. Boutrid

Application Of Flocculation In Processing Of Mineral Sludge 51
N. Ćalić

Demineralization And Desulfurization Of High Sulfur Fine Coal By Enhanced Centrifugal Concentrator 63
U. Demir

Desulfurization Of Sorgun, Yozgat Lignite Coal With
Microwave Irradiation And HNO_3 Leaching 73
C. Seflek, O. Bayat

Microwave Activated Desulfurization Of Turkish Coals And Lignite, Şirnak Asphaltite - Micro Selective Coagulation In Modified Tube Settling Seperator 77
Y. Tosun

Pre-Combustion Cleaning Of Coal 87
I. Simović; N. Kostović; M. Kostović; I. Radovanović

Investigation Of The Effect Of Microwave Application On Coal Sulphur Content 95
C. E. Yilmaz, D. Çuhadaroğlu, İ. Toroğlu, S. Kizgut, M. Bilen, S. Yilmaz

The Possibility Of Kosovo'S Coal Processing 107
H. Basholli; K.Fetahu

The Effect Of Make-Up Ball Size Regime On Grinding Efficiency Of Full-Scale Ball Mill 117
A. Hassanzadeh

Alternative Methods For Determination Of Work Index 125

B. Sarioğlu, O. Güven, H. Dincer Atesok

Economic And Technical Analysis Of The Solutions For Protection, Rehabilitation And Ecological Reconstruction Of The Land Affected By The Uranium Mining Activity 133
D.Caranda ;V.Ciocan; A.Donea

Microwave Plasma Roasting Of Pyrite And Pyrite Tailings With Coal For Reduction To Sponge Iron In Tube Furnace 143
Y. Tosun

Urban Mining 153
F. Göktepe; G. Bulut

Studies On Recovery Of Metals From Electronic And Electrical Wastes By Physical Separation Methods 161
F.Arslan; C. Arslan; F. Burat; M. Özer, K.T. Perek

Monitoring Waste Dump Of Ash And Bottom Ash Thermal Power Plant Nikola Tesla – B 173
J. Neškovic, K. Konc-Jankovic, P. Stjepanovic, I. Jovanović, D. Lazić

Study Of The Effect Of The Use Of Slag For The Production Of Clinker On The Co2 Emission, Algeria 179
Z. Mekti, M. Bounouala, M. Chettibi, A. Boutemedjet, A. Chaib, S. Berdoudi

Dental Amalgam Wastes: Properties, Environmental Effects And Recycling Processes 187
E. Yilmaz; S. Ertürk; F. Arslan; C. Arslan

Optimum Use Of Fired Ceramic Tile Waste In The Production Of Blended Cement 197
M. T. Derdiyok, H. Ergin, U. Aykaç

Removal Of Heavy Metals From Mine Wastewater From Mines Sasa And Buchim, Macedonia Using Zeolite Bearing Tuff 209
A. Zendelska, M. Golomeova, B. Krstev, B. Golomeov

Electrocoagulation Of Colloidal Kaolinite Particles 217
M. Çirak

Aggregates Extraction In Serbia-Multiple Structural Breaks Analysis 229
V. Andrić; L. Andrić,; D. Radulović

Reducing Of Colored Impurities From Feldspar Ore 237
C. Özdoğan, Z. Yeşilyurt, M. O. Kangal

The Beneficiation Of Djebel-Onk Phosphate Ore From Algeria By Flotation 243
Djamel Nettour, Mohamed Chettibi, Gülay Bulut, Onur Guven

Characterization And Magnetic Separation Of Middle Anatolian Nepheline Syenites 249
O. Kangal, G. Bulut, F. Burat, Z. Yeşilyurt, H. Baştürkcü

Selective Recovery Of Calcite And Wollastonite From Wollastonite Ore 255
M.O.Kangal; G.Bulut; F.Burat; Z.Yeşilyurt; H.Baştürkcü

The Effects Of Different Reagents On Pyrite Flotation 261
B. Ari, G. Bulut, Ü. Yenial

Technical Testing Of The Mineral Processing In The Exploration Area On Polymetallic Deposits At Prolesje 267
J. Neškovic, K. Konc-Jankovic, P. Stjepanovic, I. Jovanović, D. Lazić

Investigation Of Enrichment Conditions Of Oxide Type Copper Ores By Flotation 273
K.M. Anbar; Z. Yeşilyurt, A. Güney

Pre-Contact Pneumatic Flotation Of Silver, Lead And Copper From Zinc Cake Residue 277
I.Grigorova, Tz. Ivanova, M.Ranchev, I.Nishkov

Mechanical Activated Flotation Of Depressed Pyrite 283
S.Dzhamyarov; I.Grigorova; M. Ranchev; Tz.Ivanova; I.Nishkov

Froth Washing – The Way Of Reducing The Sio2 Content Of Zinc Concentrates 289
I.Grigorova; M.Ranchev; N.Valkanov; I.Nishkov

Effect Of Various Parameters On Settling Rate Of Limonite
And Clay From Iron Ore Sludge 295
Lj.Tankosić, N. Ćalić, M. Kostović, S. Sredić

Colloidal Properties Of Titanium Dioxide Stabilized Pickered Emulsions 305
T. Türk, O. Güven, M.S. Çelik

The Role Of The Flotation Pulp Oxidation-Reduction Potential In The Electrochemically Impacted Flotation
Of Polymetallic Ores 311
V. Vanayotov, M. Panayotova

Investigation Of Recycling Water Impact On Chalcopyrite Flotation 317
A. Çirci, Ü. Yenial, G. Bulut

Upper Size Limit Of Magnesite In The Presence Of Various Collectors 323
O. Şahbaz, E. Akbulut And C.Karagüzel

Optimization Of Flotation Parameters For Gold Ore Containing Electrum 329
S.B. Aydin, A. Gül

Flotation Of Silica/Glass Sand To Utilize For Glass Industry 343
O. Bayat, Z. Cetinkaya, S. Demirci

Nepheline Recovery From Nepheline Syenite 351
M.T. Serdengeçti, M.O. Kangal

Potential Use Of Bakery Yeast (Saccharomyces Cerevisiae) As Apatite Collector In Bioflotation 359
A.C. Silva, D.V.C. Cara, E.M.S. Silva, G.S. Leal, L.M. Silva, A.M. Machado

Effect Of Some Frothers On Flotation Kinetics Of Jameson Cell 367
O. Şahbaz, K. Demir, B.Öteyaka

Effect Of Water Quality On Bubble-Particle Interaction For Sulphur Minerals 375
O. Ozdemir, I. Kursun, M. Terzi, D. Enon

Influence Of Ultrasound On The Collectorless Micro-Flotation Of Laminar Talc 383
C. Gungoren, F. Hocaoglu, I. Demir, Y. Baktarhan, S.G. Ozkan

Effect Of Different Collectors On Floatability Of Soma Eynez Region Lignite With Flotation 391
H.Caliskan, F. Cinar, S.Taskoparan, M.Cinar

Application Of Classical Dlvo Theory On Coal Water Slurries: The Influence Of Rheology On Interaction Forces 401
O. Güven

Apatite Flotation Using Sorghum As Depressant 411
E.M.S. Silva, A.E.C. Peres, A.C. Silva, T. Elwert, S. Tuchtfeldd

Concentracion Possibility Examination Of Ore From "Ćulav Brajšor" Field, Near Medveđa 423
Đurica Nikšić, Predrag Lazić, Branko Zečević

Flotation Chemistry Of A Rare Earth Mineral: Bastnasite 435
D. Karataş, İ. E. Karaağaçlioğlu, M. S. Eygi, M. S. Çelik

Particle-Bubble Interactions In Mica/Amine System Through Dlvo Theory 445
B. Tunç, O. Güven, S. Sevinç, M. S. Çelik

Assessment Of The Possible Negative Impact Of Tailings Ponds On Soil, Surface Water And Groundwater - A Case Study 455
M. Panayotova, S. Bratkova, N. Stoyanov, S. Dimovski, V. Panayotov

Leaching Of Nickel From A Limonitic Laterite Ore In Aqueous H2So4 Solutions 467
A.Ucyildiz, I.Girgin

Effect Of Sulphuric Acid Addition On Thermal Behaviour Of A Limonitic Nickel Laterite Ore 477
A.Ucyildiz, C.T.Unaldi, A.Obut, I.Girgin

Removal Of Iron Using Oxalic Acid To Obtain High Quality Raw Material For Glass Industry 487
B. Güngörmez, H. Baştürkçü, G. Bulut

Dissolution Of Lead From Lead-Zinc Tailings With Nitric Acid 493
I. Kursun, O. Ozdemir, M.F. Eskibalci, H. Hacifazlioglu, M. Terzi

Synthesis Of Copper Nano/Microstructures Using Ascorbic Acid In Aqueous Starch Solution 501
N.S.Kiliçoğlu, Z.Yeşilyurt, A.Güney

Oxalic Acid Leaching Of A Glass Sand Plant'S Byproduct 507
M. Özer, H. Baştürkcü, B. Başkurt, F. Burat

Improved Lime Method For The Preparation Of Hihg-Purity Mg(Oh)2 From Mgcl2·6H2O 513
W. Liu, H. Xu, X. Shi, X. Yang

Synergistic Effect Of Organic Acid For Leaching Of Nickel And Cobalt From Lateritic Nickel Ore With Sulphuric Acid Solution 523
S. Kursunoglu, Z. T. Ichlas, M. Kaya

Enrichment Of Tailings At Eti Mine-Espey Waste Dam By Using Microwave Processing 535
M. Ak, A. Aydin

Strontium Carbonate Precipitation From Strontium Sulfide Solution 543
A.Bilen, İ.G. Hizli, R. Sezer, S.Ertürk, C. Arslan

Strontium Carbonate Precipitation With Ammonium Carbonate From Strontium Sulphide Solution 551
İ.G. Hizli, A. Bilen, R. Sezer, S. Ertürk, C. Arslan

Gold Recovery From Kuyumcukent Waste Water 557
H.M. Çiftci, H. Baştürkcü, F. Burat

Available Resource Of Scandium Red Mud 563
H. Basturkcu, A. Demircan, N. Acarkan

Green Synthesis Of High Purity Copper Powder From A Copper Oxide Ore 569
Z. Yeşilyurt, A. Güney

Pyrophyllite-Mineral Of The Future For Application In Agriculture 577
L. Andrić, M. Harbinja, A.Hodžić, F. Selman, D. Radulović, J. Stojanović, M. Petrović, S. Čosić

Calcium Ferrite Nanoparticle Production From Mining Wastes: Marble Dust And Pyrite Ash 587
Ü. Yenial, F. Pagnanelli, G. Bulu

Development Of An Eco-Friendly Tailing Disposal System Of Iron Ore Tailing And Study Of Issues 597
R. Kumar, G. E. Sreedhar, P. S. Jadon, T .V. S. Subramanyam, S. Mondal

Effect Of Micronized Grinding On The Quality Of The Fillers Based On Cordierite, Mullite And Zircon 607
M. Pavlović, L. Andrić, D. Radulović, M. Petrov

The Importance And Methods Of Determining Some Proporties Of Mineral Particles In Paint And Coating Industry 613
I.Y. Emek; G. Bulut

Alkali Aluminosilicates In Nature And Their Use As A Source Of Alumina In Glass Production 619
E. Aydin

Effect Of Microwave Drying On Particle Shape Of A Turkish Lignite Before And After Grinding 625
C. Gungoren; S.G. Ozkan,H. Hacifazlioglu

On-Line Coal Analyzer With 14Mev Neutron Generator 633
Ü.Çolak, İ.A. Reyhancan, M. N. Erduran

Behavior Of Feldspathic Materials Of Ain Barbar To Physical And Physico-Chemical Separation -East Of Algeria 643
A.Chaib, M. Bounouala, M.Chettibi, S. Bouabdallah, A. Benselhoubb

Removal Of Organic And Inorganic Contaminants Using Acid Modified Zeolites 655
O. Ozdemir, I. Kursun, M. Terzi, P.N. Ucok

Au And Ag Pre-Concentrate Production Possibilities From Murgul Copper Ore Using Gravity Methods 663
H. Baştürkcü, F. Burat, M. Özer, A.E. Yüce, N. Acarkan

The Benefication Of Kirşehir Nepheline Syenite As Ceramic Raw Material 667
M. Çinar, E. Durgut, H. Calişkan, Y. Yildiri

Improvement Of The Quality Of The Iron Ore By Homogenization Method 675
A. Boutrid, M. Chettibi, M.C. Djouamaa, A. Bouhedja,F. Bouterfa

Magnesite Enrichment By The Calcination Method 689
Ç. Aras, B. D. Öztürk

Investigation Of The Effects Of Clay Impurities On Ceramic Tiles And Novel Methods For Improvements 697
Y. Yildirim, H. Ergin, E. Durgut

Development Of A Process For Manufacture Of Superphosphates From Natural Phosphates Of Djebel Onk-Tebessa 705
A. Merchichi, M. Ould Hamou

Application Of Whims On Grain Size -1+0 mm In Production Process Of Preparation Of Limonite Iron Ore On Gms Plant In Omarska Mine 711
D. Simić, M. Kneževi

Design Of High Gradient Wet Magnetic Seperator With Permanent Magnets And Beneficiation Of Fine Manganese & Magnetite Ores 723
U. A. Baştaş, L. Ovacik, G. Ateşok, H. Ateşok

Fine Size Mersin Region Chromite Ore Beneficiation With High Gradient Wet Magnetic Separator Advanced With Permanent Magnets 729
N. E. Cüce, L. Ovacik, G. Ateşok , H. Ateşok

Super Quality Concentrate Production Possibilites From Denizli Region Chromite Ores 735
M. Ozer, H. Basturkcu, A.E.Yuce, G.Onal

Investigation Of Beneficiation Of A Manganese Ore By Jig 741
O. Sivrikaya, A.İ. Arol

Feldspar Production From Marrom-Guaíba Granite Tailings 747
A.C. Silva, S.D. Carolina, D.N. Sousa; C.M.S. Filho; E.M.S. Silva

Modeling And Optimisation Of Multigravity Separator For Recovery Of Iron Values From Sub Grade Iron Ore Using Three Level Three Factor Box Behnken Design 757
G. Venkateswara Rao, R. Markandeya, Rajan Kumar

Investigation Of Manisa Sart Region Gold Ore Enrichment With Gravity Methods 767
İ.Kursun, M. Terzi, I. Demir

Enrichment Of Antimonite Waste By Using Knelson Concentrator 777
S. Karaca, Ö. Canieren, O. Şahbaz, U. Demir, O. C. Karagüzel

Treatment Of Chromium Ores In Dressing Plant Of Deve 785
G.Demi, S.Boci

Optimization Of The Process With Newton Algoritm 797
H. Basholli, S.Kelmendi, R.Basholi

Polymetalic Ores Calculation Model Through Metal Equivalent 803
Sh. Kelmendi, H.Qela, B. Mustafa

Contact Angle Of Montmorillonite Basal Surface As Determined By Experimental And Molecular Dynamics Simulation 811
D. Karataş, R. Hojiyev, M.S. Çelik

Parameters Optimization Of Mineral Enrichment Of Copper Sulphides And Oxides In Gjegjan-Kukes, Albania 819
E. Toska, K. Fetahu, H. Basholli

Local And Global Review Of Flotation Kinetics 829
S. Kelmendi, H.Basholli, H.Qela

Acidic Leaching Of Thermally Activated Pyrophyllite Ore From Pütürge (Malatya-Turkey) Deposit 839
M. Birinci, T. Uysal, M. Erdemoğlu, E. Porgalı, T.S. Barry

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 $j=0,1,2\ldots m$. 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 $\delta_0 = \delta_1 = \cdots = \delta_{l+1.}$ 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.

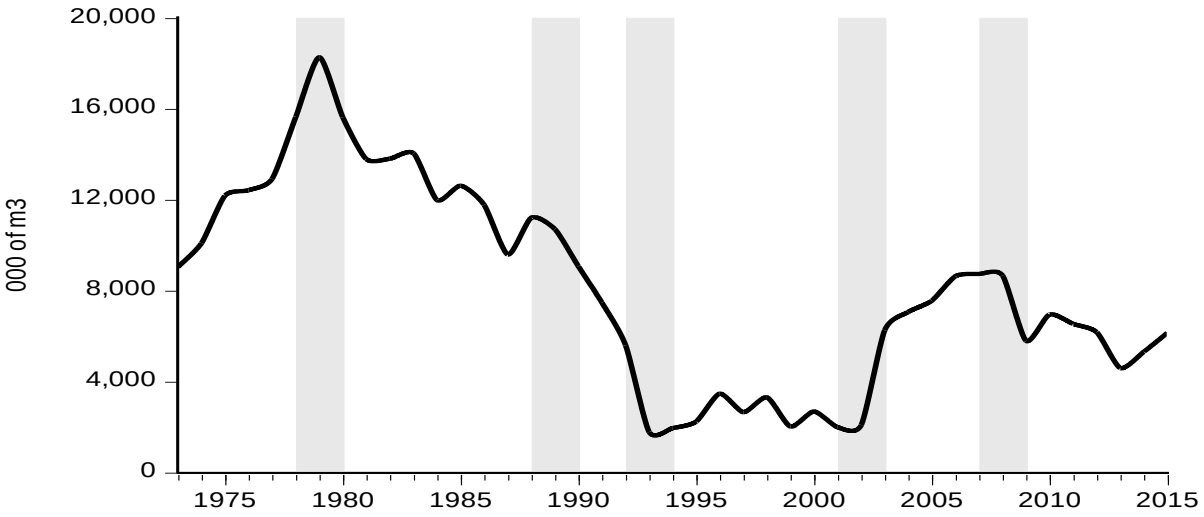

Figure 1. The extraction of Aggregates in Serbia, 1973-2015

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 m^3. 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).

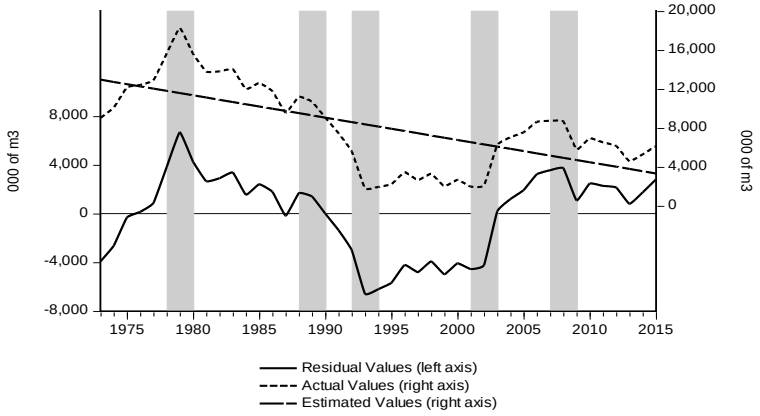

Figure 2. The Actual, Estimated and Residual Values of Aggregates Extraction in Serbia from Linear OLS Model, 1973-2015

[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 m^3); *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.

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