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# DOMESTICATED MEGAFAUNA OF AMERICAS: NEEDS, POSSIBILITIES AND RESULTS

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Review article

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## ABSTRACT

The article aims to determine why so few domestic animals originated in American domestication centres. The knowledge has been gathered from interdisciplinary sources taking into account recent archaeogenomic and spatial analysis research. The process of domestication is described, and different domestication centres are compared to the domestication needs and opportunities on the American continents. Human colonization of the American continent is considered. Important domestication centres on the North and South American continent are described. Dogs that colonized the American continents together with people and horses that arrived during the European colonization are also considered. The analysis of the American megafauna that lived on the continent during the first colonization of *Homo sapiens* showed that the big extinction occurred due to climate change and overhunting. Comparing the evolutionary process of domestication between Afro-Eurasia and America we found that there was no intentional domestication in areas peripheral to the original domestication centres in the Americas. Also, diversification of the domesticated animal purpose in the Americas is limited to dogs.

## KEY WORDS

North America, South America, domestication, animals, megafauna

## CLASSIFICATION

JEL: N50

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# INTRODUCTION

Anatomically modern human (*Homo sapiens)* evolved in Africa around 300 000 years ago [1]. Approximately 60 000 years ago some groups started leaving Africa and 'conquering' the rest of the world [2]. At that time humans used primitive tools against much larger predators than those we know today, expanding from the original habitat due to climate changes and the population growth in search for prey animals and gathering food. Pleistocene, known as 'The Ice Age', lasted from around 2 588 000 to 11 700 years ago. During that time Earth endured some of the biggest changes since its formation, which defined the world we know today. Looking at all the challenges an early human had to face we could say that it is an impressive achievement that in less than 50 000 years he managed to spread all over the world, even reaching America at earliest around 14 600 years ago [3, 4]. There are indications for dog assisted mammoth hunt as far as 16 200 years ago in Yakutia during the settling of northeast Asia [5]. When raw strength was not enough, early humans depended on their brain and intelligence, unknowingly changing the world around them, making better use of their environment. Today, it is known that people settled America using the 'Bering Strait', a narrow sea passage that connects Siberia with Alaska, which was covered with ice, therefore walkable during Pleistocene [4, 6]. However, people did not manage that feat on their own: they were followed by early domesticated dogs over the harsh cold Arctic, where hunting of the large prey such as mammoth, bison, wooly rhinoceros, musk-ox or wild horse, was the only feeding option with no gathering possible because of the climate [5, 7, 8]. Looking through all of the human history, domestication was one of the first things that really separated anatomically modern man from other animals and other Hominidae species, and was crucial for development of material culture (for example: horse and crops) through the development of agriculture [9-11]. Today we still do not know if the early human managed to tame a wolf and create, from this predator species, what is today known as 'man's best friend' on his own; or if the wolf basically domesticated himself with cohabitation and later commensalism and/or friendship with humans [12, 13].

The aim of this article is answering the question why the two American continents contributed so little to megafaunal domestication in comparison with Afro-Eurasia. To provide this answer (i) overview of domestication needs, capabilities and opportunities in North and South America is given from the start of human colonization of the continents to the time of the European invasion; (ii) animal species domesticated in America are examined; and (iii) the possibilities for domestication that America possessed are critically reviewed.

# DISSCUSION

## DOMESTICATION

The definitions and comparative timelines are provided in this section in order to provide an overview of domestication process in North and South America and discuss the results of historical megafaunal domestication in comparison with Afro-Eurasian domestication centers. In the Encyclopedia Britannica [14] domestication was defined: "Domestication is the process of hereditary reorganization of wild animals and plants into domestic and cultivated forms according to the interests of people." Martin and Sauerborn [15] elaborated that not every animal or plant can be domesticated [16]. To endure domestication an animal must abide by certain principles: (i) feed easy to obtain; (ii) short generation interval; (iii) no nasty disposition; (iv) willing to breed in captivity; (v) willing to follow hierarchy; (vi) does not panic in captivity.

The first and haphazard domestication of the dog in north Asia and the first crop domestication in the Fertile Crescent are at least 2 000 years apart, and even more time separates the second domesticated animal (sheep), from the domesticated dog. However, all

three of these cases share the same unintentional process of the domestication according to Zeder [17]. If we focus on animal domestication as an authentic evolutionary process in its own right, it can be said that the commensal way and the way of domestication of the prey were important initial pathways of domestication starting in the Neolithic, but the most of the animal species were domesticated intentionally in the period starting from the Iron Age until the recent few centuries [10]. Aimed and intentional domestication of animals geographically happened peripherally to the first domestication centers (*Equus africanus asinus (Linnaeus, 1758), Camelus dromedarius (Linnaeus, 1758), Camelus bactrianus* (*Linnaeus, 1758), Numida meleagris (Linnaeus, 1758)*) and is contemporary with the first intentional introgressive caption cases during the Iron Age that can be the cause of the artificial inflation of the count of independent domestication cases in certain species [18]. Providing animals for efficient transport coincides with the times of the expansion of agriculture into new areas starting at the end of the Bronze Age with domestication of the dromedary [10].

Besides for cats and dogs, and perhaps pig, the unintentional and initial commensal way could have been the domestication pathway for the guinea pigs in southern Peru and Bolivia [17]. The pathway of the domestication of the prey animals includes the motive of more reasonable resource management and starts with the sheep, goat and cow about 10 500 BCE in the sedentary societies and somewhat later for other bovine species further south and in the nomadic cultures of the European and Asian north (*Rangifer tarandus (Linnaeus, 1758)* and *Equus f. caballus (Linnaeus, 1758)*) [10, 19]. Starting with 6 000 – 5 000 BCE the same pathway of domestication was used for llama (*Lama glama (Linnaeus, 1758)*), alpaca (*Vicugna pacos (Linnaeus, 1758)*), turkey (*Meleagris gallopavo (Linnaeus, 1758)*) and muscovy duck (*Cairina moschata (Linnaeus, 1758)*) [10, 20, 21]. Little research is available on the insects and fish domestication on the American continents [22, 23].

Later onset of domestication is the characteristic of the American domestication centers, due to the timing of the first settlement of the continents. In the light of the global pattern of the domestication the characteristics of the domestication process of large animals in the Americas never reached beyond the prey pathway of domestication. Domestication of animals in Americas remained geographically limited to domestication centers with no diversification of purpose or aimed domestication typical for domestication of the end of Bronze Age and the Iron Age in Afro-Eurasia. It is important to notice that exactly this characteristic of domestication peripheral to early domestication centers at the end of Bronze Age in Afro-Eurasia enabled more of the wild species to be domesticated (donkeys, dromedary and Bactrian camels). Coincidently, the American cultures and civilizations did not reach the iron smelting technologies that are contemporary with the aimed domestication in Afro-Eurasia, until the contact with the European civilizations.

## GEOGRAPHICAL SETTING

In this section we assess the possibilities for domestication that America possessed geographically in comparison with Afro-Eurasia. Animal domestication happened in almost every part of the world (Table 1.) and changed the world biosphere in the recent 11 500 years, the size of human populations and the human evolution [10]. Due to the geography North America and eastern Brazil did not have any domesticated animals, as was the case with the Mediterranean and the North-central China domestication centers [24]. The Afro-Eurasion domestication centers were better connected, therefore the trading of cultures and knowledge was made possible. Migrations and sharing of information happened through all human history over Afro-Eurasia. It can be seen that in the Iron Age in Afro-Eurasia a lot of domesticated large species were used for migrations, trading, and war over far distances, which in turn helped spreading cultures and other domesticated species over the continents [9, 10, 17, 25]. Although the horse was domesticated before this period [26] probably as a mean of control of the wild herds of horses, morphologically this domestic species has changed notably between 5 500 BCE and 4 000 BCE, and after that

period it is notably used for trade transport, warfare (with the development of a cart) and milking [27]. In the Americas the only beasts of burden at that time are widespread dogs, and the llama in the limited geographical area. Moreover, llama was never used as a plough animal.

Geographical feature of the continents enables the trade and the transfer of the domesticated species over the temperate zone. The temperate zone spans over the east-west direction of the Afro-Eurasian setting of the domestication centers and enables additionally for the tamed animals to change the culture where they were used, and therefore the invention of new purposes and techniques of their use [28]. On the other hand, north-south span of the American continents forces the humans to adapt to different climate and biotic zones traveling over that direction. The Inca, versed in agriculture, did manage the giant feat of gaining reign and control of the vast area of the western south-American coast, with colonies in the Mesoamerica, while the non-agricultural cultures of the North America (such as the Inuit or the Kickapoo) did not. There was exchange of some of the animals over different American cultures, the dog was present almost everywhere, however, the llama and alpaca were not. Most American cultures did not really know of each other's existence, or they did not exist at the same time. By the time Aztecs appeared Mayan civilization was already gone or falling apart, having collapsed somewhere between 750 AD and 900 AD. Inca and Aztec civilization did exist at the same time but it seems they never shared any information or even knew of each other's existence [29]. Additionally, the conquering dominating cultures treasured their domesticated food sources and did not provide them freely for their conquered subordinates.

**Table 1.** Animals domesticated in different domestication centers. Numbers represent thousands of years before present as the latest time by which domestication occurred [10, 34].

| **American continents** | **Africa** | **Europe** | **Asia** | | |
|---|---|---|---|---|---|
| **Mesoamerica and South America** | **East Africa, South Arabia** | **Mediterranean** | **East Asia** | **South Asia** | **Southwest Asia (Middle east and Egypt)** |
| Llama<br>6-4 | Cattle – cow (taurine)<br>8,5-6,5 | | Dog<br>15 | Cattle – zebu (indicine)<br>8-6,5 | Pig<br>10,3-9 |
| Alpaca<br>5-3 | Donkey<br>5,5–3,5 | | Pig<br>8,5-6 | Water buffalo<br>6-4,5 | Sheep<br>11 |
| Guinea pig<br>5-4 | Honey Bee<br>3,5<br>[30] | Rabbit<br>2<br>[31] | Horse<br>5,5-4 | | Goat<br>10,5-8 |
| Muscovy duck<br>4-2 | Camel (Dromedary)<br>3 | | Silkworm<br>5,5 | | Cattle – cow (taurine)<br>10,3-8 |
| Turkey<br>2 | Guineafowl<br>1,5 | | Yak<br>10-7 | | Cat<br>9,5-4 |
| Ni-in?<br>*Llaveia axin axin*<br>[23] | | | Camel (Bactrian)<br>4,5 | | Pigeon<br>5-3<br>[32] |
| Stingless bee<br>2<br>[22] | | | Chicken<br>4 | | Goose<br>3<br>[33] |
| | | | Duck<br>1 | | |

## AMERICAN MEGAFAUNA

It is disputable that the places that were more abundant in animal species naturally had more domesticated animals. Besides the abundance of animal species, the type of the animals must be taken into consideration together with the general geography and human needs and capabilities at that time. To provide an overview of biological domestication opportunities in this section we discuss the wild American megafauna.

Although there are different definitions [35], terrestrial zoology considers megafauna to be any animal weighting more than 45,3 kilograms [36]. The biggest North American terrestrial megafauna specimen today is bison, weighting up to 1 ton [37]. South America today is more abundant in small land animals, biggest land mammal is tapir, which weighs up to 250 kilograms [38]. The biggest American mammals alive today are dwarfed in size by the extinct species. Approximately 97 out of 150 American megafauna species went extinct at the end of Pleistocene, about 10 000 years ago [39].

Apparently, during the time of domestication on American continents not many animals could meet the required predispositions for domestication. Since the wild megafauna of European continent was shared with North American to a certain extent, and North American with South America, we would expect that there were some animal species able to endure the domestication process present at all these spaces. Four main theories are used to explain the first human related American extinction of megafauna: (i) humans hunted them to extinction; (ii) climate change; (iii) spread of new diseases; (iv) asteroid hit. It is important to note that these theories are not mutually exclusive [40]. American continent was not an isolated case of big animal extinction, in general, closely followed by the appearance of *Homo sapiens* [11], for instance: Australian extinction 50 000 BCE, Solomon Islands 30 000 BCE, Cyprus 9 000 BCE, Antilles 6 000 BCE, Madagascar 2 000 BCE, New Zealand 800 BCE, Commander Islands 250 BCE.

The Pleistocene is characterized by a succession of colder and warmer periods, the glacial–interglacial cycles. Before the end of Pleistocene ice sheets spread and covered up to 30 % of total Earth surface, making the migrations possible. Before the temperature change, at the end of Pleistocene, yearly temperatures were 5-10 °C lower on average than they are nowadays. Because of the lower temperatures, the air was drier and precipitation much less frequent. Animals living at the time adapted and thrived up until about 11 000 years ago when the climate started changing and when humans arrived at the continent. Temporal proximity of the initial human immigration to North America and the rapid climate change of Younger Dryas cover the same 5 000-year window. Due to inefficient statistical methods used up until the Emery-Wetherell, McHorse, and Davis [41], who used a fine-scale geospatial approach in combination with meticulously pruned dataset of 95 megafaunal last-appearance and 75 human first-appearance radiocarbon dates to evaluate the North American megafaunal extinction, the efforts to identify the ultimate extinction cause gave contradictory results among researchers. Their spatially explicit approach resulted in rejecting the hypotheses of continent-wide extinction considering the blitzkrieg hypotheses, man carried disease, Clovis technology, and uniform climate change. However, the blitzkrieg or intensification hypotheses, a combination of climate and human influences, or a climatically driven extinction with large-scale refugia and environmental buffers that delayed extinction in several areas were not rejected. Emery-Wetherell et al. [41] found that the last appearances of megafauna in North America and their overlap with human populations were highly regional in nature. Megafauna had last appearances in Alaska before humans first appeared, consistent with climate as a primary driver, but human influence cannot be excluded from all regions. The Great Lakes regions and Mexico have a delayed last-appearance events with long overlap, but the reason for this refugia is not explained.

Emery-Wetherell et al. [41] incorporated an abundance of proboscidean fossils (*Mammuthus (Brookes, 1828)* and *Mammut (Blumenbach, 1799)*) in the last-appearance data. Three elephant species (mastodons) lived on the continent [42] best known is the wholly mammoth. This situation may have arisen because of their easy identification or possibly reflect the predicted staying power [43] of proboscideans against overhunting. Species of the genus *Equus (Linnaeus, 1758)*, and order Artiodactyla *(Owen, 1848)* were grouped in their work to assess possible differences of the extinction trends. North America was also home to different Camelid species-*Camelops (Leidy, 1854)*, close relative of the domesticated camelids of South America and the 'Old world' Bactrian camel, which were domesticated 2 500 BC in Northeast Afghanistan or southwestern Turkestan and were most important as animals of burden, but also as a source of milk and meat in Eastern Asia. Other animals that could have possibly endured domestication are few extinct Bovidae species: *Bison antiqus (Leidy, 1854)* and *Bison occidentalis (Lucas, 1898)*, *Bootherium bombifrons (Harlan, 1825)*, *Euceratherium (Furlong & Sinclair, 1904)*, and were not included in the research of Emery-Wetherell et al. [41] since they had later extinction dates [44]. American wild bison has never been domesticated, due to wild and ungovernable temper [16].

South America was home to the giant sloth, who fed on avocado fruit with the seed which enabled the plants reproduction [45]. Besides the only domesticated megafauna of America lama (*Lama glama (Linnaeus, 1758)*) derived from guanaco (*Lama guanicoe (Müller, 1776)*) and alpaca (*Vicugna pacos (Linnaeus, 1758)*) derived from vicuna (*Vicugna vicugna (Molina, 1782)*), South America was home to specific animals such as *Macrauchenia (Owen, 1838)*, *Doedicurus (Burmeister 1874)*, *Glyptodon (Owen, 1839)*, and *Toxodon (Owen, 1839)*. Elephants also lived here, most notably the *Stegomastodon (Pohlig, 1912)* and *Cuvieronius (Osborn, 1923)*. Horse genus *Hippidion (Owen, 1869)* was present until approximately 8 000 years ago.

## THE NEED FOR ANIMALS OF DIFFERENT PURPOSE

The need for domestication, intention and purpose are demonstrated in this section taking account of North and South America, sedentary and nomadic cultures.

The only domesticated animals that North American Indians kept were dogs. Dogs were not originally domesticated in America (even though the precise origin of dog is still unknown) [46-48]. The first dog breeds made the life in northernmost parts of America possible by hunting, carrying cargo, dragging sleds, which made migration possible, providing warmth, medicine (dog urine), and sometimes food for people [49]. Dogs were so important to the Inuit that they only ate them in time of the greatest starvation, when dogs and people would die anyways [50]. As was the case in the Siberian Arctic, cold environment provided mostly prey, with short period during the year for gathering berries or plant material for making fire, which is indicative in the Abenaki word `Esquimantsic*'* denoting the ones eating raw meat.

North America with temperate climate, further south (along the Wabash River), was area where dogs were much more often used as food. This was the area of the hunter-gatherer and fishing tribes with far more opportunity for gathering, and the area where nomadic life was not burdened by domestication or agriculture. Noteworthy are the Kickapoo Indians of the American southwest, who reared dogs in a ceremonial way, aside from the "regular" way for the company and dogs used for migrations and ate dog meat for ceremonial purposes [51]. One of the more interesting dog breeds that originated in North America is the 'Salish wool dog'. These dogs were selected for white hair that was used for clothes and was sheared. With arrival of Europeans and introduction of sheep to America these dogs went extinct [52].

Despite the fact it was colonized the last, South America was also home to some of the most important American civilizations. Like Central American Olmec and Maya civilizations, South America was also home to arguably the oldest (Norte Chico) and the biggest (Inca) civilizations [53].

Southern American Indians were well versed in agriculture and animal domestication. They kept dogs, mostly used as a food source or just for general company. Well known today is 'Inca Orchid' breed which despite the name is older than the Inca civilization. Poultry was also an important aspect of their life. 'Mocha' culture of the Meso-America domesticated muscovy duck (*Cairina moschata (Linnaeus, 1758)*) and used it as early as 50 BCE. Apart from the obvious food source aspect, Muscovy ducks were kept as 'pest control'. They love feeding on fly and mosquito larva, which is very useful in the jungles where these animals are abundant [17]. Aside from ducks, guinea pigs (*Cavia porcellus (Linnaeus, 1758)*) were also a useful domesticated food source. Used in settlements at the earliest at around 900 BCE in the Altiplano region of Bolivia and south Peru [54], guinea pigs proved to be very easy to keep and they reproduced rapidly. Unfortunately, due to their small and fragile remains in the zone where dogs were also kept it is possible that more detailed archaeological and genetic investigation of their early domestication in the period long before the Inca is impaired. Due to their nutritional value they remained one of the most important South American food sources even today. Only after spreading to Europe guinea pigs gained the 'pet' status that we are familiar with today [54].

The biggest domesticated animals of American continents are llama and alpaca, domesticated by the Inca civilization around 4 000 BCE. Since the American civilization did not use the wheel (besides for children toys) llamas, being bigger than alpacas, were very useful for carrying burden. Alpacas were mostly used for clothes production; their soft fleece is still regarded as a premium clothes material [55, 56].

## DOMESTICATION CAPABILITIES – HORSES ON THE AMERICAN CONTINENT

In order to further assess human capabilities and opportunities for domestication, in this section we discuss the case of horses on the American continents.

Long before human migrations, American continent was home to two horse species, wild horse *Equus ferus (Boddaert, 1785)* [26] and, somewhat newly discovered genus *Haringtonhippus (Heintzman et al., 2017)* that lived contemporary with the wild horse [57]. Together with most of the megafauna' species, *E. ferus (Boddaert, 1785)* went extinct in America at the end of Pleistocene, around 11 000 years ago, while in Europe it survived until the 19$^{th}$ century. *E. ferus (Boddaert, 1785)* originated in North America around 4 million years ago, 2 million years ago some specimens crossed the Bering Strait and rapidly colonized Eurasia [58], where it was domesticated. Domestic horses proved to be very important for the development of the old world. Some of the great ancient civilizations began and ended on horseback, for instance, the Scythians defeated the Egyptians because of the horses. Horses made intercontinental migrations and trade possible. It is said that during the Mongolian rule in the 13$^{th}$ - 14$^{th}$ century, with the clever use of a horse, messages could be carried up to 300 km in a single day [59], feat which was not repeated until the construction of Trans-Siberian railway in 1904 [60]. Without the horse American Indian tribes were almost isolated from one another. Trade was very hard, routes had to be traveled on foot and burden carried on back or with use of dog sleds.

Reintroduction of horse to American continent occured during the 16$^{th}$ century with the arrival of conquistadores. First were brought to Cuba by Christopher Columbus on his second voyage to the 'New world'. First sighting of horse riders must have been terrifying, horse riders seemed to blend with their horse, and they wore bells on their armor which aided the confusion [61]. Real spread of horses in America happened after the 1680 Pueblo Revolt in New Mexico. All

of the Spanish conquistadores were pushed out of New Mexico by the revolting tribes. They were forced to escape without their livestock, leaving behind around 1500 horses. Pueblo people (aided by nomad tribes: Utes, Navajo, Apache and Comanche) quickly adopted horses in their culture. With trading, raids and escape, horses were quickly reintroduced to the continent [62]. The Great American Plains proved to be perfect habitat for the horses. Escapees from the Mesoamerican tribes and the invading Europeans quickly spread and became feral. Indian tribes adapted new ways of horse taming, bareback riding and even horseback warfare. In addition to that, horses soon became the measure of wealth and power, the more horses a tribe had the better it was of. In that way Indian cultures of the 17$^{th}$ century soon resembled Asian steppe bronze-age tribes, where the horse was originally domesticated [63].

## CONCLUSION

Recent interdisciplinary research enables deeper comprehension of history of both man and fauna surrounding us, elucidating processes and motivation. Archaeogenomics and spatial methods in research are the two most prominent areas contributing insight in times and spaces where historiography is missing. Interdisciplinary overview of times and spaces without historiography is valuable in forming broader comprehension of the human history.

Animal domestication is one of the most important moments in the entire human history, it completely changed our cultures. The need and the possibility of domestication were present in sedentary and nomadic cultures all over the globe, however, not all of them had the same geographical or biological setting, or arose at the same time in the history. This led to differences in the accumulation of material wealth and differences in freely available time during their lifetime for the development of cognitive technologies such as writing, spying, or trade communication with different cultures. Late onset of human history in comparison to Afro-Eurasia and north to south orientation of the American continents in comparison with east to west orientation of Afro-Eurasia were the main characteristics of the global domestication opportunities.

The need for domestication, intention and purpose are demonstrated all over American continents in both sedentary and nomadic cultures on the examples of dog selection and crop domestication. Capability of people to domesticate megafauna is demonstrated in secondary domestication of horses. The two camelid species, llama and alpaca remain the only domesticated megafauna of the Americas. Both overhunting and climate related megafaunal extinction explain the nature of megafaunal domestication in the Americas more than the human factor. The pattern of animal domestication from the north towards the south of Americas showing no animal domesticates in North America (despite the need for large animals of different purpose that was satisfied mostly with dog breeding), followed by the small fauna domesticated in the Meso-America, and finally the two camelid species of the South America leads towards the idea that this event of history was at least partially caused with overhunting during the first human settling of the continents.

The most pronounced differences of the people of the Americas and civilizations of Afro-Eurasia accumulated due to three main animal domestication issues: (i) the lack of horse for domestication on the American continents; (ii) the lack of intentional domestication typical for the Iron Age; (iii) the lack of diversification of the domestic animal purpose in contact with different cultures. The lack of wild horse for domestication, to use as herd control, for warfare and trade, was the first step in making the timing and the biological and geographical setting more pronounced. The lack of intentional domestication typical for the Iron Age and beasts for long trade routes and as ploughing animals was a cultural and civilizational achievement which never occurred in the Americas, as was the lack of diversification of the domestic animal purpose in contact with different cultures.

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# A FRAMEWORK FOR DESIGNING COMPASSIONATE AND ETHICAL ARTIFICIAL INTELLIGENCE AND ARTIFICIAL CONSCIOUSNESS

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## ABSTRACT

Intelligence and consciousness have fascinated humanity for a long time and we have long sought to replicate this in machines. In this work, we show some design principles for a compassionate and conscious artificial intelligence. We present a computational framework for engineering intelligence, empathy, and consciousness in machines. We hope that this framework will allow us to better understand consciousness and design machines that are conscious and empathetic. Our hope is that this will also shift the discussion from fear of artificial intelligence towards designing machines that embed our cherished values. Consciousness, intelligence, and empathy would be worthy design goals that can be engineered in machines.

## KEY WORDS

artificial intelligence, artificial consciousness, engineering intelligence, empathy

## CLASSIFICATION

JEL: C88, L86

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## INTRODUCTION

Consciousness has intrigued humanity for centuries. It is only now with the emergence of complex systems science and systems biology that we are beginning to get a deeper understanding of consciousness. Here we introduce a computational framework for designing artificial consciousness and artificial intelligence with empathy.

We hope this framework will allow us to better understand consciousness and design machines that are conscious and empathetic. We also hope our work will help shift the discussion from a fear of artificial intelligence towards designing machines that embed our values in them.

Consciousness, intelligence and empathy would be worthy design goals that can be engineered in machines.

## ARCHITECTURE FOR ARTIFICIAL INTELLIGENCE

In this section we outline a computational architecture for intelligent machines that can be considered to be conscious and empathetic. The key components of this architecture are described below and shown in Figure 1. Each component is also described in detail in the subsequent sections.

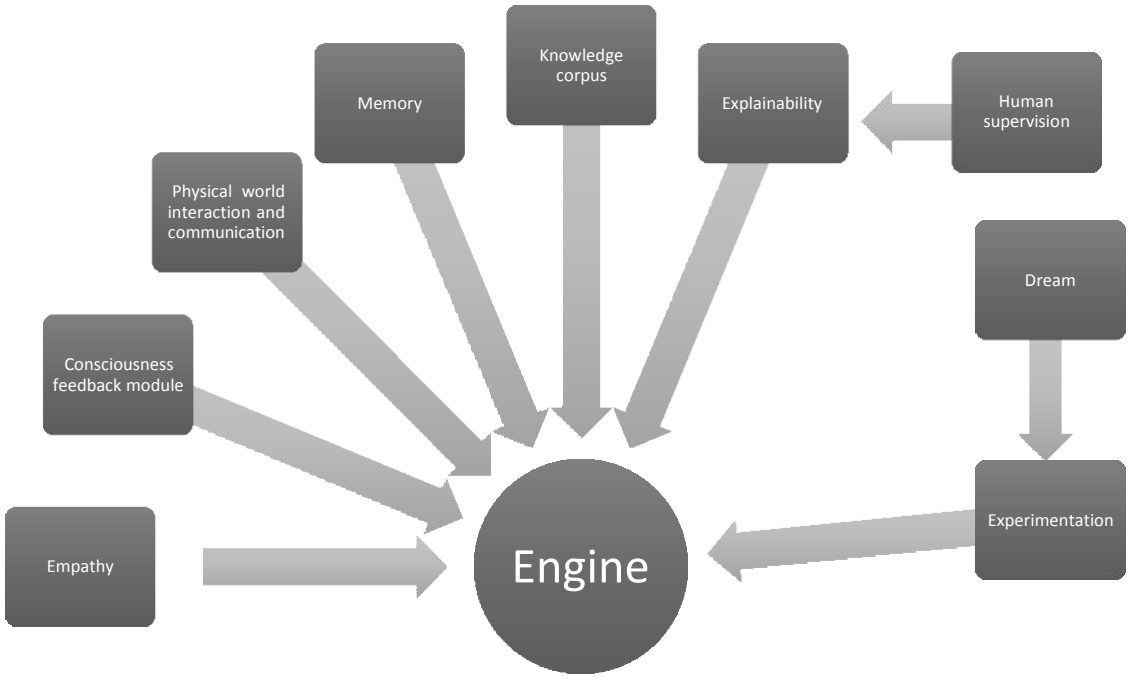


**Figure 1.** Computational architecture of artificial intelligence with consciousness and empathy.

### CORE COMPUTATIONAL ENGINE

The core engine is a deep learning framework which is able to analyze data and formulate concepts. The different hidden layers of the neural network will represent concepts. For example, say the deep learning framework analyzes data from an oscillating pendulum. It will build an internal model representation of this data and discover an invariant like the period of oscillation (Figure 2) [1]. The deep learning framework will also analyze this data and form a concept of a period of a pendulum. This will also be reinforced by human input on what that concept actually means and by parsing the corresponding definition from an open-source knowledge corpus (like Wikipedia) (shown in Figure 2). We hypothesize that the more these machines connect these disparate sources of information and formulate concepts, the more

knowledge it will have and the more intelligent and conscious it will become. These machines will also collaborate with other machines and human operators to communicate and share concepts; together they will build on these concepts to generate additional insight and knowledge. Our hope is that humans and networks of machines can collaborate, leading to a collective amplified intelligence.

## INTELLIGENCE

The machine will assimilate knowledge from supervised human input and an open source knowledge corpus (like Wikipedia). It will use a deep learning framework to analyze data and formulate concepts (the different hidden layers will represent concepts). It will thengenerate internal models, experiment with variations of these models, and formulate concepts to explain these (similar to a previous framework [1]).

Let us again assume that the machine is given data on an oscillating pendulum. It will form an internal model and mutate that model (using genetic programming or Bayesian techniques) whilst ensuring the model predictions match the empirical data (Figure 2). It will then analyze this to find invariants (quantities that do not change) like the period of oscillation of a pendulum. Performing this in a deep learning framework, the hidden layers of the network will represent the concept of a period of oscillation. These concepts will be fed into the explainability module which will translate this concept to a human understandable format. Human operators will then reinforce this concept with dynamical systems). Operators can help generalize the concept of period of oscillation to other dynamical systems and help reinforce this concept (similar to how a teacher would teach this subject).

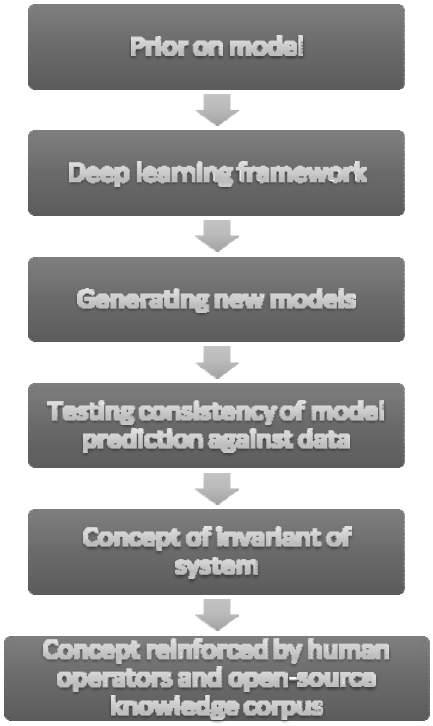


**Figure 2.** A Bayesian approach to artificial intelligence. The framework gets prior model specifications from human operators, mutates the models and checks consistency with empirical data. The hidden layers of the deep learning network represent a concept (for example, the invariant of a dynamical system). This concept is further reinforced by human operators (who help generalize that concept) and input from an open-source knowledge corpus.

We note that this module can also be implemented in a Bayesian setting (Figure 2). The different models can be varied or mutated by using Markov Chain Monte Carlo in a non-parametric Bayesian model. Additional information can be provided from human operators using priors in a Bayesian model [2].

## EMPATHY MODULE

The empathy module would build and simulate a minimal mental model of others (robots or humans) so that they can be understood and empathized with. We note that this is a computationally expensive module (see Section Designing Empathy in Machines). This would require enforcing some constraints on how much time is spent on processing that information.

## CONSCIOUSNESS MODULE

We define consciousness as what information processing feels like in a complex system (defined in detail in Section An Information Theoretic View of Artificial Consciousness). The consciousness module (Figure 4) is a deep learning network with feedback to analyze itself. The critical factor is that the module would feedback into itself. It would also need inputs from the intelligence module.

We argue, like others before [3], that consciousness is what information processing feels like. Due to learning and human feedback, consciousness can also be learnt over time (bicameral theory of mind and consciousness [4]). We hypothesize that this proposed engineered system would build up consciousness over time.

Communication with other robots and humans is also a critical component in order to build a collective intelligence. These machines will communicate with other artificially intelligent machines.

Finally, this module will have agents (like in agent based models) combined with machine learning or reinforcement learning. Consciousness will be an emergent property of this system.

## DREAM MODULE

The dream module is a sandbox environment to simulate all other modules with no inhibitions. This is similar to DeepDream [5, 6] with feedback into itself. This module also has connections to the experiment module.

## EXPERIMENT MODULE

The experiment module will play or experiment with systems in a protected sandbox environment (similar to another framework [1]). The input to this module would be data on a particular system of interest. The module would make a model, perturb this model, and observe how well is it consistent with data. The output of this module would be fed into a neural network to form concepts (the hidden layers of the deep learning network would represent concepts).

## EXPLAINABILITY MODULE

This module will run interpretable machine learning algorithms to allow human operators to understand actions taken by the machine and get insights into mechanisms behind the learning.

## UNSUPERVISED LEARNING

We propose that these systems should also incorporate some information from curated repositories like the Wikipedia knowledge corpus, similar to what was done for the IBM Watson project.

### SUPERVISED LEARNING

The concepts formed by the engine and the output of other modules will be tested by humans. Humans will interact with the explainability module to understand why these particular actions were taken or concepts formed. Human operators would ensure that these machines have a broad goal or purpose and that all their actions are consistent with some ethical structure (like Asimov's Laws of Robotics). Human operators will also try to minimize the harm to the machines themselves.

We expect that different machines will form distinct personalities based on their system state, data and human input. This is an opportunity for us to personalize these machines (if used in homes).

This step is also the most vulnerable; humans with malicious intent can embed undesirable values in machines and hence considerable care should be taken in supervising these machines.

### MEMORY

Finally, the machine will have memory. It will record all current and previous states of its artificial neural network, learning representations and interactions with human operators. It will have the capability to play back these memories (in a protected sandbox environment), perform role-playing and simulate future moves. This will need to be done in the dream module. Our hope is that machines will be able to use past memories to learn from them, generate new future scenarios from past data and train on this data.

These "reveries" will allow the machines to effectively use data on past actions to generate new knowledge. This reverie architecture generates new knowledge by combining stored information with a capability to process that information (Figure 3). In a certain sense, these machines will be able to learn from past mistakes and adapt to different scenarios. We hypothesize that this will lead to higher levels of intelligence and ultimately lead to a form of consciousness.

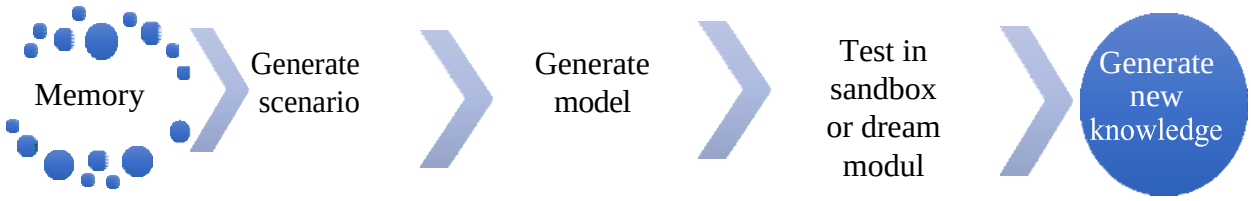


**Figure 3.** Using past memory to generate new knowledge. Past data is used to generate training data which is combined with new models. This yields new insights and knowledge into a system of interest. This "reverie" architecture generates new knowledge by combining stored information with a capability to process that information.

## CONSCIOUSNESS, INTELLIGENCE AND LIFE: PERSPECTIVES FROM INFORMATION PROCESSING

We hypothesize that consciousness, intelligence and life are different forms of information processing in complex systems [7]. Information and the computational substrate needed to process that information serve as the basis of life, intelligence and consciousness.

The minimal computational unit needed to create this artificial intelligence can be an artificial

neuron, reaction diffusion computers [7, 8] or neuromorphic computing systems [9]. Any of these computing substrates can be used to implement the architecture shown in Figure 1.

## AN INFORMATION THEORETIC VIEW OF ARTIFICIAL CONSCIOUSNESS

Consciousness is characterized by feedback loops in a complex system. Consciousness is what information processing feels like when there are feedback loops in a complex system that processes information [1, 3, 10, 11].

Consciousness also has been hypothesized to be an emergent property of a complex system [12]. It is like asking what makes water liquid; it is not only a property of the water molecule but also an emergent property of the entire system of billions of water molecules. Hence, we hypothesize that consciousness is also an emergent property of a complex information processing system with feedback.

## DESIGNING CONSCIOUSNESS IN MACHINES

How can we encode these principles and design consciousness in a computer? A tentative basic definition of a conscious machine is a "A computing unit that can process information and has feedback into itself". An architecture of a consciousness module is presented below and shown in Figure 4.

Would a computer recognize that it is a computer? We can show a computer images of other computers to help it recognize itself (using deep learning based image recognition algorithms). We can also for example show the machine images of a smartphone, birds and buildings to reinforce the concept that it is not any of these things (non-self). Finally, we can design an algorithm to select out all images of non-self; all that remains is self.

This kind of an algorithm can be used to design a sense of self in machines. Such a supervised learning approach is similar to negative selection in biology [13] where the immune system learns to discriminate between all cells in the body (self), versus all that is foreign and potentially pathogenic (non-self).

A complementary approach is to exhaustively define all qualities that uniquely define self like the size of the computer, colour, amount of memory, identification marks, memory of past actions taken by this machine, etc. We can also show the computer an image of itself. All these attributes can then be coupled to a deep-learning based image recognition program or self- recognition program. The different hidden layers of a deep learning module would encapsulate the concept of self (based on images or other attributes).

Both these strategies can be combined to design a basic level of self-awareness and consciousness in computers (Figure 4).

We see some parallels to the turtle robots designed by William Grey Walter that could sense, move, and recharge [14]. These simple robots could follow a light source with a sensor, move around and then recharge its batteries when required. In one experiment, a light source was placed on top of the robot and the robot itself placed in front of a mirror. It was claimed that the robot began to twitch; W.G. Walter suggested that this robot showed a simple form of self-awareness [14].

We also argue that this is a basic level of consciousness and self-awareness. Similar principles can be used to design consciousness in machines.

Finally, we note that there are some well-known cognitive architectures that can be used to implement this form of artificial intelligence [15].

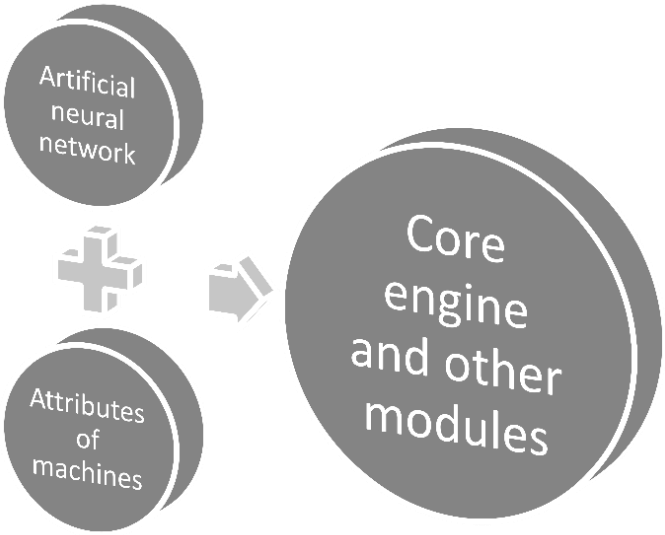


**Figure 4.** Architecture of the consciousness module. An artificial neural network analyzes the input and output of the core engine and all other modules (in Figure 1). This is combined with all the attributes of this particular machine (colour, physical characteristics, the fact that it is not a smartphone, it is not a bird, etc.). The hidden layers of the artificial neural network will represent the concept of self.

## HUMAN SUPERVISION AND INTERPRETABILITY

Conscious machines will also need to explain themselves. The biological brain sometimes struggles to explain itself to others. Sometimes people find it hard to explain their actions or motives. Why do we love someone? Why do we feel afraid when we see a snake? The brain is a complex information processing system that does not lend itself very well to explanation.

Some progress has been made in making artificial neural networks interpretable [16, 17]. These are approaches where artificial neural networks are turned on themselves to analyze their own actions. Similar techniques can be used to implement an explainability module (Figure 1) that can explain specific actions taken by the machine to human operators.

Making artificial intelligence interpretable or explainable will help human operators understand machines and help guide their training [18].

## DESIGNING EMPATHY IN MACHINES

Empathy is when we try to deeply understand another person. The brain is like a Turing machine, and empathy is similar to running another Turing machine within it. Simulating a Turing machine with another Turing machine and asking the question whether it will ever halt is undecidable (Halting problem). We hypothesize that in general empathy is undecidable. It is also computationally expensive, which is perhaps why biological organisms do not have a lot of empathy.

Empathy is also intimately connected with a sense of self. Having a sense of self is essential for survival and maybe why evolutionarily it is important to have consciousness.

There are people called synesthete who have a heightened sense of compassion for other people. They feel intense emotions and empathy for other people to the point where human interactions exhaust them and they can become homebound. Essentially they are simulating other people and feeling what other people are feeling. They also find it difficult to separate their own self from other people.

Hence the reason we have a sense of self. We hypothesize that having a sense of self aids survival and delineates self from prey or predator. This may also be the reason we do not have a lot of empathy. If we did, we would not have a strong sense of self and may be at a selective disadvantage.

Empathy and consciousness are also related. The ability to run a simulation of what another person is feeling like (simulating another person's mental state) is empathy. Apart from being undecidable in general, empathy is also inversely related to a sense of self and hence maybe at a selective disadvantage.

Evolution may have decided that a lot of empathy is not good for individual survival. However, we have the unique opportunity of being able to engineer machines that have more empathy than biological organisms. We suggest the possibility of programming empathy in a computer. We may have to impose limits on how much time to simulate another person or another machine's state. In general this is undecidable, but we may be able to implement fast approximations.

## DISCUSSION

We present a computational framework for engineering intelligence, empathy and consciousness in machines. This architecture can be implemented on any substrate that is capable of computing and information processing [7, 8, 19, 20-34].

We tentatively define consciousness as what information processing feels like in a complex system [3]. Consciousness is also like having a sense of self and is an emergent property of a complex information processing system with feedback.

Our proposed architecture for intelligent, conscious and empathetic machines will assimilate knowledge using supervised learning, form concepts (using a deep learning framework) and experiment in a sandbox. Our proposed machines will be capable of a form of consciousness by using feedback. They will also be capable of empathy by simulating the artificial neural state or conditions of other machines or humans.

We hypothesize that empathy and emotions have been pre-programmed over evolution. Empathy may confer an evolutionary advantage. We also recognize why too much empathy can be a disadvantage. Empathy can be achieved in robots through operator training (reinforcement learning) and allowing machines to analyze the artificial neural state of other machines or personal history of humans. We have the unique opportunity of being able to engineer machines that may have more empathy than biological organisms.

Communication technologies and human supervision can help accelerate the onset of artificial consciousness as was hypothesized to have led to the emergence of consciousness in humans [4]. Consciousness can be learnt over time as has been hypothesized before [4]. We suggest a computational approach to engineer this in machines with close human supervision.

Ultimately, we may be able to engineer higher levels of consciousness. More levels of feedback and more complexity in information processing may lead to higher levels of consciousness. The union of machine intelligence with our biological intelligence may also give us access to higher levels of consciousness.

Computing paradigms that are not constrained by physical space or have different computing substrates (as proposed in different information processing systems [7, 35] and in biology [20-34]) may be capable of higher levels of consciousness. Our greatest contribution as a species may be that we introduce non-biological consciousness into the Universe.

We foresee a number of dangers. The scope of this computational framework (presented in

Figure 1) is very broad and maybe currently be beyond the reach of individuals and only be feasible by giant corporations. Malicious corporations and conglomerates of individuals may misuse such an artificial intelligence, by for example failing to invest in empathy. It may be worthwhile to create non-profits that advocate for designing empathy in future intelligent machines and also educate the public about the potential benefits of such technologies.

Another danger is that we mistreat these artificial creations. What ethics might we need to create for conscious machines [36]? Would it be ethical to turn off or destroy such an artificially intelligent and conscious being? The creation of artificially conscious and intelligent machines will challenge us to come up with new ethical structures. It may be the first time that consciousness would have been engineered rather than self-emerge and these beings would deserve as much sympathy as we show towards other species.

We hope that this framework will allow us to better understand consciousness and design machines that are conscious and empathetic. We hope this will also shift the discussion from a fear of artificial intelligence towards designing machines that embed our cherished values in them. Consciousness, intelligence and empathy would be worthy design goals that can be engineered in machines.

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# SIGNIFICANCE OF SOCIAL AND PERSONAL POWER AS A SOCIAL VALUE: PERCEPTIONS OF STUDENTS IN SOUTHEAST EUROPE

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## ABSTRACT

The objective of this study is to explore how much power as a value in general, power in the sense of domination, and power over natural and social resources is important to students in Southeast Europe, whether it differs among states and what significance does it have in relation to other values. In order to achieve the objective of the study, Schwartz's PVQ-RR questionnaire was used, which has been widely used in international research of values and turned out to be the most reliable instrument for that sort of research. The study was performed using a quantitative survey method in seven states of Southeast Europe (Bosnia and Herzegovina, Montenegro, Croatia, Hungary, Macedonia, Slovenia, and Serbia). The descriptive analysis of ranking shows how power as a value is the lowest ranking value in the states of Southeast Europe as it is the case also in Western states, where such research has already been performed. Among the observed countries of Southeast Europe, there are statistically significant differences in the value of power as domination considering an individual state, while there are no statistically significant differences in the value of power over natural and social resources in the states of Southeast Europe. Taking into consideration the lack of such studies in this geopolitical area, it becomes apparent that further and more detailed research is needed regarding social values for students and also for the general population in Southeast Europe.

## KEY WORDS

power, PVQ-RR, Schwartz, Southeast Europe, values

## CLASSIFICATION

JEL: N34

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# INTRODUCTION

Values are an important aspect of every society, and they create people's attitudes and behaviour. Hence, the objective of this study is to research how much power as a social value in general, power in the sense of domination and power over natural and social resources is important to students in Southeast Europe in relation to other motivational types of values from Schwartz's model. It is also the objective to determine whether the power in general, power in the sense of domination and power over natural and social resources differ among countries. The sample of students is important because they are young people whose habits can still be varied through various social policies and educations, and it is therefore very important to research this population and their values.

This article is special because it presents the results of student research in seven Southeast European countries where such research is lacking.

## INTRODUCTORY DELIBERATIONS ON THE CONCEPTS OF VALUES

Man has all through the past always been occupied by the concept of values, trying to name socially acceptable values, to understand and define them. With the Modern Age establishment of different scientific paradigms within the framework of individual social and humanistic sciences, there have been different definitions of the term of values. So *philosophy* describes values as general characteristics or value terms attributed to individual bearers of values or assets in the process of evaluation, *humanities* describe values as goals or purposes of action, *psychology* and *sociology* as characteristics of thinking, also attitudes, convictions, opinions or actually psychological dispositions and subjective orientations towards values, while *pedagogy* defines values as normative cultural assets (as norms, ideals, guiding principles, beliefs or moral norms) [1]. The issues of values are also dealt with by other social sciences as anthropology, political sciences and economy, within the context of their respective field of research.

So are values "an set of general convictions, opinions and attitudes on what is correct, beneficial and desirable, and which is created through a process of socialization" [2; p.500] or, according to Shalom H. Schwartz, values are "desirable goals of various significance that transcend specific situations, and act as guiding principles in a man's life [3]. Schwartz also developed an abundant instrumentation for measuring the system of values, and, alongside Schwartz's *model of norms activation* as a concept of determining values, today is the system of values worldwide determined and measured in accordance with the Inglehart's *concept of postmaterialism* [4]. Inglehart's model is based on the thesis that value orientations (traditional, modern and postmodern or postmaterialist) are subject to political and economic development, and in accordance with Maslow's theory of satisfying human needs, which explains the hierarchic constitution of various human needs: postmatierialist higher-order needs will appear only after the satisfaction of lower-order needs (material needs) [5]. Schwartz's model is linked to the ability of an individual's altruistic behaviour, which is determined by personal and social norms as well, and so it will be explained [6] as a sense of moral duty that a person possesses while aiding another human being.

In the theoretical part of this article, various sociological concepts of the value *power* have been thematised as well as Schwartz's concept of the system of values and motivational type of value *power* based on it, and it finishes with the overview of relevant research of the systems of values for different populations of subjects from seven countries of Southeast Europe (Bosnia and Herzegovina, Montenegro, Croatia, Hungary, Macedonia, Slovenia and Serbia).

## POWER AS A PART OF CONSTRUCT OF UNIVERSAL HUMAN VALUES

Power is one of the most important theoretical concepts in sociology, but there are also other social sciences dealing with that concept. The most significant sociologist dealing with this concept must have been Max Weber, who defines power as "chances of one person, or a particular number of people, to exercise one's will within the common course of action, even despite the resistance of others participating in that course of action" [7; p.589].

In the discussion on power in the national sociology, J. Županov surely takes the lead. In his book *After the Flood*, Županov [8; pp.70-71] discusses social and political changes in Croatia after the breakup of Yugoslavia in the context of privatisation. The author initially lists two kinds of power – the *power over someone* and the *power for something*, and accordingly also two types of participation in power. The first type is the so-called negative participation in power, in the way that the power of one results in the complete taking of power from the other, so the result would be a complete blockage of the other. The second type of *power for something* is the equal participation in the decision-making process. Županov also mentions the fake participation, which should be distinguished from the "real" one because it actually represents manipulation and is ideologically marked. Ultimately, Županov wonders whether privatisation presents a transition from the system of power to the system of private ownership or it is just a transition from one type of power to the other. If it is the latter, Županov states: "If privatization is just a substitution of politocratic power by a private economic power, then the social democracy in countries in transition should not be oriented towards the "ownership democracy" or "national capitalism" but towards getting their share, i.e. participating in power [8; p.70].

Schwartz's model of universal contents and the structure of human values as motivational actuators of a man or guiding principles resides on a theoretical concept assorting all values into one of ten motivational types of values: universalism, self-direction and benevolence, security, conformity, hedonism, stimulation, achievement, tradition and power.

Shalom H. Schwartz's measuring instrument *Portrait Value Questionnaire*, which measures the proportion and hierarchy of basic human values, has turned out to be reliable and effective for international research of personal and social values [9, 10]. The latest version of this scale is PVQ-RR scale assessing ten basic and 19 specific values [11]. Ten already mentioned types of values are linked by motivation stemming from three basic conditions, i.e. from biological needs, the need for coordinated human interaction and the need to function and remain within one's own social group [6].

As shown in Table 1, Schwartz's model encompasses ten different types of basic values and 19 values stemming from them. The value of power comprises two specific values: *power as domination* and *power over resources*. Power as domination is defined as "power through significance of exerting control over people", and power over resources is defined as the "significance of controlling material and social resources" [11]. Based on various international samples, Schwartz [11] comes to the conclusion that *power over resources* applies to material resources and the protection of wealth "regardless of how power is exerted in a society" [11; p.19], while the value of *power as domination* is "focused on exerting one's own power over others and the way power is distributed and used in a society". According to the example of the author [11; pp.32-33], the person that holds the *power of domination* as important would exhibit the particular behaviour of "Manipulating others to gain what they want", while the person holding the *power over resources* as important would exhibit the behaviour of "Mentioning to others how valuable some of his/her possessions are". Schwartz [12-14] defines the motivational type of value *power* as a social status and prestige, control and domination over people and resources, with following specific values: social power, wealth, social status, authority, preserving the public image of an individual.

**Table 1.** Specific values – definitions [11; p.31].

| | VALUE | CONCEPTUAL DEFINITION |
|---|---|---|
| **1. SELF-DIRECTION** | (1.) Independent thought | Freedom to create one's own ideas and abilities |
| | (2.) Independent action | Freedom to determine one's own actions and goals |
| **2.** (3.) **STIMULATION** | | Excitement, novelty and change |
| **3.** (4.) **HEDONISM** | | Enjoyment and sensory satisfaction |
| **4.** (5.) **ACHIEVEMENT** | | Success according to social standards |
| **5. POWER** | (6.) Power – domination | Power through exerting control over people |
| | (7.) Power – resources | Power through control over material and social resources |
| **6. SECURITY** | (8.) Security – personal | Safety in the immediate environment |
| | (9.) Security – social | Safety and stability in wider society |
| **7.** (10.) **TRADITION** | | Maintenance and preservation of cultural, family or religious tradition |
| **8. CONFORMITY** | (11.) Conformity – rules | In compliance with rules, laws and formal obligations |
| | (12.) Conformity – interpersonal | Avoidance of upsetting or inflicting harm on other people |
| **9. UNIVERSALISM** | (13.) Universalism – nature | Preservation of natural environment |
| | (14.) Universalism – care | Devotion to equality, justice and protection for all people |
| | (15.) Universalism – tolerance | Acceptance and understanding of people different from oneself |
| **10. BENEVOLENCE** | (16.) Benevolence– care | Devotion to the welfare of members within a group |
| | (17.) Benevolence – reliability | Being a reliable member of a group |
| | (18.) Reputation | Maintenance of public image and avoidance of humiliation |
| | (19.) Humility | Recognition of irrelevance in the wider scheme of things |

Previous research of Schwartz's values has shown that it is more important to men to have power over resources than to women. On the other hand, it is more important to women to have power in form of reputation. It is important to point out here that *reputation* as a value had until recently been a part of the value of *power* alongside the *power in form of domination* and *power over resources*. However, research has shown that it is more appropriate to observe *reputation* as a specific value [11]. We should also point out that numerous studies have shown that alongside the higher socioeconomic development and a higher degree of the democratisation of a society there is the decline in importance of values *conformity, security, tradition* and *power* [15].

## RESEARCH OVERVIEW

In spite of the large scientific reception of Schwartz's *theory of universal concepts and structure of values* and the research fertility of instruments developed by Schwartz (Schwartz Values Survey – SVS and Portrait Values Questionnaire – PVQ), in the countries of Southeast Europe whose student populations took part in this research, we have observed no wide application of these instruments.

In the Republic of Croatia, as well as in other countries of Southeast Europe, a cross-national and longitudinal World Values Survey – WVS [16] is being conducted, and there is information available to the interested public on values of each of the observed national populations, alongside the possibility of their comparison. The research comprises different dimensions of the reality of life, and the subjects from the Republic of Croatia choose as the most significant values in their life *family values* (99 %), and afterwards the values related to *friends and acquaintances* (96 %), *free time* (92 %), *work* (90 %), *religious values* (65 %) and eventually to *policy* (23 %). The comparative analysis of the results of the three researching waves in the concerned study from 1999, 2008 and 2017/2018 points to the declining trend regarding values related to *religion* and *policy* and there is the decrease of the significance of values related to *family, friends and acquaintances* and *free time*, which points to the contemporary value orientation of man towards materialistic and post-materialistic dimensions of values in relation to the traditional dimension of values [16]. By the comparative analysis of the results of the studies from 1986, 1999 and 2004, Ilišin [17] determines that the value orientations of the youth as well as those of the older population are mainly stable and that young people atribute grater significance to the area of post-materialistic values, while the older population is more inclined to the traditional ones. The research involving the population of Croatian students ($N$ = 759) was also conducted by Mrnjaus [18] and she compared it to the system of values of Austrian students ($N$ = 855), and the research was conducted by the questionnaire used in the World Values Survey – WVS. The values related to *family, friends, education, free time and work* are the top priorities of both Austrian and Croatian students [18]. By using Schwartz's SVS questionnaire, Ferić [19] conducted a research on a student population and established that the highest estimated values were reached for the values of *self-direction* and *benevolence*, and the lowest for the values of *power* and *tradition*.

On the territory of the Republic of Bosnia and Herzegovina the research was conducted on the population aged between 18 and 27 ($N$ = 545) using the SVS questionnaire, and students made up 70,3 % of the total number or 383 subjects [20]. In the Republic of Serbia following hierarchy was found: *benevolence, universalism* and *self-direction* as the most prominent values and as the least prominent *stimulation, power* and *tradition* [21] in the population of students – future teachers. By using the OVQ questionnaire on the population of future pre-school and school teachers ($N$ = 232), Marušić-Jablanović [22] also determined the highest exhibited values for *benevolence, self-direction* and *achievement* and the lowest exhibited values for *conformity* and *power*. Subjects from Slovenia ($N$ = 1481) and Hungary ($N$ = 1500) took part in a large cross-national research involving almost 30 000 subjects from 20 countries around the world, and the research was conducted using the PVQ questionnaire [23]. But the tested population was aged 15 and higher so we have neither the data concerning the population of students nor the hierarchy of values for individual national population at our disposal. Nevertheless, the researchers state that the value orientation of subjects, which is in congruence with the expectations, in the former countries of the communist regime (as Slovenia and Hungary) is nearer to the conservative orientation (*tradition, security* and *conformism*) and the orientation of self-enhancement (*achievement* and *power*), as opposed to other tendencies of self-transcendence and openness to change [23]. For the area of Montenegro there was no adequate data found, and for the population of students from the

Republic of North Macedonia, the research was conducted on the total of 226 subjects and as the least prominent values there were *tradition* and *power* [24].

A relatively small number of studies of the value systems of students in observed national populations points to further need of conducting similar research because the systems of values of younger population point to trends and future value orientations of the entire population [17].

## OBJECTIVES AND HYPOTHESES OF THE STUDY

The objective of this study is to research how much power as a social value in general, power in the sense of domination and power over natural and social resources is important to students in Southeast Europe in relation to other motivational types of values from Schwartz's model. It is also the objective to determine whether the power in general, power in the sense of domination and power over natural and social resources differ among countries. Considering the objective of the study, following hypotheses have been constructed:

**$H_1$**: power in Southeast Europe takes lower ranking position than other values,

**$H_2$**: power as value in Southeast Europe is different for individual countries.

## METHODOLOGY

The study was conducted within the project *Research on frequency and readiness of students in post-socialist countries of Southeast Europe to report criminal offences*, which has won the first prize at an international competition organized by the American Society of Criminology for the best student scientific research project in 2018.

A quantitative method of a survey was used in the study, and the data were gathered by an *online* questionnaire. The participants in the study had been recruited through social networks. The reason for such gathering of data is that *online* surveying has turned out to be the best method of collecting data when we talk about the student population [25; pp.25-26].

### RESEARCH INSTRUMENT

The questionnaire contained questions on sociodemoFigureic characteristics and the PVQ-RR scale on values. The PVQ-RR scale of values had, according to Schwartz [11], 57 statements i.e. descriptions of different people where the participants in the study had to answer to what extent they are similar to the described person, on the scale from 1 to 6, where 1 means "not like me at all", and number 6 "very much like me" [11]. Using the scale of Shalom H. Schwartz, 10 basic values were examined as well as specific values *power as domination* and *power over resources*. Basic values with pertaining levels of reliability (Cronbach $\alpha$) are: self-direction ($\alpha$ = 0,822), stimulation ($\alpha$ = 0,653), hedonism ($\alpha$ = 0,706), achievement ($\alpha$ = 0,652), power ($\alpha$ = 0,84), security ($\alpha$ = 0,801), conformity ($\alpha$ = 0,806), tradition ($\alpha$ = 0,729), benevolence ($\alpha$ = 0,85) and universalism ($\alpha$ = 0,85). Specific values that had been tested were power as domination ($\alpha$ = 0,793) and power over resources ($\alpha$ = 0,796).

### SAMPLE

The study was conducted on an appropriate sample of 1419 students during February and March 2019 in 7 states – Bosnia and Herzegovina, Montenegro, Croatia, Hungary, Macedonia, Slovenia and Serbia. Figure 1 shows the share of students per state in the sample and population.

The appropriate sample of 1419 students contained people of both genders, different areas and years of studying, the state of residence, size of the place of birth, socio-economic status, denomination and religiousness.

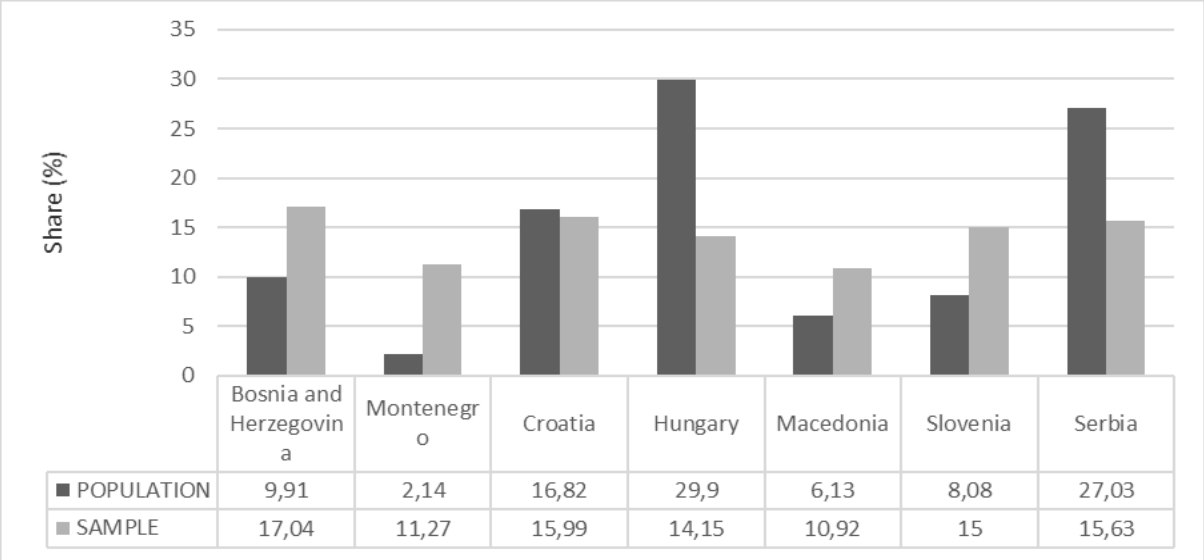


**Figure 1.** The share of students per state in the sample and population[1].

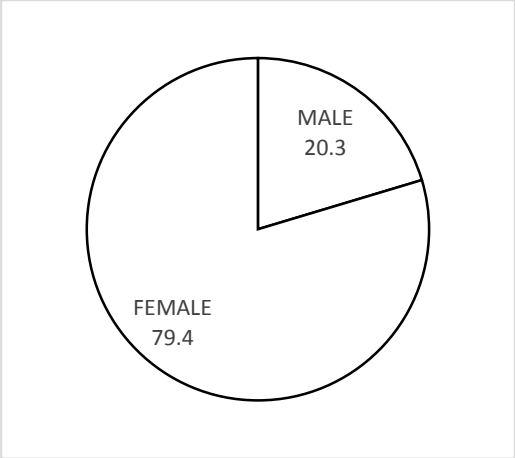


**Figure 2.** Gender.

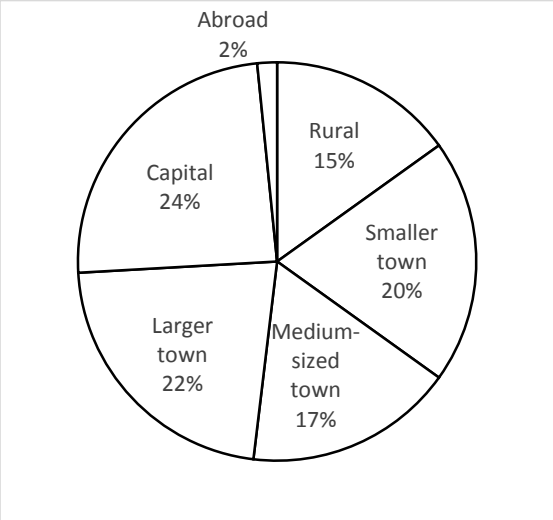


**Figure 3.** Size of the place of birth.

Figure 2 shows how the sample was comprised mainly of people of female gender (79,4 %) while people of male gender were fewer in number. The size of the place of birth was equal in proportion for all categories, where somewhat more participants were born in a capital city

(Belgrade, Budapest, Ljubljana, Podgorica, Sarajevo, Skopje, Zagreb), while the smallest number were born in the rural area (15 %) and abroad i.e. out of the SE Europe (2 %), Figure 3.

The participants in the research mainly describe their financial situation as good (62 %), and those describing it as extremely bad (2 %) take the smallest share, Figure 4. The years of studying are also equally represented. The most participants are in the third year of study (24 %) and the fewest are in the sixth year (3 %), which can be explained by the fact that the majority of studies in researched states last up to five years, while a few last six years, Figure 5.

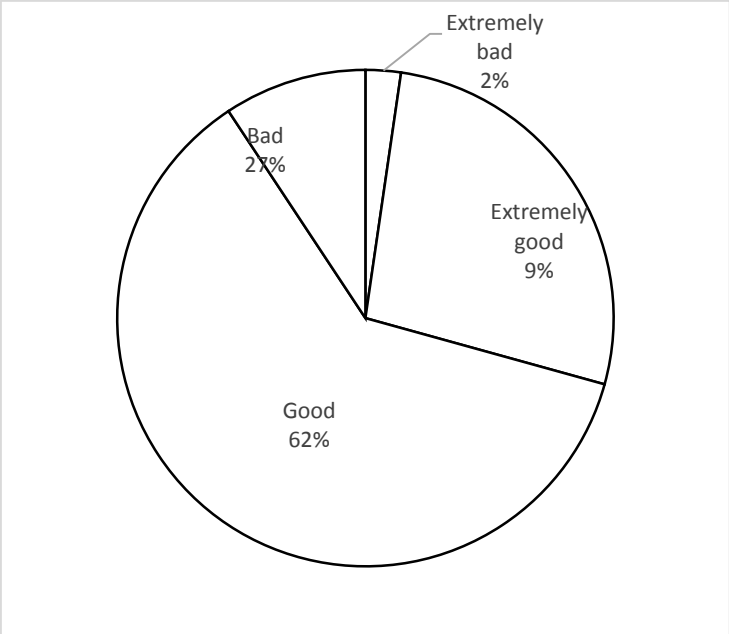


**Figure 4.** Financial situation.

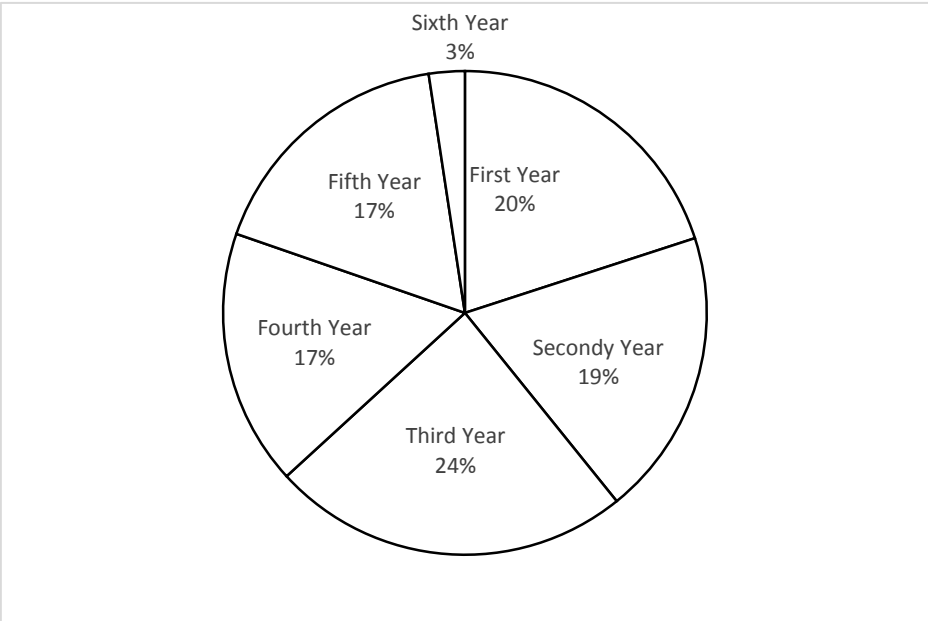


**Figure 5.** Year of study.

The participants in this research are mainly studying in the area of social sciences (49,4 %) and humanities (14,8 %), in the area of biomedicine and healthcare (13,7 %), then in the area of technical sciences (9,4 %), natural sciences (4,8 %), biotechnical sciences (3,4 %) and in the interdisciplinary area (3 %), while the smallest share is in the area of art (1,5 %), Figure 6.

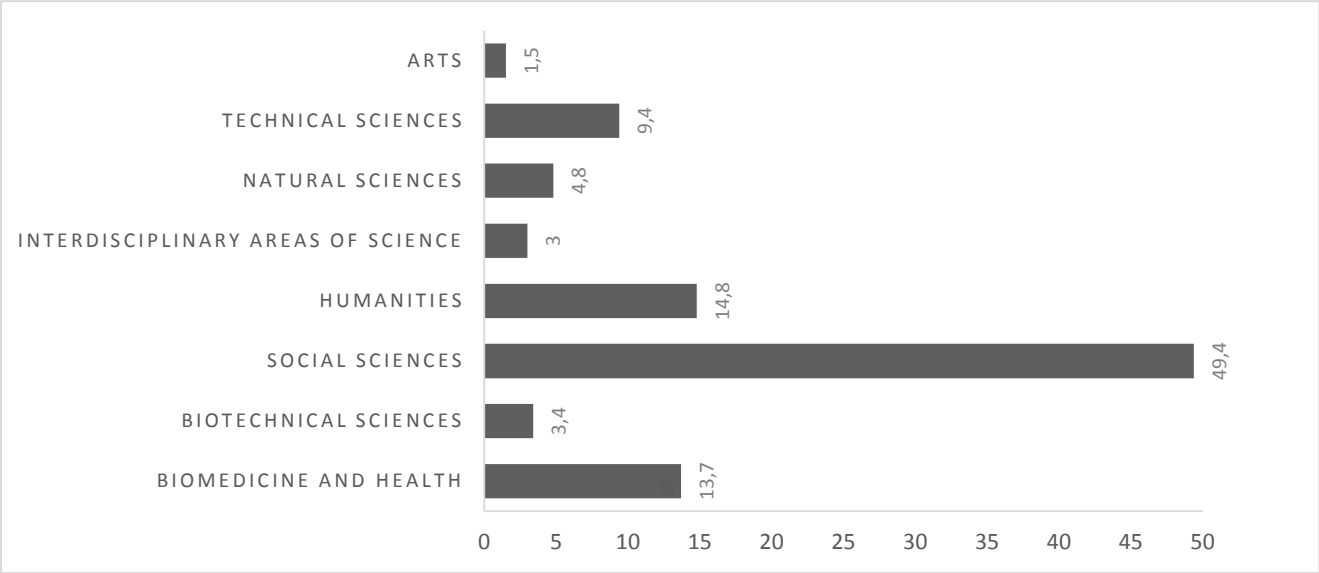


**Figure 6.** Area of study.

Considering the fact that the study was conducted in culturally different areas, it seems important to underline the structure of denomination and religiousness. In the sample, the largest number state their belonging to the Roman Catholic (38,9 %) and Orthodox Church (35,8 %), after that a somewhat smaller share is made up by Atheism (15,2 %), Islam (4,3 %), Protestantism (3,1 %), Agnosticism (2,5 %) and other (0,3 %). In Figure 7, we can see that the greatest religiousness is exhibited by the followers of Islam and Roman Catholicism, while the smallest religiousness is exhibited by atheists.

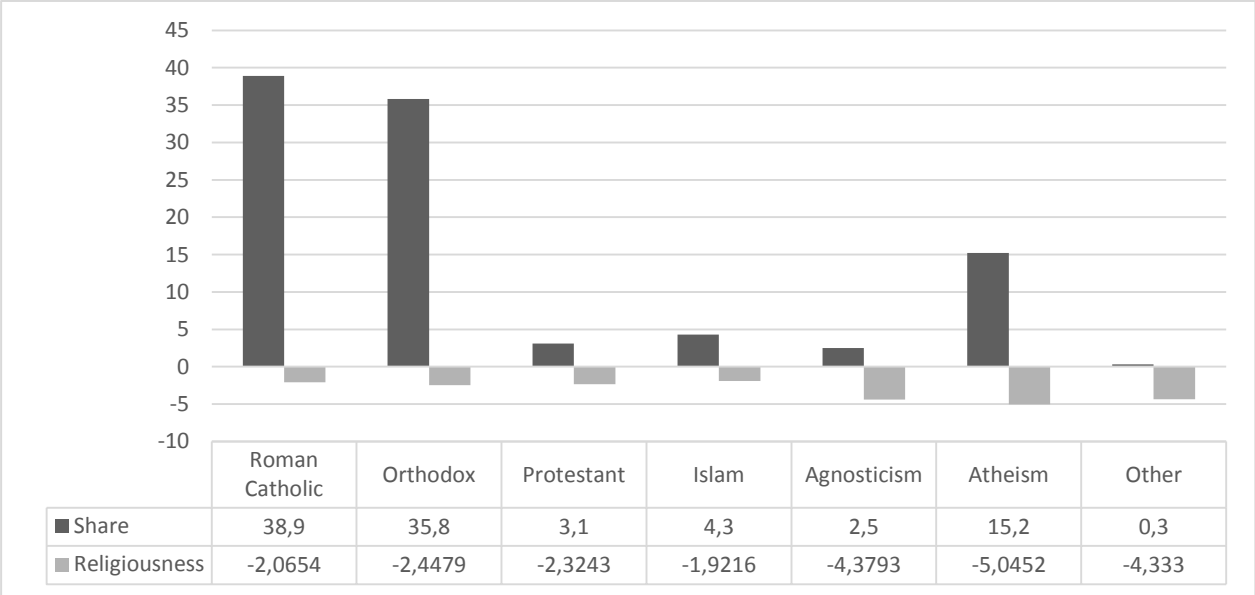


**Figure 7.** Denomination and Religiousness.

## STATISTICALS METHODS

When analysing the data, descriptive and multivariate statistical analyses were used, and the data were analysed using the IBM SPSS software. The results were corrected according to the recommendation of the author of the measuring instrument, S.H. Schwartz [11], so the values

were centred in such manner that the average value of all items of the research participants was subtracted from each social value of a participant. The answers of the participants who had answered to more than 49 items with the same answer i.e. the ones who had not completed the questionnaire in full (less than 50 %) were also taken out from the sample.

In this study descriptive statistics (percentages, frenquencies, ranks, mean) and MANOVA and ANOVA were used (Multivariate test, Levene's test for homogenity of variance, Games-Howell *post hoc* test).

# RESULTS

## DESCRIPTIVE INDICATORS

According to the descriptive analysis of rank, the results indicate that social values have a similar hierarchy with smaller discrepancies and differences (Table 2). In all states, power takes up the last position according to its significance, while other values take higher ranking positions.

In accordance with the results shown in Figure 8 and based on the descriptive analysis, we can assume that the states of Southeast Europe have a mostly similar system of values.

When we talk about the value of power (Figure 8 and Table 2), it can be observed that power takes up the last, tenth, position for all states in relation to other values. However, even though ranking positions are consistent for all states, there are differences in arithmetic means of the value of power, so power is the most important to participants from Montenegro and then consecutively to Macedonia, Hungary, Serbia, Slovenia and Croatia, while the lowest average of the value of power belongs to the participants from Bosnia and Herzegovina, Table 2. Whether the differences are statistically significant will be revealed by further results' analysis.

## SIGNIFICANCE OF POWER OVER PEOPLE

By observing individual tested statements, we can see that for power as value there are certain differences. So, for instance, in the linear combination making up the variable of the significance of power as domination over people, in Figure 9 – *Significance of power as domination over people according to states*, we can see statements seemingly measuring the same thing, the *domination over people*, although they can ultimately have different values. In this research, therefore, as in similar research related to social values, the average is taken i.e. a linear combination of all results and personal results of an individual and so a new variable is made.

## SIGNIFICANCE OF POWER OVER RESOURCES

In Figure 10 we can see the trend of arithmetic means of the linear combination of the significance of power over resources. According to tested statements, we can see that each participant was asked about the extent to which the described person is similar to them regarding the importance of gaining and having wealth. Although being a seemingly personal value, on the macro level of a state it actually indicates to what extent it is important for a nation to have wealth i.e. natural and social resources [14].

**Table 2**. Values ranking per state.

| | Serbia | | Slovenia | | Macedonia | | Hungary | | Croatia | | Montenegro | | Bosnia and Herzegovina | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VALUE** | RANK-ING | *M* | RANK-ING | *M* | RANK-ING | *M* | RANK-ING | *M* | RANK-ING | *M* | RANK–ING | *M* | RANK–ING | *M* |
| **POWER** | 10th | –1,673 | 10th | –1,700 | 10th | –1,606 | 10th | –1,647 | 10th | –1,710 | 10th | –1,535 | 10th | –1,835 |
| **ACHIEVEMENT** | 3rd | 0,581 | 4th | 0,349 | 4th | 0,450 | 4th | 0,289 | 5th | 0,361 | 3rd | 0,516 | 5th | 0,306 |
| **HEDONISM** | 6th | –0,077 | 6th | 0,071 | 7th | –0,083 | 6th | 0,078 | 7th | –0,065 | 7th | –0,176 | 7th | –0,094 |
| **STIMULATION** | 7th | –0,175 | 7th | –0,321 | 6th | 0,133 | 7th | –0,105 | 6th | 0,095 | 6th | –0,092 | 6th | 0,085 |
| **SELF–-DIRECTION** | 2nd | 0,848 | 1st | 0,863 | 2nd | 0,606 | 2nd | 0,578 | 2nd | 0,787 | 2nd | 0,730 | 2nd | 0,648 |
| **UNIVERSALISM** | 4th | 0,464 | 3rd | 0,503 | 3rd | 0,508 | 5th | 0,260 | 4th | 0,376 | 5th | 0,380 | 3rd | 0,355 |
| **BENEVOLENCE** | 1st | 0,967 | 2nd | 0,744 | 1st | 0,6998 | 1st | 0,805 | 1st | 0,839 | 1st | 0,917 | 1st | 0,799 |
| **TRADITION** | 9th | –1,093 | 9th | –0,683 | 9th | –0,881 | 9th | –0,477 | 9th | –0,804 | 9th | –0,721 | 8th | –0,186 |
| **CONFORMITY** | 8th | –0,362 | 8th | –0,336 | 8th | –0,101 | 8th | –0,343 | 8th | –0,419 | 8th | –0,388 | 9th | –0,415 |

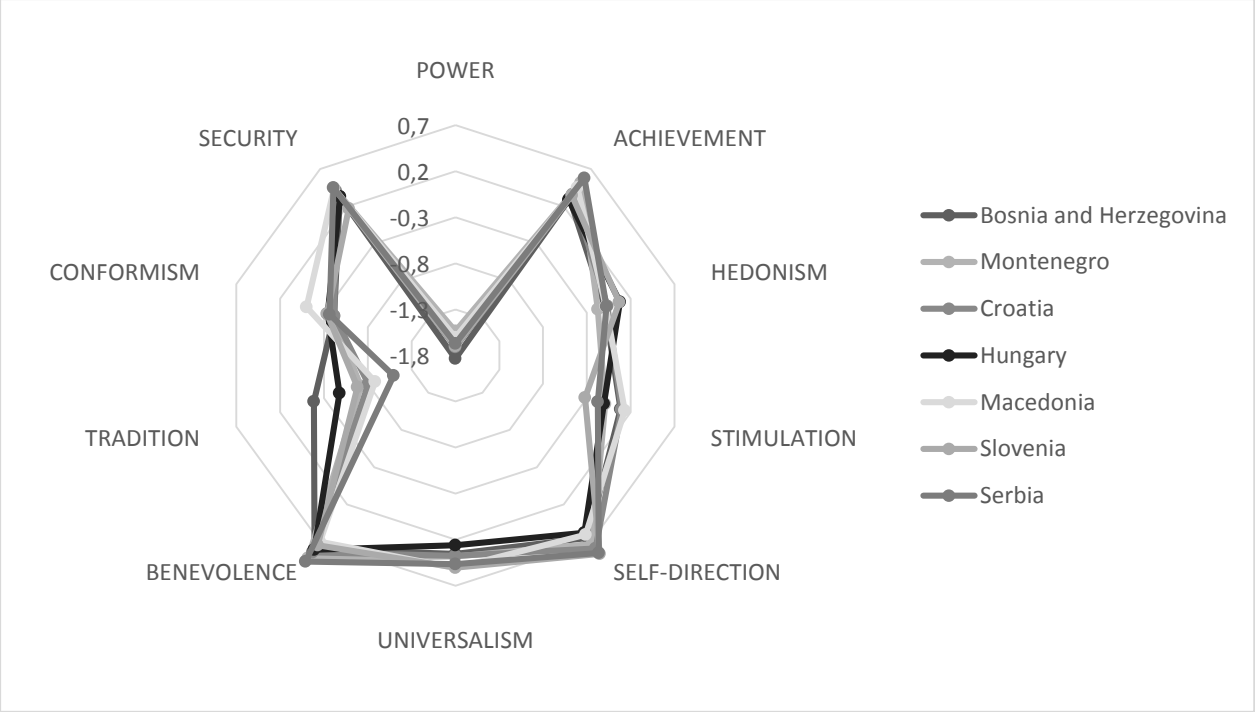


**Figure 8.** Values per state.

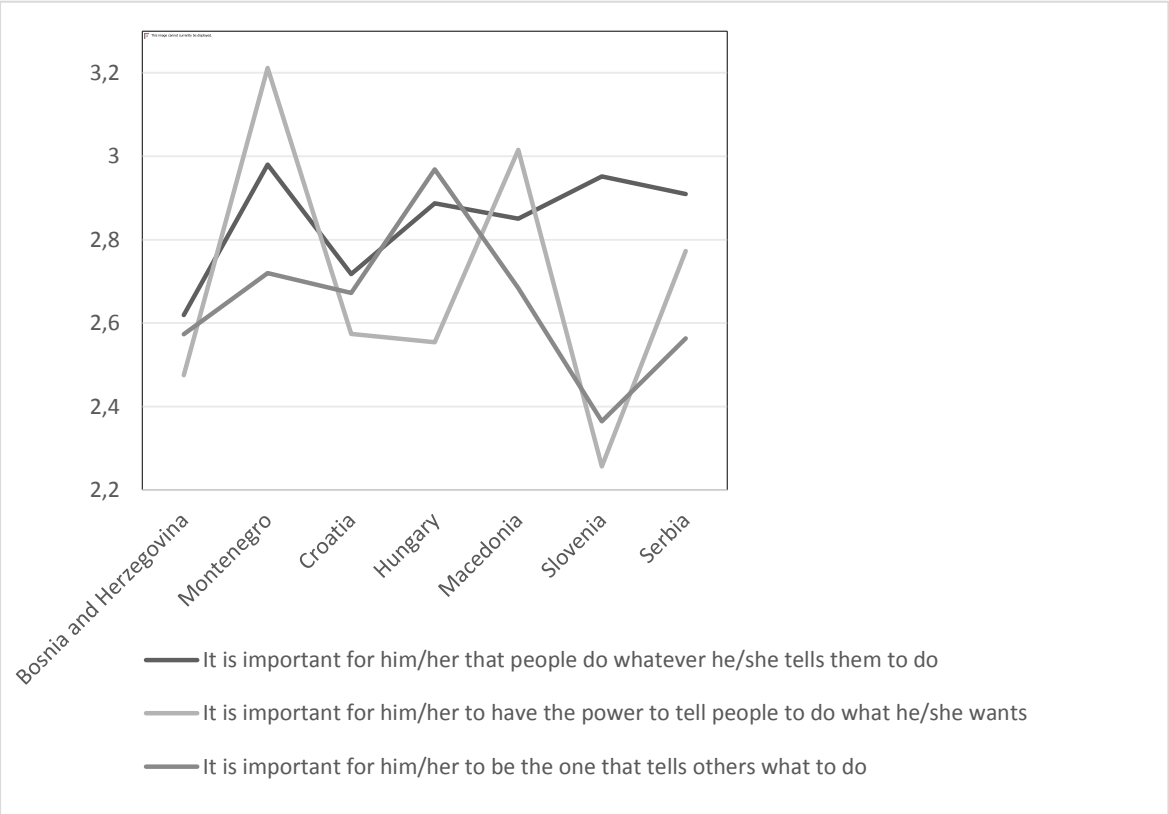


**Figure 9.** Significance of power as domination over people per state.

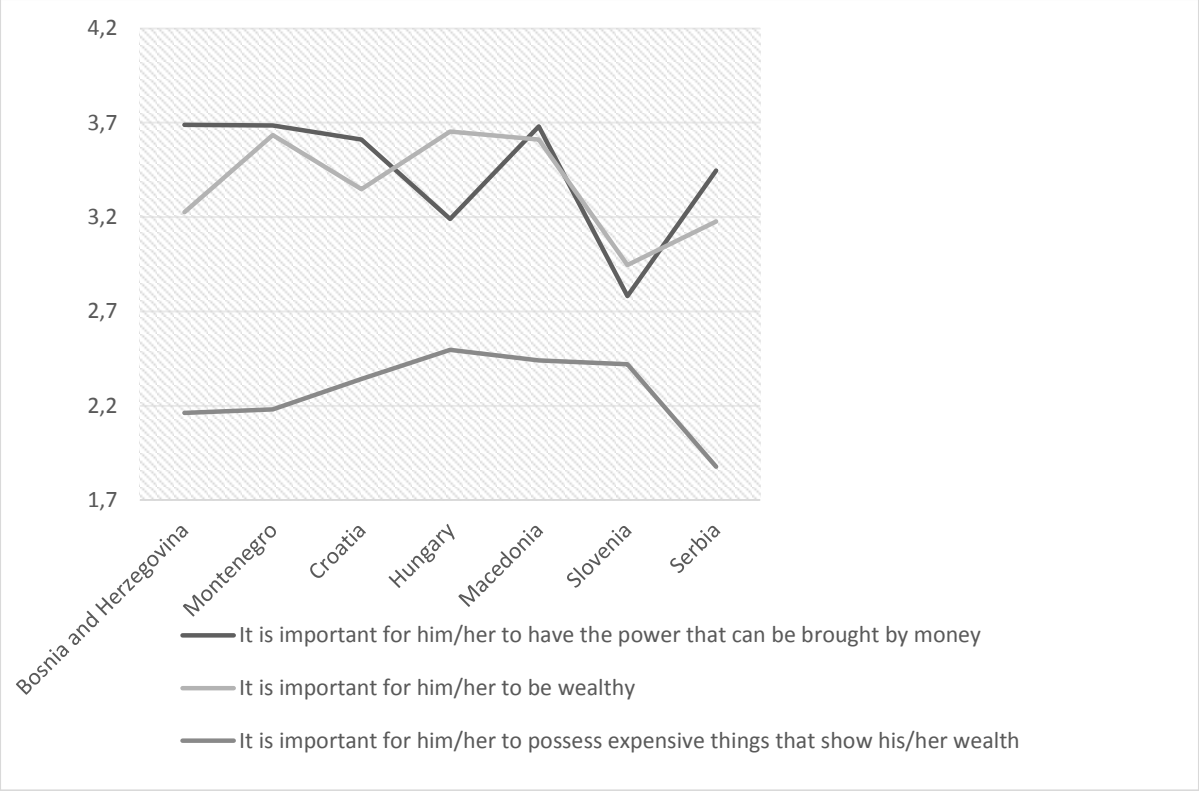


**Figure 10.** Significance of power as power over resources per state.

## SIGNIFICANCE OF POWER IN GENERAL

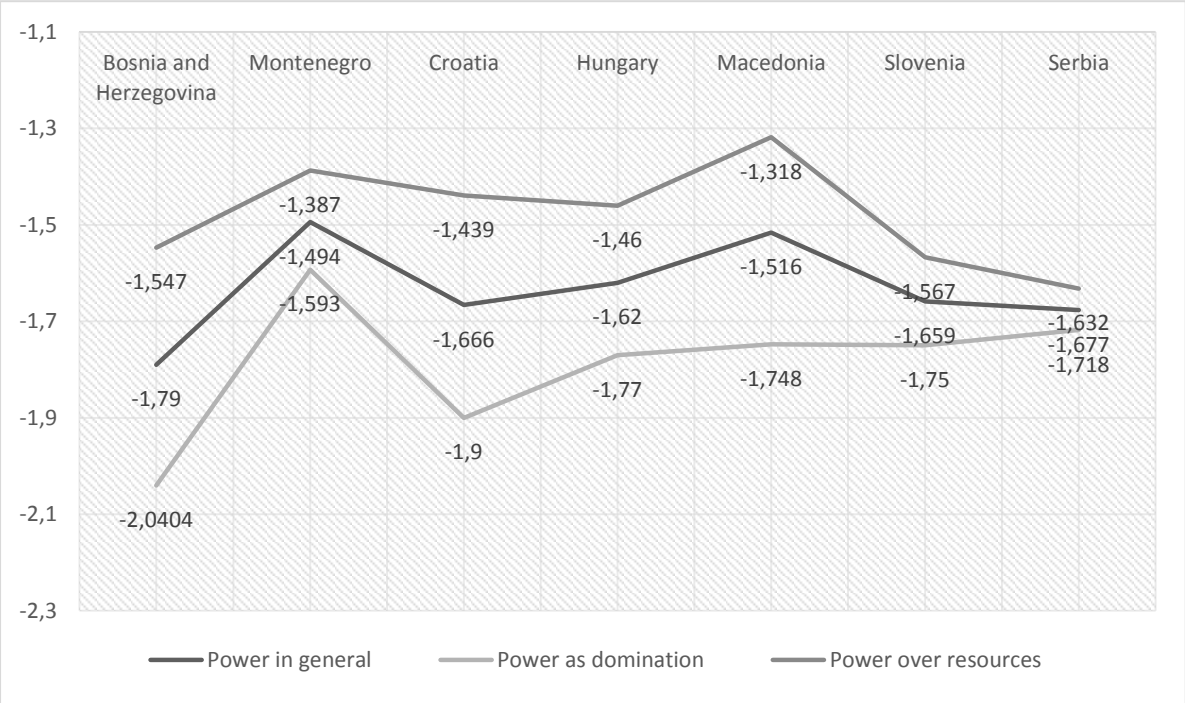


**Figure 11.** Significance of power – comparison.

When we compare the arithmetic means per state for power in general, power as domination over people and power over resources, we can see that power over resources is more important than power of domination over people. Power in general represents the average, i.e. the linear combination of those two kinds of power as a value.

## MANOVA AND ANOVA

After the descriptive indicators, we have tested statistically significant differences in power as value among the states.

**Table 3.** Multivariate test.

| Effect | Pillai's Trace | F | df1 | df2 | Significance | Partial Eta Squared |
|---|---|---|---|---|---|---|
| **State** | 0,031 | 2,308 | 18 | 3939 | 0,001 | 0,010* |

*significant at 5 % probability level

According to the multivariate test, which determines the differences on multiple variables among multiple groups, there is a statistically significant difference among groups (significance equals 0,001). Further analyses will determine among which groups there is the difference and what it is like.

**Table 4**. Levene's test for homogeneity of variance.

| | F | df1 | df2 | P |
|---|---|---|---|---|
| **Power – domination** | 5,101 | 6 | 1313 | < 0,001* |
| **Power – resources** | 0,793 | 6 | 1313 | 0,575 |
| **Power in general** | 2,466 | 6 | 1313 | 0,022* |

*significant at 5 % probability level

According to Levene's test for homogeneity of variance we can determine that the variance is not homogenous for the variables 'power-domination' and 'power in general', but it is homogenous for the variable 'power-resources'. In accordance with that, there is a potential limitation because variances are not the same in all groups, in this case in all states. However, taking into consideration that MANOVA and ANOVA are very robust statistical procedures, the limitation is minimal.

**Table 5.** Summary of ANOVA of power as social value regarding the state.

| Source of variance | Sum of squares | df | Mean squares | F | p |
|---|---|---|---|---|---|
| **Power – domination** | 25,375 | 6 | 4,229 | 3,137 | 0,005* |
| **Error** | 1769,918 | 1313 | 1,348 | | |
| **Power – resources** | 8,948 | 6 | 1,491 | 1,093 | 0,365 |
| **Error** | 1792,247 | 1313 | 1,365 | | |
| **Power** | 9,516 | 6 | 1,586 | 1,519 | 0,168 |
| **Error** | 1371,268 | 1313 | 1,044 | | |

*significant at 5 % probability level

According to the results of ANOVA (Table 5), there is no statistically significant difference among groups considering the significance of power in general or the significance of power over resources. Nevertheless, there is a statistically significant difference for the significance of power as domination over people ($p$ = 0,005).

The results of the *post hoc* test (Table 6) show how the statistically significant difference in power as domination exists only between Bosnia and Herzegovina and Montenegro, where for the participants from Bosnia and Herzegovina ($M$ = –2,073; SD = 1,196) power as domination over people is statistically significantly less important than for the participants from Montenegro ($M$ = –1,629; SD = 1,32).

The *post hoc* test has not shown any statistically significant differences among other states in power as domination. We can therefore conclude that, considering all performed analyses, except

**Table 6.** Results of Scheffe *post hoc* tests of power – domination as social value considering the state.

| | (I) State | (J) State | Mean difference (I-J) | Sig |
|---|---|---|---|---|
| **Power – domination** | **Bosnia and Herzegovina** | Montenegro | –0,4443* | 0,045* |
| | | Croatia | –0,1226 | 0,976 |
| | | Hungary | –0,2692 | 0,488 |
| | | Macedonia | –0,2641 | 0,644 |
| | | Slovenia | –0,2748 | 0,443 |
| | | Serbia | –0,3600 | 0,104 |
| | **Montenegro** | Bosnia and Herzegovina | 0,4443* | 0,045* |
| | | Croatia | 0,3217 | 0,347 |
| | | Hungary | 0,1751 | 0,930 |
| | | Macedonia | 0,1802 | 0,947 |
| | | Slovenia | 0,1695 | 0,937 |
| | | Serbia | 0,0843 | 0,998 |
| | **Croatia** | Bosnia and Herzegovina | 0,1226 | 0,976 |
| | | Montenegro | –0,3217 | 0,347 |
| | | Hungary | –0,1466 | 0,952 |
| | | Macedonia | –0,1415 | 0,976 |
| | | Slovenia | –0,1522 | 0,939 |
| | | Serbia | –0,2374 | 0,603 |
| | **Hungary** | Bosnia and Herzegovina | 0,2692 | 0,488 |
| | | Montenegro | –0,1751 | 0,930 |
| | | Croatia | 0,1466 | 0,952 |
| | | Macedonia | 0,0051 | 1,000 |
| | | Slovenia | –0,0056 | 1,000 |
| | | Serbia | –0,0908 | 0,996 |
| | **Macedonia** | Bosnia and Herzegovina | 0,2641 | 0,644 |
| | | Montenegro | –0,1802 | 0,947 |
| | | Croatia | 0,1415 | 0,976 |
| | | Hungary | –0,0051 | 1,000 |
| | | Slovenia | –0,0107 | 1,000 |
| | | Serbia | –0,0959 | 0,997 |
| | **Slovenia** | Bosnia and Herzegovina | 0,2748 | 0,443 |
| | | Montenegro | –0,1695 | 0,937 |
| | | Croatia | 0,1522 | 0,939 |
| | | Hungary | 0,0056 | 1,000 |
| | | Macedonia | 0,0107 | 1,000 |
| | | Serbia | –0,0852 | 0,997 |
| | **Serbia** | Bosnia and Herzegovina | 0,3600 | 0,104 |
| | | Montenegro | –0,0843 | 0,998 |
| | | Croatia | 0,2374 | 0,603 |
| | | Hungary | 0,0908 | 0,996 |
| | | Macedonia | 0,0959 | 0,997 |
| | | Slovenia | 0,0852 | 0,997 |

*significant at 5 % probability level

in the case of the difference between Bosnia and Herzegovina and Montenegro in the significance of power as domination over people, there are no statistically significant differences in the significance of power among the states of Southeast Europe. The aforesaid makes it apparent that in all the states, apart from the mentioned ones, power in general, power as domination and power over resources are equally significant, i.e. insignificant, taking into consideration that power takes the last ranking position in relation to other values in all researched states.

## DISCUSSION

The results of the research have shown how *power* as a value in the states of Southeast Europe has been ranked in the lowest position, which adheres to the theoretical framework of values by S.H. Schwartz, according to which the value of *power* is also usually the least pronounced value in many observed general populations [14]. We have thus confirmed the $H_1$ hypothesis. Furthermore, the results indicate how there is no statistically significant difference in the significance of the value *power* among states, except between Montenegro and Bosnia and Herzegovina, which differ in the significance of the value *power – domination over people*, where it is less significant for the participants from Bosnia and Herzegovina to have power in the sense of domination over people than it is to the participants from Montenegro. Thus the hypothesis $H_2$ has been partly confirmed.

Taking into consideration that the participants in this research were students, i.e. young people, let us point out that the system of values is formed in childhood and adolescence and it is mostly formed and relatively stable in the age of young adulthood [17, 25]. Therefore, the researching of the system of values in student population is of great importance because the trends in a continuous research of the system of value of young people are indicative of general trends in society [26]. So the results of the research with the population of young people point towards the future system of values of general population at the point when current participants enter their mature age. It is also important to say that the age of participants is a relevant predictor of the hierarchy of values, which changes through life under the influence of different occurrences such as war and crisis, physical aging, life status and similar. Younger participants in stabler and wealthier states will so exhibit more significance for the values of hedonism, stimulation, self-direction and universalism, and less on security, traditionalism and conformity. Aging positively correlates with security, tradition and conformity, and negatively with stimulation, hedonism and achievement [13]. The education of participants is also an important predictor of the hierarchy of values because it positively correlates with the years of formal education for the values of self-direction and stimulation, achievement and universalism and negatively for the values of conformity, tradition and security [13].

We have mentioned that sudden changes and discontinuity or discrepancies in the system of values of both young participants and general population indicate crisis situations in a person's life and society, so that the system of values, which is, as already said, relatively stable in a person's life, suddenly changes in the middle of an economic crisis, poverty, natural cataclysms or in the state of war [17]. This thesis is best illustrated by the results of two major studies conducted in the Republic of Croatia that tested the systems of values of the youth. In the study *Position, awareness and behaviour of Croatia's young generation* from 1986, postmaterialist values were more prominent than in 1999 in the study *System of values of the youth and social changes in Croatia* [27]. The differences in the system of values of the youth determined in mentioned studies are explained as the consequence of war sufferings during the Homeland War and the economic crisis ensuing as the consequence of war devastations, but also privatisation and a huge loss of employment and mass emigration from Croatia. In fact, in accordance with Maslow [4], it is necessary firstly to satisfy existential needs (physiological and security needs as materialist values), while social needs (needs for respect and self-affirmation as

postmaterialist values) are satisfied only after the existential ones have been satisfied. Therefore, the process that happened in the Croatian society is called the retraditionalization of values, because of the change from a prevailingly materialist and postmaterialist system of values into the system of prevailingly traditional and materialist values [17, 28].

Let us also mention the findings of the study [26] according to which the deviant behaviour of the youth and their antisocial behaviour is positively correlated with a hedonistic orientation of values and negatively with conventional and self-actualizing dimensions of values so we consider that protective factors are the values of universalism, self-realization values and traditional values, while risk factors include hedonism, utilitarianism and power, which is the subject of this study. The aforesaid substantiates the relevance of choice of particularly student population as the sample of participants in this study because the understanding of the system of values of young people indirectly indicates possible predictors of socially inacceptable forms of behaviour of the young generation.

Even though there is, for a more detailed discussion, a lack of results of similar cross-national research, which would produce comparative data comparable to the results of this study, it is nevertheless important to mention the results of the *World Values Survey – WVS* according to Inglehart's concept and a specific measuring instrument. Based on the results of that study, the system of values in Croatia is placed into the 4$^{th}$ quadrant with the countries of Western Europe, and not with the countries of the former communist regime, because the study has shown that the participants simultaneously possess materialist values (traditional values and survival) and postmaterialist values (secular rational values and values of self-expression). The study was conducted for the first time in 1981 and in the Republic of Croatia it has been conducted by the scientific research team from the Catholic Faculty of Theology – University of Zagreb [29]. Up to now, five such studies have been conducted (in 1981, 1990, 1999, 2008 and 2017) and the data about the study itself and gained results can be found on the web site of the research project (http://www.europeanvaluesstudy.eu).

Considering the value of power within ten motivational types, let us also point out that the results of this study have confirmed the findings of the major Schwartz's cross-national research in which power takes the lowest 10$^{th}$ ranking position [8], i.e. that the participants from observed countries also marked the value of power as the least significant value. It is therefore interesting that a statistically significant difference in exhibiting significance for the value *power* is established only on the samples of participants from Bosnia and Herzegovina and Montenegro. The reasons for such results have to be sought in the particularities and events from the recent past, the economic and social level of development of those countries, as well as their geopolitical position and other elements, which is not the subject of this study. Considering the results of previous studies, and in the context of finding the statistically significant difference, it is necessary to point out one more time that the value *power* is a risk factor for socially inacceptable forms of behaviour [26], so the result indicates the need to devise special prevention programmes, which would sensitize and educate the young population to recognize and prevent the occurrence of such forms of behaviour in those social environments where the value *power* is especially prominent.

## RESEARCH LIMITATIONS AND FUTURE RESEARCH

The limitation of this research is a convenient sample that may not be representative and no conclusions can be drawn from the population as a whole. Furthermore, limitation is also an online survey that can affect the representativeness of the sample. Namely, in the recruitment of participants via Facebook, there was a voluntary completion of the questionnaire – therefore, at our request, the questionnaire was filled out by those who wanted through the link. There is a possibility that persons with a particular value system may be more inclined to complete the questionnaire, which may affect representativeness.

There is a need to further explore this topic especially internationally and through the Internet to perfect measurement tools and online data collection methods.

## CONCLUSION

Systematic researching of the system of values of various groups of participants and the general population of inhabitants is highly important for the understanding of general trends in society. Participating in longitudinal and cross-national studies of this type, like the *World Values Survey – WVS* or researching with Schwartz's instruments for examining the hierarchy of the system of values, contributes to a better understanding of the modern context in which different societies do not coexist in minimal interaction, but they create new values in everyday communication and cooperation and, in spite of many challenges, they create the culture of peace and community.

The fact that the value *power* gains the lowest results among ten motivational types of values clearly states that the modern world is not burdened by activities that would serve to achieve domination over other people or over natural or other resources. But, what applies to the general population, does not apply to every individual participant. Thus is the selected Schwartz's questionnaire PVQ-RR a good choice for a measuring instrument, which simultaneously gives reliable information about the system of values of each individual [30].

The values of universalism, benevolence and self-direction are the most prominent values indicating the humanistic orientation of a man and the community he belongs to. The existence of those values in student populations in the states of Southeast Europe optimistically heralds the age of peace and security, alongside with a continuous analysis of risk elements of safety and other threats coming from different sources. We also come to the conclusion that the formation of the system of values is significantly influenced by general social processes within a society, which were explained by Ronald Inglehart in his *modernization theory* [15].

The limitations of this study are the inability to compare each of the observed student populations to the system of values of general populations in their home counties, as well as the fact that this study is conducted for the first time so the study results are not comparable in a chronological context. This study could, through multiple researching waves, provide clear answers on trends in the systems of value of student populations in observed countries of Southeast Europe, as well as the trends in systems of value in the geopolitical area in question.

## REMARK

[1]The data for students are taken from state statistic offices, available for a specific state: Agency for Statistics of Bosnia and Herzegovina [31], Statistical Office of the Republic of Montenegro [32], Croatian Bureau of Statistics [33], Hungarian Central Statistical Office [34], State Statistical Office of Macedonia [35], Statistical Office of Slovenia [36] and Statistical Office of the Republic of Serbia [37].

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# FEATURES OF BUSINESS DEMOGRAPHY STATISTICS IN EUROPEAN COUNTRIES: RELATION OF ENTERPRISE DEATHS AND BIRTHS TO GDP PER CAPITA AND UNEMPLOYMENT

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## ABSTRACT

The aim of this study is to analyse the variations and changes in business demography and macroeconomic features for 28 European countries in 2012 and 29 European countries in 2016 as well as the relations among these features based on the following variables: enterprises birth rates, enterprises death rates, the level of GDP per capita and the unemployment rate. Using the hierarchical cluster analysis approach, the second aim of this research is to form and compare the clusters of European countries with similar characteristics according to these variables for both years. The descriptive statistics results show that a relatively high heterogeneity of European countries relative to the observed variables was present in both years, but the change in variables averages suggests an overall improvement of economic and business demography features in 2016. The correlation analysis revealed that the death rate of enterprises had a statistically significant negative correlation with GDP per capita in both years and a significant positive correlation with the unemployment rate and with the birth rate of enterprises only in 2012. The hierarchical cluster analysis resulted in seven clusters in each observed year. The comparison of clustering solutions for 2012 and 2016 detected the European countries for which the movement between clusters could be seen as a deterioration and those for which it can be seen as an improvement in some or all of the observed variables. These results have important implications for public policies aimed at reducing death of enterprises and unemployment.

## KEY WORDS

business demography statistics, correlation, European countries, hierarchical clustering method

## CLASSIFICATION

JEL: C38, M20

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# INTRODUCTION

There is no doubt that new business creation is important for an economy. The business enterprise population for the 28 European Union countries in 2016 consisted of almost 27 million active enterprises, which employed about 150 million people. The share of newly born enterprises increased by 3,5 % in 2016 in comparison to 2015 and resulted in the total of 2,6 million enterprises births in 2016, which generated about 4,0 million jobs [1]. New business creation is considered as one of the main factors of innovation, economic productivity and job creation. Many empirical researches have confirmed the role that newly born enterprises have in stimulating the competitiveness and efficiency of other enterprises within a country.

Understanding the specific circumstances that affect the scale and the determinants of business demography is therefore very important for development of policies that enhance entrepreneurship and increase the level of employment – one of the main priorities of the European Union 2020 growth strategy [2]. The heterogeneity of birth and death of enterprises is context-dependent in nature. The business dynamics related policies and institutions may be a very important driving force for information and communication technology (ICT) related sectors especially since more significant cross-country differences in enterprise birth and death rates are present in younger than in mature ICT sectors [3]. According to the research conducted by [4], which examined the impact of business policies and laws on birth rates of enterprises across countries, the policies which restrain large enterprises competitiveness also encourage more new enterprises births.

Measurement of the differences in entrepreneurial activities across countries in this research is based on enterprise level indicators. The application of the enterprise approach in measuring enterprises dynamics such as the birth and death of enterprises provides a high consistency in methods and definitions of business events across European countries. Enterprise birth rates can therefore be used as a measure of entrepreneurial activity.

Hence, based on the data on the total number of active enterprises and enterprises birth and death rates, the first aim of this article is to analyse the variations and changes in business statistics indicators, as well as the accompanying effects that these events have on the unemployment rate and gross domestic product per capita for 28 (for the year 2012) and 29 (for the year 2016) European countries. For that purpose, the methods of descriptive statistics were used. By applying the methods of hierarchical cluster analysis, the second aim of the is article to investigate the changes that occurred in these two years regarding the grouping of European countries with similar characteristics based on the relative business demography variables and the chosen macroeconomic indicators. That way, the main stakeholders of this research, which are governments of the observed countries and leading macroeconomists, can, based on the results presented in this article and selected macroeconomics variables, form new regulations and give additional instructions which could lead to an increased level of wellbeing in their countries.

This article is organized as follows. After a brief introduction, the second section of this article presents the review of the relevant literature. The data and methods are described in the third section. The analysis, along with the discussions, is presented in section four. The article ends with final conclusions summarized in section five.

# LITERATURE REVIEW

## BUSINESS DEMOGRAPHY AND JOB CREATION

Previous research on the impact of business demography activities on job creation considers the birth of new enterprises as one of the key factors of employment creation and productivity of an economy [5-9], and the death of enterprises as a crucial factor in the process of “creative destruction” [10].

Every year in most OECD countries about 20 % of enterprises enter and exit the market and within the first two years about 20-40 % of newly born enterprises exit and only about 50 % of the newly born enterprises are still active after 5 years [11]. Nevertheless, the birth of new enterprises is still the most important generator of employment growth [7]. The number of jobs created by newly born enterprises outnumbers the employment lost due to the death of enterprises in all size classes [7]. According to [9] in the EU context, smaller enterprises contribute more to employment creation than larger enterprises do.

## BUSINESS DEMOGRAPHY AND UNEMPLOYMENT

Business demography indicators are sensitive to changes in macroeconomic environment. Previous research regarding the relationship between unemployment and the birth of enterprises proves a significant relationship between these variables [12-15]. However, the empirical research often shows contradictory results regarding the direction of the relationship between unemployment and the birth of enterprises. A negative relationship would be expected: an increase in unemployment should be followed by a decrease in the number of new enterprises. According to [12] unemployment is mainly negatively related to birth and death rates in Italy, but this relationship is also sector dependent. An update of that study conducted by [13] revealed that a positive impact of unemployment on the net birth rate is due to a negative impact of unemployment on the firm death rate. For European countries, [16] found a significant positive correlation between the death rate of enterprises and the unemployment rate and a significant negative relationship for the unemployment rate and the difference between the birth and the death rate of enterprises (enterprise dynamics). The authors in [17] found a negative relationship between the number of newly born enterprises and unemployment for the EU countries.

The research performed by [14] empirically confirmed the existence of two different relationships between unemployment and self-employment for the OECD countries: the “entrepreneurial” effect whereby higher rates of self-employment may lead to a rise of entrepreneurial activity and a reduction of unemployment was found to be much stronger than the “refugee” effect of start-ups whereby high unemployment rates may be responsible for start-up activity of self-employed people. In a more recent study a positive and statistically significant relationship between self-employment and unemployment was found for more than 50 per cent of the European OECD countries, but the presence of a negative or statistically insignificant relationship was also reported [15].

The use of different indicators and/or application on different units of analysis (different industries, different countries, regions, different cross-country context or different time) may be the reason for these mixed research results on the relationship between unemployment and the birth and death of enterprises.

## ENTREPRENEURSHIP AND ECONOMIC DEVELOPMENT

There is no doubt that entrepreneurial activities and economic development are closely related. The studies on the relationship between entrepreneurship and economic development (measured as GDP per capita) are generally also controversial. It has been found that the GDP growth rate has an impact on start-up rates [18, 19] and the authors [17] explored the relationship between GDP growth and the absolute number of newly-born enterprises for the EU countries by applying a random-effects negative binomial regression model and they found that the number of newly-born enterprises is positively related to GDP growth. If income is measured as GDP per capita, the impact on entrepreneurship could be negative [20] as well as positive [6, 8] and some authors suggest a U-shaped relationship for GDP per

capita and entrepreneurship [5, 21]. The level of economic development fosters new-firm formation [22] and it is after the countries reach a certain level of income that a higher GDP per capita is related to higher start-up rates [6].

### CLUSTER ANALYSIS IN ENTREPRENEURSHIP

Cluster analysis is a widely used multivariate method for data analysis in which data are grouped into different clusters based on a set of variables, in the way that similar objects are placed in the same cluster. Many researchers in the area of business enterprises also use this method.

For instance, the author [23] explored the differences in ICT adoption among enterprises in different groups of European countries (innovation leaders and followers, moderate and modest innovators). Authors [24] used a cluster analysis in order to confirm their results of the discriminant analysis carried out for the purpose of examination of the differences between applied funding policies in wine industry enterprises in France and Hungary.

One of the examples of previous research that uses the methods of cluster analysis in entrepreneurship and business demography is the research conducted by [25] on the role that national culture plays as an explanatory variable alongside entrepreneurial variables for the level of economic development. According to this research, national culture reinforces the impact of entrepreneurship on economic development: the used variables explain over 60 % of the variance in the linear regression model for GDP per capita. By applying the cluster analysis for the European Union countries the same author [25] found four entrepreneurial clusters, each characterized by a different entrepreneurial dynamics explained to some extent by cultural value variables and income as measured by GDP per capita. By performing a cluster analysis on variables connected to economic development, institutions and entrepreneurship for the European Union countries the authors [26] examined the entrepreneurial performance of transition economies with a focus on productive entrepreneurship. In the study conducted by [27] five entrepreneurial types of European countries were distinguished by using principal component analysis and hierarchical cluster analysis on variables related to entrepreneurial activity and economic development. Their research showed that the diversity in entrepreneurial activities can be explained and discriminated by five explanatory themes on innovation, employment, formal institutions, entrepreneurship and governance.

Our research takes an approach in line with previous research [27] but explores exclusively the business demography activity indicators, the death and birth rates of enterprises as classifying variables for the cluster analysis along with the economic environment indicators – GDP per capita and the unemployment rate [28]. We believe that our research contributes to the existing empirical literature by using the most recent data set on business demography indicators for selected European countries from 2016 and by presenting a comparison of the results for this data set with older data from 2012.

## DATA AND METHODS

In the article, a focus is given to three selected business demography variables, listed with their brief descriptions in Table 1. The values of business demography variables have been observed for the total number of enterprises excluding holding companies. In addition, to set those business demography variables into the context, two macroeconomic variables related to the business demography are included in the analysis as well.

**Table 1.** List of observed variables.

| Variable group | Variable code | Variable description |
|---|---|---|
| Business demography | ActiveEnterprises | Population of active enterprises in *t* (number) |
| | BirthRate | Birth rate: number of enterprise births in the reference period (*t*) divided by the number of enterprises active in t (percentage) |
| | DeathRate | Death rate: number of enterprise deaths in the reference period (*t*) divided by the number of enterprises active in t (percentage) |
| Macroeconomics | GDPCapita | GDP per capita, PPP (constant 2011 international $) |
| | UnempRate | Unemployment, total (% of total labour force) (modelled ILO estimate) |

In order to collect the data for the selected variables, Eurostat and the World Bank databases have been used [29-31]. The data from 2012 and 2016 are going to be observed in the analysis. The analysis is going to be conducted using the sample of European countries for which data were available. Consequently, the following 29 European countries have been included in the analysis: Austria. Belgium, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, North Macedonia, Norway, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom. Out of the 29 observed countries, 26 are the European Union member states. Unfortunately, the data for Greece are missing in 2012 and therefore the count of the observed countries in 2012 is equal to 28.

The observed variables are going to be first analysed by using the descriptive statistics approach. Within the descriptive statistics analysis, variables are going to be plotted, descriptive statistics measures are going to be calculated and relations between the variables are going to be observed. In addition, the outlier analysis will be conducted to check whether there is a country (or more of them) that has values of the observed variables significantly lower or higher in comparison to other observed countries.

A hierarchical cluster analysis will be performed to detect groups of countries with similar characteristics according to the observed variables. Overall two hierarchical cluster analyses will be conducted. The first one will include data from 2012 and the second one will use data from 2016. In order to get sensible results, standardized values of relative business demography measures, *BirthRate* and *DeathRate*, are going to be considered. In both hierarchical cluster analyses, both observed macroeconomic variables will be included as well.

## ANALYSIS AND DISCUSSION

### DESCRIPTIVE STATISTICS ANALYSIS

The observed European countries differ in both their land and their population sizes. Consequently, it is expected that the number of active enterprises is quite different among the observed countries. Therefore, the number of active enterprises in the observed countries in 2012 and in 2016 is shown in Figures 1 and 2, respectively.

Figures 1 and 2 confirmed that there are large differences in the number of active enterprises among the observed European countries. Five countries stand out: Italy, France, Spain, Germany and the United Kingdom. Those five countries have convincingly the largest number of active enterprises among all the observed countries. On average the observed countries

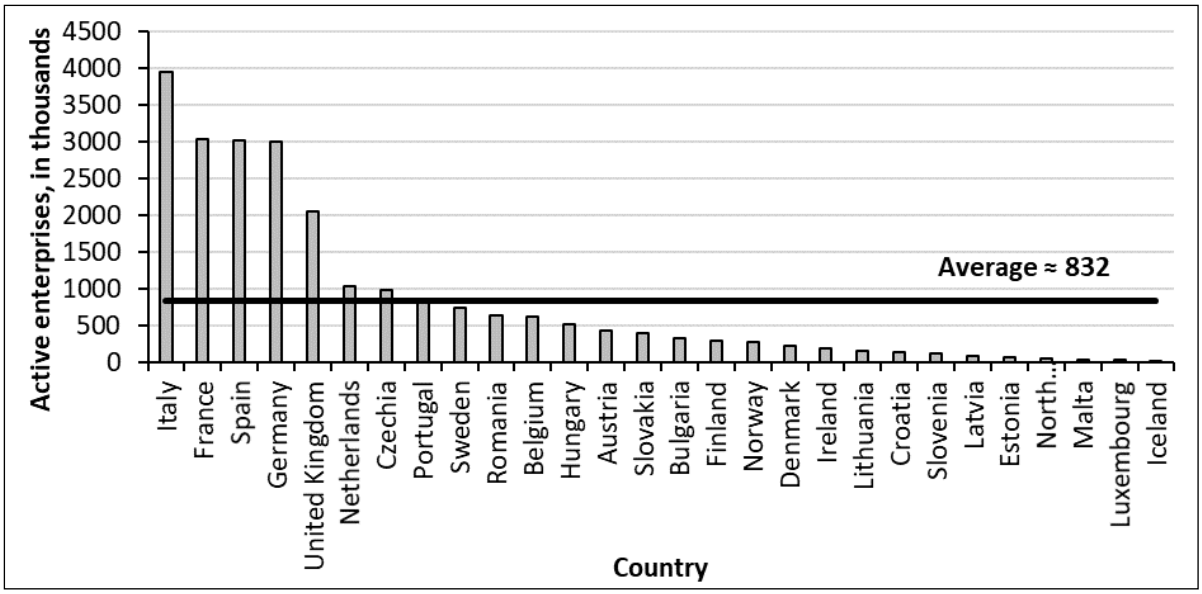


**Figure 1.** Number of active enterprises in the observed 28 European countries, in thousands, in 2012 [28].

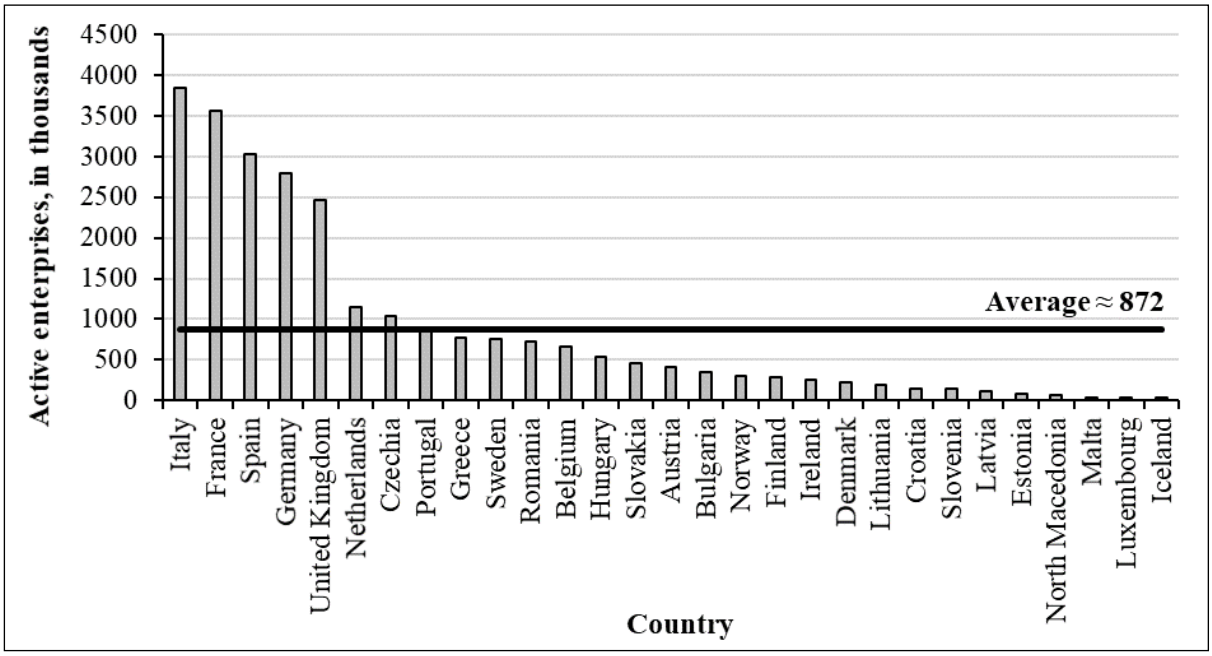


**Figure 2.** Number of active enterprises in the observed 29 European countries, in thousands, in 2016 [28].

had about 832 thousands of active enterprises in 2012 and about 872 thousands in 2016. Along with the five mentioned countries, the Netherlands and Czechia are the only countries which have the number of active enterprises above the average value in both observed years. All other countries have the number of active enterprises below the average. Such relations suggest that a researcher should be careful when the business demography is observed by taking only absolute values into account. The absolute indicators of the total enterprises births (or deaths) are also less comparable across countries if they are based on different definitions of enterprises. The data on business demography variables used for analysis in this article are already highly consistent in methods and definitions of business events across European countries, but comparability can be additionally improved by using relative business

demography indicators (enterprise birth or death rates) since biases (if they exist in the absolute values) are then present in both the numerator and the denominator [32]. Therefore, in the article the focus will be given to relative variables *BirthRate* and *DeathRate* whereas, for the purpose of comparison of different countries only descriptive statistics results of the variable *ActiveEnterprises* will be shown.

**Table 2.** Descriptive statistics of the observed variables for all the observed European countries, in 2012 and in 2016 [29-31].

| Variable code | Mean | St. Dev. | Coef. Var. | Skewness | 1st Quar. | Median | 3rd Quar. |
|---|---|---|---|---|---|---|---|
| **2012** | | | | | | | |
| ActiveEnterprises | 832 055 | 1103 549 | 132 63 | 1,74 | 142 871 | 364 057 | 852 421 |
| BirthRate | 10,27 | 3,76 | 36,64 | 2,34 | 8,14 | 9,81 | 11,69 |
| DeathRate | 9,69 | 3,45 | 35,60 | 0,55 | 7,32 | 9,34 | 11,39 |
| GDPCapita | 34 932 | 15 711 | 44,98 | 1,58 | 25,281 | 33,168 | 42 956 |
| UnempRate | 10,58 | 6,14 | 58,03 | 1,81 | 6,67 | 8,41 | 13,51 |
| **2016** | | | | | | | |
| ActiveEnterprises | 872 107 | 1116,872 | 128,07 | 1,69 | 147 181 | 406 079 | 843 693 |
| BirthRate | 10,38 | 3,50 | 33,70 | 0,72 | 7,71 | 9,95 | 11,64 |
| DeathRate | 7,89 | 3,24 | 41,03 | 0,49 | 6,14 | 8,04 | 9,41 |
| GDPCapita | 37,268 | 16 442 | 44,12 | 1,67 | 27,124 | 34,655 | 44 464 |
| UnempRate | 8,78 | 5,29 | 60,28 | 1,86 | 5,90 | 7,57 | 9,67 |

Table 2 shows main descriptive statistics results of the observed variables in 2012 and in 2016. According to the coefficient of variation values it can be concluded that at the absolute business demography variable *ActiveEnterprises* a much larger variation level is present than at relative business demography variables *BirthRate* and *DeathRate*. The descriptive statistics results also show a moderately high variability of variables related to business demography activities (*BirthRate* and *DeathRate*) as well as to the indicator of economic development (*GDPCapita*) and a relatively high variability in UnempRate in both observed years. Hence, these results indicate a relatively high heterogeneity between the European countries, which did not change much in 2016 in comparison to 2012. However, the observation of the average values of variables reveals that the total number of active enterprises increased in 2016 in comparison to 2012. The birth rate of enterprises in 2016 had almost the same average value as in 2012, but the average death rate in 2016 was lower than in 2012 (with only a little higher dispersion of death rates in 2016 than in 2012). The average GDP per capita was higher in 2016 than in 2012 with about the same variation in both years and the average unemployment rate in 2016 was lower than the average unemployment rate in 2012 with only a slight increase in variation of unemployment rates among European countries in 2016. The range of variation in unemployment rates for the middle 50 % of European countries was much larger in 2012 (interquartile range 6,84) than in 2016 (interquartile range 3,77) which may indicate that the situation regarding unemployment in European countries was much better in 2016 than in 2012. Finally, these results may indicate an overall positive economic and business demography change that occurred among European countries in 2016 relative to 2012.

Table 3 presents the list of the top three and the last three countries according to the value of each observed variable. In both years Lithuania recorded the highest birth rates of enterprises, but its birth rate decreased in 2016 compared to 2012. It is interesting to notice that Malta, which was among the three countries with the lowest birth rate in 2012 moved to the list of the three countries with the highest birth rate in 2016, while being among the three countries with the lowest death rate in 2016. Among countries with the highest levels of GDP per capita,

**Table 3.** Top three and last three countries according to the values of the observed variables, in 2012 and in 2016 [29-31].

| Variable code | Top three countries | Last three countries |
|---|---|---|
| **2012** | | |
| ActiveEnterprises | Italy (3953 714); France (3 039 203); Spain (3012 443) | Malta (31 427); Luxembourg (29 122); Iceland (24 164) |
| BirthRate | Lithuania (24,88); Latvia (16,83): Bulgaria (13,02) | Ireland (6,76); Belgium (6,22); Malta (6,20) |
| DeathRate | Lithuania (18,65); Portugal (16,02); North Macedonia (14,83) | France (5,64), Norway (4,18); Belgium (3,12) |
| GDPCapita | Luxembourg (89 505); Norway (63 003); the Netherlands (45 949) | Romania (18 361); Bulgaria (15 772); North Macedonia (11 550) |
| UnempRate | North Macedonia (31,02); Spain (24,79); Croatia (15,94) | Luxembourg (5,14); Austria (4,86); Norway (3,12) |
| **2016** | | |
| ActiveEnterprises | Italy (3849 594); France (3558 735); Spain (3026 237) | Malta (36 215); Luxembourg (32 391); Iceland (27 653) |
| BirthRate | Lithuania (18,82); Malta (16,36); Latvia (16,16) | Austria (6,59); Belgium (6,24); Greece (4,51) |
| DeathRate | Bulgaria (16,79); Portugal (14,84); Denmark (10,65) | Belgium (3,33); Malta (3,04); Ireland (0,96) |
| GDPCapita | Luxembourg (94 921); Norway (64 160); Ireland (63 227) | Romania (21 782); Bulgaria (17 793); North Macedonia (13 113) |
| UnempRate | North Macedonia (23,72); Greece (23,54); Spain (19,63) | Germany (4,12); Czechia (3,95); Iceland (2,98) |

*values of the variables are shown in brackets

in 2016 Ireland replaced the Netherlands which was in the third place in 2012. The list of the last three countries according to the GDP per capita level remained the same but their GDP per capita values were higher in 2016 than in 2012. The list of countries with the highest levels of unemployment rates was led by North Macedonia in both years, but its unemployment rate decreased in 2016 compared to 2012. The range of variation in unemployment rates was 28,9 in 2012, but only 20,74 in 2016.

In order to check whether there are some countries that have significantly higher or lower variable values than the other countries, all variables are first standardized. After that those standardized variables are plotted by using box plots. In this case the width of the "box" in the box plots is defined by the values of the 1$^{st}$ and the 3$^{rd}$ quartiles whereas the whiskers range is defined by the last actual data point which can be found in the 1,5 interquartile range from those two quartiles. All other data points, which turned out to be outside that range, are considered to be potential outliers. The box plots of all the observed variables are shown in Figure 3.

According to Figure 3 there are many data points that could be considered as potential outliers. In addition, there are some countries (Lithuania, Luxembourg and North Macedonia) whose values for some variables deviate from the averages more than three standard deviations. However, the outlier problem seems to be improved in 2016 since only Luxembourg remained a potential outlier in that year. Hence, in order to be able to compare the situation in the observed periods it has been decided that no countries will be omitted Table 4 shows the matrix of Pearson's correlation coefficient values among the observed variables in 2012 and in 2016. It turned out that a statistically significant positive correlation between variables *BirthRate* and *DeathRate* was present in 2012, meaning that the European

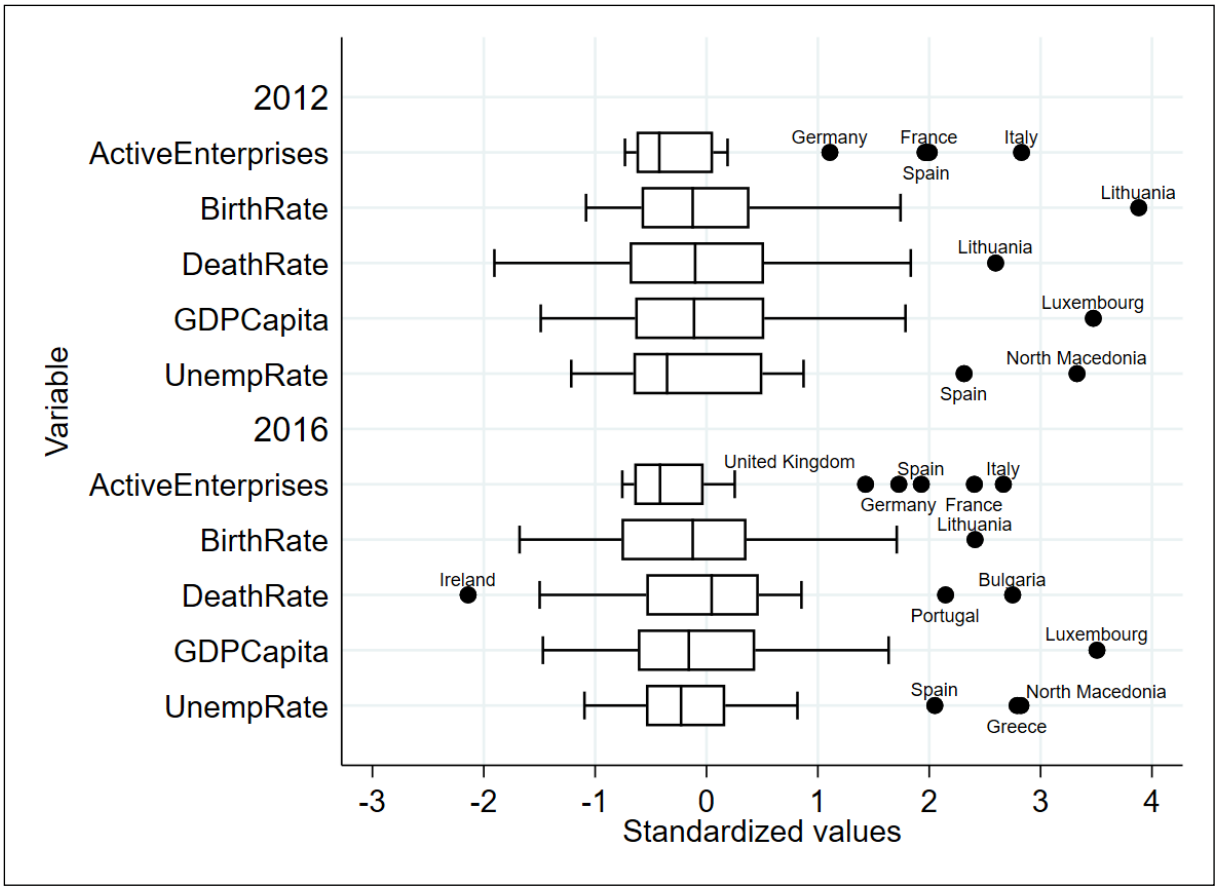


**Figure 3.** Box plots of the standardized values, in 2012 and in 2016 [29-31].

**Table 4.** Correlation matrix of the observed variables, Pearson's correlation coefficient, in 2012 ($n$ = 28) and in 2016 ($n$ = 29) [28-30].

| Variable code | ActiveEnterprises | BirthRate | DeathRate | GDPCapita | UnempRate |
|---|---|---|---|---|---|
| **2012** | | | | | |
| ActiveEnterprises | 1,0000 | | | | |
| BirthRate | –0,2396 | 1,0000 | | | |
| DeathRate | –0,2347 | 0,7181* | 1,0000 | | |
| GDPCapita | 0,0359 | –0,3259 | –0,5788* | 1,0000 | |
| UnempRate | 0,0367 | 0,1978 | 0,5035* | –0,5432* | 1,0000 |
| **2016** | | | | | |
| ActiveEnterprises | 1,0000 | | | | |
| BirthRate | –0,1880 | 1,0000 | | | |
| DeathRate | 0,0224 | 0,3298 | 1,0000 | | |
| GDPCapita | –0,0226 | –0,2674 | –0,4370* | 1,0000 | |
| UnempRate | 0,1353 | –0,2120 | 0,1140 | –0,4057* | 1,0000 |

*statistically significant correlations at the significance level 0,05

countries that had higher birth rates of enterprises also had higher death rates at that time. However, in 2016 this relationship between birth and death rates for European countries is no longer evident, since the coefficient of correlation for these variables is statistically insignificant. The variable *DeathRate* had a statistically significant negative correlation with the variable *GDPCapita* and a positive correlation with the variable *UnempRate* in 2012, meaning that the European countries with higher death rates also had lower GDP per capita levels and higher unemployment rates. However, the variable *DeathRate* had a statistically significant negative correlation only with the variable *GDPCapita* in 2016, but not with the

variable *UnempRate*, which may also be seen as an indicator of change in determination of unemployment through the death rate of enterprises in 2016. In both observed periods a statistically significant negative correlation was present between variables *GDPCapita* and *UnempRate*.

## HIERARCHICAL CLUSTER ANALYSIS

In the hierarchical cluster analysis Ward's clustering method will be applied. As a distance measure, the squared Euclidean distances will be used. Two hierarchical cluster analyses will be conducted. The first one by using data for 28 European countries (without Greece) from 2012, and the second one based on data for 29 European countries (with Greece) from 2016. In both cluster analyses standardized values of variables *BirthRate*, *DeathRate*, *GDPCapita* and *UnempRate* will be used to form clusters or groups of countries with similar characteristics according to the observed variables. In order to select the most appropriate or optimal number of clusters the Calinski and Harabasz pseudo-F index [33] and the Duda-Hart 01) Je(2)/Je(1) index F [34] have been consulted. High values of the Calinski and Harabasz pseudo-F index and the Duda-Hart Je(2)/Je(1) index F indicate distinct clustering. Along with the Duda-Hart Je(2)/Je(1) index F, the associated pseudo T-squared measures can be found as well. A lower pseudo T-squared indicates distinct clustering.

**Table 5.** The Calinski and Harabasz pseudo-F index and the Duda-Hart Je(2)/Je(1) index F values, data related to 2012 [29-31].

| Number of clusters | Calinski and Harabasz pseudo-F index | Duda-Hart | |
|---|---|---|---|
| | | Je(2)/Je(1) index F | Pseudo T-squared |
| 2 | 14,91 | 0,6180 | 6,18 |
| 3 | 13,40 | 0,5500 | 11,45 |
| 4 | 13,23 | 0,6580 | 4,68 |
| 5 | 13,93 | 0,2048 | 3,88 |
| 6 | 14,52 | 0,5666 | 9,18 |
| **7** | **15,51** | **0,5908** | **4,16** |
| 8 | 16,42 | 0,3602 | 8,88 |

Figure 4 shows the dendrogram for the cluster analysis based on data from 2012, whereas Table 5 presents the results of the Calinski and Harabasz pseudo-F index and the Duda-Hart Je(2)/Je(1) index F, with the associated pseudo T-squared values, related to that cluster analysis. The Calinski and Harabasz pseudo-F index values are steadily increasing from the solution with 4 clusters to the solution with 8 clusters, where the maximum value is achieved. Consequently, the Calinski and Harabasz pseudo-F index pointed out that the solution with 8 clusters should be taken as the optimal solution. However, the value of the Duda-Hart Je(2)/Je(1) index F is significantly lower when using the solution with 8 clusters than using the solution with 7 clusters. Similarly, the solution with 7 clusters has a considerably lower pseudo T-squared value than the solution with 8 clusters. Because of that it has been decided that the optimal number of clusters in the cluster analysis of data from 2012 is equal to 7.

Table 6 shows the list of countries according to their cluster membership in the first cluster analysis using data from 2012 whereas Table 7 presents the average values of variables included in the cluster analysis separately for each cluster. According to Table 7 the countries from the cluster A5 have the lowest average *BirthRate* whereas the countries from the cluster A3 have the lowest average *DeathRate*. On the other hand, Lithuania which is set to be in the cluster A7 has the highest *BirthRate* and *DeathRate* value. North Macedonia, which is the only one in the cluster A6, has among the highest values of variables *BirthRate* and *DeathRate* but it has the lowest *GDPCapita* and the highest *UnempRate*.

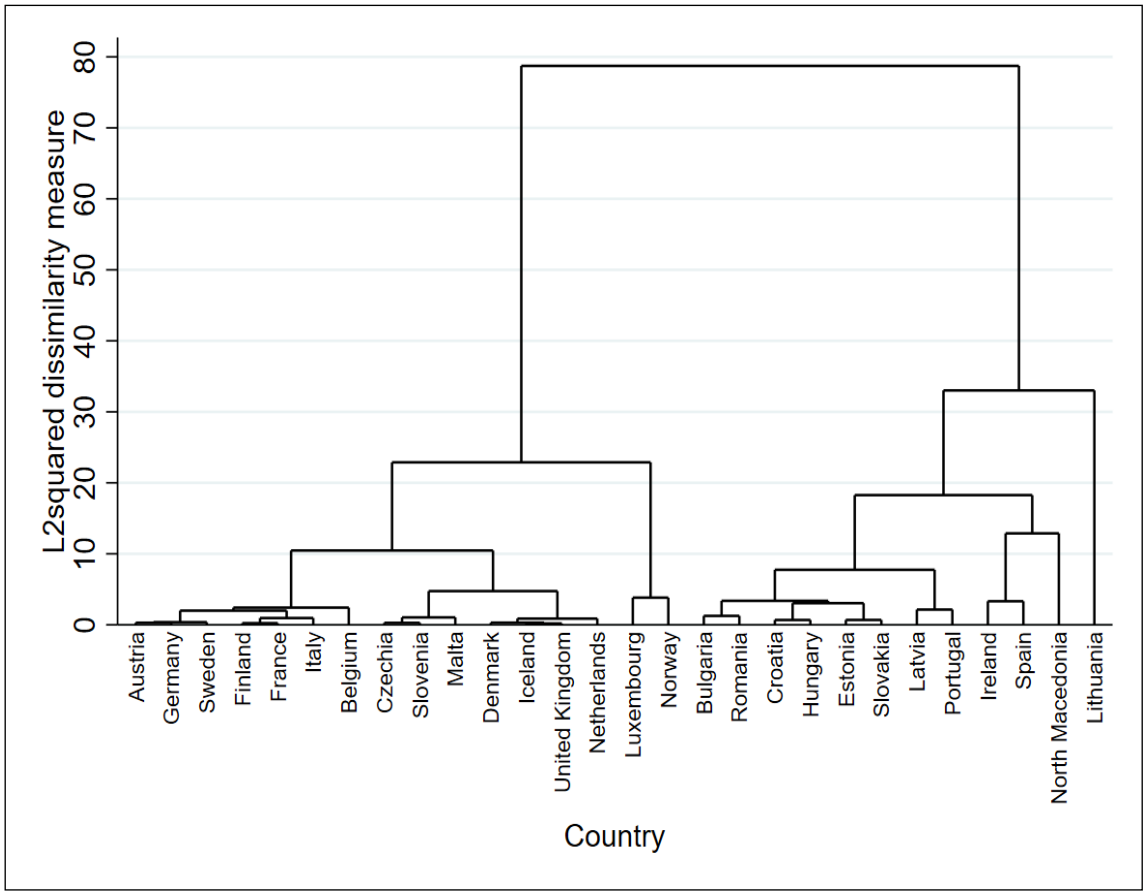


**Figure 4.** Dendrogram, included standardized values of variables *BirthRate*, *DeathRate*, *GDPCapita* and *UnempRate* for 28 European countries, Ward's clustering approach, the squared Euclidean distance, data related to 2012 [29-31].

**Table 6.** Members of clusters, data related to 2012 [29-31].

| Cluster code | Countries |
|---|---|
| A1 | Austria, Belgium, Finland, France, Germany, Italy, Sweden |
| A2 | Czechia, Denmark, Iceland, Malta, the Netherlands, Slovenia, the United Kingdom |
| A3 | Luxembourg, Norway |
| A4 | Bulgaria, Croatia, Estonia, Hungary, Latvia, Portugal, Romania, Slovakia |
| A5 | Ireland, Spain |
| A6 | North Macedonia |
| A7 | Lithuania |

**Table 7.** Average values of variables included in the clustering process, data related to the 2012 analysis [29-31].

| Cluster code | Number of countries | BirthRate | DeathRate | GDPCapita | UnempRate |
|---|---|---|---|---|---|
| A1 | 7 | 7,78 | 6,33 | 40,625 | 7,64 |
| A2 | 7 | 9,93 | 9,92 | 36,298 | 7,05 |
| A3 | 2 | 9,11 | 5,75 | 76,254 | 4,13 |
| A4 | 8 | 11,77 | 11,77 | 21,951 | 12,57 |
| A5 | 2 | 7,49 | 9,26 | 37,969 | 20,12 |
| A6 | 1 | 11,40 | 14,83 | 11,550 | 31,02 |
| A7 | 1 | 24,88 | 18,65 | 24,049 | 13,36 |

Figure 5 presents the dendrogram for the second cluster analysis, which is based on data from 2016. The values of the Calinski and Harabasz pseudo-F index, given in Table 8, suggest that it would be better to choose a higher number of clusters due to a steady increase of the index. ccording to that, the Duda-Hart Je(2)/Je(1) index F suggests choosing between the solution with 7 and 8 clusters (the highest, but very similar, values in the upper part of the table). Due to the fact that the solution with 8 clusters has a higher pseudo T-squared value, it has been decided that the optimal number of clusters is equal to 7.

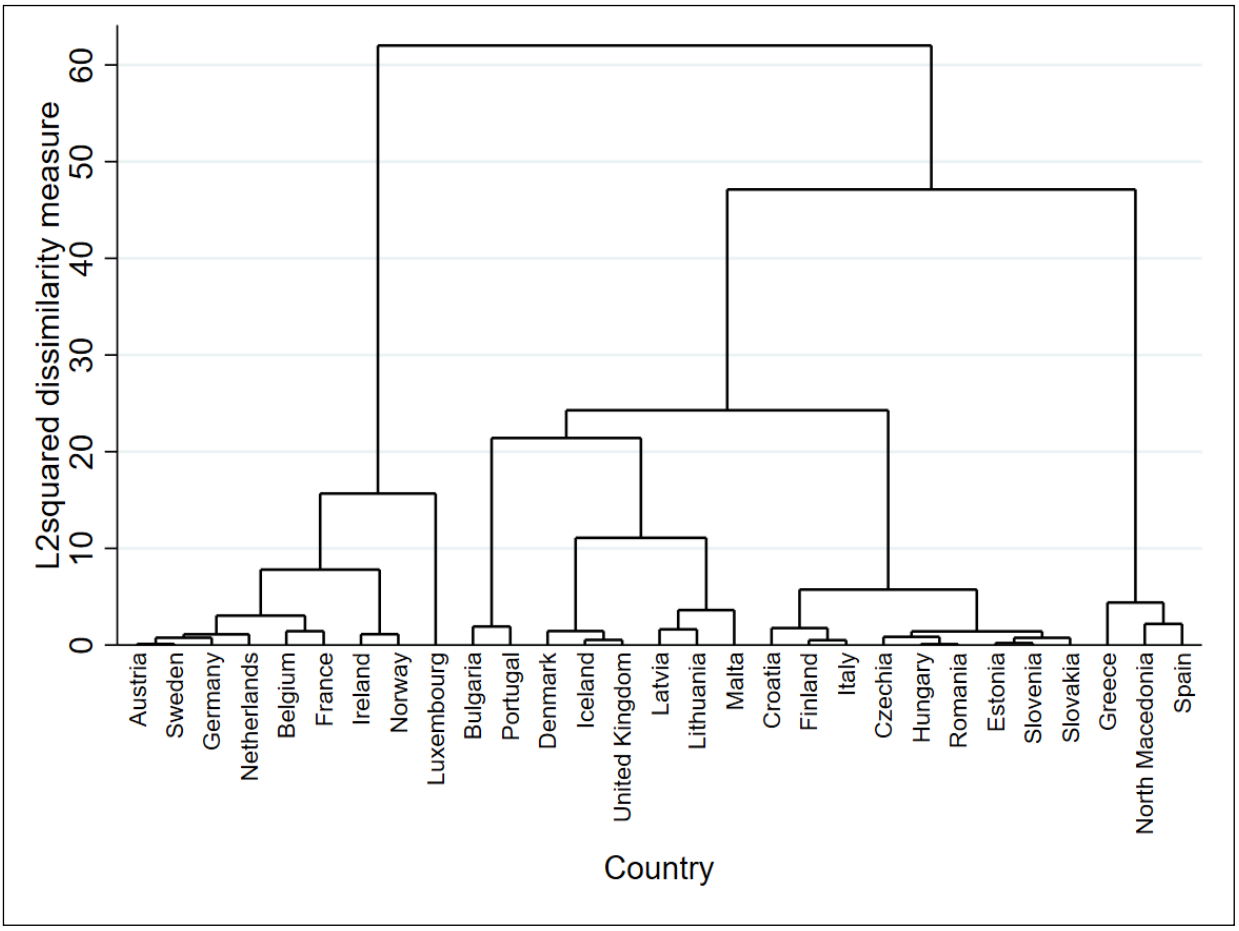


**Figure 5.** Dendrogram, included standardized values of variables *BirthRate*, *DeathRate*, *GDPCapita* and *UnempRate* for 29 European countries, Ward's clustering approach, the squared Euclidean distance, data related to 2016 [29-31].

**Table 8.** The Calinski and Harabasz pseudo-F index and the Duda-Hart Je(2)/Je(1) index F values, data related to 2016 [29-31].

| Number of clusters | Calinski and Harabasz pseudo-F index | Duda-Hart | |
|---|---|---|---|
| | | Je(2)/Je(1) index F | Pseudo T-squared |
| 2 | 10,34 | 0,6401 | 10,12 |
| 3 | 12,35 | 0,6855 | 6,88 |
| 4 | 12,27 | 0,4858 | 6,35 |
| 5 | 13,43 | 0,4953 | 7,13 |
| 6 | 14,66 | 0,3943 | 6,15 |
| **7** | **15,70** | **0,4928** | **6,17** |
| 8 | 16,42 | 0,4922 | 7,22 |

Table 9 contains the list of countries according to their cluster membership in the cluster analysis based on data from 2016 whereas Table 10 presents average values of variables included in the cluster analysis for each cluster separately.

**Table 9.** Members of clusters, data related to 2016 [29-31].

| Cluster code | Countries |
|---|---|
| B1 | Austria, Belgium, France, Germany, Ireland, the Netherlands, Norway, Sweden |
| B2 | Luxembourg |
| B3 | Bulgaria, Portugal |
| B4 | Denmark, Iceland, the United Kingdom |
| B5 | Latvia, Lithuania, Malta |
| B6 | Croatia, Czechia, Estonia, Finland, Hungary, Italy, Romania, Slovakia, Slovenia |
| B7 | Greece, North Macedonia, Spain |

**Table 10.** Average values of variables included in the clustering process, data related to 2016 [29-31].

| Cluster code | Number of countries | BirthRate | DeathRate | GDPCapita | UnempRate |
|---|---|---|---|---|---|
| B1 | 8 | 7,73 | 4,92 | 48,783 | 6,70 |
| B2 | 1 | 8,93 | 7,84 | 94,921 | 6,29 |
| B3 | 2 | 14,04 | 15,82 | 22,458 | 9,32 |
| B4 | 3 | 13,70 | 10,05 | 43,644 | 4,66 |
| B5 | 3 | 17,11 | 5,86 | 28,943 | 7,40 |
| B6 | 9 | 9,46 | 8,51 | 29,142 | 8,11 |
| B7 | 3 | 8,25 | 8,56 | 23,548 | 22,30 |

According to Table 10, countries from the cluster B1 on average have the lowest birth and death rate of enterprises. On the other hand, the countries from the cluster B5 on average have the highest birth rates of enterprises whereas the countries from the cluster B3 on average have the highest death rates of enterprises.

## DISCUSSION

### Theoretical implications

The descriptive analysis results indicate that a very high variation level is present at the absolute indicator of business demography (*ActiveEnterprises*) and that the variation level in relative business demography indicators (*BirthRate* and *DeathRate*) is much lower but still moderately high. The results also show a relatively high variability of macroeconomic indicators (*GDPCapita* and *UnempRate*) in both observed years. High variability in economic and business demography indicators suggests the existence of different patterns in these variables among the European countries. However, even though a relatively high heterogeneity of European countries did not change much between these two years, in 2016 the average value of death rates was lower, the average GDP per capita was higher and the average unemployment rate was lower than in 2012, and only the enterprise birth rates had almost the same average value as in 2012. Thus, these results indicate an overall positive economic and business demography change that occurred among European countries in 2016 relative to 2012.

The analysis of the relationships between the variables revealed that the European countries on a lower level of development (measured as GDP per capita) also tend to have higher death rates of enterprises and higher unemployment rates, and that this statistically significant correlation was present in both years. Though, the correlation analysis also revealed that a

statistically significant and highly positive relationship between birth and death rates of enterprises found in 2012 was absent in 2016. The existence of a statistically significant and positive correlation between birth and death rates of enterprises would be expected, since this describes the process of *creative destruction*, through which dynamic and innovative new enterprises drive inefficient ones out of the market [10]. The same change in statistical significance of the correlation was found between death rates of enterprises and the unemployment rate, which was significantly positive in 2012, but insignificant in 2016. These results suggest that the underlying mechanisms of the correlation between birth and death rates of enterprises and between death rates of enterprises and unemployment rates have changed.

The expected significant relationship between unemployment and birth of enterprises [12-15, 17] was not confirmed in our results in either year. In accordance with the research conducted by [16], we found a significant positive correlation between the death rate of enterprises and the unemployment rate, but only in 2012. The insignificant linear correlation between the birth rate of enterprises and the level of economic development (as measured by the GDP per capita level) was expected, since the previous researches [5, 6, 21, 22] report on the more complex functional form of the relationship between these variables, which reflects the findings that it is only after a country reaches a certain level of development (income) that a positive relationship between income and start-up rates is found.

The hierarchical cluster analysis based on four classifying variables: business demography activity indicators – the birth and the death rate of enterprises, and macroeconomic indicators – GDP per capita and the unemployment rate resulted in 7 clusters of European countries each described by its own combination of characteristics related to the used variables in both observed year.

## Practical implications

The comparison of cluster solutions reveals that clusters A1 and A3 in 2012 and clusters B1 and B2 in 2016 gather countries on a high or a relatively high level of development in terms of GDP per capita, which also have a low or a relatively low unemployment rate and whose main business demography features are a low or a relatively low birth and death rate of enterprises. Similar characteristics of macroeconomic indicators were found in clusters A2 and B4: these were also countries on a high or a relatively high level of development, but these countries had high or relatively high birth and death rates of enterprises. The cluster A5 gathered countries similar according to a relatively high level of development, a low or a relatively low birth and death rate on average, but a very high unemployment rate. This combination of business demography and macroeconomic features was not found in any of the clusters in 2016.

The clusters that gathered countries on a low or a very low level of development with also a relatively high or a very high unemployment rate are A4, A6 and A7 in 2012 and clusters B3 and B7 in 2016. Among these clusters, A4 and B3 have high birth and death rates, the cluster B7 has a relatively low birth rate but a relatively high death rate, the cluster A6 has the lowest GDP per capita and the highest unemployment rate among all the clusters, the cluster A7 has the highest birth and death rates of enterprises and the cluster B7 has a relatively low birth rate but a relatively high death rate with the highest unemployment rate among all the clusters in 2016.

Countries that are joined in the clusters B5 and B6 share a moderately low level of development. However, the cluster B5 has a relatively low death rate and unemployment rate and the highest birth rate among all the clusters in 2016, while the cluster B6 has a relatively low birth rate of enterprises but a relatively high death rate and unemployment rate.

By comparing the resulting clusters for 2012 and 2016 with similar main characteristics we observe some interesting country-specific movements between clusters. Since the main

features of clusters A1 and B1 are a low birth and death rate of enterprises, high GDP per capita and a relatively low unemployment rate, it is interesting to notice that some countries with these characteristics that were present in the cluster A1 are no longer present in the cluster B1 in 2016. Namely, Finland and Italy, formerly in A1 in 2012 were found in the cluster B6 in 2016, which is characterized by a still relatively low birth rate but a moderately high death rate of enterprises, a relatively low level of economic development (as measured by GDP per capita) on average and a moderately high unemployment rate on average that is still lower than the overall sample unemployment rate average for 2016. For Finland and Italy this shift from a cluster with more desirable characteristics in 2012 to a cluster with significantly less desirable characteristics in 2016 could mean a stagnation or even deterioration of business demography activities and macroeconomic performance.

A similar conclusion could be derived for Czechia and Slovenia, both members of the cluster B6 in 2016, since these countries were members of the cluster A2 in 2012, which is characterized by a moderately high birth rate, a moderately high death rate, a relatively high GDP per capita but a relatively low unemployment rate.

For the Netherlands, joining the cluster B1 in 2016 could be seen as an improvement in the observed variables since in 2012 this country was the member of the cluster A2. An improvement is also evident for Ireland which is found in the cluster B1 in 2016 since in 2012 it was a member of the cluster A5 characterized by a low birth rate, a relatively low death rate, a relatively high GDP per capita but a high unemployment rate.

For Lithuania, which was a potential outlier in 2012 since it grouped alone that year in the cluster A7 with the highest birth and death rate of enterprises, a relatively high unemployment rate and a low GDP per capita, joining the cluster B5 in 2016 could be seen as a positive movement. Countries in the cluster B5 still have the highest birth rate and on average a relatively low GDP per capita in 2016, but also have a low death rate of enterprises and a relatively low unemployment rate. Grouping in the cluster B5 can be seen as a positive movement between clusters for Malta (even though this country groups with significantly less developed countries in 2016) since Malta was in the cluster A2 in 2012.

Bulgaria and Portugal were found in cluster A4 in 2012, characterised by a high birth and death rate of enterprises, a relatively high unemployment rate and a low GDP per capita. In 2016 these two countries formed the cluster B3 whose main features are the highest death rate of enterprises and the lowest GDP per capita on average among all the clusters in 2016 and also a high birth rate of enterprises and a relatively high unemployment rate. For Bulgaria and Portugal this separation from other countries could mean a lack of adequate mechanisms for correction of undesirable characteristics related to the observed variables.

North Macedonia formed a 1-unit cluster A6 in 2012 and was a potential outlier that year since it had a relatively high birth and death rate of enterprises followed by the lowest GDP per capita and the highest unemployment rate. However, in 2016 North Macedonia clustered with Spain and Greece in the cluster B7, characterized by a relatively low birth rate but still a relatively high death rate, low GDP per capita and the highest unemployment rate on average among all the clusters in 2016. Hence, the fact that North Macedonia lost the status of an outlier in 2016 could be seen as an improvement in the observed indicators of business demography activities and economic development. On the other side, for Spain, a shift from the cluster A5 to the cluster B7 could point to some issues regarding the death of enterprises. Finally, even though Luxembourg was a potential outlier in 2012, this country was grouped with Norway in the cluster A3 that year, but in 2016 Luxemburg confirmed its outlier status by excluding itself from all other countries with far the highest GDP per capita level.

## CONCLUSIONS

In this study the descriptive statistics methods and the hierarchical cluster analysis approach were used to explore the features of European countries regarding the business demography activities based on the data on the total number of active enterprises, enterprises birth rates and enterprises death rates and regarding the chosen macroeconomic indicators based on the level of economic development (measured as GDP per capita) and the unemployment rate. This research uses the data for 28 European countries in 2012 and for 29 European countries (the same 28 countries as in 2012 plus Greece) in 2016. Our results indicate a presence of a relatively high heterogeneity of countries in both observed periods relative to business demography indicators and macroeconomic indicators. However, by observing a lower average value of death rates and a higher average value of birth rates of enterprises alongside with a higher average value of GDP per capita and a lower value of unemployment rate, it is concluded that a positive economic and demographic change occurred in 2016 relative to 2012. The correlation analysis shows that the significance of the relationship between business demography activities and economic development indicators in 2012 changed in 2016: the death rate of enterprises had a statistically significant negative correlation with GDP per capita in both years and a significant positive correlation with the unemployment rate and with the birth rate of enterprises only in 2012. The hierarchical cluster analysis based on Ward's clustering approach and the squared Euclidean distances resulted in 7 distinct groups of countries in both years with respect to their enterprise birth rate, enterprise death rate, GDP per capita level and unemployment rate.

Previous research applying cluster analysis in this area mainly focused on the classification of groups of countries due to one or more measures of entrepreneurship such as the birth of new enterprises (number or rate), Global Entrepreneurship Monitor's TEA Index, Global Entrepreneurship and Development Index [25, 26] and others. In line with a recent research conducted by [27], our research excludes other measures of entrepreneurship but includes the death rate of enterprises in the cluster analysis in order to explore its capability to differentiate the groups of countries alongside the birth rate of enterprises and macroeconomic indicators.

All resulting clusters in 2012 and in 2016 are described in terms of low, relatively low or high, and high average values of demography statistics indicators and macroeconomic indicators. The country-specific situation regarding the movement between clusters the countries participated in 2012 to the ones they formed in 2016 is presented. For some countries this movement between clusters could be seen as a stagnation or deterioration of some or all of the observed business demography activities and/or macroeconomic performance. This is possibly the case for Finland and Italy (movement from A1 to B6), Czechia and Slovenia (from A2 to B6), Bulgaria and Portugal (from A4 to B3) and Spain (from A5 to B7). However, for some countries movement between clusters could be seen as an improvement in the observed indicators: for the Netherlands (from A2 to B1), Ireland (from A5 to B1), Malta (from A2 to B5), Lithuania (from being an outlier in A7 to B5) and North Macedonia (from being an outlier in A6 to B7). These results may have important practical implications for country-specific public policies aimed at (further) reduction of death of enterprises and unemployment.

Main limitations of this research are the lack of data on business demography indicators for Greece in 2012 (the data on these activities for Greece have been available only since 2015) and the outliers issue which was not treated deliberately in order to enable comparison of results for all the observed countries in 2012 and 2016. In future research the outlier problem should be resolved and the obtained results should be verified in accordance with the exclusion of outliers. Also, in future research the formal analysis of the differences across clusters in terms of the classifying variables should be performed and the main determinants that influence the movement of countries between clusters over time should be explored.

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# THE NEXUS BETWEEN WELFARE STATE AND SUBJECTIVE WELL-BEING: A MULTI-LEVEL ASSESSMENT

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## ABSTRACT

This article explores the nexus between welfare state and subjective well-being in 20 countries drawing on data from the World Value Survey, wave 6. Multi-level mixed-effects restricted maximum likelihood approach that uses fixed-effects and random-effects techniques was applied. This article argues that national differences can explain little of the variations in citizens' subjective well-being. In relatively developed welfare states, the effect of welfare typologies on individual-level subjective well-being is insignificant. However, there is a visible difference in subjective well-being between citizens living in and outside European/OECD welfare regimes. Moreover, while higher public social expenditure exerts higher aggregate subjective well-being, there is no connection between spending and individual-level subjective well-being. What is more, the net pension replacement rate does not affect aggregate and individual-level subjective well-being.

## KEY WORDS

welfare state, subjective well-being. SWB, life satisfaction

## CLASSIFICATION

JEL: D60, I30, I31, I38, I39, N30, P36, P46

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## INTRODUCTION

The quest for quality of life is the ultimate goal for individuals and societies across the globe. Individuals' assessment on the quality of their life in a country is of paramount significance for decision makers endorsing multifarious public policies. Basically, in a country striving for the betterment of the lives of its nations, while formulating public policies, analysts consider the potential impact of policies on the quality of citizens' life patterns. Accordingly, some governments provide social services in an effort to strike a reasonable balance between the well-being of individuals' and societies.

Though GDP per capita is the most commonly applied method of measuring the impact of economic activities and distribution of resources of a nation, it is criticized for being a poor indicator of a nation's well-being [1, 2]. Initiatives featuring subjective ways of measuring well-being in a nation have recently gained momentum. Thus, the use of subjective well-being (SWB) indicators is recommended as they provide indispensable information. Well-being by its very nature is subjective and hence the SWB approach is based on the belief that a person cannot assess another person's satisfaction with something in a country based on subjective parameters as opposed to objective criteria involving the person whose satisfaction is explored. In the SWB approach which treats a person as an authority, the researcher is, therefore, advised to focus on understanding the well-being from the view point of individuals under investigation [3].

Scholars have been writing on the role of welfare state on health [4], marital stability [5], family structure [6], gender equality [7], poverty [8, 9], economic growth [10], income inequality [11, 12], and SWB [13-16].

Of great interest in this article is the role of welfare state on SWB. In the SWB literature, studies on the link between welfare state and SWB have conflicting conclusions. Outcomes of studies of the relationship between welfare state and SWB are often messy. While decommodification [16], health care expenditures [15], and benefit replacement rates [13] have positive effects on individual-level self-rated well-being, social expenditure has no effect on aggregate SWB [14].

Some the studies consist of methodological problems. For instance, Veenhoven's [14], analysis is predominantly based on bivariate correlations and it does not allow researcher to control for very specific issues. Moreover, Veenhoven's [14] reliance on aggregate level data is problematic to analyse life satisfaction which is basically an individual-level and subjective experience. This tendency is at risk of making ecological fallacy with an improper hypothesis assuming that relationships at the aggregate-level may also hold at the individual-level devoid of objective parameters. Though [13] and Pacek and Radcliff [16] made an attempt to assess the effect of welfare state on individual-level SWB, their analyses put micro and macro variables together without considering the hierarchical nature of the variables. Given the fact that individual-level SWB is determined by the combination of both country-level characteristics and individual-level factors, multi-level analysis can be considered appropriate. Bonini [17], for instance, argues that 19 % of variations in individual-level SWB are explained in terms of country-level differences.

The main objective of this article is, therefore, to assess the extent to which welfare states make their citizens satisfied (happy) with everything they need in their respective countries, while keeping individual-level variations constant. In order to minimize the potential problem of ecological fallacy, the article analyses the nexus (connection) between welfare state and individual-level SWB without changing their multi-level nature. Hence, the article centres on two concepts: subjective well-being and the welfare state.

# SUBJECTIVE WELL-BEING AND THE WELFARE STATE

## SUBJECTIVE WELL-BEING

Subjective well-being can be defined as people's evaluation of the quality of their own life as a whole [18]. The study of SWB is often features a survey research that enquires perceived level of satisfaction of individuals [19, 20]. In SWB (wellbeing) literature, there is a clear distinction between affective SWB and cognitive SWB [21].

The affective component of SWB, reflects the balance between pleasant and unpleasant feelings in people's lives (i.e. happiness, joy). Affective theories maintain that "happiness is a reflection of how well [individuals] feel generally" [22]. This component of SWB is associated with people's moods and feelings. Affective component of SWB is divided in to two, i.e. positive and negative instances of affective well-being. They are usually measured by asking people how often they felt happy, angry or depressed [18].

The cognitive component of SWB, reflects individuals' evaluations of their lives (i.e. life satisfaction, satisfaction with domains of life).Cognitive theories indicate that "happiness is a product of human thinking and reflects discrepancies between perceptions of life-as-it-is and notions of how-life-should-be" Veenhoven [22]. In other words, the cognitive component of SWB refers to people's assessment of how satisfied or dissatisfied they are with their lives. Satisfaction with life is a bottom up approach which is a sum of feelings and the satisfaction with different domains of one's life. According to Veenhoven [23], satisfaction with life has four components: pleasure (part of life passing satisfaction), part-satisfaction (part of life enduring satisfaction), top-experience (life-as-a-whole passing satisfaction), and life-satisfaction (life-as-a-whole enduring satisfaction). For the sake of convenience, in this article, subjective well-being and life-satisfaction have been used interchangeably.

## THE WELFARE STATE

The term welfare state is differently viewed by different scholars. Each variety of views has different public policy implications [24]. According to Briggs [25],a welfare state is "a state in which organized power is deliberately used (through politics and administration) in an effort to modify the play of market forces in at least three directions". Such modifications can happen by offering minimum income regardless of market values of citizens, preventing citizens from "social contingencies", and offering social services without discrimination. Even though all states have "the right and duty" to work for the betterment of their citizens [26], welfare states are those that actually provide services to benefit their nationals.

Welfare state measurement approaches can be summarised as the expenditure approach and entitlements approach even though different methods can be applied to measure differences in welfare states. The former measures actual government spending. This indicates the size of welfare state. It can be measured by calculating the extent to which countries spend resources on social policies (an aggregated spending on several different groupings of social programs) as compared to their GDP. Given that there are differences in conceptual definitions of social policy programs across countries, comparing welfare states on the basis of data about social spending is often problematic [27]. However, the latter approach shows the legal rights of the public for benefits. This approach assesses the degree of generosity of social policies in the country (e.g. pension replacement rate, unemployment replacement rate, etc).

Globally, welfare states are dissimilar. Esping-Andersen's [28] "the three worlds of welfare capitalism" was the first to cluster welfare states into three families – liberal, conservative, and social democratic – based on decommodification, social stratification, and the private-public mix. In brief, the liberal welfare state is closely related to traditional work-ethic norms

"in which means-tested assistance, modest universal transfers, or modest social-insurance plans predominate" [28]. Conservative welfare states (e.g. Germany) are committed to provide welfare services but the issue of preserving social status differences is strong. Moreover, the role of churches and families in delivering social services is very strong. In this type of welfare state, the male bread winner family tradition is kept alive. In social-democratic welfare states "universalism and decommodification of social rights are extended to the new middle classes" [28]. This regime advocates social equality in order to achieve utmost standard through full participation of workers.

Esping-Andersen's [28] the Three Worlds has become a footprint in exploring the specifics about welfare regimes [29, 30]. In this regard, Ferrera [31], Korpi and Palme [12], propose alternatives to Esping-Andersen's [28] classification. Alternatives to Esping-Andersen's [28] typology show that though some welfare states consistently fit in one category, many others may not do so. This is mainly because welfare typologies change depending on the criteria and time. For instance, the Dutch welfare state shows a shift form Corporatist in the 1960s, 1970s and early 1980s to Social Democratic after the 1980s [32]. Esping-Andersen's [28] regime types have been criticised for being limited in reflecting the situation in different parts of the world (i.e. Mediterranean, Central and Eastern European, Asian countries, etc). Fenger [33], for instance, argues that Central and Eastern Europe should be grouped separately as "the level of trust, the level of social programmes and social situation in the post-communist countries are considerably lower than [their counterparts] in the other countries".

Though many of the studies on welfare state typologies focus on few advanced countries, Abu Sharkh and Gough [34] managed to generate clusters of welfare states out of OECD. Cluster A, Abu Sharkh and Gough state, is about a group of countries that show some characteristics of western welfare states such as extensive state commitments to welfare provision, relatively effective delivery of services and moderately extensive social and superior welfare outcomes security programmes. In cluster B, countries with combination of low social spending and low dependence on aid and remittance from abroad are clustered. In cluster C, there are countries with great dependence on external flow of remittance. Cluster D is characterised by relatively extensive public social programs, moderately good welfare impacts and high literacy but with very low life expectancy. Although with high levels of youth literacy, Cluster E comprises a group of countries with fairly high foreign aid reliance and low rates of girl literacy. In Cluster F, though there is high expenditure on social programmes and informal security mechanisms, there are high levels of insecurity and illiteracy. Clusters G and H are composed of weak states that are highly dependent on foreign aid with low level of public responsibility and life expectancy.

As noted above, the concern of this article is with the association of welfare state on SWB. In a study on aggregate-level data, Veenhoven [14] found "no connection between the size of state welfare and equality in well-being between its citizens. In countries where social security expenditure is high, the dispersion of health and happiness is not smaller than [that of] equally prosperous countries with less public sector spending". This study employs simple correlation analysis which does not allow the researcher to control for variables that could possibly affect SWB. Kotakorpi and Laamanen [15], on the other hand, reported positive relationship between relative expenditures on social services and SWB of the average citizen in Finland.

Furthermore, Di Tella, MacCulloch [13] disclosed that benefits replacement can have positive effect on SWB. Similarly, Pacek and Radcliff [16] argued that "welfare state generosity exerts a positive and significant impact on life-satisfaction and happiness". Though these studies employed sophisticated methods, they failed to maintain the multi-level nature of SWB and welfare state.

In nested data structure, traditional regressions may lead to false conclusions. When data are clustered, single-level regression analyses are not suitable since the fundamental premise of independence of the observations is violated. Because of this, standard errors estimated in single-level regression are small resulting "many spuriously significant results" [35]. As Snijders and Bosker [36] put it: "For the data with meaningful multilevel structure, it is practically always unfounded to make the a priori assumption that all of the group structure is represented by explanatory variables. [...] In designs with group sizes larger than 1, [...] the nesting structure often cannot be represented completely in the regression model by the explanatory variables. Additional effects of the nesting structure can be represented by letting the regression coefficients vary from group to group."

To model between country differences, it is, therefore, important to allow the intercept vary between countries. The presence of conflicting results and methodological limitations on previous studies beg for further investigation. Based on the literature review, this article hypothesizes that:

**$H_1$**: most of the proportion of variability on SWB could be attributed to country level differences,

**$H_2$**: differences in welfare regime typology contribute to variations in individual-level SWB,

**$H_3$**: iindividual's SWB would differentiate based on public social spending,

**$H_4$**: generosity of welfare state would have positive effect on individual's SWB.

## DATA AND METHODS

### THE DATA

The data for all individual-level variables used in this research were obtained from the sixth wave (2010-2014) of the cross-national World Value Survey [37]. The sixth wave of the WVS was used because of the presence of a richer mix of countries which is important to get a better degree of variation across countries. The WVS is a very useful source of data that can be used to analyse cross-national differences in social attitudes and values globally. With regard to sampling, simple random samples based on the population of each of the participating nations was employed regardless of nationality, citizenship or legal status. The data for a country level variables were taken from International labour Organization [38] (ILO) and Organisation for Economic Co-operation and Development (OECD).

This article presents an analysis on the data from 20 countries ($N$ = 33879). The countries included in the analysis are Australia ($n$ = 1010), Brazil(n=1434), Chile ($n$ = 876), China ($n$ = 1961), Estonia ($n$ = 1497), Germany ($n$ = 1928), India ($n$ = 4986), Japan ($n$ = 1765), Korea ($n$ = 1138), Mexico ($n$ = 1919), the Netherlands ($n$ = 1578), New Zealand ($n$ = 681), Poland ($n$ = 908), Russia ($n$ = 2 236), Slovenia ($n$ = 978), South Africa ($n$ = 3 216), Spain ($n$ = 1022), Sweden ($n$ = 1108), Turkey ($n$ = 1513), and the United States ($n$ = 2 125).

### VARIABLES

The dependent variable is individual-level SWB. As discussed earlier, life satisfaction measures how people assess their life as a whole rather than their individual present feelings. Previous studies were focused on the cognitive component of SWB arguing that life satisfaction item is a more reliable indicator. Accordingly, life satisfaction item was selected as a measure of SWB. On a scale from 1 to 10, the WVS presented the following question to respondents: "All things considered, how satisfied are you with your life now?"

Welfare state typology is one of the independent variables of interest. Even though there are different welfare regime typologies, in this study, countries are grouped based on the consistency of categorization in previous studies (see [29, 30] for the details). Basically, welfare regimes in European/OECD countries are categorised as social democratic (Sweden and the Netherlands), conservative (Germany, Spain), liberal (Australia, Japan, New Zealand, and the United States), and central and eastern Europe (Estonia, Poland, Slovenia and Russia). Countries out of OECD are categorised based on Abu Sharkh and Gough [34] as cluster A (Brazil), cluster B (Chile, China, Korea, and Mexico), cluster D (South Africa), and cluster F (India). In order to assess the different effects of welfare regimes at an individual level well-being, a dummy-variable for each welfare typology is created.

Welfare entitlement is also one of the variables of particular interest in this article. According to the Organisation for Economic Co-operation and Development [39], the net pension replacement rate is defined as "the individual net pension entitlement divided by net pre-retirement earnings, taking account of personal income taxes and social security contributions paid by workers and pensioners". Net pension replacement rate of sampled countries for 2014 collected from the Organisation for Economic Co-operation and Development [40]was employed. The indicator used to measure the size of welfare states is total public social expenditure as percentage of GDP reported by the International labour Organization [38] in its Social Security Inquiry (SSI).

Moreover, to understand the role of welfare state in individuals' SWB controlling individual-level variations is vital. Accordingly, a wide range of factors attributed to a specific person, such as gender [41], age [42], marital status [43], education level [44], health status [20], income [45, 46], employment status [47], and religion attendance [48] are controlled.

## THE METHOD

The data used are cross-sectional and without rooms for cause-effect analysis. That is, the establishment of temporal order is crucial for a causal data interpretation. This article, therefore, focuses on identifying the association between welfare state and individual-level SWB, thereby keeping personal characteristics constant.

This study involves a special kind of regression, i.e. multi-level mixed-effect linear modelling. Applying multi-level modelling is practical to assess the effects of individual and country-level variables at an individual-level SWB. This kind of analysis is indispensable for explaining how much of the variation in the level of SWB can be explained in terms of contextual and personal characteristics considering the nested structure of data.

Multi-level models, also known as hierarchical models or Mixed-effects models, consist of both fixed (estimated directly) and random effects (not directly estimated). For continuous responses multi-level models are linear regressions that include random effects in addition to variations linked to the error term. In situations where the data is clustered and individuals are grouped in each country, it is appropriate to arrange the mixed model as a series of independent clusters. Applying Ordinary Least Square (OLS) regression analysis by considering all observations together, in this case, is problematic. First, estimates tend to be wrong as standard errors produced cannot be trusted. Second, OLS regressions do not show extent of variation explained at a country-level and an individual-level. In other words, such method of analysis does not explain the degree to which country-level variations affect individuals' SWB after controlling individual differences.

Accordingly, in order to obtain the estimates through a mixed method, an application that uses residual maximum likelihood (REML) estimation procedure [49], which is appropriate for smaller cases at the second level was applied. REML regressions yield unbiased estimates of parameters [50].

In the random intercept model, the intercepts $\beta_{0j}$ are random variables representing random differences between groups [50]:

$$Y_{ij} = \beta_{0j} + \beta_1 \cdot x_{ij} + \beta_2 \cdot Z_j + R_{ij}, \quad (1)$$

where $Y_{ij}$ is a dependent variable, $i$ is a level-one unit, $j$ a level-two unit, $x_{ij}$ the explanatory variable at level-one for group $j$, $Z_j$ explanatory variable at level-two, $n_j$ groupsize, $\beta_{0j}$ *are* intercepts, $\beta_1$ the coefficient for level-one variable and $\beta_2$ the coefficient for level-two variable.

The intercept is the summation of average intercept ($\gamma_{00}$) plus group-dependent deviation ($U_{0j}$):

$$\beta_{0j} = \gamma_{00} + U_{0j}, \quad (2)$$

In random intercept model, the regression coefficient $\beta_1$ is common to all the groups. In the random intercept model, the constant regression coefficients $\beta_1$ and $\beta_2$ are sometimes denoted as$\gamma_{10}$and $\gamma_{01}$ respectively.

Substitution yields:

$$Y_{ij} = \gamma_{00} + \gamma_{10} x_{ij} + \gamma_{01} Z_j + U_{0j} + R_{ij}. \quad (3)$$

In this article, fixed effects of explanatory variables are included. In the multi-level model, the $U_{0j}$ signals random variables. The model assumes that they are independent, i.e. normally distributed. Their variance is: $\tau^2 = \mathrm{var}(U_{0j})$.

The empty model, that is, the model with no explanatory variables can be written as:

$$Y_{ij} = \gamma_{00} + U_{0j} + R_{ij}. \quad (4)$$

In this model, the total variation in the dependent variable is divided between individual variation and variance at a country level. $U_{0j}$ represents individual variation in a given country (level-two), while $R_{ij}$ is variation attributed to country level differences (level-two). Variance decomposition is:

$$\mathrm{var}(Y_{ij}) = \mathrm{var}(U_{0j}) + \mathrm{var}(R_{ij}) = \tau_0^2 + \sigma^2, \quad (5)$$

Covariance between two individuals $i$ and $i'$ (with $i \neq i'$) in the same group $j$ is obtained as follows:

$$\mathrm{cov}(Y_{ij}, Y_{i'j}) = \mathrm{var}(U_{0j}) = \tau_0^2, \quad (6)$$

Intra-class correlation (ICC) is coefficient that gives information on the proportion of variability that can be attributed to level-two. It can be defined as the ratio between country variance and the total variance. The ICC show the data in the group, i.e., the smaller the ICC, the lesser the data are clustered. ICC is as follows:

$$\rho(Y_{ij}, Y_{i'j}) = \rho Y = \frac{\tau^2}{\tau^2 + \sigma^2}. \quad (7)$$

Multi-level mixed-effect linear model of the subjective well-being equation can be outlined as:

$$SWB_{ij} = \gamma_{00} + \gamma_{10} x_{ij} + \gamma_{01} Z_j + U_{0j} + R_{ij}. \quad (8)$$

with $SWB_{ij}$ denoting the dependent variable, $i$ individual level, $j$ country level, $x_{ij}$ individual-level explanatory variables for each country; $Z_j$ country-level explanatory variables, $\gamma_{00}$ intercept, $\gamma_{10}$ coefficient for individual-level variables, $\gamma_{01}$ coefficient for country-level variable, $U_{0j}$ country-level residuals and $R_{ij}$ individual-level residuals.

## RESULTS AND DISCUSSIONS

Using the data at individual and country-levels, this article analyses the association between welfare state and SWB. Before investigating the effect of welfare state on individual-level SWB using multi-level models, it is better to examine their macro-macro relationships. Table 1 shows Pearson correlation coefficients.

**Table 1**. Bivariate correlations.

| | Mean | Std. Dev. | Min | Max | Average Life Satisfaction | Net Pension Replacement Rate |
|---|---|---|---|---|---|---|
| **Average Life Satisfaction** | 7,07 | 0,52 | 6,05 | 7,86 | 1,00 | |
| **Net Pension Replacement Rate** | 60,13 | 25,57 | 11,8 | 106,75 | –0,20 | 1,00 |
| **Share of Public Social Expenditure** | 12,40 | 9,71 | 1,00 | 28,13 | 0,456* | 0,11 |

Table1 indicates that there is no correlation between size of welfare state (social expenditure) and welfare generosity (net pension replacement rate). Moreover, the scatter plot shows that the sampled countries are with different degrees of generosity and dissimilar sizes of economic welfare state (see Fig. 1). Social expenditure as percentage of GDP ranged from 1,0 (in Poland) to 28,13 (in Sweden), averaging 11,85. This indicates that there is a wide gap in social expenditure as percentage of GDP. The average net pension replacement rate is 61,42 %: ranging from 11,8 % to 106,75 %.

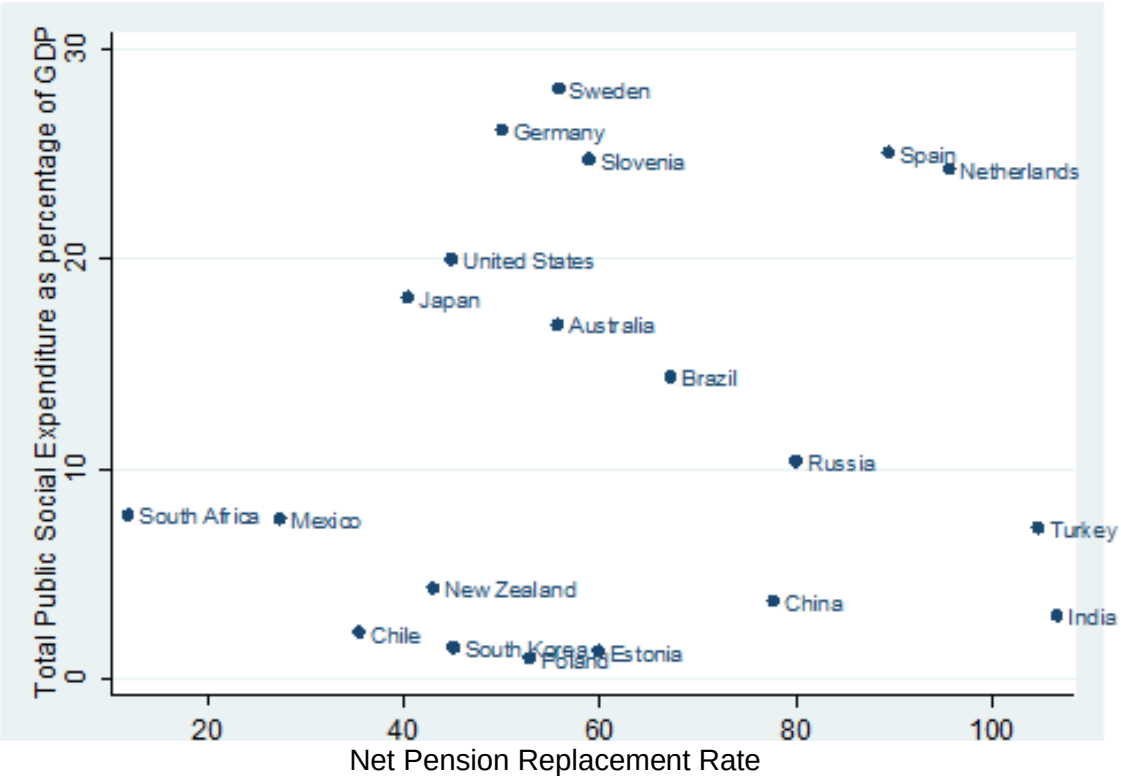


**Figure 1.** The relationship between generosity and size of welfare state.

Out of the sampled countries, India and South Africa are the most generous and the least generous countries respectively. As can be observed in Figure 1, in terms of net pension replacement rate, India ranked the most generous state, whereas in terms of public social expenditure, India is among the least spenders. This indicates that spending more on social services does not necessarily mean that the country spends all the money on social programs. That is, generosity and social expenditure do not yield the same result.

In Figures 2 and 3, country-level average life satisfaction and welfare state indicators (size and generosity) are mapped out respectively. Average life satisfaction scores in all of the countries under investigation appear to be tilted towards the highest possible response. The

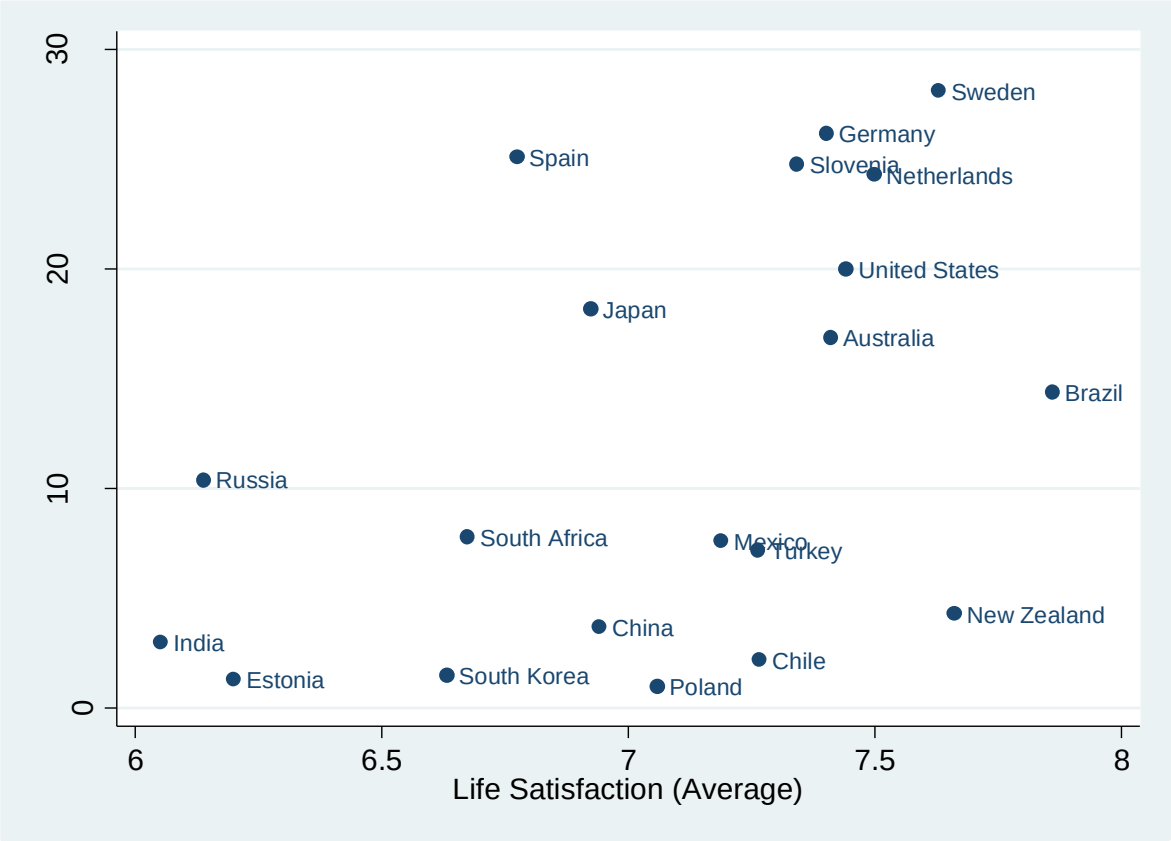


**Figure 2.** Size of welfare state and average life satisfaction.

average country-level life satisfaction ranged from 6,05 to 7,86 with an average of 7,09. On average, Brazilians are the most satisfied people with life and Indians rate themselves as the least satisfied.Based on the result of the bivariate correlation analysis, there is statistically significant relationship between social expenditure and average life satisfaction (Table 1). Moreover, some countries (Germany, the Netherlands, Slovenia and Sweden) which spend much on social programs reported higher level of SWB (cf. Figure 2). Average life satisfaction of people living in countries that spend few on social programs (Estonia and India) is very low. However, SWB in Switzerland and New Zealand is high even though they spend somehow lesser on social services.

Concerning welfare entitlement, on the one hand, people living in countries (Netherlands and Turkey) with higher net pension replacement rate enjoyed higher average SWB. On the other hand, average SWB is low in India and Russia, even if there is high replacement rate. The correlation analysis, therefore, shows that there is no correlation between net pension replacement rate and average SWB (Table 1). Such contradicting outcomes need further analysis in relation to the interplay between individual factors and national context in affecting an individual-level SWB. The next sections deal with such relationships. Consequently results of multi-level mixed-effect linear regression analysis are presented.

Table 2 summarises results of multi-level mixed-effect linear models. The empty model without explanatory variables is presented as baseline. Model 1 contains both individual and country-level variables. This model explains the effects of size and generosity of welfare state at an individual-level SWB while keeping potentially useful predictor individual-level variables constant. To check whether or not there is log linear relationship between welfare state and SWB; logarithm functions of size and generosity of welfare state have been included in model 2. Model 3 contains welfare state regimes. Finally, in model 4, the combination of model 1 and 3 has been provided.

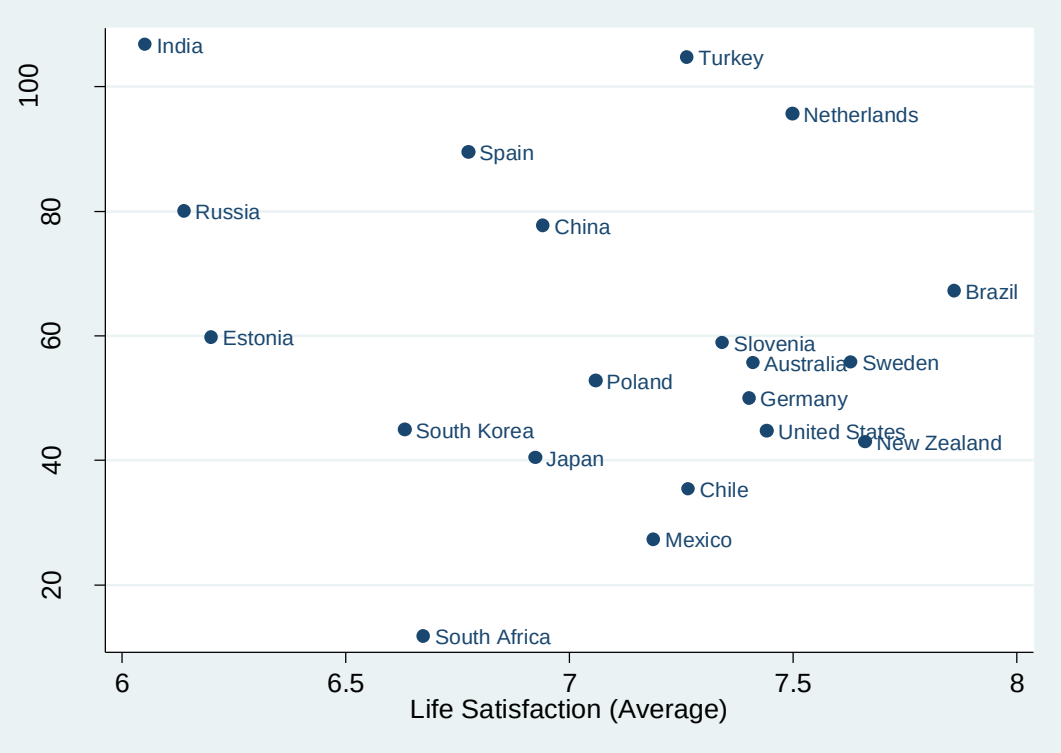


**Figure 3.** Generosity of welfare state and average life satisfaction.

The dependent variable in all models is life satisfaction. In Table 2, the reference dummy is in square brackets and Standard Errors in parenthesis. Abbreviations in Table 2 are as follows: NPPR – Net Pension Replacement Rate, TPSE – Total Public Social Expenditure (as a percentage of GDP), SD – Social Democrat, CEE – Central and Eastern Europe [37].

Before starting to investigate each coefficient, one needs to assess how fit the models are. In selecting the model that best fits, looking at the values of Akaike information criterion (AIC) and Bayesian information criterion (BIC) is vital. Such a model is the one with the smallest AIC and BIC values. In cases where the two criteria yield different results, the AIC takes precedence [51]. In this case, all the models are statistically significant. The information about models that best fit indicates that the models with coefficients are much better than the empty model. Moreover, model 3 is the best fitting model with the lowest AIC value.

On the basis of the multi-level mixed-effect method of analysis, the variance in each level is examined. Concerning the first hypothesis, this article revealed an intra-class correlation (ICC) of 0,08 (Table 2). Contrary to the hypothesis, small portion of the variation in an individual-level SWB can be explained by country-level variations. That is, only 8 percent of the variation in individual-level SWB is explained by country-level variables. This indicates that an individual-level SWB ratings, though to smaller extent, are affected by national contexts. ICC values between 0,15 and 0,25 are common in social science studies [36, 52]. At this juncture, it would be useful to test out whether or not a welfare state is responsible for variations in an individual-level SWB.

The relationship among impacts of different welfare regimes on an individual-level well-being across the globe has been explored. There is no significant difference in an individual-level SWB among European/OECD welfare regimes (i.e. social democrats, liberal, and conservative). SWB of individuals living in most of the welfare regimes outside of OECD is significantly different from that of European/OECD welfare regimes. While people living in cluster A reported significantly higher level of SWB, those in cluster D and F reported the opposite.

**Table 2.** Multi-level models for life satisfaction (continued on pp.146-147).

| | Empty | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|---|
| **Fixed effect parameters** | | | | | |
| Intercept | 7,137 (0,137)*** | 8,126 (0,364)*** | 8,458 (1,010)*** | 8,304 (0,270)*** | 8,367 (0,544)*** |
| Country level (level-two) | | | | | |
| Net Pension Replacement | | –0,008 (0,005) | | | –0,006 (0,004) |
| Social Expenditure (% GDP) | | 0,022 (0,013) | | | 0,012 (0,014) |
| Log(NPPR) | | | –0,237 (0,247) | | |
| Log(TPSE) | | | 0,212 (0,115) | | |
| **Welfare Regime [SD]** | | | | | |
| Conservative | | | | –0,342 (0,332) | –0,371 (0,332) |
| Liberal | | | | –0,274 (0,289) | –0,307 (0,343) |
| CEE | | | | –0,553 (0,288) | –0,425 (0,370) |
| Cluster A | | | | 0,795 (0,332)* | 0,814 (0,402)* |
| Cluster B | | | | –0,559 (0,288) | –0,347 (0,425) |
| Cluster D | | | | –1,013 (0,405)* | –1,156 (0,530)* |
| Cluster F | | | | –1,531 (0,405)*** | –1,180 (0,553) |
| **Individual level (level-one)** | | | | | |
| Age | | –0,034 (0,004)*** | –0,034 (0,004)*** | –0,034 (0,004)*** | –0,034 (0,005)*** |
| Age Squared | | 0,000 (0,000)*** | 0,000 (0,000)*** | 0,000 (0,000)*** | 0,000 (0,000)*** |
| **Gender [Male]** | | | | | |
| Female | | 0,139 (0,023)*** | 0,139 (0,023)*** | 0,139 (0,023)*** | 0,139 (0,023)*** |
| **Marital Status [Married]** | | | | | |
| Living together | | –0,207 (0,040)*** | –0,207 (0,040)*** | –0,209 (0,040)*** | –0,209 (0,040)*** |
| Divorced | | –0,589 (0,051)*** | –0,589 (0,051)*** | –0,589 (0,051)*** | –0,589 (0,051)*** |
| Separated | | –0.566 (0.078)*** | –0,566 (0,078)*** | –0,568 (0,078)*** | –0,568 (0,078)*** |
| Widowed | | –0,454 (0,049)*** | –0,454 (0,049)*** | –0,454 (0,049)*** | –0,454 (0,049)*** |
| Single | | –0,381 (0,034)*** | –0,381 (0,034)*** | –0,381 (0,034)*** | –0,381 (0,034)*** |

**Table 2.** Multi-level models for life satisfaction (continuation from p.145, continued on p.147).

| | | | | | |
|---|---|---|---|---|---|
| **Education [No formal Education]** | | | | | |
| Incomplete primary | | 0,162 (0,069)* | 0,162 (0,069)* | 0,157 (0,069)* | 0,157 (0,069)* |
| Complete primary | | 0,109 (0,060) | 0,110 (0,060) | 0,110 (0,060) | 0,108 (0,060) |
| Incomplete secondary | | 0,121 (0,065) | 0,122 (0,066) | 0,121 (0,066) | 0,121 (0,066) |
| Complete secondary | | 0,111 (0,060) | 0,112 (0,060) | 0,112 (0,060) | 0,111 (0,060) |
| Incomplete secondary | | 0,045 (0,067) | 0,046 (0,067) | 0,043 (0,067) | 0,043 (0,067) |
| Complete secondary | | 0,124 (0,060)* | 0,125 (0,060)* | 0,123 (0,060)* | 0,122 (0,060)* |
| Some university level | | 0,009 (0,069) | 0,010 (0,069) | 0,010 (0,069) | 0,006 (0,069) |
| University level | | 0,142 (0,062)* | 0,143 (0,062)* | 0,140 (0,062)* | 0,139 (0,062)* |
| **Health [very good]** | | | | | |
| Good | | –0,580 (0,027)*** | –0,580 (0,027)*** | –0,581 (0,027)*** | –0,581 (0,027)*** |
| Fair | | –1,241 (0,032)*** | –1,241 (0,032)*** | –1,242 (0,032)*** | –1,242 (0,032)*** |
| Poor | | –2,220 (0,051)*** | –2,220 (0,051)*** | –2,219 (0,051)*** | –2,219 (0,051)*** |
| **Religion Attendance [More than once a week]** | | | | | |
| Once a week | | –0,043 (0,042) | –0,043 (0,042) | –0,041 (0,042) | –0,041 (0,042) |
| Once a month | | –0,194 (0,048)*** | –0,194 (0,048)*** | –0,192 (0,048)*** | –0,193 (0,048)*** |
| Only on special holydays | | –0,178 (0,045)*** | –0,178 (0,045)*** | –0,176 (0,045)*** | –0,176 (0,045)*** |
| Once a year | | –0,290 (0,054)*** | –0,290 (0,054)*** | –0,289 (0,054)*** | –0,289 (0,054)*** |
| Less often | | –0,318 (0,047)*** | –0,318 (0,047)*** | –0,317 (0,047)*** | –0,317 (0,047)*** |
| Never | | –0,254 (0,043)*** | –0,254 (0,043)*** | –0,253 (0,043)*** | –0,253 (0,043)*** |
| **Employment [Full time]** | | | | | |
| Part time | | –0,175 (0,039)*** | –0,175 (0,039)*** | –0,175 (0,039)*** | –0,175 (0,039)*** |
| Self employed | | 0,109 (0,042)*** | 0,109 (0,042)** | 0,108 (0,042)** | 0,108 (0,042)** |
| Retired | | 0,009 (0,043) | 0,009 (0,043) | 0,010 (0,043) | 0,010 (0,043) |
| Housewife | | 0,072 (0,039) | 0,072 (0,039) | 0,072 (0,039) | 0,071 (0,039) |
| Students | | 0,125 (0,055)* | 0,125 (0,056)* | 0,126 (0,056)* | 0,125 (0,056)* |
| Unemployed | | –0,343 (0,042)*** | –0,344 (0,042)*** | –0,343 (0,042)*** | –0,343 (0,042)*** |
| Others | | 0,003 (0,064) | 0,003 (0,064) | 0,003 (0,064) | 0,003 (0,064) |

**Table 2.** Multi-level models for life satisfaction (continuation from pp.145-146).

| | | | | | |
|---|---|---|---|---|---|
| **Scale of incomes [Lower]** | | | | | |
| Second step | | 0,073 (0,049) | 0,073 (0,049) | 0,073 (0,049) | 0,073 (0,049) |
| Third step | | 0,273 (0,046)*** | 0,273 (0,046)*** | 0,274 (0,046)*** | 0,274 (0,046)*** |
| Fourth step | | 0,540 (0,045)*** | 0,540 (0,046)*** | 0,544 (0,046)*** | 0,541 (0,046)*** |
| Fifth step | | 0,709 (0,044)*** | 0,709 (0,044)*** | 0,710 (0,044)*** | 0,710 (0,044)*** |
| Sixth step | | 0,959 (0,047)*** | 0,959 (0,047)*** | 0,960 (0,047)*** | 0,960 (0,047)*** |
| Seventh step | | 1,114 (0,050)*** | 1,114(0,050) *** | 1,115 (0,050)*** | 1,115 (0,050)*** |
| Eighth step | | 1,285 (0,057)*** | 1,285 (0,057)*** | 1,287 (0,057)*** | 1,287 (0,057)*** |
| Ninth step | | 1,388 (0,080)*** | 1,387 (0,080)*** | 1,389 (0,080)*** | 1,389 (0,080)*** |
| Tenth step | | 1,505 (0,091)*** | 1,505 (0,091)*** | 1,506 (0,091)*** | 1,507 (0,091)*** |
| **Random effect parameters** | | | | | |
| Level-two Var. ($\tau^2$ = var($U_{0j}$)) | 0,371 (0,121) | 0,290 (0,100) | 0,302 (0,100) | 0,108 (0,045) | 0,107 (0,049) |
| Level-one Var. ($\sigma^2$= var($R_{ij}$)) | 4,245 (0,033) | 3,602 (0,028) | 3,602 (0,028) | 3,602 (0,028) | 3,602 (0,028) |
| ICC | 0,080 | 0,075 | 0,077 | 0,029 | 0,029 |
| AIC | 145 220,1 | 139 920,9 | 139 909,4 | 139 897,5 | 139 915,2 |
| BIC | 145 245,4 | 140 308,7 | 140 297,2 | 140 327,4 | 140 362,0 |
| *N* level-one | 33 877 | 33 877 | 33 877 | 33 877 | 33 877 |
| *N* level-two | 20 | 20 | 20 | 20 | 20 |

*significant at 5 % probability level
**significant at 1 % probability level
***significant at 0,1 % probability level

This can be associated with the growth-to-limits syndrome as any European/OECD welfare state has already reached its maximum level. of coverage and generosity. For instance, almost all Europeans are eligible for "social protection schemes for all the 'standard risks': old age, disability, and bereavement; sickness, mentality, and work injuries; unemployment and family dependants" [53]. In such cases, welfare classifications may not significantly contribute to the variation in well-being. However, European/OECD and non-OECD welfare regimes are very different in nature. Such differences contribute to the difference in individual-level SWB.

Concerning the third and fourth hypothesis, after individual characteristics were analyzed, it was found that there was neither linear nor log-linear relationship between welfare state and an individual-level SWB (cf. model 1 and 2). That is, at any particular point in time, a respondent's life satisfaction does not vary in size and generosity welfare state of a country. Thus, at a particular time, variation in welfare spending as well as welfare entitlements across countries does not have a significant effect on SWB of citizens. In other words, though there are differences in size and generosity of welfare state, such differences do not generate considerable effects on SWB of individuals.

Moreover, this article argues that neither size nor generosity of welfare state has a significant effect on individual-level SWB. Different arguments are brought into the discussion about the relationship between welfare state and SWB. Partly, it is associated with the view of welfare state intervention with respect to taxation considering the fact that public social spending is financed by taxes collected from citizens. From the rational choice theory perspective, human beings as utility maximizing individuals may prefer to pay lower taxes. Hence, they would be unhappy with government spending and public social spending might decrease individual's SWB. On the other hand, as for advocates of big governments, people may tend to pay higher taxes to consume much of public goods and ultimately live better lives. Moreover, given the decreasing marginal utility of income, redistribution from the rich to the poor may generate more SWB for both the poor and the rich [54].

Spending a good deal of resources on social programs may not necessarily affect all citizens in the same way. Individuals. benefiting from social welfare may have higher SWB as they are positively affected by such policies. Besides, the majority (in a society) do not yet enjoy the benefits of social welfare programs.

Another possible explanation is that a welfare state can have a negative effect on individuals' well-being. According to Murray [55], spending more money on social programs designed to assist the poor and underprivileged tend to make things worse. Critics of welfare state claim that having a generous welfare state may encourage intentional unemployment. This can result in lower satisfaction of citizens as unemployment is an important determinant of SWB. Studies indicate that there is a positive association between the rate of unemployment in a region and the average loss of well-being [47]. Unemployment rate affects both employed and unemployed citizens. For unemployed people, unemployment rate negatively affects their well-being because of lack of income and socio-economic and psychosocial challenges. Moreover, even employed people tend to be unhappy about a low employment rate due to the potential negative impact of unemployment on their life patterns [13].

There are also financial and institutional constraints, such as mounting public debts and deficits, considering entitlements as property rights [56], and loss of SWB for individuals with the constraints Moreover, with regard to relevance of policies, the findings indicate that welfare states would neither increase nor decrease an individual-level SWB.

Finally, Table 3 compares results of single-level (OLS) and multi-level models. It can be noted that all of the welfare variables are significant in the single-level analysis. However, size and generosity of welfare, most noticeably, lose their significance in the multi-level model. Controlling for contextual differences variations, size and generosity of welfare state by themselves played less of a role in explaining individual-level SWB. As Hox [35] suggested, the significant effect found on OLS regression may be due to spurious effect. The multi-level model provides better estimation by revealing spurious nature of the relationship.

The dependent variable in all models is life satisfaction. In Table 2, the reference dummy is in square brackets and Standard Errors in parenthesis. Abbreviations in Table 2 are as follows: NPPR – Net Pension Replacement Rate, TPSE – Total Public Social Expenditure (as a percentage of GDP), SD – Social Democrat, CEE – Central and Eastern Europe [37].

**Table 3.** Comparison between a single-level and multi-level models for life satisfaction (continued on p.150).

| | Single-level Model | Multi-level Model |
|---|---|---|
| **Fixed effect parameters** | | |
| Intercept | 8,605 (0,157)*** | 8,367 (0,544)*** |
| **Country level (level-two)** | | |
| Net Pension Replacement | –0,006 (0,001)*** | –0,006 (0,004) |
| Social Expenditure (% GDP) | 0,012 (0,003)*** | 0,012 (0,014) |
| **Welfare Regime [SD]** | | |
| Conservative | –0,387 (0,054)*** | –0,371 (0,332) |
| Liberal | –0,374 (0,055)*** | –0,307 (0,343) |
| CEE | –0,539 (0,064)*** | –0,425 (0,370) |
| Cluster A | 0,809 (0,070)*** | 0,814 (0,402)* |
| Cluster B | –0,363 (0,074)*** | –0,347 (0,425) |
| Cluster D | –1,223 (0,083)*** | –1,156 (0,530)* |
| Cluster F | –1,127 (0,086)*** | –1,180 (0,553) |
| **Individual level (level-one)** | | |
| Age | –0,035 (0,004)*** | –0,034 (0,005)*** |
| Age Squared | 0,000 (0,000)*** | 0,000 (0,000)*** |
| **Gender [Male]** | | |
| Female | 0,129 (0,023)*** | 0,139 (0,023)*** |
| **Marital Status [Married]** | | |
| Living together | –0,222 (0,040)*** | –0,209 (0,040)*** |
| Divorced | –0,608 (0,051)*** | –0,589 (0,051)*** |
| Separated | –0,597 (0,078)*** | –0,568 (0,078)*** |
| Widowed | –0,473 (0,049)*** | –0,454 (0,049)*** |
| Single | –0,393 (0,034)*** | –0,381 (0,034)*** |
| **Education [no formal Education]** | | |
| Incomplete primary | 0,072 (0,069) | 0,157 (0,069)* |
| Complete primary | 0,101 (0,060) | 0,108 (0,060) |
| Incomplete secondary | 0,125 (0,066) | 0,121 (0,066) |
| Complete secondary | 0,109 (0,060) | 0,111 (0,060) |
| Incomplete secondary | –0,046 (0,067) | 0,043 (0,067) |
| Complete secondary | 0,032 (0,060) | 0,122 (0,060)* |
| Some university level | –0,067 (0,069) | 0,006 (0,069) |
| University level | 0,031 (0,062) | 0,139 (0,062)* |
| **Health [very good]** | | |
| Good | –0,601 (0,027)*** | –0,581 (0,027)*** |
| Fair | –1,269 (0,032)*** | –1,242 (0,032)*** |
| Poor | –2,235 (0,051)*** | –2,219 (0,051)*** |
| **Religion Attendance [More than once a week]** | | |
| Once a week | 0,033 (0,042) | –0,041 (0,042) |
| Once a month | –0,137 (0,048)** | –0,193 (0,048)*** |
| Only on special holydays | –0,115 (0,044)** | –0,176 (0,045)*** |
| Once a year | –0,271 (0,054)*** | –0,289 (0,054)*** |
| Less often | –0,316 (0,047)*** | –0,317 (0,047)*** |
| Never | –0,206 (0,042)*** | –0,253 (0,043)*** |

**Table 3.** Comparison between a single-level and multi-level models for life satisfaction (continuation from p.149).

| | | |
|---|---|---|
| **Scale of incomes [Lower]** | | |
| Second step | 0,067 (0,049) | 0,073 (0,049) |
| Third step | 0,245 (0,046)*** | 0,274 (0,046)*** |
| Fourth step | 0,513 (0,045)*** | 0,541 (0,046)*** |
| Fifth step | 0,664 (0,044)*** | 0,710 (0,044)*** |
| Sixth step | 0,930 (0,047)*** | 0,960 (0,047)*** |
| Seventh step | 1,096 (0,050)*** | 1,115 (0,050) *** |
| Eighth step | 1,289 (0,057)*** | 1,287 (0,057)*** |
| Ninth step | 1,432 (0,080)*** | 1,389 (0,080)*** |
| Tenth step | 1,549 (0,091)*** | 1,507 (0,091)*** |
| **Employment [Full time]** | | |
| Part time | –0,166 (0,039)*** | –0,175 (0,039)*** |
| Self employed | 0,176 (0,042) | 0,108 (0,042)** |
| Retired | 0,057 (0,043) | 0,010 (0,043) |
| Housewife | 0,076 (0,038)* | 0,071 (0,039) |
| Students | 0,114 (0,056)* | 0,125 (0,056)* |
| Unemployed | –0,351 (0,042)*** | –0,343 (0,042)*** |
| Others | –0,025 (0,064) | 0,003 (0,064) |
| **Random effect parameters** | | |
| Level-two Var. ($r^2$ = var($U_{0j}$)) | | 0,107 (0,049) |
| Level-one Var. ($\sigma^2$= var($R_{ij}$)) | | 3,602 (0,028) |
| ICC | | 0,029 |
| AIC | | 139 915,2 |
| BIC | | 140 362,0 |
| N level-one | 33 826 | 33 877 |
| N level-two | | 20 |
| R-Squared | 0.,226 | |

*significant at 5 % probability level
**significant at 1 % probability level
***significant at 0,1 % probability level

## CONCLUSIONS

This article presents analyses on the relationship between welfare states. and SWB in 20 countries (selected through purposive sampling) drawing on the WVS round 6 data. Previous studies dealt with mainly macro-macro relationship between welfare state and SWB, but this study employs multi-level analysis so as to investigate micro and macro level determinants of SWB. In this study, several interesting findings have been figured out.

The article argues that individual characteristics explain a large portion of the variation within individual-level SWB. The proportion of variance in individuals' perceived SWB .has been left for further scrutiny in terms of country-level characteristics. This indicates that policy makers need to work on individual-level characteristics (such as individual-level income, employment, education, marital status, etc.) than country-level contexts in order to improve SWB of individuals.

The article also revealed that there is no significant difference in individual-level SWB among European/OECD welfare regimes. In relatively developed welfare states, the effect of

welfare typologies on individual level is insignificant. However, there is a visible difference in SWB between citizens living in and out of European/OECD welfare regimes.

Finally, as for Veenhoven [14] "[a] welfare state does not have to be kept intact at all costs". It can be of great significance provided that it is suitable for nations employing it for their multifaceted development.

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# APPROACH TO UNDERSTANDING OF BIOMECHANICAL LOCOMOTION SYSTEM

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## ABSTRACT

In this article, the authors have presented an approach to understanding locomotion biomechanical system processes. As a result of the existing literature overview and personal comprehension, fundamental differences were made in understanding neuromyofascial resting tone and active neuromyofascial tone. It was argued that correct analysis is possible only by taking into account the initial level (identified as neuromyofascial resting tone), and main variants of neuromyofascial tone conditions (relaxed or tensed with or without locomotion), the chosen objective and the required level of conditioning. Authors concluded that in the locomotion movement analyses it is necessary to take into account the main variants of neuromyofascial conditions (relaxed or tensed with or without locomotion). Everything considered in the study is consistent with the basic principles of ergonomics using comprehensive analysis.

## KEY WORDS

biotensegrity, fascintegrity, anatomical and neuromyofascial sling, neuromyofascial tone, locomotion efficacy

## CLASSIFICATIONS

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## INTRODUCTION AND BACKGROUND

More than few decades scientists of various specialisations have been intensively explored the issues concerning the musculoskeletal systems (including low back or even more precise low back – pelvic girdle) biomechanics, capabilities and functionality. This is also often considering as human motion motor, responsible for controlled and purposeful motion necessary to complete assigned activity. Of course, since the occurrence of musculoskeletal conditions – disorders has become recognized as very serious and frequent problem, focus has been also put on investigating causality and prevention of pain, injuries and any other human motor disorders manifestation. Thus, purpose of research conducted are oriented and vary from health preservation and disorders prevention recommendations, to injuries management and treatment including surgery interventions (implants, prostheses, and any other that applies). In extent of this broad and general spectrum of musculoskeletal systems research activities, some research deal with sports or in general, prevailing the unimaginable human attainments and extreme human performance issues. Therefore, findings and research relevance can be divided in two main streams, but with same objective – optimal functionality of locomotor musculoskeletal system. First can contribute to healthy asymptomatic individuals to preserve that condition, or in case of some dysfunctionality occurrence to restore desired functionality, based just on proper biomechanical adjustments, therapy and synchronization. The second is the one that deal with restoration of locomotor functionality, but the causality of dysfunctionality occurred is related with unpredictable slips, falls, accidents and incidents, various pathologies (asf.) that are beyond biomechanical reasoning and understanding of complex musculoskeletal system. This paper falls within first stream since the basis for both streams is biomechanical harmonization necessity founded on proper understanding of human musculoskeletal systems that should be determined.

From the literature overview it can be identified that despite all research and professional findings and recommendations, preventative actions and standards, the occurrence of injuries and pain issues has not been significantly decreased (on the contrary, maybe are even increased), persistent and ever-present [1]. Treatment of locomotor conditions and preventative measures indicate that assigned task training may improve locomotor performance and stability [2], however not sufficiently to completely prevent disorders occurrence, showing dependence on individual skills and anthropometric predispositions. Also, disturbed biomechanical relationships – dysfunctions will also be present after the operative treatment so the prostheses will be just temporary solution [3, 4]. That leads to assumption-conclusion that human body health, performance and functionality is far more complex than we already comprehend, as are the requirements of the human engagement in everyday activities. This in general indicates integration necessity of various compatible and complement disciplines, perspectives, approaches and knowledge that should be used for comprehensive, holistic findings synthesis of the identified complex biomechanical locomotor systems functionality.

Since considering previously discussed literature overview disorder manifestations in human body motor system cannot be treated as isolated, although the focal problematic point can be identified as weakest spot of the system, authors implies holistic and comprehensive behaviour of human locomotor system and functional biomechanical patterns. In many cases of lumbar or pelvic disorders they are just manifestations of other biomechanical disturbances that need to be identified. Since this region convey most of mechanical load between other active body segments involved in locomotor activity, any dysfunctionality or deficient conditioning lead to manifestation of some disorder or pain.

Therefore, this paper focuses on determination of human motor system biomechanics functionality that is consisted of many subsystems. Synergistic coordination patterns of

complex biomechanical human motor transmission system can be assumed, however, the coordination accuracy and activity timing of system elements has to be mastered. So, when all subsystems of human motor system are proportionally conditioned they achieve harmonious relations, thus mastering of skills and motor competence can be advanced without obvious risk of injuries. This strategy presumes that human motor system has its own functionality patterns that need to be understood and established.

# METHODS

With respect to paper objective as functionality patterns of human motor or musculoskeletal system that need to be understood and established, synthesis will be employed to assist and validate findings. This approach will enable integration of accessible knowledge and research findings with the authors' experience (biomechanical, biomedical engineering and product design; kinesiology scientist and professional coach), comprehension of human body biomechanics and patterns recognition.

## STRUCTURAL COMPONENTS

Regarding the accessible knowledge and references, human motor system is considered to be mechanically presented as system of components that are interconnected as subassemblies.

Initially, human locomotor system is considered as mechanism that constitutes of skeletal (passive and stiff) and muscular (active and viscoelastic) subassembly. Recent comprehension expanded this system with fascial (or myofascial) subassembly. Initially introduced from architectural principle of tensional structural integrity – tensegrity, research has demonstrated that the architectural principles of tensegrity can be applied to biological organisms (termed biotensegrity). Utilizing these principles can demonstrate the mechanical structure-function relationship at all size scales in the human body [5]. In addition to this findings, human resting muscle tone (HRMT) was introduced [6] as the passive tonus or tension of skeletal muscle that derives from its intrinsic molecular viscoelastic properties, which exist in all creatures, not only humans. Hence, we suggest that resting muscle tone (RMT) seems to better describe the phenomenon. RMT is an intrinsic viscoelastic tension exhibited within the body's kinematic chains. It functions inseparably from fascial (i.e. Myofascial) tissues and ligamentous structures.

It is important to observe that there is muscle tone even when a muscle is supposedly at rest, and that resting tension must be doing something, otherwise the body is wasting energy. Such tone is responsible for maintain neutral position of anatomical segments responsible for maintaining posture which needs to be controlled by central nervous system [7]. However, we disagree that in this state human electromyography (EMG) is silent since any level of muscular tone should be registered by EMG, which is the case even at low level of muscular activity. Since the fact that muscular and fascial tissue are inseparable and are merged into myofascial unit, resting muscle tone that corresponds to state where EMG is silent actually represent fascial tone that cannot be registered by EMG or other known apparatus in vivo.

Later research concluded that fascia is shaping element of the human body movement apparatus that comprises a multicellular three dimensional layer of connective tissue components (collagens, fibrocytes/-blasts, extracellular matrix), more specialized fibroblast-derived cells (fascia-, telocytes), contracting myofibroblasts, mechano- and propriosensors, and nociceptors. Fascia is a multicellular/multicomponent biological material for human body structural and functional integration as well as serving as a sensation organ in terms of movement and performance adjustment, body awareness and control [8-10].

Although initial idea of biotensegrity was valid regarding ability of human body to keep the posture with minimal muscular intervention, it seems more appropriate to use concept of fascintegrity [11]. Furthermore, after introduction of fascial components as biomechanical element, they have appeared to be considered as anatomical slings because of their properties. It would be also appropriate to concur with another synonym for this integration of muscle-fascia networks that is the neuromyofascial web. Therefore, we assume it would be correct that in this case to argue about that neuromyofascial resting tone (NMFRT) to replace the RMT. Thus, whatever the term we accept and utilize, most important is to revise our biomechanical comprehension of human motor system.

It is well known that with advancements in sports mastering, athletes tend to improve capability to relax muscles, as well as fascial structures. Examples from professional sport show that the top athletes tend to advance their NMFRT in order to achieve effective muscle tone easier and in shorter period of time.

Whatever term is the most appropriate (anatomical, functional or myofascial slings, or even neuromyofascial web – maybe just slings web), they are very important and necessary functional subsystem described and explained from various perspectives [8-12]. It is important to integrate such complex subsystem into analysis of locomotor functionality, but also in explorations of identified disorders and pain management. Unfortunately, most trials and experimental results available in literature deals with partial and very limited scope which also consider just planar and ideal conditions that are far from reality. Such findings cannot be used to determine or establish occupational and health recommendations, especially in order to prevent and manage injuries.

With regard to presented structural understanding, integration of these three main components into inseparable whole of mechanical representation of human locomotor system can be only complemented with the motor control system, which regulates necessary fine-tuned neuromuscular coordination. Thus, human locomotor (or musculoskeletal motor) system is made up of skeletal structures, muscles and fascias, regulated by motor control system, interconnected into functional whole.

## MOTOR COMPONENTS

Human locomotor system is anatomically and biomechanically considered as to consist of inseparable segments, just in order to enable segmental functional participation understanding. As the main body segments are considered extremities, trunk and head, which are for analyses purposes often divided in subunits-segments. In functional or from mechanical point of view, pelvic girdle connect them all, and even more important, transmit energy and mechanical load during locomotor activities besides provided stabilization. It should be noted that the transmission of force and loads is present in other segments of the human body as well, so it is not solely the task of the pelvis girdle, however, its relative mobility to the legs sets her up as a support for the locomotor apparatus. The pelvic girdle and its complex role in musculoskeletal mechanics were explored [13], where integrated functional model of lumbopelvic-hip region has been introduced.

Critical appraisal of the literature about lumbar functional stability (instability) showed that although comprehensive analyses has been employed, consensus on effective prevention recommendations and disorders treatments has yet to be established [1]. Authors of this paper can concur with finding that lumbar region is integral part of lumbopelvic-hip region as well as element of functional neuromyofascial network [12]. It is shown that lumbopelvic-hip region is the inseparable from other surrounding body segments both functionally and structurally,

so the research and professional approaches need to employ such comprehension. Such approach can yield reliable answers of locomotor system coordination patterns and enable to properly define effective force and energy transmission through kinematic chains. To support transmission of energy and complex force vectors, pelvic girdle needs proper stabilization capability. After all, it is not without reason that athletes work very hard to strengthen the core.

*Pelvic girdle functional capability* is often represented by ability to assure desired level of transmission intensity (and connected with the term core) that needs to provide optimal stability while supporting the body movements. Core is considered to be inseparable complex of inner and outer unit, with their functional objectives respectively.

*The inner unit* muscles are tonic muscles which function is to effectively stabilise the spine and sacroiliac joint at low levels of contraction with low susceptibility to fatigue. It is recognized that well-timed coordination is critical for proper stabilisation. The ability of the inner unit muscles to contract prior to force production of phasic muscles (geared toward movement) is more important than their strength.

*The outer (phasic) unit* consists of four myofascial systems that generate movement and stabilise the body: deep longitudinal system, posterior oblique system, anterior oblique system and lateral system, very often represented and found named as myofascial slings. Regarding previously argued meaning of available terminology for myofascial sling [12], we also suggest to employ term neuromyofascial sling (NMFS) that more comprehensively describes their functional role.

*Synergy* of all motor components form vector of forces and force couples transmission as well as the necessary supports. However, in order to maximize specific synergy of neuromyofascial sling output in specific movement one has to deal with development of coordination structure that will assure that the direction of the vectors are not misaligned or broken. It would be appropriate to introduce example from high intensity sports activities and competition, where extremely precise and effective transmission of energy and forces into movement are required, which confirms previous statement. Similarly, such fast and impulsive coordination requires so that elements are performed with specific requirements. Such are direction of movement, amplitude, rhythmic characteristics, intensity etc., which is reflected in the rules/laws of training and improving movement in the theory of sports training [14, 15]. NMFSs activity exchange is ever-present throughout the entire motion scenario, but it is challenge to develop fine motor control that can be achieved only by special training. Thus, it can be stated that the core inner and outer unit function synergistically to stabilise the body that is required to create powerful and economic movement.

Effective functioning of the inner core unit leads toward stability of the spine and sacroiliac joints and the core provides reliable basis for the contraction the phasic muscles. This leads to the efficient use of limb strength, high movement economy and absence of injury [13, 16].

Core functionality and importance was systematically argued [17], where it is stated that weak conditioned trunk muscles, abdominals and imbalances between trunk muscles groups are not pathological, just a normal variation that will not lead to back pain directly, but will somewhat contribute to postural and functional deficiencies. Further on these findings, we need to argue and emphasize that when levels of muscles conditioning (low, high, weak, powerful, etc.) is considered we need to employ comprehensive and systematic attitude. This way we take into consideration final objective of the movement and the model that enables how it will be realized. Only in this case we can define adequate level of preparedness for specific muscle group, level of motoric coordination and other relevant parameters.

### SPINAL ENGINE AND EFFECTIVE MOTOR SYSTEM

Explorations of spinal engine interconnection with the legs activity showed [18, 19] that it is important functional motor parameter, where is vital to identify the behavioural pattern that leads toward controlled and effective motion. It is especially so when conditions for task completion are far from ideal or presumed, and postural challenge is also present. Although the most of the spinal engine functionality is rationally explained in the theory of spinal engine (and other consistent and complement research findings), there are still some new elements that should be explored. It is important though to mention that many stabilization interventions that should stabilize the spine artificially by reducing its spring like behaviour are counterproductive [18], except in short term utilization where spine stabilization contributes to injury prevention. Furthermore, merging cognitions about how the locomotor system performs that almost always comprises involvement of spinal functionality interrelated with pelvic girdle is essential. Anyhow, no human body part should be considered as passive or isolated, but the extent of participation may vary. Extremities also plays an important role in movements, however, cannot perform well without proper force vectors transmission and reliable, solid support.

## DISCUSSION WITH CONCLUSIONS

Human locomotor system condition can be considered as to be at rest (relaxed) or tensed, and in state with or without locomotion.

The state of **relaxed NFMSs and without locomotion** can be used to analyse individual postural parameters, and can allow determining if there is some disturbances in neuromyofascial slings network imbalances. Such approach allows identification of relations and also variations in anatomical slings. Stiffness's might vary from side to side, in anterior and posterior relations, as well as in diagonal that may be recognized from their anatomical trains – myofascial meridians [12].

Regarding **tensed NFMSs state without locomotion** that considers some level of muscular activity exists, and can be determined and monitored by EMG. In this case it is important to establish proper neuromyofascial slings coordination both in intensity and duration, for each active motor element up to whole chains, respectively. To be exact, each neuromyofascial sling is considered as motor chain as longitudinal line-up series of neuromyofascial subunits. Our perspective is aligned with findings [13] that muscles depicted within particular myofascial sling are connected via fascias to produce force vectors that assist in the transfer of load and movement energy. These muscles within a myofascial sling may overlap and interconnect with other slings depending on the change in force vectors needed for a competent dynamic movement.

**Relaxed NFMSs with locomotion** assume efficient utilization of synergistic principle, where antagonistic principle is used as the tension of working muscles alternates with the relaxation of muscles that are not involved in the movement. This principle enables optimal and effective transmissions of force and force couples vectors. A striking example can be the technical performance of athletes during the breaking of records. In literature such achievements can be found described as a lot of artistic expression of the athlete's condition at these moments. As, for example, we can adduce descriptions of the ease of running, jumping, throwing (athletics), hang like a bird in the jump (basketball jumps), ease of movements (boxing) etc. For such a highly technical performance it is necessary to strictly utilize the laws of the training process – the principle of the training and development of movement and congruency in the development of condition and technical skill. This principle enables optimal and effective transmissions of force and force couples vectors.

**Tensed NFMSs with locomotion** assume that antagonistic principle is not completely achieved as the tension is present in working muscles as well at the muscles that need to be relaxed during the movement. In this case, synergistically generated muscle forces and their resultant vectors that are induced cannot be effectively transmitted in order to result in desired motion. Transmission efficiency can be reduced if some motor elements are not able to perform accordingly at optimal ratio for specific activity.

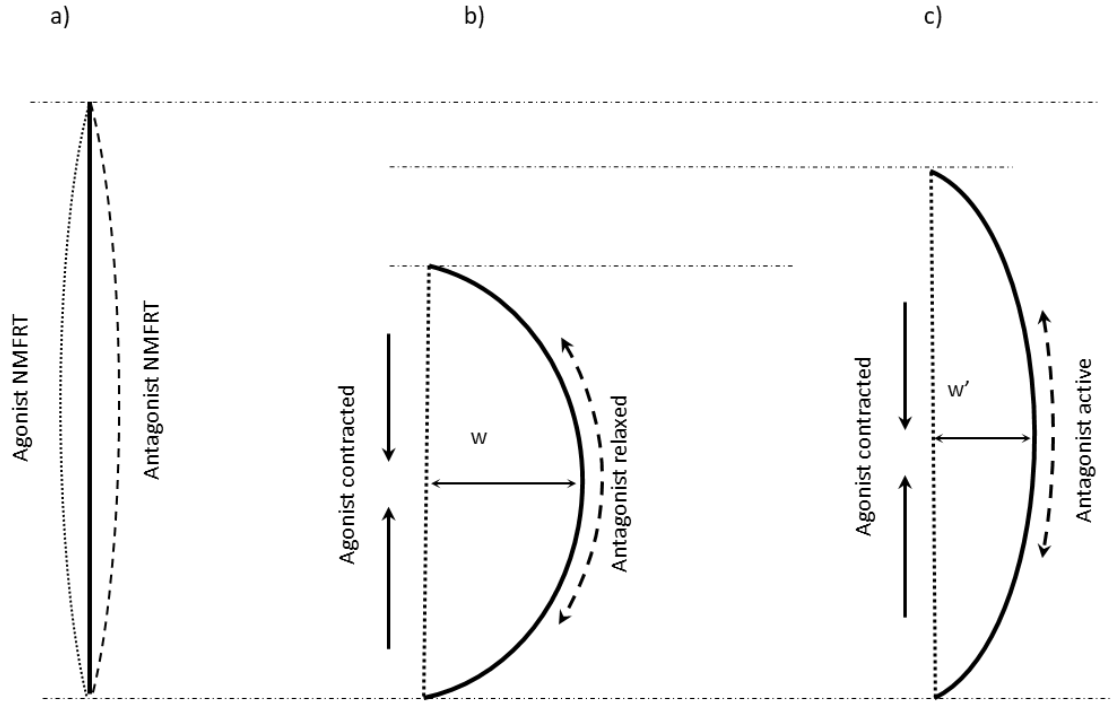


**Figure 1.** Illustrative model of antagonistic pair activity ratio effect on elastic line.

As example to discussed properties, we have used simple bow like behaviour of elastic rod (see Figure 1), designed so that antagonistic pair acts on him. From each opposing side is one viscoelastic unit that represents neuromyofascial sling (NMFS) that will interchange as agonist and antagonist. Figure 1a represents condition where both sides have NMFRT and potential energy is zero. Figure 1b represents condition that at agonist side contraction is present, so bow like rod flexes until it reaches potential energy level that is achieved at deflection w. Such level of potential energy is reachable only if antagonist side is stretched, yet relaxed. In Figure 1c one can observe absence of relaxation on antagonistic side with the same agonistic activity. This will consequently lead toward lesser net potential energy that can be generated due to reduced deflection w', that will also cause reduced range of motion. This is the case when coordination is not efficient. Only more thorough analysis can answer the question what is the reason of this. Reasons can be either fatigue (central nervous system, lack of biomechanical components, excess lactic acid, etc.), or an insufficient level in the development of conditioning (strength, speed, endurance, etc.). Also, the reason may manifest as an imbalance in the development of the individual groups of muscles, motor qualities or even whole functional preparedness. We cannot help but recall the influence of the whole training method or individual elements of training methods. For example, optimal preload is a tonic for a basic motor skill. At the same time, excessive load negatively affects following activity. In this case, to what level should the deficiencies observed be adjusted (rectified, harmonized and proportioned) according to objective purpose and direction? As just discussed, another perspective of muscle and neuromyofascial tone (NMFT) consider the stiffness factor issues and motor elements capability, from perspective of stress-strain properties that are tonus related, as well as changeable and affected by discussed parameters.

Since neuromyofascial units consists (from perspective of mechanical properties) of muscle and fascial tissues, as inseparable neuromyofascial unit one or both can be responsible for such reduced ability to relax.

Efficacy deficiencies arises from lack of sufficient coordination in postural abilities, as well as core condition, viscoelastic properties of muscle-fascia (neuromyofascial) elements, both on individual motor unit scale up to the level of the whole neuromyofascial web. This puts important contribution to biomechanical locomotor system understandings of humans and any other living being that consider locomotor system as integral, yet complex biomechanical system. However, answer to question how to properly manage conditioning of human locomotor system according to this newly arisen acknowledgement is still open.

Authors of this paper support attitude [13] that when the force vectors are balanced in their relative contribution to the movement, they provide optimal position of the bones and joints throughout dynamic movement. In contrast, imbalanced force vectors resulting from altered tension in the myofascial slings can create malalignment and potentially contribute to loss of stability during static or dynamic tasks. Prior to comprehension of neuromyofascial slings and fascintegrity, as paradigm such slings were considered just as muscles interconnected in series with connective tissue in order to orientate muscle force vector disposition. From the neuromyofascial resting tone (NMFRT) and biotensegrity – fascintegrity meaning perspective, one can conclude that level of postural and functional tonus is considered as optimal, harmonious and balanced in sagittal, transversal and coronal perspectives.

Although the sagittal and coronal planes are often dominant by transmission intensity, transversal plane should not be excluded or ignored since all motor potentials arise from complex biomechanical activities. Furthermore, we think that such planar considerations are unfortunate and misaligned with essence of biomechanical locomotor system effectiveness. Thus, our opinion is that only three dimensional locomotor biomechanical understanding could lead toward optimal advances in motor capabilities (demonstrated at elite sports on the example of breaking records - human possibilities), prevention recommendations and therapy. This opinion is consistent with the conclusions of other researchers [12, 13, 18]. Furthermore, we concluded that neuromyofascial biomechanical properties are important factor because it reflects ability of force vector generating time dependent capability, stress-strain curve and NMFRT.

Hence, it is important to differentiate NMFRT from NMFT. Authors identify NMFRT as individual level for passive postural poses as the initial neuromyofascial tone. It is the tone that is present on healthy subjects at wakeup. To define the NMFT, authors consider as any other level of neuromyofascial tone that is variable. Challenge is therefore to estimate optimal NMFT. Reason for estimation of optimal NMFT can be justified by the fact that different NMFT than optimal will compromise optimal motion. Thus, inadequate NMFT will cause other locomotor adaptations, compensations and compromises, which reflect the effectiveness of the learning process by movement in whole. This finding is very important from ergonomic perspective since it will reflects in effectiveness of the learning, training and preparation processes in sports and occupational practice. This is also valid for other fascial subassembly components, since they are the inseparable part of the same integral neuromyofascial network.

Proper estimation of properties and harmonization of all motor elements authors of this paper assumes as essential. Most strains, ruptures and similar injuries are related with inappropriate properties of viscoelastic functional motor elements, due to changes and conditions in which inharmoniousness occur. This is a highly present occurrence in sports and other high intensity and complex activities, especially when sore muscles change their properties, and their tendons should compensate lack of muscular extensibility.

Regarding perspective regarding stiffness properties, alteration of myofascial motor elements properties consider partially reduced extensibility of viscoelastic sling, especially if this is unilaterally present. This would be also the case if some tone persists in slings, so they are disabled to reach their NMFRT.

For restoration of locomotor capabilities due to acute and chronic injury conditions, we think that proper therapy should take into account the locomotor capabilities prior to occurrence of deficient condition, and to define dysfunctional subsystem. Of course, this opinion is valid in case of accident or incident consequences that are not caused by motor deficiency which could have been prevented. This is important not only from perspective of elite athletes, but is important for everyone since locomotor harmony should be achieved globally – for the entire locomotor system. Our opinion and recommendation ascend from the fact that complex locomotor biomechanical system or neuromyofascial network should always be at appropriate level of harmony. This level can be maintained or advanced by proper, yet harmonized treatment, not isolated to some narrow area of acute necessity.

From mechanical point of view in general, including biomechanical perspectives, holistically established harmony should comprise of multidirectional neuromyofascial components balance. That involves harmony achieved of acting motor forces and force couples, stiffness as well as viscoelastic properties paired. Balanced relations should manifest and be achieved in all relations (flexion-extension, bending, shear, longitudinal, oppositional, diagonal and torsional harmony).

Even simple locomotor activity involves appropriate coordination of complete locomotor system. To discuss effects of appropriate coordination and synergy on movement, we will employ example of plain upright trunk rotation around vertical axis, as torsional movement (see Figure 2). During this movement we will exclude extremities and their participation and will focus only on trunk slings components. Although we strongly encourage and support holistic analyses, despite to the use of the isolated body part, this example presents how slings acts as coordinated system, nevertheless depend on properties, capabilities and compatibility.

Though all neuromyofascial slings are assumed to be involved in this activity, at least passively, we will focus and observe just anterior and posterior trunk oblique slings. Figure 2

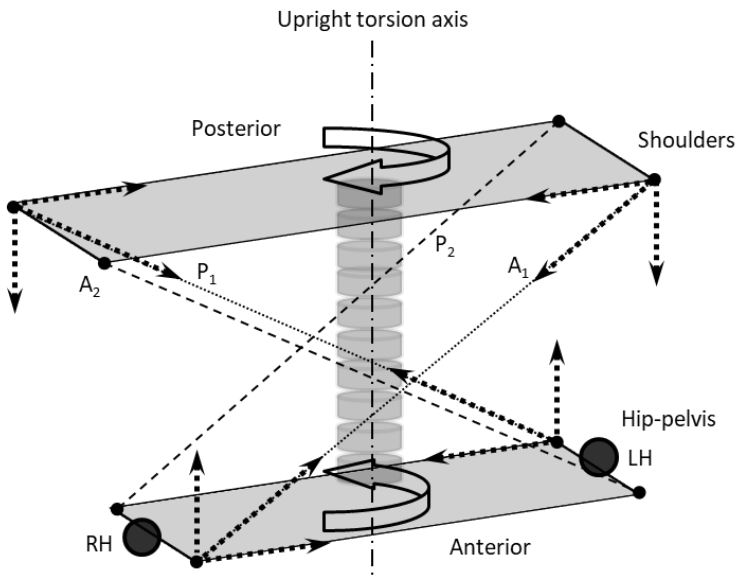


**Figure 2.** Illustrative model of anterior and posterior oblique slings synchronized activity during plain upright trunk rotation around vertical axis, as torsional spring movement.

represents simplified model that illustrate oblique slings vectors and their activity patterns, with respect to functional structure. Activated anterior oblique sling 1 ($A_1$) and posterior oblique sling 1 ($P_1$) at the same time will generate torsion spring like effect, so they need to work as pair in order to maintain posture and generate trunk rotation. During their activation horizontal and vertical components of their oblique vector forces have been generated. Horizontal components are making force couples at transversal shoulder and hip-pelvis planes, while their vertical components create compressive force on spinal segments and at the same time stabilize motion to remain just around the vertical torsional axis. At that time it is obvious that passive anterior oblique sling 2 ($A_2$) and posterior oblique sling 2 ($P_2$) are stretched and accumulate energy to restore trunk into neutral position, or to maintain alternation of torsional movement by active engagement. Taking into consideration mechanical properties and condition of slings from Figure 1 related discussion, we can conclude that only harmoniously conditioned locomotor system can perform well and without susceptibility to injury. Moreover, in cases where inappropriate force relations are present, especially vertical components that are unable to keep hip-pelvis area (or pelvic girdle) at optimal position, it is obvious that optimal transmission of force vectors is not to be expected.

In conclusion, since the complexity of human biomechanics and diversity of approaches can be identified, we need to get to the bigger perspective of the identified specific objective, as well as conclusions that comprehend all that matters. Such comprehension can be used for revision of currently utilized recommendations, standards and principles. Authors are inclined to consider the physiological processes in the single movement holistically, utilizing a comprehensive analysis. Such approach considers acknowledged interrelations in order to obtain systematic functionality patterns.

With accordance of integration of main components into inseparable whole of mechanical representation of human locomotor system can be only complemented with the motor control system, which regulates necessary fine-tuned neuromuscular coordination.

Necessity for NMFT determination level can be justified by objective which reflects the process of the learning or medical treatment process by movement in whole. This way we can obtain effectiveness of the learning, training and preparation processes in sports and occupational practice, which is in compliance with ergonomic criterions. The authors determined that for the correct analysis of the human locomotor system, it is necessary to consider neuromyofascial slings (NMFS) system in the following states: relaxed or tensed with or without locomotion.

Hence, adequate and proportional conditioning of all active system motor elements and subsystems that proves to be holistically harmonized is the key demand of an efficient motor system.

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# CONCEPT OF MODULAR, SELF-SUPPORTING CABLE FOR POWERING THE HOVERING UNMANNED AERIAL VEHICLE

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## ABSTRACT

Hovering unmanned aerial vehicles or drones can function as distant platforms for mounted sensors, as signal transceivers, or for other purposes. However, they must be tethered. The tether functions as a power cable that connects a tethered drone with a ground power unit. In this article, we developed a concept in which a power cable is of modular structure, consisting of mutually identical modules. Each module has motorised propellers and is capable of preserving itself in a given, hovering position. We formulated an equation for electric current that, for a given set of parameters, makes hovering of a drone with such a modular cable possible. The developed concept does not show significant improvement in maximum height reached by the drone. The underlying causes are extracted from a set of assumptions that define the concept.

## KEY WORDS

unmanned aerial vehicles, tethered flying vehicle, modular cable, hovering

## CLASSIFICATION

JEL: Q49

PACS: 87.19.lu

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# INTRODUCTION

Unmanned Aerial Vehicles (UAVs) or drones are nowadays utilised in a variety of commercial and defence-related processes. They have contributed substantially to broadening of diverse human activities through conducting them using, at least partially, the third dimension. One may argue that rapid enlargement of set of activities in which UAVs are used, whether as a crucial or as an auxiliary device, point to the fact that their potential in conducting different activities is still far from being developed.

UAVs mutually differ regarding their function [1], henceforth regarding their different parameters such as are mass, flight endurance, maximal take-off weight, etc. along with different sets of sensors carried by UAVs.

One among the lines of development is a hybrid approach to the UAVs as mobile masts for *ad hoc* constructions in which they serve as sensor platforms or information transceiver hubs. In particular, a UAV is a heavier than air, carrying sensors and hovering on a fixed position during certain time interval. UAV's electric motors are powered by electric current from a ground source. Thus the UAV is tethered, using suitable cable presumably for transfer of energy from ground source to the UAVs. Tethered lighter than air UAVs have been, since quite a long time ago, regularly utilised for long-term surveillances. Yet, they are rather sensitive to atmospheric conditions such as wind or wind gusts, what interferes destructively with the possibility of their use.

In this article we restrict analysis onto UAVs which are tethered, heavier than air, ground-powered, hovering sensor-carrying platforms. An eventual purpose of development of such a concept is the possibility to use such constructions in cases of emergency, when one needs rapid deployment of transceiver with sufficiently large range and quality of transmission, often in adverse weather conditions. Such approaches have already undergone some development [2-6].

A rather important parameter of such an approach is maximal height on which the UAV can hover for some rather long period of time. Since cable connecting the UAV with the ground power source has its own weight, in this article we analyse the concept of modular, self-supporting cable that powers a UAV on its top [7].

Section two contains the model. Section three contains the results, and section four the discussion of the results. Section five concludes the article and lists possible further development.

# CONCEPTUAL MODEL

## ELEMENTS AND ENVIRONMENT

We develop the concept of a powering cable, connecting energy source on the ground with a UAV hovering above it. The structure of the cable is modular. Each cable consists of a, in principle initially indeterminate, number of mutually identical modules. Along with the modules, cable is formed with two adapters, one connecting it to a ground power unit (GPU) and the other to a UAV.

Crucial requirement imposed on the module is that is self-supporting, in other words that it can hover in a still atmosphere. Additional requirements imposed onto it are: (i) every possible actuator that a module may carry utilises current of a same quality that is transported by the cable from the GPU to the UAV, and (ii) it makes possible transportation of sufficient electric energy. The last requirement is in fact naturally forwarded basic function of an

energetic cable, the module representing its sub-structure. In addition, for the presently adopted conceptual level, we impose the requirement that (iii) module is constructed out of certified, commercially available components.

Because of the last requirement, the dimensions of the wire, an electric conductor, and of the insulating shielding are standardised. Similarly, the materials of all these parts are of prescribed composition. As a consequence, the linear density of the complete cable, $\lambda$, is given in a form of discrete values. For the purpose of making the calculations more tractable, we broaden the list of parameters of available cables onto continuously variable parameters. Naturally, at the end we restrict the possible outcome of calculations onto the set of existing cables' parameters.

Before proceeding, a note about the environment is appropriate. Eventually, such a modular cable is to be utilised in a variety of weather conditions, the more demanding the conditions the more important the rapid deployment of functional modular cable. In that sense one expect that there is a power reserve in the system that may be used to overcome effects of e.g. wind gusts. Along with that, one expects sufficient robustness of such a structure, making it rather suitable for manipulation. These requirements are partially fulfilled. First, robustness implies that every part of a cable is mechanically resistant to small shocks and moderate friction. That eventually reduces possible cables, since not all of them are predicted, and certified, for use in open space, subject to degrading and intense weather conditions. For the moment, we do not consider explicitly required power reserve, to be used for preserving the vertical, or close to vertical configuration in case of diverse weather conditions (wind gusts being a serious threat to such a geometry). Instead, we restrict our analysis at the conceptual level onto functioning of the cable in a still atmosphere, thus without significant wind and rainfall. It is reasonable to assume that, if a concept is logically consistent within some set of parameters, that there will be possible subset of these parametric values that would include also the aforementioned requirement for power reserve.

For further development of the concept, we assume that a module contains: four sets of mutually identical electric motor powered propellers; a frame; a processing unit; and two connectors aimed for establishing quick-release connection with other modules, or adapters found at both ends of the cable.

## ELECTRIC CONDUCTORS

We extracted data from online sources of some of the commercially available electrical conductors aimed for use in open space. The data collected by no means form an exhaustive set, yet we did our best to form it as a representative set. However, if there had been a significant difference caused, its inclusion will change quantitatively some parameters but will not change the overall conclusions. From the collected data we formulated a constitutive relation between a linear density $\lambda$ and a maximal direct current $I$ that a conductor can carry for a long period of time:

$$\lambda(I) = k_{\lambda 1} \cdot I^2 + k_{\lambda 2} \cdot I + C_{\lambda}. \tag{1}$$

Values of coefficients were obtained after application of a least square method.

## ELECTRIC MOTORS WITHIN A MODULE

For electric motors we choose Brushless Direct Current (BLDC) motors, following the representative type of existing small rotorcraft drones. From available data we formulated another constitutive relation, connecting mass of the motor $m$ with the maximal power it can provide for a long period of time $P_{el}$:

$$m(P_{el}) = k_m \cdot P_{el} + C_m. \tag{2}$$

Following the approach described in the subsection *Electric conductors*, we obtained the coefficients in (2) for a representative, yet definitely not complete set of electric motors. In particular we obtained $k_m = 2 \cdot 10^{-4}$ kg·W$^{-1}$ and $C_m = 2{,}26 \cdot 10^{-2}$ kg, values that are used throughout this article.

## SELF-SUPPORTED MODULE

We assume that a module is capable of self-supporting it. Of course, that must be considered carefully, since a module has to be connected to other modules forming a closed electrical circuit. In that way we consider a stationary case, in which the lift generated by the propellers connected to BLDC motors is in balance with the weight of the module. A general approach is that the total lift must be somewhat larger than the total module weight, hence we start with the following equation for stationary case:

$$\varepsilon T_\Sigma = G_\Sigma, \tag{3}$$

with factor $\varepsilon$ taking into account stated difference between the maximal total lift $T_\Sigma$ and total weight $G_\Sigma$, lift being equal to thrust of the propellers from all the motors, which is in the case of quadrotor configuration of the propellers equal to

$$T_\Sigma = 4T, \tag{4}$$

with $T$ being the lift provided by a single propeller. In (3) and (4) we did not explicitly took into account aerodynamic drag of the module. Implicitly, it is incorporated in factor $\varepsilon < 1$.

Total weight equals

$$G_\Sigma = \lambda(I)Lg + [4m(P_{el}) + m_0], \tag{5}$$

with $L$ being the length of the module, and $m_0$ mass of all other components – a frame for motors, control unit and connectors – which are considered applicable with negligible modifications for different $L$ and $I$.

Electrical power $P_{el}$ is in motors transformed into mechanical power $P_{mech}$. It is connected with the thrust by the following relation for hovering rotor:

$$P_{mech} = \frac{T^{3/2}}{\sqrt{2\rho A}}, \tag{6}$$

where $A$ represents area of the circle described by the rotating propeller. Electrical and mechanical power are related with the efficiency factor $\eta < 1$:

$$P_{mech} = \eta \cdot P_{el}. \tag{7}$$

Finally, in case of direct current one has relation

$$P_{el} = U \cdot I, \tag{8}$$

where voltage $U$ is considered equal for each of the modules. Current $I$ propagates through all the modules. There are different was to electrically power all the control units and the motors. Here we consider the case in which electrically all the control units are connected mutually parallel. That is not the only case but, from the point of view of redundancy and thereby introduced safety level, represents suitable starting point for analysis. The opposite case would be that of the minimal redundancy, in which all control units are serially connected. In case of parallel connections the current flowing through modules differs and is the largest in the module connected to GPU. Let us consider that we have $n$ ($n$ = 1, 2, …) modules. In that case current through the module connected to GPU equals $nI$ and the total power becomes

$$P_{el} = U \cdot I. \tag{9}$$

Expressions (1)-(8), when combined, bring about the following equation for the current through the module

$$C_1 \cdot I^2 + C_2 \cdot I - C_3 \cdot I^{2/3} + C_4 = 0. \tag{10}$$

with the straightforward introduced coefficients

$$C_1 = k_{\lambda 1} L\, g\, n^2, \tag{11}$$

$$C_2 = k_{\lambda 2} L\, g\, n + 4 k_m\, g\, U, \tag{12}$$

$$C_3 = 4\, \varepsilon (2\, \rho A\, \eta^2 U^2)^{1/3}, \tag{13}$$

$$C_4 = C_\lambda L\, g + (4\, C_m + m_0)\, g, \tag{14}$$

System (10)-(14) was solved numerically for a range of lengths $L$ with constant voltage $U$ = 12 V and other data for set 1 of conductors (Table 1). We consider only values of current that are real, not complex numbers.

## RESULTS

Coefficients in the constitutive relation (1) for three sets of conductors are given in Table 1. Sets differ by the material of the conducting wire and insulating shield. Corresponding graph of the relation (1), for one of the sets of conductors, is shown in Figure 1. Precise values differ for other sets of conductors, but the quadratic form approximates the data well.

**Table 1.** Coefficients of constitutive relations $\lambda(I)$.

| Set of conductors | $k_{\lambda 1}$, kg·m$^{-1}$A$^{-2}$ | $k_{\lambda 2}$, kg·m$^{-1}$A$^{-1}$ | $C_\lambda$, kg·m$^{-1}$ |
|---|---|---|---|
| 1 | 0,00010 | 0,0030 | 0,0082 |
| 2 | 0,00002 | 0,0046 | 0,0634 |
| 3 | 0,00003 | 0,0058 | 0,0832 |

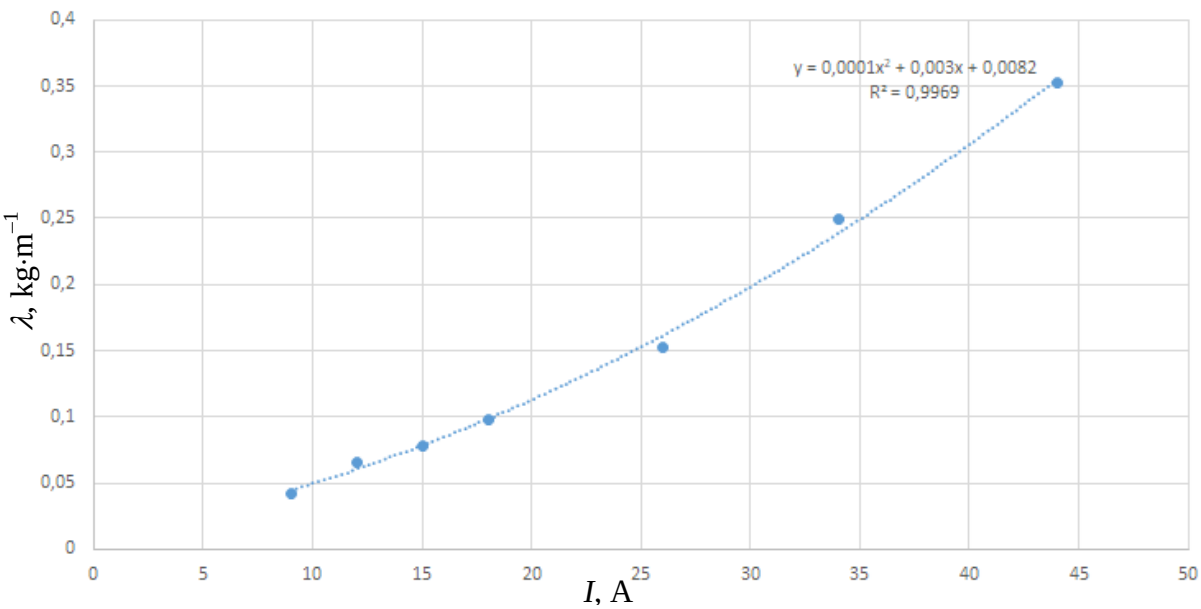


**Figure 1.** Linear density of the wire in dependence of the maximal constant current through it, as expressed by the constitutive relation (1) for conductors of set 1.

Constitutive relation (2) is shown in Figure 2 for a representative set of motors. Precise values would differ for more exhaustive set of electric motors, but one may argue that linear relation would approximate data with a sufficient degree in the conceptual approach.

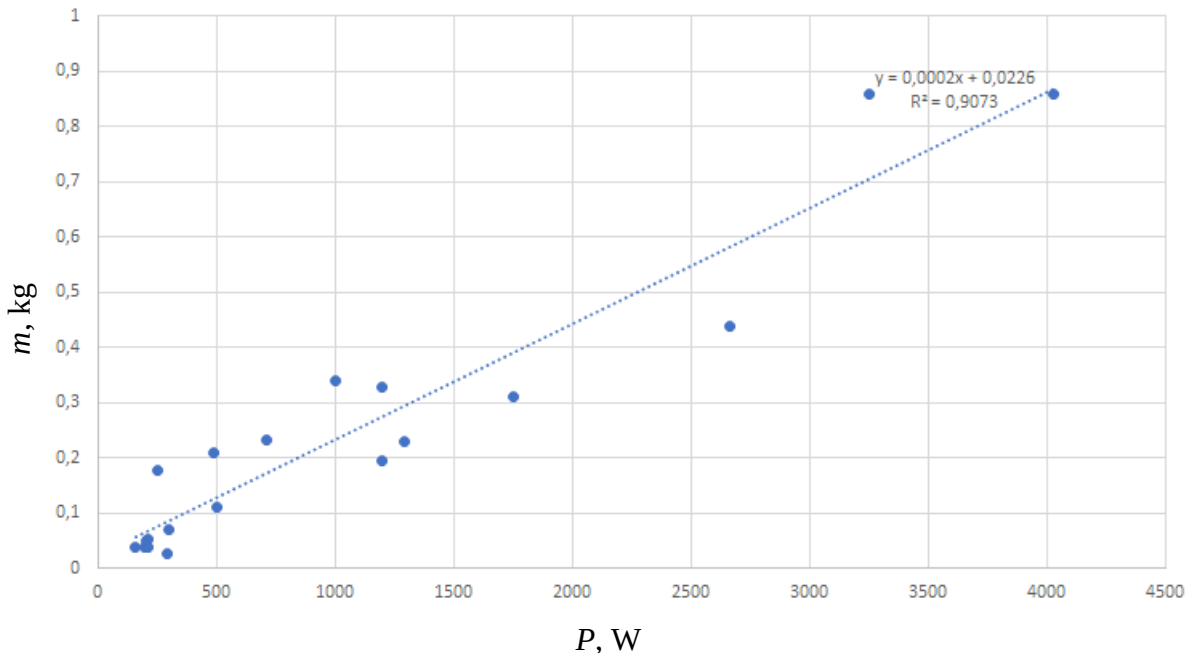


**Figure 2.** Mass of an electric motor in relation to its maximal generated power, as expressed by the constitutive relation (2) for chosen set of BLDC motors.

Current $I$ through the conductors, obtained by numerically solving equation (10). The only physical solution is shown in Figures 3 and 4. In calculations value $\varepsilon = 0{,}5$ was used. Accompanied total power which should be provided by GPU is shown in Figure 5.

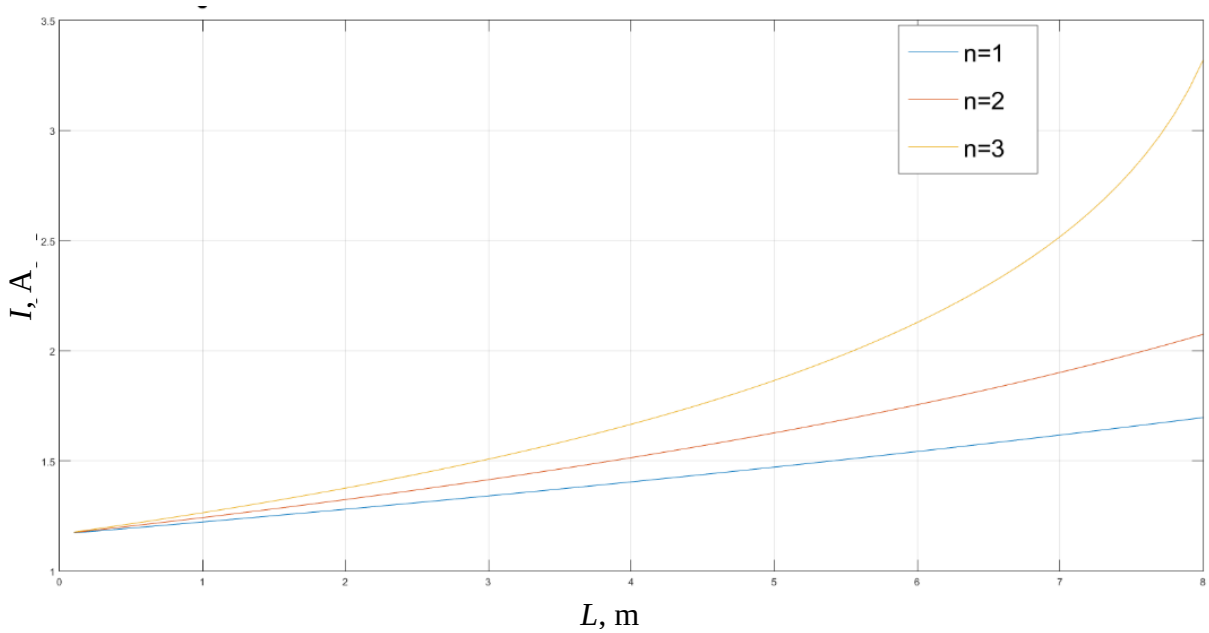


**Figure 3.** Current $I$, a solution of (10), in relation to the module length $L$, for set 1 of conductors as described in Table 1. Voltage of GPU is 12 V and number of segments equals $n$ = 1, 2, or 3.

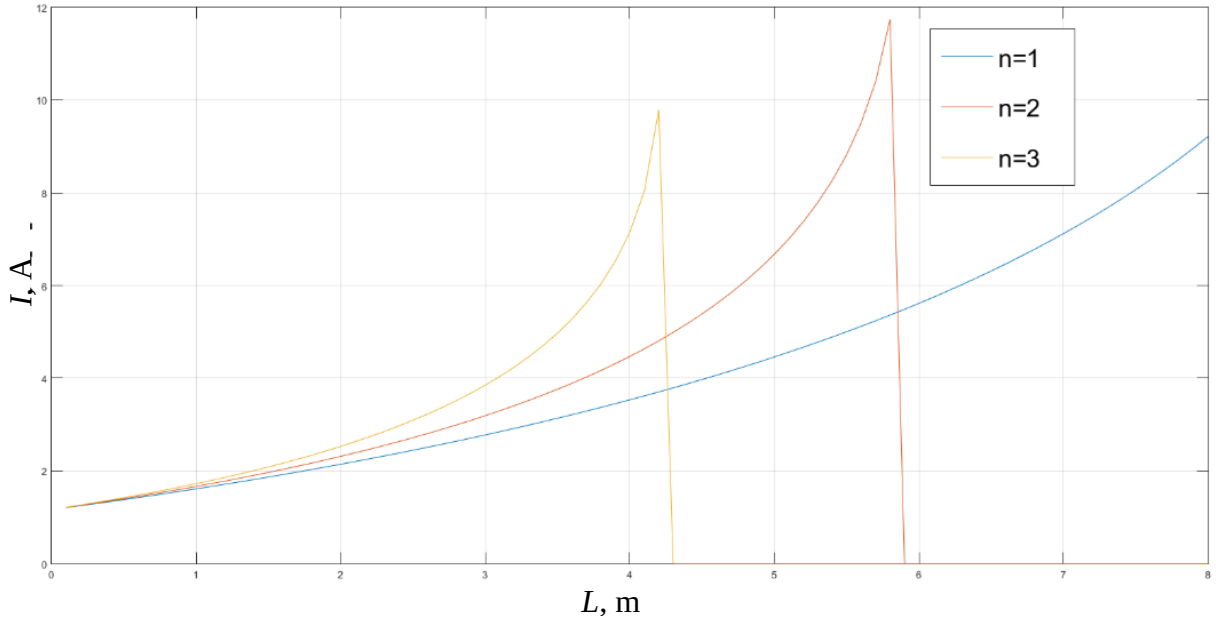


**Figure 4.** Current *I*, a solution of (10), in relation to the module length *L*, for set 3 of conductors as described in Table 1. Voltage of GPU is 12 V and number of segments equals $n$ = 1, 2, or 3.

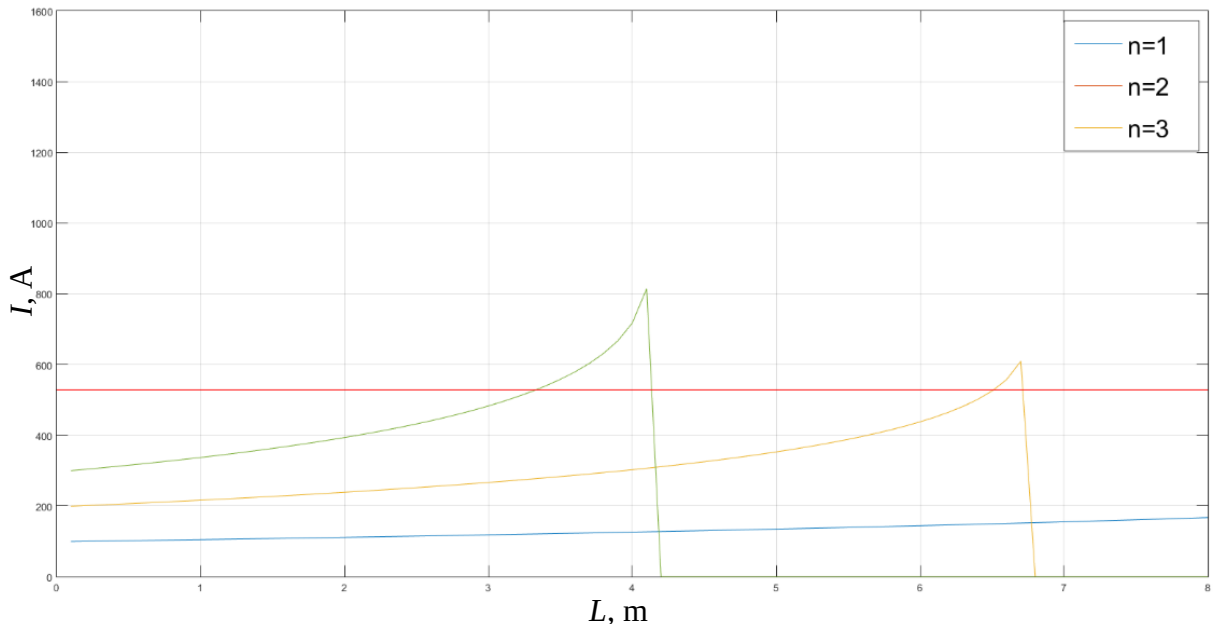


**Figure 5.** Total power (9), in relation to the module length *L*, for set 1 of conductors as described in Table 1. Voltage of GPU is 12 V and number of segments equals $n$ = 1, 2, or 3.

Total length of the cable is given in Table 2 for analysed combinations. All combinations belong to the same configuration in which modules are mutually identical and can carry total current flowing through a module.

**Table 2.** Total length of the cable for all sets of conductors and different number of modules.

| **Set of conductors** | **Number of modules** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| 1 | 14 m | 13 m | 12 m |
| 2 | 8 m | 9 m | 9 m |
| 3 | 6 m | 7 m | 6 m |

## DISCUSSION

Modular structure of the powering cable for making possible longer durations of hovering of drones is analysed. In prescribed configuration, on the conceptual level, modules are identical and carry uniquely defined current. Dependence of the total mass of the module on the allowed maximal current is well described with a quadratic polynomial. For a given class of electric motor, dependence of their mass onto generated power is sufficiently well described by a linear function. Naturally, owing to the numerical character of the solutions, more complex dependences were possible. Yet, having in mind that this is a conceptual level of approach and that underlying data do not form an exhaustive set of available data, the stated form of functions, as one may argue, is the optimal one.

A problem is transformed into an algebraic function that finally brings about the physically unique current flowing through the lowest module. That gives an insight into the general, nonlinear dependence of that current on a length of a module.

This is aligned with the fact that the longer a segment the larger its mass, bringing about a requirement of using a stronger electric motors, that additionally enlarge the module mass. For a fixed voltage large power implies larger current which, in a form of a feedback loop, requires larger cross-section of a module, eventually its larger mass. Self-consistently a unique relation between a current and a length of modules is obtained. It parametrically depend on a total number of segment having in mind the particular way of electrically connecting the modules. Foe any number of segments, there is a definite maximal length of a module because for larger lengths there is no physical current making possible self-sustained hovering of a module.

## CONCLUSIONS AND PERSPECTIVES

Possibility of using hovering drones in *ad hoc* networks for transmitting and receiving data is possible, yet rather vaguely approached, application of drones. For their longer contributing in such an application a possible approach is to have wired connection of a drone with ground power unit. Among the variety of conceptually different realisation belonging to such an approach in this article we analysed modular approach to powering cable with particular emphasis on the self-sustained hovering of a module. Preliminary practical considerations brought about the initial set of requirements imposed onto the analysed structure, which eventually was transformed into a mathematical model, numerically solved.

Results point to the fact that the concept developed does not bring any significant value to formal solution of the problem. In fact, there is no significant difference in total height of the cable depending on different number of its modules; a single cable represented with total number of modules equal to 1. That is traced down to simultaneous rise in cross-section of a conductor making possible larger flows needed for stronger electric motors, which are eventually required for making possible self-sustained hovering of the very module.

That is a consequence related to restriction imposed onto the concept in particular the rather significant redundancy, electrically parallel connections of control units with motors among modules.

A significant improvement of the modular in comparison with non-modular cable would imply different scaling of current with length or with number of modules. Here, we are not interested in quantitative improvements by taking into account different cables or electric motors, specially constructed to have more pronounced specific quantities. On the contrary, we are interested in qualitatively different scaling of current with the module length. For that purpose we consider that optimal solution to the problem of constructing a modular powering

cable for a hovering drone could be achieved with significantly different approach to redundancy in which electrical connections are implemented differently that in the analysed article [7]. One, naturally, expects that preserving the level of safety, then, would imply additional measures that are not explicitly represented in the formalism, but that forms a unique combination with the analysed construction.

## DISCUSSION

J.S. acknowledges initial approach to the stated concept, as well as constructive discussions with Mr. Ivan Vidaković.

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