The Impact of Policies Influencing the Demography of Age Structured Populations:

The Case of Academies of Science

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ABSTRACT

The age structure of academies of science is especially affected by trends in increased survival given the remarkable longevity of their members and virtual lifetime membership after election. Regulating the age structure of elections not only represents a potential way to control the pace of aging, but in fact the only one. However, many European academies have also enacted policies aimed to curb or slow down growth, which leads to the decision of choosing an age structure of intake that does not exacerbate aging while maintaining intake to acceptable levels. Given these trends and due to the fact that these policies and practices are relatively heterogeneous across learned societies, we aim to assess the role of the size and age structure of intake in influencing the potential evolution of regular membership of five European academies of science, namely the Austrian, Berlin-Brandenburg, Russian, and Norwegian Academies and the Royal Society of London. We do this by contrasting different projections of Regular Members in each academy into 2050 and measuring the age-compositional effect of enacting or not enacting a given policy vis-à-vis a standard policy scenario. We further decompose the differences brought in the age structure due to enacting or not enacting different policies from those brought by the likely evolution of mortality to evaluate the impact of both for the future of academies.

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Population aging is slowly but surely transforming the demographic makeup of Europe. While longstanding patterns of low fertility have been major contributors for the observed trends their occurrence in the context of significant reductions in adult mortality –including the old ages- have had and will continue to have a commensurable impact in the age structure.[1] Under prevailing systems of social security, labor market policies and institutional frameworks in most industrialized countries these demographic developments will pose economic challenges and endanger the sustainability of economic growth. While most economists are mainly concerned to adapt the prevailing welfare systems under changing demographic developments, demographers and sociologists are more interested to understand and suggest policies to influence demographic development. Given the continued increasing trend in adult life expectancy in the near future and the sustained tendency to low reproduction, scholars have particularly looked at the role of immigration in potentially regulating the age structure or maintaining certain dependency ratios (Alho 2006; Arthur and Espenshade 1988; Blanchet 1988; Cerone 1987; Espenshade, Bouvier and Arthur 1982; Feichtinger and Steinmann 1992; Mitra 1990; Mitra and Cerone 1986; Schmertmann 1992; Sivamurthy 1982; Wu and Li 2003).[2]

Academies of science are an example of an institution whose age structure may be especially affected by increased survival due to the remarkable longevity of their members and virtual lifetime membership after election (see Leridon 2004; Winkler-Dworak 2006). Regulating the age structure of elections (hereafter also referred to as intake), which are analogous to immigration in geographically-defined populations, does not only represent a potential way to control the pace of aging, but in fact the only one, despite the fact that age-

[1] Even if milder, the consequences of aging ‘from the top’ tend to be more immediate than those of aging brought by decreasing fertility.

[2] These studies have generally looked at conditions that ensure stationarity (i.e. fixed below-replacement fertility, a fixed mortality schedule, and a constant immigrant inflow, see (Espenshade et al. 1982).

graded inflows tend to have milder rejuvenating effects than those of fertility given the stochastic dominance of the flows (Schmertmann 1992).[3]

In addition to these structural conditions, many European academies have enacted policies aimed to curb or slow down growth. Effective growth-curbing policies, however, tend to exacerbate aging or slow down intake to very low levels (Feichtinger et al. Forthcoming-a). As such, and due to the relative heterogeneity in policies and practices aimed to regulate the size and –to a lesser extent- age structure of such intake, academies of science represent a special yet useful case-in-point of how a combination of these policies might be used to mediate between the size and age structure of many types of populations, in particular for institutions with clear size constrains (e.g. management positions in a company or professorships in a university).

In this paper, we assess the role of various policies aimed to control the size and age structure of intake in influencing the potential evolution of regular membership of five European academies of science. We do this by contrasting different projections of Regular Members (hereafter RM) in each academy into 2050 and measuring the age-compositional effect of enacting or not enacting a given policy vis-à-vis a standard policy scenario. We further decompose differences in the age structure brought by these policies from those brought by the likely evolution of mortality, thus assessing the impact of both in academies in the future. While we have done some work aimed to study how a specific set of policies could affect the age composition and size of the Austrian Academy of Sciences and its future evolution (Feichtinger et al. Forthcoming-a; Feichtinger et al. Forthcoming-b), we aim to extend our approach to include a broader set of policies and practices by way of studying four additional learned societies: the Berlin-Brandenburg Academy of Sciences, the Royal Society of London, the

[3] As retirement in learned societies tends to be only nominal (i.e. members keep all their privileges after reaching the retirement age) we do not consider this a solution to aging per se. However, we will consider the situation in which the number of elections is anchored to the ranks of those retiring.

Russian Academy of Sciences, and the Norwegian Academy of Sciences and Letters. We introduce these populations and the two most important sets of policies before sketching out our analytic strategy.

THE ACADEMIES AND THEIR POLICIES

Data come from membership records of five European learned societies, namely: the Austrian Academy of Sciences (OEAW), the Berlin-Brandenburg Academy of Sciences (BBAW), the Royal Society of London (RSL), the Russian Academy of Sciences (RAS), and the Norwegian Academy of Sciences and Letters (NoAS). The size and age structure of regular membership varies considerably across academies (see Table 1) given sizable variation in the mortality conditions to which members are exposed to (see Leridon 2004; Winkler-Dworak 2006) and the size and age structure of intake (e.g. see Figure 2).

In addition to variation in the longevity and external circumstances that could potentially affect the age distribution of elections (e.g. the age distribution of the pool of potential academicians given changes in cohort size and age-specific educational transition rates), there are two sets of policies affecting the size and –at least potentially- age structure of regular membership intake. The first refers to the fact that many learned societies elect regular members from a pool of people already belonging to the academy under a junior status generally known as corresponding members (CM hereafter). The existence of a corresponding member status could affect the size and age structure of intake by restricting the pool from which academicians might be elected.[4] Second, some academies indeed restrict the number of (generally, yearly) elections

[4] Moreover, academies that have a corresponding member status might have higher ages at election by the sole fact that, ceteris paribus, having a corresponding member status might imply an additional waiting time to election as regular member if the combination of age at election and waiting times is larger than age at election under a regime with no corresponding membership of course.

to a fixed number, or to match the number of regular members reaching a given statutory 'retirement' age. We explain each of these policies more in detail next.

Corresponding Membership

Academies such as the Austrian, the Russian, and –until 1993- the Berlin-Brandenburg have had a 'corresponding member' status with more limited (e.g. no voting) rights previous to regular membership. Even if all CMs were elected into regular membership, the size and age distribution of corresponding members would set constrains to the pool of people that can become regular members. More importantly, not all CMs get elected as RM, and this seems to be a function of age and, more interestingly, age at election at CM (to a certain extent at least). Table 2 shows estimates of lifetime probabilities of being promoted from CM to RM in Austria. In the most recent period under observation (ending in 1990 to avoid overly truncating exposure), probabilities of transitioning were lowest for those over 55, standing at 38%, and highest for the few members younger than 45 at 88%.

Furthermore, age at election as RM might be a function of age at election into the junior status. Figure 1 shows a scatter plot of waiting times before election into RM for members for both Classes of the Austrian Academy of Sciences conditional on becoming a RM in 1966-1990 according to their age at election as corresponding member (x-axis). The underdispersion in the data (i.e. the fact that the *variance* in age at RM election decreases as age at election as CM increases) is natural given the limits to election statutory retirement at age 70. In addition, age at election seems to follow a concave shape, where a lower age implies longer and similar waiting times before election for those being elected below age 50 or so, where durations before RM election shorten.

Finally, elections might potentially occur later than they otherwise would without such status.[5] Figure 2 shows mean age at election as RM in the five academies under study by period. It is rather clear that age at election not only has increased over time, but is considerably higher in academies with a corresponding status previous to regular membership, like in Russia and Austria, despite their contrasting policies regarding the size of intake (explained next). The fact that promotion from CM to RM can be viewed as a stochastic process with systematic variation by age at election and as academies with a CM status have higher ages at election as RM altogether suggest that the age distribution of CM elections is a relevant variable to consider when choosing the optimal age at RM election subject to size and age structure constrains.

-TABLE 1 ABOUT HERE-

-FIGURES 1 AND 2 ABOUT HERE-

Limiting and Anchoring the Number of Elections

The aforementioned size constrains are a clear policy variable. Academies limit the number of regular members to be inducted in a given election period in two main ways. First, there may be a fixed number of elections per period, as in the case of the Royal Society, where 44 new fellows have been elected every year in the recent past. In the short run and *ceteris paribus*, this practice implies quick growth or decline (depending on the size and age structure of

[5] For instance, if the corresponding member status was eliminated from an academy (e.g. the BBAW in the 1990s) and thereafter everyone eligible to become a regular member had the same chances of election irrespectively of having previous experience as corresponding members, the existence of a corresponding member status would have 'delayed' entry into regular membership if the age at election as regular member after the policy change was lower than the age at election as regular members under the previous policy of having a corresponding member status. While the (expected) age at election as regular member under the old policy would be exactly equivalent to the (expected) age at election as corresponding member plus the (expected) waiting time in the corresponding state, this would only be so if the covariance between age at election as corresponding member and the waiting time before entry into regular membership were zero. Hence, adding a corresponding member status (even after waiting for members to accrue experience in the corresponding state) in a situation where waiting time varied according to age at election (say, in a concave form) would change the age distribution of intake in potentially interesting ways.

membership) until reaching a stationary state in the long run if the age structure of intake and attrition remained constant.

Alternatively, intake per election period (typically, yearly) could be anchored to a given though not fixed quantity. For instance, the Austrian, Berlin-Brandenburg, and Norwegian academies have set the number of elections to match the number of people reaching a statutory retirement (SR) age (currently of 70, 68, and 67 respectively). This policy has served to fix the number of regular members below the SR age limit to 90 in Austria, 200 in Berlin-Brandenburg, and 220 in Norway. As members past SR retain all their rights and privileges as regular members, this policy has served to bound membership size nominally so-to-speak while permitting the continuous flow of new membership at rates close of that of the aging of academicians below retirement age.

Either fixing or anchoring intake may have contrasting implications for both the size and age structure of the population of reference, though these consequences also depend on the relative size of intake and its actual age structure. The higher the intake rate and the lower the mean age at election, the larger the rejuvenating effect of intake would be of course. However, under conditions of fixed intake, a larger (initial) election rate might very well mean extremely high growth depending on mortality conditions and the prevailing age structure and thus may prove undesirable in the medium run (e.g. due to cost or prestige considerations). In contrast, the effect of anchored intake on the age structure would be more moderate as said policy would set clear bounds to the size of the pre-retirement population.

While the optimality of having a younger/older ages at election and higher/lower numbers of yearly elections has been studied in the context of the Austrian Academy of Sciences (Feichtinger et al. 2007, Forthcoming-a) no study to our knowledge has considered the potential effects of other policies (or the lack thereof), like the existence of a corresponding member status, and of mortality conditions on the size and age structure of a given academy.[6]

ANALYTIC APPROACH

After describing the recent evolution of academies that might explain current differences in size and age structure, we turn to quantify the effect of policies in terms of these two parameters (e.g. in the ratio between different scenarios). Our basic approach is to compare the size and age structure across different projection scenarios for each academy into 2050. In a scenario denoted as Scenario 0 we project the likely future evolution of each learned society with no CM status, no hard limits to membership size/age structure, and standard mortality conditions in each to avoid confounding inter-country differences in longevity with the relevance of policies. We compare Scenario No. 0 to projections considering a combination of policy scenarios in which we vary our two main policies both step-wise and simultaneously as depicted in Table 3.

-TABLE 3 ABOUT HERE-

First, we develop scenarios in which we standardize the age at election as a CM while assuming that the relationship between age at election as CM and waiting time before election as RM follow a similar path across academies (e.g. a similar one to the one depicted in Figure 1). In addition to this Scenario (no. 1 in Table 3), we study the effect of changing policies with respect to the number of elections (Scenarios 2 and 3), whether by assuming linear growth (i.e. fixing

[6] Given the large variation across academies in these variables, a natural first step would be to compare their recent evolution. However, this exercise yields limited results with respect to the relevance of policies for two reasons. First, although the academies studied represent a good mix of policy conditions, these have been in place for different spans in each and in fact have varied in the recent past. Second, 'external' conditions that might have a role explaining differences in the size and age structure of academies, such as (surely) differential longevity and (potentially) differences in the age structure of the pool of potential academicians do not only vary by country but have also varied across time.

their number to a quantity representing the same rate of intake across academies in the base year, e.g. 25 elections in academy A of size 250 vs. 50 elections in academy B of size 500), or by assuming intake is anchored to the ranks of people reaching a statutory retirement age (we further plan to test the sensitivity of either the initial intake rate and the retirement age). A final pair of scenarios (i.e. 4 and 5 in Table 4) are used to compare the age structure of the academy and its size in the case where CM status and limited intake policies are combined.

Once we have these scenarios, we will compare the ratio between a few summary measures (e.g. total size, the mean age, and the percent above a certain age) for the scenario under scrutiny and the Scenario to calculate the total effect of (not) enacting a policy (Scenarios 1-3) or combination of policies (Scenarios 4-5). We will also calculate these ratios using other Scenarios as a benchmark (e.g. 4/1 or 1/4) in order to compare the marginal effect of enacting a given policy given the existence of another one, whether mutually-exclusive (e.g. fixed vs. anchored intake) or not (e.g. having a CM status and anchored intake).

Finally we shall decompose the change in summary measures over time into the effect caused by a policy change versus the change in mortality patterns by comparing the results of each scenario to alternative ones (e.g. 5b with 5, and so on) in which we do not fix mortality to a given standard, but let it vary according to its likely future evolution (e.g. by forecasting mortality using Lee-Carter). This decomposition is of great practical relevance since it addresses the role of demographic ageing as compared to ageing caused by the institutional set up. Our approach will be similar as that of (Prskawetz et al. 2005) who studied the size and composition of the labor force in five selected OECD countries. As stated by the authors, labor force indicators are sensitive to changes in the age composition of the population as well as to changes in the labor force participation rates (i.e. institutional changes).

	OEAW	BBAW	RAS	RSL	NoAS
Year of foundation	1847	1700, 1993	1724	1660	1857
Data availability	1847 – 2005	1700 - 2005	1724 – 1999	1660 - 2006	1950 - 2005
Status previous to RM	Yes	Until 1993	Yes	No	No
Current maximum intake	N/A	N/A	N/A	44	N/A
Statutory retirement (SR) age	70 (prev. 75)	68	N/A	N/A	67
Year where SR enacted	1972 (1950)	1993	N/A	N/A	1950
Current maximum size	90	200	N/A	N/A	~200
Current RMs	167	200	449	1,286	460
Current RMs below retirement age	83	154	449	1,286	216
Percent above age 70	50.3	18.2	56.5	N/A	45.7

N/A – Not Applicable

Table 1. Summary of Intake Policies and Conditions by Academy

		Raw probabilities of ever becoming a Regular Member (RM)			Mean duration as CM for those who became RMs			Mean age at election as RM		
		All	Math. Nat.	Hum. Soc.	All	Math. Nat.	Hum. Soc.	All	Math. Nat.	Hum. Soc.
All	1847-1915	0.497	0.489	0.505	7.7	8.5	7.0	49.9	49.0	50.7
	1916-1965	0.448	0.434	0.462	6.4	6.9	6.0	59.2	58.5	59.8
	1966-1990	0.629	0.641	0.618	6.7	6.8	6.5	57.3	57.8	56.7
Less than 45	1847-1915	0.637	0.644	0.630	7.7	8.5	6.8	45.3	45.5	45.0
	1916-1965	0.673	0.593	0.773	8.8	10.6	7.2	50.6	52.1	49.2
	1966-1990	0.872	0.842	0.900	8.0	8.3	7.8	49.6	50.4	48.8
45 to 49	1847-1915	0.520	0.405	0.632	8.0	8.3	7.8	55.7	55.9	55.6
	1916-1965	0.672	0.639	0.714	6.6	6.4	6.8	54.6	54.4	54.8
	1966-1990	0.792	0.800	0.786	8.1	9.3	7.3	55.7	56.9	54.8
50-54	1847-1915	0.333	0.250	0.400	7.9	9.7	7.1	60.8	62.2	60.2
	1916-1965	0.563	0.525	0.600	6.5	5.9	7.1	59.2	58.8	59.6
	1966-1990	0.764	0.800	0.720	6.0	5.8	6.2	58.4	58.5	58.3
55 and over	1847-1915	0.169	0.143	0.182	5.9	6.7	5.6	66.2	65.3	66.5
	1916-1965	0.295	0.269	0.313	5.1	5.9	4.6	66.5	66.2	66.8
	1966-1990	0.378	0.396	0.360	4.6	4.8	4.5	64.6	64.0	65.2

Table 2.Probability of Ever Becoming a Regular Member, Mean Duration before RM election, and mean age at election as RM in the Austrian Academy of Sciences by Class, Age and Period of Election as Corresponding Member

	Mortality	CM status	Fixed intake	Anchored intake	Size	Age structure	Contrast with…
Scenario 0	Y	N	N	N	P_0	$C(x)_0$	0b, 1, 2, 3, 4, 5
Scenario 1	Y	Y	N	N	P_1	$C(x)_1$	1b, 0, 4, 5
Scenario 2	Y	N	Y	N	P_2	$C(x)_2$	2b, 0, 3, 4
Scenario 3	Y	N	N	Y	P_3	$C(x)_3$	3b, 0, 2, 5
Scenario 4	Y	Y	Y	N	P_4	$C(x)_4$	4b, 0, 1, 2, 5
Scenario 5	Y	Y	N	Y	P_5	$C(x)_5$	5b, 0, 1, 3, 4
Scenario 0b	N	N	N	N	P_0	$C(x)_0$	0, 1b, 2b, 3b, 4b, 5b
Scenario 1b	N	Y	N	N	P_1	$C(x)_1$	1, 0b, 4b, 5b
Scenario 2b	N	N	Y	N	P_2	$C(x)_2$	2, 0b, 3b, 4b
Scenario 3b	N	N	N	Y	P_3	$C(x)_3$	3, 0b, 2b, 5b
Scenario 4b	N	Y	Y	N	P_4	$C(x)_4$	4, 0b, 1b, 2b, 5b
Scenario 5b	N	Y	N	Y	P_5	$C(x)_5$	5, 0b, 1b, 3b, 4b

Y/N denotes standardization across academies

Table 3. Summary of scenarios according to variable(s) being standardized

	Mortality	CM status	Fixed intake	Anchored intake	Size	Age structure	Contrast with…
Scenario 0	Y	N	N	N	P_0	$C(x)_0$	0b, 1, 2, 3, 4, 5
Scenario 1	Y	Y	N	N	P_1	$C(x)_1$	1b, 0, 4, 5
Scenario 2	Y	N	Y	N	P_2	$C(x)_2$	2b, 0, 3, 4
Scenario 3	Y	N	N	Y	P_3	$C(x)_3$	3b, 0, 2, 5
Scenario 4	Y	Y	Y	N	P_4	$C(x)_4$	4b, 0, 1, 2, 5

Scenario 5	Y	Y	N	Y	P_5	$C(x)_5$	5b, 0, 1, 3, 4
Scenario 0b	N	N	N	N	P_0	$C(x)_0$	0,1b, 2b, 3b, 4b,5b
Scenario 1b	N	Y	N	N	P_1	$C(x)_1$	1, 0b, 4b, 5b
Scenario 2b	N	N	Y	N	P_2	$C(x)_2$	2, 0b, 3b, 4b
Scenario 3b	N	N	N	Y	P_3	$C(x)_3$	3, 0b, 2b, 5b
Scenario 4b	N	Y	Y	N	P_4	$C(x)_4$	4, 0b, 1b, 2b, 5b
Scenario 5b	N	Y	N	Y	P_5	$C(x)_5$	5, 0b, 1b, 3b, 4b

Y/N denotes standardization across academies

Table 3. Summary of scenarios according to variable(s) being standardized

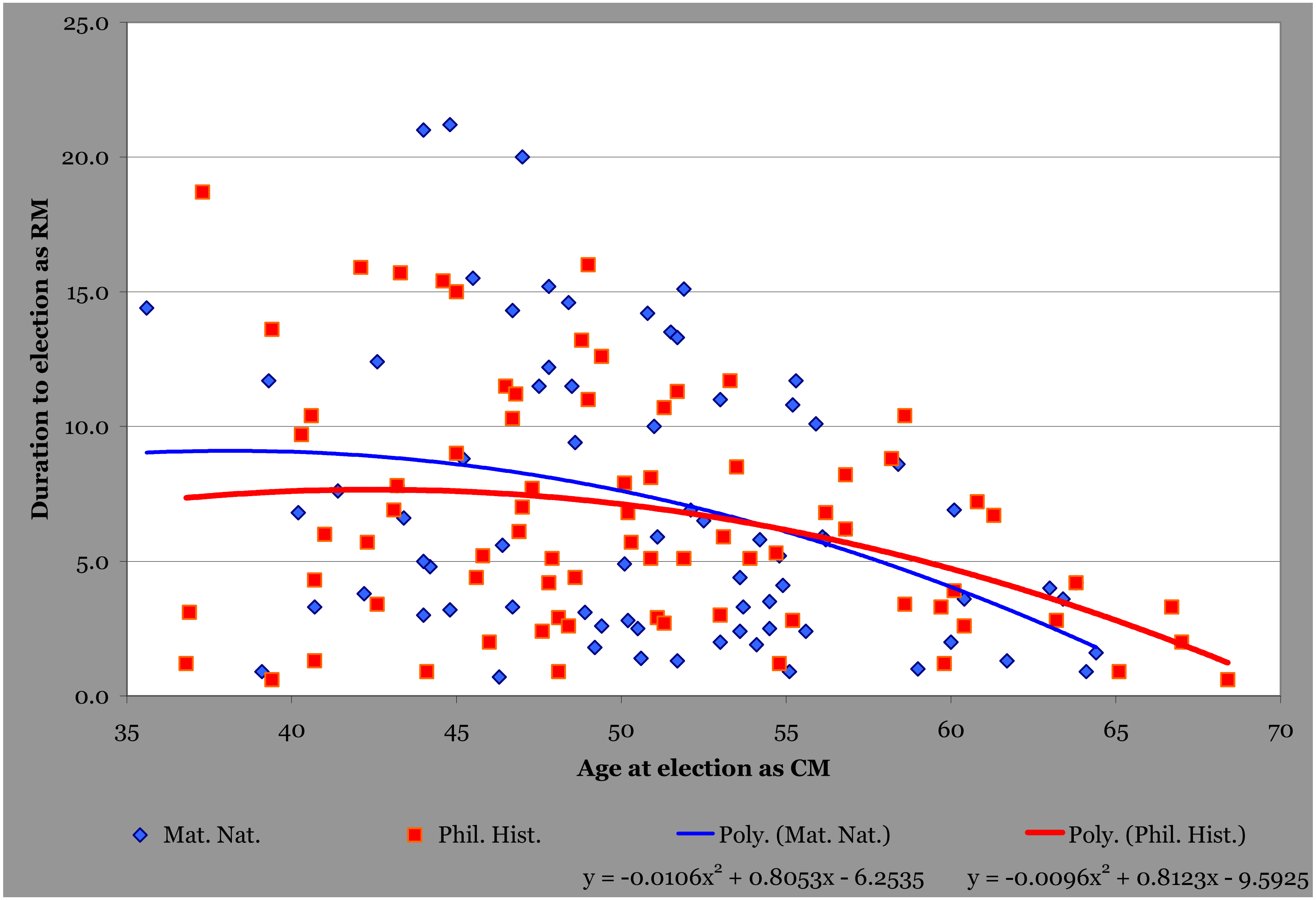

Figure 1. Scatter plot and quadratic fit of duration before election as RM in the Austrian Academy of Sciences according to age at election as a Corresponding Member, by Class

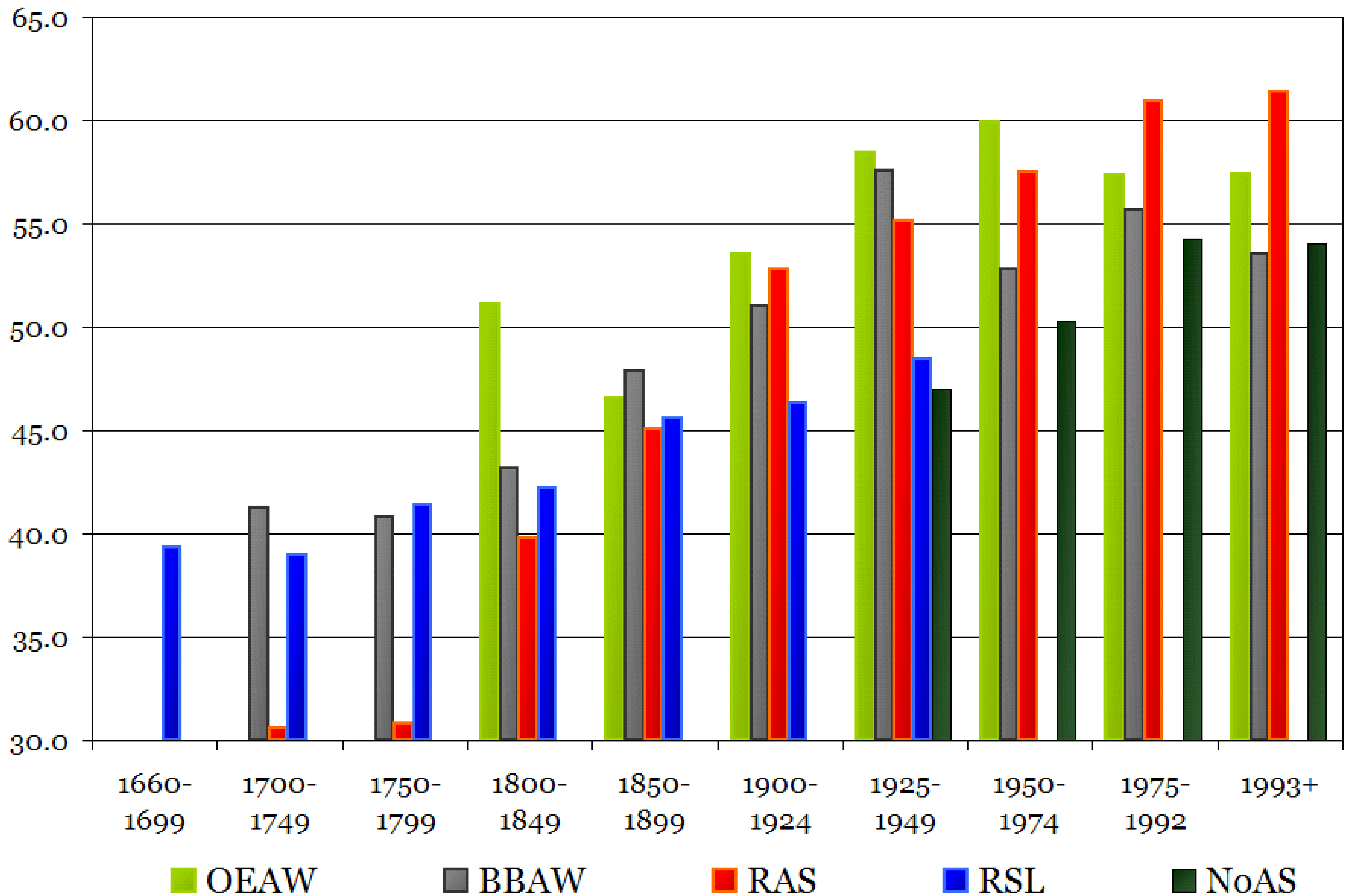

Figure 2. Mean age at election as Regular Members by Academy and Period

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