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Concentration, Positional Persistence, and Institutional Mobility Across Five Major Public Research Funding Systems

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Abstract

This study compares the concentration, positional persistence, institutional mobility, and performance associations observed in five major public research funding systems: NSF, NSFC, JSPS, NSERC, and NSTC. Institution-year funding records are linked to SciVal indicators, while explicitly recognising that agency funding and whole-institution bibliometric performance do not have identical coverage. RQ1 provides descriptive recipient-panel concentration diagnostics. RQ2 distinguishes system-level co-concentration from institution-level conditional associations and applies Benjamini–Hochberg false-discovery-rate adjustments to prespecified families of focal tests. Positive system-level slopes predominate, but only one of 123 main 41-indicator Funding Gini tests remains significant after FDR adjustment; the 24 principal pooled institution-level fixed-effects PPML specifications, covering eight outcomes under three FSL specifications, detect no consistent statistically distinguishable funding-share association. RQ3 shows substantial persistence in accumulated top-funded positions. Annual-funding and non-overlapping-window checks indicate that persistence remains when mechanical overlap is reduced, and current top-funded status is positively associated with later performance-elite status for most estimable indicators. These findings are noncausal distributional and positional diagnostics. They do not identify governance mechanisms or describe the entirety of national public research funding.

Keywords: public research funding; research funding governance; funding concentration; positional persistence; institutional mobility; cumulative advantage; institutional stratification; research evaluation

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1. Introduction

1.1. Research Background and Governance Problem

Public research funding is a central instrument through which governments sustain knowledge production, research careers, scientific infrastructure, and long-term innovation capacity. Funding decisions do more than distribute financial resources. They shape institutional research capacity, signal policy priorities, and influence the conditions under which universities compete for subsequent research opportunities (Geuna, 1999; Stephan, 2012; Lepori et al., 2023; OECD, 2023). From a governance perspective, the relevant question is therefore not limited to whether higher funding is associated with more publications or greater citation impact. It also concerns how public resources are distributed across institutions, how persistent highly funded positions become, and whether institutions outside the

upper funding tier subsequently enter it. Such observed movement should not, however, be equated with legal eligibility, procedural fairness, or equality of funding opportunity.

Funding concentration is not inherently inefficient or undesirable. Large-scale research infrastructure, specialised centres, strategic programmes, and long-term collaborative networks may require sustained investment that cannot be achieved through uniform allocation. Concentrating resources in institutions with established capabilities can create critical mass, preserve specialised expertise, and support research activities with substantial fixed costs. The governance implications become more consequential, however, when concentration is accompanied by persistent institutional positions. Funding systems with similar levels of concentration may differ substantially in the composition and stability of their upper funding tiers. In one system, concentrated resources may coexist with frequent institutional entry and exit; in another, the same institutions may repeatedly occupy the most highly funded positions. Evidence that cumulative advantage may operate through institutional resource allocation reinforces the importance of examining the development of funding positions over time rather than relying exclusively on cross-sectional distributions (Herberholz, 2023).

Research assessment further complicates this governance problem. Scientific visibility and citation impact are themselves unevenly distributed, and funding arrangements that rely heavily on previous bibliometric performance may reinforce existing differences in institutional visibility and research capacity (Nielsen & Andersen, 2021). At the same time, responsible research assessment has increasingly shifted attention from criticism of individual metrics towards the institutional design and implementation of assessment practices. The Agreement on Reforming Research Assessment emphasises broader recognition of research contributions and more responsible uses of quantitative indicators (Coalition for Advancing Research Assessment, 2022), while the Global Research Council (2024) identifies responsible administration, contextualised assessment criteria, and recognition of diverse research contributions as dimensions directly relevant to funding organisations. These developments place funding agencies themselves within the governance of research assessment. Formal commitments to assessment reform, however, do not necessarily eliminate established evaluative patterns. Evidence from the UK Research Excellence Framework, for example, indicates that journal rankings remain strongly associated with expert evaluations despite commitments to responsible assessment (Morgan-Thomas et al., 2024).

The distributional structure of public research funding should consequently be treated as a governance issue in its own right. A funding system may sustain strong aggregate research performance while concentrating resources within a relatively stable group of institutions. Conversely, a high level of concentration does not necessarily imply a completely closed funding structure if institutions outside the upper tier are subsequently observed entering it. Concentration, positional persistence, and observed institutional mobility therefore capture different properties of funding governance. Examining them together makes it possible to assess where public research resources are concentrated, how stable relative funding positions are over time, and how frequently institutions move into or out of the upper funding tier. These measures remain descriptive: they do not by themselves establish the fairness, efficiency, accessibility, or causal consequences of the underlying allocation process.

1.2. Research Gap, Analytical Focus, and Contributions

Research on public funding and university research has developed along two closely related but still insufficiently integrated lines. One examines whether research funding is associated with subsequent publication output, citation impact, or productivity (Himanen et al., 2009; Auranen & Nieminen, 2010; Jacob & Lefgren, 2011; Fortin & Currie, 2013). More recent studies indicate that the estimated relationships depend on the funding

mechanism, level of analysis, institutional setting, and performance measure considered; Zacharewicz et al. (2023), for example, find no statistically detectable effect of national- or university-level competitive funding mechanisms on highly cited publications and no clear effect on publication quantity in a multilevel sample of countries and universities. Using longitudinal NSFC grant data from one leading Chinese polytechnic university, Fan et al. (2026) distinguish grant frequency from funding amount and identify different pathways through which these dimensions are related to academic productivity. A second line of research examines the unequal distribution of research funding and the extent to which competitive allocation may reinforce existing resource advantages (Lauer & Roychowdhury, 2021; Herberholz, 2023). What remains less well understood is how the distribution of funding relates to the durability of institutional positions over time. Few studies bring funding concentration, positional persistence, and institutional mobility into a common longitudinal framework, and fewer distinguish system-level co-concentration of funding and performance from institution-level funding–performance associations.

The Matthew effect and cumulative advantage provide a theoretical basis for understanding why these distinctions matter. Existing resources, reputation, infrastructure, administrative capacity, and collaborative networks may shape access to subsequent funding and allow earlier differences to be reflected in later institutional positions (Merton, 1968, 1988; DiPrete & Eirich, 2006). Researcher-level evidence shows that early funding success can widen subsequent disparities in resource acquisition (Bol et al., 2018), while institutional evidence indicates that prior third-party funding can predict later success in competitive allocation settings (Herberholz, 2023). These patterns do not imply that persistent top-funded positions necessarily constitute governance failure. Continuity may reflect accumulated research capacity, disciplinary portfolios, organisational missions, infrastructure requirements, or programme design. Nor does persistence establish that funding causes subsequent research performance. The narrower governance question addressed here is whether sustained support for established research capacity coexists with observed entry into, exit from, and movement within the upper funding tier.

This study examines five major public research funding systems rather than complete national funding portfolios. It separates three empirical dimensions that are often conflated: the concentration of agency-linked institutional funding, the persistence and mobility of institutions within accumulated funding positions, and conditional associations between institutional funding exposure or position and subsequent bibliometric outcomes or positions. The analysis does not observe programme rules, peer-review procedures, complete eligibility rosters, eligibility reforms, or allocation criteria and therefore does not identify the governance mechanisms producing the observed distributions and transitions.

The comparative contribution is consequently distributional and positional. Concentration statistics describe resource allocation within each observed linked-institution panel; transition measures describe continuity and observed entry into or exit from relative funding positions; and regression models describe conditional associations at funding-system and institution levels. These quantities may inform governance-oriented monitoring, but they are not direct measures of governance quality, procedural fairness, allocative efficiency, legal eligibility, or equality of funding opportunity.

Throughout the article, cumulative advantage is used as a theoretical interpretation rather than as a causally identified process. Positional openness is operationalised narrowly through observed retention, upward mobility, and downward mobility within the linked panel. The study therefore avoids treating persistence as evidence of governance failure, mobility as proof of an effective allocation system, or observed transitions as direct evidence of equal institutional opportunity.

2. Theoretical Framework

2.1. Public Research Funding Governance and Cumulative Advantage

Public research funding operates not only as a financial input into research but also as a governance mechanism that shapes the distribution and development of institutional research capacity. Competitive funding decisions determine which institutions gain access to resources for infrastructure, specialised personnel, research programmes, and collaborative networks. Repeated success may strengthen these capacities and, in turn, affect an institution's ability to formulate competitive proposals, sustain research activity, and participate in subsequent funding opportunities (Lepori et al., 2023). Research funding governance therefore has a temporal dimension: current allocation patterns may shape the organisational conditions under which future competition takes place.

The Matthew effect and cumulative advantage provide a theoretical basis for understanding this process. Merton (1968, 1988) described how scientific recognition and resources tend to accrue to actors that already possess reputation and visibility, while DiPrete and Eirich (2006) conceptualised cumulative advantage as a dynamic process in which earlier differences affect subsequent access to resources and opportunities. Although much of this literature originated at the researcher level, the theoretical logic is also relevant to universities. Institutions enter funding competitions with unequal research infrastructures, personnel, administrative capabilities, application experience, disciplinary portfolios, and external networks. These differences may affect both their capacity to undertake research and their ability to secure subsequent external funding.

Empirical evidence is consistent with the possibility that cumulative processes extend beyond a single funding decision. At the researcher level, Bol et al. (2018) show that early funding success widened subsequent differences in resource acquisition among applicants located near a funding threshold. At the institutional level, Herberholz (2023) finds that German higher education institutions with stronger prior records of third-party funding were better positioned to obtain resources under a subsequent competitive allocation programme. Jappe and Heinze (2023) synthesise evidence connecting organisational status, research quality, funding concentration, and academic networks within stratified university systems. Taken together, these studies suggest that previous resource and status positions may be associated with persistent institutional advantage, even when initial allocations reflect legitimate differences in research capacity, disciplinary composition, institutional mission, or programme objectives.

Cumulative advantage is not treated here as a predetermined outcome of competitive funding. Persistent funding positions may reflect accumulated capabilities, institutional missions, disciplinary structures, infrastructure requirements, or the design of particular funding programmes. Nor does positional persistence demonstrate that funding itself causes subsequent research performance. Cumulative advantage instead provides an interpretive framework for examining whether earlier resource positions are associated with durable differences in subsequent institutional opportunity. This distinction directs attention to three related but analytically separate properties of funding governance: how concentrated resources become, how persistent highly funded positions are, and how much movement occurs into and out of those positions.

2.2. Funding Concentration, Performance Concentration, and Research Assessment

Funding concentration describes the extent to which public research resources are distributed among a relatively small group of institutions. Such concentration may result from deliberate policy choices intended to create critical mass, sustain costly infrastructure, support specialised centres, or maintain internationally competitive research capabilities. Concentration should therefore not be interpreted automatically as inefficiency or inequity.

Its governance significance depends partly on whether concentrated allocation is associated with persistent differences in institutional funding positions and whether institutions outside the most highly funded group are subsequently observed entering that group.

Evidence on the relationship between research funding concentration and research performance is mixed. Aagaard et al. (2020) review two decades of research on grant size and scientific performance and identify substantial evidence of stagnant or diminishing returns to scale, cautioning against the assumption that greater funding concentration necessarily produces proportionate performance gains. Examining the US National Science Foundation's Graduate Research Fellowship Program, Graddy-Reed and Lanahan (2023) find substantial disparities in the allocation of fellowships across institutions and individuals, while the estimated rates and impact of resulting research are similar across four broad disciplinary divisions after accounting for disciplinary differences. Cross-national evidence further indicates that the relationship between competitive funding mechanisms and highly cited research depends on the institutional and national context in which funding is allocated (Zacharewicz et al., 2023). These findings reinforce the importance of distinguishing the distribution of funding from its average relationship with research performance.

Bibliometric research outputs are themselves unevenly distributed across institutions. A relatively small group of institutions accounts for substantial shares of publications, citations, and highly visible research outputs (de Solla Price, 1976; Nielsen & Andersen, 2021). In this study, performance concentration refers to the institutional distribution of a particular bibliometric outcome within a funding system and year rather than to a composite ranking of institutional quality. Bibliometric outcomes are influenced by disciplinary publication practices, institutional missions, collaboration structures, and assessment incentives (Moed, 2005; Hicks et al., 2015; Waltman, 2016). They therefore represent particular dimensions of research performance rather than comprehensive measures of institutional contribution.

The relationship between funding and performance distributions is especially relevant when prior performance enters subsequent allocation or assessment processes. Performance-based funding can create feedback between previous achievement, resource allocation, and later evaluative advantage. Banal-Estañol et al. (2023), for example, find that the introduction of REF 2014 was associated with higher aggregate research quantity and quality in Economics and Business, but not with higher per-author productivity, and may also have contributed to a greater concentration of research excellence in elite institutions. Recent developments in responsible research assessment similarly emphasise that funding organisations should consider how evaluation criteria and quantitative indicators shape assessment practices, incentives, and institutional behaviour and opportunity (Coalition for Advancing Research Assessment, 2022; Global Research Council, 2024). Evidence that journal prestige remains strongly associated with expert evaluation in the UK Research Excellence Framework further illustrates how established evaluative signals may persist despite formal commitments to assessment reform (Morgan-Thomas et al., 2024).

This distinction has an important analytical implication. Funding-system-level co-concentration and institution-level funding–performance associations address different questions. At the funding-system level, greater concentration of funding may coincide with greater subsequent concentration of bibliometric performance even when changes in individual institutional funding shares do not consistently predict future high-end output shares. Conversely, a weak average institution-level relationship does not rule out structural co-concentration at the system level. Treating these levels separately avoids attributing an aggregate distributional pattern to a uniform organisational mechanism. Neither relationship, however, indicates how frequently institutions enter or leave the observed upper funding tier. That question requires separate analysis of positional persistence and mobility.

2.3. Positional Persistence, Institutional Mobility, and Observed Funding-Position Openness

A cross-sectional measure of funding concentration does not reveal whether the same institutions repeatedly occupy the most highly funded positions. This distinction is important for research funding governance because concentration and positional continuity need not move together. A highly concentrated system may nevertheless permit substantial movement into and out of its upper funding tier, whereas a less concentrated system may contain a comparatively stable group of institutions that repeatedly retain advantageous funding positions. The longitudinal distribution of funding therefore concerns not only how resources are distributed at a given point in time but also how stable relative institutional positions are and how frequently institutions move between them.

Positional persistence refers to the extent to which institutions remain within the upper tier of the funding distribution over time. Institutional mobility captures movement between funding positions, particularly entry into and exit from the upper tier. These concepts provide a longitudinal perspective on the distributional dynamics of institutional funding positions. High retention among top-funded institutions combined with limited upward entry indicates strong positional continuity, whereas greater entry and exit indicate a more fluid funding structure. Mobility is not interpreted as inherently desirable, nor is persistence inherently problematic. Stable funding may be necessary to sustain long-term research infrastructure, specialised expertise, and cumulative research programmes. The descriptive question examined here is whether such continuity coexists with observed movement of institutions from outside the upper tier into higher relative funding positions.

The concept of observed positional openness is used to interpret these patterns. It refers narrowly to the frequency with which institutions enter or leave the upper funding tier within the linked panel and is not a normative judgement about the fairness, accessibility, or quality of a funding system. A funding structure displays greater observed positional openness when concentrated allocation coexists with more frequent institutional movement, whereas high retention combined with limited observed entry indicates stronger positional continuity. This distinction complements conventional concentration measures because two systems with similar levels of funding inequality may exhibit markedly different transition patterns over time.

The interpretation of top-funded positions also depends on their relationship with subsequent research performance. Institutions that occupy the upper funding tier may also be more likely to occupy high-performance positions because of accumulated research capacity, infrastructure, disciplinary composition, reputation, or other organisational advantages. The analysis therefore considers whether current top-funded status is associated with subsequent performance-elite status. This relationship is interpreted as a conditional association between institutional positions rather than as evidence that top-funded status causes later performance. Maintaining this distinction is particularly important in the context of responsible research assessment, which cautions against treating a narrow range of bibliometric indicators as a complete measure of institutional contribution (Hicks et al., 2015; Coalition for Advancing Research Assessment, 2022).

Taken together, concentration, persistence, and mobility provide complementary information about the governance structure of public research funding. Concentration identifies how unevenly resources are distributed; persistence identifies the durability of advantageous funding positions; and mobility indicates whether institutions enter and exit those positions over time. Their joint consideration distinguishes stable support for established research capacity from the observed frequency with which institutions move into and out of advantageous relative funding positions.

2.4. Analytical Framework and Research Questions

The analytical framework integrates three distinct dimensions of public research funding governance: concentration, positional persistence, and institutional mobility. Concentration describes how annual or accumulated funding is distributed across institutions. Persistence captures the durability of top-funded positions, while mobility describes observed movement into and out of the upper funding tier. Supporting performance analyses distinguish funding-system-level co-concentration from institution-level funding–performance associations, thereby preventing aggregate distributional patterns from being interpreted as evidence of a uniform organisational mechanism. The study addresses the following three research questions:

RQ1. How concentrated is annual public research funding among higher education institutions observed within each of the five agency-linked funding systems, and how does concentration change over time?

RQ2. At the funding-system level, is greater concentration of accumulated funding associated with greater subsequent concentration of bibliometric performance? At the institution level, is a larger share of lagged accumulated funding associated with a larger subsequent share of high-end research outputs? As a secondary exploratory analysis, do these institution-level associations differ descriptively by research orientation or public/private ownership?

RQ3. How persistent are accumulated top-funded positions, what patterns of upward and downward mobility occur, and how is current top-funded status conditionally associated with subsequent top-funded and performance-elite status?

For RQ3, institutions in the top 10% or top 20% of accumulated funding-stock distribution within each funding system and year are classified as top-funded institutions. Their positions are followed at $t + 1$, $t + 2$, and $t + 3$ to assess retention, upward mobility, and downward mobility. Performance-elite status is defined using the same percentile thresholds. The principal subsequent performance analysis uses eight count-based indicators comprising outputs in the top 1%, 5%, 10%, and 25% citation percentiles and publications in the top 1%, 5%, 10%, and 25% journal percentiles. The broader set of 41 SciVal indicators provides a supplementary multidimensional assessment. Associations between current top-funded status and subsequent top-funded or performance-elite status are interpreted as conditional relationships rather than as causal effects.

Figure 1 summarizes the analytical framework and empirical strategy.

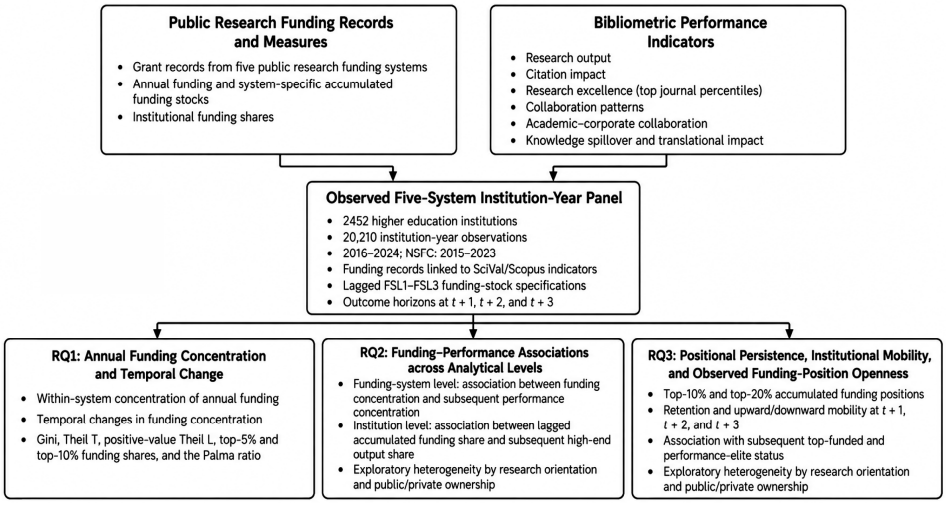


Figure 1. Analytical framework for public research funding governance and empirical strategy. **Note.** The framework concerns five public research funding systems and linked institution-year observations

available within each system; it does not represent complete national funding portfolios or fully verified eligible-institution populations. Funding concentration, positional persistence, observed mobility, and funding–performance associations are treated as analytically distinct dimensions. Governance implications are limited to distributional and positional diagnostics. No governance mechanism or causal effect is directly identified.

3. Data and Methods

3.1. Data Sources and Sample Construction

The analytical file links annual awards from NSF, NSFC, JSPS, NSERC, and NSTC to institution-year SciVal records. The funding data represent awards observed for these agencies, not the entirety of public research funding in the corresponding countries. The risk set is the observed agency-linked institution panel. An external annual roster of every legally eligible higher education institution was unavailable; consequently, observed eligible-looking institution-years without awards are retained as zero funding where represented in the linked panel, while unobserved or ineligible institutions cannot be added reliably.

Data coverage reflects the availability of public award records and corresponding SciVal indicators. Funding and SciVal data for NSF, JSPS, NSERC, and NSTC cover 2016–2024, whereas NSFC data cover 2015–2023. The 2015 NSFC observations constitute the initial year of the NSFC panel and also contribute to the construction of accumulated and lagged funding measures. Effective sample sizes vary across analyses because of differences in indicator availability, funding-stock construction, and the $t + 1$, $t + 2$, and $t + 3$ outcome horizons.

For data harmonisation and descriptive reporting, award amounts were converted into New Taiwan dollars (TWD) using fixed reference exchange rates on 11 November 2025: TWD 31 per US dollar, TWD 23 per Canadian dollar, TWD 4.5 per Chinese yuan, and TWD 0.2 per Japanese yen. Currency conversion provides a common recording scale and is not used to infer differences in purchasing power, national research expenditure, or the absolute generosity of the five funding systems. The principal analyses are based on within-system distributions, concentration measures, institutional funding shares, and relative funding positions. Consequently, cross-system comparisons concern the structure and persistence of funding distributions rather than absolute funding volumes.

The bibliometric measures are whole-institution SciVal indicators, whereas the funding records cover the focal agencies and their programme portfolios. The two measurement scopes therefore do not identify outputs directly attributable to the observed awards. RQ2 estimates institution-level conditional associations between agency-linked funding position and whole-institution bibliometric position, not the productivity effect of a particular agency or grant. Subject-restricted SciVal data were not available for the present revision, and this scope mismatch is addressed through cautious interpretation and an explicit limitation.

Funding-agency and SciVal records were linked through semi-automated institutional matching followed by manual verification. Initial matching used official English institution names, abbreviations, locations, and institution types. Cases involving translated names, institutional renaming, campuses, affiliated organisations, and university-system labels were individually reviewed to minimise false matches and duplicate institutional identities. Only higher education institutions linked to valid SciVal institution identifiers were retained in the linked panel.

Analyses are conducted at the funding-system–year and institution–funding-system–year levels. The same university may legitimately appear in more than one funding system, and such observations constitute distinct funding-exposure panels. Cross-system comparisons are conditional on the observed linked-institution population in each system; they are not comparisons based on a common national census of higher education institutions. The coverage of the linked institution-year panel by funding system is summarized in Table 1.

Table 1. Coverage of the linked institution-year panel across the five public research funding systems.

Country/Funding System	Funding Data Period	SciVal Data Period	Unique Institutions	Institution-Year Observations
United States/NSF	2016–2024	2016–2024	859	6310
China/NSFC	2015–2023	2015–2023	770	6636
Japan/JSPS	2016–2024	2016–2024	587	5232
Canada/NSERC	2016–2024	2016–2024	95	825
Taiwan/NSTC	2016–2024	2016–2024	141	1207
Total	—	—	2452	20,210

Note. The table reports higher education institutions linked to valid SciVal institution identifiers before outcome- and model-specific restrictions. Effective sample sizes vary because of lagged funding measures, future outcome horizons, and indicator availability. The reported institutions represent the observed agency-linked panels rather than complete national populations of eligible higher education institutions.

The resulting panel supports within-system temporal descriptions and qualified cross-system comparisons. Differences in observed panel coverage, programme breadth, and agency remit should therefore be considered when interpreting differences in concentration levels across funding systems.

3.2. Variable Construction and Measurement

Five groups of variables operationalise the study's core concepts: funding concentration; performance concentration; institution-level funding position and high-end output share; top-funded and performance-elite status; and institutional characteristics. The first two capture the distribution of resources and research outcomes within each funding system, whereas the remaining measures describe institutional funding position, subsequent performance position, positional persistence, mobility, and institutional heterogeneity.

For each funding system and year, funding concentration is measured using the Gini coefficient, Theil T, positive-value Theil L, the top-5% funding share, the top-10% funding share, and the Palma ratio (Gini, 1912; Theil, 1967; Palma, 2011). The top-share measures are calculated using the highest-funded $\lceil 0.05N \rceil$ and $\lceil 0.10N \rceil$ institutions, respectively, rather than fixed counts of five or ten institutions. RQ1 applies these measures to annual funding, whereas the funding-system-level component of RQ2 calculates concentration from accumulated funding stocks under FSL1, FSL2, and FSL3. Observed zero-funding institution-years are included, while missing funding observations are excluded and are not silently converted to zero. Theil L is computed only over positive funding values because the logarithm is undefined at zero. The Palma ratio is recorded as missing when the bottom 40% of institutions has zero total funding. The denominator audit reports the observed institution count used for each funding-system–year statistic and verifies the corresponding arithmetic identities within the available panel, but it cannot establish eligibility or population completeness without an external eligibility roster. The resulting statistics are therefore interpreted as concentration within the observed linked institution-year panel rather than the complete legally eligible institutional population. Detailed annual estimates and denominator diagnostics are reported in Supplementary Table S1.

For the funding-system-level RQ2 analysis, each SciVal indicator is transformed into three measures of performance concentration at the funding-system–year–indicator level: Performance Gini, Performance Theil T, and the top-10% performance share. The first two measure the dispersion of a bibliometric outcome across institutions, whereas the third represents the proportion of the corresponding funding-system–year total accounted for

by the $\lceil 0.10N \rceil$ highest-performing institutions. At the institution level, funding share is defined as an institution's proportion of total accumulated funding under the relevant FSL specification within its funding system and year. Funding percentile provides a rank-based alternative in the RQ2a robustness analysis. High-end output share is calculated as an institution's value on a given count indicator divided by the corresponding funding-system–year total. The principal institution-level outcomes comprise eight count-based indicators: outputs in the top 1%, 5%, 10%, and 25% citation percentiles and publications in the top 1%, 5%, 10%, and 25% journal percentiles.

To account for the time required for research funding to translate into project implementation, publication, and citation accumulation, RQ2 uses three lagged funding-stock windows. For institution i in the funding system c, the k-th lagged cumulative funding stock observed in year t is defined as:

$$FundingStock_{i,c,t}^{FSL_k} = \sum_{j=k}^{k+N_c-1} Funding_{i,c,t-j}, k \in \{1,2,3\} \quad (1)$$

Here, annual funding is aggregated by institution, funding system, and year, and N_c denotes the assigned accumulation window for the funding system c. The assigned windows were determined from the system-specific median durations of valid unique projects linked to recipient higher education institutions with valid SciVal institution IDs, rounded to the nearest whole year. The observed median durations were 3.96 years for NSF, 5.00 years for NSFC, 3.00 years for JSPS, 1.00 year for NSERC, and 1.20 years for NSTC, resulting in assigned windows of four, five, three, one, and one years, respectively. Project duration was calculated from exact project start and end dates for NSF, JSPS, NSERC, and NSTC. NSFC records provided start and end years only, so NSFC durations were measured at annual rather than exact-date precision. Each assigned window falls within the corresponding empirical interquartile range reported in Supplementary Table S2. FSL1, FSL2, and FSL3 exclude current-year funding and shift the accumulated stock by one, two, and three years, respectively. At the beginning of an institution's observed series, a stock is calculated from the available historical years when at least one year is observed; these partial-window observations are retained by the implementation. Each FSL specification is estimated separately.

RQ3 uses a contemporaneous accumulated funding stock comprising current-year funding and funding received during the preceding $N_c - 1$ years. At the beginning of an institution's observed series, partial stocks are constructed from the historical years available. Within each funding system and year, percentile ranks are calculated using average ranks for tied funding-stock values. Institutions with percentile ranks of at least 0.90 or 0.80 are classified as top-10% or top-20% funded institutions, respectively. Because tied observations receive the same average rank, the realised proportion classified as elite need not equal exactly 10% or 20%. Unlike the lagged FSL measures used in RQ2, the RQ3 accumulated funding stock includes current-year funding.

Performance-elite status is defined separately for each bibliometric indicator using the same percentile thresholds. Performance percentile ranks likewise use average ranks for tied values. The principal analysis uses the eight high-end output indicators, while 41 SciVal indicators are considered for supplementary multidimensional assessment; 40 have sufficient outcome variation for the principal RQ3b regressions. Top-funded status in year t is matched to top-funded and performance-elite status at $t + 1$, $t + 2$, and $t + 3$. Because adjacent rolling stocks share annual-funding observations, annual-funding and non-overlapping-window analyses are also reported.

Exploratory heterogeneity analyses use research orientation and public/private status. Research orientation is classified within each funding system after aggregating each

institution's observations across years. One point is assigned when an institution ranks in the top quartile on each of five measures: accumulated funding, scholarly output, citations, high-end outputs and the scholarly output-weighted mean Field-Weighted Citation Impact. Scores of 4–5 identify research-intensive institutions, scores of 2–3 identify research-active institutions, and scores of 0–1 identify teaching-oriented institutions.

This data-derived classification describes observed institutional research profiles rather than predetermined missions. Because accumulated funding and bibliometric performance contribute to the classification and also enter the focal models, research orientation is neither independent nor exogenous to the analysed relationship. Research-orientation and ownership interactions are estimated separately, supported by cell-size diagnostics, and interpreted only as exploratory descriptive heterogeneity.

3.3. Empirical Models and Analytical Strategy

The empirical strategy follows the three research questions. RQ1 provides a descriptive assessment of funding concentration and its temporal development. RQ2 distinguishes funding-system-level FE-OLS co-concentration models from institution-level PPML models and reports coefficient estimates, uncertainty statistics, sample information, and BH-FDR-adjusted q-values for estimable focal results. RQ3 combines transition matrices, principal linear probability models, auxiliary Logit and PPML specification checks, and annual-funding and non-overlapping-window persistence checks. Failed or unidentified models are explicitly labelled "Not estimated" and are not interpreted as nonsignificant results. Fixed effects and variance estimators are reported separately because they address different aspects of model specification and statistical inference. All relationships are interpreted as noncausal conditional associations or descriptive distributional patterns.

3.3.1. Funding Concentration and Temporal Change

RQ1 examines annual-funding concentration within the observed agency-linked higher education institution panel for each funding system. The Gini coefficient, Theil T, positive-value Theil L, top-5% funding share, top-10% funding share, and Palma ratio are calculated separately by funding system and year. The top-share measures refer to the funding shares received by the highest-funded $\lceil 0.05N \rceil$ and $\lceil 0.10N \rceil$ institutions, respectively, rather than fixed counts of five or ten institutions. No regression model or hypothesis test is used for RQ1. Because a common cross-country eligibility roster is unavailable, level comparisons are conditional descriptive comparisons of the observed linked panels and should not be interpreted as nationally exhaustive or as mechanically comparable institutional populations.

3.3.2. Funding Concentration and Subsequent Research Performance

At the funding-system level, RQ2 examines whether greater concentration of accumulated research funding is associated with greater subsequent concentration of bibliometric performance. A separate funding-system–year dataset is constructed for each performance indicator, and fixed-effects ordinary least squares (FE-OLS) models are estimated using the pooled five-system sample. The dependent variable is the concentration of the performance indicator d, while the principal explanatory variable is funding concentration constructed under FSL1, FSL2 or FSL3:

$$PerformanceConcentration^{d}_{c,t} = \beta_{d,k} FundingConcentration^{FSL_k}_{c,t} + \alpha_c + \lambda_t + \epsilon^{d,k}_{c,t}, k \in \{1,2,3\} \quad (2)$$

Here, c, t, d, and k index funding systems, years, bibliometric performance indicators, and FSL specifications, respectively; α_c and λ_t denote funding-system and year fixed effects. Each indicator–FSL combination is estimated separately, and FSL1, FSL2, and FSL3 are not

entered jointly in the same regression. A positive $\beta_{d,k}$ indicates that, after accounting for persistent differences across funding systems and common year-specific shocks, greater funding concentration is conditionally associated with greater subsequent concentration of performance indicator d under the FSL specification k.

Robustness and sensitivity analyses use alternative-concentration measures and leave-one-funding-system-out samples. Alternative-concentration estimates and leave-one-funding-system-out influence diagnostics are reported in Supplementary Tables S4–S4C. HC1 heteroskedasticity-robust standard errors are reported without clustering. Because the macro analysis contains only five funding systems, conventional p-values are interpreted cautiously, and the results are treated as descriptive and exploratory. Substantive interpretation therefore considers coefficient magnitude and direction, confidence intervals, FDR-adjusted evidence, and sensitivity across the retained specifications.

At the institution level, RQ2 examines whether a larger share of lagged accumulated funding is associated with a larger share of high-end research outputs in the subsequent performance observation year. Because the outcome variables are non-negative, right-skewed, and contain many zero observations, Poisson pseudo-maximum likelihood (PPML) is used as the principal estimator (Santos Silva & Tenreyro, 2006):

$$E(HighPerformanceShare_{i,c,t}) = \exp[\beta_{m,k} FundingShare_{i,c,t}^{FSL_k} + \mu_i + \lambda_{c,t}],\ k \in \{1,\ 2,\ 3\} \quad (3)$$

Here, i, c and t denote the institution, funding system and performance observation year, respectively; m indexes the high-end output measure, and the funding exposure is constructed from the corresponding lagged FSL window; μ_i and $\lambda_{c,t}$ are institution and funding-system–year fixed effects. A positive $\beta_{m,k}$ indicates that a larger lagged accumulated funding share is conditionally associated with a larger subsequent share of high-end output measure m within the same institution, under the FSL specification k.

The principal institution-level models use high-dimensional fixed-effects PPML. Pooled specifications absorb institution and funding-system-by-year fixed effects, whereas funding-system-specific specifications absorb institution and year fixed effects. The principal estimates retain their reported model-based IID standard errors. As a sensitivity analysis, focal pooled and system-specific institution-level specifications were also re-estimated with standard errors clustered by institution; BH-FDR values were recalculated from the clustered p-values. Institution-clustered results are reported in Supplementary Table S15, and the RQ2b/c institution-fixed-effects sensitivity estimates are reported in Supplementary Table S16.

Exploratory heterogeneity analyses examine whether the conditional association between funding share and high-end research output differs by research orientation or public/private ownership. The two institutional characteristics are examined in separate interaction PPML specifications:

$$\begin{aligned} &E\left(HighPerformanceShare_{i,c,t}\right) \\ &= \exp[\beta_{1,m,k,g} FundingShare_{i,c,t}^{FSL_k} + \textstyle\sum_{j \in J_g} \gamma_{m,k,g,j} T_i^{g,j} + \sum_{j \in J_g} \delta_{m,k,g,j} \left(FundingShare_{i,c,t}^{FSL_k} \times T_i^{g,j}\right) \\ &+ \alpha_c + \lambda_t], k \in \{1,2,3\} \end{aligned} \quad (4)$$

In Equation (4), g indexes the institutional characteristic examined in the heterogeneity analysis: research orientation in RQ2b and public/private ownership in RQ2c. The two institutional characteristics are entered in separate PPML specifications rather than simultaneously in a single regression. For the research-orientation models, research-intensive institutions constitute the reference category, while research-active and teaching-oriented institutions are represented by separate indicators. For the ownership models, public institutions constitute the reference category, while private institutions are represented by a single indicator.

The coefficient $\beta_{1,m,k,g}$ represents the conditional funding-share slope on the log-mean scale for the corresponding reference category. The coefficient $\gamma_{m,k,g,j}$ represents the difference in the conditional log mean between category j and the reference category when the funding share equals zero; equivalently $\exp(\gamma_{m,k,g,j})$ represents the corresponding conditional-mean ratio. The coefficient $\delta_{m,k,g,j}$ represents the difference in the funding-share slope on the log-mean scale between category j and the reference category. The total conditional funding-share slope on the log-mean scale for category j is therefore $\beta_{1,m,k,g} + \delta_{m,k,g,j}$.

The pooled interaction models include funding-system and year fixed effects and report HC1 heteroskedasticity-robust standard errors. Funding-system-specific models include year fixed effects. Because these models do not absorb institution fixed effects, the time-invariant institutional-category main effects are retained. Their estimates combine between-institution and within-institution information and are interpreted as exploratory conditional associations rather than as causal or exclusively within-institution effects.

Research orientation and ownership are estimated in separate specifications. The principal RQ2b/c interaction specifications include funding-system and year fixed effects, but not institution fixed effects, and use HC1 heteroskedasticity-robust standard errors without clustering. Separate sensitivity analyses add institution fixed effects and, separately, institution-clustered standard errors. Institution-clustered estimates are reported in Supplementary Table S15, and institution-fixed-effects estimates in Supplementary Table S16. The principal funding-system/year specification retains both between- and within-institution variation to estimate category-specific differences while accounting for funding-system and year effects; the institution-fixed-effects sensitivity models assess whether the contrasts persist when identification relies primarily on within-institution variation.

3.3.3. Top-Funded Positions: Persistence, Mobility, and Subsequent Performance Associations

RQ3 first examines transition probabilities for top-10% and top-20% accumulated funding positions over one-, two-, and three-year horizons. Counts, denominators, probabilities, and Wilson 95% confidence intervals are reported for retention, downward mobility, upward mobility, and non-elite persistence. These intervals quantify binomial uncertainty for the pooled transition records but do not model arbitrary dependence from repeated observations of the same institution. Annual-funding positions and system-specific non-overlapping accumulated-stock windows provide additional persistence checks.

$$P_{ab}^{(c,h)} = \Pr\left(S_{i,c,t+h} = b | S_{i,c,t} = a\right),\ a, b \in 0, 1 \tag{5}$$

The corresponding transition matrix for funding system c is:

$$\boldsymbol{P}^{(h)} = \begin{pmatrix} P_{00}^{(c,h)} & P_{01}^{(c,h)} \\ P_{10}^{(c,h)} & P_{11}^{(c,h)} \end{pmatrix} \tag{6}$$

Rows indicate status at t and columns status at t + h. Retention and upward mobility are interpreted as limited distributional measures of positional continuity and entry. They do not measure fairness, efficiency, or governance quality. Adjacent-stock transitions may share annual-funding observations, so the annual and non-overlapping checks are used to assess the extent to which continuity remains after reducing mechanical overlap.

At the institution level, two related analyses extend the transition analysis. The persistence analysis examines whether current top-funded status is associated with subsequent top-funded status, whereas the subsequent performance analysis examines whether current

top-funded status is associated with subsequent performance-elite status. Because both dependent variables are binary, linear probability models are used as the principal estimators:

$$FundingElite^{q}_{i,c,t+h} = \beta_{q,h} FundingElite^{q}_{i,c,t} + \alpha_c + \lambda_t + \varepsilon^{q}_{i,c,t+h}, h \in \{1,2,3\} \quad (7)$$

$$PerformanceElite^{m,q}_{i,c,t+h} = \beta_{m,q,h} FundingElite^{q}_{i,c,t} + \alpha_c + \lambda_t + \varepsilon^{m,q}_{i,c,t+h}, h \in \{1,2,3\} \quad (8)$$

Here, i, c and t index institutions, funding systems, and years, respectively; q indexes the top-10% or top-20% elite definition; m indexes bibliometric performance indicators; and $h \in \{1,2,3\}$ indexes the outcome horizon. In the persistence analysis, $\beta_{q,h}$ represents the conditional probability difference in subsequent top-funded status associated with current top-funded status. In the subsequent performance analysis, $\beta_{m,q,h}$. represents the corresponding conditional probability difference in subsequent performance-elite status.

The principal pooled specifications include funding-system and year fixed effects, whereas the funding-system-specific specifications include year fixed effects. Principal LPM standard errors are HC1 heteroskedasticity-robust and are not clustered. As a sensitivity analysis, the same focal LPMs were re-estimated with standard errors clustered by institution; clustered estimates are reported in Supplementary Tables S17 and S18. An institution-fixed-effects sensitivity analysis for RQ3 is reported in Supplementary Table S19. In an unadjusted binary-outcome LPM, the coefficient on current elite status equals the retention probability minus the upward-mobility probability. The reported models additionally condition on funding-system and year effects, so their coefficients are adjusted probability contrasts and need not equal that unadjusted transition difference.

The principal subsequent performance analysis uses the eight high-end output indicators. The supplementary analysis considers all 41 SciVal indicators, of which 40 provide sufficient outcome variation for the principal regression. Per-indicator estimates, standard errors, confidence intervals, raw p-values, BH-FDR q-values, sample sizes, and model metadata are supplied; the main text additionally reports the median, interquartile range, and full range rather than relying on mean coefficients alone.

Exploratory RQ3 heterogeneity analyses examine research orientation and public/private ownership in separate interaction models. Main-text interpretation is limited to patterns with adequate empirical support and does not convert failed, unidentified, zero-standard-error, or missing-p-value entries into evidence of no association.

$$\begin{aligned} &PerformanceElite^{m,q}_{i,c,t+h} \\ &= \beta_{1,m,q,h,g} FundingElite^{q}_{i,c,t} + \textstyle\sum_{j \in J_g} r_{m,q,h,g,j} T^{g,j}_{i} + \sum_{j \in J_g} \delta_{m,q,h,g,j} \left(FundingElite^{q}_{i,c,t} \times T^{g,j}_{i} \right) + \alpha_c \\ &+ \lambda_t + \varepsilon^{m,q}_{i,c,t+h}, h \in \{1,2,3\} \end{aligned} \quad (9)$$

In Equation (9), g indexes the institutional characteristic examined, and $T^{g,j}_{i}$ denotes the indicator for the non-reference institutional category j. Research orientation and public/private ownership are examined in separate interaction models rather than simultaneously in the same regression. Research-intensive institutions constitute the reference category in the research-orientation models, while public institutions constitute the reference category in the ownership models. The coefficient $\beta_{1,m,q,h,g}$ represents the conditional probability difference associated with current top-funded status for the corresponding reference category. The coefficient $r_{m,q,h,g,j}$ represents the category main effect, while $\delta_{m,q,h,g,j}$ represents the difference in that conditional probability association between category j and the reference category. The total association for category j is therefore $\beta_{1,m,q,h,g} + \delta_{m,q,h,g,j}$. The pooled interaction models include funding-system and year fixed effects and report HC1 heteroskedasticity-robust standard errors; funding-system-specific models include year fixed effects. Because these specifications do not absorb institution fixed effects, the institutional-category main effects are retained, and the estimates combine between-institution and within-institution information. They are interpreted as exploratory descriptive heterogeneity rather than

as causal or exclusively within-institution effects. Supplementary interaction estimates are reported in Supplementary Table S13, and sample-support diagnostics are reported in Supplementary Tables S14 and S14A.

3.3.4. Statistical Inference, Dependence, and Multiplicity

Each bibliometric indicator, FSL specification, elite threshold, and outcome horizon is estimated in a separate regression, as applicable; the indicators are not stacked within a common regression. The principal estimators and their original variance estimators are retained for the primary analyses. Institution-clustered standard-error sensitivity estimates are reported for the institution-level RQ2 models in Supplementary Table S15 and for RQ3a and RQ3b models in Supplementary Tables S17 and S18; institution-fixed-effects sensitivities are reported in Supplementary Tables S16, S17 and S19. BH-FDR is recalculated within the corresponding prespecified families using the clustered *p*-values. Macro RQ2 estimates remain unclustered because there are only five funding systems and are interpreted descriptively. Clustering addresses within-institution dependence in the variance estimates but does not resolve dependence across the five funding systems.

Benjamini–Hochberg false-discovery-rate adjustment is applied only within prespecified focal-test families and does not replace the reporting of raw *p*-values. For the pooled Macro Main Gini analysis, the conservative Full41 family contains all 123 indicator-by-FSL tests, while the Primary8 family contains 24 count-based high-end-output tests. An additional sensitivity analysis defines six conceptually specified outcome-domain families: research output (15 tests), citation impact (24), research excellence (42), collaboration patterns (24), Academic–Corporate Collaboration (6), and Knowledge Spillover and Translational Impact (12). Alternative macro specifications form separate model-by-scope families, and leave-one-funding-system-out diagnostics are excluded from FDR correction. RQ2a families are defined by analytical scope and model, whereas the RQ2b and RQ2c interaction families are defined separately by research question and analytical scope. For RQ3a, families are defined by country scope and model. For RQ3b, families are defined by country scope, model, and indicator set (Primary8 or supplementary indicators). For RQ3c, research-orientation and ownership interaction tests form separate families defined by research question, country scope, model, and indicator set. Only the focal funding-elite coefficients or interaction terms, as applicable, enter these families. Fixed-effect coefficients, intercepts, leave-one-out diagnostics, and failed, unidentified, or missing-*p*-value estimates are excluded from FDR adjustment.

Taken together, the empirical strategy distinguishes descriptive funding concentration, system-level co-concentration, institution-level conditional funding–performance associations, and positional persistence and mobility. Multiple-testing adjustments and coefficient-level uncertainty statistics are reported for estimable focal regression results, while failed or unidentified specifications are explicitly labelled "Not estimated" rather than interpreted as nonsignificant. Results based on the five-system macro sample, incomplete population coverage, or exploratory interaction specifications are interpreted descriptively and are not treated as confirmatory or causal evidence.

4. Results and Discussion

4.1. Funding Concentration and Temporal Change Across Funding Systems

Within the observed agency-linked panels, all five systems display substantial funding concentration. The unweighted means of the annual Gini coefficients are 0.851 for NSF, 0.763 for NSFC, 0.841 for JSPS, 0.723 for NSERC, and 0.820 for NSTC. These values describe different linked-institution populations, observation periods, and agency remits. They therefore support within-system description and carefully qualified conditional comparison,

but they do not establish that national research funding as a whole is definitively more concentrated in one country than another.

The corresponding mean top-10% funding shares are 76.2% for NSF, 63.4% for NSFC, 76.9% for JSPS, 53.0% for NSERC, and 73.1% for NSTC. The Gini coefficient, Theil T, positive-value Theil L, top-5% and top-10% funding shares, and Palma ratio collectively indicate marked upper-tail concentration within each observed panel. Their broad agreement strengthens the within-panel description. However, differences in observed institutional coverage, eligibility populations, and measure-specific treatment of zero funding continue to preclude unconditional cross-system ranking.

The temporal trajectories also differ across the observed funding-system panels. NSTC shows the clearest overall upward tendency: its Gini coefficient increased from 0.8 in 2016 to 0.82 in 2024, its top-10% funding share increased from 69.6% to 72.8%, and its Palma ratio increased from 35.3 to 75.9. NSFC moved in the opposite direction, with its Gini coefficient declining from 0.76 in 2015 to 0.74 in 2023 and its top-10% funding share declining from 63.7% to 60.5%. NSERC also recorded lower endpoint values, with its Gini coefficient decreasing from 0.73 in 2016 to 0.71 in 2024 and its top-10% funding share decreasing from 52.5% to 51.2%. NSF reached its highest annual Gini coefficient in 2018 at 0.89 before returning to 0.83 in 2024, close to its 2016 value of 0.828. JSPS remained highly concentrated within its observed panel but showed a modest endpoint decline: its Gini coefficient decreased from 0.84 in 2016 to 0.83 in 2024, while its top-10% funding share decreased from 77.1% to 75.7%. These endpoint comparisons are descriptive and are not estimates from formal time-trend hypothesis tests. They show that a high observed concentration level does not necessarily imply continuing concentration and that similar cross-sectional values may accompany different temporal trajectories. Figure 2 presents the annual trends in public research funding concentration across the five funding systems examined.

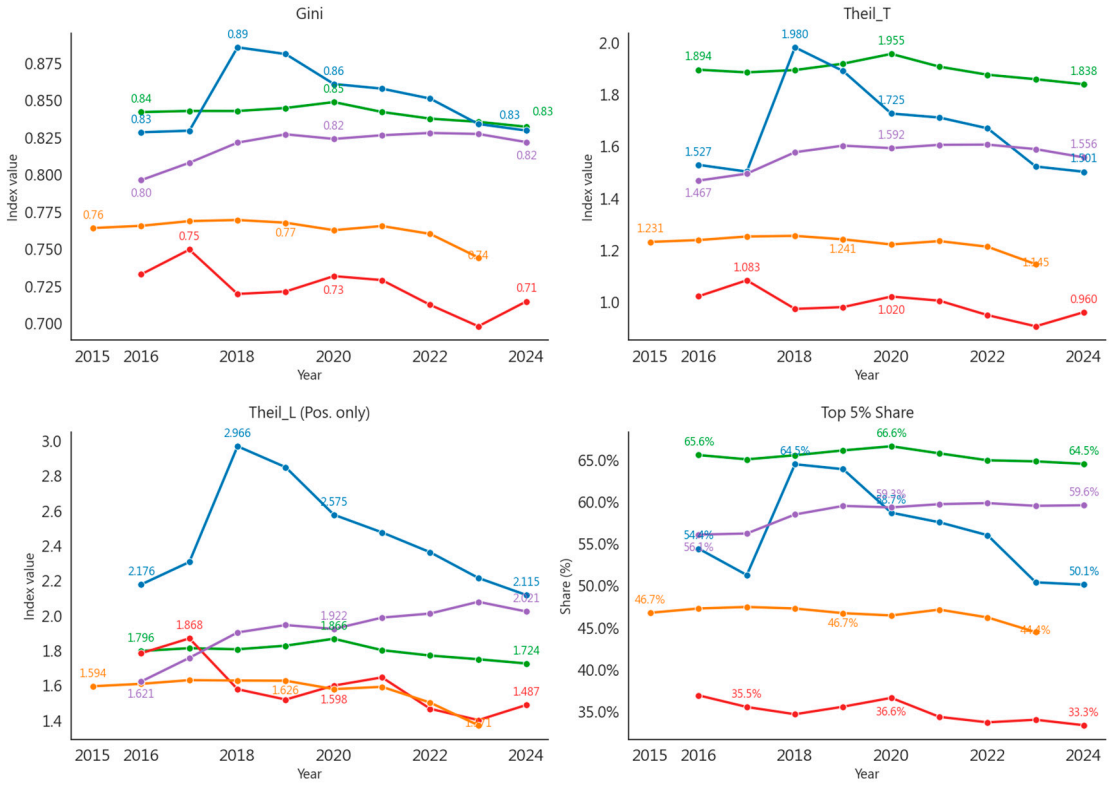


Figure 2. *Cont.*

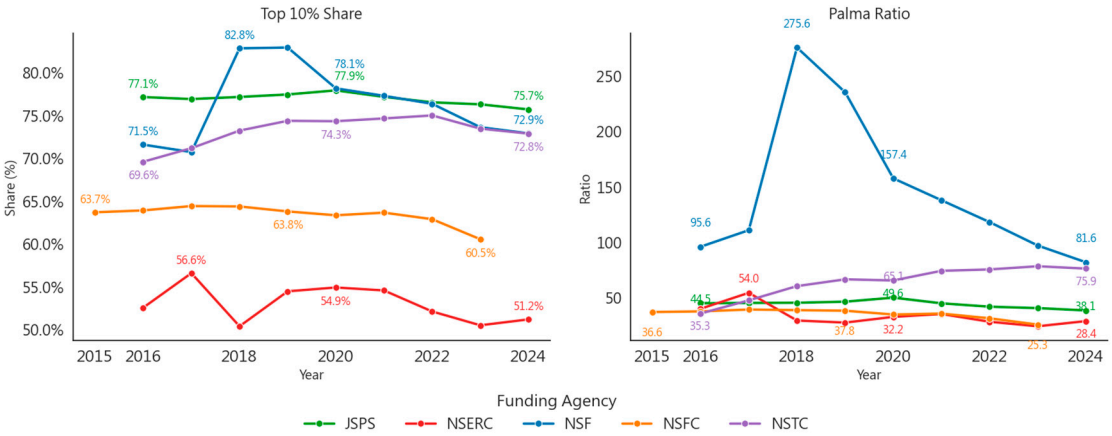


Figure 2. Annual trends in public research funding concentration across the five public research funding systems examined. **Note.** All concentration measures are calculated separately within each observed funding system and year panel. The top-5% and top-10% funding shares denote the proportions of total annual funding received by the highest-funded $\lceil 0.05N \rceil$ and $\lceil 0.10N \rceil$ institutions in the corresponding system-year distribution, respectively. NSFC data cover 2015–2023; NSF, JSPS, NSERC, and NSTC data cover 2016–2024.

These patterns distinguish concentration level from temporal direction, but they do not identify the programme rules, eligibility conditions, review procedures, or administrative mechanisms that produced either pattern. References to governance therefore concern the possible use of distributional indicators for monitoring rather than an empirical test of governance arrangements.

For the funding systems examined, longitudinal concentration diagnostics can complement expenditure totals by indicating whether the observed distribution is relatively stable, dispersing, or becoming more concentrated. The statistics do not establish an optimal distribution and cannot by themselves justify programme redesign or causal claims about the effects of funding concentration.

4.2. Funding Concentration and Subsequent Bibliometric Performance Across Analytical Levels

RQ2 separates system-level co-concentration from institution-level conditional associations. In the 41-indicator Main Funding Gini models, positive coefficients predominate: 38 of 41 under FSL1, 38 under FSL2, and 35 under FSL3. The corresponding median coefficients are 0.406, 0.376, and 0.257, and eight, nine, and ten raw p-values are below 0.05. Under the conservative Full41 BH-FDR correction, one of the 123 indicator-by-FSL tests remains supported: the share of outputs in the top 5% of citation percentiles under FSL1 ($\beta = 1.033$, HC1 SE = 0.277, 95% CI [0.490, 1.575], raw $p = 0.00019$, Full41 $q = 0.02343$). None of the 24 Primary8 tests remains supported after adjustment. Complete Main Funding Gini coefficient-level results are reported in Supplementary Table S3.

As an additional post-estimation sensitivity analysis, BH-FDR was also applied separately within six conceptually defined outcome domains using the raw p-values reported by the Main Funding Gini models. Three of the 24 tests in the citation impact domain remain supported: the top-5% citation-percentile output share under FSL1 (domain $q = 0.004572$), the top-10% citation-percentile output share under FSL1 ($\beta = 0.927$, HC1 SE = 0.314, 95% CI [0.311, 1.543], raw $p = 0.00316$, domain $q = 0.03106$), and the top-5% citation-percentile output share under FSL3 ($\beta = 1.303$, HC1 SE = 0.451, 95% CI [0.419, 2.188], raw $p = 0.00388$, domain $q = 0.03106$). No domain-adjusted test remains supported in the other five domains. The domain-specific results are treated as sensitivity evidence rather than as a replacement for the more conservative Full41 correction. Overall, positive macro-level directions

are widespread, but multiplicity-adjusted support is sparse and concentrated in selected citation-impact specifications.

The macro evidence also depends on the concentration measure. In the alternative Theil models, 30 of 123 tests remain supported under the Full41 correction, and 6 of 24 remain supported in the Primary8 family. By contrast, none of the 123 Full41 tests or 24 Primary8 tests remain supported in the Top10Share models. These contrasting results indicate that the strength of adjusted evidence is sensitive to how concentration is operationalised. Because the pooled macro models contain only five funding systems and use HC1 heteroskedasticity-robust standard errors without clustering or small-cluster correction, these findings are interpreted as descriptive and exploratory rather than as definitive cross-system inference. Leave-one-funding-system-out analyses provide influence diagnostics but do not support a blanket robustness claim. Coefficient signs are consistent in 54 of the 122 specifications with adequate LOO coverage. CitingPatentCount under FSL3 is an explicit exception: only the model excluding NSFC produces a usable estimate ($\beta = 0.149$, SE $= 0.334$, $p = 0.655$), whereas the other four omissions yield no usable estimate. This specification is therefore classified as having insufficient LOO coverage and is not described as directionally consistent or robust. Alternative-concentration estimates and leave-one-funding-system-out diagnostics are reported in Supplementary Tables S4–S4C. Here, sign consistency means that all usable leave-one-system-out estimates for the same indicator–FSL specification have the same sign; at least two usable omission estimates are required.

Under the principal model-based IID inference, none of the 24 pooled RQ2a funding-share tests is statistically distinguishable from zero after BH-FDR adjustment (all q-values $= 0.996701$). The institution-clustered sensitivity analysis likewise yields no BH-FDR-supported result: none of the 24 tests survives adjustment, although one has a raw p-value below 0.05 ($q = 0.296$). Across these clustered estimates, 95% CI lower limits range from -20.272 to -2.177 and upper limits from -0.315 to 2.623, indicating substantial uncertainty. Pre-estimation funding-share within SDs are 0.001174, 0.001164, and 0.001149 for FSL1, FSL2, and FSL3, respectively; the corresponding diagnostic samples contain 18,998, 16,614, and 14,237 institution-year observations. These variation diagnostics describe pre-estimation input samples, not the final model estimation samples. Principal model estimates, institution-clustered sensitivity estimates, and pre-estimation variation diagnostics are reported in Supplementary Tables S5, S15 and S5A, respectively. The clustered standard errors range from approximately 0.917 to 5.284 across the 24 focal specifications. Table 2 summarizes the principal RQ2 results across the system and institution levels, together with the secondary exploratory heterogeneity analyses.

The separate research-orientation and ownership models yield FDR-adjusted interaction differences in the principal specifications, but these patterns are secondary and exploratory. With institution-clustered standard errors, all 48 pooled research-orientation and all 24 pooled ownership contrasts remain supported after BH-FDR adjustment. In contrast, none of these 72 pooled contrasts is supported after BH-FDR adjustment in the institution-fixed-effects sensitivity analysis, and those estimates are highly imprecise. The contrast between specifications indicates sensitivity to identifying variation; it does not establish that the underlying category differences are zero. System-specific estimates are heterogeneous. Complete principal interaction estimates and cell-support diagnostics are reported in Supplementary Tables S6, S7 and S7A; institution-clustered estimates and institution-fixed-effects sensitivities are reported in Supplementary Tables S15 and S16. On a one-percentage-point funding-share scale, the pooled interaction estimates correspond to relative conditional-mean multipliers of approximately 1.88 to 4.23 for the compared versus reference categories; these are slope contrasts, not category-specific total effects.

Table 2. Funding concentration and conditional bibliometric performance associations across system and institution levels.

Analytical Component	Evidence Reported	Principal Result	Interpretation
Panel A. Principal RQ2 analyses			
Macro RQ2: Main Funding Gini (41 indicators)	Direction, median β, raw-p counts, and estimation N. Complete code-generated β, HC1 SE, 95% CI, raw *p*, Full41 q, and Primary8 q are provided in the machine-readable coefficient file.	Positive β: 38/41, 38/41, and 35/41 for FSL1–FSL3; raw $p < 0.05$: 8, 9, and 10. Median β: 0.406, 0.376, and 0.257. *N* ranges: 32–40, 28–35, and 24–30.	Positive system-level co-concentration is common in direction, but counts and medians are descriptive summaries and do not replace coefficient-level uncertainty.
Main Funding Gini: BH-FDR family sensitivity	Full41: 123 tests; Primary8: 24 tests; six domain families: 15, 24, 42, 24, 6, and 12 tests. Domain *q*-values are additional post-estimation BH calculations based on the reported raw *p*-values.	Full41: 1/123; Primary8: 0/24. Domain FDR: citation impact 3/24; all other domains 0. Top-5% citation share, FSL1: β = 1.033, SE = 0.277, 95% CI [0.490, 1.575], $p = 0.000190$, Full41 $q = 0.023431$, domain $q = 0.004572$. Top-10% citation share, FSL1: β = 0.927, SE = 0.314, 95% CI [0.311, 1.543], $p = 0.003160$, Full41 $q = 0.114758$, domain $q = 0.031063$. Top-5% citation share, FSL3: β = 1.303, SE = 0.451, 95% CI [0.419, 2.188], $p = 0.003883$, Full41 $q = 0.114758$, domain $q = 0.031063$.	Only the first estimate survives the conservative Full41 correction. All three survive the domain-specific correction. Domain results are treated as sensitivity evidence, not as a replacement for Full41 inference.
Macro RQ2: sensitivity analyses	Alternative Theil and Top10Share models; LOO diagnostics	Full41 $q < 0.05$: Theil 30/123 and Top10Share 0/123. Primary8 $q < 0.05$: Theil 6/24 and Top10Share 0/24. LOO signs are consistent in 54/122 adequately covered specifications.	Results depend on the concentration measure and omitted funding system. Alternative models form separate FDR families and do not replace Main Funding Gini inference.
LOO coverage exception	CitingPatentCount × FSL3; LOO excluded from FDR families	Only the estimate excluding NSFC is usable: β = 0.149, SE = 0.334, $p = 0.655$. The other four omission models provide no usable estimate.	Insufficient LOO coverage; no directional-consistency or robustness claim is made.
Micro RQ2a: principal pooled HDFE-PPML (8 outcomes)	Country_Scope × Model family: 24 tests; institution and funding-system–year FE; model-based IID SE	Raw $p < 0.05$: 0/24; BH $q < 0.05$: 0/24; all pooled $q = 0.996701$. Median β: −3.809, −3.324, −1.958 for FSL1–FSL3; N = 10,282–17,479.	No consistent statistically distinguishable pooled within-institution association is detected. The result is specification- and measurement-bound and is not proof of no relationship.

Table 2. *Cont.*

Analytical Component	Evidence Reported	Principal Result	Interpretation
Panel B. Secondary exploratory heterogeneity analyses			
Micro RQ2b: research-orientation heterogeneity	RQ × Country_Scope family: 48 pooled interactions; funding-system and year FE; HC1 SE; no institution FE	BH $q < 0.05$: 48/48; all contrasts positive ($\beta = 63.207$–118.510). Cell support: 360 Strong, 24 Moderate, 48 Weak across recorded cells.	Exploratory between-and-within heterogeneity only. Category slopes require the baseline coefficient plus the interaction; classification overlaps focal variables.
Micro RQ2c: ownership heterogeneity	RQ × Country_Scope family: 24 pooled interactions; funding-system and year FE; HC1 SE; no institution FE	BH $q < 0.05$: 24/24; all interaction contrasts are positive ($\beta = 135.434$–144.266). All 48 pooled ownership support cells are Strong. Across pooled and system-specific analyses, 240 cells are Strong, 24 Moderate, and 24 Weak.	Exploratory between- and within-institution category differences, not causal evidence. Interactions must be interpreted jointly with the reference-group slope.
Model comparability	RQ2a: institution and funding-system–year FE, model-based IID SE. RQ2b/c: funding-system and year FE, HC1 SE, without institution FE.	The model families use different fixed effects, identifying variation, and variance estimators.	RQ2b/c coefficients and significance rates are not directly comparable with RQ2a and do not resolve, reverse, or explain the RQ2a null findings.
Cross-model inference scope	Actual estimator, FE, SE, clustering status, FDR family, and estimation status	No clustering is imposed. Failed models are labelled Not estimated. Raw p-values and BH q-values are retained; LOO diagnostics are excluded from FDR families.	Macro inference is limited by five systems sample; micro SEs do not accommodate arbitrary within-institution serial dependence.

Note. Panel A reports the principal RQ2 analyses and sensitivity checks, whereas Panel B reports secondary exploratory heterogeneity analyses. Primary8 refers to the eight count-based high-end output measures defined in Section 3.2; with FSL1–FSL3 estimated separately, this family contains 24 tests. Full41 q-values adjust all 123 pooled Main Gini indicator-by-FSL tests, whereas domain q-values adjust tests separately within each of the six outcome domains; LOO diagnostics are excluded from FDR correction. RQ2a and RQ2b/c are not nested or directly comparable because they use different fixed effects, identifying variation, and variance estimators. Complete coefficient-level estimates and model metadata are reported in Supplementary Tables S3–S7. Institution-clustered and institution-fixed-effects sensitivity estimates are reported in Supplementary Tables S15 and S16.

Research orientation is classified based on sample-period cumulative funding, scholarly output, citation counts, high-end output counts, and scholarly output-weighted mean FWCI. Institutions receive one point for each indicator on which they fall within the top 25% of their funding system; scores of 4–5, 2–3, and 0–1 define research-intensive, research-active, and teaching-oriented institutions, respectively. Because this classification is derived partly from the same broad funding and performance dimensions examined in RQ2, the RQ2b interaction results are interpreted only as descriptive heterogeneity within the observed sample and not as evidence of differences arising from exogenous institutional missions. Ownership status, although established from independently verified institutional sources, is likewise used only for exploratory and noncausal category comparisons. Separate RQ2b/RQ2c estimates and support diagnostics are reported in Supplementary Tables S6, S7 and S7A.

The central RQ2 conclusion is therefore one of level-specific divergence with substantial inferential qualification. Positive system-level co-concentration is common in direction in the Main Funding Gini models, but adjusted support is sparse and sensitive to the concentration measure. The principal institution-level RQ2a models yield no consistently

distinguishable pooled association under the available agency-linked funding and whole-institution performance measures. RQ2b and RQ2c provide separate exploratory between- and within-institution heterogeneity descriptions and are not treated as directly comparable evidence against the RQ2a findings. None of these model families supports a causal claim.

From a research funding governance perspective, the two analytical levels provide distinct monitoring information. Funding-system-level concentration measures describe the architecture of the observed funding and performance distributions, whereas the institution-level models assess whether changes in agency-linked institutional funding shares are conditionally associated with subsequent whole-institution bibliometric outcomes. Aggregate co-concentration should therefore not be interpreted as institution-level performance evidence. The results support maintaining a clear distinction between system-level distributional diagnostics and institution-level conditional associations without assuming that they arise from a common causal mechanism.

4.3. Positional Persistence, Institutional Mobility, and Subsequent Performance Associations

The transition analysis indicates substantial continuity in accumulated top-funded positions. In the pooled sample, top-10% retention is 0.964 (95% CI [0.955, 0.972]) at $t + 1$, 0.945 [0.932, 0.955] at $t + 2$, and 0.932 [0.917, 0.944] at $t + 3$. The corresponding upward-mobility probabilities are 0.006, 0.009, and 0.012. Top-20% retention is 0.976 [0.970, 0.980], 0.964 [0.957, 0.970], and 0.953 [0.944, 0.960], while upward mobility increases from 0.010 at $t + 1$ to 0.016 at $t + 2$ and 0.021 at $t + 3$. These estimates describe transitions between relative funding positions and are not causal effects. The Wilson intervals are descriptive binomial intervals and are not adjusted for repeated transitions contributed by the same institution.

System-specific transition estimates also indicate substantial but heterogeneous continuity. JSPS and NSFC generally display the highest retention, whereas NSERC displays greater turnover. For example, top-10% retention across $t + 1$ to $t + 3$ ranges from 0.983 to 0.960 for JSPS, from 0.978 to 0.954 for NSFC, and from 0.861 to 0.831 for NSERC. Because the elite groups are substantially smaller in some systems, particularly NSERC, Table A1 reports transition numerators, denominators, probabilities, and Wilson intervals. The system-specific estimates are therefore interpreted as conditional descriptions of the observed panels rather than as definitive rankings of funding-system openness. Complete transition probabilities, confidence intervals, and counts are reported in Table A1 and Supplementary Table S8. Figure 3 displays top-funded retention rates across the five funding systems at $t + 1$, $t + 2$, and $t + 3$.

Across annual system-year panels, realised Top-10% shares range from 10.01% to 11.11%, and Top-20% shares range from 20.03% to 21.11%; the yearly observed counts and shares are reported in Supplementary Table S20. The audit comparing archived and current NSERC retention estimates confirms the numerical differences but cannot identify a single cause among possible panel-construction, missingness, grouping, ranking, and transition-alignment changes. We therefore do not attribute the difference to ties or to one processing step; the comparison is documented in Supplementary Table S21. The Supplementary Table S20 boundary audit records one institution tied at each observed system-year-threshold cutoff, providing no indication of large tie groups as an explanation for the NSERC difference.

The principal pooled linear probability models closely mirror the descriptive persistence pattern. For top-10% status, the coefficients are 0.959 (SE = 0.004, 95% CI [0.950, 0.967], N = 17,848 at $t + 1$, 0.935 (0.006, [0.924, 0.947], N = 15,437 at $t + 2$, and 0.920 (0.007, [0.907, 0.934], N = 13,052 at $t + 3$. For top-20% status, the corresponding coefficients are 0.966 (0.003, [0.961, 0.971], N = 17,848, 0.948 (0.003, [0.942, 0.955], N = 15,437, and 0.932 (0.004, [0.923, 0.940], N = 13,052. All six coefficients remain supported after BH-FDR adjust-

ment $q < 0.001$. They represent conditional probability differences from models containing funding-system and year fixed effects. Because the models do not contain institution fixed effects, the coefficients combine between-institution and within-institution information and should not be interpreted as causal persistence effects or as estimates identified exclusively from changes within the same institution. Complete principal persistence regressions are reported in Supplementary Table S9.

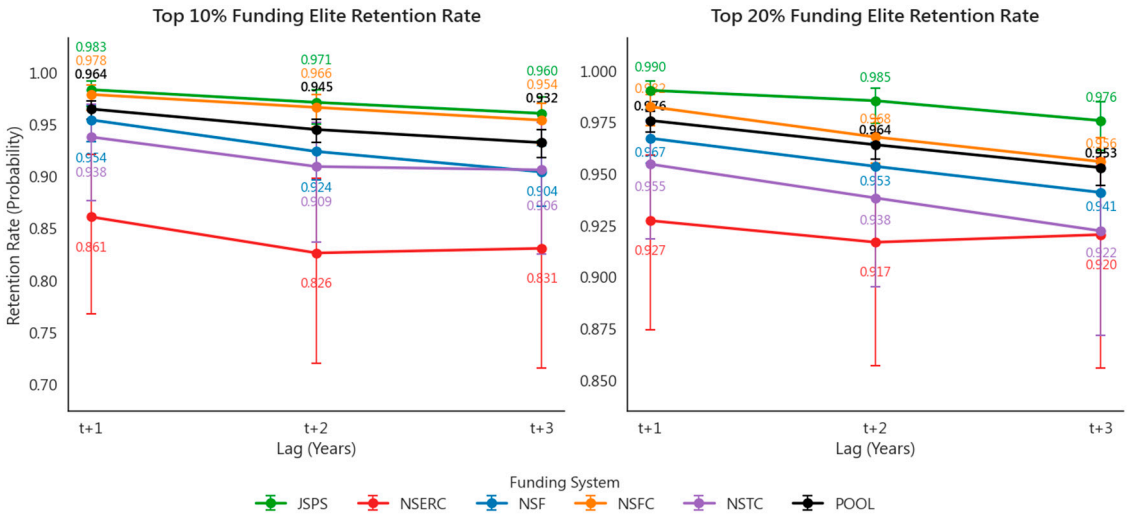


Figure 3. Retention rates of top-funded institutions across five funding systems at $t + 1$, $t + 2$, and $t + 3$ outcome horizons. **Note.** Retention probabilities refer to accumulated top-funded status within each funding system and year. Wilson 95% confidence intervals and transition numerators/denominators are reported in Table A1; confidence intervals are not plotted in this figure. The intervals are descriptive binomial intervals and are not adjusted for repeated transitions contributed by the same institution.

Institution-clustered standard errors leave all six pooled RQ3a coefficients supported after BH-FDR adjustment (all $q < 0.001$), although uncertainty is larger than under the unclustered specification. The institution-fixed-effects sensitivity estimates differ materially: pooled Top-10% coefficients are 0.415, 0.076, and −0.114 at $t + 1$, $t + 2$, and $t + 3$, and Top-20% coefficients are 0.416, 0.132, and −0.074. These are specification-sensitivity results, not causal persistence effects. Clustered and institution-fixed-effects estimates are reported in Supplementary Table S17.

Uncertainty and estimation status are reported separately for transition probabilities and regression coefficients. Principal LPM estimates use HC1 heteroskedasticity-robust standard errors without clustering; institution-clustered sensitivity estimates and their BH-FDR adjustments are reported in Supplementary Tables S17 and S18. Failed models, missing p-values, and unidentified terms, including zero-estimate/zero-standard-error artefacts, are labelled Not estimated, excluded from BH-FDR families, and never interpreted as nonsignificant results.

Across the combined Primary8 and broader indicator analysis, 40 of the 41 indicators are estimable in the principal pooled subsequent performance models. For top-10% funding status, mean coefficients are 0.432, 0.430, and 0.426 at $t + 1$, $t + 2$, and $t + 3$, respectively; the corresponding medians are 0.659, 0.659, and 0.653. The IQRs are [0.157, 0.721], [0.155, 0.717], and [0.151, 0.714], and the ranges are [−0.109, 0.746], [−0.108, 0.742], and [−0.106, 0.740]. Within the separately defined Primary8 and supplementary BH-FDR families, 40 of 40 estimable indicator coefficients remain supported at $t + 1$ and $t + 2$, and 39 of 40 remain supported at $t + 3$. The exception is International collaboration percentage at $t + 3$ ($\beta = 0.017$, SE = 0.009, 95% CI [−0.001, 0.035], raw $p = 0.059$, $q = 0.059$.

For top-20% funding status, mean coefficients are 0.508, 0.506, and 0.503 across the three horizons, and the corresponding medians are 0.693, 0.690, and 0.687. The IQRs are [0.278, 0.778], [0.274, 0.775], and [0.272, 0.772], while the ranges are [−0.221, 0.796], [−0.219, 0.797], and [−0.215, 0.795]. All 40 estimable coefficients remain supported within their respective BH-FDR families at each horizon. The ranges include negative coefficients for selected ratio-based outcomes, however, demonstrating that adjusted statistical support should not be interpreted as a uniformly positive association across every bibliometric dimension. Complete per-indicator estimates are therefore reported alongside the distributional summaries. Complete pooled indicator-specific estimates are reported in Supplementary Table S10.

The remaining indicator, the share of publications in the top 100% of journal percentiles, does not provide sufficient usable variation or sample support for the principal models and is classified as Not estimated. It is excluded from coefficient summaries and FDR families rather than treated as a nonsignificant result.

For the eight Primary8 count-based high-end outcomes, the system-specific principal LPM results exhibit a consistent pattern. Across five funding systems, eight outcomes, two top-funded thresholds, and three outcome horizons, all 240 focal coefficients are positive and remain supported within their corresponding system-specific BH-FDR families. The estimated magnitudes nevertheless vary across funding systems, outcomes, thresholds, and horizons. The presence of this pattern in each funding system provides descriptive evidence of positional alignment between current top-funded status and subsequent high-end performance status, but it does not establish that funding status causes subsequent performance differences or that the pooled coefficient is unaffected by differences in system size and composition. System-specific Primary8 estimates are reported in Supplementary Table S11, while the principal persistence, subsequent performance, and overlap-robustness results are summarised in Table 3.

Table 3. Persistence of top-funded positions, conditional associations with subsequent performance-elite status, and overlap-robustness checks.

Outcome	Threshold/Horizon	Estimate and Uncertainty	Inference
Funding-elite persistence LPM	Top 10%, $t+1/t+2/t+3$	β = 0.959 (SE = 0.004); 95%CI [0.950, 0.967]; N = 17,848 β = 0.935 (SE = 0.006); 95%CI [0.924, 0.947]; N = 15,437 β = 0.920 (SE = 0.007); 95%CI [0.907, 0.934]; N = 13,052	BH $q < 0.001$ BH $q < 0.001$ BH $q < 0.001$
	Top 20%, $t+1/t+2/t+3$	β = 0.966 (SE = 0.003); 95%CI [0.961, 0.971]; N = 17,848 β = 0.948 (SE = 0.003); 95%CI [0.942, 0.955]; N = 15,437 β = 0.932 (SE = 0.004); 95%CI [0.923, 0.940]; N = 13,052	BH $q < 0.001$ BH $q < 0.001$ BH $q < 0.001$
Subsequent performance, 40 indicators	Top 10%, $t+1/t+2/t+3$	Mean β = 0.432/0.430/0.426; Median = 0.659/0.659/0.653; IQR = [0.157, 0.721]/[0.155, 0.717]/[0.151, 0.714]; Range = [−0.109, 0.746]/[−0.108, 0.742]/[−0.106, 0.740]	BH-supported: 40/40, 40/40, and 39/40; N ranges = 11,076–17,671, 9405–15,286, and 7744–12,928
	Top 20%, $t+1/t+2/t+3$	Mean β = 0.508/0.506/0.503; Median = 0.693/0.690/0.687; IQR = [0.278, 0.778]/[0.274, 0.775]/[0.272, 0.772]; Range = [−0.221, 0.796]/[−0.219, 0.797]/[−0.215, 0.795]	BH-supported: 40/40, 40/40, and 39/40; N ranges = 11,076–17,671, 9405–15,286, and 7744–12,928

Table 3. *Cont.*

Outcome	Threshold/Horizon	Estimate and Uncertainty	Inference
Annual-funding persistence check	Pooled $t \rightarrow t + 1$	Top-10% retention = 0.943; Top-20% retention = 0.959	Continuity remains when annual rather than accumulated funding positions are used
System-specific annual-funding checks	Available system windows	Top-10% retention = 0.861–0.972; Top-20% retention = 0.927–0.986	Descriptive sensitivity to nonaccumulated funding positions
System-specific non-overlapping-stock checks	System-specific non-overlapping horizons	Top-10% retention = 0.861–0.960; Top-20% retention = 0.927–0.976	Continuity remains after shared annual observations are reduced or removed
Estimator and estimation status	Principal LPM; auxiliary Logit/PPML	Complete SE, CI, raw p, BH q, N, FE, and variance-estimator information supplied in machine-readable files	Principal LPM uses HC1 SE without clustering. Failed or unidentified models are labelled Not estimated and are not interpreted as nonsignificant

Note. Pooled principal LPMs include funding-system and year fixed effects; system-specific models include year fixed effects. HC1 heteroskedasticity-robust standard errors are reported without clustering. BH-FDR adjustment is applied separately to the focal persistence, Primary8, and supplementary-indicator families within each model and analytical scope. Wilson 95% confidence intervals for transition probabilities are descriptive and are not adjusted for repeated institutional observations. The 40-indicator summaries exclude the share of publications in the top 100% of journal percentiles because it lacks sufficient usable variation or sample support. Complete coefficient-level results and model specifications are reported in Supplementary Tables S8–S14 and S14A. Institution-clustered and institution-fixed-effects sensitivity estimates are reported in Supplementary Tables S17–S19.

Research-orientation and ownership interactions are reported as separate secondary exploratory analyses. The research-orientation classification is derived from sample-period cumulative funding and bibliometric characteristics and is therefore neither independent of the focal variables nor an exogenous institutional-mission classification. Sparse or unidentified system-specific cells are retained in the support diagnostics and failure logs rather than interpreted. These interaction analyses are not used to infer category differences solely from counts of significant coefficients and are not treated as causal evidence. Separate exploratory interaction estimates and support diagnostics are reported in Supplementary Tables S13, S14 and S14A.

Persistence remains substantial in checks designed to reduce the mechanical overlap between adjacent accumulated funding stocks. In the pooled annual-funding analysis, retention is 0.943 for the top 10% and 0.959 for the top 20%. Across the system-specific annual-funding checks, retention ranges from 0.861 to 0.972 for the top 10% and from 0.927 to 0.986 for the top 20%. In the non-overlapping accumulated-stock checks, the corresponding ranges are 0.861 to 0.960 and 0.927 to 0.976. For NSERC and NSTC, whose assigned window is one year, the annual-funding and non-overlapping-stock definitions are identical and are not independent sensitivity checks. For systems with longer assigned windows, non-overlapping checks reduce shared annual observations; these estimates are generally lower than adjacent accumulated-stock retention but do not eliminate uncertainty about the appropriate funding horizon. The complete checks are reported in Supplementary Table S12.

The results require a clear distinction between positional association and causal performance effects. The observed continuity is compatible with cumulative processes through which existing resources, infrastructure, reputation, and organisational capacity may be reflected in later institutional positions, but the analysis does not identify the mechanisms

producing that continuity. Research capacity, disciplinary composition, institutional reputation, programme design, and funding-system characteristics may jointly influence funding position and subsequent performance status.

For governance-oriented monitoring, high retention should therefore be treated as a distributional diagnostic rather than as evidence of allocation efficiency, fairness, or governance quality. Similarly, the positive associations for the Primary8 outcomes do not demonstrate that top-funded status itself produces later high-end performance. Joint monitoring of retention, upward mobility, downward mobility, and indicator-specific performance associations can document whether stable support for established research capacity coexists with observed institutional movement, but it cannot establish the availability of equal funding opportunities or the causal consequences of the allocation process.

5. Conclusions and Implications for Research Funding Governance

5.1. Main Findings and Contributions

This study provides a comparative distributional and positional analysis of five major public research funding systems using observed agency-linked institutional panels. It does not evaluate complete national funding portfolios or directly identify the governance mechanisms that produced the observed distributions and transitions.

RQ1 documents substantial funding concentration within each observed agency-linked institutional panel, together with different temporal trajectories across the five systems. Because the panels differ in institutional coverage, agency remit, observation period, and the availability of common eligibility rosters, the estimated concentration levels should be interpreted as conditional descriptions of the observed panels rather than as definitive rankings of national research funding systems.

RQ2 shows that positive system-level co-concentration coefficients are common in the Main Funding Gini models, but multiplicity-adjusted support is sparse. Only one of the 123 indicator-by-FSL tests remains supported under the conservative Full41 correction. Three citation impact tests remain supported under the additional domain-specific sensitivity correction, whereas the alternative Theil and Top10Share specifications produce markedly different adjusted-evidence patterns. The macro findings are therefore descriptive and sensitive to the operationalisation of concentration. At the institution level, the principal RQ2a PPML models yield no consistently statistically distinguishable pooled association between agency-linked funding share and subsequent whole-institution high-end output share. This null finding is specification- and measurement-bound because the funding and bibliometric measures have different institutional and disciplinary scopes. The RQ2b and RQ2c interaction models provide secondary exploratory heterogeneity descriptions and are not directly comparable with, or explanations of, the principal RQ2a results. None of the RQ2 analyses identifies a causal effect of agency funding.

RQ3 documents substantial observed continuity in accumulated top-funded positions. In the pooled transition analysis, top-10% retention declines from 0.964 at $t + 1$ to 0.932 at $t + 3$, while top-20% retention declines from 0.976 to 0.953. Annual-funding and non-overlapping-stock checks produce generally lower but still substantial retention, indicating that shared observations in adjacent accumulated stocks contribute to, but do not fully account for, the observed continuity. Current top-funded status is positively associated with subsequent performance-elite status across all Primary8 outcomes, funding systems, thresholds, and horizons in the principal LPM analyses. The broader 40-indicator results are more heterogeneous and include negative coefficients for selected ratio-based outcomes; one additional indicator is not estimable and is not treated as nonsignificant. These conditional associations do not establish that top-funded status causes subsequent performance. Persistent positions are compatible with cumulative advantage, prior capability, programme

continuity, institutional specialisation, and other mechanisms that the analysis cannot causally distinguish.

The principal contribution of the study lies in integrating concentration, positional persistence, and observed institutional mobility within a common comparative framework. Concentration measures describe how resources are distributed within each observed panel; transition measures document the persistence of accumulated top-funded positions and the observed frequency of entry into and exit from those positions; and subsequent performance models estimate conditional associations between current funding position and later performance position. Treating these dimensions separately avoids equating concentrated funding with superior performance, persistent funding positions with administrative failure, or greater observed turnover with more effective or equitable governance.

A second contribution is the explicit separation of funding-system-level and institution-level relationships. System-level co-concentration and institution-level funding–performance associations may coexist, diverge, or vary across specifications because they represent different estimands and rely on different sources of variation. Recognising this distinction reduces the risk of drawing organisational conclusions from aggregate distributional patterns. It also requires caution when agency-specific funding measures are related to whole-institution bibliometric outcomes and when exploratory interaction models use different fixed effects and identifying variation from the principal institution-level models. Persistent top-funded positions may be consistent with the reinforcement of institutional advantage, but they may also reflect differences in research infrastructure, institutional mission, disciplinary portfolio, programme design, and established organisational capacity.

The resulting framework is best understood as an analytical monitoring framework. It makes resource distributions, positional continuity, and observed institutional transitions visible without converting them into direct measures of governance quality, procedural fairness, allocative efficiency, or equality of opportunity. The findings may identify patterns requiring further programme-level investigation, but they do not by themselves justify a particular funding allocation or programme redesign.

5.2. Implications for Research Funding Governance

The findings do not support a universal prescription for either greater concentration or greater dispersion. The observed panel measures can identify distributional patterns that warrant further programme-specific investigation, but they cannot determine an optimal allocation structure.

Funding agencies may consider concentration and mobility indicators alongside programme objectives, peer-review evidence, disciplinary context, eligibility conditions, and funding-instrument characteristics. In the present study, these indicators are descriptive diagnostics only; no empirical threshold of excessive concentration, insufficient mobility, or positional closure is estimated.

High positional continuity and the positive subsequent performance associations observed for the Primary8 outcomes may motivate closer examination of continuity and contestability, but they do not establish that a particular programme design caused either pattern. The broader indicator analysis shows heterogeneity in coefficient direction and magnitude. Stable support may reflect research infrastructure, accumulated capability, programme continuity, or institutional specialisation, whereas limited observed entry may reflect eligibility conditions, institutional composition, programme design, or other unobserved factors.

Possible programme responses, including capacity-building routes, broader entry mechanisms, or scheduled review points, should therefore be treated as hypotheses for future programme-level evaluation rather than as recommendations derived from the present

estimates. Assessing such designs would require information on eligibility, application and review procedures, programme objectives, unsuccessful applicants, and policy changes, together with an appropriate counterfactual or policy-evaluation design.

Research assessment should likewise avoid treating bibliometric indicators as interchangeable. The association between current top-funded status and subsequent performance-elite status is consistently positive across the eight Primary8 count-based outcomes, whereas the broader indicator analysis reveals substantial variation in coefficient direction and magnitude. In particular, statistical support does not necessarily imply a positive association, because selected ratio-based outcomes have negative coefficients. Publication volume, institutional output share, citation impact, collaboration patterns, academic–corporate engagement, and patent-related influence therefore represent different dimensions of institutional performance. No single indicator in the present analysis provides a comprehensive measure of institutional contribution.

The exploratory heterogeneity analyses are more useful for generating questions about evaluation design than for ranking institutional categories. RQ2b/c differs from the principal RQ2a models in fixed effects, identifying variation, and variance estimation; their coefficient magnitudes, significance rates, and adjusted q-values are therefore not directly comparable. The pooled interaction cells have strong empirical support, but some funding-system-specific cells are moderate, sparse, or unidentified. Research orientation is derived partly from sample-period funding and bibliometric characteristics and is not an independent or exogenous institutional-mission classification. Public/private ownership is externally verified, but its interactions likewise represent conditional category differences rather than causal effects. Neither analysis demonstrates that any category has an inherently stronger or weaker capacity to convert funding into performance.

The findings do not provide an empirical basis for assigning different evaluation criteria to the three data-derived research-orientation categories. A mission-sensitive assessment system would require institutional missions to be defined independently of the funding and bibliometric outcomes used in the focal models. Future programme-level evaluation could examine whether independently specified missions and programme objectives warrant different combinations of research visibility, collaboration, capacity development, regional contribution, talent development, or applied impact. Such differentiation should be justified by programme purposes and independently validated institutional characteristics rather than inferred from the exploratory classifications used here.

An integrated assessment should keep resource distribution, positional mobility, performance association, and governance mechanisms analytically separate. The present evidence addresses the first three as descriptive or conditional empirical patterns; it does not directly measure programme rules, procedural fairness, allocative efficiency, equality of opportunity, or the mechanisms producing the observed outcomes.

5.3. Limitations and Future Research

The study develops a comparative framework using institution-level data from five public research funding systems and SciVal/Scopus indicators. Its cross-system comparisons and institution-level findings should nevertheless be interpreted within several empirical, inferential, and conceptual boundaries.

Funding records cover the observed awards of NSF, NSFC, JSPS, NSERC, and NSTC rather than all public research funding in the corresponding countries. The linked panels also lack a complete external annual roster of every institution eligible to apply for each funding programme, and NSFC has a different observation period from the other four systems. Concentration levels, percentile classifications, and transition probabilities therefore depend partly on agency remit, observed panel coverage, and period composition. They

should not be interpreted as exhaustive national comparisons or as direct measures of legal eligibility, procedural accessibility, or equality of funding opportunity.

The institution-year design is appropriate for examining resource distributions and positional change at the university level, but it cannot identify the behavioural and organisational mechanisms operating within individual grants, research teams, or researchers. Project type, disciplinary field, team composition, research infrastructure, internal governance, grant-support capacity, and collaborative networks may shape both funding acquisition and subsequent outcomes. The observed association between top-funded and subsequent performance-elite positions may consequently reflect funding exposure together with prior capability, talent structures, administrative capacity, disciplinary composition, and institutional networks. Linking institutional panels to grant-, team-, and researcher-level records would permit more direct examination of these mechanisms.

SciVal outcomes describe whole-institution bibliometric activity across fields and funding sources, whereas the funding measures describe awards from the focal agencies. Subject-restricted and grant-attributable output data were unavailable, so the institution-level models do not link agency funding to outputs directly supported by that agency. This measurement-scope mismatch may attenuate, amplify, or otherwise alter the estimated associations and is central to interpreting the RQ2a null findings. Future research should link agency awards to field-restricted, grant-acknowledged, or project-level outputs where compatible data are available.

The assigned FSL windows were calibrated to the system-specific median durations of valid unique projects linked to recipient higher education institutions with valid SciVal institution IDs, rounded to the nearest whole year. Exact project start and end dates were available for NSF, JSPS, NSERC, and NSTC, whereas NSFC provided start and end years only; NSFC durations were therefore verified at annual rather than exact-date precision. Although each assigned window falls within its system-specific empirical interquartile range, correspondence with the observed duration distribution does not establish that the selected window is the optimal lag between funding and bibliometric outcomes. Project durations vary within systems and across project types. Adjacent accumulated stocks share annual observations. Annual-funding and non-overlapping-stock checks generally produce lower retention, but for NSERC and NSTC the assigned one-year window makes the annual and non-overlapping definitions identical rather than independent checks. These analyses do not make funding cycles fully comparable across systems.

Statistical inference remains limited by the implemented variance estimators and dependence structure. The macro RQ2 FE-OLS models use HC1 standard errors without clustering and contain only five funding systems; their conventional p-values do not provide reliable small-cluster inference and are treated descriptively. The principal institution-level RQ2a PPML, RQ2b/c interaction, and RQ3 LPM estimates retain their stated model-based IID or HC1 standard errors without clustering. Institution-clustered sensitivity analyses are now reported for the focal institution-level models, with BH-FDR recalculated from the clustered p-values; these analyses do not eliminate all uncertainty or address cross-system dependence in the five-system macro models. Wilson intervals for transition probabilities remain descriptive and are not adjusted for repeated institutional transitions. BH-FDR addresses multiplicity within the specified families, not dependence, and adjusted results may vary with the substantively defined family.

The estimated relationships should not be interpreted as causal effects. Prior performance may influence subsequent funding, while policy priorities, disciplinary composition, historical reputation, organisational capacity, and governance arrangements may affect both funding and performance positions. The pooled RQ3 LPMs contain funding-system and year fixed effects rather than institution fixed effects and therefore combine between-

institution and within-institution information. Lagged measures, fixed effects, transition matrices, and sensitivity checks improve temporal and descriptive comparability but do not eliminate reverse causality, omitted-variable bias, selection, or other forms of endogeneity. Future studies could use funding-policy reforms, eligibility thresholds, programme discontinuities, or other quasi-experimental settings to strengthen causal identification.

Exploratory heterogeneity requires particular caution. RQ2b/c does not absorb institution fixed effects and therefore combines between-institution and within-institution information, unlike the principal RQ2a specification. Its coefficients and significance rates are consequently not directly comparable with the RQ2a results. Research orientation is constructed partly from the same sample-period funding and performance dimensions used in the focal models and is neither independent nor exogenous. Although pooled interaction cells have strong empirical support, some funding-system-specific cells are moderate, weak, or unidentified. Public/private ownership is based on externally verified sources, but its interaction coefficients also remain conditional category comparisons rather than causal effects. Future research should use independently defined mission classifications and, where estimable, interaction specifications with fixed effects and identifying variation directly comparable to the principal models.

Finally, programme rules, eligibility conditions, application behaviour, unsuccessful applications, review procedures and scores, policy reforms, and allocation criteria are not observed. The study therefore cannot determine which governance arrangements generate the observed concentration, persistence, or mobility patterns, or whether observed entry and exit reflect genuine accessibility to funding. Programme-level causal and institutional analyses are required before specific design recommendations, fairness assessments, or efficiency claims can be evaluated.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/admsci16100511/s1, Supplementary_Material_Anonymous_20261007_new.docx reports denominator and project-duration audits; principal and sensitivity coefficient estimates; institution-fixed-effects and institution-clustered analyses; confidence intervals and multiplicity adjustments; annual realised elite shares; transition counts and Wilson intervals; leave-one-system-out coverage; within/between variation diagnostics; annual and non-overlapping persistence checks; cell-support diagnostics; and model-failure logs.

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Data Availability Statement: The public research funding records analysed in this study were obtained from publicly accessible sources maintained by NSF, NSFC, JSPS, NSERC, and NSTC. An anonymised version of the analysis code used for the reported analyses is provided as supplementary code files. Institution-level bibliometric indicators were obtained from Elsevier SciVal using Scopus data under an institutional licence. Owing to Elsevier's licencing restrictions, the raw SciVal- and Scopus-derived data cannot be made publicly available. Aggregated results may be made available by the corresponding author upon reasonable request, subject to the applicable licencing conditions.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

FE-OLS	Fixed-effects ordinary least squares
FSL	Funding-stock lag specification
FWCI	Field-Weighted Citation Impact
JSPS	Japan Society for the Promotion of Science
NSF	National Science Foundation
NSERC	Natural Sciences and Engineering Research Council of Canada
NSFC	National Natural Science Foundation of China
NSTC	National Science and Technology Council
PPML	Poisson pseudo-maximum likelihood

Appendix A. Transition Patterns of Accumulated Top-Funded Positions

Table A1 reports retention, downward mobility, upward mobility, and non-elite persistence by funding system, threshold, and all three horizons. Each entry includes the estimated probability, Wilson 95% confidence interval, and transition numerator/denominator. These intervals quantify descriptive binomial uncertainty and are not adjusted for repeated transitions contributed by the same institution.

Table A1. Retention and mobility of accumulated top-funded positions by funding system.

Funding System	Threshold	Horizon	Retention [95% CI]	Downward [95% CI]	Upward [95% CI]	Non-Elite Persistence [95% CI]
Pooled	Top10%	$t+1$	0.964 [0.955, 0.972] (1759/1824)	0.036 [0.028, 0.045] (65/1824)	0.006 [0.005, 0.007] (93/16,024)	0.994 [0.993, 0.995] (15,931/16,024)
		$t+2$	0.945 [0.932, 0.955] (1502/1590)	0.055 [0.045, 0.068] (88/1590)	0.009 [0.008, 0.011] (130/13,847)	0.991 [0.989, 0.992] (13,717/13,847)
		$t+3$	0.932 [0.917, 0.944] (1262/1354)	0.068 [0.056, 0.083] (92/1354)	0.012 [0.010, 0.014] (141/11,698)	0.988 [0.986, 0.990] (11,557/11,698)
Pooled	Top20%	$t+1$	0.976 [0.970, 0.980] (3539/3627)	0.024 [0.020, 0.030] (88/3627)	0.010 [0.008, 0.012] (141/14,221)	0.990 [0.988, 0.992] (14,080/14,221)
		$t+2$	0.964 [0.957, 0.970] (3049/3163)	0.036 [0.030, 0.043] (114/3163)	0.016 [0.014, 0.018] (192/12,274)	0.984 [0.982, 0.986] (12,082/12,274)
		$t+3$	0.953 [0.944, 0.960] (2567/2694)	0.047 [0.040, 0.056] (127/2694)	0.021 [0.019, 0.024] (220/10,358)	0.979 [0.976, 0.981] (10,138/10,358)
JSPS	Top10%	$t+1$	0.983 [0.967, 0.991] (461/469)	0.017 [0.009, 0.033] (8/469)	0.002 [0.001, 0.004] (10/4176)	0.998 [0.996, 0.999] (4166/4176)
		$t+2$	0.971 [0.950, 0.983] (398/410)	0.029 [0.017, 0.050] (12/410)	0.004 [0.002, 0.007] (15/3648)	0.996 [0.993, 0.998] (3633/3648)
		$t+3$	0.960 [0.934, 0.976] (337/351)	0.040 [0.024, 0.066] (14/351)	0.005 [0.003, 0.009] (17/3121)	0.995 [0.991, 0.997] (3104/3121)
JSPS	Top20%	$t+1$	0.990 [0.982, 0.995] (925/934)	0.010 [0.005, 0.018] (9/934)	0.004 [0.002, 0.006] (13/3711)	0.996 [0.994, 0.998] (3698/3711)
		$t+2$	0.985 [0.975, 0.992] (805/817)	0.015 [0.008, 0.025] (12/817)	0.005 [0.003, 0.008] (17/3241)	0.995 [0.992, 0.997] (3224/3241)
		$t+3$	0.976 [0.961, 0.985] (682/699)	0.024 [0.015, 0.039] (17/699)	0.008 [0.006, 0.012] (23/2773)	0.992 [0.988, 0.994] (2750/2773)

Table A1. *Cont.*

Funding System	Threshold	Horizon	Retention [95% CI]	Downward [95% CI]	Upward [95% CI]	Non-Elite Persistence [95% CI]
NSERC	Top10%	$t+1$	0.861 [0.768, 0.920] (68/79)	0.139 [0.080, 0.232] (11/79)	0.019 [0.011, 0.032] (12/644)	0.981 [0.968, 0.989] (632/644)
		$t+2$	0.826 [0.720, 0.898] (57/69)	0.174 [0.102, 0.280] (12/69)	0.023 [0.014, 0.039] (13/564)	0.977 [0.961, 0.986] (551/564)
		$t+3$	0.831 [0.715, 0.905] (49/59)	0.169 [0.095, 0.285] (10/59)	0.023 [0.013, 0.041] (11/480)	0.977 [0.959, 0.987] (469/480)
NSERC	Top20%	$t+1$	0.927 [0.874, 0.959] (140/151)	0.073 [0.041, 0.126] (11/151)	0.023 [0.013, 0.038] (13/572)	0.977 [0.962, 0.987] (559/572)
		$t+2$	0.917 [0.857, 0.953] (121/132)	0.083 [0.047, 0.143] (11/132)	0.026 [0.015, 0.044] (13/501)	0.974 [0.956, 0.985] (488/501)
		$t+3$	0.920 [0.856, 0.958] (104/113)	0.080 [0.042, 0.144] (9/113)	0.026 [0.014, 0.046] (11/426)	0.974 [0.954, 0.986] (415/426)
NSF	Top10%	$t+1$	0.954 [0.933, 0.968] (538/564)	0.046 [0.032, 0.067] (26/564)	0.011 [0.009, 0.015] (57/4981)	0.989 [0.985, 0.991] (4924/4981)
		$t+2$	0.924 [0.896, 0.944] (447/484)	0.076 [0.056, 0.104] (37/484)	0.020 [0.016, 0.025] (85/4234)	0.980 [0.975, 0.984] (4149/4234)
		$t+3$	0.904 [0.871, 0.929] (367/406)	0.096 [0.071, 0.129] (39/406)	0.027 [0.022, 0.033] (96/3513)	0.973 [0.967, 0.978] (3417/3513)
NSF	Top20%	$t+1$	0.967 [0.955, 0.976] (1088/1125)	0.033 [0.024, 0.045] (37/1125)	0.022 [0.018, 0.027] (97/4420)	0.978 [0.973, 0.982] (4323/4420)
		$t+2$	0.953 [0.938, 0.965] (922/967)	0.047 [0.035, 0.062] (45/967)	0.037 [0.031, 0.043] (137/3751)	0.963 [0.957, 0.969] (3614/3751)
		$t+3$	0.941 [0.922, 0.955] (763/811)	0.059 [0.045, 0.078] (48/811)	0.051 [0.044, 0.059] (158/3108)	0.949 [0.941, 0.956] (2950/3108)
NSFC	Top10%	$t+1$	0.978 [0.963, 0.987] (587/600)	0.022 [0.013, 0.037] (13/600)	0.002 [0.001, 0.003] (8/5275)	0.998 [0.997, 0.999] (5267/5275)
		$t+2$	0.966 [0.947, 0.978] (510/528)	0.034 [0.022, 0.053] (18/528)	0.002 [0.001, 0.004] (10/4577)	0.998 [0.996, 0.999] (4567/4577)
		$t+3$	0.954 [0.930, 0.969] (432/453)	0.046 [0.031, 0.070] (21/453)	0.003 [0.002, 0.005] (12/3884)	0.997 [0.995, 0.998] (3872/3884)
NSFC	Top20%	$t+1$	0.982 [0.973, 0.988] (1176/1197)	0.018 [0.012, 0.027] (21/1197)	0.002 [0.001, 0.004] (10/4678)	0.998 [0.996, 0.999] (4668/4678)
		$t+2$	0.968 [0.955, 0.977] (1019/1053)	0.032 [0.023, 0.045] (34/1053)	0.004 [0.003, 0.007] (17/4052)	0.996 [0.993, 0.997] (4035/4052)
		$t+3$	0.956 [0.940, 0.967] (864/904)	0.044 [0.033, 0.060] (40/904)	0.006 [0.004, 0.009] (21/3433)	0.994 [0.991, 0.996] (3412/3433)
NSTC	Top10%	$t+1$	0.938 [0.877, 0.969] (105/112)	0.062 [0.031, 0.123] (7/112)	0.006 [0.003, 0.014] (6/948)	0.994 [0.986, 0.997] (942/948)
		$t+2$	0.909 [0.836, 0.951] (90/99)	0.091 [0.049, 0.164] (9/99)	0.008 [0.004, 0.017] (7/824)	0.992 [0.983, 0.996] (817/824)
		$t+3$	0.906 [0.825, 0.952] (77/85)	0.094 [0.048, 0.175] (8/85)	0.007 [0.003, 0.017] (5/700)	0.993 [0.983, 0.997] (695/700)

Table A1. *Cont.*

Funding System	Threshold	Horizon	Retention [95% CI]	Downward [95% CI]	Upward [95% CI]	Non-Elite Persistence [95% CI]
NSTC	Top20%	$t+1$	0.955 [0.918, 0.975] (210/220)	0.045 [0.025, 0.082] (10/220)	0.010 [0.005, 0.019] (8/840)	0.990 [0.981, 0.995] (832/840)
		$t+2$	0.938 [0.895, 0.964] (182/194)	0.062 [0.036, 0.105] (12/194)	0.011 [0.006, 0.022] (8/729)	0.989 [0.978, 0.994] (721/729)
		$t+3$	0.922 [0.871, 0.954] (154/167)	0.078 [0.046, 0.129] (13/167)	0.011 [0.005, 0.023] (7/618)	0.989 [0.977, 0.995] (611/618)

Note. Retention is Elite → Elite; downward mobility is Elite → Non-Elite; upward mobility is Non-Elite → Elite; and non-elite persistence is Non-Elite → Non-Elite. Each cell reports the transition probability [Wilson 95% confidence interval] (numerator/denominator). Wilson intervals are descriptive binomial intervals and are not adjusted for repeated transitions contributed by the same institution; cross-system comparisons remain descriptive.

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