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Revealed Comparative Advantage and Specialisation in Athletics

in:

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Introduction

The degree to which individual countries are successful in sports differs considerably. Whereas some nations dominate (given) sports, others hardly ever come into the picture. A lot of empirical work has been published demonstrating that the macro-economic, geographical, sociological and political context plays a crucial role. These studies focus mainly on success during Olympic Games, notably the Summer Olympics. While demonstrating that – indeed – (economic, sociological, etc.) context matters for sporting success in general, they also show that these determinants have divergent impacts on specific sports. Recently, Glejser as well as Tcha and Pershin compare this to specialisation in international trade.[1] Just like some countries are (relatively) better in producing exotic fruits and others have an advantage in the production of cars, the context of some countries may create comparative advantages in specific sport disciplines: "Producing" athletes that are successful at the Winter Olympics is easier in Switzerland than in, say, Spain or Senegal. Specialisation in specific disciplines is a natural result.

Recognition of the methodological similarity between specialisation in international trade and in sports opens up a rich empirical toolbox for sports economists. Tcha and Pershin illustrate this convincingly.[2] They show how nations' macro-economic, geographical, sociological and political contexts affect their degrees of specialisation in one or more Olympic sports. A similar type of comparative advantage can be expected to exist within a heterogeneous sport, such as athletics. The context that is favourable to "produce" long distance runners is likely to be different from the context favouring success in pole vault-

[1] Glejser (2002) and Tcha/Pershin (2003).

[2] Tcha/Pershin (2003).

ing. These type of differences in specialisation are the focus of the present article. We analyse empirically how macro-contextual variables shape specialisation patterns across countries. We amend Tcha and Pershin's framework in two ways. First, we use a different indicator of specialisation. Tcha and Pershin use an index of Revealed Comparative Advantage (RCA) as developed by Balassa.[3] Still, as demonstrated by Laursen, this indicator suffers from a number of weaknesses, especially in the context of empirical work as we envisage here.[4] Thereto, for our own empirical work we make use of Laursen's index of Revealed Symmetric Comparative Advantage (RSCA). Second, whereas Tcha and Pershin use Tobit I analysis, we make use of a Tobit II estimator.[5] This allows us to disentangle two interrelated characteristics of a country's performance in sports: its level of success on the one hand and its degree of specialisation in specific sports on the other.

The paper is organised as follows. In section 1, we briefly discuss the literature on determinants of nations' sports successes and introduce the theoretical notion of (revealed) comparative advantage. In section 2, we demonstrate how indicators developed by Balassa as well as Laursen allow to measure the different degrees and natures of specialisation in sub-disciplines within athletics.[6] Section 3 presents the empirical model explaining intercountry differences in revealed comparative advantage. The main results are discussed in section 4. Section 5 concludes.

International Success and Specialisation in Sports

Many authors explore the relationship between the international sporting success of countries and the macro-economic, sociological and political context.[7] The two central environmental factors for success are population and wealth. For obvious reasons, a larger population as a rule increases the level of success in sports. The larger the pool of talent is in a country, the more likely it is that "exceptional" talents will be detected and developed. Wealth – expressed as per capita gross domestic product (GDP) – is an important determinant of success

[3] Ibid. and Balassa (1965).

[4] Laursen (2000).

[5] Tcha/Pershin (2003).

[6] Balassa (1965) and Laursen (2000).

[7] Recent examples are Bernard/Busse (2000), Johnson/Ayfer (2002), De Bosscher et al. (2003), and Lins et al. (2003).

as it not only increases a country's potential to invest in sports but it is also a proxy for the living conditions of the population. Other important determinants of success are: area (larger countries generally have a greater physiological, as well as climatological and geographical diversity); degree of urbanisation (sports tend to be an urban activity); religion (the protestant value system tends to translate into sporting success, the Muslim countries "underperform"); and politics (former communist countries tend to be more successful).

This literature focuses on determinants of sporting success, most often in terms of success at the Olympics. The typical focus is the level of success as measured by the (weighted) number of medals won. As a complement to the standard approach in the literature that focuses on the level of sport success, Tcha and Pershin analyse the issue of specialisation.[8] While a country may or may not be successful in sports in general, typically it will have some specific sports where its performances are relatively better and other sports where its success is less impressive. To analyse this, Tcha and Pershin introduce the notion of comparative advantage into the sports economics literature.[9] The notion was introduced as early as 1817 in the economics of international trade by Ricardo, who showed that it may be beneficial for countries to specialise (and trade) even if those countries are able to produce every item more cheaply than any other country. As a rule, a country is expected to specialise in the production of those items where its cost advantage is largest in relative – or comparative – terms. If in a two-country world country *A* can produce both goods *X* and *Y* more cheaply, it is said to have an absolute cost advantage for both. It may still benefit from specialising and trading in the good where the ratio of production costs is most beneficial. For example, specialisation in *X* is beneficial for country *A* if this country can produce *X* three times as cheaply as country *B* while it can produce *Y* "only" twice as cheap. In that case, country *B* should specialise in the production of *Y* (where its relative cost disadvantage is smallest) and both countries will benefit from mutual trade. As a result, comparative cost advantages in the production of *X* and/or *Y* translate into different patterns of production and import/export.

Tcha and Pershin show that a similar type of specialisation is present in sports.[10] Even if some countries are "better" in all (or many) sports, they will specialise. This specialisation depends upon the underlying cost and produc-

[8] Tcha/Pershin (2003).

[9] Ibid.

[10] Ibid.

tion functions which, in turn, depend on the context. Just as in international trade, these cost and production functions are not observable. Still, the actual trade patterns and sports specialisation (successes in international competitions) are. In the trade literature a number of indicators have been developed to empirically identify the specialisation patterns. The "classic" indicator is Balassa's measure of Revealed Comparative Advantage (RCA).[11] "The concept of RCA pertains to the relative trade performances of individual countries in particular commodities, and it is based on the assumption that the commodity pattern of trade reflects intercountry differences in relative costs, as well as in nonprice factors."[12]

Tcha and Pershin use Balassa's indicator to measure the comparative advantages in "producing" success at the summer Olympics. The intuition is similar to the idea underlying the notion of revealed comparative advantage in international trade: "For example, in a simple two-factor (capital and labour) model, a developed country with a relatively large supply of capital but a small population would specialize in capital-intensive sports, such as yachting. In contrast, a poor country with a relatively low level of capital would specialize in those sports where capital is relatively less important (or labor-intensive), say marathon running or boxing."[13] The identification of comparative advantages means in practical terms that for each country *i* and sport *j* the authors calculate Balassa's RCA-index (*Rij*) as:

$$R_{ij} = \frac{M_{ij}/M_i}{T_j/T} \qquad (1)$$

where M_i is the total amount of medals won by country *i*. M_{ij} is country *i*'s number of medals in sport *j*. *T* is the total number of medals at the Olympics (over all sports) and T_j is the number of medals won in sport *j*. Put differently: the denominator of the RCA-index for a given sport *j* gives the share of all

[11] Balassa (1965).

[12] Ibid., in: Tcha/Pershin (2003, p. 219).

[13] Ibid. (p. 220).

(Olympic) medals in that specific sport. The nominator gives the corresponding share for country *i*. The indicator will take a value of one if – for country *i* – the share of medals from sport *j* (as a percentage of all medals won by *i*) equals the share of medals that were given in that specific sport. Larger values indicate that in relative terms country *i* won more medals in sport *j* than the average country (and thus is considered to reveal a comparative advantage in that sport). Smaller values indicate that it won less medals than average (and thus reveals a comparative disadvantage, RCD).

In their empirical analysis Tcha and Pershin consider performance in five sports (swimming, athletics, weights, ball games, gymnastics) and a rest category. Of course, the ranking of countries in terms of RCA diverges from the "typical" rankings in terms of absolute or relative (to population size) measures. For example, Tcha and Pershin observe that for the Summer Olympics from 1988 to 1996 the US is the country with the highest medal total in athletics. In terms of RCA, the US ranks 20th. Still, when comparing the RCA values over the different sports for the US, the RCA index for athletics (R_{ij} = 1.55) is higher than for any other sport. This reflects that the US has a (revealed) comparative advantage in athletics. The fact that in spite of this the country only ranks 20th merely illustrates that 19 countries have an even stronger RCA. In practical terms, this often means that those are countries that may (or may not) be highly successful in absolute terms but that they at the same time are unsuccessful elsewhere. Examples are countries like Uganda and Zambia that won respectively 1 and 2 Olympic medals in athletics (compared to the 174 by the US) but for which these were the only medals (whereas the US totalled 632 Olympic medals).

Tcha and Pershin find clear patterns in the degrees of specialisation across countries.[14] For example, in athletics, the RCA index is significantly affected by countries' land masses, altitudes, per capita GDP and the lengths of their coastlines. While the first three determinants exert a positive influence on the RCA index, the length of the coastline leads to a revealed comparative disadvantage. Finally, African countries have a systematically higher RCA index indicating that they perform better in athletics than in the other sports under consideration.

[14] Ibid.

Revealed Comparative Advantage in Athletics

As discussed, Tcha and Pershin find clear evidence of inter-country differences in specialisation in sports.[15] But, of course, just as the set of all Olympic Sports is highly heterogeneous, it is the case that (some) sports are themselves highly heterogeneous. Athletics is a case in point. It goes without saying that an environment that is favourable to produce "marathon success" is likely to be different from an environment producing "pole vaulting success". For example, whereas the former involves little "capital", the latter is highly capital-intensive. This is true for physical capital: In contrast to the pole vaulter, a marathon runner hardly needs any specialised infrastructure to practice. This is also true for "human" capital: Whereas the starting age for marathon runners is relatively unimportant – indeed, many successful marathon runners started running at (almost) adult age – the high technical demands on pole vaulters makes it necessary to start the education of the sport at a relatively young age in order to develop the necessary skills. An immediate implication is that a country's success in pole vaulting is expected to depend much more on its system of talent detection and on the available infrastructure and training facilities (which in turn likely depend on the country's wealth). These differences between marathon running and pole vaulting can be expected to exist between most events within athletics. As a result, we may expect that countries will have comparative advantages (or disadvantages) in the events depending on their macro-economic, political and sociological environments.

To investigate RCA in athletics, we did not restrict ourselves to success at the Summer Olympics but chose a more general approach based on data from the official 2005 IAAF-rankings (International Association of Athletics Federations).[16] Both women's and men's performances were considered. The rankings give – for each event – all performances above a given threshold as defined by the IAAF.[17] For 2005 a total of 7,856 athletes were thus considered (3,901 male

[15] Ibid.

[16] Data obtained from http://www.iaaf.org/statistics/toplists/index.html; accessed on December 24, 2005.

[17] Of course, it often occurs that some athletes more than once performed better than the IAAF threshold. Evidently, for our calculations, we only took each athlete into account once. For example, 100 m sprint world record holder Asafa Powell appears 6 times in the ranking. To determine Jamaica's success we, of course, consider this as "one". Powell's appearance in the 200 m rankings is, however, considered as a separate Jamaican 'output'. Note that alternatives could be advocated if only because in the existing empirical work on Olympic success such double counting is not controlled for. When counting the number of medals it is not common practice to account for the fact that some athletes win more than just one medal. Note that this may bias results in favour of countries that specialise in sports where single talents can win more medals (like in swimming or athletics).

and 3,955 female), coming from 141 different countries. While, of course, the number of athletes passing a given threshold differs from year to year and among events, this corresponds to considering on average the top-167 in the world. We only consider “classic” disciplines (leaving out ranking information on 1,000 m, mile, 2,000 m running as well as the relays) and grouped the remaining disciplines. In a first step, we consider four main categories:

1. Sprinting (incl. hurdling) and Middle distance running
2. Long distance running
3. Non-running events
4. Race walking

Of course, these are still highly heterogeneous categories. For example, specialisation in hammer throwing is likely to depend on other environmental characteristics than specialisation in long jump. Similarly, the lumping together of sprinting events with middle distance running is likely to miss out crucial differences between these events. Therefore, in a second step, we further subdivide the above categories into twelve subcategories:[18]

1. Sprinting: 100 m, 200 m, 400 m
2. Hurdling: 110 m, 400 m
3. Middle distance: 800 m, 1,500 m
4. Long distance: 3,000 m, 5,000 m, 10,000 m, 3,000 m steeplechase
5. Street running: (1/2) Marathon
6. Long jump and Triple jump
7. High jump
8. Pole Vault
9. Shot put and Discus throw
10. Javelin throw
11. Hammer throw
12. Heptathlon and Decathlon

While Balassa’s indicator captures the notion of comparative advantage, Laursen demonstrates that if the index is to be used for econometric analysis,[19] it should be replaced by a symmetric version of it. Indeed, as can be seen from expression (1), the R_{ij} index for RCA ranges from zero to one if a country is not specialised, while it ranges from one to infinity in case of specialisation. The

[18] Race walking is not subdivided further.

[19] Laursen (2000).

index is thus clearly asymmetric. The higher values unavoidably bias empirical estimates in a model trying to explain degrees of specialisation. Therefore, Laursen suggests transforming Balassa's indicator to an index of Revealed Symmetric Comparative Advantage (RSCA). This indicator is defined as:

$$RS_{ij} = \frac{R_{ij} - 1}{R_{ij} + 1} \quad (2)$$

The RS_{ij} index ranges between -1 and +1. Positive numbers indicate specialisation. Negative numbers indicate that a country *i* is not specialised in discipline *j*. The special status of "-1" observations should be noted. This value is obtained if Balassa's indicator R_{ij} = 0; that is, if a country has not a single entry in the corresponding IAAF-ranking. This means that the comparative advantage or disadvantage is not revealed. The estimation technique in a model explaining cross-country differences in revealed comparative advantage should explicitly account for this. We return to this issue later in the text.

Table 1 gives the values for a selection of countries and for the main event categories as defined earlier. Table A1 in the appendix gives similar information for the more detailed set of athletic events.

Table 1: Index RS for Revealed Symmetric Comparative Advantage (RSCA) in Athletics, IAAF-rankings 2005 (main categories) – Selection of Countries

	Sprinting and Middle distance running	Long distance running	Non-running events	Race walk
Australia	0.031	-0.187	0.080	0.227
Belgium	0.156	-0.001	-0.062	-1.000
Cameroon	0.508	-1.000	-0.309	-1.000
Cuba	0.035	-0.946	0.372	-0.734
Ethiopia	-0.821	0.472	-1.000	-1.000
France	0.063	-0.216	0.149	-0.232

	Sprinting and Middle distance running	Long distance running	Non-running events	Race walk
Gambia	0.573	-1.000	-1.000	-1.000
Germany	-0.088	-0.535	0.341	-0.444
Great Britain	0.218	-0.080	-0.079	-0.744
US	0.262	-0.329	0.058	-0.867

Table 1 (and A1 in the appendix) reveals a number of important general characteristics. First, as expected, some countries have IAAF-entries in only a selected number of events. Countries like the US and Australia, however, have entries in all the event categories in Table 1. Table A1 shows that even when we subdivide the events further, the US and Australia still have entries for the twelve subcategories. At the other extreme, countries like Cameroon or Gambia have few athletes that surpass the IAAF thresholds. Gambia only has sprinters passing the IAAF standard threshold (see Table A1). This is taken to reflect very strong specialisation. Such a lack of diversification is a typical characteristic of smaller and/or less developed countries. The situation is analogous to "regular" trade situations: "In terms of RCA, Balassa pointed out that large countries are expected to have a more diversified export structure (have RCA for more goods but to a smaller degree),[20] mainly because their large domestic markets permit the exploitation of economies of scale in a wide range of industries".[21]

A second characteristic that is apparent from Table 1 is that for those countries that have entries in all disciplines, RS_{ij} exceeds zero for some events while being negative for other. This reflects the fact that specialisation in a set of events X by definition means that a country is not specialised in the complement set $-X$. Taking the US as an example, in Table A1, we see that the country is specialised in sprinting, hurdling, pole vaulting, shot put and discus throwing, and heptathlon/decathlon (positive values for the index of RS). They have a revealed comparative disadvantage for all other events (negative values). Specialisation is strongest in sprinting (RS = 0.371) and weakest in middle distance running (RS = -0.839). The issue is more complicated for countries that have a number of "-1"-entries. As discussed, this reflects the fact that no comparative advantage or disadvantage is revealed. It is of crucial importance to see that

[20] Balassa (1977).

[21] Tcha/Pershin (2003, p. 231).

the fact that the comparative (dis-)advantage is not revealed does not mean it is not there. The reason for this lies in the measure of success that we use: the presence of an athlete in the 2005 IAAF rankings. A country that has no athletes in any of the IAAF rankings may in certain disciplines have athletes that "almost" made it to the rankings; whereas in other disciplines, they are much further away from the threshold performance [then the country would have a comparative advantage in the former events while having a comparative disadvantage in the latter].[22] This insight is crucial when empirically testing a model that aims to explain cross-country variation in the index of RSCA. Intuitively, it should be clear that a value RS_{ij} = -1.000 is not to be interpreted as a value that lies close to say, -0.999. Whereas the latter value would be an indication of very strong comparative disadvantage, the $RS_{ij} = -1.000$ may "hide" comparative disadvantage or advantage.[23]

Empirical Model and Method

A stylized model explaining inter-country differences in specialisation can be written as:

$$RS^*_{ij} = \beta_o + \beta_1 POP_i + \beta_2 PCGDP_i + \beta_3 AREA_i + \beta_4 SOC_i + \beta_5 ASIA_i + \beta_6 AFRIC_i + \beta_7 CARI_i + \mu_i \quad (3)$$

where the dependent variable (RS^*_{ij}) is to be defined below. POP_i is country *i*'s population size, $PCGDP_i$ is per capita GDP, and *AREA* is the country's size. SOC_i is a dummy variable that takes the value of one if country *i* is a (former) socialist

[22] Put differently, suppose we would be using a much stricter definition of success, like the number of Olympic medals. In that case, countries that did not win a medal would turn up having no revealed comparative advantage. It is needless to say that still for most countries the likelihood of winning a medal differs across disciplines.

[23] While there may be reasons to expect that the likelihood of there being a comparative disadvantage is larger in athletic event $j = y$ with $RS_{iy} = -1.00$ if a country has revealed comparative (dis-)advantage for all other events ($RS_{ij} > -1.00$ for $j \neq y$), nothing can be said with respect to this likelihood if the country has values of –1.00 for multiple or even all other events.

country and zero in all other cases.[24] $ASIA_i$, $AFRIC_i$ and $CARI_i$ are "geographical" dummies taking a value of one for Asian, African and Caribbean countries respectively and zero in all other cases. These dummies capture the impact of physiological differences among the population from different countries.[25] μ_i is a random error term.

The estimation method should account for the bounded nature of our dependent variable. Especially the lower bound of the index needs consideration. Indeed, for each of the disciplines it is the case that a sizeable amount of countries do not have any entry in the rankings. This is the case in the situation that we consider our four main categories (as documented in Table 1). It is, of course, much more the case when we consider subcategories (see Table A1). The number of countries that do not have an athlete in the IAAF rankings differs between events. It is most pronounced in pole vaulting (48 countries out of 141 have athletes in the IAAF rankings), heptathlon/decathlon (46 countries) and hammer throwing (46 countries). It is well known that estimating by OLS (Ordinary Least Squares) would lead to biased results. Tcha and Pershin – estimating a model of Balassa's RCA index – proceed by estimating a Tobit regression[26] that relates the (latent) athletic success to a set of explanatory variables derived from the literature. Still, as explained earlier, we cannot know what a -1.000 value (a zero-value for the RCA index) for country *i* in discipline *j* tells us with respect to the comparative advantages or disadvantages: No information is revealed (see also footnote 6). It does tell us, however, something on the level of success that the country has in the event under consideration. Countries with RS_{ij} = -1.00 in a certain event can be categorised as being "unsuccessful", whereas any other value indicates that the country has at least one athlete that made it to the IAAF rankings. As such, the -1.00/>1.00 corresponds to a dichotomous indicator of success. The Tobit I estimator is therefore not appropriate in the current context as it implicitly treats countries with RS_{ij} = - 1.00 (R_{ij} = 0) as having a latent comparative disadvantage. As the RS_{ij} indicator actually incorporates information on the level of success on the one hand and comparative advantage or disadvantage on the other, we use a sample selection model (Tobit II model). This allows us to identify the determinants of comparative (dis-)advantage in a model that controls for the determinants of success. Estimating by Tobit II corresponds to simultaneously estimating a selection

[24] Following Tcha/Pershin (2003, p. 237), Germany is not considered to be formerly socialist.

[25] Tcha/Pershin (2003).

[26] Tobin (1958).

equation (having or not having an athlete in the IAAF rankings) and an outcome equation (the RS_{ij} index *given* that the country has at least one athlete in the IAAF rankings). The Tobit II estimator assumes that the dependent variable is only observed when another variable exceeds a certain value. We can write the sample selection model as:[27]

Selection equation: $$z_{ij}^* = w_i'\alpha + e_{ij} \qquad \begin{cases} z_{ij} = 0 & \text{if } z_{ij}^* \leq 0 \\ z_{ij} = 1 & \text{if } z_{ij}^* > 0; \end{cases}$$

Outcome equation: $$RS_{ij}^* = x_i'\beta + u_{ij} \qquad \begin{cases} RS_{ij} = RS_{ij}^* & \text{if } z_{ij} = 1 \\ RS_{ij} \text{ not observed} & \text{if } z_{ij} = 0. \end{cases}$$

The selection equation can be thought of as estimating the "real" or latent success z_i^* of country i. The variable z^* is, of course, not actually observed. We do observe, however, $z_{i;}$ i.e. the fact that country i has at least one athlete in the rankings (when $z_{ij}^* > 0$). The outcome equation estimates the country's RS_{ij}^*. This corresponds with actual level of RS_{ij} for those countries that had at least one athlete in the rankings ($z_i = 1$). It is unobserved (latent) in the other countries. When estimating the Tobit II model we will assume the determinants that were identified earlier to be valid both for the selection equation and the outcome equation. In practical terms, determinants of both success and comparative advantage can be the same. Still, crucially, the effects may diverge. Consider for example population size. This has been identified as probably the most important determinant of success: Countries with larger populations typically have more (Olympic) success, if only because they have a larger pool of talent. Thus, we expect a positive relationship between population size and success. The effect from population on RS_{ij} is (by definition) less clear-cut. While it is possible that larger countries specialise in some sports (say team sports),[28] the very notion of specialisation and comparative advantage in sport j implies that the country has comparative disadvantage in at least one other sport. So, the predicted empirical relation between population and RS_{ij} will be positive for some sports/events while being negative for other. Moreover, to

[27] Breen (1996).

[28] Glejser (2002).

the extent that there is a tendency for larger countries to diversify more, specialisation as measured through RS_{ij} will – in general – tend to be lower and a negative impact from population size will be observed.

Empirical Results

Tables 2 and 3 summarise our main results. In Table 2, we consider the four main categories of events. Tables 3 a and 3 b give the results for the further disaggregated data. In Table 2, for each of the (four) event categories a selection and outcome equation are presented. Because of space constraints, Tables 3 a and 3 b only report the results for the outcome equations. Before discussing the results in detail, two general conclusions can be drawn from the tables. First, we find clear effects from economic, demographic and political variables on both athletic success and specialisation. Second, determinants of success (selection equation) and specialisation (outcome equation) sometimes coincide, but this is certainly not true in all cases, as will be discussed further. This in itself is an additional argument in favour of using a Tobit II estimator.

While our main interest lies in the outcome equation that explains intercountry variation in specialisation, we control for the athletic success through the selection equation. The results from this equation mirror the general findings in the existing literature on Olympic success. Larger countries – in terms of population – have a significantly higher probability of having athletes in the IAAF rankings for sprinting and middle distance running, for race walking and for non-running events. For long distance running (including marathon) there is not such an effect: Having a large pool of talent is not a “sufficient” reason to “produce” successful long distance runners. Similarly, the results for countries’ wealth are unsurprising: Richer countries (higher per capita GDP) perform better in all four event categories. Also, the selection equations clearly indicate the role of the political context: (Former) socialist countries perform significantly better in running events, irrespective of the distance. African and Caribbean countries are systematically less successful in non-running events and race walking (in the latter event, also Asian countries tend to be less successful). They are more successful than average in sprinting and middle distance running.

Table 2: Explaining RSCA-index (main categories)

	Sprinting & Middle distance running		Long distance running		Non-running events		Race Walking	
	Selection Equation	*Outcome equation*	*Selection Equation*	*Outcome equation*	*Selection Equation*	*Outcome equation*	*Selection Equation*	*Outcome equation*
C	-0.47 (-1.27)	0.13 (1.28)	-0.73 (-2.29)	-0.33 (-1.98)	0.20 (0.56)	0.23 (2.52)	-0.93 (-2.68)	0.29 (1.45)
POP	19.92 (1.74)	-0.18 (-1.82)	-1.27 (-0.94)	-0.08 (-0.42)	6.09 (2.89)	-0.07 (-0.52)	18.44 (3.28)	0.13 (0.38)
PCGDP	58.17 (2.71)	-9.10 (-2.29)	60.19 (3.44)	5.53 (0.91)	47.98 (2.25)	-5.15 (-1.18)	35.65 (2.03)	-21.35 (-2.44)
AREA	0.01 (0.06)	0.03 (3.56)	0.44 (1.43)	0.00 (-0.34)	0.02 (0.16)	-0.01 (-2.57)	0.12 (1.35)	-0.01 (-0.63)
SOC	0.93 (2.31)	-0.28 (-3.07)	0.75 (1.99)	-0.11 (-0.94)	0.70 (1.54)	0.12 (1.69)	0.53 (1.51)	0.08 (0.51)
ASIA	-0.11 (-0.25)	-0.13 (-1.25)	-0.23 (-0.66)	0.22 (1.46)	-0.35 (-0.83)	0.06 (0.60)	-1.41 (-3.49)	-0.17 (-0.89)
AFRIC	0.73 (1.91)	0.11 (1.08)	0.25 (0.70)	0.48 (3.47)	-0.85 (-2.19)	-0.31 (-2.50)	-1.75 (-2.45)	-0.64 (-2.48)
CARI	1.46 (2.78)	0.45 (6.27)	-0.69 (-1.57)	-0.36 (0.11)	-0.69 (-1.68)	-0.32 (-3.11)	-1.19 (-2.31)	-1.65 (-8.35)
Rho	0.43		0.34		0.28		0.83	
Sigma	0.30		0.32		0.27		0.43	
LL	-78.97		-9.23		-75.65		-66.59	
N° observations	141		141		141		141	
N° uncensored observations	112		74		101		44	

Notes: z-values based on heteroskedasticity-consistent standard errors in parentheses;
POP, PCGDP, AREA expressed in billion, million Euro and million km² respectively.

Table 3 a: Explaining RSCA-index (sub categories; only outcome equations are reported)

	Sprinting	Hurdling	Middle distance	Long distance	Street running	Long and triple jump
C	0.14 (1.00)	0.45 (3.16)	-1.03 (-9.52)	-0.43 (-3.84)	0.18 (1.26)	0.41 (0.80)
POP	-0.30 (-1.35)	-0.03 (-0.20)	-0.19 (-1.71)	-0.02 (-0.11)	-0.35 (-1.90)	-0.23 (-0.73)
PCGDP	-14.06 (-2.35)	-15.51 (-2.55)	4.91 (1.01)	13.05 (2.67)	-20.36 (-3.38)	-21.49 (-1.41)
AREA	0.03 (2.88)	0.00 (0.22)	0.02 (2.74)	-0.01 (-0.64)	0.00 (-0.18)	0.00 (0.07)
SOC	-0.37 (-3.06)	-0.31 (-2.55)	0.09 (1.14)	-0.02 (-0.22)	-0.38 (-3.14)	0.08 (0.31)
ASIA	0.13 (0.66)	-0.12 (-0.98)	0.16 (1.40)	0.15 (0.89)	0.37 (2.54)	0.11 (0.75)
AFRIC	0.31 (2.03)	-0.19 (-0.96)	0.10 (0.76)	0.54 (3.28)	0.13 (0.75)	-0.08 (-0.61)
CARI	0.67 (6.13)	0.05 (0.40)	-0.01 (-0.06)	-0.32 (-1.28)	-0.19 (-0.48)	-0.10 (-0.57)
Rho	0.26	0.05	1	0.26	0.12	0.26
Sigma	0.33	0.36	0.31	0.32	0.34	0.30
LL	-98.42	-118.86	-59.04	-89.71	-98.47	-94.84
Observations	141	141	141	141	141	141
Uncensored observations	77	74	72	60	64	78

Notes: z-values based on heteroskedasticity-consistent standard errors in parentheses; *POP*, *PCGDP*, *AREA* expressed in billion, million Euro and million km² respectively.

Table 3 b: Explaining RSCA-index (sub categories – continued; only outcome equations are reported)

	High jump	Pole vault	Shot put and discus	Javelin	Hammer	Heptathlon/ Decathlon
C	0.34 (2.66)	0.20 (1.66)	0.29 (1.88)	-0.19 (-0.73)	0.33 (1.12)	-0.03 (-0.11)
POP	-0.52 (-3.25)	-0.15 (-0.67)	0.44 (2.19)	-0.06 (-0.21)	-0.40 (-1.76)	-0.06 (-0.23)
PCGDP	-10.76 (-1.87)	2.66 (0.47)	-13.70 (-2.00)	8.23 (0.94)	-10.59 (-1.12)	5.30 (0.48)
AREA	0.00 (-0.27)	-0.01 (-1.07)	-0.02 (-1.58)	-0.02 (-1.68)	-0.01 (-0.70)	-0.02 (-1.48)
SOC	0.11 (1.10)	-0.04 (-0.32)	-0.03 (-0.26)	0.31 (1.88)	0.09 (0.52)	0.26 (1.55)
ASIA	0.08 (0.49)	-0.05 (-0.19)	-0.20 (-1.18)	0.41 (2.45)	-0.02 (-0.09)	-0.15 (-0.45)
AFRIC	-0.05 (-0.28)	-0.19 (-1.10)	-0.41 (-2.20)	0.02 (0.09)	-0.23 (-0.76)	-0.12 (-0.37)
CARI	-0.17 (-0.96)	-0.12 (-0.48)	-0.82 (-3.54)	-0.37 (-1.54)	-0.40 (-1.58)	-0.09 (-0.30)
Rho	0.46	0.16	0.89	0.89	0.54	0.51
Sigma	0.29	0.33	0.40	0.40	0.36	0.38
LL	-76.26	-75.86	-22.84	-75.02	-79.61	-79.70
Observations	141	141	141	141	141	141
Uncensored observations	57	48	65	52	46	46

Notes: z-values based on heteroskedasticity-consistent standard errors in parentheses; *POP, PCGDP, AREA* expressed in billion, million Euro and million km² respectively.

Turning to the issue of specialisation as apparent from the outcome equations, we observe clear geographical patterns in revealed comparative advantage. *Ceteris paribus,* African countries tend to specialise in long distance running while having significantly lower RS-values for both non-running events and race walking. Table 3 a reveals a revealed comparative advantage in sprinting too (an effect which is not apparent from Table 2 where sprinting is lumped together with middle distance running and hurdling events). Table 3 b learns that the low RS-values in non-running events are most apparent in shot put and discus throwing. Caribbean countries tend to have comparative advantage in sprinting and middle distance running (Table 3 a reveals that this result is due to Caribbean specialisation in sprinting) 'compensated' by an underspecialisation in non-running events and race walking. Finally, according to the general picture offered in Table 2, Asian countries tend not to differ systematically in terms of revealed comparative (dis-)advantage from the rest of the sample. Tables 3 a and 3 b do, however, reveal specialisation in street running and javelin throwing.

Controlling for these geographical/physiological effects, Table 2 reveals a clear role of population size on specialisation in sprinting and middle distance running. More populated countries have significantly lower values for the RS_{ij} index in these events. It is noteworthy to see that, while being insignificant, the sign on population is negative for all other event categories as well. This indicates that controlling for geographical and other determinants highly populated countries have a revealed comparative disadvantage or possibly a revealed comparative advantage that is smaller than less populated countries. This reflects the general idea that highly populated countries diversify more. This is apparent from Table 1, where the extreme values are observed in smaller countries.

Wealth, as measured by per capita GDP, has a similar effect: The coefficients in the outcome equation are negative for all event categories but one (long distance running). The effect is significantly negative for sprinting and middle distance running as well as for race walking. The interpretation is similar to the one with respect to the effect of population size: Richer countries diversify, as wealth allows to produce elite athletes in more events. That the revealed comparative disadvantage is strongest for middle distance running and race walking may not come as a surprise as it implies a relative better performance for non-running events that, as a rule, involve much more investment in infrastructure and athletic education. The positive (while insignificant) effect for long distance running may be less expected to the casual observer who is struck by the strong dominance by Kenyan and Ethiopian long distance runners in international competitions. Still, it should be noted that some (relatively) rich countries have a remarkable degree of specialisation in long distance running that does not always translate in success at the Olympic games or world championships. A closer look at the RSCA-index data does indeed learn that both countries have a clear revealed comparative advantage. The index for long distance running takes a value of 0.44 for Kenya and 0.47 for Ethiopia. While these are indeed large values, they are by no means exceptional: (Rich) countries like Japan and Qatar (with some former Kenyan runners) have similar degrees of revealed symmetric competitive advantage (with RSCA-index values of 0.40 and 0.36 respectively). The case of Japan is interesting. Consider the 10,000 m ranking: 35.1 % of all runners are Japanese, compared to 20.2 % Kenyan and 6.0 % Ethiopian. Interestingly, the Japanese "dominance" does not translate into the presence of absolute elite athletes: When considering only top-20 runners, Kenya and Ethiopia each have 25 % while Japan has 2.5 % (only one Japanese runner enters the top 20).

A large area positively affects the index of comparative advantage in sprinting and middle distance running while leading to comparative disadvantages in non-running events. This may be taken to reflect the dependence on sports infrastructure and training facilities for individual athletes in non-running events. A country's area is a proxy for the average travelling distance to these facilities. Larger distances make the entry to training facilities more costly. This may be especially relevant for young children and athletes who may forgo opportunities to get a (good) technical education, which is highly important in most non-running events.

Finally, we find clear effects from the political regime. Socialist countries have a significant revealed comparative advantage in non-running events and a revealed disadvantage in sprinting and middle distance running. This is in line with the view that (former) socialist countries tend to stress sports successes as a means to promote their image worldwide. That these countries specialise in non-running events is as expected. Indeed, the impact of talent detection systems and well-organised youth athletic development programs are of crucial importance in those events that put high technical demands on the athletes. As discussed, it is a general finding in the literature that the investments made by (former) socialist countries translated into international successes in many sports. Our findings on 2005 IAAF rankings indicate that the investments made under socialist regimes still affect the level of international success, even after the fall of the Berlin Wall. The selection equation revealed that socialist countries are more successful in sprinting and middle distance events as well as in non-running events. The outcome equation shows that specialisation is most pronounced in the latter. This suggests that sports culture and the know-how that has been built up under those regimes as well as the investments in infrastructure still have their effects (it would take a time series analysis to see at what pace, if at all, this effect is actually disappearing).

Conclusions

One of the first and most influential theoretical concepts in the history of economics is Ricardo's notion of comparative advantage. The notion was introduced as early as 1817 in the economics of international trade. Ricardo showed that countries benefit from specialisation (and trade) even if they themselves would be able to produce every item more cheaply (or more expensively) than any other country. Actual patterns of international trade reveal underlying cost functions that differ across countries. A similar situation can be found in sports: The macro-economic, sociological and political context of a country is expected to translate into different (relative) cost functions. The optimal environment to produce successful skiers differs from the ideal context to "produce" windsurfing champions. Thus, while it is theoretically possible to "produce" Olympic champions in Alpine skiing in countries like Mexico or the Netherlands, there is little doubt that it would be relatively more realistic to hope for Mexican or Dutch successes in soccer. The country's environment helps in determining in which sports it will specialise. Results in international competitions like the Olympic Games can thus be taken to reveal underlying cost structures. A similar argument can be made for a heterogeneous sport such as athletics.

Following Tcha and Pershin we analyse intercountry differences in comparative advantage (specialisation) as revealed by a symmetric version – suggested by Laursen – of Balassa's index. This measure for Revealed Symmetric Comparative Advantage (RSCA) indicates the degree of specialisation in specific athletic disciplines. A country's number of entries in the 2005 IAAF rankings is taken as an indicator of its success. We find strong differences among countries. Estimating a Tobit II model, we identify determinants of the degree of specialisation. The Tobit II estimator allows to disentangle two interrelated characteristics of a country's performance in sports: its level of success on the one hand and its degree of specialisation in specific sports on the other. While the latter is the main focus of our analysis, it proves crucial to control for the former.

We observe clear geographical patterns in revealed comparative advantage: African and Caribbean (and to a lesser extent Asian) countries have a "typical" pattern of specialisation that differs significantly from the rest of the world. As for the level of success, population size and a country's wealth prove to be important determinants of revealed comparative advantage. Highly populated as well as richer countries tend to diversify more. They have a larger pool of talents and the (financial) means to excel in many events. Smaller and/or poorer countries on the other hand tend to specialise. Interestingly, also the size of a country matters: A large area positively affects the index of comparative advantage in sprinting and middle distance running while leading to comparative disadvantages in non-running events. This is taken to reflect the dependence on sports infrastructure and training facilities for individual athletes in non-running events. Finally, politics matters. Socialist countries have a significant revealed comparative advantage in non-running events where talent detection and youth development programs are crucial. They have a revealed disadvantage in sprinting.

Identifying revealed comparative advantages in different events in athletics and their determinants provides an insight that is both interesting from a (positive) academic perspective and helpful for policy makers and federations. Indeed, the identification of determinants not only helps to understand actual sports successes; it may also be used to understand structural changes therein. From a policy perspective the insight is a crucial input into any planning that aims at maximising a country's or federation's success rate in international competitions. Also from a policy perspective, it is crucial to keep in mind that even if favourable conditions exist to "produce" sport successes, it may still be necessary to complement "natural" conditions with active policy measures.

Appendix

Tabelle A 1: Index for Revealed Symmetric Comparative Advantage in Athletics for 12 Event Categories – Selected Countries

	Sprint-ing	Hurd-ling	Middle Dis-tance	Long Dis-tance	Street	Long & Triple Jump	High jump	Pole Vault	Shot put & Discuss	Javelin throw	Ham-mer throw	Hep-tathlon & De-cathlon
Australia	0.169	-0.333	-0.808	-0.083	-0.320	0.128	-0.041	0.316	-0.065	0.171	-0.155	0.040
Belgium	0.130	-0.039	-0.672	0.021	-0.024	-0.516	0.154	0.243	-0.013	-1	-1	0.412
Cameroun	0.684	0.377	-1	-1	-1	0.391	-1	-1	-1	-1	-1	-1
Cuba	0.004	0.215	-0.872	-1	-0.892	0.523	0.175	-0.187	0.369	0.548	0.386	0.145
Ethiopia	-1	-1	-0.927	0.412	0.523	-1	-1	-1	-1	-1	-1	-1
France	-0.011	0.094	-0.764	-0.060	-0.435	0.110	-0.104	0.519	-0.204	-0.136	0.160	0.312
Gambia	0.777	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
Germany	-0.237	0.220	-0.912	-0.418	-0.680	0.002	0.177	0.426	0.366	0.516	0.309	0.542
Great Britain	0.158	0.194	-0.672	0.009	-0.190	-0.133	0.200	-0.207	-0.167	-0.253	0.098	-0.110
USA	0.371	0.264	-0.839	-0.080	-0.750	-0.071	-0.052	0.271	0.224	-0.484	-0.086	0.071

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