Remunerative Combinatorics: Mathematicians and their Sponsors in the Mid-Twentieth Century
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Preprint of chapter to appear in *Mathematical Cultures*, ed. Brendan Larvor, Springer, 2015.

Abstract
Conventional wisdom notwithstanding, mathematics is not cheap. Particularly in the era of mathematics following World War 2 and accelerating after the Cold War, where mathematicians' extensive regional and international travel for workshops, seminars, conferences, and residencies became the norm, the problem of funding mathematical research and publication has relied upon one of the most consequential areas of interaction between mathematicians and non-mathematicians—namely, relations between mathematicians and their financial sponsors. This chapter examines the work of the American organizers of the 1950 International Congress of Mathematicians to marshal a wide range of state, philanthropic, corporate, and intergovernmental interests in support of their discipline, with a focus to the lasting effects of World War 2 on their efforts. I argue that money-driven processes of elaboration and accommodation shaped both the framing and substance of mathematicians' research, pedagogy, and professional organization at mid-century.

Introduction: Natural Sources of Support
On April 15, 1937, Marston Morse met Warren Weaver to ask for money.[2] Weaver was, since 1932, the director of the Division of Natural Sciences of the Rockefeller Foundation, a prominent philanthropy based in New York chartered in 1913 and bankrolled by oil magnate John D. Rockefeller.[3] Trained as a mathematician, Weaver would become best known for directing the Rockefeller Foundation's tremendous resources to reshape the field of experimental biology, including the area of molecular biology whose name he coined. But Weaver never strayed far from his initial vocation, and mathematics remained for him an important area of academic interest and financial intervention.

Morse, for his part, was by 1937 an established leader and active organizer in his own field of mathematical analysis and in the broader mathematical discipline. Having completed his doctorate at Harvard under the dean of American mathematics, George Birkhoff, and having worked at a variety of elite institutions in the American northeast, Morse had in 1935 settled at the new Institute for Advanced Study in Princeton, New Jersey, where he would spend the

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This material is based in part upon work supported under a National Science Foundation Graduate Research Fellowship (Grant No. DGE-0646086). I am grateful to Slava Gerovitch for his insightful criticisms and suggestions, and to Brendan Larvor and the participants in the *Mathematical Cultures 3* conference.
[2] Their exchange is documented in Warren Weaver's officer diary, excerpted in folder 1545, box 125, series 200D, Record Group 1.1, Rockefeller Foundation Archives, Rockefeller Archive Center, Sleepy Hollow, New York (hereafter Rockefeller Foundation Archives; this folder hereafter Rockefeller AMS/ICM 1937-1941 dossier).
[3] On the Rockefeller Foundation's interventions in international mathematics in this period, which began before Weaver's arrival, see Reinhard Siegmund-Schultze *Rockefeller and the Internationalization of Mathematics Between the Two World Wars: Documents and Studies for the Social History of Mathematics in the 20th Century*. Basel: Birkhäuser, 2001.

remainder of his illustrious career.[4] At the 1936 International Congress of Mathematicians in Oslo, Norway, he had been a part of the delegation from the American Mathematical Society that officially invited the world's mathematicians to the United States for the next such Congress, in 1940.[5]

Hosting so large an international meeting was going to be expensive, and in 1937 Morse and the American mathematics community had few places to turn. Following the Great War, largely in response to the growing costs of publication, American mathematicians had begun to reach beyond their traditional financial base in institutions of higher education.[6] Some sponsors, like the Carnegie Corporation of New York and the Rockefeller Foundation, proved amenable to underwriting mathematicians' work as part of their broader programs in support of the natural and life sciences. Corporate sponsors, where present at all, tended to contribute in relatively small amounts on the basis of personal connections to institutionally well-connected mathematicians. Larger corporate contributions to American mathematics, such as from the American Telephone & Telegraph Company, were the exception rather than the rule. Peacetime military sponsorship was out of the question. Mathematics, Morse pled at his meeting with Weaver, was in "the unique position of … having no natural sources of support," and Weaver agreed.[7]

I aim in this chapter to denaturalize mathematicians' support in the mid-twentieth century. By tracing some financial underpinnings of the discipline, I here show the dependence of the cultures of elite mathematics on the societies and infrastructures from which they are often considered independent. As with other scholarly disciplines, practitioners of mathematics have historically relied on a combination of personal means, patronage from states and wealthy individuals, relations with commercial enterprises, and participation in various pedagogical infrastructures for their material and intellectual sustenance. Whether from royal courts or royal societies, from medieval universities or military academies, from mints, mills, or mines, these sponsors of mathematics have demonstrably shaped what mathematicians know and do and how they know and do it.[8] Individual scholars have historically moved frequently between different settings and have counted on the successive or simultaneous moral or financial support of multiple sponsors in order to bolster their influence and prestige and to furnish themselves both the wherewithal to pursue their work and the means to seek future sponsorship. As they had for centuries prior, mathematicians at mid-century shaped their institutional and financial milieux to their advantage, but also adapted their own pliable values and priorities in the face of new challenges and opportunities.

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[4] See William Aspray, "The Emergence of Princeton as a World Center for Mathematical Research, 1896-1939," in William Aspray and Philip Kitcher (eds.) *History and Philosophy of Modern Mathematics* (Minneapolis: University of Minnesota Press, 1988), pp. 346-366. The Institute's early years are discussed on pp. 357-359.

[5] *Comptes Rendus du Congrès International des Mathématiciens, Oslo 1936* (Oslo: A.W. Brøggers, 1937), vol. 1, p. 49.

[6] Loren Butler Feffer, "Oswald Veblen and the Capitalization of American Mathematics: Raising Money for Research, 1923-1928," *Isis*, 1998, 89:474-497.

[7] Weaver's agreement is evident in his formal appropriation request to the Foundation for its November docket, which echoes Morse's claim nearly verbatim. Rockefeller AMS/ICM 1937-1941 dossier.

[8] E.g. Mary Terrall, *The Man Who Flattened the Earth: Maupertuis and the Sciences in the Enlightenment* (Chicago: University of Chicago Press, 2002); Judith V. Grabiner, " 'Some Disputes of Consequence': Maclaurin among the Molasses Barrels," *Social Studies of* Science, 1998, 28(1):139-168.

Two and a half years after Morse met with Weaver the 1940 Congress became a casualty of the Second World War. That war and its aftermath transformed mathematicians' financial and institutional circumstances, and comparing the planned 1940 Congress with the 1950 Congress that replaced it makes these changes perspicuous. Historians of science, especially of physics, have studied the institutional, cultural, and even epistemic changes associated with the war-mediated advent of "big science," among other signal changes that would come to characterize the postwar era.[9] Yet conventional accounts of international mathematics often portray the Second World War as little more than an ellipsis.[10]

Many of those active at the time remarked on the field-changing transformations the war had wrought for mathematicians' research, organization, and funding.[11] These included changes to existing channels of revenue from states, academic institutions and philanthropies, as well as the advent of sponsors largely or wholly new to mathematicians. Postwar mathematics differed from its interwar predecessor in the scope and scale of participation and activity, both in its traditional centers and on its widening periphery. This, in turn, reconfigured the problems, methods, and means of communication mathematicians shared and developed. While there is space here only to gesture at these larger changes, for the American-hosted International Congress of Mathematicians the contrasts between 1940 and 1950 are clear and striking. In the remunerative combinatorics of the Congress's organizers, one can see the negotiations and adaptations that would come to define a distinctive transformation in the cultures of elite mathematics whose effects remain visible today.

Promises and Projections

One month before his meeting with Weaver, on March 13, 1937, Morse and fourteen colleagues on a committee chaired by his Princeton University neighbor Luther Eisenhart had submitted to the American Mathematical Society a formal blueprint for the 1940 Congress, which was duly adopted with a few amendments.[12] As a part of their planning, the members of Eisenhart's

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[9] E.g. Peter Galison and Bruce Hevly (eds.) *Big Science: the Growth of Large-Scale Research* (Stanford: Stanford University Press, 1992); Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University of Chicago Press, 1997); David Kaiser *Drawing theories apart: the dispersion of Feynman diagrams in postwar physics* (Chicago: University of Chicago Press, 2005). Two important early statements are Paul Forman, "Behind quantum electronics: National security as basis for physical research in the United States, 1940-1960," *Historical Studies in the Physical and Biological Sciences*, 1987, 18(1):149-229, and Dan Kevles, "Cold war and hot physics: Science, security, and the American state, 1945-56," *Historical Studies in the Physical and Biological Sciences*, 1990, 20(2):239-264.

[10] E.g. Olli Lehto's *Mathematics Without Borders: A History of the International Mathematical Union* (New York: Springer, 1998) skips directly from 1933-1939 (chapter 3) to 1945-1951 (chapter 4) in the chronology of its table of contents. The war consumes just three paragraphs (on pp. 125-126) of Guillermo P. Curbera's *Mathematicians of the World, Unite! The International Congress of Mathematicians: A Human Endeavor* (Wellesley, MA: A.K. Peters, 2009); the 1950 Congress is discussed on pp. 127-132. Several important exceptions to this historiographical generalization are cited below.

[11] E.g. Marshall H. Stone, "Science and Statecraft," *Science*, May 16, 1947, 105(2733):507-510; Mina Rees, "The Mathematical Sciences and World War II," *The American Mathematical Monthly*, 1980, 87(8):607-621.

[12] Report as amended by the American Mathematical Society in the "ICM – Analysis" folder, box 7, Papers of Marston Morse, Harvard Depository HUGFP 106.10, courtesy of the Harvard University

Committee on the International Congress of Mathematicians had worked out a preliminary budget of $23,000 for the event (figure 1).[13] The greatest anticipated expense was for preparing and printing proceedings for the Congress. The American Mathematical Society had, by 1937, a long and often vexing experience with the logistical and financial burdens of publication.[14] Its representatives estimated a cost of $10 per printed page and anticipated volumes running to 800 pages, though they considered provision for 1,000 pages desirable. The second major category of expenses, for "entertainment," included the costs of hosting an estimated 300 foreign mathematicians and guests. A final line item encompassed organizational costs and publicity. Subventions for foreign travel were suggested if further pledges could be secured, but it was also reasonable to assume that many foreign mathematicians could seek such support from their home governments and institutions.

Estimated Sources of Funds	**$23,000**
Pledges	$15,000
Carnegie Corporation, $7,500	
Anonymous, $7,500	
Membership fees	$7,000
600 regular members x $10	
200 associate members x $5	
Sale of Proceedings	$1,000
Major Expenses	**$23,000**
Proceedings (800 pages)	$8,000
Entertainment	$8,000
Secretariat	$7,000

Figure 1. Projected budget for the 1940 Congress, from the 1937 Eisenhart report.

To pay for this, the planners anticipated $7,000 in income from membership fees assessed on all formal participants and often paid by those participants' home institutions—$10 from each of an estimated 600 regular members and $5 from each of an estimated 200 associate members, typically wives of members. They expected an additional $1,000 from selling the Congress's proceedings to libraries. To balance their sums, the planners reported a pair of generous pledges of $7,500 from each of the Carnegie Corporation and an anonymous source. They were also optimistic about securing further support from the National Academy of Sciences or the National Research Council, with the latter's beneficence courtesy of an unused allocation from Weaver's Rockefeller Foundation.

On April 15, Morse spoke with Weaver as chair of the newly-appointed Financial Committee for the Congress. He summarized the expected budget, inflating the estimated total cost of the Congress from the $23,000 in the report to "Approximately $25,000," including "At least $9,000" for publication. He also revealed that the anonymous $7,500 sponsor was his own Institute for Advanced Study—except that the Institute had never planned to pay. To allow Eisenhart's committee to present a balanced projected budget to the American Mathematical

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Archives (hereafter Morse Papers). Annotated versions from March are in folder 71, box 26, American Mathematical Society records, Ms. 75, John Hay Library, Brown University (hereafter AMS Records).

[13] In terms of buying power, this represents about $380,000 in 2014 dollars. From http://www.bls.gov/data/inflation_calculator.htm.

[14] Butler Feffer, "Oswald Veblen and the Capitalization of American Mathematics."

Society, the Institute for Advanced Study had agreed to underwrite the $7,500 sum and then request it from the Rockefeller Foundation. The committee had determined, owing to a change in personnel within the Rockefeller Foundation, that it would have been inappropriate to trouble the Foundation for funds any time earlier. But without the hoped-for funds to match those pledged by the Carnegie Corporation, the Congress's financial prospects were precarious at best.[15]

The Institute, for its part, hoped to fund lectures and short-term appointments for important European mathematicians so that they could more easily be in the vicinity of the Congress. Morse further supposed that the National Research Council would likely transmit $1,000 (and no more than $2,000) of its Rockefeller grant for "international scientific purposes" to the Congress. Morse did not mention the expected contributions of Boston-area host universities toward expenses, nor did he suppose that the small number of other institutions with his Institute's unusual combination of financial wherewithal and mathematical notability would make much of a dent in the Congress's budget. He knew that scientific organizations like the National Research Council already relied on a small collection of philanthropic benefactors to support their work.

Ultimately, the 1940 Congress succumbed not to finances but to geopolitics. Planning was suspended on September 6, 1939, on the heels of the German invasion of Poland. Morse became chair of a new Emergency Committee for the Congress whose first tasks included convincing donors to allow the American Mathematical Society to keep their contributions in trust "until a more favorable time."[16] Morse's new committee was also to seek immediate payment of the $2,000 pledge they had ultimately secured from the National Research Council, as they had good reason to fear the money would not long remain the NRC's to give.

By the time the Congress ultimately took place, in 1950, its nominal budget had grown by a factor of four.[17] The Carnegie Corporation and Rockefeller Foundation remained the largest individual sources of funds, combining to account for 30% of the Congress's revenues. They would be joined, however, by a diverse cohort of other sponsors, most of which had not substantially funded academic mathematics before the Second World War and some of which did not even exist in 1940. Far from having no natural sources of support, postwar mathematics seemed to teem with them.

In Morse's 1937 meeting with Weaver, a non-committal overture for funds for an international meeting that did not take place, one finds evidence both of the dramatic differences between the funding situations for mathematics on either side of the Second World War and of the substantial continuities that persisted. On either side of the war, the costs of publication represented considerable demands on resources. Private foundations which underwrote such costs before the war were joined in its aftermath by military and other government research enterprises. Travel was important to mathematicians on either side of the war, but its scale, sponsors, and assumptions changed considerably. Small cohorts of well-connected individuals

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[15] Such balance sheet gamesmanship was not unique to this proposal. Just three years later, it can be found in proposals surrounding the founding of *Mathematical Reviews*, during which a sizeable longer-term commitment from the Carnegie Corporation was omitted from grant reports in 1940-1941 to the Rockefeller Foundation, which instead presented just enough of the undertaking's balance sheet to suggest that the Foundation's contribution was sufficient but also necessary. See grant reports in AMS Records, folder 33, box 15 and folder 49, box 15; see also the correspondence in folder 124, box 26.

[16] Minutes of September 6, 1939, AMS Records, folder 17, box 15.

[17] Adjusted in terms of buying power, this represented close to $1,000,000 in 2014 dollars, an increase of more than 150% above the inflation-adjusted prewar budget.

continued to control many of the purse strings for mathematics and individual appeals continued to play an outsized role, but there emerged in tandem new bureaucracies and frameworks for seeking and justifying support for mathematical work.

In the mid-1930s, a top American mathematician could command as much as $20,000 in annual salary and count on his expenses being subsidized for regular travel for lectures and short appointments.[18] Salaries only rarely topped $15,000, but such sums already quickly dwarf those faced by the organizers of the International Congress of Mathematicians. War conditions and broader differences in compensation structure make direct comparisons with Europe difficult, but at least at the top of the profession salaries and institutional infrastructure (including libraries) for professional scholars and educators can safely be said to account for the vast majority of expenditures for academic mathematics in the developed world. These costs were borne principally by academic institutions of various forms, which were in turn supported by governments, donors, and fee-paying constituents. But elite mathematicians were few, and even they sometimes faced problems funding their publications, conferences, and other undertakings. Mathematicians with doctorates were largely dependent on academic positions for their livelihoods.[19] Outside the most developed corners of Europe, North America, and a few other scattered outposts, mathematicians sometimes could hardly count on a salary, much less a well-stocked library or the means to travel and publish.

A decade later, American mathematicians went from worrying about a shortage of posts to worrying about training enough men (and occasionally women) to fill them. There were more positions for mathematicians at research institutes and in several industries and more fellowships and subventions for beginning and established mathematicians alike. Like their American counterparts, and (in Western Europe) with substantial American funding, European universities expanded rapidly as well. In the developing world, new institutions and resources began to concentrate in a way that could begin to sustain academic mathematics as a stable career and profession. The difference between the 1930s and the 1940s was World War 2.

A War of Mathematics

In January, 1942, Harvard President and chairman of the National Defense Research Committee James Bryant Conant, trained as a chemist, was said to have remarked to his counterpart, Frank Jewett, of the National Academy of Sciences, what would become a truism for Americans by the war's end: "The last was a war of chemistry but this one is a war of physics." To that, Jewett, trained as an electrical engineer, replied "It may be a war of physics but the physicists say it is a war of mathematics."[20]

If the Second World War seemed even to some as a war of mathematics, it owed in no small part to the strenuous efforts of a number of well-connected American mathematicians who aggressively courted military patronage in the first half of the 1940s while simultaneously

[18] The $20,000 figure is from the Institute for Advanced Study's offer to Harvard's George Birkhoff. From "Weyl, Hermann, 1932-1933," folder 1, Records of the Office of the Director: Faculty files, Box 37, from the Shelby White and Leon Levy Archives Center of the Institute for Advanced Study, Princeton, NJ, USA (hereafter IAS Archives).

[19] The American career landscape in this decade is surveyed in Nathan Reingold, "Refugee Mathematicians in the United States of America, 1933-1941: Reception and Reaction," *Annals of Science*, 1981, 38: 313-338. See also Parshall, "A New Era."

[20] As recounted by RGD Richardson to Dunham Jackson, January 19, 1942, "Jackson, Dunham" folder, box 9, Morse Papers.

trumpeting the importance of mathematics and mathematicians to scientists, policy makers, and the general public. Latching onto the notions of "total war" and the "manpower problem," these figures aggressively sought the ear of military officials and any, like Conant and Jewett, who seemed to have the ear of military decision-makers. With surveys, reports, letters, editorials, and radio interviews, these mathematicians insisted that not just the war but the technical patrimony of the nation owed its present and future to their profession.[21] As Marshall Stone wrote in July, 1940, "If mathematics is to be brought to bear upon our defense problems in full measure, we shall have to organize and conduct propaganda to this end."[22]

For the two leading American professional organizations of mathematicians, the American Mathematical Society and Mathematical Association of America, the chief organ of such propaganda was their joint War Preparedness Committee, founded in 1940 and later renamed the War Policy Committee. Its initial chair was Marston Morse, who would soon assume the presidency of the American Mathematical Society, as well. The committee, which received substantial financial support from the Rockefeller Foundation for its activities, gathered information about mathematicians' current and potential participation in the war effort and advocated for the mathematicians' professional interests.[23]

Among the many outgrowths of this effort was the creation in 1943 of an Applied Mathematics Panel at the Office of Scientific Research and Development, a civilian organization established in 1942 to support American military operations.[24] The panel included several grandees of the American Mathematical Society, including Marston Morse, Griffith Evans, and Oswald Veblen, who would play central roles in organizing the renewed International Congress of Mathematicians in 1950. It was also, by no means incidentally, directed by none other than Warren Weaver. At the suggestion of panelist Richard Courant, Weaver invited Mina Rees to join as a technical aide, and it was her work on the Applied Mathematics Panel that set the template for Rees's influential position brokering funding for both pure and applied mathematics at the Office of Naval Research after the war.[25]

The Applied Mathematics Panel and Office of Naval Research primarily sponsored research through a contract model. Academic mathematicians organized into research centers on broad topics like dynamics, differential equations, or statistics, with a small number of established researchers and a varyingly-sized and rotating cast of post-doctoral and doctoral student assistants. These would be assigned contracts centered on particular research questions formulated or refined by expert mathematicians on the Applied Mathematics Panel or consulting for the Office of Navel Research. Letters and reports from the War Policy Committee stressed

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[21] See Parshall, "A New Era," pp. 22-27. Transcripts of radio broadcasts frequently appear in the collected papers of leading mathematicians. See e.g. "Hart, William L. (Hart Committee)" folder, box 7; "Stone, Marshall H." folder, box 13; "War" folder, box 15, Morse Papers. For a recording, see Bennington P. Gill, "The Role of Science in War," WNYC radio broadcast at http://www.wnyc.org/story/bennington-p-gill/.

[22] July 21 1940, Stone to Dunham Jackson, "Stone, Marshall H." folder, box 13, Morse Papers.

[23] See folder 1561, box 127, series 200D, Record Group 1.1, Rockefeller Foundation Archives (hereafter Rockefeller AMS War Policy Committee dossier).

[24] Rees, "The Mathematical Sciences." Amy Shell-Gellasch, "Mina Rees and the Funding of the Mathematical Sciences," *The American Mathematical Monthly*, 2002, 109(10):873-889, on 875-876. See also Judy Green and Jeanne LaDuke, "Rees, Mina S." in *Pioneering Women in American Mathematics: The Pre-1940 PhD's* (Providence: American Mathematical Society, 2008), online supplementary material (www.ams.org, updated 2011).

[25] Shell-Gellasch, "Mina Rees," pp. 876-885.

the value of dividing labor between a small group of elite mathematicians capable of formulating problems for research and a much larger group of competent working mathematicians who could solve those mathematical problems.[26]

At the same time, leading mathematicians personally assumed military roles as advisors and technical experts, often arranging leaves from their academic posts in order to do so. Morse, again, sat near one extreme. As a technical expert for the U.S. Army's Ordnance Department he compiled, by his own count, some eighty reports on various aspects of bomb deployment. He consulted directly as well for the National Defense Research Committee that preceded the Office of Scientific Research and Development. For his efforts, the War Department cited him for "outstanding meritorious service … of great value to every branch of our Armed Forces and to Allied Nations."[27] Such service furnished Morse and those who played similar roles with privileged access to military and civilian government authorities by the war's end.

A Cold War of Mathematics

Total war provided the impetus for mathematicians to form close connections with U.S. Government funding infrastructures at an unprecedented scale, but it could not guarantee their continued support at the end of hostilities. Mathematicians who had learned to apply their theoretical expertise toward military problems during the war transitioned quickly to applying the military's willingness to finance applied research toward financing their theoretical projects. In many cases this happened through the continuation of wartime research groups, such as Solomon Lefschetz's ONR-sponsored differential equations project at Princeton. Initially receiving $25,000 annually, later reduced to $20,000, the project formally ran from 1946 to 1959 but traced its origins to Lefschetz's war work and contacts from 1942. The US Navy funded a considerable amount of departmental administrative and overhead costs, a weekly research seminar, occasional conferences, and salaries or subventions for established scholars, post-doctoral researchers, and fifteen graduate students who completed doctorates under the project. Lefschetz's summary report to the Navy made note of his group's mathematical findings, but it placed a particular emphasis on the personnel value of the Navy's support, particularly in developing the talents of younger scholars.[28]

Mathematicians during and after the war maintained that the potential future military usefulness of their present theoretical work could be significant but was hard to evaluate, and might not be manifest for some time. The promise of such research was enough to secure military sponsorship for a wide range of research and publication activities, including efforts

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[26] See reports in Rockefeller AMS War Policy Committee dossier.

[27] "Marston Morse - War Work, 1940-1946," folder 8, Records of the Office of the Director: Faculty Files, Box 24A, IAS Archives.

[28] Solomon Lefschetz, "Nonlinear Differential Equations and Nonlinear Oscillations," Final Report for Office of Naval Research Contract NONR-1858(04), Project NR043-942, August 15, 1946 - September 30, 1959, Lewis Library, Princeton University, Princeton, NJ, USA (hereafter Princeton Lewis Library). Lefschetz's report and project are discussed in David Aubin and Amy Dahan Dalmedico, "Writing the History of Dynamical Systems and Chaos: *Longue Durée* and Revolution, Disciplines and Cultures," *Historia Mathematica,* 2002, 29:1-67, on 19-20; Amy Dahan Dalmedico, "L'essor des Mathématiques Appliquées aux États-Unis: L'impact de la seconde guerre mondiale," *Revue d'histoire des* mathématiques, 1996, 2:149-213, on 187-188; Amy Dahan Dalmedico, "La renaissance des systèmes dynamiques aux États-Unis après la deuxième guerre mondiale: L'action de Solomon Lefschetz," *Supplemento ai Rendiconti del circolo matematico di Palermo,* ser. II, 1994, 34:133-166.

devoted to particular problems or theoretical programs.[29] While the future uses of present research were at best unclear, academic mathematicians could point to a more immediately manifest problem that they were distinctively positioned to solve: that of "manpower" or "scientific manpower." This felt shortage of qualified mathematical practitioners and instructors who could capitalize on the amply demonstrated usefulness of existing mathematical techniques thus became the subject of numerous reports and discussions. These stipulated the urgency of funding advanced research and education not primarily for its research output but for the reserve of skilled mathematicians it would make available in times of war. In particular, mathematicians argued for an aggressive remedy for the wartime hiatus in graduate education.[30]

This kind of advocacy for peacetime mobilization was a significant motive for the American Mathematical Society's decision in September of 1945 to convert the War Policy Committee to a longer-term Policy Committee for Mathematics. Like the War Policy Committee, the latter Policy Committee was financed by annual grants of a few thousand dollars from the Rockefeller Foundation.[31] It worked with other policy groups and advisory organs to advocate for the continued support of mathematical research and higher education under both civilian and military auspices. It did not, however, actively advocate for greater roles for mathematicians in the private sector, which figured into its discussions principally as a useful place where the reserve of potential military mathematicians could beneficially ply their trade in peacetime.

Like its predecessor, the Policy Committee mixed formal studies and analysis with the informal organization and cultivation of contacts that might facilitate funding for mathematics. Formal reports considered, for instance, how to structure a National Science Foundation or whether to re-establish an International Mathematical Union.[32] Both came to fruition in 1950. Informal contacts often worked in service of formal petitions for resources. Thus, members of the American Mathematical Society who had worked closely with Mina Rees on the Applied Mathematics Panel during the war turned to her after the War to help them win Office of Naval Research funding for a major project to translate Russian mathematical articles shortly thereafter, in 1948.[33] The project would use the infrastructure of the American Mathematical Society's largest publication undertaking to date, the *Mathematical Reviews* review journal launched during the war with backing from the Rockefeller Foundation and Carnegie Corporation.[34] An

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[29] E.g. Analytic Sheaves Seminar, Princeton University 1953-1954, Office of Ordnance Research, U.S. Army, Contract DA-36-034-ORD-1469RD, Princeton Lewis Library.

[30] Marhsall H. Stone, "Universal Military Service in Peacetime: A Statement by the American Mathematical Society and the Mathematical Association of America," *Science*, May 10, 1946, 103(2680):579-581. See also reports in Rockefeller AMS War Policy Committee dossier. Cf. David Kaiser, "Cold War requisitions, scientific manpower, and the production of American physicists after World War II," *Historical Studies in the Physical and Biological Sciences,* 2002, 33(1):131-159.

[31] Kline report, October 30, 1945, in Rockefeller AMS War Policy Committee dossier. See other reports in this folder. See also reports of the Policy Committee to the AMS Council and Rockefeller Foundation, folder 112, box 15, AMS Records.

[32] See reports in previous note. On NSF planning, see WT Martin to JR Kline, March 8, 1950, folder 33, box 36, AMS Records; on considerations of NSF funding prerogatives after its establishment see John von Neumann to AMS, March 13, 1951, folder 26, box 21, AMS Records.

[33] Negotiations and contracts are documented in folder 1, box 34, and folders 66 and 67, box 36, AMS Records.

[34] See Reingold, "Refugee Mathematicians," pp. 327-333; Reinhard Siegmund-Schultze, " 'Scientific Control' in Mathematical Reviewing and German-U.S.-American Relations between the Two World Wars," *Historia Mathematica*, 1994, 21:306-329; Siegmund-Schultze, "The Emancipation of

initial grant of $25,000 (later extended and augmented to $40,000) would pay for the translation of some 730 pages of Russian-language mathematics per year, with 150 copies of the translations furnished to the Navy for distribution and the remainder circulated directly by the American Mathematical Society. The grant also funded the production of a pamphlet of Russian technical terms and basic grammar, and included a small amount for executive and clerical overhead.

The Russian Translation project, unlike grants for conferences and research groups, was justified to its military sponsors as an efficient response to a problem in the availability of research. The project's backers insisted on the high quality of particular branches of Soviet mathematical research and its importance for advancing related research in the United States. The provision for three quarters of the printed translations included in the contract for Naval distribution suggests that at least some in the Navy agreed, although the range and military relevance of articles varied considerably and military relevance was not a stated criterion for choosing articles to translate. Here, funding mathematics could be posed as a direct response not to some potential future war need but to the immediate demands of the nascent Cold War. The advances of mathematics were, in themselves, a military prerogative.

This notion, of a military stake in mathematics as such, would find a later voice in other forums as well. Marston Morse advised the Air Force Office of Scientific Research in 1957, for instance, that "The Air Force cannot leave the job of supporting mathematics, which it has such a great stake in, to the whims of the National Science Foundation or any other such organization."[35] Morse and Marshall Stone were particularly vocal but joined by a large share of their academic colleagues in minimizing the distinction between pure and applied mathematics, a distinction that might make their own theoretical work seem less urgent as a funding priority. Rather, they emphasized "the lessons of the history of science and particularly the way mathematics has unexpectedly affected scientific theory."[36] Resources that were too specifically tailored toward any ends, concrete or otherwise, would only lead to a "gold-rush" toward well-funded areas and the production of "pseudo-mathematics" not driven by the discipline's internal values and processes.[37]

Arguments like these helped mathematicians justify directions of research that may have lacked immediate appeal to their Cold War sponsors, and indeed this was the case for many lines of inquiry. But the presence of such arguments indicates, at the same time, that worries over the influence of military and other funders persisted. The research of those ostensibly disconnected from Cold War prerogatives still subsisted in an environment whose personnel and publishing infrastructure depended heavily on military and other extra-academic support and was often

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Mathematical Research Publishing in the United States from German Dominance (1878-1945)," *Historia Mathematica*, 1997, 24:135-166, on 153-156.

[35] Morse to Mathematics Advisory Committee to the AFOSR (Bochner, Golstein, Stone, Walsh, Wilder), November 18, 1957, planning for a statement of policy to give to high officers on 13 December, "AFOSR" folder, box 1, Morse Papers.

[36] Morse to Dr. Merle M. Andrew, AFOSR, January 23, 1958 [recapping the December meeting], "AFOSR" folder, box 1, Morse Papers. On the broader context of this distinction in postwar mathematics, see Amy Dahan Dalmedico, "An image conflict in mathematics after 1945," in U. Bottazzini and A. Dahan Dalmedico (eds.), *Changing images in mathematics: from the French Revolution to the new millennium* (London: Routledge, 2001), pp. 223-253; Alma Steingart, *Conditional Inequalities: American Pure and Applied Mathematics, 1940-1975* (PhD Dissertation, Massachusetts Institute of Technology, 2013). On the corresponding distinction between "basic" and "applied" physics, see Forman, "Behind quantum electronics," esp. pp. 216-224.

[37] 18 December 1956 advisory council meeting minutes, "AFOSR" folder, box 1, Morse Papers.

more explicitly targeted to sponsors' goals. Even theories and practices without an obvious Cold War orientation in this period were significantly shaped by their funding milieux through the latter's effects on access to publications, pedagogical aims and resources, and other channels for the creation and propagation of mathematical knowledge. At the same time, American military and philanthropic sponsorship for broad programs of research made it socially, institutionally, and intellectually normal for mathematicians to work under those sponsors' auspices, so that mathematical researchers who did pursue more directed military, corporate, or other extra-academic research could do so from well within the mainstream of the profession. Even if all of mathematics did not bend to its Cold War sponsors' wills, those Cold War sponsors' wills nonetheless bent all of mathematics.

Funding an International Discipline

Although they were not acknowledged among the direct sponsors of the 1950 International Congress of Mathematicians, the military and civilian government offices that financed an increasing share of salaries, publications, equipment, and travel expenses for mathematicians after the war provided crucial indirect support for the undertaking. While a full accounting from individual grant files would be difficult, it is clear from those encountered in the course of my research that travel funds associated with fellowships and contracts supported the attendance of a significant share of American attendees and a non-trivial number of foreign ones as well. The Congress's organizers' wartime contacts and advocacy also substantially facilitated their other efforts to secure financial and other forms of support. Most immediately, the war helped the organizers to reinforce and expand interwar relationships with major philanthropic and other institutional sponsors who continued to supply the largest share of funds for the meeting. Such relationships with government officials, in particular, also positioned the organizers to seek logistical assistance from the U.S. Department of State for reaching and then facilitating the visits of foreign participants. Broader publicity efforts and wartime service, meanwhile, helped them build ties to commercial sponsors.

All but one of the Congress's "regular" pre-war donors had agreed after its postponement to continue their pledges until circumstances allowed the Congress to take place, and the two universities which had already contributed to a travel grant fund allowed the money to remain in trust. All told, the American Mathematical Society counted $30,250 in intact pledges and held a balance of $8,150 already paid.[38] Close to two thirds of the pledged funds, as noted above, came from the Rockefeller Foundation and Carnegie Corporation, the latter of which had increased its offering to $12,000 by the end of 1938.[39]

It was, in part, Warren Weaver's doubts about the Rockefeller Foundation's ability to extend its commitment without a formal reconsideration beyond 1950 that spurred the Congress's Emergency Committee, in 1946, to settle on a 1950 date and resume planning in earnest.[40] At the end of 1946, however, the financial outlook for the Congress looked considerably different. Where in 1938 the Committee on Invitation of Speakers projected a desired minimum of just some 30 travel grants of approximately $100 per person, the Emergency Committee's European informants now informed them that attendance would be all but

[38] Minutes, January 1, 1941, folder 42, box 15, AMS Records.
[39] Minutes, December 28, 1938, folder 11, box 15, AMS Records.
[40] Weaver to Hildebrandt, October 22, 1946, and Morse to Emergency Committee, undated, "ICM – Emergency Committee" folder, box 7, Morse Papers.

financially impossible without support from abroad for European delegates.[41] Before the war, foreign delegates (which meant in nearly every case European delegates) were expected to fund their attendance from a combination of personal resources, support from their home institutions and national scientific societies, and allowances for travel from North American institutions they might visit on either side of the Congress for lectures or other exchanges. This last source of support remained a considerable resource, but something would have to replace the first two sources.

Meanwhile, philanthropic enterprises including the Rockefeller and John Simon Guggenheim Foundations had, since the interwar period but accelerating after the war, vastly increased the integration of mathematicians from Latin America with the established institutions of North America and, to a lesser extent, Europe. They were joined after the war by the United Nations Educational, Cultural and Scientific Organization (UNESCO), which also supported mathematical liaisons to North Africa, South Asia, and other developing regions. With a combination of fellowships for scholars from the developing world to pursue doctorates or research abroad and a system of programs to provide technical assistance (including sponsoring medium-term visits from elite mathematicians) to the developing world, there was now a considerable number of mathematicians from beyond Europe and North America who could reasonably hope to attend the Congress. Many applied to these same organs for fellowships timed to put them in the right region of the United States at the right time, while others applied directly to the Congress for subventions.

As early as 1946, those closely tied to the Congress's organization had begun to discuss direct UNESCO support for international travel to the gathering.[42] Arnold Dresden wrote separately to family friend and UNESCO Deputy Director General Walter Laves, although it is unclear whether this made much difference.[43] UNESCO ultimately supplied $10,000 directly to the Congress to underwrite travel grants, and furnished a further $10,000 for participants in an organizing conference for a revived International Mathematical Union to take place in New York just before the Congress.[44] In sum, the Congress spent more than $24,000 to subsidize the travel of nearly a third of foreign participants directly. Individual grants ranged from $30 to $500, with most between $100 and $200, and accounted for between a third and a half of their recipients' travel costs.[45] While nearly four-fifths of these grants went to those "from war-devastated countries" in Europe, the funds aided those from eleven non-European countries as well, including several from the developing world (figure 2).[46]

Europe	$19,005

[41] Minutes, December 28, 1938, folder 11, box 15, AMS Records. Kline report sent to Weaver October 29, 1946, folder 1546, box 125, series 200D, Record Group 1.1, Rockefeller Foundation Archives.
[42] Richardson to Needham, June 18, 1946, and Morse to Needham, October 11, 1946, UNESCO 51 A06 (73) "50": International Congress of Mathematicians — USA 1950. The organizers' request was ultimately communicated in Birkhoff to Wang, November 10, 1948. News of the grant was communicated in Wang to Birkhoff, 18 October and 19 December, 1949.
[43] Dresden to Laves, March 11, 1949, UNESCO 51 A06 (73) "50".
[44] UNESCO NS/84 (Unesdoc 126553eb), pp. 69-70, 73-74.
[45] Figures documented in folder 15, box 36, AMS Records. Categories and totals in figure 2 are my own determinations from these data. $24,000 in 1950 has the buying power of over $230,000 in 2014 dollars. On travel grants for foreign delegates to later Congresses, cf. "NRC – Travel Grants" folders, box 9, Morse Papers.
[46] Quote from Wang to Birkhoff, 23 February, 1950, UNESCO 51 A06 (73) "50".

France, $4,600	
Great Britain, $3,900	
(West) Germany, $2,500	
Latin America	$2,040
Asia/Oceania	$1,810
Middle East	$1,400
Total	$24,255

Figure 2. Direct travel grants from the Congress by region.

Exceeding even that of direct travel subsidies, the Congress's largest single area of expenditure was to publish and distribute the proceedings.[47] This expense alone accounted for nearly a quarter of the Congress's final budget, with three quarters of that cost borne by the Carnegie Corporation and a large share of the rest anticipated from sales to libraries. A further eighth of the Congress's budget went toward housing foreign participants, and another eighth went to the secretariat and for legal expenses. The Congress's banquet and other miscellaneous expenses consumed the remainder of the budget.

Membership fees for participants dropped from about one third of the Congress's anticipated revenue for 1940 to around one fifth of its resources for 1950. Just over half of all revenues ultimately came from the philanthropic and institutional supporters which represented the main sources of sponsorship for mathematics between the World Wars.[48] UNESCO, born after World War 2, gave another $10,000, and a further $4,300 came from individual patrons who were not contributing on behalf of companies. The remainder, totaling more than $18,000, came from commercial sponsors ranging from Aetna Life Insurance to U.S. Steel and United Fruit (figure 3).

Philanthropies	$30,500	Companies by industry:	
Companies	$18,150	*Electrical, Computing, Telecom.*	*$6,100*
Academic Institutions	$11,650	*Insurance*	*$4,525*
Scientific Societies	$10,000	*Oil*	*$4,000*
UNESCO	$10,000	*Chemical*	*$1,600*
Private Individuals	$4,315	*Other*	*$1,925*

Figure 3. Donors to the Congress by category.

Commercial support for the Congress mirrored the "increasing mathematical requirements of government and industry" that one observer saw on display in the scientific program itself.[49] Some industries had greater requirements, and proved more central, than others. William Lloyd Garrison Williams, a Quaker born and trained in the United States but who made his career in Canada at McGill University, had found success courting insurance companies as a part of his central role in the founding of the Canadian Mathematical Congress.[50] As early as the

[47] Figures in this paragraph are from the budget in folder 140, box 15, AMS Records.
[48] Figures for contributions are from the enclosure in Kline to Warren Weaver, Feb 22, 1951, folder 1546, box 125, series 200D, Record Group 1.1, Rockefeller Foundation Archives. Categories and totals in figure 3 are my own determinations from these data.
[49] C. Raymond Adams in *Mathematical Reviews*, November 3, 1950, in folder 24, box 36, AMS Records.
[50] Testimony to Williams's organizational activities can be found in file 2634, Box 92, Record Group 2, McGill University Archives.

summer of 1946, he had raised similar prospects for the 1950 Congress, and he eventually served as vice chairman of the Congress's Financial Committee, making him the only mathematician at a non-U.S. institution on any of the organizational committees.[51] Telecommunications companies had a mixed but not insignificant record of financial support for the American Mathematical Society before the war. As employers of several institutionally influential mathematicians both before and after the war, they represented the largest category of commercial donors. The Standard Oil Development Company (a technical subsidiary with its origins in Rockefeller's oil monopoly) alone dwarfed all other single categories of contributors beyond the insurance and computing and telecommunications industries.

Conclusions: Follow the Money

The particular negotiations over funding that preceded the 1950 International Congress of Mathematicians were in many ways exceptional. The Congress was an unusual event of unusual scale, unusually timed and located in a region of the world that was only just becoming the crucial node in international mathematics that it has been since that period.[52] It depended far more on some sources, such as UNESCO, than was typical for the period, and on other sources, such as the United States Navy, much less than was typical for American mathematicians and their institutions. Its organizational history nevertheless brings to light important features of the postwar sponsorship of mathematics, both for Americans and across the broader institutional and political geographies of mathematical scholarship. In part, it bears upon this much wider field through its atypical scale, which ensured that the Congress abutted many figures and institutions of which it was not strictly representative. In part, the synchronic adaptations of the Congress's organizers tracked larger disciplinary, institutional, and geopolitical changes manifested in their own ways across the mid-century mathematical world.

Even where this organizational history is not explicitly about money, it centers on relationships and institutional formations shaped by the pursuit and allocation of financial resources. In this chapter, money offers an alternative to theoretical schools, famous treatises, and other ways of tracking a changing discipline, while at the same time bringing into focus different kinds of relationships amongst these latter elements. Following the money, in this way, can point to connections, problems, and tensions in other aspects of mathematics beyond its quotidian institutional organization. It is common, for instance, to allow that funding can affect the direction of one's research. But the negotiations discussed above suggest that not just research but significant aspects of the structure and identity of an entire discipline can be implicated in the pursuit and accommodation of sponsors. Historians have documented several such aspects—such as the relationship between pure and applied mathematics and the organizational consequences of contract and fellowship-based funding—but many more await definitive exploration.

The effects of such interactions can be far from neutral. Though I have only been able to hint at these here, a few bear special mention as avenues for further study. The predominance of military and philanthropic funders, for one, meant that a relatively small collection of socially

[51] "ICM – Emergency Committee" folder, box 7, Morse Papers.

[52] See Karen Hunger Parshall, " 'A New Era in the Development of Our Science': The American Mathematical Research Community, 1920-1950," preprint from the author, to appear in David E. Rowe and Wann-Sheng Horng (eds.), *A Delicate Balance: Global Perspectives on Innovation and Tradition in the History of Mathematics: A Festschrift in Honor of Joseph W. Dauben* (Basel: Birkhauser Verlag, 2014).

and institutionally well-connected men had a disproportionate influence on the prerogatives that governed access to resources. This shaped not just the fields that were studied and the institutions that grew and thrived, but also the socioeconomic, racial, and gender composition of a mathematics community that to this day struggles to achieve many desiderata of diversity. The 1950 Congress, for example, featured comparatively large delegations from parts of Latin America where UNESCO, the Rockefeller Foundation, and other sponsors were active. Its decentralized but top-down approach to soliciting institutional delegates, on the other hand, likely contributed to the comparative scarcity of women from such delegations.[53] In the closed world of mathematical sponsorship, it was easy for sponsors and recipients alike to maintain the conceit of universality and color-blindness while undeniably perpetuating gendered and otherwise segregating regimes of access and control. There were, of course, many exceptions to this pattern, and these too demand investigation and explanation.

Inquiries like these help us explore not just how mathematicians interact with public culture, but how public culture shapes mathematics—directly, profoundly, and in ways we might not otherwise recognize.

[53] The notable exception here is the delegation of the British Association for the Advancement of Science, whose four delegates included two women. One was the spouse of a male delegate, though an accomplished mathematician in her own right as well. Several British delegations included women, and Mary Cartwright figured in two formal delegations. Invitations to women's colleges in the United States were another source of female delegates.