E-Democracy's Representatives, a Proposal and a Case Study

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E-Democracy is nowadays seen as the viable alternative to contemporary representative democracy, which is blamed for being tributary to political clientelism or, even worse, oligarchic cliques. Some of both laymen and scholars misunderstand E-Democracy either for E-voting or for a perpetual referenda democracy mediated by digital instruments. In this paper we propose a model of E-Democracy which is based on representation using the perfect justice's procedure known so far: lottery. We advocate for lot selection of representatives or members of parliament (MPs) giving proofs of ancient, modern and contemporary political approaches. We try to identify some variables that define a political community and we also make simulations using random numbers on statistical data of Romanian population.
Keywords: *E-Democracy, Representatives, Random Numbers Simulation, Lottery, Sampling*

1 Introduction

Digital democracy or Electronic Democracy (E-Democracy) is nowadays seen as *the* possible and probable solution for implementing a new type of democracy [***1***] abiding real Participation, Deliberation and Inclusion (PDI). While ballot and elections are considered as the most important instruments of democracy, we propose in this paper a different approach that better supports PDI. Most laymen and political thinkers regard E-Democracy as merely a product of a new system or rather of a large digital application that consists of E-Voting. But E-Democracy represents more than voting using digital devices and different models of it have been already developed [***2***]**.** The author will insist in this research only on the problem of MPs and their cross-sectional representation, but he will also briefly discuss the citizen-MP relationship when describing E-Democracy's model.

PDI is the foundation of E-Democracy, and both are ends themselves but also instruments of a society seeking permanent advancement. While criticism of representative democracy mounts on a strong ground, the abolition of representative in favor of an institution such as permanent direct political initiative is utopian. Even with an outstanding technology in a future knowledge society where citizens are non-apathetic and well informed, pure democracy abiding perpetual referenda is rather a dream that can become a nightmare. Standing in front of a device and deliberating and voting is time consuming and eventually overwhelming for common citizen, neither a god nor a beast as Aristotle defined them. Thus we must not discredit scholars that support representative democracy [***3***], but we must definitely subordinate it to PDI for the same perennial reason: the fiercest enemy of democracy is democracy itself. Either tyranny of majority given by abandonment of PDI or apathy induced by higher standards of life commonly achieved may disrepute democracy [***4***]. This paper presents a technique which prevents both of them.

This article is organized as follows: Section 2 presents a model of E-Democracy where PDI is the foundation of citizen-MP association, Section 3 makes a theoretical proof of lottery as institution in democratic society, Section 4 discusses random number generators (RNG) , Section 5 displays empirical evidence of cross-sectional MPs representation when using lot and final conclusions are presented in Section 6.

2 E-Democracy's Model

E-Democracy's simplified model (ESM) is based on services provided to citizens but also on their providers. ESM is a growing and living system, which requires perpetual learning through experience but also demands institutions. Firstly, we define the already established institution of Chamber(s) of MPs (CMP), which must provide Political Service (PS). Secondly, CMP is helped and also supervised by two citizen services which are denoted as Helping Service (HS) and, respectively, Controlling Service (CS). HS is provided by Helping Committee of Citizens (HCC) and CS is the attribute of people's will **[**5**]** or Citizenry Committee (CC). Figure 1 illustrates the inter- and intra-relations of ESM:

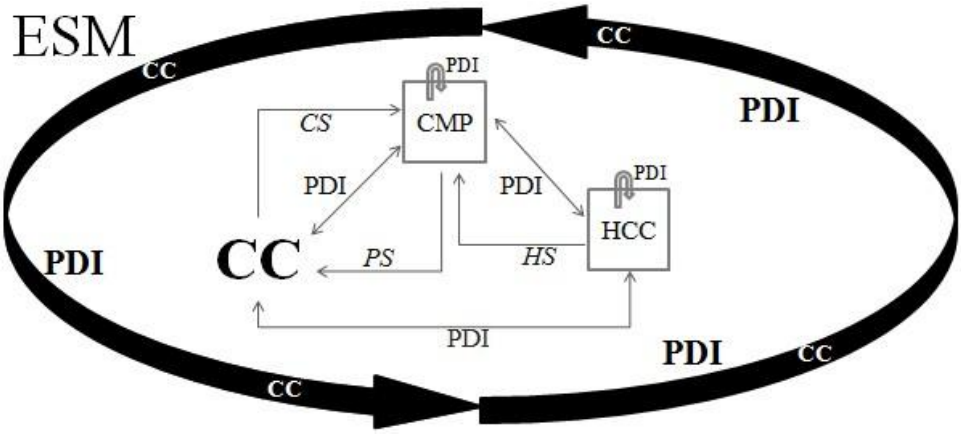

Fig. 1. ESM and its components

Although last mentioned between the institutions of ESM, CC is practically not only the most important, but also the essence of the model. CC contains the other institutions of E-Democracy and, with a perpetual activity of PDI that concocts them, provides the framework of ESM. While CC does not change its form and size, only for objective demographic reasons with time passing, CMP and HCC are subjects to quicker renewal. The former normally has a well-delimited duration and their PSs are based on contextual issues (CIs). For each CI of any PS a new instance of HCC is created and this provides counseling for CMP through HS as long as CI requires resolution. Both CMP and HCC headline inner and outer PDI. After several rounds of deliberation, which are or are not time constrained on a initial phase (on a later phase this may become an issue) CMP will receive a final solution from HCC. The solution provided by HCC for any CI will be based on voting (and not on consensus) or, hopefully, on E-Voting. If CMP ignores the solution of an instance of HCC an automatic procedure will create an instance of CS, which will initiate an E-Referendum where CC may express their will to support either CMP or HCC. If HCC does not get support from CC this proves that CMP took the right decision (we do not discuss here constitutional issues and the role of a body with constitutional advisory or mandatory attributes), otherwise CMP should be dismissed or may receive a warning (e.g. 'yellow card') as the procedures previously obtained through PDI stipulate. Thus, ESM proposes a two-tier body of representatives, i.e. CMP and HCC, under the control of CC. On a minimal level, ESM does not take into account other important institutions of democracy: executive, justice or presidency/monarchy (which are subject to a more elaborated model of democracy). We may group, in this simplified model, these missing actors under the hood of CMP, although justice representatives definitely have a different status and executive body, as a rule, is not directly resulted from CC.

ESM describes an approach (see Figure 1) that does not question contemporary representative democracy (CRD), but rather establishes a framework that at least validates if not improves it. To better support this allegation we illustrate in Figure 2 the dynamic display of ESM through moments M_i of time, $i = 1, 5$.

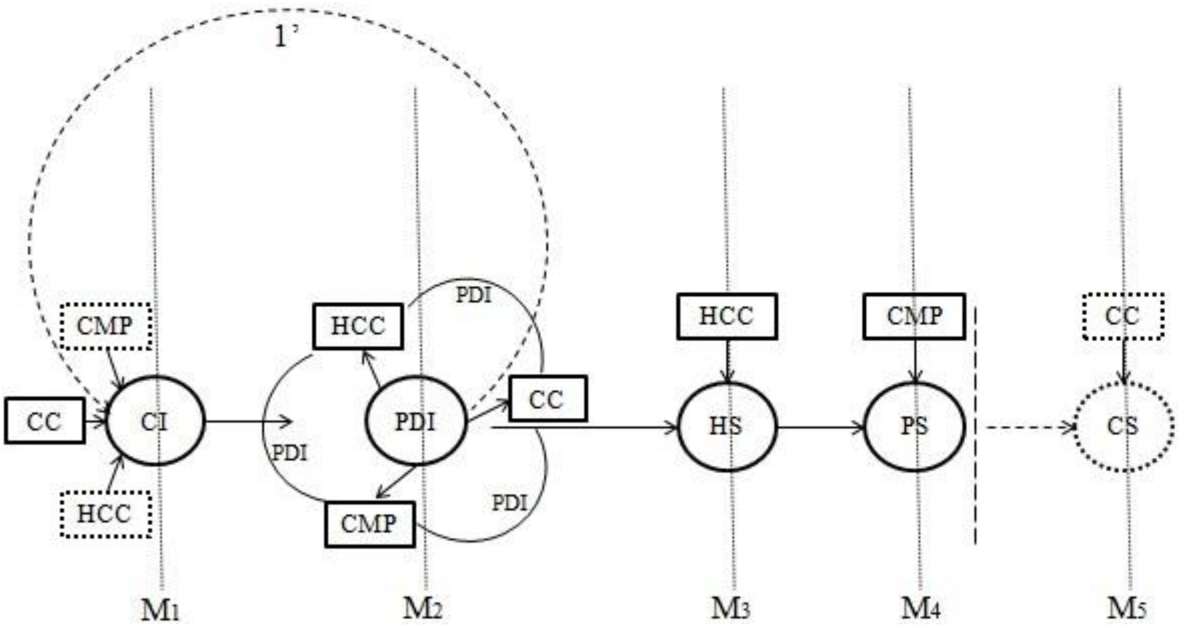

Fig. 2. Dynamic model of E-Democracy

We observe in Figure 2 that M_1 is similar to actual formula of CRD, with the difference that those who establish the agenda in CRD are MPs (i.e. CMP) rather than citizens (i.e. CC). ESM emphasizes the role of CC as a principal institution of democracy, but it does not deny (on the contrary, it encourages) the right and capacity of both HCC and CMP to identify a CI.

For i = 2, 5 each of M_i are elements of an extension of the contemporary democratic political system. M_2 is the moment when, under the hood of PDI, all actors are involved in solving a CI, although a simulacrum of deliberation may be seen nowadays. Figure 2 illustrates, when we focus on M_2, what is intuitively regarded as the most important part of ESM. This is the time when CC, HCC and CMP must cooperate and exercise the instruments of E-Democracy for two main reasons: a valid decision and perpetual training by trial and error through PDI. This is normally the moment when the actors of ESM identify a new CI. We also must argue on the issue of right representation at M_2, but we will discuss this in more detail in Section 3.

In the moment of time M_3, HS is activated and the result must be interpreted, under a probability given by mathematical and statistical apparatus, as an expression of people's will. Voting or, even better, E-Voting is the method to evaluate and decide on a CI. Consensus has two major problems: a) totalitarianism that might emerge from bringing all participants to a common denominator (e.g. by propaganda and manipulation or by inducing a psycho sociological state of non-participation and exclusion to those opposing majority) and b) the probable impossibility of reaching a result accepted by all participants and the consequently deadlock.

M_4 is the moment when PS is activated, and the destination of the latter's result is CC, which includes HCC and CMP and also some other institutions of democracy that are willing to actively participate (e.g. NGOs, political parties, unions and professional associations etc.). Normally, CMP should conform to the decision of HCC, if it exists. On the other hand, CMP has the right to ignore HCC's decision if some criteria, a priori established through PDI, are not respected (e.g. the quorum, which is an important indicator of real representation and which will be subject to a different research). If we take into consideration the ridiculous situation, but not so improbable at all given the nowadays political behavior, that citizens do not get involved at M_3, CMP becomes the only representative institution of ESM.

The last moment of CI's itinerary (i.e. M_5) might seem undesirable at a first glance. Yet,

M_5 is a necessary procedure and it represents an instance of the automated process caused by the disregard of HCC's decision at M_3 by CMP at M_4. Ideally, it would appear that M_4 never produces M_5 and the probability of casting an E-Referendum is null. Still, there are a couple of elements that support the necessity and need for M_5 in situations defined by a low probability. First, the odds that HCC is not always representative are very high and, thus, CMP might took the right decision ignoring HCC's resolution. Second, the system (e.g. ESM) or a specific problem (e.g. CI) may need a larger participation and/or validation from time to time. More, a solid reason is that ESM demands the training of all its procedures, given the fact that on long term there will be auspicial results from the conflict between CMP and HCC. If M_5 is latent from a long period, there are high odds that, once it is arisen, CS would be incapable to be effectively run, due to lack of practice.

The political system of ESM has two strong aspects that would make it at least acceptable for the supporters of CRD: a) it does not exclude the institution of representatives and b) it provides a larger framework for PDI, which, refused by the citizens (e.g. HCC), would only validate CRD (through the latency of M_i, where $i = 2, 5$).

Even on a minimalist framework ESM has an important problem to solve (before dealing with the important issue of quorum): designating representatives, i.e. CMP and HCC. While for CMP democracy has developed the institution of 'free-elections' from ancient to modern and contemporary times, the author proposes in this paper a new approach that definitely fits HCC, but also applies to CMP under the constraints of pure democracy abiding PDI: lottery.

3 Selection of Representatives

At a first glimpse, it may seem that lot and politics are irreconcilable because it would throw over society a veil of triviality and randomness which may lead to chaos. On the contrary, lottery is rather the perfect procedural justice that was illuminatingly described as the veil of ignorance by the 20th century innovative thinker J. Rawls [***6***]. Although E-Democracy is rather a non-contractualist system based on permanent PDI [***1***] that would rather find solution for any CI without a priori biases, it needs some rules that will also support PDI. And lottery as the optimum rule for designated members of political bodies that represents almost accurately the members of the entire community or population was discovered from antique Greece [***7***]. Athenians used lot to assign political offices as a form of political equality, but also acknowledged elections as political opportunity based on merit [***8***]. Lot was rather for positions were particular skills were not required and for members of boards, committees and assemblies, rather than military or some administrative officials [***7***]. Athenians divided duties on boards and committees (e.g. HCC) rather than to expect the providential leader that would figure out the solution, and members of these representative bodies were designated for a year by lot, which also prevented intrigues and corruption. More, Mulgan, based on research on antique democracy, identifies four strong reasons that uphold lottery as a democratic device for selection in old Greece: a) reducing factionalism and competition; b) preventing influence over particular bodies or officials; c) reducing authority of delegates and d) providing typically representative bodies [***4***,***8***].

But ancient Greece influenced the advocates of modern and contemporary democracy. In the 18th century the illuminating propaganda for general will of J.J. Rousseau, inspired by Montesquieu and which revitalized democracy after two millennia, also made appeal to lottery (giving the example of Republic of Venice) as procedural just selection of representatives [***5***]. Switzerland, one of the most participative democracies nowadays, used lot allocation for public offices in 16th and 17th century [***9***].

Starting with the middle of the 20th century, lot has aroused much more interest in social and political life. Separating ignorance of randomness as co-operative social bond from ignorance of responses as conflict behavior, Aubert identifies the propensity of Homo Ludens for game of chance, rather than for those of skills and strategy. But he also discusses the transcendent lottery benefits and proposes several social functions of chance theory and practice (Communication with the Supernatural, Innovation and Creativity, Representativity, Equality and Justice) that act through redistributing: "money, goods, prestige, the benevolence of the gods, future prospects in love and business, the joys of victory, and frustrations of defeat" [***10***]. Greely made strong proofs for lot allocation over choice, undertaking random selection for several goals [***11***]: "satisficing" over maximization, reducing discretion, avoiding undesirable self-perceptions, human dignity by equality of opportunity and fair treatment, choice avoidance.

While Goodwin [***12***] advocates for social justice and Amar [***13***] goes further with pure justice by lot and both agree with some random selection in politics, Mueller et al. endorsed, more than a decade before them, randomized legislature by strata and proposed several alternatives: an additional national legislature to the present ones or replacing one of them, an exclusive national legislature replacing one or all of the existing, a mandatory or an advisory body to be used by request [***14***]. Participation from citizens (with educational benefits on human equality) and their random selection, promoting alternation and division of duties, will prevent monopolization of leadership from "oligarchic cliques" [***8***].

In hope that lottery, as democratic instrument of selection, has proved to be essential for public offices assignment, we must define a procedure of sorting representatives abiding [***15***]: impartiality, independent choice, ignorance and fairness (IIIF).

4 Methods of Random Number Generators (RNGs)

Randomness or unexpected or aleatory is part of our life, which either we want to ignore or we want to believe that is a component of a deterministic process. Only that last century's researches in physics, chemistry and biology with practical applications in economy, outline a framework of stochastic processes. Politics and its implications at psychological and sociological level are probably more complicated, and definitely not described by a determinist approach. Randomness, as we have seen in Section 3, is an aspect of true importance and not only to politics but to computer science fields: simulation, sampling, numerical analysis, computational programming, decision theory and leisure [***16***]. Starting with the 1950s and the developing of computational methods, RNGs have been improved and adapted to specific fields, with two major types of RNGs: real and computational. The former is based on observation of a real happening in different courses of action: acoustic and visual signals in atmosphere, level of radiations etc. This kind of aleatory is based on pure haphazard, but respects all IIIF except for the second one (i.e. independent choice). The problem appears when we need to re-run the process, which is an important part of a democratic electoral system (e.g. in case of results contestation). Hence, the latter, computational RNG which is consider in this paper as ordinary or aleatory, is more suitable for our purpose. We also have two types of computational approach: (regular) random numbers and quasi-random numbers [***17***]. Quasi-RNGs are similar to RNGs, but they have a regular behavior and are very useful for Monte-Carlo simulations, which is not our case. We need to extract on aleatory basis some indicatives of individuals without knowing a priori the distribution of sorted numbers, respecting IIIF and especially the third and fourth rules.

Regular or quasi-RNGs, they have the same mathematical definition [***18***]: a generator of random numbers is a procedure that creates a sequence

$$U_1, U_2, U_3, \ldots \overset{IID}{\sim} Dist$$

where all variables U_i, with i = 1,2,3,..., are independent and identically distributed (IID), meaning each variable has the same probabil-

istic distribution and does not depend on other variable.
Let us define:
- S is a finite set of states
- f is a mapping function, $f : S \rightarrow S$
- μ is the probabilistic distribution of selecting S_0 from S
- U is the output space, which contains the variables U_i cu $i = 1,2,3,...$
- g is an output function, $g : S \rightarrow U$

Let us take MRNG as the general method of any RNG, which is a tuplu (S,f,μ,U,g), and let us define the (initial value) *seed* S_0. The algorithm of MRNG is [***17***,***18***]:
1. Initialize: Draw the seed S_0 from the distribution μ on S. Set $t = 1$.
2. Transition: Set $S_t = f(S_{t-1})$.
3. Output: Set $U_t = g(S_t)$.
4. Repeat: Set $t = t + 1$ and return to Step 2.

The sequence of generated values U_1, U_2, U_3, ... has a number of steps until it enters a previous generated state and the smallest such number is called the period length. In general, this is probably the most important aspect for most researchers when judging a RNG, but there also are some other properties that we should take into consideration [***17***] passing statistical tests, theoretical support, reproducible, fast and efficient, multiple streams, cheap and easy, not producing 0 and 1.
Before discussing the taxonomy of RNG, let us present some proof for not using quasi-RNG. Figure 3 illustrates quasi-numbers of four algorithms: Sobol, Halton, Faure, Korobov [***17***]:

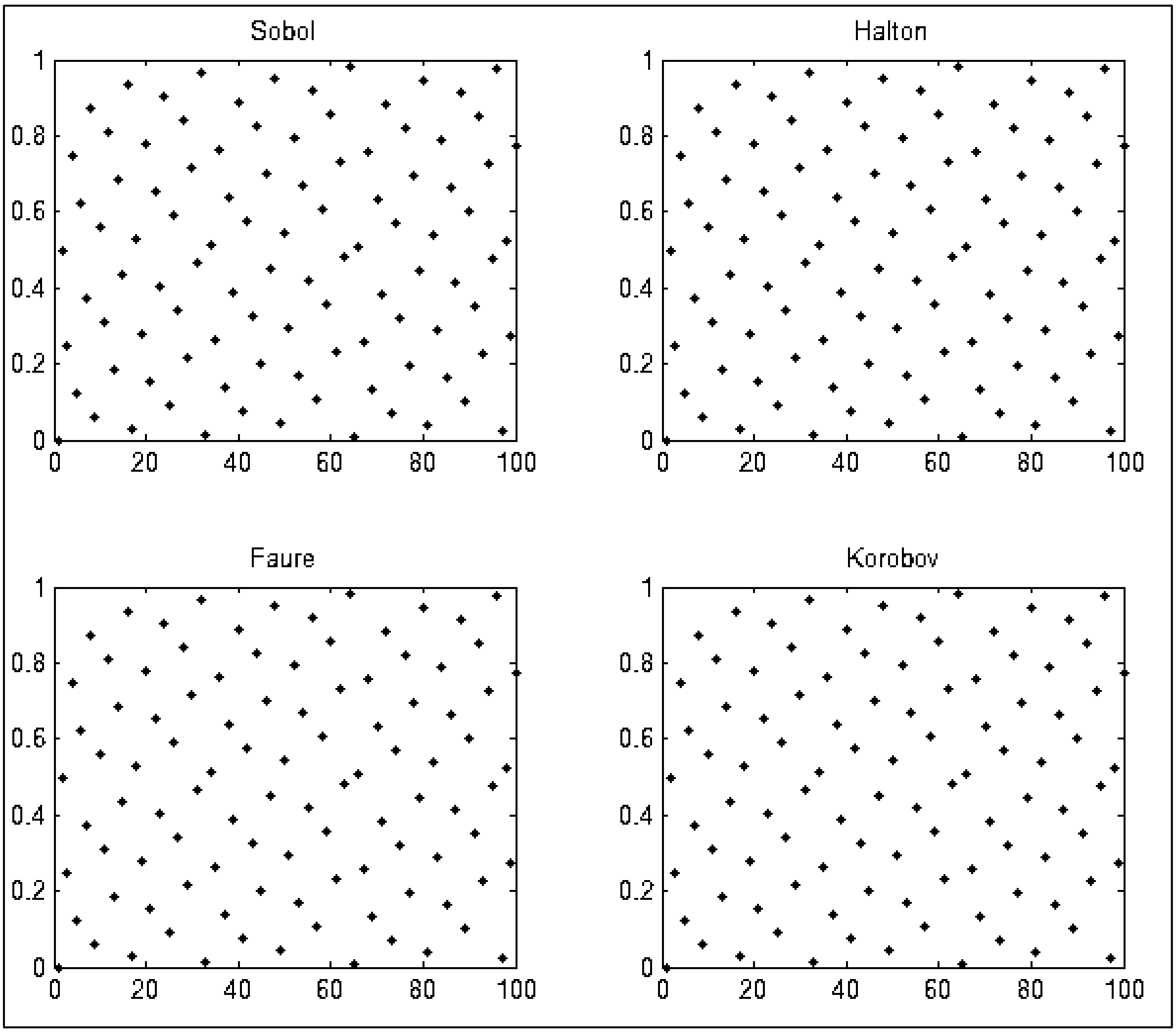

Fig. 3. Examples of quasi-RNG for 100 generated numbers between 0 and 1

In order to strengthen our proof for avoiding the use of quasi-RNG, we also present some results of computational simulations for each of the four approaches. Using the interval between 0 and 1, Table 1 displays some values of generated numbers from Figure 3.

Table 1. Values of some generated numbers between 0 and 1

Index	Sobol	Halton	Faure	Korobov
1	0	0	0	0
2	0.5	0.5	0.5	0.5
4	0.25	0.25	0.25	0.25
5	0.75	0.75	0.75	0.75
6	0.125	0.125	0.125	0.125
7	0.625	0.625	0.625	0.625
80	0.9453125	0.9453125	0.9453125	0.9453125
98	0.5234375	0.5234375	0.5234375	0.5234375
99	0.2734375	0.2734375	0.2734375	0.2734375
100	0.7734375	0.7734375	0.7734375	0.7734375

We observe in both Figure 3 and Table 1 the predictable and identical pattern (i.e. recursive dividing into halves) of each of the four algorithms when generating quasi-random numbers of a one-dimensional vector (suitable for our purpose). Without detailing the mathematical background of quasi-RNG (see [***17***] for this), we believe that these empirical proofs of not respecting IIIF, visual (i.e. Figure 3) and numerical (i.e. Table 1), ground the decisions of not taking them into consideration and of focusing on (regular computational) RNG.

There are three main classes of RNG [***16***,***17***,***18***]: generators based on linear recurrences, combined generators (they use mixed methods of the first class) and others (they belong neither to the first nor to the second class). From the first class we identify several types: linear congruential generators and the particular case of multiplicative congruential generator, multiple-recursive generators, matrix congruential generators and matrix multiplicative recursive generators, modulo 2 linear generators and their particular type of feedback shift register generators. Examples of the second class include algorithms that mix individually methods of the first class resulting a good quality output: based on several linear congruential generators or on combined multiple-recursive generators etc. Algorithms of the third class are variations of linear congruential methods, generalizations of methods from second class using different kinds of binary operations (e.g. shifting), nonlinear congruential generators with particular type of inverse congruential generator etc.

We only discuss here two types of algorithms that we find useful for our purpose: selection of individuals for public offices by lottery. The first type that is worth a mention belongs to the second class and it includes methods that act like a twisted version of generalized feedback shift register generator: Mersenne twisters. The most popular, with a huge period of 2^{19937}-1 and passing most of statistical tests [***17***], is MT19937 and Equation 1 presents its linear recurrence formula for a sequence of random uniform integers between 0 and 2^w-1, given the following original notations [***19***]:

- n - an integer designating the state index (see t of MRNG), or degree of recurrence
- $x_0, x_1, \dots x_{n-1}$ - initial seeds (see S_0 of MRNG)
- r - an integer, $0 \le r \le w - 1$
- m - an integer, $1 \le m \le n$
- A - a square matrix of $w \times w$ dimensions, element $A_{i,j} \in \{0,1\}$, $i = 1,w$, $j = 1,w$
- x_k^u - the upper w-r bits of x_k
- x_{k+1}^h - the lower r bits of x_{k+1}
- $\otimes$ - bitwise addition modulo two
- | - concatenation of two vectors

$$x_{k+n} = x_{k+m} \otimes (x_k^u \mid x_{k+1}^h)A, \ (k = 0,1,...) \quad (1)$$

The second algorithm that we consider suitable for our research is MRG32k3a [***20***] and, although with a shorter (than MT19937) period of 3 × 10^{57}, it passes all of statistical tests [***17***]. This is a typical algorithm of the second class (i.e. combined generators) coupling two multiple-recursive generators of order three, with a formula presented in Equation 2 using the following notations:

- *t* - an integer, designating the state index (see *t* of MRNG)
- mod - modulo operation
- X_t - current state of the first algorithm used in combination (see S_t of MRNG)
- Y_t - current state of the second algorithm used in combination.

$$X_t = (1403580 X_{t-2} - 810728 X_{t-3}) \bmod m_1 \ (m_1 = 2^{32} - 209) X_1, \ldots, X_n$$
$$Y_t = (527612 Y_{t-1} - 1370589 Y_{t-3}) \bmod m_2 \ (m_2 = 2^{32} - 22853) \quad (2)$$
$$U_t = \begin{cases} \dfrac{X_t - Y_t + m_1}{m_1 + 1} & \text{if } X_t \le Y_t \\ \dfrac{X_t - Y_t}{m_1 + 1} & \text{if } X_t > Y \end{cases}$$

In Figure 4 we illustrate some generations of random numbers using MT19937 (see Equation 1) and MRG32k3a (see Equation 2), each time starting with a different seed (see MRNG).

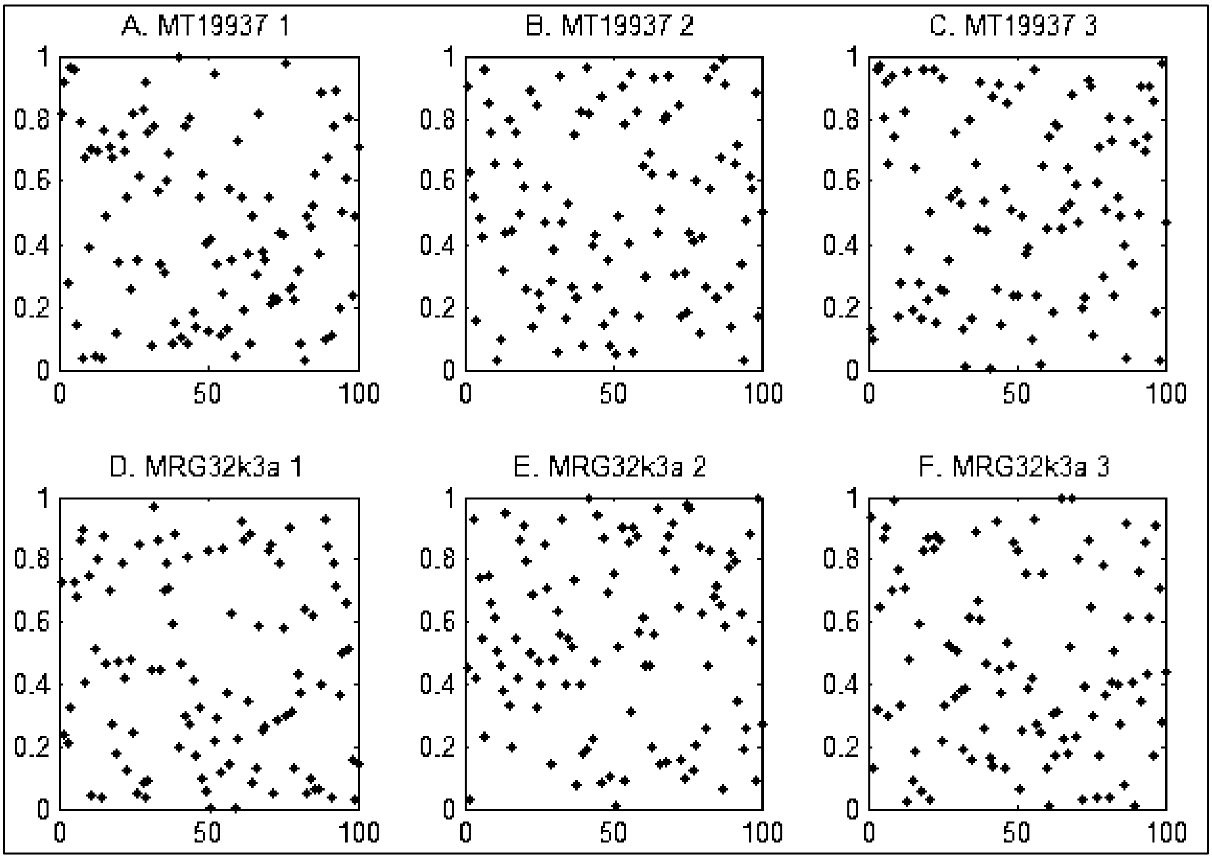

Fig. 4. Examples of 100 generated numbers using MT19937 and MRG32k3a

The visual empirical proof of Figure 4, with any numerical needed but with theoretical

support provided [***19***,***20***], assures us that there is no obvious pattern in generating random numbers with MT19937 and MRG32k3a, unlike the quasi-random numbers displayed in Figure 3 and Table 1.
Both MT19937 and MRG32k3a need a seed to start the generating sequence of random numbers. Choosing haphazardly a seed (e.g. using a Geiger counter or a computer clock time) will raise the important issue of authenticating the result by re-running the process. It may become totally arbitrarily the choice of the seed and uncontrollable by a large audience. Hence, we recommend a method of generating the seed (MGS) that can be re-run and which involves great participation from individuals (seen as voters):

MGS1) Every voter chooses one number from a certain range.
MGS2) All numbers are stored in different locations and open to public only after voting.
MGS3) The seed is extracted as a result of some operation on voted numbers.
MGS4) The seed is used for RNG and for extraction of indicatives of individuals.

MGS requires some hardware and software resources, which will not be minutely discussed in this research. Yet, from a sociopolitical point of view we need to explain the steps of MGS. The first one establishes the accountability of citizens, the more participants the more representative and secure the result is. If low involvement, the anticipation and manipulation of result is easier and much more probable if anyone tries to hack or even crack the system. The second step requires the most of the attention, especially from the integrity (e.g. security, storing, protecting etc.) point of view. This is such a vast domain that it cannot be discussed here, but it is definitely worth being mentioned. Storing of voting numbers must be done locally by individuals and on distributed servers by institutions (e.g. CMP, HCC etc.), such as the rerun of the process should be available in case of controversy. MGS3 demands sorting the voted numbers by some criteria (e.g. moments of time: hour or seconds or milliseconds) before the operations (e.g. bitwise and XOR) applied to them yield the seed. Sorting the numbers from distributed locations will increase the security and will give a queue of numbers waiting to be processed. The last step of generating random numbers, using the seed obtained in the third step, should be proceeded by a shuffle of the vector that contains the indicatives of potential assigned individuals to public offices. This shuffle is done in the same manner: using a RNG algorithm with a seed calculated by MGS (applying different operations in step three, for example). As concluding remarks of MGS, we say that this proposed method of generating the seed requires hardware and software resources at low and, respectively, medium level and also requires a high level of participation from citizens.

5 Results

Selection of representatives is similar to the well-known technique of sampling of population, very useful in sociological, statistical, marketing and other researches. This means that it is possible to extract a small part (i.e. sample) from a population which reveals the characteristics of the whole population under some probability defined by a rigorous mathematical apparatus. In order to verify the empirical work of selecting representatives for public offices we need to define some important sampling characteristic (ISC) of the population and then to confront the theoretical background with the results yielded using computational simulated MRNG, MT19937 or/and MRG32k3a (CSM).
Before discussing the results of CSM, let us define and explain the variables of ISC especially from E-Democracy's point of view:

- ISC1: *Gender*. The benchmark of democracy, but totally ignored until J.S. Mill's propaganda of 19th century and never openly accepted afterwards [***21***], is the role of women in public offices. We state that the unequally representation of women in politics is a severe infringement (or rather a violation) of democratic principles with negative benefits for society. Without detailing, we must point out on the quantity factor (i.e. the indubitable parity between the two sexes) in order to support a compulsory representation by gender. Thus, women should held political positions at least in an equal percentage with men, if not a little bit more (see Table 2). We have already discussed that competency is not necessary in politics but in administration, see Section 3, so that opponents of compulsory representation of women in public offices or even radical feminists eager to compete on all levels with men receive the same answer: men and women do not compete but complement each other. Of course, we never say that there is absolutely no competition or shouldn't be, but rather an interdependent and reciprocal relationship. One argumentation of this latter statement is the simple act of human reproduction, although cloning might be a solution for a new breed of future society which we do not support at all. Another reasoning on behalf of compulsory women representation is the Jungian thesis of psychological development of human personality. Thus we both develop ourselves on two bases: Logos or knowledge personified as man and Eros or love as woman. More, the individual spirit is defined by a female side for man (i.e. *anima*) and a male side for woman (i.e. *animus*) and the lack of one of them entails a malfunction of the human psychic [***22***]. Finally, we do not challenge the assertion that woman normally has a high aversion to risk and is more conservative, but in a society that exalts speed, technological and economical progress (Logos facet) and forgets the spiritual, cultural and emotionality (Eros inclination), gender parity is imperious for E-Democracy's society of inclusion.

- ISC2: *Age*. This another important criterion of a democratic society, as important as gender. Most of a time, a sort of elitism of senectitude is preached, congruent with the wisdom for so many. We do not argue that life experience is important, but definitely not decisive. A first reason to support age representation is the simple fact that being able to vote put one in the consequent position of being eligible for politics and public offices. More, let us not forget the not so long faded times when young people over 18 years old were cannon fodder in case of war. And we all know that for many artists and researchers the youth was the time of high creativity and inspiration. And politics needs this creativity and sally of young people, and the latter can be easily reassured by older generations. But the strongest reason for age representation is the conflict between generations and we do not want that E-Democracy's rule developed nowadays through PDI to be imposed to future generations, when the latter should comply to their own way of life. The clash of generations is subject of new researches in economic [***23***] and political [***24***] aspects and E-Democracy is a short, medium and long term commitment and none of these terms ought to be omitted. Without further discussing and explanations for our choice, we propose three classes (or sub-groups) of age to be taken into consideration in this paper: young, mature and senior. A more extended research on this subject could find different ways of establishing the sub-groups of ISC2, but for our computational simulations on representatives selection we rely on this common approach that needs no additional debate.
- ISC3: *Area*. The environment where people live should not be a concern on normal grounds, but for our study we argue that urban and rural areas in Romania are quite discrepant. Due to the distribution of population by area [***25***], we experience a binomial statistical dispersion at high level (i.e. 24.63% very close to a maximum of 25%, given by the multiplication of areas percentage: urban - 56.09% and rural - 43.91%). More, unlike the other central and western European democracies, the Romanian society is described by a large differentiation at social, eco-

nomic, cultural and spiritual level [***26***]. It is also true that other democracies have experienced the same problem sometime in their early age [***27***] and some are still confronted with this social and economic aspect [***28***].

We have identified two criteria that we should take into account for any E-Democracy's selection of representatives (i.e. gender and age) and one criterion for a particular case such as Romania (i.e. area). There are no rules to establish these accountable variables, but rather the use of PDI at every community level. On regular basis, there are two criteria that scholars and laymen find important in political (and not only) representation: race and ethnicity. In this paper, we state than any act of affirmative action on behalf of the latter two is rather a discriminative policy which leads to acknowledging the fact that race and ethnicity indeed differentiate people. We believe that citizens should be differentiated on the three grounds of ISC, but this may be subject of PDI in any community. Still, we make a concession in our case study by taking into consideration an extended group (ISC^+) of ISC by adding ethnicity (ISC4) to it, only to see how representation is affected at secondary level (primary level is given by ISC). This is important when choosing the type of representatives selection, using the following methods of sampling and notations:

- *N* - the population number of voters
- *n* - the number of selected representatives
- *SR* - sampling by random (non-strata) selection, aleatory extraction of *n* representatives from *N* candidates
- *SS* - sampling by strata selection, guided extraction using 12 independent and proportional samples n_j of each ISC strata, see last column of Table 2 (i.e. using Cartesian product of sub-groups percentage of each of the gender, age and area), $j = 1,12$
- *SRS* - sampling by random selection taking into account multiple strata, calculating *n* by summing each dependable (on each other) sample n_j, $j = 1,12$

Let us take the following notations for all of the ISC^+ classes:

- ISC1 (i.e. gender): female: 0, male: 1
- ISC2 (i.e. age) - 18-29 years (young): 0, 30-64 years (mature): 1, over 65 (senior): 2
- ISC3 (i.e. area): urban: 0, rural: 1
- ISC4 (i.e. ethnicity): Romanian: 0, Magyar: 1, Roma: 2, others: 3

Using data from two sources, for the three ISC [***25***] and for gender, age and ethnicity [***29***], we linearly interpolate them to obtain the results of Table 2:

Table 2. Population structure by ISC^+

ISC2	ISC1	ISC3	ISC4				Total
			0	1	2	3	
0	0	0	5.45%	0.37%	0.26%	0.08%	6.16%
		1	3.77%	0.26%	0.18%	0.06%	4.28%
	1	0	5.43%	0.37%	0.26%	0.08%	6.14%
		1	4.19%	0.29%	0.20%	0.07%	4.76%
1	0	0	16.69%	1.29%	0.41%	0.25%	18.65%
		1	10.63%	0.81%	0.28%	0.19%	11.91%
	1	0	15.16%	1.17%	0.38%	0.23%	16.94%
		1	11.48%	0.88%	0.30%	0.20%	12.86%
2	0	0	4.42%	0.39%	0.04%	0.09%	4.94%
		1	5.40%	0.43%	0.05%	0.10%	5.98%
	1	0	2.91%	0.26%	0.03%	0.06%	3.26%
		1	3.72%	0.30%	0.03%	0.07%	4.12%
Total			89.26%	6.82%	2.42%	1.49%	100.00%

The last column of Table 2 contains the percentage of ISC strata, and these figures are used for calculating *n* in simulations of *SR*, *SS* and *SRS* and for primary level comparisons (regarding ISC), while the extra percentages of ISC4 (the last row) are useful for secondary level comparisons (regarding ethnicity) in all of the *SR*, *SS* and *SRS*. The 48 strata (see Table 2, columns four to seven) given by Cartesian product of ISC^+ are used to generate the simulated population characteristics that define Romanian eligible voters in this research.

Before analyzing the results of different simulations of sampling representatives using RNG, let us take N = 17,460,469 the number of Romanian population eligible to vote [***25***]. We will try different values for *n* and we will compare the results of simulated sampling with figures from Table 2. Practically, we will simulate selection of representatives using RNG and we will compare the initial shares of ISC^+ variables with the shares obtained through simulation. We also remind the formulae of the first two statistical moments (mean or average and, respectively, standard deviation or sigma) in Equation 3:

$$\begin{aligned} &mean = \mu_X = \frac{1}{n}\sum_{k=1}^{n} x_k \\ &sigma = \sigma_X = \sqrt{\mathrm{var}(x)} \\ &\mathrm{var}(x) = \mathrm{cov}(x,x) = \frac{1}{n}\sum_{k=1}^{n}(x_k - \mu_x)^2 \\ &x \text{ is a vector of size } n \end{aligned} \tag{3}$$

Let us take n = 311, the number of MPs that is actually used in Romanian legislative (the inferior Chamber) before any compensatory allocation of seats. If we use a sample this large, the results of 100 simulations of both *SR* and *SS* are shown in Table 3:

Table 3. Absolute relative errors of 100 simulations. IS: initial share. ST: strata

ISC^+	IS (%)	ST	Relative errors SR (%)				Relative errors SS (%)			
			minim	mean	maxim	sigma	minim	mean	maxim	sigma
ISC1	21.34	0	0.95	8.70	25.06	6.16	0.55	0.55	0.55	0.00
	60.36	1	0.15	3.84	12.10	2.92	0.15	0.15	0.15	0.00
	18.30	2	0.15	8.64	31.78	6.53	0.15	0.15	0.15	0.00
ISC2	51.92	0	0.29	4.80	16.39	3.45	0.29	0.29	0.29	0.00
	48.08	1	0.32	5.19	17.70	3.72	0.32	0.32	0.32	0.00
ISC3	56.09	0	0.25	3.85	12.86	3.03	0.25	0.25	0.25	0.00
	43.91	1	0.32	4.91	16.43	3.86	0.32	0.32	0.32	0.00
ISC4	89.27	0	0.14	1.59	5.19	1.12	0.14	1.57	7.42	1.25
	6.82	1	1.00	17.12	52.86	12.70	1.00	18.34	65.00	14.00
	2.42	2	6.09	26.68	73.48	17.72	6.09	28.24	85.67	21.62
	1.49	3	7.54	37.38	100.00	24.18	7.54	40.40	158.11	30.45

The ISC figures of Table 3 are very different in the two approaches and rather similar for ISC4. The results of *SS* are outstanding in case of ISC, but this is due to the fact that we used proportional allocation for each of the 12 ISC strata. Still, there are mean values different from zero, because the a priori allocation of seats is based on rounding the proportions of each of the 12 strata, see last column in Table 2. But the ISC values of mean, minimum and maximum of absolute relative errors are equal (implying a naught standard deviation) and so close to zero in this case that we may state that *SS* assures an outstanding representation of important units (given by ISC) of population. On the contrary, the results of *SR* for ISC are not that good, with values substantially different from zero for the mean of absolute relative errors. While, from ISC representation point of view, the minimum of this errors provides a decent figure, their maximum raises serious questions about the usefulness of selecting public officers by lottery. In case of ISC4 for both *SR* and *SS*, the absolute relative errors have similar values of minimum, mean, maximum and sigma, with very small improvements for *SR* (except for ISC4-0 mean, i.e. the Romanian ethnics average). This gives an empirical hint on the fact that strata selection may slightly diminishes the representation of the other population sub-groups that are not taken directly into account (further theoretical and empirical work must be done to verify if this assumption is related to non-normal distribution, see ISC4-3 in Table 3 for example). Still, the differences of *SR* from *SS* are not considerable in case of ISC4 so that we neglect this aspect for now.

We have mentioned that *SR* absolute relative errors are not acceptable, but we did not provide any reference for an acceptable range of values for one of the minimum, maximum, mean and/or standard deviation. We only compare these to almost zero *SS* absolute relative errors, but we need to establish a firm groundwork and this is achievable using a probabilistic-statistic mathematical apparatus.

Let us take:

- e - a given value corresponding to a desired margin of error, it is similar to results presented in Table 3
- z - a given value corresponding to a desired level of confidence α (e.g. a frequently used 95% certainty that the results deviation are less than the margin of error e); z is obtained, under the assumption of normal distribution of population, in two ways: a) applying the inverse ($^{-}$) of cumulative distribution function (*cdf*) that requires α as parameter and b) using statistical tables of pre-determined z for different values of α
- $\hat{S}^2$ - an estimate of the population variability of a characteristic, see var(x) in Equation 3; it is determined in different ways: a) from previous researches, b) calculated with variance formula presented in Equation 3 and c) using an estimated probability $\hat{P}$ of a binary distribution of a characteristic yielding $\hat{S}^2 = \hat{P}(1-\hat{P})$; when $\hat{P}$ is unknown, the maximal value of 0.5 is chosen

Under the assumption of normal distribution, the formula of sampling dimension is [***30***]:

$$n = \frac{z^2 \hat{S}^2}{e^2 + \frac{z^2 \hat{S}^2}{N}} \tag{4}$$

Another approach for calculating n is to look up in statistical tables of sample sizes corresponding to different dimensions of the population (i.e. N). Practically, the formula of n from Equation 4 or figures from statistical sampling tables yield similar results, with a maximum size calculated of n = 384 for any population exceeding 1,000,000.

We propose a more refined approach of calculating n, using a formula that is already implemented in Matlab environment as function *smpsizepwr* [***31***]:

$$n = \left(\frac{-cdf^{-1}(\alpha) - cdf^{-1}(1-\alpha)}{e\mu_X} \sigma_X \right)^2 \tag{5}$$

Function *smpsizepwr* not only determines the sample size n when e and z (or α) are sent as parameters, but also returns the values of e (when n and α are known) or α (when n and e are given). In order to calculate the two statistical moments (i.e. mean μ and sigma σ) we use population dispersal of the 12 ISC strata. The characteristic of the population is the population itself on the ground of component units (and not by some extrinsic characteristic). Practically, we have three criteria (ISC: gender, age, area) that define the whole and they are combined in 12 strata. Applying formula displayed in Equation 5, we present in Table 4 values of e and α when one of them changes and the other is fixed. The sample size n is always fixed (i.e. n = 311) and we present the theoretical scores of any *SR* sampling:

Table 4. Values of e and $\boldsymbol{\alpha}$. A: e is given and n is fixed. B: $\boldsymbol{\alpha}$ is given and n is fixed

Index		1	2	3	4	5	6	7	8
A	e	16.00%	14.00%	12.00%	10.00%	8.00%	6.00%	4.00%	2.00%
	α	99.28%	97.11%	91.09%	78.67%	59.64%	37.96%	19.66%	8.54%
B	e	9.56%	10.17%	10.88%	11.77%	12.21%	12.76%	13.47%	14.91%
	α	75.00%	80.00%	85.00%	90.00%	92.00%	94.00%	96.00%	98.00%

We observe in Table 4 a clearly inverse dependence between e and α, which is also intuitively acknowledged given the fact that the level of confidence (i.e. α) of a sampled characteristic to occur grows while the percentage of appearances (i.e. 100% - e) diminishes. When using *SR* we treated population as a whole but we verified three principal characteristic (i.e. ISC) and a secondary one (i.e. ISC4), see Table 3. In case of *SS* we guided the random sampling through proportional allocation for each of the 12 ISC strata, which gave outstanding results for ISC but not for ISC4, as the latter did not receive the same a priori proportional allocation. The figures of Table 4A demands, for example in observation five, that errors from average should not be over 8% in more than 59.64% of cases. Observation four of Table 4B tells us that in 90% of cases there should be no more than 11.77% deviations from estimated mean.

Given the theoretical background of representation presented in Table 4, let us verify the ISC$^+$ absolute relative errors from initial shares and the numbers of their appearances. We illustrate in Table 5 the number of absolute relative errors that overpasses a given margin of error e and we also provide the theoretical confidence level α for each given e using data of Table 3.

Table 5. Number of errors of 100 simulated samplings. T: total. Idx: index of observation

Idx	**ISC1**			**ISC2**				**ISC3**			**ISC4**					$\boldsymbol{e}$	$\boldsymbol{\alpha}$
	T	**0**	**1**	***T***	**0**	**1**	**2**	***T***	**0**	**1**	***T***	**0**	**1**	**2**	**3**		
1	***0***	0	0	***10***	5	0	5	***0***	0	0	***91***	0	30	56	69	0.2	0.9998
2	***5***	5	5	***47***	40	1	12	***8***	1	8	***99***	0	60	76	86	0.12	0.9108
3	***29***	29	29	***77***	58	24	56	***37***	22	27	***100***	0	73	100	100	0.06	0.3795

The results of Table 5 are not good in some aspects and not bad in others. We observe in the first row that we should have no errors over 20% (i.e. for a level of confidence of 99.98%, meaning that number of errors ≤ 1-0.9998). The variables of ISC$^+$ that respect the theoretical demands of e and α are ISC1 and ISC3 in totality, while for the other two criteria only sub-groups ISC2-1 and ISC4-0 always respects the constraints of Table 5. This is due to the dispersal of population by strata which does not have a similar distribution for all ISC$^+$. Yet, the sub-groups of variables that are numerous and well represented in all strata, ISC2-1 (i.e. mature age) and ISC4-0 (Romanian ethnics), respect the theoretical constraints. We also observe in Table 5 that the total number of errors for one ISC variable is given either by summing (e.g. first row of ISC2) or by overlaying (e.g. second row of ISC1) the errors from sub-groups.

We only discussed the absolute relative errors of ISC$^+$ from initial shares, because this is more demanding and corresponds to a short-medium time approach. People may not be interested in a sort of representation on long and very long term (given by non-absolute relative errors), but have expectations on short terms. Thus, we calculated indicators only for absolute relative errors and not for relative errors which always compensate each other. Now, we present in Table 6 the former on long term using 1,000 simulations, and along with them we discuss the latter's average of the 100 simulations previously presented in Table 3 and also of two collections of another 1,000 simulations.

The figures of Table 6 belong to *SR* simulations (for *SS* the errors are given by the a priori allocation of seats by ISC strata no matter the number of simulations) and they are quite similar to those of Table 3 (in case of Table 6A), so that we may say that small improvements on longer term appear on behalf of mean and minimum and small declines on behalf of maximum and sigma of absolute relative errors. But the non-absolute relative errors of *SR* simulations (i.e. Table 6B) prove that on long term the mean tends to an intuitive zero, especially when number of selections increases (even for ISC4).

Table 6. *SR* simulations. A: 1000 simulations. B: three collections of simulations

ISC$^+$	**IS (%)**	**ST**	**A. Absolute relative errors (%)**				**B. Average relative errors (%)**		
			minim	**mean**	**maxim**	**sigma**	**100**	**1000**	**1000**
ISC1	51.92	0	0.29	4.38	17.67	3.26	-0.60	-0.13	0.23
	48.08	1	0.32	4.73	19.08	3.52	0.64	0.14	-0.25
ISC2	21.34	0	0.55	8.89	33.70	6.57	-1.49	-0.43	0.01
	60.36	1	0.15	3.60	15.83	2.83	0.25	0.30	0.13
	18.30	2	0.15	9.19	45.84	7.07	0.93	-0.48	-0.44
ISC3	56.09	0	0.25	3.85	16.88	3.00	0.06	-0.14	-0.05
	43.91	1	0.32	4.92	21.56	3.84	-0.08	0.19	0.07
ISC4	89.27	0	0.14	1.57	6.34	1.19	0.41	0.01	0.08
	6.82	1	1.00	16.46	69.72	12.41	-3.45	-0.13	0.05
	2.42	2	6.09	28.76	125.45	20.62	-0.93	0.21	-1.03
	1.49	3	7.54	37.92	179.62	27.54	-7.51	-0.44	-3.21

So far, we have been discussing only sampling for $n = 311$, which is also the theoretical number of allocated seats in Romanian inferior Chamber. It is a number that would assure some basic representation under constraints of adequate space and resources limits for debating with or without the mediation of digital instruments. Using Matlab's function *smpsizepwr* (see Equation 5) we calculate the sample size for a standard level of confidence $\alpha = 95\%$ and with a margin of error of $e = 5\%$ for our given $N = 17{,}460{,}469$. The result is $n = 1775$ and Table 7 shows the behavior of the average of relative errors of two collections of 100 and 1,000 simulated selections of representatives.

Table 7. *SR* Average of errors for $n = 1775$, $e = 0.05$ and $\boldsymbol{\alpha} = 95\%$

ISC$^+$	**IS**	**ST**	**Relative (%)**		**Absolute relative (%)**		**No. of absolute errors** > 0.05			
			100	**1000**	**100**	**1000**	**100**		**1000**	
ISC1	51.92	0	0.05	0.09	1.98	1.82	2	(3)	34	(43)
	48.08	1	-0.05	-0.10	2.14	1.96	3		43	
ISC2	21.34	0	-0.40	0.06	3.35	3.55	24	(38)	256	(499)
	60.36	1	0.00	0.08	1.32	1.55	0		12	
	18.30	2	0.47	-0.34	2.98	4.05	18		325	
ISC3	56.09	0	-0.08	-0.06	1.80	1.68	1	(6)	17	(71)
	43.91	1	0.10	0.08	2.30	2.15	6		71	
ISC4	89.27	0	-0.04	-0.02	0.59	0.63	0	(95)	0	(978)

	6.82	1	0.25	-0.19	6.47	6.65	53		535	
	2.42	2	1.38	0.91	13.13	11.82	68		688	
	1.49	3	-0.85	0.39	15.42	15.54	79		849	

The numbers between parentheses represent the total absolute errors exceeding the given margin e = 0.05. It appears that, on both collections of 100 and 1,000 simulations, only ISC1 respects the theoretical constraint of less than 5% (i.e. 100% - 95%) absolute relative errors while, for the others ISC$^+$, they do it partially (i.e. ISC2-1, ISC3-1, ISC4-0). The number of absolute errors exceeding 0.05 are not proportionally in 100 and 1,000 simulations, as for the latter increases with a rate higher than 10 (i.e. the ratio of two). Thus, while for the non-absolute errors we have an improvement on longer term (i.e. more simulations done), for absolute errors we observe an obvious decline in precision due to a raise in the number of errors.

Although higher than expected, the numbers of absolute relative errors for n = 1775 are similar to those for n = 311 (except for ISC3-1 which is surprisingly poorer for larger n), but the former's averages are substantially better than the latter's.

It is now the time to introduce a formula that calculates the sample size taking into account strata sampling without a priori proportional allocation. So far, we either used guided sampling by proportional allocation of seats (i.e. *SS*) or random sampling (i.e. *SR*). For the latter we used a formula (see Equation 5) that takes into consideration one general characteristic, but we practically verify the simulated results on three (i.e. ISC) or even four (i.e. ISC$^+$) characteristics. Equation 6 provides a method of calculating n using the different strata approach *SRS*, where H is the number of strata and N_h is the population of stratum h, $h = 1,H$:

$$n_h = a_h \frac{\sum_{h=1}^{H} N_h^2 \hat{S}_h^2 / a_h}{e^2 \hat{Y}^2 + \sum_{h=1}^{H} N_h^2 \hat{S}_h^2} \qquad (6)$$

$$a_h = \frac{N_h}{\sum_{h=1}^{H} N_h}$$

Table 8 presents results of 100 simulations of three approaches using Equation 6 for α = 95% and taking into account the 12 ISC strata, although all ISC$^+$ are verified.

Table 8. *SRS* simulations and absolute relative errors

ISC$^+$	**ST**	***e*=0.1; *n*=3605**				***e*=0.05; *n*=14394**				***e*=0.01; *n*=352733**			
		mean	**maxim**	**errors**		**mean**	**maxim**	**errors**		**mean**	**maxim**	**errors**	
ISC1	0	1.18%	3.76%	0	-	0.60%	1.81%	0	-	0.13%	0.42%	0	-
	1	1.28%	4.05%	0		0.64%	1.96%	0		0.14%	0.46%	0	
ISC2	0	2.74%	10.70%	1	(*2*)	1.30%	4.42%	0	-	0.23%	0.70%	0	-
	1	1.17%	4.00%	0		0.59%	1.95%	0		0.10%	0.27%	0	
	2	3.03%	10.05%	1		1.53%	4.71%	0		0.28%	0.80%	0	
ISC3	0	1.31%	4.11%	0	-	0.58%	2.04%	0	-	0.12%	0.47%	0	-
	1	1.67%	5.25%	0		0.74%	2.60%	0		0.16%	0.60%	0	
ISC4	0	0.53%	1.96%	0	(*73*)	0.19%	0.68%	0	(*61*)	0.05%	0.17%	0	(*69*)
	1	5.42%	15.50%	17		2.27%	6.85%	10		0.54%	2.34%	19	
	2	9.26%	23.35%	37		3.73%	12.03%	30		0.88%	3.20%	40	
	3	11.51%	50.30%	46		4.52%	17.74%	37		0.93%	3.53%	37	

It is clear now that the zero error results are outstanding for ISC (with the small exception of ISC2-0 and ISC2-2 for e = 10%), but what are the costs? The answer is: a larger sample size n. The larger n, also better results of ISC4 regarding average and maximum values of absolute relative errors from initial shares of ISC^+ (see Table 2). Yet, is it possible to make a debate with 14,394 or 352,733 citizens so that we have a certain ISC representation of 95% or, respectively, 99%? The author's subjective answer is no and, on personal consideration, it may be more suitable to debate with 311 people, and less appropriate with 1,775 or 3,605 representatives, although further researches must definitely be made on this vast subject.

The simulated lot allocation of public offices leads us to some interesting finales on ground of representation. Firstly, it is better to determine the size of a representative body for a community and to proportional allocate seats for each identified community's characteristic. Secondly, pure random lottery of representatives gives good results on long term judging by non-absolute relative errors and poor results on short term considering absolute relative errors.

6 Conclusions

In this paper we proposed a simplified model of E-Democracy and lottery as an alternative for public offices allocation. We also proposed three important criteria for representatives selection: gender, age and area, but we took into consideration, on most results verifications, a fourth one: ethnicity. We used computational simulations to determine the level of lot representation and we concluded that this representation depended on two grounds: sample size and method of sampling. With unbiased random sampling we need quite large samples of population for standard parameters representation. Using guided a priori proportional sampling by given strata, the size of representatives body may decrease to any level that is determined through errors value given by rounding seats of such a priori proportional allocation.

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