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DECREASING RETURNS TO SCALE FOR THE SMALL COUNTRY DUE TO SCARCITY OR INDIVISIBILITY – A TEST ON SPORT

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Abstract

This paper envisages economies of scale – or rather, diseconomies of low scale – caused in small nations by a sometimes acute shortage of talent and to indivisibility of teams: for example, a small country such as Iceland or Luxembourg cannot participate in an international football tournament with only three players, even if they are exceptionally gifted. After devising a few models we test them on sports (especially on Olympic results). We find that, indeed, the comparative superiority of large nations is to be found in (especially large) team events. Several results are significant at the 0.001 significance level. We conclude by suggesting the establishment of institutions similar to customs unions: a European Sport Associations United (ESAU) could fight with some hope the giants of today and tomorrow (China, India, etc.).

JEL Classification: Z11, F04, F14

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Decreasing returns to scale for the small country due to scarcity or indivisibility – A test on sport[1]

H. Glejser

"Suppose that France suddenly lost fifty of her best physicists, chemists, physiologists, mathematicians, poets, painters, ... engineers, bankers, ... businessmen, ... farmers, ...miners, ... metal workers, ...The nation would become a ... corpse as soon as it lost them ... It would require at least a generation to repair this misfortune ..."

H. Comte de Saint-Simon: "Selected Writings ", 1819, (1952) quoted in J. Oser: "The Evolution of Economic Thought" p. 116.

1. Introduction

For a long time, economists have been looking for the mechanisms of *economies* of scale with the same tenacity as biologists searching for a gene. This paper endeavours to examine a phenomenon which *also* tends to favour large countries: smaller returns to scale affecting *small* nations only or much more than large ones. The essential ingredients are two: first, the acute scarcity of talent; second, indivisibility (down to a certain level) of teams: a team can play football with 11 players but is then at the mercy of the unavailability of one single player; that is why you need, in fact, at least 22 (players are only partially substitutable), and some rich clubs have many more; forget about playing with only 5 players (which, I think, is forbidden anyway), even if they are utterly gifted. In the same way, you cannot line up only 3 swimmers for the 4 x 400 metre relay[2]. The conjunction of a few such individuals is scarce so that it is not frequent in large countries and is all but exceptional in small ones. For that reason, the service or the good must be of lower quality there. (Although there is some

[1] We gratefully acknowledge the remarkable assistance of A. Arambatzoglou, P. Lavry, B. Heyndels, J.F. Dubuisson, and J. Vuchelen.

[2] Theoretically this would be possible if comparing the mean (instead of the total) time of the two teams or by eliminating one of the swimmers of the large team. The latter would no doubt alleviate the problem of the small team and nation but it would by no means solve its problem: the athletes of the large country will still dominate as they were selected in a population that could be more than 4,000 times as large (the ratio of the population of China to that of Iceland amounts to about 4,200). Moreover, the public would hardly appreciate the arrangement as, in the limit, the 4 x 100 metre relay would be brought back to another 100 metre event, and all team events would so to speak disappear.

similarity we shall not speak of “critical mass”, which is rather a technical and purely quantitative phenomenon.)

Thus we should observe generally a lower quality of not only sports teams but also of national orchestras, ballets, operas, newspapers, research teams, universities … and last but not least, of the main sector in the economy – governments – in small nations. Thus the results we obtain here for sports are to be generalised for many sectors of the economy.

Of course, small countries could buy talent or even genius abroad. However, this often proves unfeasible: you cannot set up a government composed of foreigners! A team made up partly of foreigners will not do for espionage, biological warfare or star wars. Just imagine Edgar Hoover in charge of the Luxembourg police!

As for sport, the rule that a country can only call on nationals for an international competition is inescapable. Besides, buying in people is usually quite costly, and those who can best gather the funds are the big, rich nations[3]. Brain drain is frequently associated with the U.S. (as in the Biblical parable, she would rather snatch away the poor’s only lamb than lose one from her abundant flock).

Finally, talent attracts talent: it is then much easier for a U.S. ivy league university to bring over a newly born star, say from Iceland, than the other way round: in this case, the Gulf stream flows westwards. Thus it looks likely that international movements of human capital will not lessen, but will rather exacerbate the disparity between teams of small and large nations. To sum up: while theory considers small countries with no *economies* of scale as found in the *large* nations, we consider here *diseconomies* of scale in the *small* countries as against more or less constant returns to scale abroad. In that case, there is a force creating *comparative* advantage for the large nations.

2. Tentative models

A. Talent proportional to population

Consider Australia (20 million inhabitants) and Germany (80 million) in a competition, for example, 100 m swimming. Suppose that Nature always apportions nations with only *one*

[3] Cf. the purchase of works of art dominated by the Americans and the Japanese. The richest nations, as far as possession of Western art in public collections is concerned, must be ranked approximately as follows : U.S., Italy, France, Germany, U.K., Spain, the Netherlands, Switzerland, Austria, Belgium, etc.: the large nations are on top. Consider also the many persecuted scientists, musicians, etc. who fled from several European countries to the U.S. (and to a lesser extent, to France and the U.K.,) during the 20th century.

champion of the paramount strength for every 20 million people: so Australia has 1 and Germany 4. If the event only allows one participant for each nation, Australia's chance of winning is 0.5 (the stochastics will decide). If Germany can bring all four of its masters into the race, Australia's probability of winning is 0.2 (1 divided by 5). However, when a 4 x 100 m relay is programmed, the chances of Australia go to zero as it has to enlist three less gifted swimmers. Thus, the greater the number of participants, the greater the affliction of the small country.

B. Probability of star appearance varying according to population

Suppose that in all events Australia and Germany have the same number of participants. The probability of finding i masters in Australia is e.g. 0.5^i for i=1,2,….,N (the equal numbers of participants from each country); for Germany it is 0.9^i .

If i = 1, the chance of Australia winning is: $\frac{0.50}{0.50+0.99} = 0.34$

For i = 4, we have: $\frac{0.0625}{0.0625+0.96} = 0.07$

As in the previous case, Australia's chances plummet for values of i going from 1 to 4.

C. Talents distribution model

This model resembles model A, except that here we delve into the question of the different qualities of talents available in each country. Suppose that for each quality of would-be ministers (or football players, or quartet musicians, etc.), Germany has exactly 4 times as many people as Australia. Suppose also – big question mark[4] – that everywhere the best is chosen first and then one goes by declining quality so as to reach the canonical total number of 20 ministers. The availability of cabinet members in both countries is now as follows:

Table 1. Number of people available per quality level

	Australia	Germany
Quality 1	1	4
Quality 2	2	8
Quality 3	4	16 (half of whom are needed to reach the total number of 20)
Quality 4	8	
Quality 5	16 (5 of whom are needed to reach the total number of 20)	

[4] But the relative wastage of talent can be assumed the same everywhere: for one Adlai Stevenson or H.H. Humphrey in the U.S. you have one Mendes France in France. Of course it is easier to fool the public in politics than in sport, if only because it has more understanding of sport.

Germany can rely upon 4 ministers of quality 1, 8 of quality 2 and 8 of quality 3 (the median and the mode are of quality 2 or 3). In Australia, the median and the mode are of quality 4; the next strongest group is of quality 5. Supposing that the prime minister (P.M.) is to be chosen next at random, then someone of quality 4 has the most chances in Australia and one of quality 2 or 3 in Germany. If, on the other hand, all groups are supposed to vote for the same person in the category just ahead of theirs, such that everyone of quality 1 will vote for the same person of quality 1, Australia will be blessed with a P.M. of quality 3 and Germany with quality 1[5].

We shall thus test here a theory somewhat similar to comparative costs: the "superiority" of large nations may or may not occur in individual events but is relatively more pronounced in team events.

3. The tests

"Grey, friend, is any theory but permanently green the golden tree of life".

(Goethe, "Faust").

We are going to test the hunch of the first sections on sports (mostly Olympic) results: they have the merit of containing the inputs by nationality and the outputs by success and failure. They can hardly be biased by cronyism or by sleaze but only by drugs, which are quite evenly spread among nations and were hardly available in the distant decades from which our data also come.

We shall consider as large countries those counting more than 40 million inhabitants, i.e. China, India, the U.S., Indonesia, Brazil, Russia, Pakistan, Japan, Bangladesh, Nigeria, Mexico, Germany, Philippines, Vietnam, Iran, Egypt, Turkey, Thailand, Ethiopia, France, the United Kingdom, Italy, Ukraine, Congo, South Africa and South Korea – 26 nations in all, one third of which account for a large majority of the gold medals counted. Those 26 represent about two thirds of mankind.

There are more than 100 small countries, starting with Spain and Poland (around 39 million inhabitants each) and ending with Liechtenstein. Some of them are, or were, predators of gold medals, for example East Germany (up to 1988), Australia, Canada, Cuba, Hungary, Poland and

[5] Some small nations have tried to compensate for the shortcoming by appointing bigger cabinets: in 1972, Belgium counted a ministry of 36 members. That of course will not do, as it further dilutes quality. In the Belgian example of 36, Australia would go down as far as quality 6 and would have an elected P.M. of quality 4!
On the contrary, a better policy for small nations is to restrict the number: in Switzerland 7 is the upper limit imposed by the constitution: with seven ministers, Australia would stop at quality 3 and Germany at quality 2. For the P.M, it would be quality 2 and 1 respectively.

Spain. Average income per head is somewhat higher than in the first group in view of the presence of more than a score of relatively wealthy small European nations and since about 1980 of another score of mainly Asian and European nations. Thus, whatever "superiority" we find for the large countries cannot be attributed to income differences in general; besides, the large countries' share of gold medals lies somewhere above 70%, a little more than their share of world population.

The bulk of our sample consists of Olympic Games results from 1960 onwards (though some events started later). These ten Olympic Games provided 143 to 164 matches each – as shown in Table 3 – which produced 1618 observations for all events and years. The method of assessment consisted of a χ^2 test in a comparison of large and small country wins for individual and collective representation in the same sport.

4. Statistical results

Table 2 reproduces the test for swimming:

Table 2. Number of wins in individual and team swimming events (results from ten Olympic Games)

	Large countries (1)	**Small countries (2)**	**Superiority of large nations: (3)=(1)/(2)**
Observed			
in individuals events	65	44	1.48
in collective events	34	6	5.67
Total	99	50	1.98
Expected (null hypothesis)			
in individual events	72.4	36.6	1.98
in collective events	26.6	13.4	1.98

χ^2 value: 8.45, significant at the 1% level.

Swimming has, in fact, the highest significance level of the eleven disciplines; a little behind comes canoe-kayak (also at the 1% level) then track and field events, then rhythmic gymnastics (both at the 5% level). Pentathlon and ice-skating would be significant at the 11% level (viz. Table 3). There is no significant comparative superiority of large nations in team events for fencing, cycling, horse-riding, rowing or alpine skiing: five disciplines generally less popular than those belonging to our first group and with many fewer events than swimming or field and track, which count as many observations as the latter five taken together (viz. Table 3). Nowhere is there a comparative superiority of small nations in team events. So testing 11-0 by the χ^2 test, we conclude that the null-hypothesis is rejected at the 1% significance level in favour of our theory.

Table 3. Summary of test results for the Olympic Games

Groups of data observations	Number of observations	Number of years	χ^2 values	Significance levels
Global tests				
All events	1618	10	16.02****	0.0001
All equivalent events	435	10	11.49****	0.0007
Sport disciplines				
Field and track	129	10	4.96**	0.0260
Modern pentathlon	19	10	2.57	0.1086
Rhythmic gymnastic	40	10	4.33**	0.0375
Fencing	80	10	1.61	0.2039
Horse-riding	30	10	0.34	0.5593
Cycling	49	10	0.57	0.4515
Figure skating	30	10	2.57	0.1086
Alpine skiing	69	10	0.10	0.7494
Swimming	149	10	8.44***	0.0037
Rowing	68	10	0.03	0.8537
Canoe, kayak	60	10	8.08***	0.0045
Equivalent sport disciplines only				
Field and track	59	10	0.74	0.3890
Horse-riding	20	10	0.39	0.5312
Cycling	19	10	0.54	0.4624
Alpine skiing	39	10	0.74	0.3890
Swimming	79	10	3.63*	0.0566
Rowing	20	10	0.20	0.6531
Olympics (all events)				
(Rome-Squaw Valley)	159	1	0.11	0.7401
(Tokyo-Innsbruck)	162	1	0.40	0.5271
(Mexico-Grenoble)	163	1	1.96	0.1615
(Munich-Sapporo)	163	1	6.32**	0.0199
(Montreal-Innsbruck)	163	1	2.71*	0.0997
(Moscow-Lake Placid)	164	1	0.29	0.5902
(Los Angeles-Sarajevo)	164	1	0.00	0.9563
(Seoul-Calgary)	164	1	1.77	0.1834
(Barcelona-Albertville)	164	1	6.24**	0.0125
1996 (Atlanta-Lillehammer)	158	1	3.69*	0.0547

Note:
**** : significant at the 0.1% level
*** : at the 1% level
** : at the 5% level
* : at the 10% level
(two tail test)

The so-called "equivalent disciplines" in Table 3 are observations restricted to events which have no counterpart: boxing has no team and football no individual version, thus they are excluded from those equivalent disciplines.

When we retain only events with counterparts (equivalent disciplines), only swimming – out of five disciplines before – remains significant (at the 10% - or rather 6% - level (see Table 3). However, in half the cases the number of observations is 20 or less. Besides that scarcity of data, this new result could be due to the fact that many of the excluded events were those of large teams – football, basketball, baseball, volleyball, water polo, hockey, etc., where large countries have a very strong superiority. However, for all the sports taken together the superiority of large-country teams is accepted at the level of 0.1% for equivalent events (χ^2 = 11.49, second row of Table 3).

5. Some additional tests

We switched from the Olympic Games to world records (not necessarily Olympic) as they stood in 1970, 1985 and 1997. As the years are spaced, practically all records were broken from one year to the next in the ranking, as records generally live less than 12 or 15 years. The results are given in Table 4.

Table 4. Three-yearly observations of world records between 1970 and 1997

	Large nations (1)	**Small nations (2)**	**Superiority of large nations: (3)=(1)(2)**
Observed			
in individuals events	65	84	0.77
in collective events	28	8	3.50
Expected (null hypothesis)			
in individual events	74.9	74.1	
in collective events	18.1	17.9	

χ^2 value: 13.53, significant at the 0.1% level.

This is the most significant result of all, except for the global test of all events (first row of Table 3).

Although there are no counterparts there, we also tested the rough superiority of large nations for a few collective sports: in football, for example, even counting Argentina (2 victories) as small, the large countries[6] won the world championships (1930-1998) 12 times out of 16. The small

[6] Brazil, Italy, Germany, the U.K. and France.

nations participating in the final phase were almost twice[7] as numerous. The null hypothesis of an equal number of wins for the two sets is rejected at the 5% level. For the 16 men's Olympic basketball finals over the last 70 years or so, the success of the large countries was even more impressive: 15 to 1. For women it was 6 to 0, which is significant at the 5% level of the binomial test: for ice hockey at the Olympics, 11 to 7 victories with a superiority again but no significance. In general, small countries win here less than 20% of the time, much less than their share in world population. Without collective events the number rises to approximately 33% that share: i.e., somewhat above that share. These large team gains suggest testing an effect of the second order: if large countries indeed have superiority in team events, this superiority must be larger for ten- and twenty-athlete teams than for small ones (two- to four-athlete), as small countries have then to line up more second-rate men. Table 5 shows that if there is such an effect, it is not blinding.

Table 5. A super-superiority of large teams in Olympic events

	Large countries	**Small countries**	**Total**	**Superiority of large nations**
Number of wins observed				
Team of 10-20 players	43	12	55	3.6
Team of 2-4 players	198	85	283	2.3
Total	**241**	**97**	**338**	**100.0**
Number of wins expected				
Team of 10-20 players	39.3	15.7	55	
Team of 2-4 players	201.8	81.3	283	

χ^2 value: 1.68 Significant at the 20% level

Table 3 also reproduces the evolution of the χ^2 test for the 10 Olympic Games since 1960: the aim is to detect a possible trend over time. We shall, however, delete the years 1980 and 1984, which were marked by boycotts; the first by the U.S.A., Germany etc. and the second by the Soviet Union and its allies: the three most important large countries were thus removed from the scene. A Spearman rank correlation between the χ^2 value and time yields $\rho = 0.64$ and $\sigma_\rho = 0.38$. The existence of a positive trend is an unproved possibility: the last two years gave, in fact, the third and second highest value of χ^2, which is a slight indication of a positive trend.

A look at the Davis cup victors will give us a long term view of trend (and possibly cycle). Data are available for a whole century as the first championship dates back to 1900. Remember that

[7] Three or four times, if we consider the qualification process at the start.

a Davis cup team consists of 2 or 3 players. It is thus relevant to our subject. The victories of large and small nations are given in that order for the following periods:

1900-1934:	23-6	Significant at the 1% level
1935-1996:	20-27	
Total:	**53-33 (62% - 38%)**	**Significant at the 1% level**

This demonstrates the superiority of the large nations in the first third of the century, followed by a period of balance. For women, data from a Federation Cup Championship have been available since 1963. These are:

1963-1980:	18-8	(viz. 1900-1934 for men)
1981-1996:	8-8	(viz. 1935-1962 for men)
Total:	**26-16**	**(62% - 38%) (viz. Total for men) Significant at the 5% level**

The results suggest that the superiority is the same for women and men. But this does not seem to be the rule, as is shown in Table 6.

Table 6. Superiority of large-nation men's teams compared with women's teams

Olympic Sports	**Men (1) (2)**	**Women (3) (4)**	**Superiority of large countries: men (1)/(2), women (3)/(4)**
Basketball	15 - 1	7 - 2	15 and 3.5
Track and field			
100 m (individual)	19 - 3	11 - 4	6.3 and 2.7
4x100 m (relay)	17 - 2	12 - 4	8.5 and 3.0
400 m (individual)	16 - 3	10 - 5	5.3 and 2.0
4x200 m (relay)	18 - 4	5 - 5	4.5 and 1.0
Swimming			
100 m freestyle (individual)	15 - 7	10 - 7	2.1 and 1.4
4x100 m freestyle (relay)	7 - 0	13 - 5	∞ and 2.6
4x100 m freestyle (individual)	14 - 7	10 - 7	2.0 and 1.4
4x200 m freestyle (relay)	11 - 2	7 - 3	5.5 and 2.3
4x200 m medley (individual)	1 - 5	3 - 3	0.2 and 1.0
4x100 m medley (relay)	15 - 5	6 - 2	3.0 and 3.0
Figure skating			
Singles	11 - 8	8 - 11	1.4 and 0.7
Pairs (one man, one woman)	14 - 5	14 - 5	2.8
Rowing (1996)			
Single	0 - 1	1 - 0	- -
Team	3 - 4	1 - 4	0.7 0.2

Table 6 raises two questions: why is it that even for individuals, large countries generally do better for men than for women (viz. e.g. track and field)? And why is it that the gap between genders generally increases in the case of team events? One also observes that in a less well-known or less spectacular discipline, the superiority of large nations dwindles (viz. rowing in Table 6). Those results could be explained by discrimination against women. As women's victories may have been perceived to be less valuable in terms of national glory, especially in large countries competing for prestige, they devoted less funds to search for and to train gifted women – who were then no symbols of warriors. This reduced the clout of large countries even for individual women's events. Thus, for example, while for men there would be 4 gifted athletes against 2, making victory a quasi-certitude, in the women's relay we had 2 against 1, which would make the result more dubious.

As individuals (Table 6), men from large countries outperform women skaters (11-8 as against 8-11) but pairs yield a much superior ratio (14-5). The large country would search for a woman as a complement to the man and the team of two will generally be superior.

6. A generalisation of the approach?

Decathlon is a discipline where the athlete performs ten events (various runs, jumps and throws). The heptathlon and pentathlon are somewhat lighter tasks with 7 and 5 events respectively – and are reserved for women. It can be surmised that an athlete who excels at ten events is even rarer than a one-event master. Thus as before for teams, we should expect that large countries are at an advantage. Tables 7 and 8 show that this is not the case for men and not significantly so for women. The number of observations for the n-athlon event is, however, small. Note, however, that considered separately, decathletes are significantly superior in large nations.

Table 7. Results of the decathlon and of its ten components (from 1912): men

	Large nations (1)	Small nations (2)	Superiority of large nations: (3)=(1)/(2)
Decathlon victories	14	5	2.8
10 component victories	137	39	3.5

Table 8. n-athlons and their components: women

	Large nations (1)	Small nations (2)	Superiority of large nations: (3)=(1)/(2)
5 or 7-athlon victories	7	4	1.7
5 or 7 component victories	43	34	1.2

There is no indication of a large nations superiority for the decathlon with respect to men in the 10 separate events. As before there is, however, a relative superiority of men versus women in column (3) of the tables.

7. Conclusion

We have exposed and tested a theory of decreasing return to scales in small countries (in lieu of focusing as usual on the increasing returns in the large countries) based on the extreme rarity of some type of labour (statesmen, musicians, scientists, athletes, etc.) and on the indivisibility of teams. The theory has been positively tested on Olympic results, on world-record holders, on Davis cup players and on the football world champions. There is, however, only a slight indication that the results of 10- or 20-person teams surpassed those of 2- to 4-person teams (which would have yielded an even stronger statement). We also detected a disadvantage of women athletes compared with men for both individual and collective events and hazarded that long time neglect of their capacities has been at play. Finally we tried a generalisation: are decathletes (a special scarcity of talents) in large countries superior to plain athletes? It did not show, but the number of observations was small.

An incidental question is the fairness of competition when small and large nations are participating. A possible solution would be to create institutions similar to customs unions: a European Sport Association United (ESAU) could become a dragon in the field and make its members – small and large – resist the foreseeable push of the huge and late newcomers in the world arena. But with Mercosur and Asean, Latin American and Asian countries could also step in to threaten the old superiority of the U.S. and the foreseeable one of China and India.

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