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Institutionalized inequity in the USA: The case of postdoctoral researchers

Monica Gaughan[1,*] and Barry Bozeman[2]

[1]School of Human Evolution and Social Change, Arizona State University, PO Box 872402, Tempe, AZ, USA; [2]School of Public Affairs, Arizona State University, 411 N. Central Ave., Suite 480 Phoenix, AZ, USA

*Corresponding Author: monica.gaughan@gmail.com

Abstract

Coalitions of powerful higher education stakeholders, a weak federal government, controversial overlapping policy domains, and a vulnerable postdoctoral labor force combine to create exploitative conditions in the United States. Recent calls for postdoctoral reform are likely to fall by the wayside, just as they have for the last half century. We use several analytic tools to examine the situation: a thematic content analysis of National Academy of Science reports dating back to 1969, stakeholder analysis based on the content analysis, and an in-depth demographic assessment of the postdoctoral labor force. We use these data in concert with agenda-setting theory to explain why major change has not occurred, and is unlikely to occur in the future. We suggest that one way forward is for the federal government to engage in bureaucratic reforms, which are more politically insulated than the domains of science, education, immigration, and inclusion policies in the USA.

Key words: Keywords: postdoctoral researcher; stakeholder analysis; agenda setting theory; demographic diversity

1. Introduction

As with so many dynamics relating to the evolution of scientific institutions in the USA, the important changes in the composition of the US science work force had their genesis with the end of World War II and the rise of Vannevar Bush's (1945) post-war research policy plans (Zachary 1997). The scientific and technical demands of the war effort brought multidisciplinary scientific teams together in large scientifically and institutionally complex new ways (de Solla Price 1963; Rhodes 1986). The American Federal Government plays a central role in the organization and financing of scientific endeavor, whether through neoliberal or interventionist approaches (Berman 2014). Indeed, the postwar period has seen the development of complex innovation systems throughout the world that focus, in particular, on building scientific capacity through education, training, and skills development, all of which arguably constitute the most important components of innovation policies (Borrás and Edquist 2014). One of the significant outgrowths of the changed scientific landscape is the emergence and growth of the postdoctoral fellowship as a fundamental component of scientific education and career development in the sciences (Cantwell and Taylor 2015; Su 2013, 2014). In this paper, we focus on academic postdoctoral research.[1]

The National Academy of Science (NAS) has for many years tracked the issue (NAS, 1969, 1981, 2000, 2005, 2014), even if public officials and the public seem unaware of postdoctoral researchers. During the 1960s, postdoctoral research positions, then much less common, were prestigious and signaled that recipients had been anointed and were well on their way to successful scientific careers. Postdoctoral fellowships are increasingly used as way stations in the scientific career, neither imparting the advanced training for which they were devised, nor conferring advantage in establishing an independent research career (NAS 2014). They are associated with low salaries, sparse benefits, exploitation, and isolation (NAS 1969, 1981, 2000, 2005, 2014). All of this occurs against a political backdrop in the USA of eroding employment protections, increasing politicization of immigration, and backlash against diversification and inclusion.

The recent publication (2014) of another NAS report on the status of postdoctoral researchers in the USA was replete with critical analysis and commentary: concern about the nation's dependence on foreign born scientists and engineers, the misuse of the position as a cheap way to employ highly skilled labor, and the persistence of a system that contributes to gender, racial, and ethnic disparities in representation. The scant progress achieved in addressing the problems facing postdoctoral researchers presents two puzzles of interest to us. The first puzzle is why is it that the problems associated with postdoctoral research persist despite half a century of analyses and recommendations presented over decades by professional associations, the NAS and federal science policy agencies? The second puzzle is if no sweeping reforms are likely regarding postdoctoral policy, then are there any incremental steps that could alleviate the problems? Our study focuses on both puzzles, the 'how we got to this point with so little reform?' puzzle and the 'what can we possibly do about it now?' puzzle.

There are many types of analysis in the social sciences; in this article, we present three, each with its own method and unit of analysis: content analysis of NAS reports, stakeholder analysis of interested groups, and demographic analysis of the postdoctoral labor force. Each of these approaches provides a unique perspective on postdoctoral scholars, which together provide insight into why the problems are so persistent, and suggest ways forward. Rather than present a single methodology section, we describe how we approached data collection and analysis at the beginning of each section. We begin with a thematic content analysis of nearly 50 years of policy recommendations related to postdoctoral researchers to elucidate the major institutional actors and policy problems. Using the stakeholders identified in the content analysis, we conduct a stakeholder analysis to evaluate how the interests of the federal government, universities, principal investigators (PIs), and postdoctoral researchers converge and diverge to create disparate interests in the system. We then analyze demographic trends in the population of US postdoctoral researchers since 1973, paying particular attention to intersections of gender, race, ethnicity and foreign-born statuses not usually analyzed together. Drawing from all three of these methodological and analytic approaches, we use agenda-setting theory (Baumgartner and Jones 1993; Cobb 1983; Kingdon 1995) to argue that there are good reasons why the postdoctoral policy issue has had little resonance to date. Postdoctoral policy issues have few of the characteristics predicting serious political attention and many structural factors explaining policy inertia. We conclude with policy recommendations to augment those made by other bodies; we stress federal bureaucratic rulemaking as an approach that may succeed incrementally, particularly during a time of increased politicization of national science, immigration, education, and diversity policies.

2. Half a century of NAS studies

The US Congress created the NAS in 1863 to 'investigate, examine, experiment, and report on any subject of science.' Since its establishment during the Civil War, the academy has expanded, incorporating the National Research Council (1916), the National Academy of Engineering (1964), and the Institute of Medicine (1970).

Although chartered by Congress, the NAS provides independent advice, undertaking hundreds of reports each year by thousands of independent scientific professionals with the support of hundreds of professional scientists employed by NAS. A typical NAS committee will include a dozen independent experts, with NAS professional support of three to five people. As such, they are not political documents *per se*, although arriving at scientific consensus is a contested process, and the result tends to be conservative findings and recommendations insofar as they reflect the consensus views of a variety of experts at a specific point in time.

In this section, we use thematic content analysis (Bernard 2006; Kuckartz 2014) to study the body of policy documents to elucidate some of the primary dynamics of the postdoctoral training system. For this analytic approach, the units of analysis are reports and recommendations. We chose specifically to focus on those NAS reports that included 'postdoctoral' in the title. We note there are dozens of other reports by NAS addressing the early career period of scientific training, many of which also include discussion of the postdoctoral research period. We analyze the five reports distinguished by their predominant focus on the postdoctoral period, including a 2005 report that focused on international students and scholars, with extensive treatment of the postdoctoral period. We selected and coded six themes common across reports focusing on postdoctoral researchers: primary purpose, time limits, remuneration, accountability, data, and demographic composition. The primary purpose and time limits themes come directly from the 2014 definition, with the goal of assessing the extent to which these were addressed in each report. We identified remuneration as a theme because of (relatively) recent work by the National Institutes of Health to increase and standardize remuneration; although NIH policy applies only to postdoctoral positions it funds, other institutions look to NIH for guidance (NPA 2017). The National Postdoctoral Association has been a steady advocate for accountability by institutions as employers, so we were interested to see how far back this type of issue appeared in the reports. Finally, the following editorial comment, in bold, in the recommendation section of the 2014 report: 'this recommendation on data collection has been made many times before with little effect (p. 74)' led us to inquire as to just how far back the recommendation for greater NSF data collection efforts had been made. Coding was based on critical reading of the reports combined with keyword searches of the documents by the first author. Table 1 presents an overview of major recommendations and findings based on our thematic codes; we elaborate with illustrative quotes below.

We first address definitional issues related to the postdoctoral researcher[2]: the NAS (2014) report on the postdoctoral experience provides a consensus definition:

> By the mid-2000s, the need to formalize a definition of the postdoctoral researcher arose. The NIH, NSF, Association of American Medical Colleges, and the National Postdoctoral Association all developed definitions. All converge on three basic aspects: (1) prior completion of a doctoral degree; (2) a primary focus on advanced research training (that includes publications, grants, and professional networking); and (3) a fixed term of appointment. (NAS 2014: 20–21)

Note that the current definition differs little from that presented in the 1969 report:

> Appointments of a temporary nature at the postdoctoral level that are intended to offer an opportunity for continued education and experience in research, usually, though not necessarily, under the supervision of a senior mentor. (NAS 1969: 42).

We found that the primary purpose of the postdoctoral research position has always been conceptualized as a form of advanced training in preparation for an independent research career. Each of the reports acknowledges in its findings (and increasingly over the time period) that postdoctoral positions are often used as a temporary holding position while awaiting permanent employment, as well as a way for universities to maintain inexpensive scientific labor practices not considered to be consistent with the purpose of such a position. For example, the 1969 report warns:

> When the training aspect is ignored or neglected the experience may not be as useful for the postdoctoral and for his subsequent employer as it could be: The origin of the difficulties lies in the indirectness of the support of much postdoctoral activity, both by the federal agencies and by the universities. (NAS 1969: 243).

The 2014 report is more direct:

> In general, the practice of employing postdoctoral researchers, with little mentoring and little hope of moving into a career that requires advanced research training, is becoming more common. The mentored training aspect of a postdoctoral researcher's

Table 1. NAS report findings and recommendations.

	1969	1981	2000	2005	2014
Primary purpose	Education and experience in research	Strengthening research potential	Broaden and deepen research skills	Deepen research training	Mentored advanced training in research
Time limits	2 years	2 years	5 years	Temporary	5 years
Remuneration	No recommendation	$22,500 recommendation	$26,256 NIH benchmark	No recommendation	$50,000 NIH benchmark
Accountability	Federal and University	Federal and University	Federal and University	Federal and University	Federal and University
Data	NSF	NSF	NSF	NSF	NSF
Demographic	Focus on men	Lacking diversity	Majority foreign-born	Majority foreign-born	Majority foreign-born

> experience can be inconsistent and often inadequate. (NAS 2014: 68).

The reports are consistent in their identification of the primary purpose, and each identifies inconsistencies in application that lead to erosion of the primary purpose of advanced research training. We return to the issue of accountability in the stakeholder section.

Postdoctoral research positions started with the idea that they would last one or at most two years, lengths reflected in the 1969 and 1981 reports. By the year 2000, a consensus had emerged that the postdoctoral period should not extend beyond 5 years, inclusive of all appointments. Despite the consistent recommendations, research has shown that both the length and frequency of postdoctoral terms have been increasing (Stephan and Ma 2005), and that the postdoctoral researcher position confers limited career advantages (Su 2011, 2013, 2014). These problems with the early career period are not unique to the American system: European scholars have characterized 'the postdoctoral phase is a bottleneck in the system,' noting many of the same problems (Huisman et al. 2002: 154). In short, despite half a century of recommendations, there continues to be significant increases in the length of time and transience of such positions. The 2014 report attributes this to the use of postdoctoral researchers to staff labs, and inadequate labor market demand:

> The practice of hiring postdoctoral researchers to staff laboratories has created a situation where the number of postdoctoral researchers is out of equilibrium with the number of available positions that require advanced training. (NAS 2014: 69).

We return to the issue of mismatches in interest in the next section on stakeholder analysis.

Although there has been universal agreement across reports that these positions are by definition temporary, there has been increasing recognition over time that postdoctoral researchers should be treated as normal employees for the purpose of salaries and benefits (NAS 1981, 2000, 2014). This consistent—and as yet, not universally adopted—recommendation dating back to the 1981 report must seem quite odd to our colleagues in systems with stronger national social insurance. In the USA, externally funded postdoctoral researchers[3] have traditionally been classified as trainees; hence, they and their universities are exempt from national labor and social insurance laws. In the USA, where employers confer social insurance benefits, such exclusions mean that students and trainees of any kind are often excluded from the kinds of social benefits that derive from citizenship or residence in many other national systems. A recent analysis by the National Postdoctoral Association (2017) found uneven access to health insurance by postdoctoral researchers—even within the same university—with many postdoctoral researchers offered student health plans, with no health coverage for family members.[4] There has been limited progress on the salary issue, most notably by the National Institutes of Health setting a goal of $50,000,[5] but consistent treatment of postdoctoral researchers as employees remains decentralized, inconsistent, and inadequate throughout the US innovation system. Others have found that foreign postdoctoral scholars have weaker professional social networks, and have to rely on *ad hoc* job placement arrangements to a greater extent, than their native-born colleagues, suggesting that they are particularly vulnerable to lack of institutionalized employment practices (Wei et al. 2012).

Nearly 50 years after the first NAS report (1969) recommended a data system that would allow formal study of postdoctoral researchers the task remains unrealized (NAS 2014). The National Science Foundation does not report data in a way that allows direct comparison with general population dynamics, a significant shortcoming.[6] Stephan et al. (2013) also note the lack of data about postdoctoral researchers in the European system. Note that the need for a federally organized system of counting has been present in recommendations since the 1969 report. For decades now, the federal government has been identified as the appropriate authority to take leadership on data.

To summarize, half a century of NAS reports have stipulated that the primary purpose of postdoctoral positions is temporary research training while simultaneously documenting the increasing amount of time spent in such positions. The dependence on foreign-born scientific talent was noted as early as 1969, and has only increased over time, as have the documentation of worker exploitation and insecurity. The 2014 report summarizes the situation well:

> Postdoctoral researchers at many institutions continue to lack adequate mentoring, recognition, status, and benefits. Many institutions do not have a coherent set of policies, practices, and procedures for postdoctoral researchers that are equivalent to those available for students, faculty, or staff. (p. 68)

One of our primary objectives is to understand how such a situation continues to worsen, so we turn now to stakeholder analysis to elucidate the key policy actors in this domain.

3. Understanding policy change via stakeholder analysis

We rely on the NAS reports just reviewed to identify our stakeholders, with a particular debt to the 2000 report that identified the locus of responsibility as shared among postdoctoral researchers, advisors, institutions, and funding agencies. Stakeholder analysis examines the dynamics of multiple actors in a policy system engaging in a variety of activities over a long period of time (Weible 2007). Stakeholder analysis examines the dynamics of multiple

interconnected actors in a social system, including public policy systems (Brugha and Varvasovszky 2000; Bryson 2004). At its core, stakeholder analysis points to the distribution of power among actors, and hence their likelihood of being able to affect change in the policy system (World Bank, n.d.). Most uses of stakeholder analysis, especially in policy analysis and public administration, are advocacy oriented, seeking ways to facilitate choice in the context of complex and often contested policy options. The approach we use here is more exploratory in its goals than advocacy-focused. We are not so much interested in identifying coalition partners and common interests as in simply describing stakeholders to understand policy complexities related to stakeholders in policies about postdoctoral researchers. We start our stakeholder analysis at the macro-level, the US federal government.

3.1 Federal government as stakeholder

Despite its contested status in the USA, the federal government[7] is the most powerful stakeholder in this policy domain, as it is responsible for funding the majority of research in US universities. The federal science bureaucracy established in powerful executive cabinet agencies is the primary means of implementing this federal power in science policy. The federal government funds the majority of postdoctoral researchers, either directly through external funding, or indirectly through internal grants-funded research and subsidization of American research universities (NPA 2017). Furthermore, as Stephan et al. (2013) noted, visa concerns are central for the decision of foreign-born scholars to come to the USA; immigration is also amenable to federal policy making.

A lack of transparency and accountability on the part of grants-funded postdoctoral positions (e.g., internally funded positions) has been identified as a significant problem in the system of postdoctoral fellowship training in the USA (NIGMS 2011). Given the powerful financial incentives universities have historically enjoyed to maintain temporary workers, it hardly seems reasonable to expect independent progressive labor action on their parts: Universities potentially have a lot to lose from greater federal involvement in their internal personnel affairs (like any other organization). Similar dynamics have been noted in other science systems (Huisman et al. 2002; Stephan et al. 2013). The earliest NAS reports called for greater accountability in the postdoctoral training system at the level of universities. By the 2000s, however, policy documents were much more likely to place ultimate authority with the federal government through the science policy bureaucracy, with responsibility delegated to universities. This makes sense since most of the money comes from the federal government in any case, and a uniform approach makes sense on both efficiency and equity grounds.

Of particular relevance most recently, immigration policy—including highly skilled immigration—is a hotly contested issue in developed economies in general, and in the United States in particular. It is difficult to disentangle highly skilled immigration from the scientific labor force in the USA. Indeed, the vitality of whole areas of American science is related to the success of foreign-born scientists (Walsh 2015), and the development and maintenance of scientific capacity in innovation systems is significantly grounded in migration policies (Borrás and Edquist 2014). Therefore, making the federal government a central locus is crucial to any future postdoctoral reforms.

3.2 Universities as stakeholders

Modern research universities face a variety of financial pressures, forcing them to become creative in assembling diverse funding portfolios. We would argue that no part of funding diversification is more important to a university than developing the capacity to receive research money from the federal funding establishment. What universities have are the personnel and facilities central to the scientific enterprise, and what the federal government has is research funding. Together, these dynamics support the interpretation that resource dependence, especially on the federal government, fosters organizational strategies that stimulate demand for postdoctoral researchers (Cantwell and Taylor 2015). To state the obvious, without the university, there is no such thing as an academic postdoctoral researcher, just as there is no such thing as a professor or a tenure committee. As with other types of organizations, universities have to perform the same functions that any other employer performs, while having additional functions that are unique to the academic enterprise.

In the USA, the provision of benefits such as sick leave, vacation, and family leave are traditionally at the discretion of the employer. Because benefits constitute large operating expenses for any organization, universities—like other organizations in the United States—create as many exempt labor categories as possible. Viewed in this light, the decline in tenured and tenure track jobs and the rise in contingent academic labor make perfect sense: part-time, temporary, and adjunct employees minimize the university's short, medium, and long-term obligations to expensive social insurance benefits. Because postdoctoral researchers are traditionally classified in exempt employee categories, it is not surprising that poor pay, few social benefits, and minimal rights have characterized their employment for decades.

Postdoctoral researchers are temporary, cheap, and do not require expensive benefits. In this way, postdoctoral researchers occupy similar positions as graduate students, whereby educational decentralization results in departmental autonomy and individual control over the researcher's future (Fox 2000).

Any extension of rights to postdoctoral researchers as employees will have direct and negative effects on universities by increasing their administrative and personnel costs. Rather than the net benefit of overhead return currently enjoyed by the universities, a system in which they had greater accountability would require that overhead return actually be converted into meaningful benefits to the postdoctoral researchers. In fairness, many universities that are members of the National Postdoctoral Association are already doing this. The fact remains that the recommendation of the most recent NAS (2014) that universities follow such best practices is advisory only—there is no enforcement mechanism. Today's training path differs little from the system established decades ago. By and large, the system manifests the same structure, composition, personnel and incentive structures as those identified in the 1960s (NAS 1969). Some continue to place primary responsibility with the universities.

A prominent study of biochemists and mathematicians by Nerad and Cerny (1999) placed responsibility for creating institutional structures for postdoctoral deployment at the university level. The policy mechanisms they recommended—time limits, fostering postdoctoral community and professional resources, having designated administrative leadership—have also been forwarded by the National Postdoctoral Association (2014, 2017). Whether one conceptualizes the universities as having primary authority or delegated authority, it is clear that they are a key stakeholder in the system. Ultimately, universities already engage in a wide variety of labor-force-related accountability, so the addition of postdoctoral researchers would not constitute a novel set of demands.

3.3 PIs as stakeholders

Professors sponsor and supervise academic postdoctoral researchers primarily through traineeships and research project grants.

Traineeships are funded with the expectation on the part of the funder that the training is appropriate to the needs of the postdoctoral researcher's professional development (NIGMS 2011; NIH 2012). In contrast, postdoctoral researchers funded by research project grants are hired to help the PI perform his or her research project; the professional development of the postdoctoral researcher is secondary to this primary goal (Müller 2014). The majority of postdoctoral fellowships—like those of graduate research assistantships—is funded through the postdoctoral supervisor's research grants (NIGMS 2011; NSF 2000). Increasingly, universities require that PIs pay the tuition of their graduate students; this creates a powerful financial incentive to use personnel funds to hire better trained postdoctoral researchers (Stephan 2012), and in the case of the foreign born, at lower wages (Stephan et al. 2013). This tension—between the interests of postdoctoral researchers and their supervisors—was noted as early as the 1969 report:

> Grants and contracts in support of research at universities should be consciously given with the purpose of achieving simultaneously both the research objectives [of the PI] and the training of postdoctorals. (NAS 1969: 244).

That many of postdoctoral researchers nevertheless receive valuable advanced training is highly likely, but it is worth noting that a system of accountability for such training is in its very earliest stages of implementation (NIGMS 2011; NIH 2012).

Fox (1998, 2000) has commented extensively on the 'privatization' of advisor–advisee relationships through decentralization and lack of organizational oversight; although her work focuses on doctoral training, her observations also apply to the advisor–postdoctoral researcher relationship as well. Recent research determined the importance of postdoctoral advisor quality, mentoring behavior, and fostering research independence in reducing dissatisfaction among postdoctoral researchers (Miller and Feldman 2015; Wei et al. 2012). Cantwell and Taylor (2015) concluded that the individuals involved—postdoctoral scholars and faculty members alike—operate in a federal research economy mediated by their universities, and over which the individuals have limited opportunities for agency. Many professors are outstanding mentors and supervisors to their postdoctoral researchers, irrespective of the source of funding; our purpose in this section is to illuminate the ways in which the interests of principal-investigators and postdoctoral researchers diverge.

3.4 Postdoctoral researchers as stakeholders

At any given point of time, postdoctoral researchers are the key stakeholders in the system. The decision to complete a postdoctoral position is a complex one, and likely a mix of motivations such as advanced training in scientific research, and queuing to wait for a permanent position to open (Stephan and Ma 2005). The temporary nature of the position makes them the least powerful of all the stakeholders, and there are significant forces at work related to immigration status that make it highly unlikely that postdoctoral researchers as a whole would constitute a major threat to the status quo.

Research indicates that the USA remains a particularly attractive location for advanced scientific training; for many, the ability to emigrate for science was the strongest motivation: having completed rigorous scientific training in their home countries, these early career researchers perceived the USA as providing the best support for science and research (Stephan et al. 2013). In the European Union, such training presses postdoctoral trainees into narrowly defined ideas about scientific productivity (Fochler et al. 2016), a dynamic also likely to be present in the United States postdoctoral experience.

Furthermore, postdoctoral researcher supervisors may also use the postdoctoral researchers to perform the teaching functions of the supervisors (Müller 2014), another exploitive dynamic likely to be at play in the USA. There is evidence that postdoctoral scholars—and in particular foreign-born postdoctoral scholars—receive less formal job advising and matching, reflective of the lack of administrative control over this category of employee (Wei et al. 2012). Given the current state of immigration policy in the USA, the postdoctoral position is the easiest way for a foreign-born scholar to immigrate to the USA for such a purpose (Stephan and Ma 2005). These highly trained, highly skilled individuals nevertheless encounter extremely complex scientific knowledge systems and highly politicized environments for which they have no particular knowledge, training, or experience (Ackers 2008). The entire landscape of postdoctoral researchers as a group is shaped by national immigration, education, and labor policies that together often left postdoctoral researchers with low pay and limited benefits (Stephan et al. 2013).

In recent years, postdoctoral researchers have started to organize, and to have their own professional association, the National Postdoctoral Association (National Postdoctoral Association 2014). Recent scholarship on unionization of postdoctoral researchers in the University of California system underscored the vulnerability of such knowledge workers in the neoliberal university (Camacho and Rhoads 2015). Despite such unionization efforts, we argue it is imperative that the difficult task of negotiation and advocacy occur at the institutional and governmental levels: postdoctoral researchers—like other 'at will' employees—cannot be expected to negotiate the conditions of their employment individually. They are in temporary positions, and they need to maintain the good will of their postdoctoral supervisors to obtain a permanent position. Furthermore, the majority of postdoctoral researchers are foreign born, and dependent on their universities to sponsor their visas. Although postdoctoral researchers are the stakeholders with the most interest in the problem, they are also the most numerous, least powerful and most vulnerable ones. What are exploitive wages and working conditions in the USA may be generous compared to those in the postdoctoral researcher's country of origin.

3.5 Multiple stakeholders, many interests

There are many major stakeholders trying to accommodate what are, at their heart, major limitations of the US federal government to confront basic general social problems in the following policy domains: immigration, education, and labor. From this perspective, the intractability of the problems related to postdoctoral education are generated by political processes requiring creative approaches to accommodate, and general dynamics related to self-interest at the level of individual actors, universities, and federal agencies that lead to a tragedy of the commons problem whereby the problems continued to increase for decades. It is not only a narrowly defined professional training problem, but also one that encompasses a number of cultural, policy and political issues that make it a particularly intractable problem. Although the stakes are quite high overall, they are not particularly salient to any agency or to the public at large; furthermore, the fragmented nature of the system means that no single stakeholder emerges for sustained or collective action.

One of the primary problems that erodes ability to respond to identified problems in the postdoctoral training system is that

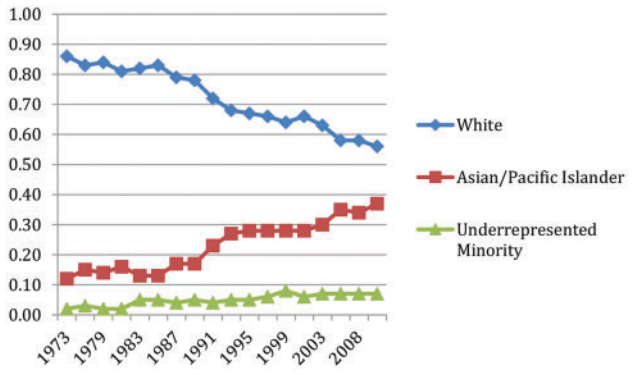

Figure 1. Postdoctoral researchers by race and ethnicity, 1973–2010. Figure is calculated from Appendix Tables 5–16, Science and Engineering Indicators (NSB 2014).

everyone benefits to some extent, and the costs are short-term and distributed. The beneficiaries include: (1) ordinary citizens interested in the economic productivity gains from the US National Innovation System and who enjoy the investments made from low-wage scientific and technical talent from all over the world; (2) federal agencies that can extend their human resources-intensive budgets by paying a larger number of contributors from science funds; (3) universities that have yet another category of contingent workers making high-productivity contributions; and (4) PIs who increase their research capacity by employing low-wage, high-productivity labor. There are even benefits to postdoctoral researchers from the current system, as noted in numerous NAS reports—it is a way to wait for a position to open up, to balance work and family needs, to immigrate to the USA, and to make a (relatively) higher wage than in a home country. It is worth noting, however, that none of these benefits is particularly consistent with the primary purpose of the postdoctoral research position: to provide advanced research training necessary for assuming the next scientific position. Indeed, the primary benefit is to create another large contingent labor force sector of the economy. For those who are members of that labor force, the costs are temporary (albeit not optimally temporary) while the benefits are potentially quite large. In the next section, we take an in-depth view of this population, which is much more diverse than the general US population.

4. Population dynamics, diversity, and inclusion in US society

In this section, we rely on demographic analysis employing extant data series to evaluate the population dynamics of postdoctoral researchers. In this section, the unit of analysis is the population composition of the postdoctoral population over time. For all calculations presented here, we use NSF's definition of STEM disciplines, which includes physical and life sciences, engineering, and social sciences. Recall that one of the universal recommendations of the NAS reports is the need for an integrated data-system on postdoctoral researchers maintained by the National Science Foundation. We faced the same types of data problems that the NAS study committees did, relying on diverse sources of original data to assemble a picture of postdoctoral population dynamics. We decompose the population trends by bringing together disparate appended data series collected by the National Science Foundation (NSB 2004, 2010, 2014). NSF typically presents[8] information about scientists by gender or by race/ethnicity, or by foreign-born status. Furthermore, NSF tends to report aggregated statistics about members of racial and ethnic group, and the foreign-born in ways that mask important differences stemming from the intersection of ethnicity and nativity. Our analysis endeavors to tease out some of the heterogeneity within these categories, and to compare them to larger US population dynamics. Our approach provides a new perspective on how postdoctoral dynamics relate to foreign-born, gender, racial and ethnic dynamics in the US scientific workforce.

The USA has a dynamic population with rapidly increasing numbers and proportions of traditionally under-represented racial and ethnic groups, a large and growing foreign-born population, and very high levels of women's labor force participation. Because of rapid population change, we focused on the racial, ethnic, and nativity distribution of the US population for the ages 25–39—the age of individuals most likely to occupy a postdoctoral position. In this age group, Non-Hispanic Whites comprised less than 60% of the population, members of under-represented racial and ethnic groups comprised over one-third,[9] and Asians comprised 6%. The majority of Americans—80%—were native born, while 6% were naturalized citizens and 14% were not US citizens (US Census 2010, 2012).[10] We use this demographic backdrop—in which whites constituted a slight majority, members of domestic minority groups comprised over one-third, and in which one in five persons was foreign born—to look at how the postdoctoral population composition compared.

In 1973, women occupied 15% of postdoctoral positions, attaining a stable representation hovering around 40% in the new millennium (NSF 2013). This is on par with the percentage of women earning PhDs in 2010. Figure 1 shows the racial and ethnic distribution of US-trained postdoctoral researchers from 1973 to 2010 (NSB 2014). Although members of under- represented minority groups occupy 7% of all academic postdoctoral positions (up from 1% in 1973), this percentage stands in stark contrast to the 35% of the US population that was comprised of members of such groups at the last Census (US Census 2010).

While the decennial US Census does not collect data about citizenship, many other Census Bureau instruments, such as the Current Population Survey, do.

Asians—who comprise 6% of the population age group—started the series in 1973 comprising 12% of the postdoctoral population, but represented 37% by 2010—over six times their general population representation (NSB 2004, 2010). This figure illustrates the continuing and profound lag in incorporating members of domestic minority groups into STEM, and US immigration policy, which favors the STEM educated (Wasem 2012).

Figure 2 presents a somewhat shorter data series of postdoctoral researchers by nativity between 1977 and 2006. General population data reveal a general population that is 20% foreign born and 80% native-born citizens. Unfortunately, NSF collapses these categories in ways that obfuscate rather than clarify. Permanent residents are foreign-born people who are citizens of another country; NSF combined citizens with permanent residents in its data series. Therefore, it is not possible to discern from these data the representation of citizens (whether native born or naturalized citizens) was among postdoctoral researchers. We decided to treat the NSF estimate as a conservative test of domestic representation in postdoctoral positions (combining, as it does, permanent residents with citizens): Citizens comprised 86% of all Americans in this age group, but only 43% of postdoctoral positions were held by citizens or permanent residents. Another conservative test was to evaluate the non-citizen trend. According to the Census Bureau, 14% of Americans are not

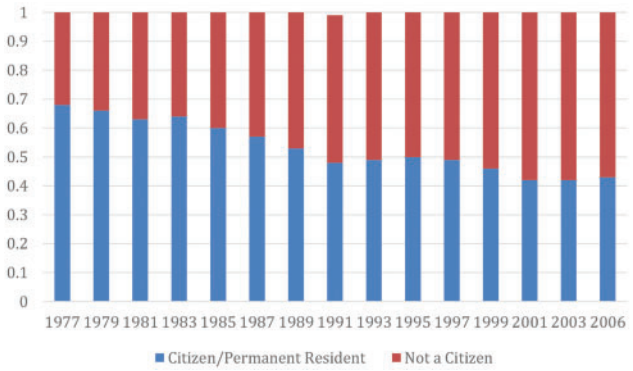

Figure 2. Postdoctoral researchers by nativity, 1977–2006. Figure is calculated from Appendix Tables 2–30, Science and Engineering Indicators (NSB 2004) and Appendix Tables 2–32, Science and Engineering Indicators (NSB 2010).

citizens (the majority of whom have not earned PhDs). This is in contrast to the 57% of postdoctoral positions occupied by non-citizens—a figure that would have been even higher if permanent residents (who also are not citizens) are excluded from the citizen trend. This dependence on the foreign-born has been noted in each of the NAS reports studied in this research, and is the primary focus of the 2005 report.

To summarize, the demographic characteristics of the postdoctoral population in the USA diverge substantially from that of the general population, and diverge in ways that touch upon policy issues well beyond science policy. Under-representation on the part of domestic minority groups mirrors that affecting higher education as a whole, and reflects failures in the social and educational policy systems of the nation. At the same time, over-representation on the part of the foreign-born suggest problems in immigration and employment policy.

Together—members of domestic minority groups and the foreign-born—represent politically weak and vulnerable stakeholders in a complex policy system. Therefore, demographic shifts in the composition of postdoctoral researchers toward marginalized groups is likely to increase the difficulty with which policy makers can address postdoctoral policy reform.

5. Agenda-setting theory and the fate of fragmented problems

In this article, we have documented the longstanding problem of the status of the postdoctoral researcher in the American science system. We now turn to the question, why is it that these problems remain at the cusp of policy agendas, without ever quite making it to policy action?

According to agenda-setting theory, policy change often occurs because of 'focusing events' (Birkland 1998: 53). Another way of thinking about this is policy-making by crisis (Boin 2009). Especially in the less visible policy problems, it is often important to have accompanying changes in indicators (Kingdon 1995) designed to provide data or statistical analysis, or sometimes just cogent and systematic stories; elite constituencies can use these to advance the problem to the policy agenda and to action.

In the case of postdoctoral researcher policies, there has been no focusing event sufficient to precipitate intensive policy action and reform, and as already demonstrated, limitations in the coverage of the data available to make the case for reform. The various policy reports that have been promulgated for the past half century cited general problems for the health and well-being of science rather than specific and immediate impacts from crises, impacts that policy elites and the general public tend to care about. Most postdoctoral policy analyses provide diverse indicators, but these usually fall on fallow ground in the absence of strong constituencies to make use of them.

The agenda-setting literature (Portz 1996) tells us that predictors of problems moving to agendas include strong political sponsorship. Under this criterion, the postdoctoral researcher problem is not a strong candidate. Clearly, this set of issues has no strong sponsorship, but why? The first problem, quite simply, is that it is often thought of as in the realm of science policy (this despite the fact that our analysis demonstrates that it entails many policy areas). By nearly every indicator, science policy has few champions compared to policy domains such as defense, national security, social welfare, public health and immigration. If one needs evidence of this, we can consider that the Presidential science advisor position would not make anyone's list of top 100 influential people in Washington (Katz 1978; Pielke and Klein 2009). Science- related committees in Congress are not considered plum assignments by anyone and less senior legislators disproportionately occupy them (Krehbiel 1990). Nor is the public engaged in many science policy issues, excepting perhaps those related to medicine and public health (Miller 2004).

Another well-known predictor of problems proceeding to policy agendas is media attention and the resultant publicity provided, publicity often reaching policy elites (McCombs and Shaw 1972; McCombs 2013; Wolfe et al. 2013). Here, again, the postdoctoral researcher problem falls short. In the first place, the issues, because of the fragmentation, are difficult to sort out and lend no easy message and relatively few obvious story 'hooks'. In general, science policy receives short shrift but when the issue is inputs to science rather than either accomplishments or disasters, there is little likelihood of media attention, at least not beyond the highly specialized science press.

A crucially important factor inhibiting the uptake of a reform agenda is that policy issues for postdoctoral researchers are fragmented, cutting across several policy actors and jurisdictions. Postdoctoral policy problems relate, as we note above, not only to STEM careers and scientific and technical productivity but also to universities and higher education policies, labor policy, and immigration policy. Each policy domain and each constituency includes officials who well understand the problems presented by postdoctoral research policies. The respective officials realize that the problems within their domains are significant and, in many cases, getting worse. However, from the perspective of the participants in varied policy domains and policy institutions, the postdoctoral researcher problems suffered in their own policy domains, while significant, are not generally as great as other pressing problems. Administrators in universities worry about postdoctoral researchers, but they also must worry about declining budgets, demographic shifts and crumbling infrastructure. People in immigration policy may be well aware of the various visa issues of postdoctoral researchers, but they face far more pressing political concerns in the current national climate.

Funding agencies are very much in touch with postdoctoral researcher problems, but they also focus on managing Congressional hostility to many of their programs. As a result, the postdoctoral researcher policy problem, ever with us, never gets to the top of anyone's priority list.

6. Moving toward reform of postdoctoral researcher training

In most papers identifying social problems or policy problems in need of remedy, the concluding section presents a call to action, urging policy-makers to attend to the problems identified in the paper by passing or implementing legislation or changing bureaucratic regulations or procedures. We do not stray far from this path. However, in these conclusions we try to keep in mind the arguments we have just made. Namely, the postdoctoral researcher issue has been in need of attention for decades; not much has happened beyond renewed attempts to stimulate policy change for a worsening problem; those who have the capacity to act are attending to problems they see as more critical to their interests; and the status quo provides little immediate threat to any of the major stakeholders. In light of this state of affairs, what can we urge that is potentially beneficial but also feasible?

Before articulating our suggestions let us briefly note an underlying assumption: We do not think that there is much likelihood, absent some unimaginable crisis, that Congress or any President will suddenly take up the cause of STEM human resources, much less the specific plight of postdoctoral researchers. Nor do we expect that universities will move away from their steady march toward more and more low wage contingent labor; every indicator points toward university leaders making more, not less, use of their leverage over highly qualified, unorganized, surplus STEM labor (AAUP 2015; AAU 2011; Rhoades 2008). In the face of mounting budget and financial pressures, vanishing state support for state higher education, and the increasing costs of higher education to students and their families, there seems to us little likelihood that university leaders, motivated by the long-term health of the sciences and engineering and a sense of benevolent fairness will lead the path to postdoctoral reform. Universities, university research administrators, and PIs benefit hugely from having a fluid, easily manipulated and contingent labor supply eager to work at salaries well below those of full-time faculty and at costs rivaling or less than graduate student research assistants. Nor do we feel that the majority of postdoctoral researchers themselves will organize through the NPA or a union to improve their lot.

Who, then, is the stakeholder most likely to be attentive to the need to reform postdoctoral policies? We answer: the federal bureaucracy, the principal agent of the US government. Indeed, the modest positive changes in academic employment policies during the past decade have come from incremental changes emanating from the science bureaucracy. Here are the reasons the science bureaucracy has the most potential for initiating positive change.

First, the very fact that the issue is so little salient to policymakers (Congress, President, White House staff, executive agency political appointees) who control the bureaucracy, gives the bureaucracy the ability to formulate and implement rules, regulations and procedures at its discretion using its delegated authority. Second, the agenda-setting literature tells us that bureaucratic policy-level changes tend to occur not *de nova* but as a function of existing roles in implementing policy (West and Raso 2013). Thus, in the case of the science bureaucracy, relatively low-level changes in grants policy can be developed and implemented with only modest likelihood of rankling more powerful political actors. Third, the science bureaucracy has no substantial stake in continued exploitation of postdoctoral researchers: The benefits of low- cost, substitutable contingent labor do not particularly accrue to NSF or the NIH. The science bureaucrats in these agencies generally focus on specific agency missions and on the overall health and well-being of the STEM fields receiving and deploying the resources they provide. It is true that postdoctoral reform might be opposed by some universities and perhaps even some powerful scientists, but some in these groups have previously (and largely unsuccessfully) voiced their opposition to such diverse science bureaucracy-led initiatives as: the NSF 'broader impacts' review criteria; NSF's use of cooperative agreements to fund Engineering Research Centers; and online distributed peer review. If the science bureaucracy succeeds in improving life for postdoctoral researchers and in increasing attention to their long-run employment prospects, we suspect there will be no public outcry.

With these thoughts in mind, we suggest the following 'inside the bureaucratic box' proposals for reform. Our first recommendation is to assess grant proposals based not on only on a postdoctoral mentoring plan but also in terms of demonstrated success in placing agency funded postdoctoral researchers in full time jobs. We certainly have no quarrel with the relatively recently established requirement from NSF and NIH to provide postdoctoral researcher mentoring plans in grants. It is critically important that imposing the requirement for a plan should also require that it must be realistic, implemented, and evaluated to increase the likelihood of attentive and effective mentoring. While we expect that the adoption of such criteria will not have a revolutionary effect, we expect that it would have at least modest direct effects and that it would send a strong signal about expectations. Such a requirement would also enable the federal government to collect valuable data about the range of postdoctoral outcomes—which should not be limited to academic careers. Since only about half of postdoctoral researchers obtain permanent employment in academia, it is important to be able to document the range and impact of postdoctoral researchers on the innovation system as a whole. Asking universities and PIs to be accountable for their training outcomes may be unpopular—witness the controversy about asking universities to track undergraduate learning and educational outcomes—but seems to us to be entirely consistent with the idea of open and transparent government. Funded researchers already have to provide evidence about the scientific output produced by grants-funded research, and doctorates and postdoctoral researchers are two examples of scientific outputs supported by the taxpayer.

We endorse the NAS and NPA calls for a consistent minimum salary for postdoctoral researchers, but also note the need to take account of variation in the cost of living. Our second recommendation is to make financial disincentives for serial postdoctoral appointments. One of the most important changes occurring since the initial days of prestigious, competitive postdocs is the serial postdoctoral research position. Due to increased numbers of postdoctoral opportunities and, in many fields, decreased numbers of full-time faculty positions, some individuals have become career postdoctoral researchers. Here is our proposal for disrupting the serial postdoctoral researcher pattern and perhaps at the same time rationalizing employment markets. It is another candidate for bureaucratic policymaking: Mandate a graduated wage scale for postdoctoral researchers, or perhaps more realistically, a set of minimum percentage raises, associated with hiring the same postdoctoral researcher. Thus, for example, any given university (and it should be the university that is the subject of the rule, not a department, research center, or PI), must require a minimum increase in pay. This would allow PIs to continue using valued postdoctoral researchers, but: (1) it would require recognition of their value, given a pay increase; and (2) it would provide a cap on the time they could work in a postdoctoral position at the same institution. Related, the costs of funding

postdoctoral researchers should be higher than those for graduate research assistants to remove perverse incentives for PIs to switch from funding graduate students to postdoctoral researchers. Finally, increasing transparency about whom is performing which research functions would lend support to NAS recommendations that science-funding agencies support research scientists (rather than postdoctoral researchers) when they are warranted for the actual work being undertaken.

We recommend that all universities that receive federal research funds be required to provide standard employee benefits. At the current time, some universities are forging ahead to create and implement employment benefits for postdoctoral researchers (National Postdoctoral Association 2014, 2017), while most either are not doing so, or it is impossible to verify. Given that employers confer basic social insurance benefits in the USA, it is critically important that universities treat postdoctoral researchers as employees for the purpose of important social insurance benefits. Currently, the universities that are following policy recommendations related to postdoctoral researcher benefits are at a competitive disadvantage with those universities that have yet to organize a systematic approach. The federal science apparatus can and must level this institutional playing field, which would also have the benefit of improving working conditions for postdoctoral researchers.

Finally, we join the most recent NAS report (2014) and its predecessors (NAS 1981, 2000, 2005) in calling for meaningful and substantive change in the way the National Science Foundation collects data about postdoctoral researchers, and its subsequent reporting. Our analysis of several data series, as well as the conclusions of prior policymaking bodies, is that the postdoctoral researcher population is directly relevant to other scientific labor force matters of pressing national concern, including highly skilled immigration, racial and ethnic diversification, and the incorporation of women into science careers.

Continuing to treat these as separate population dynamics and policy problems is not consistent with good theory or with good data practice. Finally, statistics related to the scientific workforce should follow best Census Bureau practices: This would include racial and ethnic disaggregation, specification of citizen and immigration status in all data series, and the ability to analyze each of these series with respect to gender differences. The development and maintenance of such integrated data series will improve the ability of researchers to study postdoctoral researchers and their employment at the individual, meso, and macro levels of analysis.

7. Conclusion

We have argued that the postdoctoral research labor force is best understood as part of the more general phenomenon of contingent labor force trends occurring in the higher education sector. As such, postdoctoral researchers may be more similar to adjuncts, instructors, and research faculty on fixed-term contracts than they are part of the regular university labor force. Furthermore, the dependence on foreign-born scholars to fill the postdoctoral researcher ranks allows it to rely on the investments of other nations in order to enjoy an endless supply of highly trained and inexpensive labor, but also exposes the nation to the vicissitudes of highly political immigration policy debates. The "foreigner" issue has been raised in all of the policy documents dating back to the 1960s, but clearly, the situation has become only more pronounced, especially in light of increasingly politicized US immigration policy. The recent shift in national discourse about immigration is particularly problematic because immigration policy is a key component of national innovation systems (Borrás and Edquist 2014). The rapidly changing landscape related to immigration is not limited to the USA, and continuing work must evaluate the extent to which research-policy dialogues related to highly skilled migration may be politicized (Scholten and Verbeek 2014), with consequent potential effects on national innovation systems. Finally, the continuing failure of the nation to provide educational opportunity to a racially and ethnically diverse domestic population highlights many of the challenges facing the nation as a whole with respect to equity and allocation of scarce educational resources. Seen in this light—as a contingent immigrant labor force whose cost of training is born elsewhere—it is, perhaps, easier to understand why postdoctoral reform is so elusive. Our content, stakeholder, and demographic analyses, in light of agenda-setting theory, show that high-level political attention is unlikely to be forthcoming, so we target our recommendations to the federal science bureaucracy. Using the science funding mechanism, federal program managers can create accountability mechanisms for universities in order to increase transparency and competition, to the potential benefit of these knowledge workers.

Notes

1. Sixteen percent of institutional sponsors of postdoctoral researchers are in industry (NPA 2017); future research should assess this important sponsor type.
2. We follow NAS (2014) usage, 'postdoctoral researcher'.
3. Internally funded postdoctoral researchers are funded by the university, primarily with funds generated by grants to the PI.
4 The national Affordable Care Act has been interpreted to exclude student health plans, and excludes non-citizens, who comprise the majority of postdoctoral researchers.
5. The 1969 NAS report properly identifies the appropriate salary benchmark as being entry-level with a PhD. In 2015, the median entry-level salary for a STEM PhD was academe, $60,000; industry, $100,000; government, $85,000 (NSF 2016).
6. We focus on the composition of the postdoctoral research population in Section 4, where we identify more specifically the national data limitations, as well as calculate estimates that do allow some direct comparison.
7. Foreign governments are also arguably stakeholders, but are not addressed in any of the NAS reports we study.
8. National Science Foundation publications present data in ways that make it difficult to see these dynamics (e.g., Science and Engineering Indicators), but the underlying data can be reanalyzed—as we do here—to illuminate the dynamics.
9. The race/ethnicity terms we employ are consistent with US Census Bureau practice.

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