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OLYMPIC MEDALS AS AN INDICATOR OF SOCIAL WELFARE

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ABSTRACT. The relation between the amount of medals won at the Olympic games and various welfare indicators has been established for the games of Barcelona and Seoul using a Bayesian method of Poisson regression. It was found that medals won correlate strongly with income as well as with more general welfare indicators and that the elasticity with respect to the size of the population is surprisingly smaller than unity.

1. INTRODUCTION

The construction of indicators which allow a quantitative comparison of the level of welfare between countries is a major area of research in social sciences. In economics the discussion on the measurement of welfare traditionally focused on the appropriate definition of national income in the context of national accounting. This has a long history and goes back to the first estimates of the national income for England by Petty and King in 1665 and 1696 respectively. These calculations were to demonstrate that England was as wealthy as France and The Netherlands, so that it could afford to finance further warfare with these two competitors. Nowadays national income per person is often regarded as a too narrow indicator of social welfare and much broader measures have been proposed such as a (physical) quality of life index (see e.g. Larson and Wilford, 1979; Ram, 1982; Johnston, 1988; Slottje, 1991), a basic needs index (see e.g. Hicks and Streeten, 1979), a life product index (Lind, 1993) or the human development index (United Nations Development Program, 1990; Lind, 1992). However, in the popular media success in sports of a nation sometimes seems to be valued much more than a high ranking with respect to one of the indices of social welfare mentioned above. Especially during large events such as the Olympic

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games, where (representatives of) all nations compete, comparisons of the performance of these nations are made and frequently published. A major example is the list of rankings of countries by winners of Olympic medals.

Against this background this article gives a quantitative economic analysis of the following four related topics:

(1) to what extent is economic and/or social welfare related to a good performance of nations in the Olympic games; or to phrase it differently: to what extent can national income and the welfare of countries be considered as a determinant for 'producing' Olympic winners;

(2) if so, what measure of welfare is most relevant in this respect;

(3) given the relationship between welfare and Olympic winners, how should the ranking of countries be adjusted for the level of welfare, and what country did win the Olympic games according to this adjusted ranking;

(4) how do the Barcelona games compare with the Seoul games in these respects.

2. METHOD

In order to assess a quantitative and uniform ranking of countries we have computed the total number of medals won by representatives of each participating country. For example the CIS (former Soviet-Union) obtained the highest rank in the Barcelona games by winning 112 medals, namely 45 gold, 38 silver and 29 bronze medals. We investigate by regression analysis whether the relative performance of the participating countries, measured by the number of medals won, can be explained by the usual measures of welfare, given the size of the population. As our principal interest lies in the income elasticity of 'producing' Olympic medals we *a priori* selected a log-linear specification. This specification implies a constant elasticity, i.e. when the income of a country is $\chi\%$ higher than that of another country and the elasticity is equal to α, the first country is expected to win α χ times as many medals as the second country. However, a major technical problem is that the dependent variable in the regression is either zero (for a large set of countries that participated in the Olympic games but did not win medals) or positive. Usually some variant of the Tobit method is applied in order to estimate the parameters in a regression where the dependent variable is either zero or positive. Yet, this method does not allow for a log-linear specification as we cannot take the logarithm of zero.

Instead we use an estimation procedure developed (for this purpose) by De Vos (1993) for models with Poisson dependent variables, including (log-)normal specification errors. The procedure assumes that the probability of winning Olympic medals has a Poisson distribution, with the logarithm of its parameter μ depending on the characteristics of the country including a (specification) error term with variance σ^2. The Poisson distribution is especially adequate for the description of the occurrence of rare events (which winning an Olympic medal is), with μ the expected number of events during a certain period. Our estimation procedure is in essence a Bayesian procedure which boils down to a generalized least squares regression with the dependent variable equal to log(0.14) and the variance equal to $\sigma^2 + 4.93$ for a country that did not win any medal, and with the dependent variable equal to log(z) and the variance equal to $\sigma^2 + z^{-1}$ for a country that won z medals. Loosely stated, the procedure assumes that countries that did not win a medal, have in fact won 0.14 medals. We note that 0.14 is *not* an arbitrarily chosen number, but is implied by the estimation procedure. This is also true for the 4.93, which is to be added to the variance σ^2, in case a participating country did not win any medal.

This procedure implies that in the generalized least squares regression countries that won very few medals, or no medals at all, obtain less weight, computed as the inverse of the variance, than countries that won a lot of medals. Thus the regression focuses on the major medal winning countries but does not completely discard the information contained in the data on participating countries that did not win medals. For more details on this intriguing procedure we refer to De Vos, who, moreover, proves that the procedure is also valid for the multinomial distribution. The latter probability process is even more appropriate for the description of the winning of Olympic medals than the Poisson process as the number of medals to be won is (almost) fixed whereas the total number of rare events described by the sequence of drawings from a Poisson distribution is not.

In Den Butter and Van der Tak (1992) we have somewhat arbitrarily valued a gold medal with 4, a silver medal with 2 and a bronze medal with 1 medal points and we have used OLS estimation on the censored set of positive observations of medal *points* won by each country. This valuation was inspired by the fact that the lists of rankings published in the media value winning a gold medal higher than winning a silver medal etc. However, from a statistical viewpoint and given the total number of medals, the probabilities of winning a golden, a silver or a bronze medal are about equal. In order to investigate this aspect further the null hypothesis that the probability of winning a medal is equal for each type of medal was tested against the alternative hypothesis that countries winning many medals have a higher probability of winning golden medals. The null hypothesis could not be rejected.

3. REGRESSION RESULTS

Table I gives the estimation results for three alternative measures of per capita national income as explanatory variables. We have estimated each equation both for the Barcelona games and the Seoul games. All our regression equations contain a dummy variable (dumsoc) for former socialist countries and the size of the population as scale variable. The dummy is to account for the (ideologically motivated) specific interest in sports in those countries and also for the possible systematic bias in the statistical records of national income and on other welfare measures in these countries. The fact that the parameter estimates of this dummy variable appears to be higher for the Seoul games than for the Barcelona games in all regression equations suggests that the focus on sporting performance in those countries gradually declines with the disintegration of the second world.

For the population variable an elasticity of unity was expected but surprisingly the estimated values are significantly lower in all specifica-

TABLE I

Relationship between population, national income and number of medals won

Games at		Explanatory variables (logs)						
		pop	NI/pop	NIpp/pop	NIsh/pop	dumsoc	LL	σ^2
1.	Barcel.	0.70	0.77			1.52	−94	0.64
		(0.08)	(0.09)			(0.33)		
	Seoul	0.60	0.80			2.09	−95	0.64
		(0.08)	(0.09)			(0.32)		
2.	Barcel.	0.62		0.99		1.45	−111	1.04
		(0.08)		(0.11)		(0.33)		
	Seoul	0.50		1.06		2.09	−98	0.72
		(0.08)		(0.13)		(0.33)		
3.	Barcel.	0.64			1.07	1.44	−96	0.64
		(0.08)			(0.12)	(0.33)		
	Seoul	0.53			1.17	2.08	−95	0.68
		(0.08)			(0.14)	(0.32)		

Note: dependent variable: log of number of medals won; standard errors in parentheses; LL: log likelihood of regression; σ^2: variance of specification error; pop: population; NI: traditional national income; NIpp: national income corrected for purchasing power; NIsh: 'real' national income from PENN World Table; dumsoc: dummy for (former) socialist countries.

tions. It means that, all other things equal, a country with two times as many inhabitants as another country is not expected to win two times as many Olympic medals. Or in the economists' jargon: the 'production' of Olympic medals is apparently subject to diseconomies of scale with respect to population. This may partly be caused by the fact that each country is only allowed to delegate a limited number of participants per sporting event. An alternative explanation might be found in so-called national sports – sports which are especially popular in some country. Examples might include hockey in for instance Pakistan, table tennis in China, and basketball in the USA. If national sports do attract sporters more than proportionally, the overall performance of countries with a large population at the Olympic games will decline, as the amount of medals to be won in a specific discipline is limited. We note that our estimates of the population elasticities below unity are at variance with the results of Suen (1993) who finds elasticities above unity using Tobit-regression on data for medals won at the 1952–1988 Olympic games.

Equation 1 of Table I gives the estimation results for the traditional national income (NI) from the national accounts as explanatory variable. These income data are made comparable across countries using (dollar) exchange rates. Equation 2 of Table I has national income standardized by the United Nations for purchasing power (NIpp) as explanatory variable. According to this measure the coefficient of the income variable in both the Seoul and Barcelona games is higher than according to equation 1. This coefficient is again somewhat higher in equation 3 of Table I. Now we have taken the real national income data of the PENN World Table project (see Summers and Heston, 1991) (NIsh) as explanatory variable. The unique feature of this project is that its expenditure entries are denominated in a common set of prices in a common currency so that real international quantity comparisons can be made both between countries and over time. In all regressions the coefficient of the income measure is slightly lower in the Barcelona than in the Seoul games. Remarkably, as measured by the values of the log-likelihood (LL) and the variance (σ^2), the fit of the specifications 2 and 3 is worse than that of specification 1, whereas the national income data corrected for purchasing power or valued at international prices is likely to be a more appropriate measure of welfare than the conventional national income data. We note, however, that we are unable to test whether specification 1 performs *significantly* better than specifications 2 and 3, and that the differences between specification 1 and 3 are extremely small. The specifications with NIpp and NIsh as measures of income yield estimates of the income elasticity, which do not differ significantly from unity. On the other hand, the income elasticity estimated by the specification with usual gnp as measure of income is significantly lower than unity. In consumer theory an income elasticity of a certain good below unity indicates that the demand for that good does not rise in proportion with

TABLE II

Relationship between welfare indices and number of medals won

Games at		Explanatory variables					
		log pop	HDI	log QOL	dumsoc	LL	σ^2
4.	Barcel.	0.65	4.66		0.85	−96	0.60
		(0.08)	(0.52)		(0.33)		
	Seoul	0.53	4.58		1.54	−100	0.74
		(0.09)	(0.59)		(0.34)		
5.	Barcel.	0.66		−2.98	2.62	−96	0.64
		(0.09)		(0.52)	(0.45)		
	Seoul	0.57		−3.16	3.38	−110	1.04
		(0.09)		(0.55)	(0.45)		

Note: See Table I: HDI: UN human development index; QOL: Slottje's quality of life index.

(real) income. Such goods are labelled necessary goods. Hence, our estimation results suggest that Olympic medals are a necessary good.

However, social welfare and opportunities for human development are by no means completely determined by the level of national income (see the introduction). Other aspects such as income equality, literacy and life expectance at birth constitute dimensions of a country's welfare as well. The United Nations Development Program (1990) calculates the human development index (HDI) for countries by a composite ranking procedure which takes all three dimensions of welfare into account. In equation 4 of Table II this HDI is taken as explanatory variable for the amount of medals won during the games. In this specification we have not taken log's of the HDI because national income already enters into the ranking in a log-linear way. The estimation results show that the significance of this welfare indicator is somewhat higher for the Barcelona games than for the Seoul games. This is also true for Slottje's quality of life index (QOL), which is the explanatory variable in equation 5 of Table II. This QOL is a combined welfare index based on twenty different dimensions of welfare, which can be regarded as an alternative of the HDI of the United Nations. The main differences between the HDI and QOL are that QOL uses, besides more dimensions of human development, a more advanced weighing scheme. Because a low value (low ranking) of the QOL indicates a high level of welfare, its coefficients obtain a negative sign in the regression equation.

4. CONCLUSION

All regressions prove that the level of welfare is a major determinant of the relative performance of nations at the Olympic games. Surprisingly, multidimensional welfare indicators do not outperform national income in this respect. There are two reasons which might explain this result. Firstly it may be true that money income is the major determinant for the relative performance in sports indeed and that other aspects of the quality of life, which are included in the multidimensional indicators of human welfare, play a minor role only in the 'production' of Olympic winners. This is somewhat against intuition, as one expects performance in sports to be dependent upon the state of health of the population – we note that life expectancy is an element of the multidimensional indicators. And especially schooling, another element of human welfare indicators, seems important as an additional determinant because most sports require technical skills and/or aids and appliances, which can only be obtained through schools. However, it may be true that these specific elements of human welfare are highly correlated with national income. Therefore, the second reason for the relatively good fit of the regressions using national income as indicator of welfare may be that the specific elements of human welfare mentioned above are important indeed, but that the additional information contents of the multidimensional welfare indicators is too poor to yield a better explanation of performance in sports than simple national income data do.

Yet, the apparent relationship between (material) welfare and performance in sports shows that, in order to establish a proper ranking of countries at the Olympic games, it is relevant to correct the amount of medals won by each country for national income and for the size of the

TABLE III

Medals won for each million of dollars national income, adjusted for population size to the power 0.4, in millions

	Barcelona, 1992	Seoul, 1988 (rank; points)
1. Kenya	3.58	(1; 4.03)
2. Hungary	3.25	(4; 2.49)
3. Cuba	3.02	Boycott
4. China	2.74	(7; 1.42)
5. Jamacia	2.52	(9; 1.26)
6. Ethiopia	2.18	No medals won
7. South Korea	1.13	(8; 1.29)
13. CIS	0.86	(10; 0.98)
23. Germany	0.43	E-G. (3; 2.60); W-G. (19; 0.23)
24. Spain	0.41	(42; 0.07)
25. Netherlands	0.25	(26; 0.15)
26. United States	0.21	(23; 0.18)

population. Assuming an income elasticity of unity a simple calculation of the number of medals per billion dollars national income would suffice. However, our estimates show that the per capita income elasticity can be set equal to unity, but the elasticity with respect to population size appears to be smaller than one. Therefore Table III gives a ranking for the Barcelona games according to the criterion: number of medals won per million of dollars national income, adjusted for population size by multiplication with the population size to the power 0.4 (assuming a population elasticity of 0.6). According to this ranking Kenya has won the Barcelona games (as it did win the Seoul games) with Hungary in second and Cuba in third place. East Germany, after Kenya and Djibouti third in the Seoul games according to this way of ranking, now ends (together with West Germany) only at the 23rd place. The CIS and the

United States which won the largest absolute amount of medals, end up in the middle of the list.

Another method for picking the winners is to consider the country that has the largest positive residual in the regression equation. According to this criterion and specification 1 Jamaica is winner of the Barcelona games. Yet this residual has two components – the stochastics of the Poisson distribution and the specification error, which are 0.90 and 1.66 respectively – so that the interpretation is ambiguous. Hence this large residual can partly be ascribed to just good luck and partly to a specification error which can be associated with a specific Jamaican sporting culture. The Bayesian modelling of the Poisson distribution also allows us to predict the amount of medals won at the Barcelona games, given the measured specification error at the Seoul games. According to this method Indonesia, which won 1 medal at the Seoul games and 5 medals at the Barcelona games, yields the largest relative underprediction and could be declared winner of the Barcelona games. This manner of ranking shows the improvement of countries in performance at the Olympic games, given their level of welfare. These considerations demonstrate that it proves impossible to determine the true and only winners of the Olympic games, just as it is virtually impossible to determine which country has the highest standard of living in a comparative analysis of social welfare. Therefore, the only aim of this article is to show how differences in welfare (as measured by national income) should be taken into account when comparisons between nations are based on performance in sports. We do *not* advocate to include information on performance in sports into regular indicators of social welfare.

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