

Discussion on the geometric measures of the size of the scientific elites

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What we shall discuss

- 1 *On the basis of the Lorenz curve for publications ownership we introduce geometric measures for the size and productivity of scientific elites of research organizations.*
- 2 *We apply these quantities for a study of the scientific production at the mathematics and physics institutes of the Bulgarian Academy of Sciences (BAS).*

What we shall discuss

- 1 *The sizes of the elites as well as their scientific production do not vary much from institute to institute and between the two areas of research.*
- 2 *The elites at the mathematics and the physics institutes consist of about $1/3$ of the scientists and these elites own about $2/3$ of the scientific publications of the corresponding institute. The superelites consists of about $1/7$ of the scientists and they own about $2/5$ of the scientific production.*

BAS, SCOPUS, 1996-2012

- 1 The BAS has the largest concentration of scientific activity in Bulgaria.
- 2 The research performance of the scientists from the BAS is well documented after 1996. The database SCOPUS was used.
- 3 The results are for the period 1996-2012
- 4 The measures are based on the ownership of scientific publications
- 5 Normal count of the scientific publications has been used

Mathematics institutes of the BAS

- Institute of Mathematics and Informatics (IMI),
- Institute of Mechanics (IMECH),
- Institute of Information and Communication Technologies (IKT).

Physics institutes of the BAS

- Institute of Solid State Physics (ISSP),
- Institute of Electronics (IE),
- Institute of Optical Materials and Technologies (IOMT),
- Institute of Nuclear Research and Nuclear Energy (INRNE),
- Central Laboratory for Solar Energy and New Energy Sources (CLSENES).

The Lorenz curve

The Lorenz curve is an instrument for visualization of inequality in a population

- 1 Let us consider a population of size n , and each member of this population possesses a quantity y_i , $i = 1, \dots, n$ of something (money, gold, scientific papers, etc.).
- 2 Let y_i be indexed in non-decreasing order ($y_i \leq y_{i+1}$).
- 3 Then the Lorenz curve is the continuous piecewise linear function connecting the points (F_i, L_i) , $i = 0, \dots, n$, where $F_0 = 0$, $L_0 = 0$, and for $i = 1$ to $i = n$:

$$F_i = \frac{i}{n}; \quad S_i = \sum_{k=1}^i y_k; \quad L_i = \frac{S_i}{S_n} \quad (1)$$

The Lorenz curve (2)

The use of the Lorenz curve below

The Lorenz curve is very popular for the case of wealth where it shows the percentage of wealth owned by a given percentage of population.

The Lorenz curve (3)

The use of the Lorenz curve below

Here we shall consider the population of scientists and what they own will be their scientific publications.

Size of the elite of a scientific organization measured by the Lorenz curve

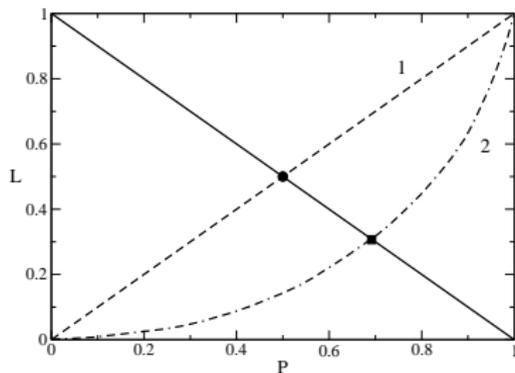


Figure: Elite size measure by the Lorenz curve. The measure is the coordinate $1 - P_e$ of the diagonal $(P, 1 - P)$ where the diagonal (solid line) crosses the corresponding Lorenz curve. For the Lorenz curve marked by 1 (all scientists own the same number of papers) the cross point (filled circle) has coordinates $(0.5, 0.5)$. In percentages this is the 50/50-curve (non-elitary distribution). For the Lorenz curve marked by 2 (corresponding to the situation at the Institute of Mechanics of the Bulgarian Academy of Sciences) the cross point (filled square) is $(0.69, 0.31)$. In percentages this is 69/31 - curve.

One step further: The superelite

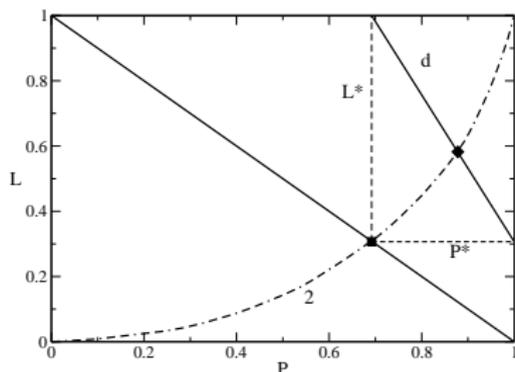


Figure: Geometric measure for the scientific superelite by the Lorenz curve. The Lorenz curve marked by 2 is the same as in the previous figure. One introduces new Cartesian coordinate system with axes P^* and L^* and initial point that coincides to the point $(P_e, 1 - P_e)$ connected with the definition of the size of the scientific elite from previous figure. In this new coordinate system the diagonal marked with d is plotted. The point (P_s, L_s) marked by a diamond gives the size and the productivity of the corresponding superelite. For the case of the Lorenz curve 2 (corresponding to the Institute of Mechanics of the Bulgarian Academy of Sciences) the coordinates of the point marked by diamond are approximately $(P_s, L_s) = (0.88, 0.58)$ which means that the corresponding superelite consists of $1 - P_s = 0.12$, i.e., 12% of the population of scientists owns $1 - L_s = 0.42$, i.e, 42% of all papers.

- 1 **elite**: the coordinate P_e gives us the information about the size and productivity of the scientific elite of the group of scientists described by the corresponding Lorenz curve.
- 2 **superelite**: The coordinates P_e and P_s give us the information about the size and productivity of the corresponding superelite.
- 3 **hyperelite**: We can continue the process of construction of geometric measures starting now from the point S . What we shall obtain is the next point (let us call it H) which shall give us an information about smaller group of scientists called hyperelite. The coordinates of this point will be $(P_h, \frac{P_h - P_s}{1 - P_s})$. Then the coordinates P_e, P_s, P_h will give us the information about the size and productivity of the hyperelite.

Strength of the elite

Let us consider the geometric measure connected to the size and productivity of the elite. This measure is connected to the point E that has coordinates $(P_e, L_e = 1 - P_e)$. We define the strength of the elite as

$$s_e = \frac{1 - L_e}{1 - P_e} = \frac{P_e}{1 - P_e} \quad (2)$$

Strength of the superelite

The coordinates of the point S connected to the size and productivity of the superelite are $S = (P_s, L_s)$. Then the strength of the superelite is defined as

$$s_s = \frac{1 - L_s}{1 - P_s} = \frac{1 - P_e \frac{P_s - P_e}{1 - P_e}}{1 - P_s} = \frac{1 - P_e(1 + P_s - P_e)}{(1 - P_e)(1 - P_s)} \quad (3)$$

Relative size of the superelite with respect to the size of corresponding elite

$$S_{se} = \frac{1 - P_s}{1 - P_e} \quad (4)$$

Lorenz curves for the two kinds of institutes

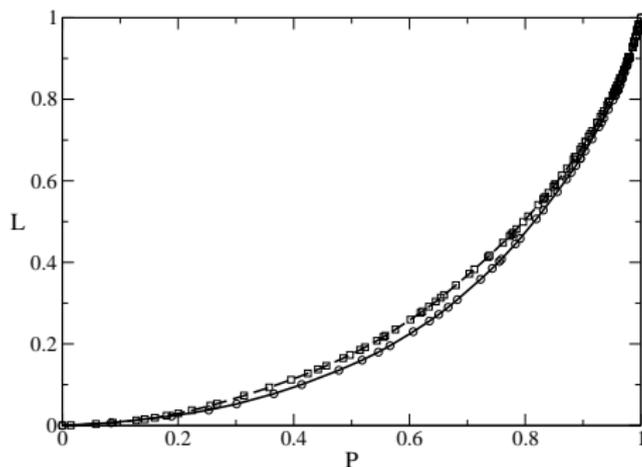


Figure: Lorenz curves for all mathematics institutes (solid line marked by circles) and for all physics institutes (dashed line marked with squares).

Results for the elite sizes

Table: Parameters of the scientific elites and superelites of the studied institutes of the Bulgarian Academy of Sciences. $1 - P_e$: size of the scientific elite; $1 - L_e$: percentage of total number of papers own by the members of the scientific elite; s_e : strength of the scientific elite; $1 - P_s$: size of the scientific superelite; $1 - L_s$: percentage of total number of papers own by the members of the scientific superelite; s_s : strength of the scientific superelite.

Institute	$1 - P_e$ (%)	$1 - L_e$ (%)	s_e	$1 - P_s$ (%)	$1 - L_s$ (%)	s_s
IMI	34	64	1.88	14	38	2.71
IICT	30	70	2.33	12	40	3.33
IMECH	31	69	2.23	12	42	3.50
CLSENES	32	68	2.13	14	39	2.79
IOMT	35	65	1.86	16	35	2.19
IE	32	68	2.13	13	41	3.15
ISSP	34	66	1.88	14	39	2.79
INRNE	32	68	2.13	13	40	3.08

The elites at the mathematics and the physics institutes consist of about $1/3$ of the scientists and these elites own about $2/3$ of the scientific publications of the corresponding institute. The superelites consists of about $1/7$ of the scientists and they own about $2/5$ of the scientific production.

In addition about $2/3$ of the scientists do not belong to the scientific elites and all these scientists own about $1/3$ of the scientific production of the corresponding institute. $6/7$ of the scientists do not belong to the superelite and these scientists own about $3/5$ of the scientific production of the corresponding institute.

The age of the members of the elites

What is alarming is the age structure of the elites and superelites. The age structure of the superelites is not good as almost 80 % of these people are of age 60 and larger. In 10 years these scientists will be not anymore staff scientists of the corresponding institute. Such people are majority also at the corresponding elites. The younger generation of scientists (age between 50 and 60) is insufficiently represented at the scientific elites and scientific surepelites.

Thank you for your attention