

# Analiza ljudskog razvoja korištenjem otkrivanja znanja u bazama podataka

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**Sveučilište u Zagrebu**

**Ekonomski fakultet**

**Integrirani preddiplomski i diplomski sveučilišni studij**

**Poslovna ekonomija – smjer Menadžerska informatika**

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Diplomski rad

**Filip Lisjak**

**Zagreb, rujan 2020.**

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**Analysis of the Human Development using  
knowledge discovery in databases**

Diplomski rad

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**Zagreb, rujan 2020.**

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## SAŽETAK

Analiza ljudskog razvoja korištenjem otkrivanja znanja u bazama podataka proučava razine razvijenosti prema podacima o Indeksu ljudskog razvoja Programa Ujedinjenih naroda za razvoj. Analiza se vrši korištenjem programa za rudarenje podataka Weka. Weka je besplatan računalni program otvorenog koda za rudarenje podataka. Otkrivanja znanja u bazama podataka je postupak pronalaženja vrijednih podataka u velikim bazama podataka. Interpretacijom podaci postaju informacije od velike važnosti za poduzeća i državu. U ovom radu biti će provedena analiza grupiranja podataka i analiza vremenskih serija. Analiza grupiranja podataka, odnosno klaster analiza, promatrane subjekte svrstava u grupe prema zajedničkim obilježjima. Analiza vremenskih serija promatra i predviđa buduće kretanje vrijednosti varijabli. Indeks ljudskog razvoja mjeri ljudski razvoj kroz tri dimenzije. Dimenzije dugog i zdravog života, obrazovanja i pristojnog standarda života.

**Ključne riječi:** indeks ljudskog razvoja, rudarenje podataka, baze podataka, klaster analiza, analiza vremenskih serija

## **ABSTRACT**

Analysis of the Human Development using knowledge discovery in databases studies levels of development according to Human Development Indeks of the United Nations Development Programme. The analysis is performed using Weka data mining software. Weka is a free open source software for data mining. Discovering knowledge in databases is the process of finding valuable data in large databases. Interpreted data becomes information of great value for companies and the government. In this paper, data grouping analysis and time series analysis will be performed. Data grouping analysis, i.e. cluster analysis, classifies the observed subjects into groups according to common characteristics. Time series analysis observes and predicts future movements in the values of variables. The Human Development Index measures human development through three dimensions. Dimensions of a long and healthy life, knowledge and a decent standard of living.

**Key words:** Human Development Index, data mining, databases, cluster analysis, time series analysis

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# **1 UVOD**

## **1.1 Predmet i cilj rada**

Trend iseljavanja mladog stanovništva u zemlje srednje Europe potiče raspravu o kvaliteti života u pojedinim državama. Program Ujedinjenih naroda za razvoj (*engl. United Nations Development Programme*) (UNDP) svake godine mjeri Indeks ljudskog razvoja (*engl. Human Development Index*) za 189 država svijeta i rangiraju ih sukladno tom indeksu. Cilj rada je pomoću računalnog programa za rudarenje podataka provesti klaster analizu i analizu vremenskih serija nad danim podacima o vrijednostima Indeksa ljudskog razvoja. Provođenje klaster analize grupirati će države u klastere prema razini razvijenosti. Temeljem rezultata klaster analize za 1990. i 2018. godinu dobiti ćemo uvid u početno stanje pripadnosti država klasteru, te uvid u promjenu stanja i odnosa razvijenosti na kraju promatranog razdoblja. Analiza vremenskih serija prikazati će nam buduće predviđeno kretanje vrijednosti Indeksa ljudskog razvoja za promatrane države. Cilj provođenja analize vremenskih serija je predvidjeti kretanje vrijednosti Indeksa ljudskog razvoja i promjene u redoslijedu razvijenosti 28 država članica Europske unije.

## **1.2 Izvor podataka i metode prikupljanja**

Program Ujedinjenih naroda za razvoj svake godine mjeri Indeks ljudskog razvoja za 189 država svijeta i rangiraju ih sukladno tom indeksu. Indeks ljudskog razvoja uključuje očekivano trajanje života na dan rođenja, očekivane godine školovanja, prosječan broj godina školovanja i bruto nacionalni dohodak po stanovniku. Podaci o indeksu javno su dostupni na internetskim stranicama Programa Ujedinjenih naroda za razvoj.

## **1.3 Sadržaj i struktura rada**

Rad je strukturiran u 5 poglavlja. Uvod predstavlja temu rasprave, cilj i način obrade podataka te izvor podataka. Nakon uvoda slijedi poglavlje ljudskog razvoja u kojem će biti govora o demografskim resursima, indeksu ljudskog razvoja, načinu izračuna indeksa ljudskog razvoja i trendovi indeksa ljudskog razvoja u svijetu od 1990. do 2018. godine. Treće poglavlje rada

odnosi se na otkrivanje znanja u bazama podataka u kojem će biti objašnjene baze podataka, što je zapravo otkrivanje znanja u bazama podataka, biti će prikazane metode otkrivanja znanja u bazama podataka te računalni programi kojima se provodi otkrivanje znanja u bazama podataka. Četvrto poglavlje čini analiza ljudskog razvoja korištenjem otkrivanja znanja u bazama podataka koje obuhvaća metodologiju istraživanja, biti će prikazani podaci korišteni u istraživanju, rezultat istraživanja te će se analizirati rezultati. Peto poglavlje čini zaključak u kojem će biti iznesena završna misao temeljena na provedenoj analizi.

## **2 LJUDSKI RAZVOJ**

### **2.1 Demografski resursi**

Demografija je znanost o stanovništvu temeljena na podacima kao što su broj rođenih, broj umrlih, dob, rasa i spol stanovništva. Podatke o demografskim karakteristikama stanovništva koriste država, neprofitne organizacije i poduzeća za razvoj politika ili istraživanje tržišta.

Oliveira-Roca (1991.) u svome djelu kao važnu sastavnicu ljudskog razvoja navodi demografske resurse koji obuhvaćaju ukupna kvalitativna i kvantitativna, stvarna i potencijalna društvena i biološka obilježja stanovništva u određenom vremenu i prostoru. Demografski resursi zapravo predstavljaju potencijal države koji se očituje putem stanovništva države. Determinante indeksa ljudskog razvoja također spadaju u demografske resurse.

Hrvatska je danas suočena s negativnim demografskim resursima, kao što su starenje stanovništva, depopulacija i prirodna i mehanička kretanja stanovnika. Prirodna i mehanička kretanja stanovnika zadnjih nekoliko godina u Hrvatskoj predstavljaju najveći udio negativnih demografskih resursa. Prirodna kretanja stanovnika odnose se na natalitet i mortalitet. Mehanička kretanja stanovnika odnose se na migracije. Migracije mladog stanovništva u zemlje srednje i zapadne Europe svakodnevna su tema kojom su suočene i ostale države regije. Nepovoljni demografski resursi dovode do smanjenja ljudskog kapitala i smanjenja "demografskog" potencijala koji čini temelj društveno-gospodarskog razvoja. Države istočne i južne Azije kao što su Kina i Indija bilježe visoke stope prirodnog prirasta što se u budućnosti može očitovati kao porast radno intenzivnog ljudskog kapitala koji pridonosi razvoju već zastupljene primarne i sekundarne djelatnosti. Države zapada razvijanjem tercijarne i kvartarne djelatnosti odmiču se od potreba demografskih resursa kao što je visoka stopa nataliteta, već se približavaju potrebama demografskih resursa kao što je prosječan broj godina školovanja stanovništva.

### **2.2 Indeks ljudskog razvoja**

Indeks ljudskog razvoja je statistički složeni indeks koji se sastoji od očekivanog trajanja života, obrazovanja i dohotka. Ljudski razvoj fokusiran je na bogatstvo ljudskog života, na mogućnosti

i želje ljudi, a ne samo na bogatstvo ekonomije zemlje u kojoj ljudi žive. Bogatstvo ekonomije indeks promatra kao sredstvo razvoja, a ne cilj razvoja, što znači da bogatije zemlje imaju veće mogućnosti za rast i razvoj. Proces ljudskog razvoja mora stvoriti okolinu u kojoj ljudi mogu postići svoj puni potencijal prema svojim ambicijama i odlukama koje donose. Države se rangiraju u 4 kategorije. Niska kategorija se kreće u rasponu od 0 do 0,549 poena, srednja od 0,550 do 0,699 poena, visoka od 0,700 do 0,799 poena i vrlo visoka od 0,800 do 1,000 poena indeksa. Nacija postiže veći rezultat kada je životni vijek njezinih stanovnika duži, razina obrazovanja veća i kada je bruto nacionalni dohodak po stanovniku veći. Program Ujedinjenih naroda za razvoj (UNDP) svake godine od 1990. mjeri indeks ljudskog razvoja i objavljuje rang zemalja u svom godišnjem izvještaju.

Indeks ljudskog razvoja prvi put se pojavljuje 1990. godine u Izvješću ljudskog razvoja (*engl. Human Development Report*) nakladnika Ureda za izvještaj o ljudskom razvoju (*engl. Human Development Report Office*) od Programa Ujedinjenih naroda za razvoj unutar međunarodne organizacije Ujedinjenih naroda. Mahbub ul Haq je pakistanski ekonomist, političar i teoretičar internacionalnog razvoja pod čijim je vodstvom utvrđen Indeks ljudskog razvoja. Zajedno s još 6 ekonomista za razvoj Haq je imao cilj preusmjeriti fokus s nacionalnog dohotka na ljudsko-centrične politike. Korten (1984.) ljudsko-centrični razvoj (*engl. People-centered development*) tumači kao pristup internacionalnog razvoja koji se usredotočuje na poboljšanje lokalnih društava, socijalne pravednosti i sudjelovanje u donošenju odluka. Ekonomski rast sam po sebi ne pridonosi ljudskom razvoju.

Brojne kritike su upućivane na Indeks ljudskog razvoja zbog toga što ne uzima u obzir tehnološki napredak ili doprinos nekih zemalja ljudskoj civilizaciji u globalu. Npr. doprinos zapadnih država u obliku lijekova siromašnim Afričkim državama koji su smanjili smrtnost dojenčadi. U svojoj publikaciji Wolff, Chong i Howard (2011.) diskutiraju Indeks ljudskog razvoja sa perspektive pogrešaka u temeljnim statistikama zdravstva, obrazovanja i dohotka koje su korištene za izradu izvješća. Identificiraju tri pogreške u podacima, a to su ažurnost podataka, revidiraju formulu izračuna i pragove za razvrstavanje statusa ljudskog razvoja. Ažurnost podataka se dovodi u pitanje zbog male vjerojatnosti da su svi podaci zemalja točni i prikazuju stvarno stanje promatranih parametara. 2010. godine formula se revidirala prema uputama Wolffa, Chonga i Howarda. Publikacija Wolffa, Chonga i Howarda predlaže zamjenu

starih pragova ljudskog razvoja koji su bili niski, srednji, visoki i vrlo visoki u nove pragove za razvrstavanje statusa ljudskog razvoja, a to su niski, srednji i visoki, no ta odluka o promjeni pragova ljudskog razvoja je odbačena.

2010. godine Izvještaj ljudskog razvoja predstavlja Indeks ljudskog razvoja prilagođen za nejednakosti (*engl. Inequality-adjusted Human Development Index*) (IHDI). Izvještaj navodi kako je Indeks ljudskog razvoja prilagođen za nejednakosti pravi pokazatelj ljudskog razvoja zbog toga što u obzir uzima nejednakosti između promatranih zemalja. Također Izvještaj navodi da se Indeks ljudskog razvoja može promatrati kao indeks potencijalnog ljudskog razvoja u slučaju da ne postoje nejednakosti između promatranih zemalja.

### 2.3 Izračun Indeksa ljudskog razvoja

Indeks ljudskog razvoja sastoji se od tri dimenzije. Dimenzija dugog i zdravog života sastoji se od indikatora očekivanog trajanja života prilikom rođenja koji čini indeks očekivane životne dobi. Dimenzija obrazovanja sastoji se od indikatora očekivanog trajanja školovanja i prosječan broj godina školovanja koje čine obrazovni indeks. Dimenzija pristojnog standarda života sastoji se od bruto nacionalnog dohotka po stanovniku i čini indeks bruto nacionalnog dohotka.

Slika 1 Determinante Indeksa ljudskog razvoja



Izvor: United Nations Development Programme: <http://hdr.undp.org/en/content/human-development-index-hdi> [20. kolovoza 2020.]

### 2.3.1 Metoda izračuna Indeksa ljudskog razvoja u razdoblju od 1990. do 2010. godine

Prema uputama Wolffa, Chonga i Howarda revidirala se metoda izračuna indeksa. Stara metoda se revidirala 2010. godine te je zadnji Izvještaj prema staroj metodi napravljen za 2009. godinu. Stara metoda koristila je parametre očekivanog trajanja života na dan rođenja, udjela pismenih u ukupnom stanovništvu, prosječan broj godina školovanja stanovništva i bruto domaći proizvod usklađen s paritetom kupovne moći. Vrijednosti pojedinih indeksa treba svesti u raspon od 0 do 1 kako bi se međusobno mogli uspoređivati. Program Ujedinjenih naroda za razvoj dao je sljedeću formulu koja vrijednosti indeksa pretvara vrijednosti u raspon od 0 do 1.

$$x \text{ indeks} = \frac{x - a}{b - a}$$

*Jednadžba 1 Izračun vrijednosti indeksa*

Vrijednost  $x$  indeks predstavlja jedan od indeksa korištenih u kalkulaciji Indeksa ljudskog razvoja. Simbol  $x$  predstavlja stvarnu vrijednost varijable  $x$  indeksa u pojedinoj zemlji. Simbol  $a$  predstavlja najmanju vrijednost, dok simbol  $b$  predstavlja najveću vrijednost koju varijabla  $x$  može poprimiti. Na taj način dobivamo vrijednost indeksa u rasponu od 0 do 1.

$$LEI = \frac{LE - 25}{85 - 25}$$

*Jednadžba 2 Indeks očekivanog trajanja života*

LEI (*engl. Life Expectancy Index*), odnosno Indeks očekivanog trajanja života na dan rođenja izračunava se na način da se od vrijednosti LE (*engl. Life Expectancy*), očekivano trajanje života, oduzme najmanja zadana vrijednost i podijeli s razlikom najveće i najmanje zadane vrijednosti. UNDP kao najmanju zadanu vrijednost daje 25 godina života, a najveću 85 godina života. U slučaju izračuna LEI-a vrijednost 0 predstavlja 25 godina života kao očekivano trajanje života, a vrijednost 1 predstavlja 85 godina života kao očekivano trajanje života.

$$EI = \frac{2}{3} \times ALI + \frac{1}{3} \times GEI$$

*Jednadžba 3 Indeks obrazovanja*

EI (*engl. Education Index*), odnosno Indeks obrazovanja, sastoji se od 2 varijable. ALI (*engl. Adult Literacy Index*), odnosno Indeks pismenosti odraslih, koja predstavlja 2/3 indeksa i GEI (*engl. Gross Enrollment Index*), odnosno Indeks bruto upisanih stanovnika u obrazovni sustav, koji predstavlja 1/3 indeksa.

$$ALI = \frac{ALR - 0}{100 - 0}$$

*Jednadžba 4 Indeks pismenosti*

ALI (*engl. Adult Literacy Index*), odnosno Indeks pismenih odraslih. ALR (*engl. Adult Literacy*), odnosno pismenost starijih uzima u obzir osobe starije od 15 godina. Vrijednost 0 predstavlja 0 pismenih u zajednici ili zemlji, dok vrijednost 100 znači da su svi pismeni u zajednici ili zemlji.

$$GEI = \frac{CGER - 0}{100 - 0}$$

*Jednadžba 5 Indeks bruto upisanih stanovnika u obrazovni sustav*

GEI (*engl. Gross Enrollment Index*), odnosno Indeks bruto upisanih stanovnika u obrazovni sustav. CGER (*engl. Combined Gross Enrolment Ratio*), odnosno kombinirani bruto omjer upisanih predstavlja zbroj upisanih osoba u sve stadije školovanja, tj. osnovnu i srednju školu. Vrijednost 0 predstavlja da nitko nije upisan u jedan od ta dva oblika školovanja, dok vrijednost 100 predstavlja da su svi koji mogu biti upisani u osnovnu ili srednju školu upisani.

$$GDP = \frac{\log(GDPpc) - \log(100)}{\log(40000) - \log(100)}$$

*Jednadžba 6 Bruto domaći proizvod*

Bruto domaći proizvod (*engl. Gross Domestic Product*) je makroekonomski pokazatelj vrijednosti finalnih dobara i usluga proizvedenih u zemlji tijekom godine. U izračunu Indeksa ljudskog razvoja koristi se BDPpc, odnosno bruto domaći proizvod po stanovniku. Za najmanju vrijednost uzima se 100 dolara BDPpc, a najveću vrijednost uzima se 40.000 dolara BDPpc.

$$HDI = \frac{LEI + EI + GDP}{3}$$

*Jednadžba 7 Stara formula izračuna HDI*

Stara metoda izračuna Indeksa ljudskog razvoja zbrajala je sva tri indeksa i dijelila ih na tri tako da je svaki indeks nosio jednu trećinu vrijednosti.

### **2.3.2 Metoda izračuna Indeksa ljudskog razvoja u razdoblju od 2010. godine do danas**

Revidiranjem stare metode izračuna Indeksa ljudskog razvoja uvedene su preinake. Izmjene formule i izračuna objavljene su 2010. godine u Izvješću ljudskog razvoja za 2009. godinu. Nove preinake prvi put su korištene u izračunu indeksa za 2010. godinu. Jedini parametar indeksa koji se nije promijenio bio je očekivano trajanje života na dan rođenja. Pismenost starijih i bruto upisanih stanovnika u obrazovni sustav obrazovne dimenzije zamijenjeni su očekivanim godinama školovanja i prosječnim brojem godina školovanja. Indikator bruto domaćeg proizvoda dimenzije pristojnog standarda života zamijenjen je bruto nacionalnim proizvodom po stanovniku usklađen za paritet kupovne moći. Na taj način se u izračun svrstao i dohodak stanovnika cijele nacije, odnosno ne samo onih koji privređuju u domovini već i van svoje domovine. Navedena promjena je jako utjecala na rang zemalja čiji stanovnici imaju tendenciju mehaničkih migracija.

$$LEI = \frac{LE - 20}{85 - 20}$$

*Jednadžba 8 Indeks očekivanog trajanja života (nakon 2010.)*

Izračun Indeksa očekivanog trajanja života na dan rođenja prilikom revidiranja nije se puno promijenio. Jedina promjena koja je nastala je ta što se minimalna granica s 25 godina života



smanjila na 20 godina života. Kada LEI iznosi 1 očekivano trajanje života na dan rođenja iznosi 85 godina, a kada LEI iznosi 0 tada je očekivano trajanje života na dan rođenja 20 godina.

$$EI = \frac{MYSI + EYSI}{2}$$

*Jednadžba 9 Indeks obrazovanja (nakon 2010.)*

Indeks obrazovanja nakon 2010. sadrži dvije nove varijable. To su Indeks prosječnog broj godina školovanja (*engl. Mean Years of Schooling Index (MYSI)*) i Indeks očekivanog broja godina školovanja (*engl. Expected Years of Schooling Index (EYSI)*). Indeks obrazovanja izračunava se zbrajanjem MYSI i EYSI te dijeljenjem s 2.

$$MYSI = \frac{MYS}{15}$$

*Jednadžba 10 Indeks prosječnog broja godina školovanja*

Indeks prosječnog broja školovanja izračunava se dijeljenjem prosječnog broja godina školovanja s 15. 15 zbog toga što je 15 godina uzeto kao projicirani maksimum za taj indikator.

$$EYSI = \frac{EYS}{18}$$

*Jednadžba 11 Indeks očekivanog broja godina školovanja*

Indeks očekivanog broja godina školovanja izračunava se dijeljenjem očekivanog broja godina školovanja s 18. 18 zbog toga što je 18 godina školovanja ekvivalentno za postizanje magisterija u većini zemalja svijeta.

$$II = \frac{\ln(GNIpc) - \ln(100)}{\ln(75000) - \ln(100)}$$

*Jednadžba 12 Indeks dohotka*

Indeks dohotka (*engl. Income Index (II)*) nakon revidiranja varijabla bruto nacionalnog dohotka po stanovniku se mijenja u bruto nacionalni dohodak po stanovniku. Sukladno promjenama BDPpc u BNPpc mijenja se i maksimalna moguća vrijednost koja se može postići. Maksimalna granica diže se s 40.000 dolara na 75.000 dolara. Indeks dohotka iznosi 1 kada je BNPpc 75.000 dolara, a 0 kada je BNPpc 100 dolara. Promjena indeksa dohotka najviše je utjecala na rang slabije razvijenih zemalja.

$$HDI = \sqrt[3]{LEI * EI * II}$$

*Jednadžba 13 Nova formula izračuna HDI*

Indeks ljudskog razvoja nakon revidiranja se računa kao treći korijen prijašnja tri normalizirana indeksa.

## **2.4 Trendovi Indeksa ljudskog razvoja u svijetu od 1990. do 2018. godine**

Indeks ljudskog razvoja 1990. godine mjerio se za 144 države svijeta, dok se 2018. godine mjerio za 189 države svijeta. Države se rangiraju prema rezultatima koje postižu i svrstavaju se u kategorije država s vrlo visokim, visokim, srednjim i niskim indeksom ljudskog razvoja. Ovo potpoglavlje prikazati će nam promjene u rezultatima indeksa prema kategorijama.

Zemlje s vrlo visokim Indeksom ljudskog razvoja 1990. godine su ostvarile u prosjeku 0,779 poena indeksa. Australija je zauzela prvo mjesto, SAD drugo, Kanada treće mjesto, dok se Norveška našla tek na četvrtom mjestu. 2018. godine zemlje s vrlo visokim Indeksom ljudskog razvoja su ostvarile u prosjeku 0,891 poena indeksa, što je povećanje za 14,23% u odnosu na 1990. godinu. Prvo mjesto 2018. godine zauzela je Norveška, drugo Švicarska, treće Irska, a Australija koja je 1990. bila prva, danas je tek na šestom mjestu.

Visoki Indeks ljudskog razvoja 1990. godine imale su države koje su ostvarile u prosjeku 0,568 poena indeksa, dok 2018. godine države s visokim Indeksom su one koje su ostvarile u prosjeku 0,750 poena indeksa, što relativno predstavlja povećanje od 32,04%. 1990. godine na prvom

mjestu među visoko razvijenim državama našla se Austrija, slijedio je Izrael, a treći je bio Luksemburg. 2018. godine prvo mjesto dijele Francuska i Češka, druga je Malta, a treća Italija.

Srednju razinu ljudskog razvoja 1990. godine ostvarile su države čiji je Indeks iznosio u prosjeku 0,437 poena, a 2018. u prosjeku 0,634 poena. To je povećanje od 45,08% koje je najveće među kategorijama razvijenosti. 1990. prvo mjesto je zauzela Sirija, drugo Egipat, a treće Svazi država. 2018. godine prvo mjesto među srednje razvijenim državama zauzeo je Tunis, drugo Mongolija, a treće Libanon. Zanimljivo je kako prosjek ljudskog razvoja svijeta iznosi 0,731 poena 2018. godine.

Niski Indeks ljudskog razvoja 1990. ostvarile su države čiji je Indeks iznosio u prosjeku 0,352 poena, a prema Izvještaju iz 2018. godine nisko kategorizirane su države koje su ostvarile u prosjeku 0,507 poena Indeksa. Države niskog ljudskog razvoja relativno su ostvarile rast ljudskog razvoja od 44,03%. 1990. godine Indija je zauzela prvo mjesto, Zambija drugo, Haiti treće, a na posljednjem mjestu se našao Niger s 0,213 poena. 2018. godine prvo mjesto zauzeo je Istočni Timor, drugo Honduras, treće Kiribati, dok se na posljednjem mjestu ljudskog razvoja našao Sudan s ostvarenih 0,332 poena Indeksa.

### **3 OTKRIVANJE ZNANJA U BAZAMA PODATAKA**

#### **3.1 Baze podataka**

Date (2003.) u vlastitoj publikaciji navodi kako korijeni baza podataka sežu do prvih knjižnica, vladinih, poslovnih i medicinskih bilježaka prije nego su kompjuteri izumljeni. Ljudi su shvatili važnost skladištenja podataka te osmislili način pohranjivanja, indeksiranja i ponovnog pozivanja podataka. Pojavom računala skladištenje podataka postalo je brzo, ekonomično i manje prostorno i radno izdašno prikupljanje i održavanje baze podataka. Baze podataka predstavljaju skup međusobno povezanih organiziranih podataka skladištenih u računalnom sustavu. Podaci su dostupni korisnicima računalnih sustava i aplikacijskim programima s ovlastima pristupa sustavu. Programska rješenja se koriste za unos, manipulaciju i brisanje podataka unutar baze podataka. Takav programski sustav se naziva sustav za upravljanje bazom podataka (*engl. Data Base Management System*). Sustav za upravljanje bazom podataka komunicira s krajnjim korisnicima, aplikacijama i samom bazom podataka. Komunikacija sustava i same baze podataka je u svrhu bilježenja i analiziranja podataka. Sustav za upravljanje bazom podataka unutar samog sebe ima ugrađene sigurnosne protokole i kontrole tako da brine za sigurnost podataka od neželjenog pristupa.

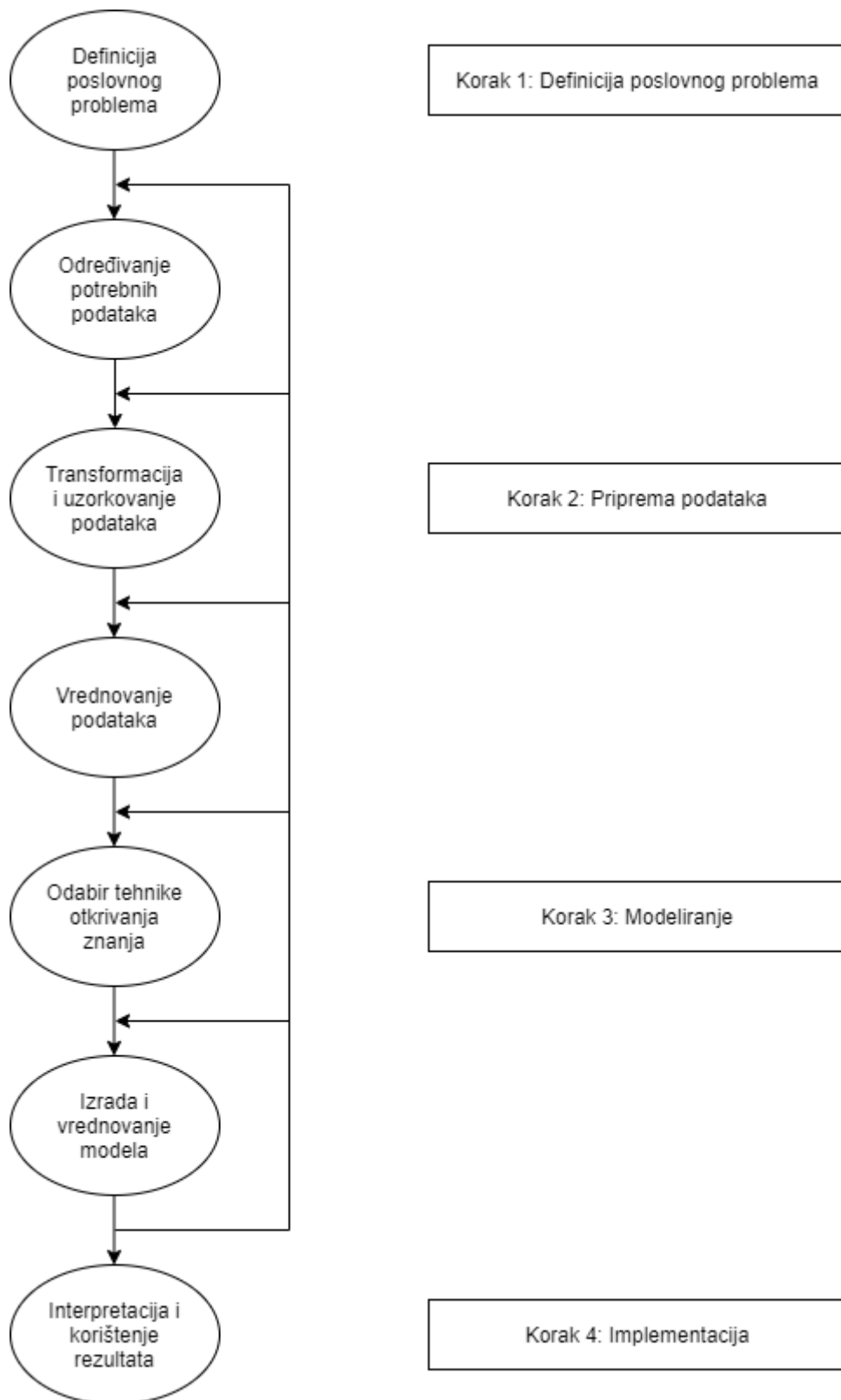
#### **3.2 Otkrivanje znanja u bazama podataka**

Pojavom računala, mobitela i drugih elektroničkih uređaja pojavila se i mogućnost bilježenja podataka istih. Podatke mi sami proizvodimo nesvjesno bilo to na poslu ili u slobodno vrijeme. Zanimljiv je podatak koji ističe Marr (2018.) u kolumni za Forbes da Google svake sekunde obavi 40.000 pretraživanja, što čini 3,5 milijardi pretraživanja svaki dan. Svaki korak unutar sustava se bilježi, mjeri i analizira. Koliko nam je digitalno doba olakšalo život, toliko smo mi sami postali proizvod digitalizacije. Proizvodimo podatke za poduzeća čijih smo proizvoda i usluga korisnici. Bilo to trgovački lanci, internetski portali, banke ili vlastiti poslodavac. Trgovački lanci analizom podataka o potrošačkoj košarici znaju koje proizvode bolje istaknuti i promovirati. Portali znaju naše interese. Banke analizom klijenata znaju kojim se skupinama klijenata moraju prikloniti kako bi povećali njihov udio u svom portfelju korisnika. Vlastiti poslodavac praćenjem aktivnosti računala i mobitela zna kada i na čemu radimo. Svaki

ostavljeni trag se bilježi u bazama podataka. No, postoji velika neiskorištenost svih zabilježenih podataka. Podaci se prikupljaju, a ne analiziraju. Imate auto, a ne znate voziti. Posljednjih godina možemo primijetiti kako su poslovni subjekti shvatili važnost podataka. Trend se uočava na ponudi poslova poduzeća, sve je veća potražnja za kadrom koji ima iskustva u prikupljanju, bilježenju i analizi podataka, pa se samim time pojavila i ponuda izobrazbe takvog kadra.

Pejić Bach i Kerep (2011.) navode kako se proces otkrivanja znanja iz baza podataka sastoji od četiri koraka: definicija poslovnog problema, priprema podataka, modeliranje i implementacija. Koraci se sastoje i od potprocesa. Korak definicija poslovnog problema je samostalan. Korak priprema podataka sastoji se od određivanja potrebnih podataka, transformacije i uzrokovanja podatka te vrednovanja podataka. Korak modeliranje obuhvaća odabir tehnike otkrivanja znanja i izrada te vrednovanje modela. Implementacija se sastoji od interpretacije i korištenja rezultata provedenog procesa. U nastavku će svaki korak biti jasnije objašnjen prema slici procesa iz knjige autora Pejić Bach i Kerep (2011.).

Slika 2 Proces otkrivanja znanja iz baza podataka



Izvor: Pejić Bach, M. i Kerep, I. (2011.) *Weka alat za otkrivanje znanja iz baza podataka: Proces otkrivanja znanja iz baza podataka* (2011., str. 10)

### **3.2.1 Definicija poslovnog problema**

Definiciju poslovnog problema možemo formulirati i kao postavljanje pitanja na koja želimo pronaći odgovor. Predstavlja prvi i važan korak u smjeru u kojem će teći sam proces otkrivanja znanja iz baza podataka. Kraj provedbe procesa otkrivanja znanja iz baza podataka nam mora dati odgovore na postavljena pitanja. Pitanja također moraju biti postavljena realno. Kako kažu autori Pejić Bach i Kerep (2011.) najbolji pristup definiranju poslovnog problema je analizirati već uspješno provedene procese otkrivanja znanja iz baza podataka i njih primijeniti na vlastitim podacima. Tako već imamo uspješan kostur za koji znamo da je primjenljiv. Koraku definiranja poslovnog problema također pripada i određivanje osoba koje sudjeluju u projektu. Tim se sastoji od analitičara koji poznaje metode i proces provedbe otkrivanja znanja iz baza podataka, informatičara koji poznaje baze podataka i osobe iz poduzeća koja je zadužena za definiranje zahtjeva i nadgledavanje. Također je važno imati i osobu iz menadžmenta koja nosi i brani projekt pred menadžmentom kako se provedba projekta ne bi narušila i ukinula.

### **3.2.2 Priprema podataka**

Korak priprema podataka sastoji se od određivanja potrebnih podataka, transformacija i uzrokovanja podataka i vrednovanja podataka. Kantardžić (2011.) navodi da se u stručnoj literaturi slabo spominje proces pripreme podataka za rudarenje podataka, a da je u stvarnom svijetu situacija potpuno drugačija. Više napora je potrebno uložiti u proces pripreme podataka nego je potrebno uložiti napora za primjenjivanje metoda za rudarenje podataka. Također navodi da su dvije ključne zadaće pripreme podataka organiziranje podataka u standardnu formu koja je spremna za procesuiranje i priprema podatkovnih setova koja vode najboljim performansama rudarenja podataka.

Sudionici procesa otkrivanja znanja iz baza podataka zajedno odabiru vrstu podataka koja će se koristiti i koja će biti od koristi u procesu. Pejić Bach i Kerep (2011.) navode da su podaci koji se najčešće koriste za otkrivanje znanja iz baza podataka pohranjeni u transakcijskim bazama

podataka i bazama klijenata. Podaci mogu biti numerički, ordinarni i nominalni. Potproces određivanja potrebnih podataka rezultira popisom podataka koji će se koristiti u izradi modela.

Korak transformacija podataka kako i sam govori, služi za transformaciju podataka u oblik pogodan za proces otkrivanja znanja iz baza podataka. Podaci korišteni u procesu moraju biti u tabelarnom obliku. Stupci prikazuju varijable, a reci opažanja. Uzorkovanje podataka je postupak analiziranja podskupa svih podataka. Zbog toga se u velikim skupovima podataka uzima samo uzorak koji se koristi u procesu otkrivanja znanja u bazama podataka te se rezultati uzorka primjenjuju na čitavi skup podataka.

Kantardžić (2011.) u poglavlju Missing Data daje jednostavno rješenje za podatke netipičnih vrijednosti i problematičnih podataka. Sugerira tri rješenja. Prvo rješenje je zamjena netipičnih vrijednosti i problematičnih podataka konstantom iz promatranog područja. Drugo rješenje je zamjena netipičnih vrijednosti i problematičnih podataka prosječnom vrijednosti cijelog raspona (npr. Indeks ljudskog razvoja je od 0 do 1, što bi značilo bilježenje 0,5 za države čiji nam podaci fale). Treće rješenje je zamjena netipičnih vrijednosti i problematičnih podataka prosječnom vrijednošću bilježenih podataka (npr. ako je minimalan zabilježeni Indeks ljudskog razvoja 0,350, a maksimalni 0,950, treće rješenje bi bilježilo Indeks ljudskog razvoja od 0,650 poena).

### **3.2.3 Modeliranje**

Modeliranje je korak koji obuhvaća potprocese odabir tehnike otkrivanja znanja i izrada i vrednovanje modela. Nad prethodno odabranim i pripremljenim podacima primjenjuju se različite metode za rudarenje podataka, ovisno o kakvim se podacima radi. Pejić Bach i Kerep (2011.) u poglavlju Modeliranje navode metode za klasifikaciju, predviđanje vrijednosti i grupiranje.



Metode za klasifikaciju predstavljaju algoritme koji uče iz danih podataka da bi naučili klasificirati, odnosno odrediti ishod novih zapažanja. Može se koristiti na način da se prema danim uvjetima odredi je li klijent nisko, srednje ili visoko kreditno rizičan.

Metode za predviđanje vrijednosti koriste se za predviđanje numeričkih vrijednosti na način da se trenutne informacije koriste u predviđanju, a predviđa se buduće stanje ili kretanje vrijednosti.

Metode za grupiranje koriste se za pronalaženje grupe objekata koji su slični jedan drugome u grupi, ali različiti od objekata iz drugih grupa. Zadatak grupiranja je svrstati populaciju u grupe sličnih vrijednosti i dodijeliti ih klasterima. Grupiranje se primjenjuje u marketingu i prodaji kako bi se personalizirala ponuda prema grupama kupaca.

#### **3.2.4 Implementacija rezultata**

Korak implementacija rezultata sastoji se od interpretacije i korištenja rezultata procesa otkrivanja znanja iz baza podataka. Rezultati se moraju interpretirati na način da ih razumije osoba iz menadžmenta koja je podržavala i branila projekt pred ostatkom poduzeća, te koja će rezultate prenijeti ostatku menadžmenta. Preferirani je oblik grafova za interpretaciju rezultata zbog lakog razumijevanja i grafičkog intuitivnog prikazivanja. Kvalitetnije prezentirani podaci, odnosno informacije dovest će do veće iskorištenosti i većeg izgleda provedbe novih procesa otkrivanja znanja iz baza podataka. Najbolji ishod provede samog projekta je implementacija tehnika u sam informatički sustav. Korišteni software sam uzima potrebne podatke na dnevnoj bazi i provodi proces otkrivanja znanja iz baza podataka i generira nove rezultate u stvarnom vremenu.

### **3.3 Metode otkrivanja znanja u bazama podataka**

Postoje različite metode otkrivanja znanja u bazama podataka, a na korisniku programa za rudarenje podataka je da odabere najpogodniju metodu. Metodu koja odgovara zadanom setu

podataka i metodu komplementarnu cilju provedbe procesa otkrivanja znanja u bazama podataka. Različite metode rudarenja podataka su asocijativna pravila, klasifikacija, klaster analiza, prognoziranje vremenskih serija, stabla odlučivanja, analiza netipičnih vrijednosti i problematičnih podataka i mnoge druge tehnike. U ovom radu jasnije će biti objašnjenje tehnike koje će se koristiti u samoj analizi podataka, a to su klaster analiza i prognoziranje vremenskih serija.

### **3.3.1 Klaster analiza**

Klaster analiza (*engl. Cluster Analysis*) ili grupiranje podataka je multivarijantna metoda čija je svrha grupirati uzorak subjekata ili objekata u grupe tako da su slični subjekti svrstani u istu grupu. Multivarijantna analiza grana je statistike koja se bavi analizom višestrukih izmjera većeg broja varijabli na jednom ili više uzoraka jedinki (Cooley i Lohnes, 1971.). Klaster analiza primjenjiva je u područjima gdje postoje uzorci koji dovode do određenog zaključka, npr. u medicini ili marketingu. Karakteriziranje pacijenta na bazi grupiranja simptoma može biti korisno pri identificiranju bolesti ili poremećaja i na taj način odabrati pravilan oblik terapije za liječenje pacijenta. Marketinški stručnjaci identificiraju grupe potencijalnih kupaca te tako ciljno provode marketinške kampanje, znaju kojoj skupini odgovara koji proizvod. Na primjer osobe koje se bave skijanjem su voljne izdvojiti veću količinu novca za svoje slobodne aktivnosti.

Postoji više metoda za provedbu klaster analize, no one se mogu klasificirati kao hijerarhijske i nehijerarhijske metode. Hijerarhijske metode su aglomerativna i dijeleće metode, a nehijerarhijska metoda je češće referencirana kao algoritam k-srednjih vrijednosti. Aglomerativna metoda na početku tretira svaki subjekt u svom zasebnom klasteru, odnosno grupi. Dva najbliža klastera se potom spajaju i tako dugo se klasteri međusobno kombiniraju dok ne nastane samo jedan klaster. Na kraju se odabere optimalan broj klastera iz svih mogućih rješenja prethodnih spajanja. Dijeleća metoda funkcionira na obrnuti način, svi subjekti se inicijalno nalaze u jednom klasteru, te se dijele sve dok svaki subjekt nema svoj klaster, tada se opet kao u aglomerativnoj metodi odabire optimalan broj klastera iz svih mogućih rješenja dijeljenja klastera. Korištenje algoritma k-srednjih vrijednosti započinje korisnikovim odabirom broja klastera, svaki subjekt se dodjeljuje "najbližem" klasteru (dužina se određuje

prema udaljenosti od centroida). Zatim se pronalaze centriodi formiranih klastera, to su točke unutar svakog klastera koja predstavljaju prosječnu vrijednost, odnosno sredinu klastera. Ponovno se računa udaljenost svakog subjekta od svakog centroida i subjekti se dodjeljuju drugom klasteru ako su bliži njegovom centroidu. Postupak se ponavlja sve dok centriodi postanu relativno stabilni, odnosno kad nema više "seljenja" subjekata iz jednog klastera u drugi klaster.

Cornish (2007.) u publikaciji za Mathematics Learning Support Centre upozorava da klaster analiza nema mehanizam za diferenciranje između relevantnih i irelevantnih varijabli, stoga je teret odabira varijabli na korisniku. Klasteri formirani klaster analizom jako ovise o varijablama koje su uključene u analizu, pogrešno odabrane varijable mogu imati veliki utjecaj na ishod analize.

### **3.3.2 Prognoziranje vremenskih serija**

Prognoziranje označava postupak predviđanja budućnosti na temelju prošlih podataka analizom trendova. Uočavaju se trendovi i uzorci kretanja vrijednosti. Vremenske serije predstavljaju niz podatkovnih točaka indeksiranih u određenom vremenskom redoslijedu. Najčešće je slijed snimljen u uzastopnim jednako raspoređenim vremenima (satu, danu, tjednu, mjesecu ili godini). Podaci se mogu bilježiti kontinuirano ili u vremenskim razmacima.

Prognoziranje vremenskih serija (*engl. Time-Series Forecasting*) predstavlja prognoziranje budućih kretanja promatranih vrijednosti. Kombinacija je prognoziranja i vremenskih serija, što znači da se na temelju prošlih podataka predviđa kretanje vrijednosti promatranih varijabli. Prolaskom vremena i bilježenim stvarnih podataka uspoređujemo prijašnje predviđene podatke sa stvarnima, te ih analiziramo. Time testiramo uspješnost našeg prognostičkog modela. Nove podatke možemo ponovo implementirati u sustav i napraviti novo prognoziranje budućih kretanja vrijednosti varijabli. Na taj način sustav uči iz prethodne pogreške i korigira se za nastale pogreške. Analiza vremenskih serija uključuje razvoj modela koji na temelju zabilježenih opažanja promatraju vremenski niz kako bi razumjeli uzorke zašto se nešto dogodilo. Prognostičke pogreške predstavljaju razlike između zabilježene vrijednosti i njezine

prognozirane vrijednosti. "Služe kao alat procjene uspješnosti tretiranja modela te omogućavaju daljnju optimizaciju. Njihova primjena daje korisniku uvid u pouzdanost modela" Pejić Bach i Medić (2020.). Prognoziranje vremenskih serija koristi se za analizu tržišta kapitala, otkrivanje uzoraka, prognoziranje potresa, prognoziranja kretanja ekonomija i drugim područjima čiji povijesni podaci mogu dati uvid u buduće stanje.

### **3.4 Programi za otkrivanje znanja u bazama podataka**

Postoji niz programa na tržištu za otkrivanje znanja u bazama podataka, nazivaju se programi za rudarenje podataka (*engl. Data Mining Software*). Teško je, odnosno skoro nemoguće zamisliti proces rudarenja podataka bez specijaliziranog programskog rješenja. Brojna programska rješenja rudarenja podataka su komercijalnog tipa, no postoji i niz programa otvorenog koda. Neki od prepoznatljivih komercijalnih su Sisense, Neural Designer, Rapid Insight Veera i SAS Enterprise Miner. Programi otvorenog koda predstavljaju programe čiji je izvorni kod dostupan unutar licence svim korisnicima koji mogu mijenjati, prepravljati i poboljšavati njegov sadržaj. Prepoznatljivi programi otvorenog koda su RapidMiner, Orange Dana mining, Anaconda i Weka.

#### **3.4.1 Weka**

Weka, skraćeno za Waikato Environment for Knowledge Analysis, je besplatan program za strojno učenje razvit na Sveučilištu Waikato u Novom Zelandu. 1993. godine započelo je razvijanje programa. Sadrži alate za pripremu podataka, klasifikaciju, grupiranje, asocijativna pravila, predviđanje i vizualizaciju te postoji mogućnost nadogradnje programa skidanjem dodatnih paketa alata, modela i metoda sa repozitorija programa koji su besplatni. Weka je besplatan program pod GNU General Public License. O samom postavljanju programa i njegovom korištenju biti će više govora na primjerima koji slijede u radu.

## **4 ANALIZA LJUDSKOG RAZVOJA KORIŠTENJEM OTKRIVANJA ZNANJA U BAZAMA PODATAKA**

### **4.1 Metodologija istraživanja**

Istraživanje će se provoditi u računalnom programu za rudarenje podataka Weka. Provoditi će se klaster analiza i analiza vremenskih serija.

Klaster analiza nad danim podacima Indeksa ljudskog razvoja grupirati će države prema vrijednosti Indeksa u grupe sebi sličnijima država. Države će biti grupirane u četiri klastera prema razvijenosti. Nisko razvijene države, srednje razvijene, visoko razvijene i vrlo visoko razvijene države prema Indeksu ljudskog razvoja. Program Ujedinjenih naroda za razvoj također grupira države u ta četiri stupnja razvijenosti. Analiza će se provesti za 1990. godinu i 2018. godinu. Na taj način moći ćemo vidjeti kako se mijenjao stupanj razvijenosti država i koje su iz jednog klastera prešle u drugi. Vidjeti ćemo također kako se mijenjala vrijednost centroida svakog stupnja razvijenosti kroz promatrano razdoblje.

Prognoziranje vremenskih serija prikazati će nam buduće kretanje Indeksa ljudskog razvoja kroz odabrani period godina i za odabrane države. Analizom vremenskih serija moći ćemo doći do odgovora koje će se zemlje u budućnosti bolje i brže razvijati te na taj način prestići zemlje iza kojih se trenutno nalaze. Prognozirati će se 10 godina unaprijed, tj. do 2028. godine. Koristiti će se mjere MAE i RMSE za računanje prognostičke pogreške modela.

### **4.2 Korišteni podaci**

Podaci koji će se koristiti u provedbi rudarenja podataka javno su dostupni na internetskim stranicama Programa Ujedinjenih naroda za razvoj. Danas se bilježe podaci o Indeksu ljudskog razvoja za 189 države svijeta.

Slika 3 prikazuje preuzete podatke u .csv formatu. Za lakše čitanje podataka, podaci se moraju manipulirati tako da svaka vrijednost prije i unutar dva zarezata bude u svojoj ćeliji. U Excelu označimo stupac A, zatim odaberemo karticu Data i naredbom Text to Columns pretvaramo podatke u lako čitljive podatke gdje svaki podataka ima svoju ćeliju. Slika 4 prikazuje pretvorene podatke u .xls format. Nepostojeći podaci, na čijim mjestima stoji "..", izbačeni su iz analize.

Slika 3 HDI podaci u .csv formatu

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
1	Human development index (HDI)																										
2	HDI Rank (2018), Country, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018																										
3	170 Afghanistan, 0.298, 0.304, 0.312, 0.308, 0.303, 0.327, 0.331, 0.335, 0.339, 0.343, 0.345, 0.347, 0.378, 0.387, 0.400, 0.410, 0.410, 0.419, 0.431, 0.436, 0.447, 0.464, 0.474, 0.479, 0.485, 0.488, 0.490, 0.491, 0.493, 0.496																										

Slika 4 Pretvoreni podaci u .xls format

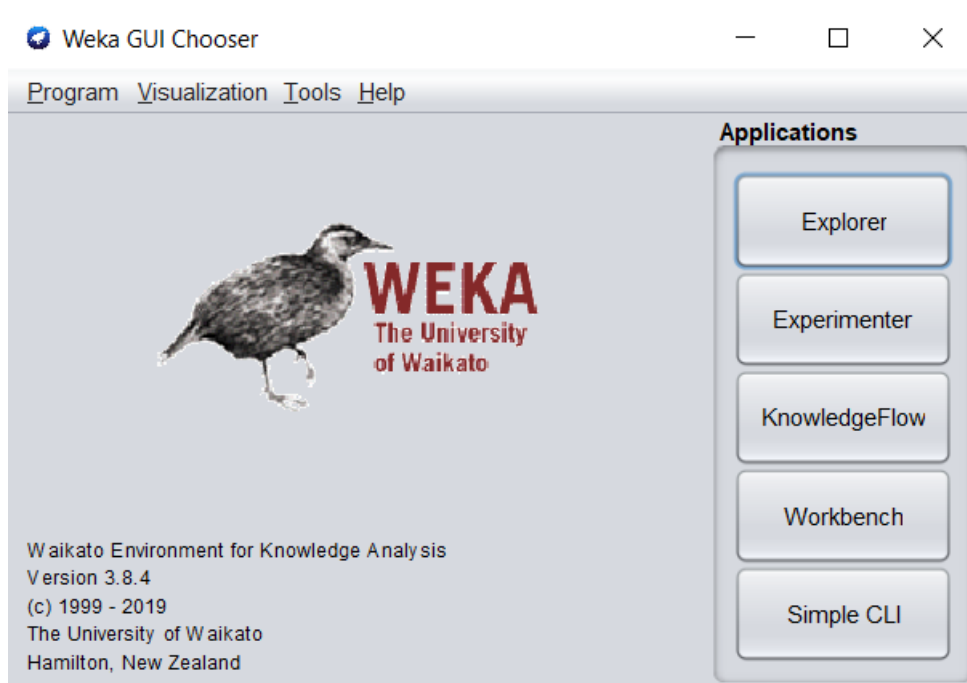
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE		
1	Human development index (HDI)																																
2	HDI Rank Country 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018																																
3	170 Afghanistan 0.644 0.615 0.608 0.611 0.617 0.619 0.619 0.639 0.639 0.645 0.660 0.667 0.673 0.680 0.687 0.692 0.702 0.709 0.718 0.724 0.729 0.734 0.739 0.741 0.759 0.771 0.787 0.788 0.788 0.789 0.791																																

## 4.3 Rezultat istraživanja

### 4.3.1 Klaster analiza

Podatke korištene u klaster analizi prvo moramo učitati u panel Preprocess koji se nalazi unutar korisničkog sučelja Explorer u računalnom programu Weka. Korisničkom sučelju Explorer odabiremo u početnom izborniku programa.

Slika 5 Početni izbornik



Odabirom korisničkog sučelja Explorer otvara nam se novi prozor. Novi prozor sadrži panel Preprocess u koji učitavamo podatke. Slika 6 prikazuje učitane podatke korištene u analizi. Kako bi program prepoznao podatke, potrebno ih je transformirati u programu prepoznatljivom obliku. Korisničko sučelje Explorer također sadrži panele za klasifikaciju, grupiranje, asocijativna pravila, odabir relevantnih atributa, vizualizaciju i u ovom slučaju panel predviđanja koji je naknadno dodani zbog potreba rada.

## Slika 6 Panel Preprocess

The screenshot shows the Weka Explorer interface in the Preprocess mode. The top menu bar includes Preprocess, Classify, Cluster, Associate, Select attributes, Visualize, and Forecast. Below the menu are buttons for Open file..., Open URL..., Open DB..., Generate..., Undo, Edit..., and Save....

The Filter section shows a dropdown menu set to 'None' with 'Ap...' and 'Stop' buttons.

The Current relation section displays: Relation: Human Development Index (HDI) final excel st..., Instances: 189, Attributes: 30, and Sum of weights: 189.

The Attributes section has buttons for All, None, Invert, and Pattern. Below is a list of attributes with checkboxes:

No.	Name
1	<input type="checkbox"/> Country
2	<input checked="" type="checkbox"/> 1990
3	<input type="checkbox"/> 1991
4	<input type="checkbox"/> 1992
5	<input type="checkbox"/> 1993
6	<input type="checkbox"/> 1994
7	<input type="checkbox"/> 1995
8	<input type="checkbox"/> 1996
9	<input type="checkbox"/> 1997
10	<input type="checkbox"/> 1998
11	<input type="checkbox"/> 1999
12	<input type="checkbox"/> 2000
13	<input type="checkbox"/> 2001
14	<input type="checkbox"/> 2002
15	<input type="checkbox"/> 2003
16	<input type="checkbox"/> 2004
17	<input type="checkbox"/> 2005

A 'Remove' button is located below the list.

The Selected attribute section shows: Name: 1990, Missing: 0 (0%), Distinct: 130, Type: Numeric, Unique: 116 (61%). Below this is a table of statistics:

Statistic	Value
Minimum	0
Maximum	0.866
Mean	0.453
StdDev	0.292

Below the statistics is a dropdown menu for 'Class: 2018 (Num)' and a 'Visualize All' button.

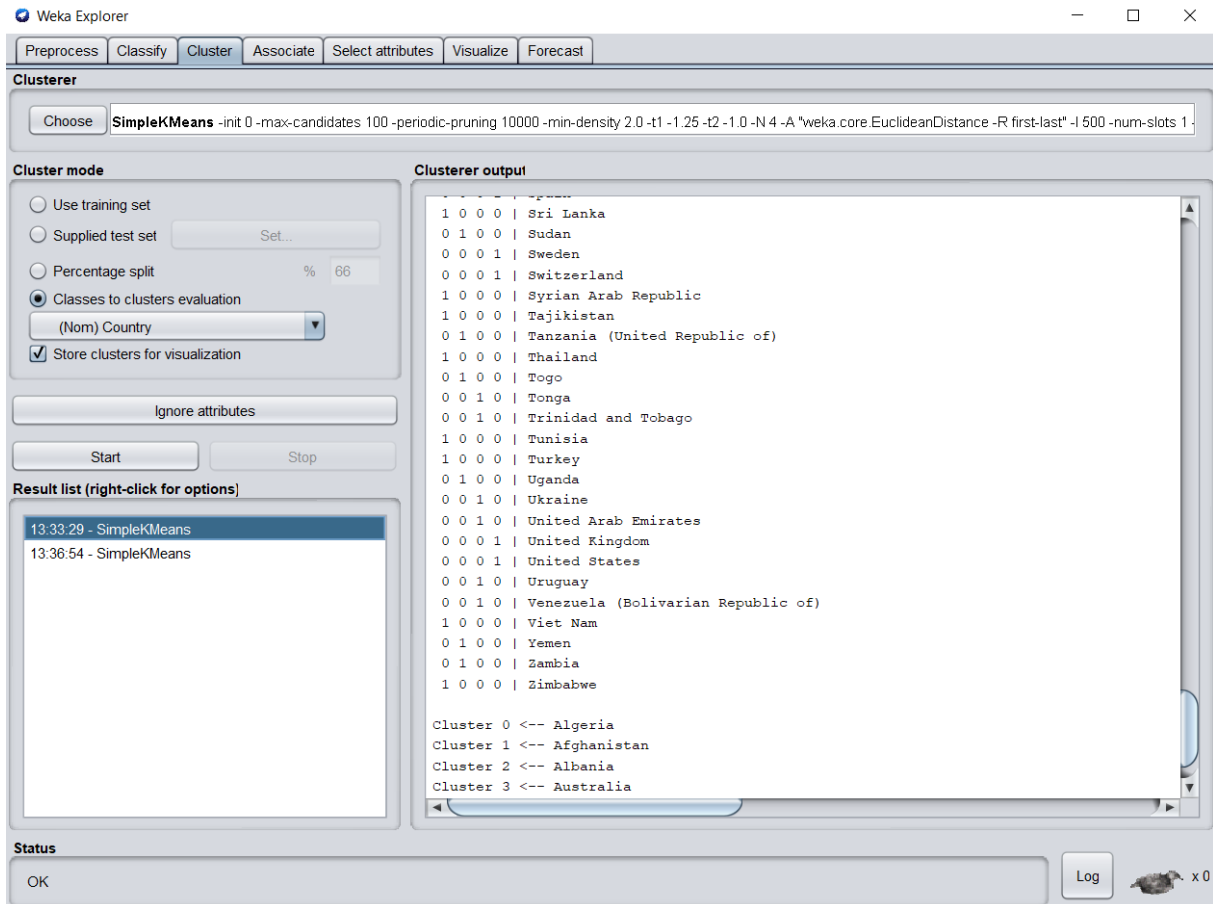
The histogram shows the distribution of the selected attribute. The x-axis ranges from 0 to 0.87. The y-axis represents frequency. The bars are labeled with their respective frequencies: 45, 13, 30, 50, and 51.

The Status bar at the bottom shows 'OK' and a 'L...' button with a small icon and 'x 0'.

Slika 7 prikazuje panel Cluster u kojem se provodi klaster analiza. U polju "Clusterer" odabiremo algoritam kojim provodimo klaster analizu. Klikom na ime odabranog algoritma otvaraju nam se postavke samog algoritma koje su prikazane u slici 8. Polje Cluster mode daje mogućnosti odabira načina klasteriranja. Odabrani je način Classes to cluster evaluation u analizi Indeksa ljudskog razvoja. Način Classes to cluster evaluation prvo određuje klaster prema danim podacima, zatim tijekom faze testiranja pridodaje klase klasterima. U nastavku će biti prikazane pridodane klase klasterima. Pritiskom na gumb Start pokrećemo algoritam, a u prozoru Clusterer output su prikazani rezultati provedenog klasteriranja.



## Slika 7 Panel Cluster

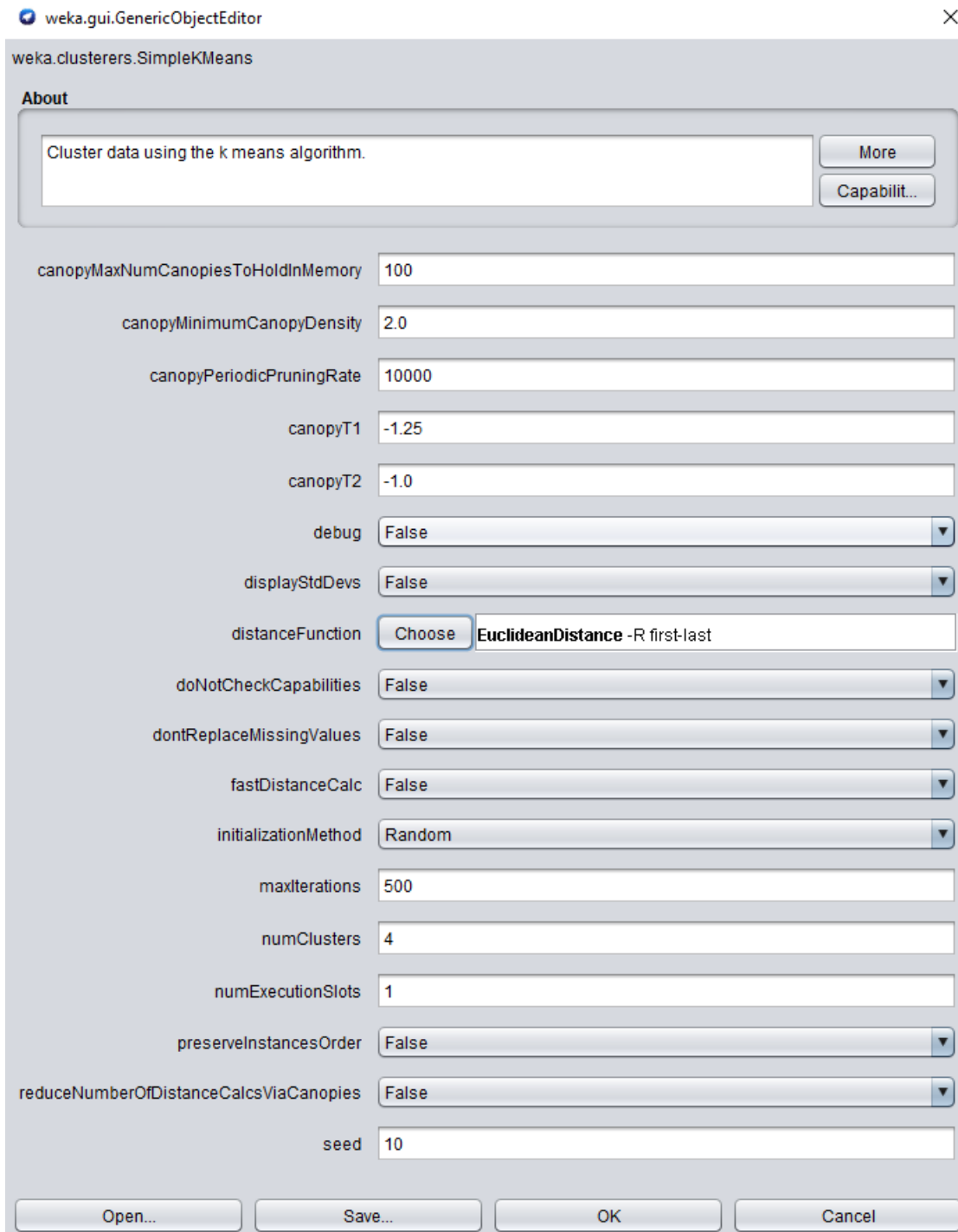


Slika 8 prikazuje postavke algoritma SimpleKMeans. U odnosu na zadane postavke algoritma promijenjeni je samo parametar numClusters kojim zadajemo broj klastera u analizi. Odabrana su četiri klastera zbog toga što i sam Indeks ljudskog razvoja ima četiri razine razvoja po kojima svrstava države. U slučajevima gdje sami biramo broj klastera možemo primijeniti jednadžbu za izračun povoljnog broja klastera, a ona glasi:

$$k \sim \sqrt{\frac{n}{2}}$$

*Jednadžba 14 Formula za izračun broja klastera*

Slika 8 Postavka SimpleKMeans



Slika 9 prikazuje rezultate provedbe klaster analize na temelju podataka iz 1990. godine, godine kada se Indeks ljudskog razvoja prvi puta mjerio. Sa slike je vidljiv broj instanci, broj atributa, vrijednosti centroida klastera i broj država u pojedinom klasteru.

## Slika 9 Rezultat klaster analize za 1990. godinu

```
=== Run information ===

Scheme:      weka.clusterers.SimpleKMeans -init 0 -max-candidates 100 -per
Relation:    Human Development Index (HDI) final excel stari 1990
Instances:   144
Attributes:  2
              1990

Ignored:
Country

Test mode:   Classes to clusters evaluation on training data

=== Clustering model (full training set) ===

kMeans
=====

Number of iterations: 12
Within cluster sum of squared errors: 0.7588791484455621

Initial starting points (random):

Cluster 0: 0.732
Cluster 1: 0.525
Cluster 2: 0.734
Cluster 3: 0.82

Missing values globally replaced with mean/mode

Final cluster centroids:

Attribute    Full Data      Cluster#
              (144.0)      0          1          2          3
=====
1990         0.595         0.564      0.355      0.6916     0.8016

Time taken to build model (full training data) : 0 seconds

=== Model and evaluation on training set ===

Clustered Instances

0          40 ( 28%)
1          35 ( 24%)
2          42 ( 29%)
3          27 ( 19%)
```

Slike 10, 11 i 12 prikazuju pripadnost pojedine države klasteru. 0 označava nepripadnost, dok 1 označava pripadnost klasteru. Klaster 1 slabo razvijene države, klaster 0 srednje razvijene države, klaster 2 visoko razvijene države i klaster 3 vrlo razvijene države. Možemo primijetiti kako je Hrvatska 1990. godine pripadala visoko razvijenim državama prema Indeksu ljudskog razvoja. Države su poredane abecednim redom.

*Slika 10 Pripadnost države klasteru 1990. godine (1)*

Class attribute: Country

Classes to Clusters:

```
0 1 2 3 <-- assigned to cluster
0 1 0 0 | Afghanistan
0 0 1 0 | Albania
1 0 0 0 | Algeria
0 0 1 0 | Argentina
0 0 1 0 | Armenia
0 0 0 1 | Australia
0 0 0 1 | Austria
0 0 1 0 | Bahrain
0 1 0 0 | Bangladesh
0 0 1 0 | Barbados
0 0 0 1 | Belgium
1 0 0 0 | Belize
0 1 0 0 | Benin
1 0 0 0 | Bolivia (Plurinational State of)
1 0 0 0 | Botswana
1 0 0 0 | Brazil
0 0 0 1 | Brunei Darussalam
0 0 1 0 | Bulgaria
0 1 0 0 | Burundi
0 1 0 0 | Cambodia
0 1 0 0 | Cameroon
0 0 0 1 | Canada
0 1 0 0 | Central African Republic
0 0 1 0 | Chile
1 0 0 0 | China
1 0 0 0 | Colombia
1 0 0 0 | Congo
0 1 0 0 | Congo (Democratic Republic of the)
0 0 1 0 | Costa Rica
0 0 1 0 | Croatia
0 0 1 0 | Cuba
0 0 1 0 | Cyprus
0 0 1 0 | Czechia
0 1 0 0 | Ivory Coast
0 0 0 1 | Denmark
1 0 0 0 | Dominican Republic
0 0 1 0 | Ecuador
1 0 0 0 | Egypt
1 0 0 0 | El Salvador
0 0 1 0 | Estonia
1 0 0 0 | Eswatini (Kingdom of)
0 0 1 0 | Fiji
0 0 0 1 | Finland
0 0 0 1 | France
1 0 0 0 | Gabon
0 1 0 0 | Gambia
0 0 0 1 | Germany
0 1 0 0 | Ghana
0 0 0 1 | Greece
1 0 0 0 | Guatemala
0 1 0 0 | Guinea
1 0 0 0 | Guyana
```

*Slika 11 Pripadnost države klasteru 1990. godine (2)*

1 0 0 0 | Guyana  
0 1 0 0 | Haiti  
1 0 0 0 | Honduras  
0 0 0 1 | Hong Kong  
0 0 1 0 | Hungary  
0 0 0 1 | Iceland  
0 1 0 0 | India  
1 0 0 0 | Indonesia  
1 0 0 0 | Iran (Islamic Republic of)  
1 0 0 0 | Iraq  
0 0 0 1 | Ireland  
0 0 0 1 | Israel  
0 0 0 1 | Italy  
0 0 1 0 | Jamaica  
0 0 0 1 | Japan  
1 0 0 0 | Jordan  
0 0 1 0 | Kazakhstan  
1 0 0 0 | Kenya  
0 0 1 0 | Korea (Republic of)  
0 0 1 0 | Kuwait  
1 0 0 0 | Kyrgyzstan  
0 1 0 0 | Lao Peoples Democratic Republic  
0 0 1 0 | Latvia  
1 0 0 0 | Lesotho  
0 0 1 0 | Libya  
0 0 1 0 | Lithuania  
0 0 0 1 | Luxembourg  
0 1 0 0 | Malawi  
0 0 1 0 | Malaysia  
0 1 0 0 | Mali  
0 0 1 0 | Malta  
0 1 0 0 | Mauritania  
1 0 0 0 | Mauritius  
0 0 1 0 | Mexico  
0 0 1 0 | Moldova (Republic of)  
1 0 0 0 | Mongolia  
0 1 0 0 | Morocco  
0 1 0 0 | Mozambique  
0 1 0 0 | Myanmar  
1 0 0 0 | Namibia  
0 1 0 0 | Nepal  
0 0 0 1 | Netherlands  
0 0 0 1 | New Zealand  
1 0 0 0 | Nicaragua  
0 1 0 0 | Niger  
0 0 0 1 | Norway  
0 1 0 0 | Pakistan  
0 0 1 0 | Panama  
0 1 0 0 | Papua New Guinea  
1 0 0 0 | Paraguay  
1 0 0 0 | Peru  
1 0 0 0 | Philippines  
0 0 1 0 | Poland  
0 0 1 0 | Portugal  
0 0 0 1 | Qatar  
0 0 1 0 | Romania

*Slika 12 Pripadnost države klasteru 1990. godine (3)*

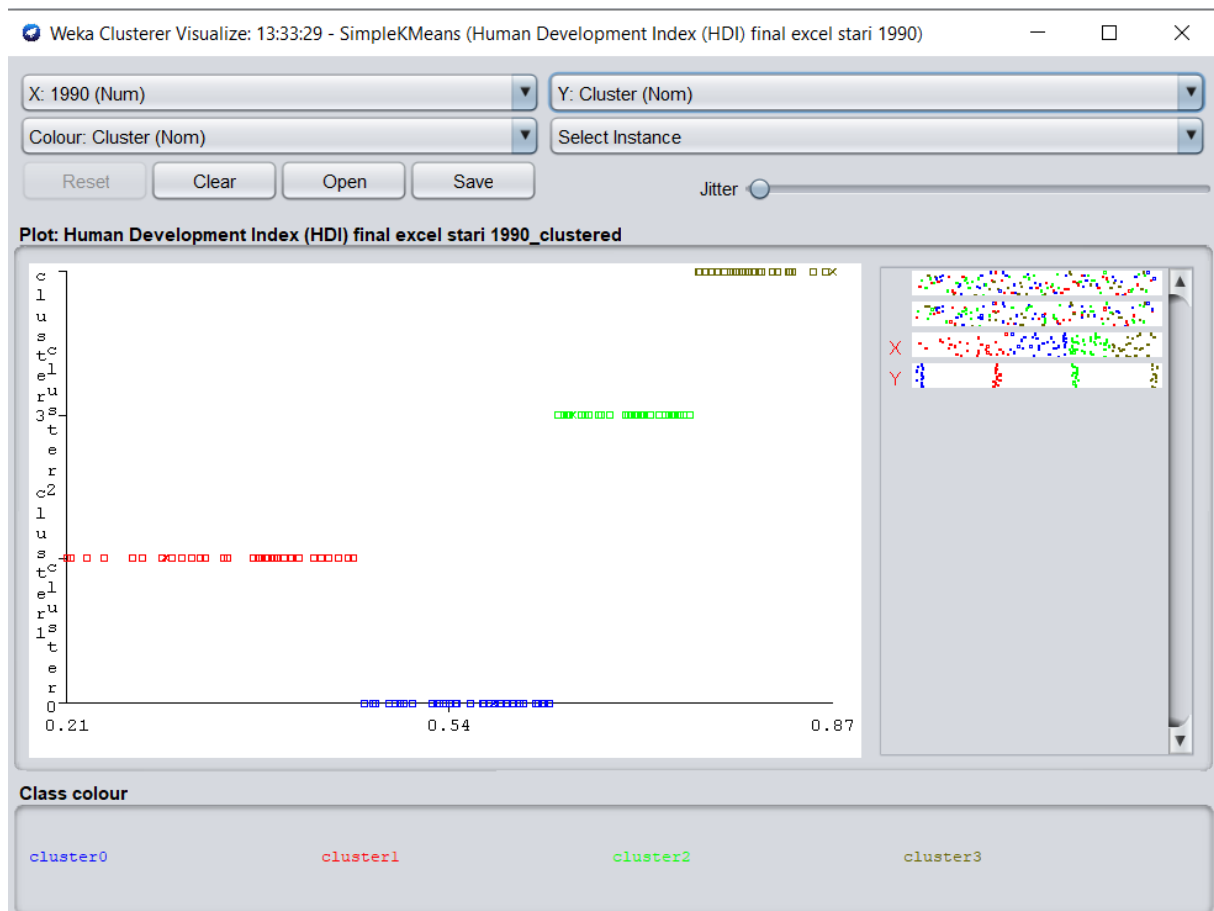
```
0 0 0 1 | Qatar
0 0 1 0 | Romania
0 0 1 0 | Russian Federation
0 1 0 0 | Rwanda
1 0 0 0 | Samoa
0 1 0 0 | Sao Tome and Principe
0 0 1 0 | Saudi Arabia
0 1 0 0 | Senegal
0 0 1 0 | Serbia
0 1 0 0 | Sierra Leone
0 0 1 0 | Singapore
0 0 1 0 | Slovakia
0 0 0 1 | Slovenia
1 0 0 0 | South Africa
0 0 0 1 | Spain
1 0 0 0 | Sri Lanka
0 1 0 0 | Sudan
0 0 0 1 | Sweden
0 0 0 1 | Switzerland
1 0 0 0 | Syrian Arab Republic
1 0 0 0 | Tajikistan
0 1 0 0 | Tanzania (United Republic of)
1 0 0 0 | Thailand
0 1 0 0 | Togo
0 0 1 0 | Tonga
0 0 1 0 | Trinidad and Tobago
1 0 0 0 | Tunisia
1 0 0 0 | Turkey
0 1 0 0 | Uganda
0 0 1 0 | Ukraine
0 0 1 0 | United Arab Emirates
0 0 0 1 | United Kingdom
0 0 0 1 | United States
0 0 1 0 | Uruguay
0 0 1 0 | Venezuela (Bolivarian Republic of)
1 0 0 0 | Viet Nam
0 1 0 0 | Yemen
0 1 0 0 | Zambia
1 0 0 0 | Zimbabwe

Cluster 0 <-- Algeria
Cluster 1 <-- Afghanistan
Cluster 2 <-- Albania
Cluster 3 <-- Australia

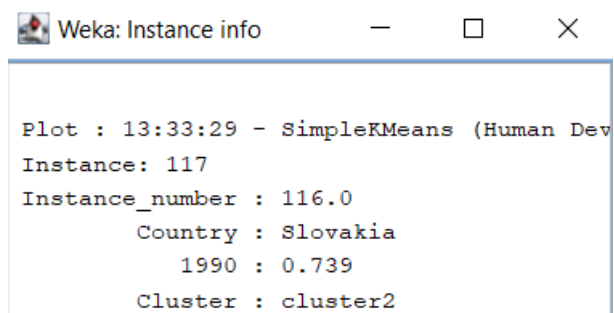
Incorrectly clustered instances :      140.0      97.2222 %
```

Slika 13 predstavlja vizualni prikaz pripadnosti država klasteru generiran u programu Weka. Klikom na pojedinu točku otvara se novi prozor u kojem stoji naziv države, vrijednost Indeksa i pripadnost klasteru (Slika 14).

Slika 13 Vizualni prikaz pripadnosti klasteru 1990.



Slika 14 Prozor informacija o točki na grafu



Slika 15 prikazuje provedbu rezultata klaster analize za 2018. godinu.

## Slika 15 Rezultat klaster analize za 2018. godinu

```
=== Run information ===

Scheme:      weka.clusterers.SimpleKMeans -init 0 -max-candidates 100 -peri
Relation:    Human Development Index (HDI) final excel stari 2018
Instances:   189
Attributes:  2
              2018

Ignored:
Country

Test mode:   Classes to clusters evaluation on training data

=== Clustering model (full training set) ===

kMeans
=====

Number of iterations: 21
Within cluster sum of squared errors: 0.9038193375806289

Initial starting points (random):

Cluster 0: 0.759
Cluster 1: 0.496
Cluster 2: 0.536
Cluster 3: 0.518

Missing values globally replaced with mean/mode

Final cluster centroids:

Attribute    Full Data      Cluster#
              (189.0)      0          1          2          3
=====
2018         0.7135      0.8924     0.4785     0.7546     0.6116

Time taken to build model (full training data) : 0 seconds

=== Model and evaluation on training set ===

Clustered Instances

0      49 ( 26%)
1      35 ( 19%)
2      71 ( 38%)
3      34 ( 18%)
```

Slike 16, 17, 18 i 19 prikazuju pripadnost države klasteru za 2018. godinu. 0 predstavlja nepripadnost, a 1 predstavlja pripadnost države klasteru. Klaster 0 predstavlja države s jako visokim Indeksom ljudskog razvoja, klaster 1 predstavlja države niske razine razvijenost, klaster 2 predstavlja države s visokom razinom razvijenosti i klaster 3 predstavlja države sa srednjom razinom razvijenosti.



*Slika 16 Pripadnost države klasteru 2018. godine (1)*

Class attribute: Country

Classes to Clusters:

```
0 1 2 3 <-- assigned to cluster
0 1 0 0 | Afghanistan
0 0 1 0 | Albania
0 0 1 0 | Algeria
1 0 0 0 | Andorra
0 0 0 1 | Angola
0 0 1 0 | Antigua and Barbuda
1 0 0 0 | Argentina
0 0 1 0 | Armenia
1 0 0 0 | Australia
1 0 0 0 | Austria
0 0 1 0 | Azerbaijan
0 0 1 0 | Bahamas
1 0 0 0 | Bahrain
0 0 0 1 | Bangladesh
0 0 1 0 | Barbados
0 0 1 0 | Belarus
1 0 0 0 | Belgium
0 0 1 0 | Belize
0 1 0 0 | Benin
0 0 0 1 | Bhutan
0 0 1 0 | Bolivia (Plurinational State of)
0 0 1 0 | Bosnia and Herzegovina
0 0 1 0 | Botswana
0 0 1 0 | Brazil
1 0 0 0 | Brunei Darussalam
0 0 1 0 | Bulgaria
0 1 0 0 | Burkina Faso
0 1 0 0 | Burundi
0 0 0 1 | Cabo Verde
0 0 0 1 | Cambodia
0 0 0 1 | Cameroon
1 0 0 0 | Canada
0 1 0 0 | Central African Republic
0 1 0 0 | Chad
1 0 0 0 | Chile
0 0 1 0 | China
0 0 1 0 | Colombia
0 1 0 0 | Comoros
0 0 0 1 | Congo
0 1 0 0 | Congo (Democratic Republic of the)
0 0 1 0 | Costa Rica
1 0 0 0 | Croatia
0 0 1 0 | Cuba
1 0 0 0 | Cyprus
1 0 0 0 | Czechia
0 1 0 0 | Ivory Coast
1 0 0 0 | Denmark
0 1 0 0 | Djibouti
0 0 1 0 | Dominica
0 0 1 0 | Dominican Republic
0 0 1 0 | Ecuador
0 0 1 0 | Egypt
0 0 0 1 | El Salvador
```

---

*Slika 17 Pripadnost države klasteru 2018. godine (2)*

0 0 0 1 | El Salvador  
0 0 0 1 | Equatorial Guinea  
0 1 0 0 | Eritrea  
1 0 0 0 | Estonia  
0 0 0 1 | Eswatini (Kingdom of)  
0 1 0 0 | Ethiopia  
0 0 1 0 | Fiji  
1 0 0 0 | Finland  
1 0 0 0 | France  
0 0 1 0 | Gabon  
0 1 0 0 | Gambia  
0 0 1 0 | Georgia  
1 0 0 0 | Germany  
0 0 0 1 | Ghana  
1 0 0 0 | Greece  
0 0 1 0 | Grenada  
0 0 0 1 | Guatemala  
0 1 0 0 | Guinea  
0 1 0 0 | Guinea-Bissau  
0 0 0 1 | Guyana  
0 1 0 0 | Haiti  
0 0 0 1 | Honduras  
1 0 0 0 | Hong Kong  
1 0 0 0 | Hungary  
1 0 0 0 | Iceland  
0 0 0 1 | India  
0 0 1 0 | Indonesia  
0 0 1 0 | Iran (Islamic Republic of)  
0 0 1 0 | Iraq  
1 0 0 0 | Ireland  
1 0 0 0 | Israel  
1 0 0 0 | Italy  
0 0 1 0 | Jamaica  
1 0 0 0 | Japan  
0 0 1 0 | Jordan  
0 0 1 0 | Kazakhstan  
0 0 0 1 | Kenya  
0 0 0 1 | Kiribati  
1 0 0 0 | Korea (Republic of)  
0 0 1 0 | Kuwait  
0 0 0 1 | Kyrgyzstan  
0 0 0 1 | Lao Peoples Democratic Republic  
1 0 0 0 | Latvia  
0 0 1 0 | Lebanon  
0 1 0 0 | Lesotho  
0 1 0 0 | Liberia  
0 0 1 0 | Libya  
1 0 0 0 | Liechtenstein  
1 0 0 0 | Lithuania  
1 0 0 0 | Luxembourg  
0 1 0 0 | Madagascar  
0 1 0 0 | Malawi  
0 0 1 0 | Malaysia  
0 0 1 0 | Maldives  
0 1 0 0 | Mali  
1 0 0 0 | Malta

*Slika 18 Pripadnost države klasteru 2018. godine (3)*

1 0 0 0 | Malta  
0 0 1 0 | Marshall Islands  
0 1 0 0 | Mauritania  
0 0 1 0 | Mauritius  
0 0 1 0 | Mexico  
0 0 0 1 | Micronesia (Federated States of)  
0 0 1 0 | Moldova (Republic of)  
0 0 1 0 | Mongolia  
0 0 1 0 | Montenegro  
0 0 0 1 | Morocco  
0 1 0 0 | Mozambique  
0 0 0 1 | Myanmar  
0 0 0 1 | Namibia  
0 0 0 1 | Nepal  
1 0 0 0 | Netherlands  
1 0 0 0 | New Zealand  
0 0 0 1 | Nicaragua  
0 1 0 0 | Niger  
0 1 0 0 | Nigeria  
0 0 1 0 | North Macedonia  
1 0 0 0 | Norway  
1 0 0 0 | Oman  
0 0 0 1 | Pakistan  
0 0 1 0 | Palau  
0 0 1 0 | Palestine  
0 0 1 0 | Panama  
0 1 0 0 | Papua New Guinea  
0 0 1 0 | Paraguay  
0 0 1 0 | Peru  
0 0 1 0 | Philippines  
1 0 0 0 | Poland  
1 0 0 0 | Portugal  
1 0 0 0 | Qatar  
0 0 1 0 | Romania  
1 0 0 0 | Russian Federation  
0 1 0 0 | Rwanda  
0 0 1 0 | Saint Kitts and Nevis  
0 0 1 0 | Saint Lucia  
0 0 1 0 | Saint Vincent and the Grenadines  
0 0 1 0 | Samoa  
0 0 0 1 | Sao Tome and Principe  
1 0 0 0 | Saudi Arabia  
0 1 0 0 | Senegal  
0 0 1 0 | Serbia  
0 0 1 0 | Seychelles  
0 1 0 0 | Sierra Leone  
1 0 0 0 | Singapore  
1 0 0 0 | Slovakia  
1 0 0 0 | Slovenia  
0 0 0 1 | Solomon Islands  
0 0 1 0 | South Africa  
0 1 0 0 | South Sudan  
1 0 0 0 | Spain  
0 0 1 0 | Sri Lanka  
0 1 0 0 | Sudan  
0 0 1 0 | Suriname  
1 0 0 0 | Sweden

*Slika 19 Pripadnost države klasteru 2018. godine (4)*

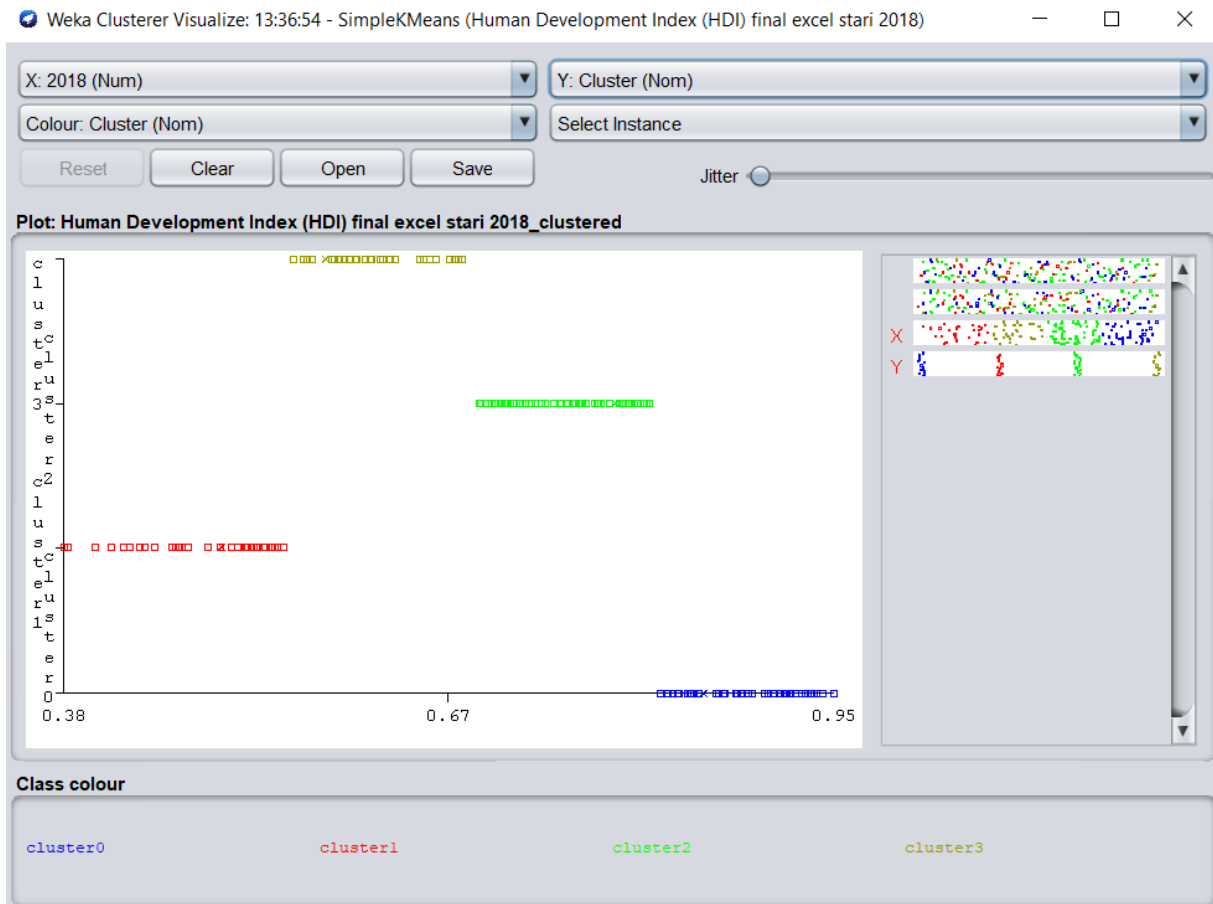
```
1 0 0 0 | Sweden
1 0 0 0 | Switzerland
0 0 0 1 | Syrian Arab Republic
0 0 0 1 | Tajikistan
0 1 0 0 | Tanzania (United Republic of)
0 0 1 0 | Thailand
0 0 0 1 | Timor-Leste
0 1 0 0 | Togo
0 0 1 0 | Tonga
0 0 1 0 | Trinidad and Tobago
0 0 1 0 | Tunisia
0 0 1 0 | Turkey
0 0 1 0 | Turkmenistan
0 1 0 0 | Uganda
0 0 1 0 | Ukraine
1 0 0 0 | United Arab Emirates
1 0 0 0 | United Kingdom
1 0 0 0 | United States
0 0 1 0 | Uruguay
0 0 1 0 | Uzbekistan
0 0 0 1 | Vanuatu
0 0 1 0 | Venezuela (Bolivarian Republic of)
0 0 1 0 | Viet Nam
0 1 0 0 | Yemen
0 0 0 1 | Zambia
0 0 0 1 | Zimbabwe

Cluster 0 <-- Andorra
Cluster 1 <-- Afghanistan
Cluster 2 <-- Albania
Cluster 3 <-- Angola

Incorrectly clustered instances :      185.0    97.8836 %
```

Slika 20 predstavlja vizualni prikaz pripadnosti države pojedinom klasteru.

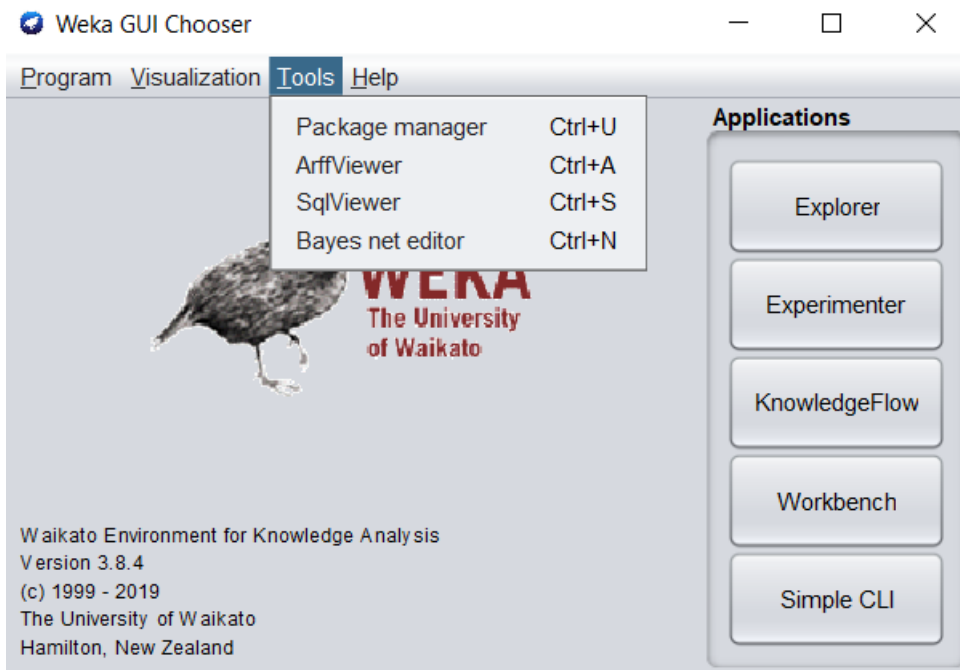
Slika 20 Vizualni prikaz pripadnosti klasteru 2018



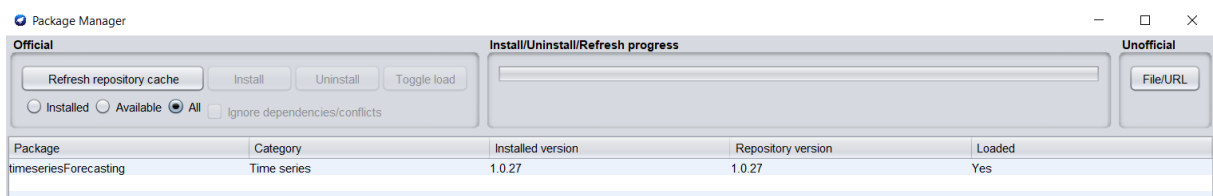
### 4.3.2 Vremenske serije

Provedba istraživanja predviđanja vremenskih serija nije moguća standardnim programom Weka, već ga je potrebno proširiti paketom "timeseriesForecasting". Klikom na tab Tools odabiremo gumb Package manager (Slika 21). Otvara nam se novi prozor u kojem pretražujemo "timeseriesForecasting" i instaliramo proširenje programa (Slika 22).

Slika 21 Proširivanje programa "timeseriesForecasting"



Slika 22 Instalacija paketa "timeseriesForecasting"



Podaci korišteni u klaster analizi nisu pravilno formatirani i za provođenje analize vremenskih serija, već ih je potrebno transponirati tako da se atribut država nalazi u stupcima, a vrijednosti

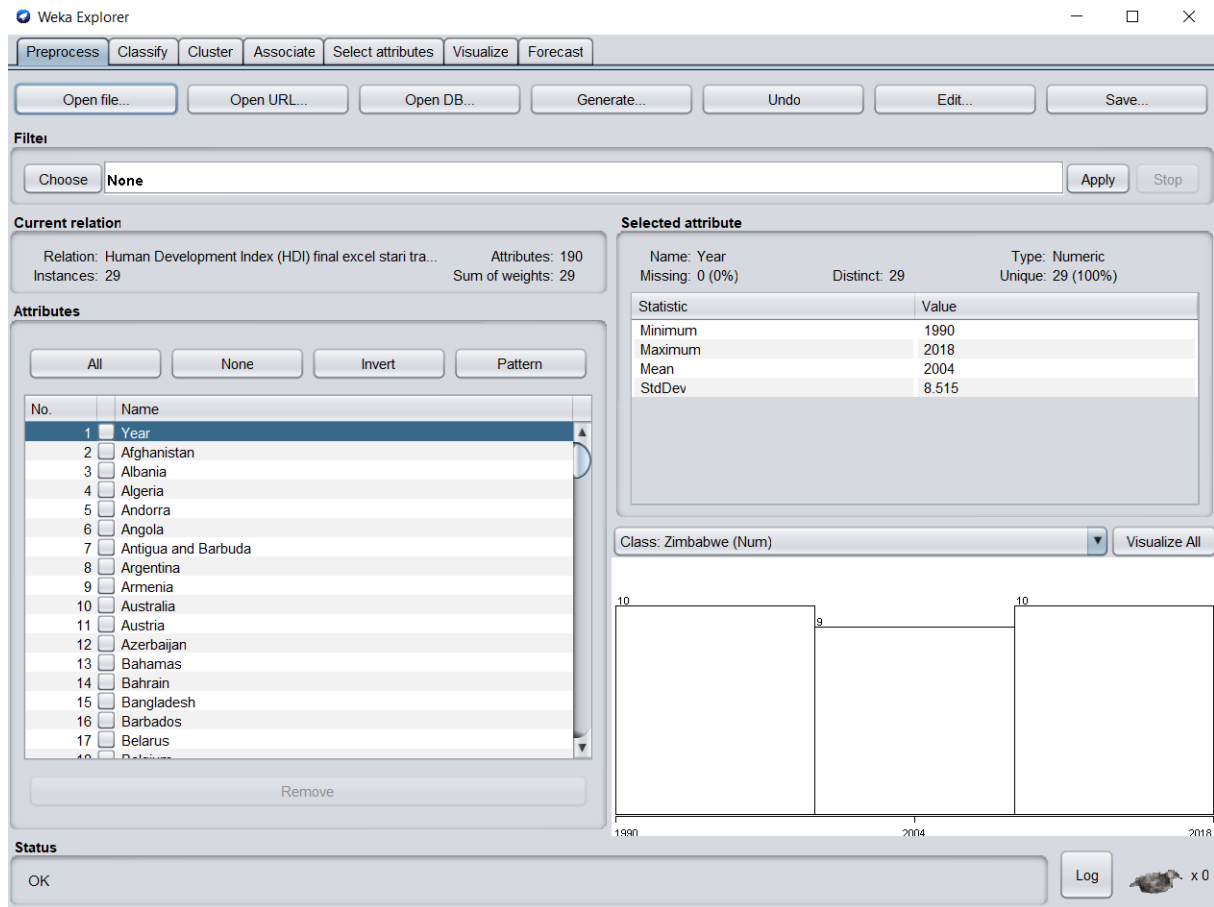
po pojedinoj godini i recima. Na taj način Weka prepoznaje da se vrijednosti Indeksa ljudskog razvoja odnose na državu čijem su stupcu pridodani.

Slika 23 Transponirani podaci za analizu vremenskih serija

#	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC		
1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															
12																															
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23																															
24																															
25																															
26																															
27																															
28																															
29																															
30																															

Transponirane podatke u .csv formatu učitamo u programu Preprocess. Kartica Attributes sadrži nazive država, dok su se u klaster analizi kao atributi nalazile godine (Slika 24).

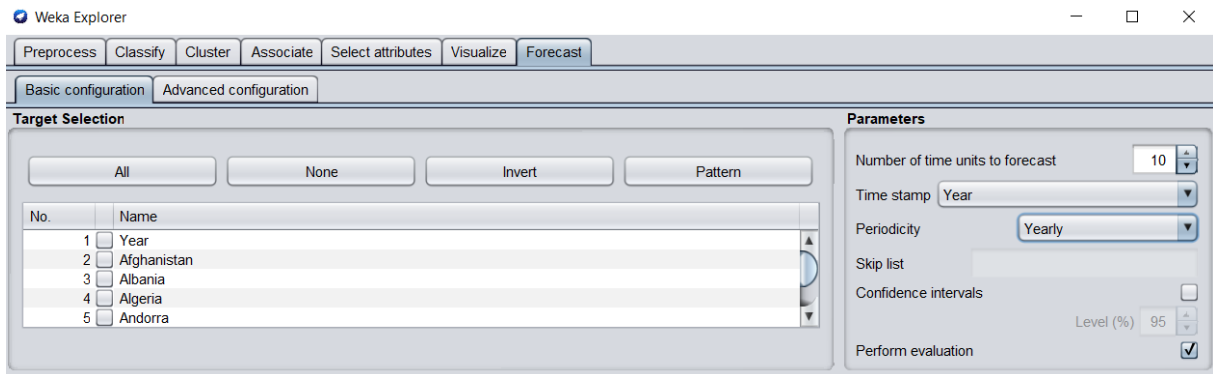
Slika 24 Panel Preprocess analiza vremenskih serija



Slika 25 prikazuje osnovne postavke modela predviđanja vremenskih serija. Prozor ciljni atribut (*engl. Target Selection*) omogućava odabir države za koje će se provesti istraživanje. U kartici parametri (*engl. Parameters*) broj vremenskih jedinica za predviđanje (*engl. Number of time units to forecast*) predstavlja za koliko će se vremenskih jedinica prognozirati kretanje. Određeno je 10 vremenskih jedinica, što će se u primjeru očitovati kao 10 godina. Vremenski korak (*engl. Time stamp*) označava koji atribut sadrži vremensku oznaku, u primjeru je to atribut Year. Periodičnost (*engl. Periodicity*) označava odabir periodičnosti podataka. Odabrana je Yearly periodičnost, zbog toga što se Indeks ljudskog razvoja mjeri godišnje. Također označavamo kvačicu kraj obavi evaluaciju (*engl. Perform evaluation*) kojom će program procijeniti model.

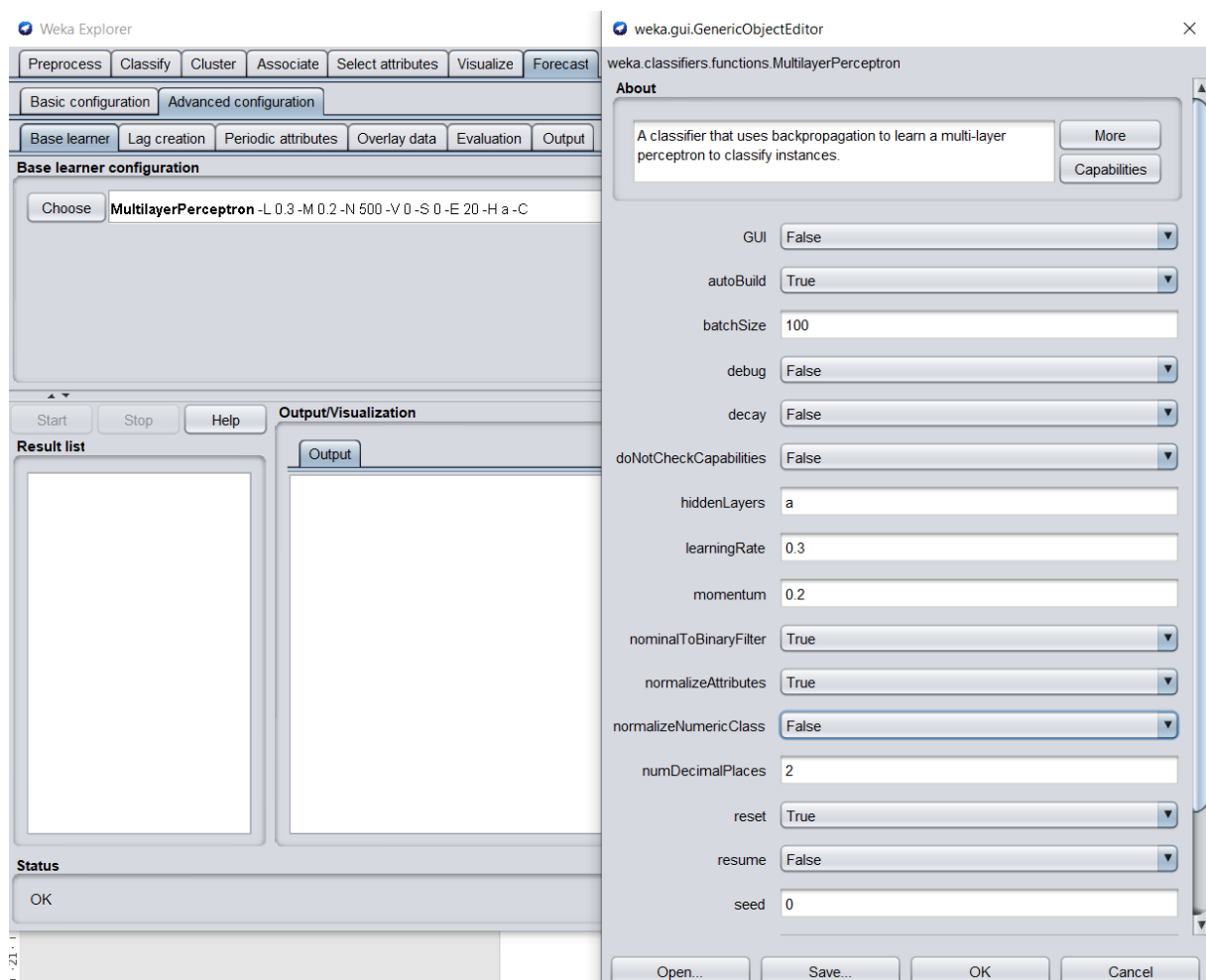


Slika 25 Postavke modela predviđanja vremenskih serija (1)



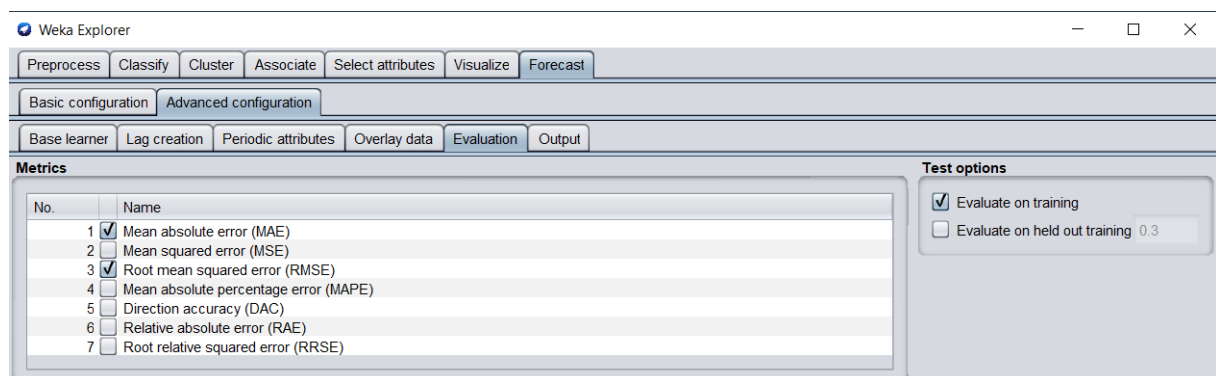
Napredne postavke (*engl. Advanced configuration*) sadrže karticu osnovno učenje (*engl. Base learner*) u kojoj se odabire algoritam za provođenje istraživanja. Odabran je MultilayerPerceptron (Slika 26). Višeslojna Perceptron neuronska mreža analizira unesene podatke, uči iz njih i predviđa buduće kretanje vrijednosti Indeksa. Važno je u konfiguraciji algoritma kraj `normalizeNumericClass` odabrati `False`, tako da program ne provodi normalizaciju atributa zbog toga što su podaci Indeksa u rasponu od 0 do 1 i ne smije ih se normalizirati.

Slika 26 Postavke modela predviđanja vremenskih serija (2)



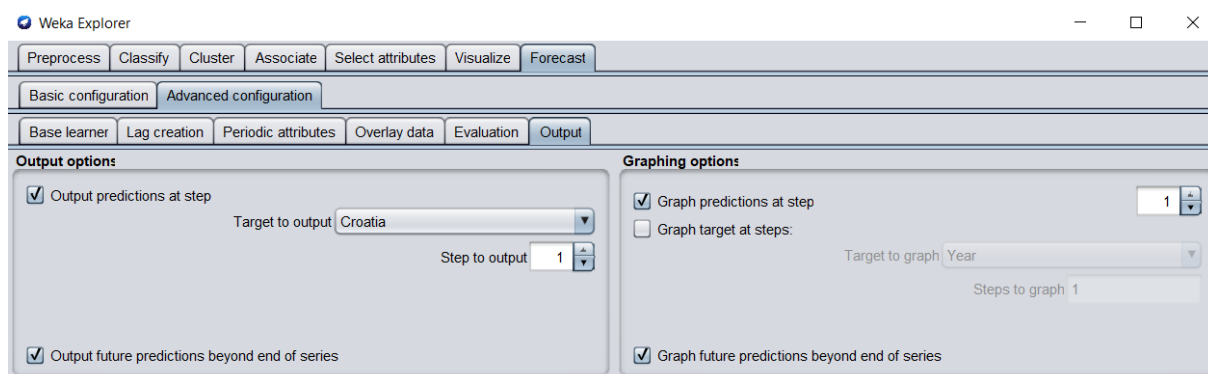
Slika 27 prikazuje karticu evaluacije (*engl. Evaluation*) u kojoj su odabrane metrike po kojima će program odraditi procjenu točnosti modela, odabrane metrike su srednja apsolutna pogreška (MAE) i korijen srednje kvadratne pogreške (RMSE).

Slika 27 Postavke modela predviđanja vremenskih serija (3)



Slika 28 prikazuje karticu izlazne opcije. Odabrana je opcija izlazna predviđanja uz korak (*engl. Output predictions at step*) koja postavlja program tako da se za svaki vremenski korak prikaže stvarna vrijednost, predviđena vrijednost i stupanj pogreške. Odabrano je predviđanje za Hrvatsku. Odabirom izlaznih predviđanja za budućnost nakon kraja serije (*engl. Output future predictions beyond end of series*) prikazati će se podaci o treningu i predviđenim vrijednostima izvan dostupnih podataka. Opcije grafičko predviđanje uz korak (*engl. Graph predictions at step*) i grafičko predviđanja za budućnost nakon kraja serije (*engl. Graph future predictions beyond end of series*) grafički prikazuje odabrane opcije na kartici izlazne opcije.

Slika 28 Postavke modela predviđanja vremenskih serija (4)



Klikom na gumb start pokrećemo predviđanje vremenskih serija. U radu je napravljeno previđanje za svih 28 država članica Europske unije. To su Austrija, Belgija, Bugarska, Hrvatska, Cipar, Češka, Danska, Estonija, Finska, Francuska, Njemačka, Grčka, Mađarska, Irska, Italija, Latvija, Litva, Luksemburg, Malta, Nizozemska, Poljska, Portugal, Rumunjska, Slovačka, Slovenija, Španjolska i Švedska. Slika 28 prikazuje postavke i subjekte korištene u provedbi istraživanja.

## Slika 29 Parametri istraživanja

---

=== Run information ===

Scheme:

MultilayerPerceptron -L 0.3 -M 0.2 -N 500 -V 0 -S 0 -E 20 -H a -C

Lagged and derived variable options:

-F Austria,Belgium,Bulgaria,Croatia,Cyprus,Czechia,Denmark,Estonia,Finland,Fr:

Relation: Human Development Index (HDI) final excel stari transponderirano

Instances: 29

Attributes: 190  
[list of attributes omitted]

Transformed training data:

Year  
Austria  
Belgium  
Bulgaria  
Croatia  
Cyprus  
Czechia  
Denmark  
Estonia  
Finland  
France  
Germany  
Greece  
Hungary  
Ireland  
Italy  
Latvia  
Lithuania  
Luxembourg  
Malta  
Netherlands  
Poland  
Portugal  
Romania  
Slovakia  
Slovenia  
Spain  
Sweden

Slika 30 prikazuje dio procesa učenja programa. Sigmoid Node predstavlja čvor ponovne evaluacije i pridruživanja podataka u skrivenom sloju. Čvor 0 predstavlja izlazni čvor, odnosno rezultat, dok ostali čvorovi od 1 na dalje predstavljaju čvorove u skrivenom sloju.

*Slika 30 Dio procesa učenja*

```

Attrib Year*Lag_Spain-5      0.029556996045298215
Attrib Year*Lag_Sweden-1    -0.04571787271560118
Attrib Year*Lag_Sweden-2    -0.015380626424180567
Attrib Year*Lag_Sweden-3    0.028563216549508892
Attrib Year*Lag_Sweden-4    -0.03424789312656655
Attrib Year*Lag_Sweden-5    0.03396907430271517
Sigmoid Node 98
Inputs      Weights
Threshold   -0.05009081644433209
Attrib Year  -0.012578738360292021
Attrib Lag_Austria-1      -0.013856376585218518
Attrib Lag_Austria-2      0.044641655202046965
Attrib Lag_Austria-3      -0.043725382306506425
Attrib Lag_Austria-4      0.016623966290887592
Attrib Lag_Austria-5      -0.03468790594508367
Attrib Lag_Belgium-1      0.030241142077165283
Attrib Lag_Belgium-2      -0.01767147760016852
Attrib Lag_Belgium-3      -0.04759727109152617
Attrib Lag_Belgium-4      0.006249534989152131
Attrib Lag_Belgium-5      0.03579930208528254
Attrib Lag_Bulgaria-1     -0.029547833337989937
Attrib Lag_Bulgaria-2     -0.029417427052834788
Attrib Lag_Bulgaria-3     -0.010652574121317952

```

Slika 31 prikazuje stvarne i predviđene razine Indeksa ljudskog razvoja, te pogrešku u izračunu istog. Primjećujemo kako prvih 5 podataka u izračunu nedostaju, to je zbog toga što ih program tretira kao zaostale varijable pomoću kojih algoritam trenira.

*Slika 31 Stvarne i predviđene pogreške i razlika među njima za Hrvatsku*

```

=== Predictions for training data: Croatia (1-step ahead) ===

```

inst#	actual	predicted	error
6	0.696	0.6858	-0.0102
7	0.78	0.745	-0.035
8	0.72	0.7396	0.0196
9	0.731	0.7385	0.0075
10	0.74	0.7726	0.0326
11	0.749	0.7433	-0.0057
12	0.761	0.8023	0.0413
13	0.767	0.7695	-0.0025
14	0.773	0.7727	-0.0003
15	0.779	0.766	-0.013
16	0.785	0.774	-0.011
17	0.794	0.8057	0.0117
18	0.81	0.7741	-0.0359
19	0.85	0.8588	0.0088
20	0.84	0.834	-0.006
21	0.811	0.801	-0.01
22	0.817	0.8076	-0.0094
23	0.82	0.8396	0.0196
24	0.825	0.8433	0.0183
25	0.827	0.8209	-0.0061
26	0.83	0.8611	0.0311
27	0.832	0.8391	0.0071
28	0.835	0.8581	0.0231
29	0.837	0.8127	-0.0243



Slike 34, 35 i 36 prikazuju prosječnu apsolutnu pogrešku (MAE) i korijen srednje kvadratne pogreške (RMSE) za promatrane države. Metrike za evaluaciju rezultata koriste se za naknadno podešavanje modela kako bi se postigli što bolji rezultati.

Slika 34 Metrike evaluacije istraživanja (1)

```

=== Evaluation on training data ===
Target      1-step-ahead  2-steps-ahead  3-steps-ahead  4-steps-ahead  5-steps-ahead  6-steps-ahead  7-steps-ahead  8-steps-ahead  9-steps-ahead 10-steps-ahead
-----
Austria
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0209      0.022      0.0195      0.0257      0.0325      0.0346      0.034      0.0348      0.0382      0.0314
Root mean squared error  0.0262      0.0291      0.0247      0.0315      0.0394      0.0427      0.0428      0.0489      0.0555      0.0459
Belgium
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0116      0.0212      0.0221      0.0206      0.021      0.022      0.0249      0.0281      0.0233      0.0244
Root mean squared error  0.0141      0.0257      0.0265      0.024      0.0246      0.0245      0.0274      0.0307      0.029      0.029
Bulgaria
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0256      0.0296      0.0232      0.0249      0.027      0.0232      0.0241      0.0264      0.032      0.0313
Root mean squared error  0.0296      0.0346      0.0281      0.0304      0.0318      0.0304      0.0305      0.0365      0.0456      0.0435
Croatia
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0162      0.0172      0.015      0.0193      0.0193      0.0206      0.0208      0.0212      0.0215      0.0238
Root mean squared error  0.0199      0.021      0.0186      0.0227      0.0237      0.024      0.025      0.0247      0.0252      0.0285
Cyprus
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0144      0.0173      0.0143      0.016      0.016      0.0131      0.0121      0.0125      0.0185      0.0197
Root mean squared error  0.0182      0.0204      0.017      0.0197      0.0197      0.0159      0.0149      0.0177      0.0236      0.0273
Czechia
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0148      0.0182      0.0163      0.0187      0.0183      0.0154      0.0153      0.0141      0.0185      0.0216
Root mean squared error  0.0187      0.0216      0.0187      0.0212      0.0215      0.0193      0.018      0.0198      0.0235      0.03
Denmark
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0157      0.0159      0.0173      0.0333      0.0342      0.0308      0.0353      0.0325      0.0302      0.0281
Root mean squared error  0.021      0.0197      0.0214      0.039      0.0412      0.0378      0.042      0.0389      0.037      0.0363
Estonia
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0195      0.022      0.0181      0.0167      0.0303      0.0332      0.0248      0.0275      0.0278      0.0211
Root mean squared error  0.0228      0.0251      0.0213      0.0199      0.0341      0.0364      0.0291      0.0312      0.0321      0.0274
Finland
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0228      0.0269      0.0249      0.0241      0.0232      0.0189      0.0205      0.0216      0.0305      0.0363
Root mean squared error  0.0319      0.0353      0.0322      0.0313      0.0273      0.0231      0.0246      0.0271      0.038      0.0437
France
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0104      0.0113      0.0091      0.0111      0.0122      0.0128      0.0121      0.0136      0.0157      0.0152
Root mean squared error  0.0136      0.0146      0.0119      0.0143      0.0156      0.015      0.0141      0.0182      0.021      0.02
Germany
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0108      0.0135      0.0154      0.0179      0.015      0.016      0.0186      0.0157      0.0144      0.0148
Root mean squared error  0.0149      0.016      0.0191      0.0222      0.0195      0.0191      0.0222      0.0201      0.0173      0.0194
Greece
N           24           23           22           21           20           19           18           17           16           15
Mean absolute error  0.0124      0.0141      0.012      0.0144      0.0142      0.0122      0.0139      0.0133      0.0156      0.0153
Root mean squared error  0.0158      0.0172      0.0143      0.0166      0.0169      0.0155      0.0163      0.0176      0.0194      0.0201

```

Slika 35 Metrike evaluacije istraživanja (2)

Hungary										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0078	0.0116	0.0116	0.0136	0.015	0.0151	0.0157	0.0168	0.0144	0.0139
Root mean squared error	0.0108	0.0145	0.0146	0.0167	0.0176	0.0183	0.0183	0.0199	0.0173	0.0167
Ireland										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.009	0.0138	0.0161	0.0176	0.0185	0.0198	0.0246	0.0223	0.0213	0.0237
Root mean squared error	0.0107	0.0165	0.0194	0.0221	0.0225	0.0252	0.0283	0.0277	0.0254	0.0276
Italy										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.013	0.0156	0.014	0.0137	0.0132	0.0123	0.0146	0.0157	0.0148	0.0154
Root mean squared error	0.0166	0.0186	0.016	0.0164	0.0157	0.0154	0.0183	0.019	0.0176	0.0196
Latvia										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0207	0.0285	0.0301	0.0369	0.0363	0.0268	0.0273	0.0286	0.023	0.0212
Root mean squared error	0.0247	0.0324	0.034	0.0408	0.0399	0.0308	0.0328	0.0354	0.0306	0.028
Lithuania										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0097	0.0128	0.014	0.0168	0.019	0.0162	0.0159	0.0142	0.0123	0.0085
Root mean squared error	0.0134	0.016	0.0171	0.0202	0.0226	0.0195	0.0183	0.0166	0.0139	0.0102
Luxembourg										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0118	0.0129	0.0119	0.015	0.0164	0.0159	0.015	0.0186	0.0183	0.0252
Root mean squared error	0.0145	0.0157	0.0168	0.019	0.0197	0.02	0.0205	0.0237	0.0243	0.029
Malta										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0136	0.0151	0.0136	0.0135	0.0161	0.0182	0.018	0.0174	0.016	0.0134
Root mean squared error	0.0172	0.0186	0.0163	0.0158	0.0192	0.0209	0.0194	0.0192	0.0173	0.0145
Netherlands										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.013	0.0142	0.0138	0.0125	0.0123	0.0129	0.0126	0.0134	0.0161	0.0183
Root mean squared error	0.0163	0.0181	0.0175	0.0157	0.0161	0.017	0.016	0.0165	0.0198	0.0226
Poland										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.03	0.0315	0.0287	0.0253	0.0261	0.0272	0.0266	0.0258	0.0247	0.0225
Root mean squared error	0.0345	0.0363	0.0334	0.0305	0.0303	0.0344	0.0338	0.0319	0.0306	0.0287
Portugal										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0115	0.0134	0.0111	0.0124	0.0119	0.0112	0.0105	0.0111	0.0126	0.0153
Root mean squared error	0.0152	0.017	0.0136	0.015	0.0144	0.0132	0.0129	0.0135	0.0152	0.0183
Romania										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0186	0.0224	0.0201	0.0213	0.0233	0.0245	0.0243	0.0243	0.0309	0.0295
Root mean squared error	0.0221	0.026	0.0241	0.0265	0.0279	0.0324	0.0331	0.0367	0.0444	0.0456

Slika 36 Metrike evaluacije istraživanja (3)

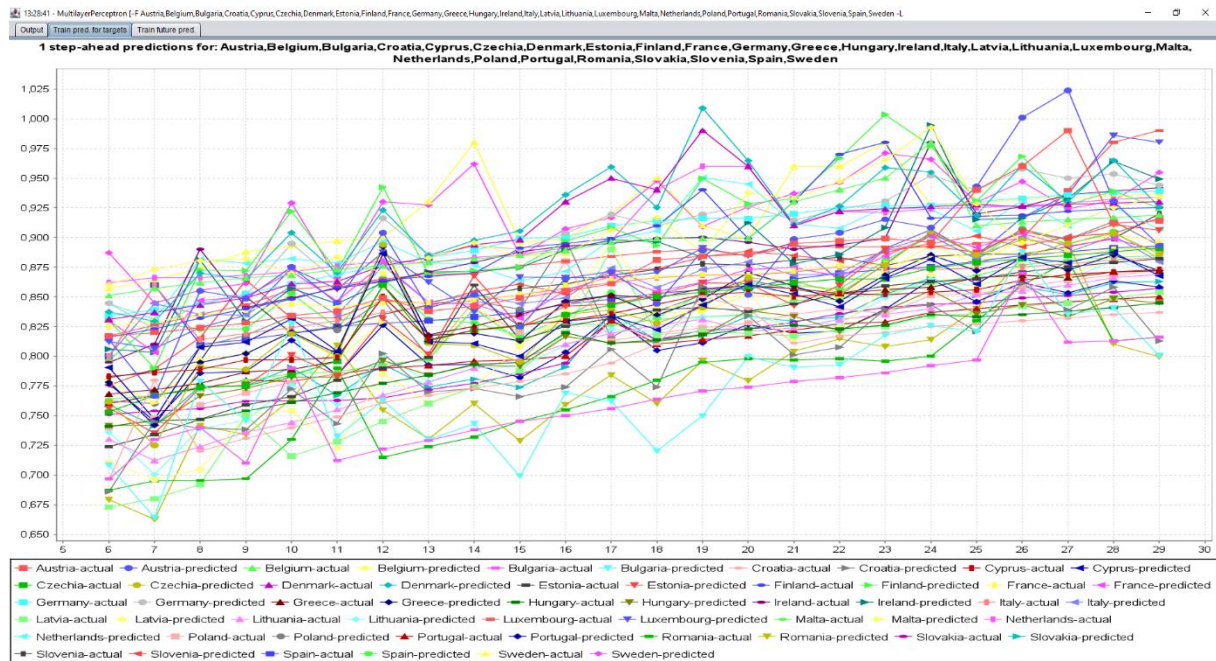
Slovakia										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0092	0.0126	0.0127	0.013	0.013	0.0106	0.0091	0.0098	0.0099	0.0092
Root mean squared error	0.0121	0.0156	0.0149	0.0155	0.0153	0.0121	0.0111	0.0119	0.0119	0.0115
Slovenia										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0076	0.0093	0.0146	0.0158	0.0154	0.0155	0.014	0.0121	0.012	0.0105
Root mean squared error	0.009	0.0113	0.0186	0.02	0.0197	0.0193	0.0172	0.0149	0.0142	0.0124
Spain										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0128	0.015	0.0135	0.0149	0.0141	0.0143	0.0165	0.016	0.0162	0.0203
Root mean squared error	0.0167	0.0183	0.016	0.0168	0.0163	0.0168	0.0192	0.019	0.02	0.0248
Sweden										
N	24	23	22	21	20	19	18	17	16	15
Mean absolute error	0.0165	0.0176	0.0181	0.0195	0.0205	0.0217	0.0199	0.0177	0.0189	0.0307
Root mean squared error	0.0201	0.0208	0.0206	0.0217	0.0228	0.025	0.0239	0.0218	0.0226	0.0349

Total number of instances: 29

Slika 37 grafički prikazuje tabelarno zabilježene podatke sa slike 32 i 33 za sve države Europske unije od 1990. do 2018. godine.

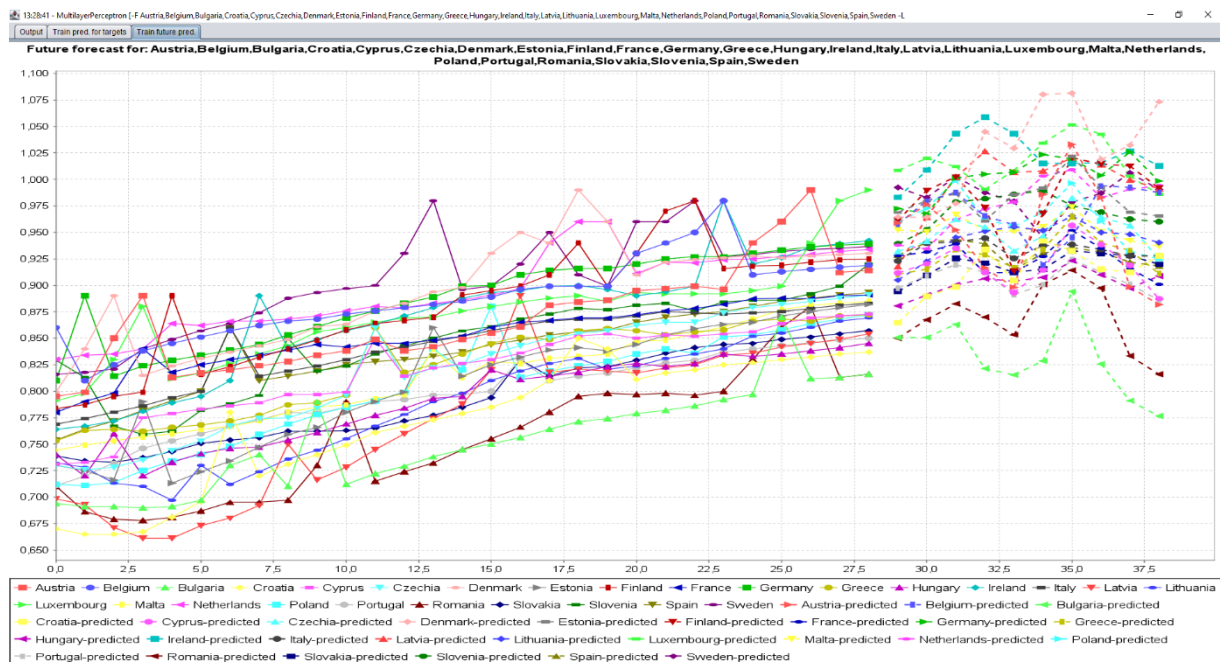


Slika 37 Grafički prikaz stvarnog i predviđenog kretanja Indeksa ljudskog razvoja



Slika 38 grafički prikazuje sadašnje i buduće predviđeno kretanje vrijednosti Indeksa ljudskog razvoja za države Europske unije od 1990. do 2028. godine. Podaci su tablično prikazani na slici 32 i 33.

Slika 38 Sadašnja i predviđena buduća kretanja vrijednosti Indeksa ljudskog razvoja



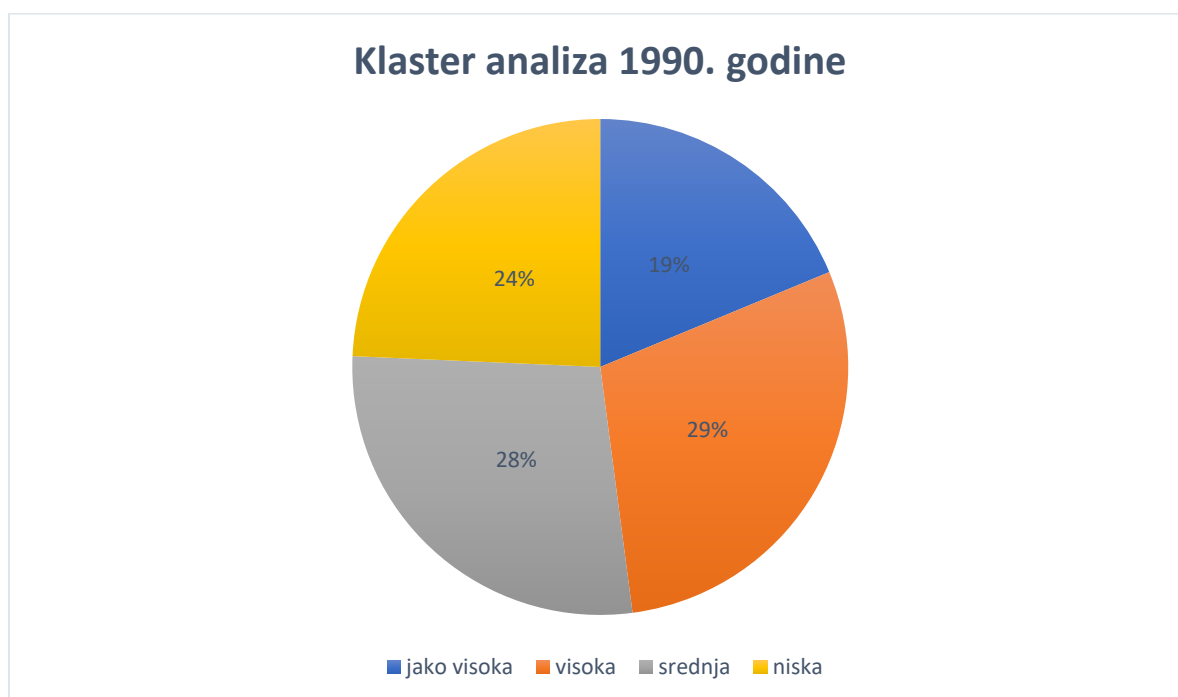
## 4.4 Analiza rezultata

### 4.4.1 Klaster analiza

Slika 9 prikazuje rezultate klaster analize za 1990. godinu. Vidljiva je podjela u četiri klastera i vrijednosti centroida pojedinog klastera. Klaster 1 predstavlja grupu s niskim Indeksom ljudskog razvoja čiji centroid iznosi 0,355 poena. Pripada mu 35 država od ukupnog broja od 144 država, što predstavlja 24% ukupnog broja promatranih država. Klaster 0 predstavlja srednje razvijene države čiji centroid prema Indeksu ljudskog razvoja iznosi 0,564 poena. Sadrži 40 od 144 države, što u relativnom smislu predstavlja 28% ukupnog broja promatranih država. Klaster 2 prikazuje visoku razinu razvijenosti prema Indeksu ljudskog razvoja čiji centroid iznosi 0,6916 poena. Klasteru pripadaju 42 od 144 države, što predstavlja 29% ukupnog broja promatranih država. Klaster 3 prikazuje vrlo visoku razinu razvijenost prema Indeksu ljudskog razvoja čiji centroid iznosi 0,8016 poena. Sadrži 27 od 144 države, što u relativnom smislu predstavlja 19% svih promatranih država. Slika 15 prikazuje rezultate provedbe klaster analize za 2018. godinu. Analiza je provedena nad 189 država. Klaster 0 predstavlja jako visoku razinu razvijenosti država prema Indeksu ljudskog razvoja i njezin centroid iznosi 0,8924 poena. Jako visokom klasteru država pripada 49 država od ukupno 189 država, što predstavlja 26% ukupnog broja promatranih država. Klaster 1 označava nisku razinu razvijenosti čiji centroid iznosi 0,4785 poena i pripadaju mu 35 država od ukupno 189 država, što predstavlja 19% ukupnog broja promatranih država. Klaster 2 označava visoku razinu razvijenosti država čiji centroid iznosi 0,7546 poena i sastoji se od 71 države od ukupno 189 država, što u relativnom smislu predstavlja 38% svih promatranih država. Klaster 3 predstavlja srednju razinu razvijenosti prema Indeksu ljudskog razvoja i njegov centroid iznosi 0,6116 poena, pripada mu 34 država od ukupno 189 država, što predstavlja 18% ukupnog broja promatranih država. Primjećujemo kako je 1990. godine većina država, 29% svih promatranih država, bila svrstana u razinu visoke razvijenosti prema Indeksu ljudskog razvoja (Graf 1), dok je 2018. godine došlo do značajnih promjena u pripadnosti pojedinom klasteru. Klaster visoke razine razvijenosti i dalje je na vodećoj poziciji, 2018. godine njegov relativni udio iznosi 38% od ukupnog broja promatranih država. Klaster jako visoke razvijenost je sa posljednjeg mjesta 1990 godine, kada je iznosio samo 19% ukupnog broja promatranih država, 2018. bio na drugom mjestu razvijenosti s 26% ukupnog broja promatranih država (Graf 2). Treba imati na umu i činjenicu kako se povećao broj promatranih država, s 144 države 1990. godine na 189 država 2018. godine. Većina tih novih pridodanih država bila je srednje i visoke razine

razvijenosti, no to ne pobija činjenicu da je period razvijanja od 28 godina doveo do pomicanja država iz nižih razina razvijenosti u više razine razvijenosti. Tome u korist ide i činjenica tendencije razvitka država kroz povijest i težnje za prosperitetom. Vrijednosti centroida također su jedan od pokazatelja razvijanja država kroz povijest. Centroid 144 promatrane države 1990. godine iznosio je 0,595 poena, a 2018. godine za 189 država iznosi 0,7135 poena, što relativno predstavlja povećanje od 19,92% vrijednosti centroida.

*Graf 1 Veličine klastera 1990. godine*



Izvor: Izrada autora

Tablica 1 prikazuje pripadnost država klasteru prema vrijednostima Indeksa ljudskog razvoja za 1990. godinu.. Podjela se temelji na provedenoj klaster analizi čiji su rezultati vidljivi na slikama 10, 11 i 12. Države su podijeljene u klastere prema razini razvijenosti abecednim redom. Klaster 1 predstavlja zemlje niske razine razvijenosti, klaster 2 predstavlja zemlje srednje razine razvijenosti, klaster 3 predstavlja zemlje visoke razine razvijenosti i klaster 4 predstavlja zemlje vrlo visoke razine razvijenosti.

Tablica 1 Pripadnost država prema klasteru 1990. godine

Klasteri Indeksa ljudskog razvoja 1990. godine			
Niska	Srednja	Visoka	Vrlo visoka
Afghanistan	Algeria	Albania	Australia
Bangladesh	Belize	Argentina	Austria
Benin	Bolivia (Plurinational State of)	Armenia	Belgium
Burundi	Botswana	Bahrain	Brunei Darussalam
Cambodia	Brazil	Barbados	Canada
Cameroon	China	Bulgaria	Denmark
Central African Republic	Colombia	Chile	Finland
Congo (Democratic Republic of the)	Congo	Costa Rica	France
Ivory Coast	Dominican Republic	Croatia	Germany
Gambia	Egypt	Cuba	Greece
Ghana	El Salvador	Cyprus	Hong Kong
Guinea	Eswatini (Kingdom of)	Czechia	Iceland
Haiti	Gabon	Ecuador	Ireland
India	Guatemala	Estonia	Israel
Lao Peoples Democratic Republic	Guyana	Fiji	Italy
Malawi	Honduras	Hungary	Japan
Mali	Indonesia	Jamaica	Luxembourg
Mauritania	Iran (Islamic Republic of)	Kazakhstan	Netherlands
Morocco	Iraq	Korea (Republic of)	New Zealand
Mozambique	Jordan	Kuwait	Norway
Myanmar	Kenya	Latvia	Qatar
Nepal	Kyrgyzstan	Libya	Slovenia
Niger	Lesotho	Lithuania	Spain
Pakistan	Mauritius	Malaysia	Sweden
Papua New Guinea	Mongolia	Malta	Switzerland
Rwanda	Namibia	Mexico	United Kingdom
Sao Tome and Principe	Nicaragua	Moldova (Republic of)	United States
Senegal	Paraguay	Panama	
Sierra Leone	Peru	Poland	
Sudan	Philippines	Portugal	
Tanzania (United Republic of)	Samoa	Romania	
Togo	South Africa	Russian Federation	
Uganda	Sri Lanka	Saudi Arabia	
Yemen	Syrian Arab Republic	Serbia	
Zambia	Tajikistan	Singapore	
	Thailand	Slovakia	
	Tunisia	Tonga	
	Turkey	Trinidad and Tobago	
	Viet Nam	Ukraine	

Zimbabwe	United Arab Emirates
	Uruguay
	Venezuela (Bolivarian Republic of)

Izvor: Izrada autora

*Graf 2 Veličine klastera 2018. godine*



Izvor: Izrada autora

Tablica 2 prikazuje pripadnost država klasteru prema vrijednostima Indeksa ljudskog razvoja za 2018. godinu.. Podjela se temelji na provedenoj klaster analizi čiji su rezultati vidljivi na slikama 16, 17, 18 i 19. Države su podijeljene u klastere prema razini razvijenosti abecednim redom. Klaster 1 predstavlja zemlje niske razine razvijenosti, klaster 2 predstavlja zemlje srednje razine razvijenosti, klaster 3 predstavlja zemlje visoke razine razvijenosti i klaster 4 predstavlja zemlje vrlo visoke razine razvijenosti.

Tablica 2 Pripadnost država prema klasteru 2018. godine

Klasteri Indeksa ljudskog razvoja 2018. godine			
Niska	Srednja	Visoka	Vrlo visoka
Afghanistan	Angola	Albania	Andorra
Benin	Bangladesh	Algeria	Argentina
Burkina Faso	Bhutan	Antigua and Barbuda	Australia
Burundi	Cabo Verde	Armenia	Austria
Central African Republic	Cambodia	Azerbaijan	Bahrain
Chad	Cameroon	Bahamas	Belgium
Comoros	Congo	Barbados	Brunei Darussalam
Congo (Democratic Republic of the)	El Salvador	Belarus	Canada
Ivory Coast	Equatorial Guinea	Belize	Chile
Djibouti	Eswatini (Kingdom of)	Bolivia (Plurinational State of)	Croatia
Eritrea	Ghana	Bosnia and Herzegovina	Cyprus
Ethiopia	Guatemala	Botswana	Czechia
Gambia	Guyana	Brazil	Denmark
Guinea	Honduras	Bulgaria	Estonia
Guinea-Bissau	India	China	Finland
Haiti	Kenya	Colombia	France
Lesotho	Kiribati	Costa Rica	Germany
Liberia	Kyrgyzstan	Cuba	Greece
Madagascar	Lao Peoples Democratic Republic	Dominica	Hong Kong
Malawi	Micronesia (Federated States of)	Dominican Republic	Hungary
Mali	Morocco	Ecuador	Iceland
Mauritania	Myanmar	Egypt	Ireland
Mozambique	Namibia	Fiji	Israel
Niger	Nepal	Gabon	Italy
Nigeria	Nicaragua	Georgia	Japan
Papua New Guinea	Pakistan	Grenada	Korea (Republic of)
Rwanda	Sao Tome and Principe	Indonesia	Latvia
Senegal	Solomon Islands	Iran (Islamic Republic of)	Liechtenstein
Sierra Leone	Syrian Arab Republic	Iraq	Lithuania

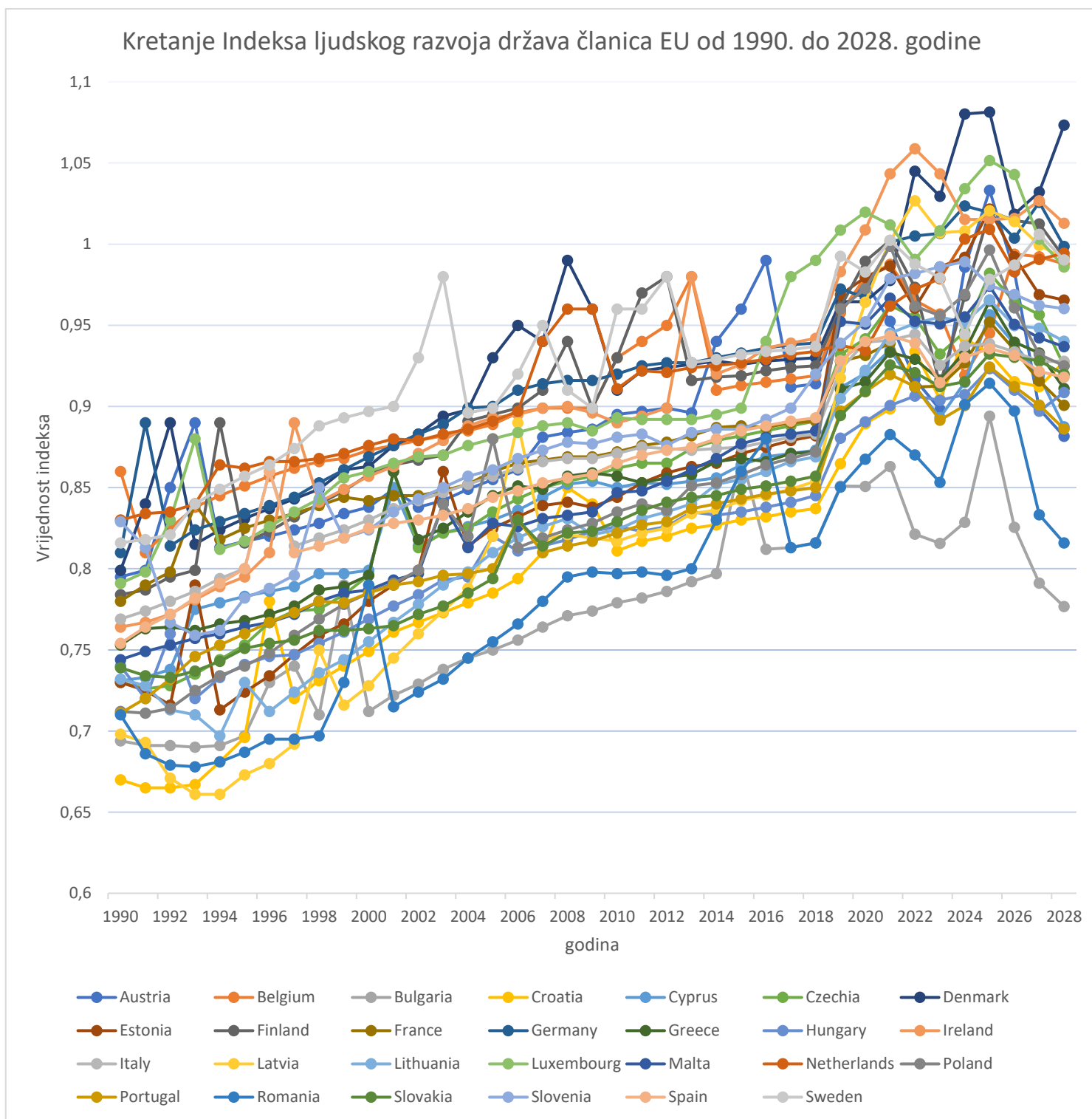
South Sudan	Tajikistan	Jamaica	Luxembourg
Sudan	Timor-Leste	Jordan	Malta
Tanzania (United Republic of)	Vanuatu	Kazakhstan	Netherlands
Togo	Zambia	Kuwait	New Zealand
Uganda	Zimbabwe	Lebanon	Norway
Yemen		Libya	Oman
		Malaysia	Poland
		Maldives	Portugal
		Marshall Islands	Qatar
		Mauritius	Russian Federation
		Mexico	Saudi Arabia
		Moldova (Republic of)	Singapore
		Mongolia	Slovakia
		Montenegro	Slovenia
		North Macedonia	Spain
		Palau	Sweden
		Palestine	Switzerland
		Panama	United Arab Emirates
		Paraguay	United Kingdom
		Peru	United States
		Philippines	
		Romania	
		Saint Kitts and Nevis	
		Saint Lucia	
		Saint Vincent and the Grenadines	
		Samoa	
		Serbia	
		Seychelles	
		South Africa	
		Sri Lanka	
		Suriname	
		Thailand	
		Tonga	
		Trinidad and Tobago	
		Tunisia	
		Turkey	
		Turkmenistan	
		Ukraine	
		Uruguay	
		Uzbekistan	
		Venezuela (Bolivarian Republic of)	
		Viet Nam	

#### 4.4.2 Analiza vremenskih serija

Analiza budućih kretanja Indeksa ljudskog razvoja u radu se provela nad 28 država članica Europske unije. Odabrane su zemlje članice EU zbog toga što Hrvatska pripada, ovisi i teži ka državama Europske unije. Graf 3 prikazuje nam kretanje Indeksa ljudskog razvoja od 1990. do 2028. godine. Od 1990. do 2018. godine graf prikazuje stvarne vrijednosti kretanja Indeksa, dok od 2019. do 2028. godine prikazuje kretanja Indeksa ljudskog razvoja u računalnom programu za rudarenje podacima Weka. Primjećujemo trend porasta Indeksa ljudskog razvoja kroz promatrani period. Hrvatska se 1990. nalazila na dnu Indeksa ljudskog razvoja promatranih država s 0,670 poena Indeksa, Belgija se našla na prvom mjestu s 0,860 poena Indeksa, dok je prosjek 1990. godine iznosio 0,758 poena Indeksa. Hrvatska se u to doba nalazila u teškim okolnostima u odnosu na ostale promatrane države, no tijekom 1990.-tih osamostaljenjem krenuo je razvitak Hrvatske. Tako se Hrvatska 2000. godine našla na 26. mjestu razvitka među sadašnjim državama članicama Europske unije. Latvija i Bugarska su zauzele 27. i 28. mjesto. 2018. godine Hrvatska se i dalje nalazila na 26. mjestu razvijenosti prema Indeksu ljudskog razvoja ispred Rumunjske i Bugarske. Primjećujemo nastavak jednakog trenda razvitka država članica tijekom 2000.-tih i 2010.-tih, nije došlo do značajnijeg pomaka u poretku država prema razvijenosti. Države koje su se nalazile ispod razine prosjeka 2000. godine, 2018. godine također su bile ispod razine prosjeka razvijenosti. Češka je jedina tijekom perioda od 2000. do 2018. godine prešla iznad prosječne razine razvijenosti, dok se Italija spustila ispod prosječne razine razvijenosti. Za razliku od slabije razvijenih država članica, kod bolje razvijenih država članica došlo je do značajnijeg pomaka u razinama razvijenosti. 2000. godine Švedska je bila na prvom mjestu, iza nje su slijedile Nizozemska, Belgija, Njemačka i Danska. 2018. godine na prvom mjestu se našao Luksemburg, a na drugom Irska. Države koje su 2000. godine zauzele šesto i osmo mjesto. Njima u korist pomaka u poretku ide činjenica provođenje politike privlačenja stranih korporacija nižim stopama poreza i lakoćom pristupanja tržištu Europske unije. Prema predviđanjima za 2028. godinu Danska će se naći na prvom mjestu razvijenosti prema Indeksu ljudskog razvoja ispred Irske, dok će njih slijediti Njemačka i Nizozemska. Predviđa se i pomak istočnih zemalja ispred zapadnih zemalja EU. Španjolska, Francuska i Austrija će se prema predviđanjima 2028. godine naći ispod prosječne razine razvijenosti, dok će ih ispred prosječne razine razvijenosti zamijeniti Latvija, Estonija i Litva. Hrvatska će se prema predviđanjima kretanja Indeksa ljudskog razvoja naći na 16 mjestu razvitka, 3. mjestu ispod prosječne razine razvijenosti.



Graf 3 Kretanje Indeksa ljudskog razvoja država članica EU od 1990. do 2028. godine



Izvor: Izrada autora

## 5 ZAKLJUČAK

Cilj ovog rada bila je provedba istraživanja ljudske razvijenosti prema podacima Indeksa ljudskog razvoja u besplatnom programu za rudarenje podataka Weka. Primijene su dvije metode rudarenja podataka dostupne unutar programa.

Klaster analizom otkrili smo koje su promatrane države međusobno slične, odnosno različite. Utvrdili smo pripadnost država klasterima za 1990. i 2018. godinu. Time smo dobili uvid u pripadnost država klasterima na početku i na kraju promatranog razdoblja, te utvrdili kako se stanje u pojedinim klasterima mijenjalo, odnosno kako se promijenio omjer razina razvijenosti. Za detaljniju analizu mogli bismo podijeliti države prema kontinentima, regijama ili pripadnosti različitim savezima i ujedinjenima. Dubljom analizom detaljnije podjele dobili smo jasnije podatke pripadnosti određenoj grupi i precizirati uzorke u razlici razvijenosti.

Analizom vremenskih serija utvrdili smo buduće predviđeno kretanje Indeksa ljudskog razvoja za 28 država članica Europske unije. Grafički smo prikazali sadašnje i buduće predviđeno kretanje Indeksa ljudskog razvoja i time dobili uvid u smjer kretanja razvijenosti promatranih država. Otkrili smo kako se neke države razvijaju brže od drugih, a neke stagniraju u svom razvoju prema Indeksu ljudskog razvoja. Primjećujemo zavisnost bogatstva države i njezine brzine razvijenosti. Jačom procesnom snagom istraživanje budućih kretanja Indeksa ljudskog razvoja može se primijeniti na sve države za koje Program Ujedinjenih naroda za razvoj mjeri Indeks ljudskog razvoja. Dobili bi sliku kretanja ljudske razvijenosti na globalnoj razini i utvrditi uzroke bolje i brže, odnosno slabije i sporije ljudske razvijenosti.

Svijet se neprestano mijenja prema boljem. Težimo zdravijem životu, kvalitetnijem obrazovanjem, boljim poslom, zadovoljstvom i unutarnjim mirom. Zbog tih težnji rastu i razvijaju se zajednice, odnosno države. Indeks ljudskog razvoja mjeri upravo tu razvijenost zajednica i stavlja je u kontekst poboljšanja života na globalnoj razini. Zajedničkim naporima učiniti ćemo naš svijet boljim i ljepšim mjestom za život.

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2006,2007,2008,2009,2010,2011,2012,2013,2014,2015,2016,2017,2018  
Afghanistan,0.298,0.304,0.312,0.308,0.303,0.327,0.331,0.335,0.339,0.343,0.345,0.347,0.378,0.387  
,0.400,0.410,0.419,0.431,0.436,0.447,0.464,0.465,0.479,0.485,0.488,0.490,0.491,0.493,0.496  
Albania,0.644,0.625,0.608,0.611,0.617,0.629,0.639,0.639,0.649,0.660,0.667,0.673,0.680,0.687,0.6  
92,0.702,0.709,0.718,0.724,0.729,0.740,0.759,0.771,0.781,0.787,0.788,0.788,0.789,0.791  
Algeria,0.578,0.582,0.589,0.593,0.597,0.602,0.610,0.619,0.629,0.638,0.646,0.655,0.666,0.676,0.6  
85,0.694,0.699,0.708,0.711,0.720,0.730,0.738,0.737,0.746,0.749,0.751,0.755,0.758,0.759  
Andorra,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.759,0.767,0.780,0.820,0.  
826,0.819,0.829,0.829,0.831,0.830,0.828,0.827,0.849,0.846,0.853,0.850,0.854,0.852,0.857  
Angola,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.384,0.394,0.404,0.419,0.428,0.44  
0,0.453,0.466,0.482,0.494,0.508,0.510,0.525,0.537,0.547,0.557,0.565,0.570,0.576,0.574  
Antigua and  
Barbuda,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.  
000,0.773,0.779,0.784,0.783,0.776,0.772,0.764,0.767,0.767,0.767,0.770,0.772,0.774,0.776  
Argentina,0.707,0.714,0.719,0.725,0.729,0.731,0.738,0.746,0.752,0.763,0.770,0.775,0.770,0.775,0.  
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Armenia,0.633,0.629,0.585,0.590,0.600,0.604,0.614,0.625,0.637,0.644,0.649,0.653,0.663,0.672,0.  
681,0.694,0.708,0.724,0.727,0.724,0.729,0.733,0.737,0.743,0.746,0.748,0.751,0.758,0.760  
Australia,0.866,0.867,0.868,0.872,0.875,0.883,0.886,0.889,0.892,0.895,0.898,0.900,0.903,0.904,0.  
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Austria,0.795,0.799,0.805,0.809,0.813,0.817,0.820,0.824,0.828,0.834,0.838,0.849,0.838,0.842,0.8  
49,0.855,0.861,0.881,0.884,0.886,0.895,0.897,0.899,0.896,0.904,0.906,0.909,0.912,0.914  
Azerbaijan,0.000,0.000,0.000,0.000,0.000,0.612,0.612,0.618,0.627,0.634,0.641,0.649,0.658,0.667,  
0.674,0.681,0.707,0.712,0.721,0.734,0.732,0.731,0.736,0.741,0.746,0.749,0.749,0.752,0.754  
Bahamas,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.787,0.788,0.790,0.789,0.  
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92,0.792,0.793,0.796,0.796,0.794,0.796,0.798,0.800,0.807,0.810,0.834,0.839,0.839,0.838  
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Belgium,0.806,0.810,0.825,0.838,0.845,0.851,0.857,0.862,0.866,0.868,0.873,0.876,0.879,0.882,0.8  
85,0.889,0.896,0.899,0.899,0.899,0.903,0.904,0.905,0.908,0.910,0.913,0.915,0.917,0.919  
Belize,0.613,0.618,0.624,0.627,0.627,0.627,0.627,0.630,0.631,0.636,0.643,0.647,0.655,0.663,0.66  
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Benin,0.348,0.354,0.358,0.365,0.368,0.373,0.377,0.381,0.385,0.391,0.398,0.410,0.419,0.426,0.43  
4,0.440,0.447,0.455,0.462,0.468,0.473,0.479,0.489,0.500,0.505,0.510,0.512,0.515,0.520  
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Bolivia (Plurinational State  
of),0.540,0.549,0.555,0.562,0.570,0.578,0.585,0.587,0.599,0.608,0.616,0.619,0.625,0.629,0.630,0.  
632,0.638,0.638,0.647,0.651,0.656,0.660,0.663,0.673,0.678,0.685,0.692,0.700,0.703

Bosnia and

Herzegovina,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.669,0.675,0.681,0.686,0.692,0.700,0.706,0.713,0.720,0.720,0.714,0.722,0.741,0.748,0.754,0.755,0.765,0.767,0.769

Botswana,0.570,0.576,0.574,0.573,0.567,0.573,0.572,0.575,0.577,0.579,0.578,0.580,0.576,0.583,0.589,0.598,0.612,0.625,0.638,0.647,0.660,0.676,0.687,0.699,0.709,0.714,0.719,0.724,0.728

Brazil,0.613,0.620,0.626,0.634,0.642,0.651,0.657,0.664,0.670,0.675,0.684,0.691,0.698,0.694,0.697,0.700,0.701,0.705,0.716,0.718,0.726,0.730,0.734,0.752,0.755,0.755,0.757,0.760,0.761

Brunei

Darussalam,0.768,0.773,0.778,0.783,0.788,0.791,0.794,0.797,0.798,0.804,0.805,0.806,0.809,0.815,0.820,0.824,0.827,0.827,0.828,0.831,0.832,0.836,0.843,0.844,0.845,0.843,0.844,0.843,0.845

Bulgaria,0.694,0.691,0.691,0.690,0.691,0.697,0.703,0.704,0.710,0.709,0.712,0.722,0.729,0.738,0.745,0.750,0.756,0.764,0.771,0.774,0.779,0.782,0.786,0.792,0.797,0.807,0.812,0.813,0.816

Burkina

Faso,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.286,0.290,0.296,0.303,0.312,0.324,0.333,0.344,0.357,0.366,0.375,0.385,0.394,0.401,0.405,0.413,0.420,0.429,0.434

Burundi,0.295,0.298,0.294,0.294,0.291,0.287,0.283,0.283,0.287,0.288,0.293,0.294,0.304,0.312,0.322,0.329,0.351,0.363,0.375,0.391,0.402,0.410,0.416,0.422,0.429,0.427,0.427,0.421,0.423

Cabo

Verde,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.564,0.566,0.576,0.580,0.586,0.592,0.606,0.615,0.622,0.623,0.626,0.633,0.634,0.641,0.641,0.643,0.645,0.647,0.651

Cambodia,0.384,0.388,0.393,0.397,0.374,0.387,0.391,0.397,0.402,0.407,0.419,0.434,0.453,0.466,0.478,0.490,0.502,0.516,0.521,0.524,0.535,0.542,0.548,0.555,0.561,0.566,0.572,0.578,0.581

Cameroon,0.445,0.442,0.438,0.432,0.430,0.429,0.428,0.429,0.434,0.434,0.439,0.455,0.457,0.463,0.468,0.469,0.470,0.481,0.489,0.497,0.471,0.513,0.524,0.531,0.540,0.548,0.556,0.560,0.563

Canada,0.850,0.853,0.856,0.854,0.859,0.861,0.863,0.863,0.861,0.864,0.868,0.872,0.877,0.882,0.887,0.892,0.895,0.891,0.893,0.893,0.895,0.899,0.906,0.910,0.914,0.917,0.920,0.921,0.922

Central African

Republic,0.320,0.314,0.299,0.299,0.300,0.304,0.301,0.304,0.306,0.308,0.307,0.311,0.314,0.314,0.319,0.323,0.328,0.334,0.339,0.346,0.355,0.363,0.370,0.351,0.355,0.362,0.372,0.376,0.381

Chad,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.298,0.306,0.311,0.310,0.326,0.331,0.337,0.345,0.350,0.366,0.374,0.385,0.393,0.399,0.406,0.403,0.398,0.401,0.401

Chile,0.703,0.712,0.719,0.712,0.717,0.725,0.732,0.739,0.741,0.747,0.753,0.764,0.767,0.773,0.782,0.788,0.787,0.801,0.811,0.819,0.800,0.812,0.818,0.830,0.834,0.839,0.843,0.845,0.847

China,0.501,0.509,0.520,0.530,0.537,0.549,0.558,0.566,0.574,0.583,0.591,0.599,0.610,0.622,0.631,0.643,0.657,0.670,0.681,0.690,0.702,0.711,0.719,0.727,0.735,0.742,0.749,0.753,0.758

Colombia,0.600,0.603,0.613,0.621,0.628,0.633,0.643,0.651,0.658,0.658,0.662,0.664,0.667,0.666,0.680,0.693,0.700,0.713,0.720,0.724,0.729,0.735,0.736,0.746,0.750,0.753,0.759,0.760,0.761

Comoros,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.457,0.462,0.467,0.473,0.474,0.480,0.487,0.492,0.499,0.506,0.513,0.524,0.529,0.532,0.534,0.535,0.537,0.539,0.538

Congo,0.531,0.530,0.530,0.524,0.521,0.505,0.503,0.506,0.511,0.500,0.495,0.501,0.504,0.504,0.508,0.506,0.508,0.523,0.538,0.550,0.557,0.559,0.571,0.581,0.595,0.614,0.613,0.609,0.609

Congo (Democratic Republic of

the),0.377,0.371,0.369,0.364,0.334,0.333,0.337,0.334,0.334,0.331,0.333,0.333,0.340,0.349,0.357,0.364,0.372,0.382,0.393,0.400,0.416,0.419,0.423,0.429,0.441,0.445,0.453,0.456,0.459

Costa

Rica,0.655,0.661,0.670,0.676,0.682,0.687,0.690,0.696,0.702,0.706,0.711,0.714,0.717,0.720,0.724,0.728,0.734,0.742,0.750,0.751,0.754,0.768,0.774,0.777,0.785,0.786,0.789,0.792,0.794

Croatia,0.670,0.665,0.665,0.667,0.681,0.696,0.708,0.720,0.731,0.740,0.749,0.761,0.767,0.773,0.779,0.785,0.794,0.801,0.805,0.804,0.811,0.817,0.820,0.825,0.827,0.830,0.832,0.835,0.837

Cuba,0.676,0.670,0.663,0.656,0.652,0.654,0.665,0.669,0.672,0.679,0.686,0.692,0.693,0.704,0.718,0.730,0.752,0.768,0.778,0.780,0.776,0.775,0.764,0.762,0.764,0.768,0.771,0.777,0.778

Cyprus,0.731,0.733,0.738,0.775,0.779,0.783,0.786,0.789,0.797,0.797,0.799,0.805,0.814,0.822,0.826,0.830,0.836,0.844,0.852,0.854,0.850,0.853,0.852,0.854,0.856,0.864,0.869,0.871,0.873  
 Czechia,0.730,0.726,0.728,0.735,0.744,0.753,0.767,0.774,0.775,0.784,0.796,0.806,0.813,0.822,0.825,0.835,0.843,0.850,0.854,0.857,0.862,0.865,0.865,0.874,0.879,0.882,0.885,0.888,0.891  
 Ivory  
 Coast,0.391,0.393,0.393,0.393,0.395,0.397,0.401,0.403,0.403,0.408,0.407,0.408,0.409,0.411,0.417,0.425,0.430,0.435,0.441,0.448,0.454,0.457,0.467,0.475,0.478,0.494,0.508,0.512,0.516  
 Denmark,0.799,0.804,0.809,0.815,0.824,0.831,0.837,0.843,0.849,0.861,0.863,0.876,0.883,0.894,0.898,0.903,0.905,0.904,0.909,0.906,0.910,0.922,0.924,0.926,0.928,0.926,0.928,0.929,0.930  
 Djibouti,0.000,0.000,0.000,0.000,0.000,0.353,0.351,0.355,0.356,0.360,0.361,0.370,0.376,0.386,0.394,0.402,0.414,0.424,0.432,0.437,0.446,0.451,0.459,0.467,0.475,0.482,0.489,0.492,0.495  
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 Ecuador,0.642,0.645,0.649,0.653,0.657,0.661,0.663,0.667,0.670,0.667,0.669,0.674,0.679,0.682,0.687,0.692,0.695,0.706,0.711,0.712,0.716,0.742,0.740,0.751,0.750,0.758,0.756,0.757,0.758  
 Egypt,0.546,0.551,0.557,0.563,0.569,0.576,0.584,0.591,0.592,0.605,0.611,0.616,0.621,0.623,0.629,0.635,0.643,0.651,0.659,0.660,0.666,0.669,0.676,0.681,0.683,0.690,0.695,0.696,0.700  
 El  
 Salvador,0.529,0.533,0.544,0.555,0.564,0.573,0.581,0.590,0.598,0.600,0.608,0.612,0.619,0.625,0.631,0.637,0.645,0.644,0.647,0.647,0.659,0.656,0.660,0.662,0.660,0.660,0.662,0.665,0.667  
 Equatorial  
 Guinea,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.520,0.523,0.536,0.535,0.545,0.569,0.579,0.585,0.586,0.588,0.580,0.583,0.587,0.588,0.590,0.593,0.592,0.590,0.588  
 Eritrea,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.424,0.425,0.427,0.423,0.432,0.433,0.433,0.422,0.425,0.436,0.433,0.434,0.431,0.434  
 Estonia,0.730,0.725,0.716,0.709,0.713,0.724,0.734,0.747,0.759,0.766,0.780,0.790,0.799,0.806,0.814,0.825,0.832,0.839,0.841,0.838,0.844,0.853,0.859,0.863,0.865,0.871,0.875,0.879,0.882  
 Eswatini (Kingdom  
 of),0.545,0.546,0.543,0.538,0.531,0.526,0.519,0.507,0.493,0.483,0.468,0.457,0.445,0.440,0.448,0.459,0.472,0.482,0.491,0.501,0.513,0.528,0.542,0.558,0.573,0.585,0.596,0.603,0.608  
 Ethiopia,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.283,0.298,0.306,0.310,0.325,0.346,0.362,0.377,0.394,0.402,0.412,0.423,0.429,0.439,0.446,0.453,0.460,0.467,0.470  
 Fiji,0.640,0.645,0.651,0.655,0.660,0.666,0.668,0.667,0.667,0.672,0.675,0.675,0.678,0.679,0.685,0.687,0.687,0.691,0.691,0.694,0.694,0.698,0.702,0.707,0.712,0.718,0.718,0.721,0.724  
 Finland,0.784,0.787,0.795,0.799,0.809,0.816,0.823,0.832,0.840,0.848,0.858,0.864,0.867,0.870,0.891,0.895,0.899,0.901,0.904,0.899,0.903,0.907,0.908,0.916,0.918,0.919,0.922,0.924,0.925  
 France,0.780,0.790,0.798,0.804,0.818,0.825,0.830,0.834,0.839,0.844,0.842,0.845,0.845,0.848,0.852,0.860,0.865,0.867,0.869,0.869,0.872,0.876,0.878,0.882,0.887,0.888,0.887,0.890,0.891  
 Gabon,0.619,0.623,0.623,0.625,0.628,0.630,0.632,0.633,0.636,0.631,0.627,0.630,0.632,0.633,0.632,0.638,0.638,0.643,0.645,0.653,0.658,0.663,0.672,0.679,0.688,0.692,0.696,0.700,0.702  
 Gambia,0.328,0.335,0.339,0.343,0.346,0.350,0.356,0.362,0.368,0.376,0.382,0.389,0.392,0.400,0.409,0.413,0.418,0.424,0.431,0.434,0.437,0.435,0.441,0.448,0.449,0.454,0.456,0.459,0.466  
 Georgia,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.669,0.673,0.678,0.688,0.695,0.705,0.712,0.724,0.723,0.727,0.732,0.738,0.749,0.756,0.764,0.771,0.776,0.783,0.786  
 Germany,0.801,0.809,0.814,0.824,0.829,0.834,0.839,0.844,0.853,0.861,0.869,0.876,0.883,0.889,0.899,0.900,0.910,0.914,0.916,0.916,0.920,0.925,0.927,0.927,0.930,0.933,0.936,0.938,0.939  
 Ghana,0.454,0.459,0.463,0.467,0.469,0.472,0.473,0.475,0.476,0.478,0.483,0.482,0.487,0.489,0.497,0.508,0.518,0.529,0.542,0.547,0.554,0.563,0.570,0.578,0.577,0.585,0.587,0.591,0.596

Greece,0.753,0.763,0.764,0.762,0.766,0.768,0.772,0.777,0.787,0.789,0.796,0.806,0.818,0.825,0.835,0.845,0.851,0.849,0.857,0.859,0.857,0.853,0.856,0.858,0.866,0.868,0.866,0.871,0.872

Grenada,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.711,0.719,0.721,0.734,0.735,0.740,0.743,0.740,0.743,0.746,0.747,0.750,0.752,0.756,0.760,0.760,0.763

Guatemala,0.477,0.484,0.489,0.495,0.500,0.507,0.515,0.523,0.531,0.539,0.546,0.553,0.560,0.564,0.567,0.571,0.579,0.588,0.594,0.597,0.602,0.607,0.613,0.616,0.643,0.647,0.648,0.649,0.651

Guinea,0.278,0.283,0.288,0.293,0.297,0.302,0.306,0.314,0.321,0.328,0.335,0.341,0.351,0.338,0.363,0.373,0.384,0.393,0.400,0.400,0.408,0.421,0.431,0.439,0.446,0.449,0.456,0.463,0.466

Guinea-Bissau,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.393,0.401,0.407,0.413,0.419,0.426,0.435,0.437,0.441,0.450,0.453,0.457,0.460,0.461

Guyana,0.537,0.533,0.548,0.561,0.571,0.578,0.589,0.594,0.597,0.601,0.606,0.609,0.612,0.609,0.614,0.619,0.624,0.627,0.630,0.633,0.639,0.648,0.652,0.656,0.660,0.663,0.666,0.668,0.670

Haiti,0.412,0.416,0.416,0.416,0.413,0.421,0.426,0.430,0.433,0.437,0.440,0.442,0.444,0.447,0.448,0.451,0.456,0.460,0.463,0.468,0.467,0.474,0.478,0.483,0.488,0.492,0.497,0.501,0.503

Honduras,0.508,0.507,0.513,0.519,0.523,0.529,0.534,0.540,0.545,0.548,0.555,0.559,0.564,0.569,0.575,0.581,0.587,0.595,0.591,0.593,0.598,0.601,0.600,0.603,0.606,0.613,0.618,0.621,0.623

Hong Kong,0.781,0.786,0.791,0.799,0.804,0.808,0.811,0.816,0.817,0.821,0.827,0.835,0.842,0.851,0.862,0.871,0.883,0.887,0.896,0.898,0.901,0.904,0.911,0.916,0.924,0.927,0.931,0.937,0.939

Hungary,0.704,0.702,0.706,0.720,0.733,0.741,0.746,0.747,0.754,0.761,0.769,0.777,0.784,0.793,0.795,0.802,0.811,0.814,0.818,0.823,0.826,0.823,0.826,0.835,0.833,0.835,0.838,0.841,0.845

Iceland,0.804,0.817,0.820,0.821,0.826,0.829,0.834,0.841,0.851,0.855,0.861,0.867,0.876,0.882,0.886,0.891,0.893,0.899,0.892,0.891,0.892,0.901,0.908,0.920,0.924,0.927,0.932,0.935,0.938

India,0.431,0.436,0.442,0.449,0.456,0.463,0.471,0.477,0.484,0.492,0.497,0.502,0.508,0.521,0.530,0.539,0.548,0.558,0.565,0.571,0.581,0.590,0.600,0.607,0.618,0.627,0.637,0.643,0.647

Indonesia,0.525,0.530,0.535,0.541,0.551,0.560,0.574,0.587,0.587,0.595,0.604,0.610,0.616,0.623,0.629,0.633,0.643,0.644,0.648,0.659,0.666,0.674,0.682,0.688,0.691,0.696,0.700,0.704,0.707

Iran (Islamic Republic of),0.577,0.594,0.608,0.619,0.629,0.640,0.647,0.653,0.659,0.664,0.671,0.678,0.683,0.690,0.691,0.696,0.732,0.736,0.741,0.747,0.756,0.767,0.782,0.785,0.788,0.789,0.799,0.799,0.797

Iraq,0.574,0.532,0.548,0.563,0.566,0.569,0.575,0.583,0.597,0.604,0.608,0.615,0.616,0.604,0.628,0.632,0.637,0.639,0.646,0.648,0.652,0.658,0.662,0.662,0.662,0.665,0.672,0.684,0.689

Ireland,0.764,0.767,0.772,0.781,0.789,0.795,0.801,0.809,0.841,0.849,0.857,0.863,0.871,0.879,0.888,0.893,0.895,0.899,0.900,0.896,0.890,0.894,0.899,0.908,0.920,0.926,0.936,0.939,0.942

Israel,0.792,0.800,0.807,0.813,0.818,0.824,0.828,0.836,0.843,0.850,0.853,0.857,0.865,0.865,0.867,0.871,0.872,0.881,0.880,0.882,0.887,0.892,0.893,0.895,0.900,0.901,0.902,0.904,0.906

Italy,0.769,0.774,0.780,0.786,0.794,0.800,0.806,0.814,0.819,0.824,0.830,0.837,0.842,0.847,0.852,0.857,0.862,0.866,0.868,0.868,0.871,0.875,0.874,0.873,0.874,0.875,0.878,0.881,0.883

Jamaica,0.641,0.646,0.650,0.660,0.662,0.665,0.668,0.669,0.670,0.672,0.669,0.680,0.683,0.678,0.695,0.698,0.702,0.710,0.728,0.724,0.723,0.723,0.722,0.720,0.720,0.722,0.722,0.725,0.726

Japan,0.816,0.821,0.824,0.829,0.835,0.840,0.845,0.848,0.847,0.850,0.855,0.859,0.862,0.865,0.869,0.873,0.877,0.880,0.881,0.880,0.885,0.890,0.895,0.900,0.904,0.906,0.910,0.913,0.915

Jordan,0.616,0.627,0.648,0.659,0.669,0.683,0.685,0.689,0.693,0.696,0.702,0.708,0.706,0.711,0.717,0.729,0.732,0.735,0.736,0.734,0.728,0.725,0.726,0.720,0.720,0.721,0.722,0.722,0.723

Kazakhstan,0.690,0.684,0.681,0.675,0.667,0.664,0.666,0.669,0.672,0.676,0.685,0.700,0.713,0.725,0.737,0.747,0.754,0.758,0.758,0.762,0.764,0.772,0.782,0.791,0.798,0.806,0.808,0.813,0.817

Kenya,0.467,0.465,0.461,0.456,0.454,0.453,0.452,0.449,0.448,0.447,0.446,0.450,0.450,0.462,0.475,0.484,0.499,0.507,0.515,0.524,0.533,0.540,0.545,0.551,0.556,0.562,0.568,0.574,0.579

Kiribati,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.564,0.582,0.580,0.586,0.585,0.585,0.582,0.583,0.586,0.585,0.589,0.587,0.596,0.605,0.613,0.619,0.622,0.623,0.623

Korea (Republic

of),0.728,0.739,0.746,0.756,0.767,0.778,0.789,0.800,0.797,0.808,0.817,0.824,0.832,0.839,0.847,0.855,0.862,0.869,0.874,0.871,0.882,0.888,0.890,0.893,0.896,0.899,0.901,0.904,0.906

Kuwait,0.712,0.673,0.666,0.695,0.722,0.748,0.772,0.775,0.781,0.786,0.786,0.785,0.788,0.791,0.789,0.783,0.788,0.789,0.790,0.792,0.794,0.796,0.800,0.798,0.800,0.807,0.809,0.809,0.808

Kyrgyzstan,0.618,0.611,0.601,0.588,0.569,0.563,0.568,0.576,0.580,0.587,0.594,0.602,0.604,0.611,0.615,0.616,0.621,0.628,0.631,0.635,0.636,0.639,0.649,0.658,0.663,0.666,0.669,0.671,0.674

Lao Peoples Democratic

Republic,0.399,0.404,0.410,0.415,0.425,0.427,0.440,0.447,0.454,0.462,0.466,0.471,0.480,0.488,0.496,0.505,0.511,0.521,0.528,0.539,0.546,0.558,0.569,0.579,0.586,0.594,0.598,0.602,0.604

Latvia,0.698,0.693,0.671,0.661,0.661,0.673,0.680,0.692,0.705,0.716,0.728,0.745,0.760,0.774,0.788,0.802,0.809,0.818,0.821,0.819,0.817,0.822,0.825,0.834,0.836,0.842,0.845,0.849,0.854

Lebanon,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.724,0.723,0.736,0.742,0.749,0.751,0.753,0.744,0.741,0.732,0.728,0.725,0.732,0.730

Lesotho,0.488,0.487,0.485,0.478,0.479,0.475,0.470,0.463,0.453,0.445,0.444,0.445,0.440,0.438,0.433,0.430,0.431,0.441,0.446,0.455,0.461,0.470,0.480,0.486,0.493,0.499,0.507,0.514,0.518

Liberia,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.361,0.422,0.421,0.423,0.402,0.412,0.417,0.424,0.431,0.436,0.438,0.441,0.457,0.455,0.463,0.464,0.463,0.463,0.466,0.465

Libya,0.676,0.688,0.692,0.695,0.700,0.704,0.709,0.716,0.719,0.723,0.728,0.733,0.737,0.745,0.745,0.749,0.753,0.754,0.759,0.757,0.757,0.708,0.742,0.707,0.693,0.691,0.690,0.704,0.708

Liechtenstein,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.862,0.868,0.873,0.878,0.883,0.886,0.890,0.893,0.899,0.899,0.904,0.909,0.910,0.912,0.911,0.912,0.915,0.916,0.917

Lithuania,0.732,0.728,0.713,0.701,0.697,0.703,0.712,0.724,0.736,0.744,0.755,0.767,0.778,0.790,0.798,0.810,0.819,0.826,0.831,0.821,0.824,0.831,0.835,0.840,0.852,0.855,0.860,0.866,0.869

Luxembourg,0.791,0.798,0.803,0.808,0.812,0.817,0.826,0.835,0.843,0.856,0.860,0.865,0.869,0.870,0.876,0.880,0.884,0.888,0.890,0.885,0.893,0.892,0.892,0.892,0.895,0.899,0.904,0.908,0.909

Madagascar,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.456,0.462,0.457,0.466,0.472,0.479,0.484,0.491,0.500,0.503,0.504,0.504,0.507,0.509,0.512,0.514,0.515,0.518,0.521

Malawi,0.303,0.310,0.319,0.327,0.323,0.363,0.366,0.367,0.368,0.368,0.362,0.362,0.363,0.367,0.368,0.373,0.383,0.394,0.411,0.426,0.437,0.447,0.452,0.463,0.472,0.475,0.478,0.482,0.485

Malaysia,0.644,0.652,0.661,0.668,0.676,0.683,0.695,0.706,0.709,0.715,0.724,0.722,0.724,0.731,0.734,0.732,0.738,0.751,0.762,0.766,0.773,0.779,0.782,0.787,0.792,0.797,0.801,0.802,0.804

Maldives,0.000,0.000,0.000,0.000,0.000,0.546,0.559,0.573,0.587,0.601,0.610,0.616,0.619,0.633,0.638,0.632,0.647,0.647,0.657,0.658,0.669,0.681,0.688,0.693,0.702,0.709,0.713,0.716,0.719

Mali,0.231,0.238,0.243,0.250,0.256,0.262,0.271,0.281,0.291,0.302,0.308,0.321,0.330,0.343,0.352,0.363,0.372,0.367,0.390,0.398,0.403,0.408,0.408,0.408,0.414,0.412,0.420,0.426,0.427

Malta,0.744,0.749,0.753,0.757,0.760,0.764,0.767,0.772,0.780,0.785,0.787,0.793,0.797,0.804,0.813,0.828,0.826,0.831,0.833,0.835,0.847,0.848,0.854,0.861,0.868,0.877,0.881,0.883,0.885

Marshall

Islands,0.000,0.696,0.698

Mauritania,0.378,0.383,0.391,0.403,0.415,0.422,0.431,0.430,0.438,0.445,0.446,0.446,0.451,0.455,0.465,0.470,0.479,0.479,0.480,0.487,0.490,0.494,0.503,0.511,0.518,0.521,0.519,0.524,0.527

Mauritius,0.620,0.627,0.634,0.639,0.644,0.649,0.653,0.657,0.663,0.668,0.674,0.683,0.688,0.697,0.705,0.713,0.720,0.728,0.734,0.742,0.748,0.756,0.768,0.775,0.786,0.786,0.790,0.793,0.796

Mexico,0.652,0.655,0.660,0.664,0.670,0.672,0.679,0.685,0.693,0.698,0.705,0.708,0.714,0.720,0.726,0.729,0.737,0.738,0.740,0.739,0.739,0.746,0.752,0.750,0.754,0.759,0.764,0.765,0.767

Micronesia (Federated States

of),0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.541,0.547,0.553,0.560,0.564,0.572,0.578,0.583,0.587,0.590,0.595,0.598,0.599,0.599,0.598,0.606,0.608,0.612,0.614

Moldova (Republic

of),0.653,0.642,0.622,0.620,0.598,0.605,0.602,0.604,0.604,0.607,0.609,0.618,0.628,0.641,0.651,0.658,0.667,0.672,0.677,0.673,0.681,0.687,0.693,0.702,0.705,0.703,0.705,0.709,0.711

Mongolia,0.583,0.575,0.561,0.547,0.549,0.553,0.560,0.566,0.574,0.581,0.589,0.600,0.609,0.622,0.636,0.649,0.660,0.671,0.682,0.688,0.697,0.711,0.719,0.728,0.733,0.736,0.730,0.729,0.735

Montenegro,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.741,0.748,0.753,0.764,0.775,0.785,0.787,0.793,0.797,0.798,0.801,0.803,0.807,0.809,0.813,0.816

Morocco,0.458,0.464,0.468,0.474,0.485,0.489,0.499,0.503,0.511,0.520,0.531,0.542,0.553,0.564,0.573,0.581,0.588,0.596,0.603,0.609,0.618,0.627,0.636,0.646,0.653,0.660,0.669,0.675,0.676

Mozambique,0.217,0.220,0.215,0.221,0.228,0.235,0.258,0.271,0.283,0.294,0.301,0.314,0.320,0.334,0.343,0.354,0.361,0.372,0.381,0.389,0.396,0.391,0.398,0.412,0.420,0.428,0.435,0.442,0.446

Myanmar,0.350,0.357,0.371,0.377,0.384,0.388,0.394,0.400,0.405,0.414,0.424,0.432,0.441,0.451,0.460,0.470,0.479,0.490,0.501,0.512,0.523,0.534,0.541,0.551,0.558,0.565,0.571,0.577,0.584

Namibia,0.579,0.582,0.586,0.586,0.586,0.581,0.571,0.563,0.556,0.546,0.543,0.542,0.540,0.542,0.544,0.544,0.550,0.558,0.566,0.575,0.588,0.601,0.612,0.622,0.631,0.637,0.639,0.643,0.645

Nepal,0.380,0.388,0.395,0.400,0.407,0.411,0.421,0.427,0.432,0.439,0.446,0.446,0.456,0.461,0.468,0.474,0.484,0.490,0.500,0.513,0.527,0.534,0.548,0.555,0.562,0.568,0.572,0.574,0.579

Netherlands,0.830,0.834,0.835,0.840,0.864,0.862,0.866,0.866,0.868,0.871,0.876,0.880,0.879,0.883,0.886,0.891,0.897,0.904,0.906,0.906,0.911,0.922,0.921,0.924,0.925,0.927,0.929,0.932,0.934

New

Zealand,0.820,0.821,0.826,0.838,0.847,0.853,0.856,0.861,0.864,0.865,0.870,0.874,0.882,0.885,0.887,0.889,0.892,0.894,0.895,0.898,0.899,0.902,0.905,0.907,0.910,0.914,0.917,0.920,0.921

Nicaragua,0.494,0.491,0.493,0.499,0.513,0.523,0.533,0.542,0.551,0.560,0.568,0.575,0.581,0.584,0.589,0.593,0.596,0.602,0.607,0.608,0.614,0.619,0.625,0.630,0.640,0.644,0.649,0.653,0.651

Niger,0.213,0.217,0.217,0.221,0.226,0.230,0.236,0.240,0.248,0.251,0.253,0.259,0.263,0.268,0.276,0.283,0.290,0.295,0.304,0.309,0.319,0.326,0.338,0.345,0.353,0.360,0.365,0.373,0.377

Nigeria,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.452,0.462,0.467,0.474,0.479,0.485,0.491,0.484,0.494,0.502,0.520,0.523,0.527,0.528,0.533,0.534

North

Macedonia,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.669,0.673,0.679,0.686,0.693,0.702,0.708,0.713,0.729,0.731,0.735,0.739,0.740,0.743,0.747,0.753,0.757,0.758,0.759

Norway,0.850,0.856,0.862,0.870,0.885,0.883,0.888,0.894,0.906,0.911,0.917,0.916,0.918,0.924,0.934,0.932,0.936,0.938,0.938,0.938,0.942,0.943,0.942,0.946,0.945,0.948,0.951,0.953,0.954

Oman,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.704,0.716,0.725,0.735,0.742,0.748,0.752,0.764,0.782,0.789,0.793,0.795,0.804,0.811,0.815,0.827,0.834,0.833,0.834

Pakistan,0.404,0.409,0.415,0.418,0.423,0.428,0.433,0.436,0.440,0.445,0.449,0.456,0.464,0.472,0.486,0.499,0.503,0.511,0.513,0.520,0.524,0.528,0.533,0.537,0.546,0.550,0.556,0.558,0.560

Palau,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.736,0.741,0.745,0.747,0.752,0.759,0.761,0.766,0.767,0.772,0.776,0.783,0.787,0.811,0.809,0.803,0.808,0.811,0.814

Palestine,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.638,0.646,0.647,0.657,0.661,0.666,0.671,0.679,0.684,0.681,0.682,0.685,0.687,0.689,0.690

Panama,0.659,0.665,0.673,0.680,0.684,0.688,0.694,0.700,0.708,0.713,0.719,0.722,0.728,0.730,0.735,0.739,0.744,0.751,0.755,0.756,0.758,0.764,0.770,0.775,0.779,0.782,0.789,0.793,0.795

Papua New

Guinea,0.377,0.386,0.393,0.404,0.405,0.414,0.421,0.425,0.428,0.431,0.436,0.441,0.446,0.450,0.459,0.468,0.473,0.486,0.490,0.500,0.510,0.517,0.508,0.521,0.531,0.539,0.541,0.543,0.543

Paraguay,0.588,0.593,0.597,0.607,0.615,0.622,0.629,0.633,0.638,0.641,0.640,0.648,0.658,0.657,0.664,0.667,0.666,0.671,0.680,0.678,0.692,0.697,0.697,0.709,0.712,0.718,0.718,0.722,0.724

Peru,0.613,0.619,0.620,0.625,0.636,0.646,0.651,0.657,0.667,0.677,0.679,0.688,0.688,0.687,0.694,0.700,0.697,0.705,0.715,0.718,0.721,0.734,0.734,0.742,0.752,0.750,0.755,0.756,0.759

Philippines,0.590,0.593,0.596,0.599,0.603,0.607,0.615,0.619,0.623,0.627,0.631,0.634,0.639,0.643,0.653,0.656,0.657,0.663,0.667,0.666,0.672,0.677,0.684,0.692,0.697,0.702,0.704,0.709,0.712

Poland,0.712,0.711,0.714,0.725,0.734,0.740,0.748,0.759,0.769,0.778,0.785,0.791,0.799,0.804,0.802,0.808,0.813,0.819,0.824,0.828,0.835,0.840,0.836,0.851,0.853,0.858,0.864,0.868,0.872

Portugal,0.711,0.720,0.732,0.746,0.753,0.760,0.767,0.773,0.780,0.779,0.785,0.790,0.792,0.796,0.797,0.800,0.803,0.810,0.814,0.817,0.822,0.827,0.829,0.837,0.840,0.843,0.846,0.848,0.850

Qatar,0.757,0.754,0.757,0.768,0.780,0.789,0.801,0.806,0.810,0.814,0.816,0.817,0.822,0.830,0.832,0.838,0.835,0.838,0.843,0.841,0.834,0.845,0.850,0.857,0.854,0.851,0.847,0.848,0.848

Romania,0.701,0.686,0.679,0.678,0.681,0.687,0.695,0.695,0.697,0.703,0.709,0.715,0.724,0.732,0.745,0.755,0.766,0.780,0.795,0.798,0.797,0.798,0.796,0.800,0.803,0.806,0.808,0.813,0.816

Russian Federation,0.734,0.729,0.719,0.711,0.702,0.701,0.702,0.704,0.703,0.710,0.721,0.727,0.733,0.740,0.746,0.752,0.759,0.767,0.774,0.771,0.780,0.789,0.797,0.803,0.807,0.813,0.817,0.822,0.824

Rwanda,0.245,0.218,0.200,0.195,0.189,0.228,0.260,0.288,0.303,0.322,0.337,0.346,0.361,0.374,0.391,0.409,0.430,0.446,0.456,0.472,0.488,0.496,0.504,0.506,0.513,0.515,0.525,0.529,0.536

Saint Kitts and Nevis,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.713,0.720,0.725,0.740,0.742,0.747,0.751,0.748,0.767,0.768,0.769,0.772,0.774,0.777

Saint Lucia,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.694,0.691,0.692,0.694,0.694,0.698,0.712,0.712,0.723,0.726,0.730,0.736,0.731,0.726,0.728,0.736,0.744,0.744,0.745

Saint Vincent and the Grenadines,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.674,0.678,0.683,0.690,0.693,0.698,0.704,0.705,0.713,0.713,0.711,0.713,0.713,0.714,0.715,0.721,0.725,0.726,0.728

Samoa,0.621,0.622,0.622,0.627,0.606,0.611,0.619,0.621,0.628,0.633,0.638,0.645,0.653,0.658,0.666,0.670,0.673,0.679,0.681,0.683,0.690,0.695,0.696,0.696,0.698,0.699,0.704,0.706,0.707

Sao Tome and Principe,0.437,0.438,0.441,0.444,0.449,0.452,0.458,0.462,0.467,0.474,0.480,0.489,0.494,0.502,0.509,0.517,0.526,0.531,0.532,0.541,0.546,0.553,0.558,0.568,0.577,0.590,0.593,0.603,0.609

Saudi Arabia,0.698,0.706,0.711,0.715,0.719,0.723,0.728,0.732,0.737,0.739,0.744,0.747,0.749,0.756,0.765,0.771,0.778,0.784,0.793,0.797,0.810,0.824,0.837,0.846,0.853,0.857,0.857,0.856,0.857

Senegal,0.377,0.377,0.378,0.377,0.377,0.378,0.379,0.380,0.383,0.385,0.390,0.406,0.410,0.418,0.426,0.434,0.439,0.448,0.458,0.462,0.468,0.479,0.489,0.494,0.501,0.504,0.506,0.510,0.514

Serbia,0.706,0.703,0.688,0.685,0.689,0.695,0.698,0.705,0.708,0.703,0.710,0.716,0.720,0.726,0.734,0.742,0.750,0.754,0.760,0.762,0.762,0.772,0.772,0.775,0.780,0.785,0.791,0.794,0.799

Seychelles,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.712,0.708,0.709,0.713,0.715,0.731,0.720,0.744,0.748,0.754,0.762,0.755,0.777,0.782,0.796,0.801,0.801,0.800,0.801

Sierra Leone,0.270,0.267,0.260,0.266,0.265,0.268,0.275,0.278,0.283,0.289,0.298,0.302,0.319,0.329,0.338,0.346,0.354,0.368,0.378,0.386,0.391,0.398,0.413,0.426,0.430,0.422,0.423,0.435,0.438

Singapore,0.718,0.728,0.739,0.750,0.762,0.771,0.780,0.791,0.796,0.807,0.818,0.822,0.830,0.839,0.846,0.869,0.872,0.879,0.884,0.885,0.909,0.914,0.920,0.923,0.928,0.929,0.933,0.934,0.935

Slovakia,0.739,0.734,0.733,0.737,0.743,0.751,0.754,0.756,0.762,0.762,0.763,0.765,0.772,0.777,0.785,0.794,0.803,0.814,0.822,0.823,0.829,0.836,0.841,0.844,0.845,0.849,0.851,0.854,0.857

Slovenia,0.829,0.813,0.767,0.759,0.762,0.782,0.788,0.796,0.805,0.819,0.824,0.835,0.843,0.850,0.857,0.861,0.868,0.873,0.878,0.877,0.881,0.883,0.876,0.884,0.886,0.886,0.892,0.899,0.902

Solomon Islands,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.490,0.476,0.480,0.486,0.492,0.498,0.503,0.515,0.517,0.517,0.506,0.524,0.532,0.546,0.550,0.551,0.555,0.553,0.555,0.557

South Africa,0.625,0.632,0.640,0.646,0.648,0.652,0.649,0.644,0.638,0.633,0.629,0.610,0.618,0.617,0.618,0.620,0.624,0.631,0.644,0.654,0.662,0.663,0.673,0.683,0.691,0.699,0.702,0.704,0.705

## South

Sudan,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.425,0.443,0.438,0.439,0.435,0.428,0.418,0.414,0.413

Spain,0.754,0.764,0.772,0.782,0.791,0.800,0.806,0.810,0.814,0.819,0.825,0.828,0.830,0.833,0.837,0.844,0.848,0.853,0.856,0.858,0.865,0.870,0.873,0.875,0.880,0.885,0.888,0.891,0.893

## Sri

Lanka,0.625,0.630,0.635,0.637,0.646,0.650,0.655,0.662,0.669,0.677,0.687,0.693,0.699,0.708,0.715,0.721,0.728,0.734,0.742,0.745,0.750,0.756,0.762,0.765,0.769,0.772,0.774,0.776,0.780

Sudan,0.332,0.337,0.345,0.353,0.359,0.367,0.375,0.385,0.391,0.397,0.403,0.409,0.415,0.421,0.430,0.437,0.447,0.452,0.464,0.469,0.471,0.475,0.485,0.477,0.496,0.501,0.505,0.507,0.508

Suriname,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.671,0.676,0.682,0.687,0.692,0.698,0.701,0.708,0.720,0.724,0.726,0.730,0.726,0.722,0.724

Sweden,0.816,0.818,0.821,0.840,0.849,0.857,0.864,0.874,0.888,0.893,0.897,0.900,0.903,0.908,0.896,0.899,0.902,0.905,0.901,0.899,0.906,0.906,0.908,0.927,0.929,0.932,0.934,0.935,0.937

Switzerland,0.832,0.834,0.836,0.841,0.844,0.848,0.854,0.864,0.874,0.881,0.889,0.891,0.891,0.896,0.901,0.906,0.912,0.915,0.917,0.927,0.932,0.932,0.935,0.938,0.939,0.943,0.943,0.943,0.946

## Syrian Arab

Republic,0.558,0.562,0.568,0.571,0.576,0.579,0.583,0.587,0.590,0.589,0.590,0.597,0.600,0.610,0.623,0.635,0.643,0.649,0.646,0.648,0.644,0.642,0.631,0.572,0.551,0.540,0.539,0.544,0.549

Tajikistan,0.603,0.598,0.577,0.560,0.527,0.532,0.517,0.522,0.526,0.530,0.538,0.548,0.559,0.571,0.582,0.590,0.596,0.602,0.616,0.619,0.630,0.634,0.639,0.643,0.642,0.642,0.647,0.651,0.656

## Tanzania (United Republic

of),0.373,0.374,0.372,0.372,0.371,0.372,0.374,0.375,0.382,0.388,0.395,0.402,0.412,0.421,0.431,0.442,0.452,0.461,0.470,0.479,0.487,0.492,0.501,0.503,0.509,0.519,0.518,0.522,0.528

Thailand,0.574,0.583,0.589,0.597,0.604,0.611,0.619,0.625,0.630,0.640,0.649,0.657,0.665,0.674,0.683,0.693,0.694,0.710,0.714,0.718,0.721,0.729,0.733,0.731,0.739,0.746,0.753,0.762,0.765

## Timor-

Leste,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.505,0.512,0.522,0.525,0.519,0.496,0.537,0.582,0.599,0.611,0.620,0.627,0.601,0.613,0.608,0.628,0.628,0.624,0.626

Togo,0.405,0.408,0.400,0.391,0.397,0.410,0.418,0.425,0.424,0.425,0.426,0.427,0.428,0.432,0.435,0.437,0.444,0.441,0.449,0.458,0.468,0.480,0.484,0.490,0.495,0.502,0.506,0.510,0.513

Tonga,0.645,0.651,0.653,0.657,0.664,0.667,0.667,0.667,0.670,0.670,0.666,0.670,0.676,0.685,0.674,0.674,0.675,0.678,0.681,0.686,0.692,0.696,0.700,0.699,0.699,0.714,0.715,0.717,0.717

## Trinidad and

Tobago,0.667,0.668,0.674,0.676,0.680,0.686,0.691,0.699,0.698,0.717,0.721,0.729,0.730,0.744,0.753,0.751,0.767,0.777,0.784,0.786,0.788,0.786,0.784,0.787,0.788,0.796,0.796,0.799,0.799

Tunisia,0.569,0.575,0.583,0.589,0.600,0.607,0.616,0.623,0.635,0.645,0.653,0.661,0.666,0.673,0.682,0.689,0.695,0.701,0.708,0.710,0.717,0.719,0.721,0.725,0.728,0.731,0.736,0.738,0.739

Turkey,0.579,0.583,0.589,0.597,0.599,0.607,0.615,0.624,0.635,0.643,0.655,0.661,0.672,0.679,0.685,0.691,0.702,0.709,0.714,0.721,0.743,0.759,0.765,0.781,0.792,0.800,0.800,0.805,0.807

Turkmenistan,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.673,0.680,0.686,0.691,0.696,0.701,0.706,0.708,0.710

Uganda,0.312,0.312,0.305,0.312,0.314,0.320,0.336,0.350,0.365,0.381,0.395,0.403,0.418,0.427,0.427,0.434,0.447,0.457,0.469,0.478,0.489,0.494,0.497,0.503,0.509,0.515,0.520,0.522,0.528

Ukraine,0.705,0.701,0.692,0.681,0.668,0.664,0.661,0.663,0.665,0.667,0.671,0.681,0.689,0.699,0.706,0.715,0.722,0.729,0.733,0.727,0.732,0.737,0.742,0.744,0.747,0.742,0.746,0.747,0.750

## United Arab

Emirates,0.724,0.735,0.738,0.745,0.755,0.764,0.765,0.766,0.769,0.776,0.782,0.787,0.793,0.798,0.803,0.809,0.814,0.819,0.821,0.819,0.821,0.826,0.832,0.839,0.847,0.860,0.863,0.864,0.866

## United

Kingdom,0.775,0.787,0.801,0.813,0.827,0.839,0.844,0.849,0.855,0.861,0.867,0.871,0.874,0.878,0.886,0.890,0.889,0.892,0.896,0.899,0.905,0.899,0.897,0.914,0.918,0.916,0.918,0.919,0.920



United

States,0.860,0.862,0.000,0.872,0.875,0.878,0.879,0.000,0.884,0.885,0.881,0.884,0.886,0.889,0.892,0.896,0.899,0.902,0.907,0.908,0.911,0.914,0.916,0.914,0.915,0.917,0.919,0.919,0.920

Uruguay,0.692,0.697,0.700,0.703,0.709,0.711,0.717,0.727,0.735,0.737,0.742,0.745,0.747,0.750,0.754,0.756,0.761,0.763,0.767,0.779,0.774,0.783,0.788,0.797,0.800,0.802,0.806,0.807,0.808

Uzbekistan,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.596,0.603,0.610,0.615,0.622,0.629,0.635,0.646,0.653,0.658,0.665,0.672,0.681,0.688,0.693,0.696,0.701,0.707,0.710

Vanuatu,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.000,0.569,0.575,0.577,0.584,0.584,0.585,0.585,0.584,0.588,0.589,0.592,0.592,0.595,0.597

Venezuela (Bolivarian Republic

of),0.638,0.648,0.654,0.656,0.657,0.660,0.662,0.666,0.668,0.670,0.672,0.680,0.688,0.687,0.700,0.714,0.727,0.743,0.753,0.752,0.753,0.764,0.767,0.772,0.770,0.763,0.752,0.735,0.726

Viet

Nam,0.475,0.484,0.496,0.506,0.517,0.529,0.540,0.539,0.559,0.566,0.578,0.586,0.594,0.603,0.612,0.616,0.624,0.632,0.639,0.650,0.653,0.663,0.668,0.673,0.675,0.680,0.685,0.690,0.693

Yemen,0.392,0.396,0.395,0.398,0.398,0.393,0.408,0.418,0.430,0.423,0.432,0.449,0.456,0.464,0.471,0.472,0.478,0.486,0.488,0.503,0.499,0.511,0.501,0.506,0.504,0.493,0.477,0.463,0.463

Zambia,0.424,0.421,0.420,0.422,0.418,0.419,0.419,0.420,0.419,0.424,0.428,0.436,0.445,0.455,0.464,0.475,0.486,0.492,0.507,0.521,0.531,0.541,0.552,0.559,0.565,0.570,0.580,0.589,0.591

Zimbabwe,0.498,0.500,0.485,0.480,0.478,0.472,0.471,0.466,0.461,0.457,0.452,0.453,0.444,0.430,0.427,0.425,0.429,0.434,0.432,0.448,0.472,0.490,0.516,0.527,0.537,0.544,0.549,0.553,0.563

# ŽIVOTOPIS



## Filip Lisjak

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Whatsapp Messenger: 00385989984979 |

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## ● RADNO ISKUSTVO

01/09/2020 – Zagreb, Hrvatska

### **ANALITIČAR U ODJELU REVIZIJE – Deloitte d.o.o.**

10/06/2019 – TRENUTAČNO – Zagreb

### **ADMINISTRATOR KADROVSKE SLUŽBE – Atalian Global Services Croatia**

- student u HR odjelu
- vođenje kadrovske evidencije djelatnika te ažuriranje promjena vezanih uz radni odnos djelatnika (prikupljanje dokumentacije za zapošljavanje, izrada i kontrola ugovora o radu, sporazuma raskida RO, izrada raznih potvrda za zaposlenike, rješenja za godišnji odmor, plana godišnjeg odmora i evidencija stanja godišnjeg odmora)
- vođenje administracije u HR odjelu
- zaprimanje i rješavanje upita radnika
- unos podataka o radnicima i promjenama u poslovni sustav
- vođenje evidencije službenih vozila
- obavljanje tekućih dnevnih zadataka

Zagreb, Hrvatska

07/08/2018 – 12/10/2018

### **HUMAN RESOURCES – Atalian Global Services Croatia d.o.o.**

Knjiženje faktura, prijava i odjava radnika, pisanje dopisa partnerima, bilježenje kilometraže vozila, razvažanje ugovora i računa poduzeća partnerima.

Zagreb, Hrvatska

## ● MREŽE I ČLANSTVA

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13/11/2017 – 30/09/2018

### **Case Study Competition**

Zagreb

Član Case Study Competition tima studentske udruge eSTUDENT u akademskoj godini 2017./2018. Bio sam koordinator za poduzeće Samsung.

01/11/2017 – 17/12/2019

### **Član Predsjedništva Udruge studenata Međimurja**

Zagreb

Član predsjedništva Udruge studenata Međimurja. Glavni poslovi su bili organiziranje različitih događaja za studente i pomaganje studentima s poteškoćama i pitanjima.

## ● OBRAZOVANJE I OSPOSOBLJAVANJE

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05/10/2015 – TRENUTAČNO – Zagreb, Hrvatska

### **Prvostupnik – Ekonomski fakultet Zagreb**

Smjer Menadžerska informatika

razina 7 EKO-a | <http://www.efzg.unizg.hr/>

05/09/2011 – 01/06/2015 – Čakovec, Hrvatska

### **Upravni referent – Ekonomska i trgovačka škola Čakovec**

razina 4 EKO-a

## ● JEZIČNE VJEŠTINE

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Materinski jezik/jezici: HRVATSKI

	RAZUMIJEVANJE		GOVOR		PISANJE
	Slušanje	Čitanje	Govorna produkcija	Govorna interakcija	
<b>NJEMAČKI</b>	C1	C1	C1	C1	C1
<b>ENGLJSKI</b>	C1	C1	C1	C1	C1

Razine: A1 i A2: temeljni korisnik; B1 i B2: samostalni korisnik; C1 i C2: iskusni korisnik

- **VOZAČKA DOZVOLA**

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Vozačka dozvola: B

- **ORGANIZACIJSKE VJEŠTINE**

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**Organizacijske vještine**

Organizacija vremena za rješavanje zadataka

Organizacija zadataka prema važnosti

Dobre organizacijske stečene prilikom organiziranja događaja za Udrugu čiji sam član

- **KOMUNIKACIJSKE I MEĐULJUDSKE VJEŠTINE**

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**Komunikacijske i međuljudske vještine**

- dobre komunikacijske vještine stečene tijekom aktivnosti u udrugama i u odjelu kadrova prilikom komunikacije s ostalim zaposlenicima

- **POSLOVNE VJEŠTINE**

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**Poslovne vještine**

- komunikacijske vještine

- organizacijske vještine

- vještine uočavanja

- vještine vođenja skupine ljudi