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An *Extramuros* Portfolio Equivalent of the Traditionally Earned PhD

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Introduction

The present essay ponders two interrelated questions: (1) whether *extramuros* accomplishments (*i.e.*, accomplishments outside university walls) by scientists and engineers might rationally be viewed as the equivalent of a doctorate earned in the traditional way, and (2) where and how such equivalence may be recognized. Discourse begins with a brief review of the generic structure of the research doctorate, and continues with an examination of the specific structure of a STEM PhD at a large, land-grant university. The thesis that follows from this examination focuses on crossing thresholds. In particular, an argument is offered that a scientist or engineer working outside the university has clearly crossed the doctoral threshold with a discipline-appropriate master's degree and two sole-author (or a larger plurality of first-author) peer-reviewed publications. Limitations of this argument are then proposed. Various thoughts taken from the literature are presented regarding these questions.

What is the Essence of a Doctoral Degree?

Traditionally, doctoral degrees granted by universities in the United States comprise two distinct components. The first component consists of advanced coursework that is intended to give the student a broad background in a particular discipline, such as physics, and deeper knowledge of a particular subfield, such as electromagnetic theory. In effect, this is a non-thesis master's degree. The second component is a research apprenticeship under the tutelage of senior faculty. The two components are often separated by a "qualifying" gateway.

The gateway is Protean – it may take the form of face-to-face grilling on a research proposal; or a written, subject-matter examination; or a *viva voce* on a specific set of journal papers assigned to the student; or a report on an appropriate project chosen by, or assigned to, the student; and so forth. Given the widely divergent manifestations of the gateway, it is logical to conclude that no particular form is an essential component of doctoral training, which suggests that the gateway itself is not essential, except by fiat.

Successful navigation of the gateway grants entry into the world of research. At this point, "students" become "candidates," now ready to begin their apprenticeships. During apprenticeships, candidates learn the tools, methods, and skills of the discipline,

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along with the folkways and mores of academia. The culmination of an apprenticeship is, of course, a candidate's dissertation.

In principle, the dissertation serves at least three purposes. The first is to record the candidate's contribution to knowledge, which advances the state of the discipline. The second is to demonstrate the candidate's mastery of the tools and skills needed to accomplish independent research. The third is to showcase the candidate's ability to argue logically, in writing, from premises or observations to conclusions, in an articulate way.

Ultimately, candidates defend their dissertations before panels of experts, and, with a good showing, graduate from "candidates" to "doctors of philosophy." Often, defense is just a formality, although in some cases dissertations may be rejected, or accepted conditionally, subject to revision.

What, For Example, is a PhD in Engineering?

As a point of reference, consider today's doctoral program in electrical engineering at North Carolina State University. Although each doctoral program is structured differently, at least to a certain extent, State's current approach is mentioned because it provides insight into what might be considered typical at a large, R1, land-grant university.

According to the *University Catalog 2024-2025*, a student who completes a master's degree in electrical engineering at NC State is not required to take any further courses toward the PhD.[1] The formal post-master's requirement is 54 credits of research. Along the way, a doctoral student is evaluated in a "qualifying review" – the aforementioned "gateway" – that includes examination of a project completed under the supervision of a potential doctoral-committee member. This review stands in lieu of the old-style written qualifying exam, which, in the now-distant past, could come perilously close to being an unproductive exercise in institutional sadism.

The Dissertation as a Coherent Collection of Published Papers

At many universities, if not most, the old-style, single-manuscript, monographic dissertation in STEM fields has given way to a coherent collection of individual but topically interconnected papers. These are sometimes called "stapler dissertations." The benchmark for a stapler dissertation has converged to three papers, more or less. Ordinarily, the doctoral candidate needs to be first-author of at least one of these papers, and sometimes two, or even all three. In American universities, students must be *intramuros* while writing these papers – formally enrolled and supervised by their committees. The key distinction here is between traditional *intramuros* accomplishment as a student or candidate, as opposed to *extramuros* accomplishment while working, for example, in a commercial research laboratory after leaving the university without completing a traditional doctorate.

Advantage accrues to a traditional doctoral candidate when the papers of a stapler dissertation are examined outside the university and accepted for publication in peer-reviewed journals before the final defense. When this is the case, any claim that the work falls short of standards may be summarily refuted, at least in principle. One problem, however, is that publication cycles can be disruptively long, sometimes taking years, thereby threatening to delay a candidate's defense and graduation. To ameliorate this, papers may be *deemed publishable* by a candidate's doctoral committee rather than examined outside the university and actually published (or accepted for publication). In either case, of course, the candidate's committee makes the ultimate decision about the acceptability of the work.

Deeming has advantages and disadvantages. On one hand, doctoral committees can provide timely, effective, interactive review. Moreover, the committee's involvement should ensure that the papers represent meaningful accomplishments rather than low-value contributions to predatory journals. On the other hand, committee members may be unrealistically favorable toward work that they have personally supervised, especially if they are co-authors of a resulting paper or two, or if they form an emotional bond with the candidate, or if they face institutional pressure to push candidates through the doctoral program according to time-to-graduation guidelines. For these reasons, external review by disinterested referees is arguably more dispassionate than internal review solely by a student's committee. Consequently, a portfolio of *extramuros* papers may be a more reliable credential than an *intramuros* dissertation.

Another shortcoming of committee-only review is that it shields candidates from experiencing the full spectrum of the publication ritual. In particular, they may earn research doctorates without ever having experienced the joy of seemingly endless delays and anonymous review comments, which at their worst can be gratuitously nasty and even brutal. *Extramuros* people will likely experience such comments more than once in their careers, which suggests that the *extramuros* experience often includes a component that the traditional doctoral program may lack.

Why Three Papers?

The idea of a three-paper benchmark is interesting in itself. Where did this number come from? One guess would be that the requirement of three is entirely subjective, its nature being *ex cathedra*, as are many aspects of academia. Another way to look at the number is to follow the path suggested long ago by Yale University's historian of science, Derek J. De Sola Price, in *Little Science, Big Science.*[2] Price develops his thoughts around Lotka's Law for total numbers of publications over the course of a career. [3] According to Price, Lotka's Law: [4]

> *". . . is an inverse-square law of productivity. The number of people producing N papers is proportional to $1/N^2$. For every 100 authors who produce but a single paper in a certain period, there are 25 with two, 11 with three, and so on. Putting it a little differently by permitting the results to accumulate, one achieves an integration that gives approximately an inverse-first-power law for the number of*

> *people who produce more than* [sic] *N papers; thus, about one in five authors produces five papers or more, and one in ten produces at least ten papers."*

Consider a sample of 164 authors, each of whom contributes at least one paper. With this scaling, 64 of the 164 authors contribute more than one first-author paper, *i.e.,* 100/164, or about 61%, of the entire sample of authors contribute only one first-author paper each. Thus, the median contribution is one first-author paper, per author, per career. [5]

Lotka's Law pertains only to those who publish at least one paper. Many recipients of doctorates, however, never publish at all, and consequently fall outside the domain of Lotka's Law. For example, a study appearing in the prestigious *Journal of Economic Perspectives* reports that, at the fiftieth percentile, those who receive doctoral degrees from the nation's top-thirty programs in economics publish nothing of any consequence in the six years after they complete their dissertations. The authors note "Most of the graduates of even the very highest ranked departments produce little, if any, published research." [6] Although this may be a field-dependent anomaly, such has long been the case over various fields, as reported, for example, by Gilman[7] in 1974 and Boice[8] in 1984. According to searches performed using three independent artificial-intelligence (AI) programs, the distribution of post-dissertation publications for virtually all fields is highly "right-skewed" (*i.e.*, has a long positive tail, and a median value of zero).[9]

Co-Authorship

By the measure of Lotka's Law, requiring three papers for a dissertation sets a high bar. At this point, however, the unavoidable question of co-authorship arises. Should students be afforded full credit for papers that they write jointly with more-senior contributors? If not, how should credit be apportioned? Nils Hagen studies this quagmire in detail.[10] Based on an examination of several hundred doctoral dissertations, he proposes that:

> *Bibliographically identifiable authorship credit* [may be] *partitioned between PhD candidates and their coauthors according to a harmonic counting scheme based on relevant byline information including authorship rank, the number of coauthors and any indication of equal contribution by two or more coauthors. Harmonic credit for the i^{th} author of a publication with N coauthors* [may be] *calculated as follows:*
>
> $$i^{th} \text{ author credit} = (1/i) / [1 + ½ + \ldots + (1/N)].$$

Hagan observes that *"Unbiased partitioning of authorship credit between graduates and their coauthors provides a post hoc bibliographic measure of current PhD requirements, and sets a de facto baseline for the requisite scientific productivity of approximately 1.6 undivided* [sole-author] *papers per dissertation."*

PhD "or its Equivalent"

Postings for positions that demand graduate-level training often specify something like "PhD or equivalent required," without ever explaining what the equivalent of a PhD might be. In reality, academia may not accept any accomplishment or credential as equivalent, other than the PhD under a different name (*e.g.*, the DPhil from Oxford or Cambridge), or, in special cases, a professional degree (*e.g.,* MD, JD, or EdD).

At the other extreme, human-resource practitioners outside academia sometimes define equivalence in terms of years of experience. For example, the U.S. federal government appears to consider a master's degree and two years of "directly related experience" to be the equivalent of a PhD in many cases. Surely, PhDs who have completed a traditional dissertation and its defense would find this definition of equivalence to be quite galling.

Another standard, which occasionally appears in recruiting notices for faculty positions, holds that the combination of a master's degree and a professional engineer's (PE) license is the equivalent of a PhD.[11] This is, *prima facie*, nonsensical. Although a master's degree and PE license make an excellent combination for certain kinds of work, and may indeed be appropriate credentials for teaching basic engineering courses, the PE license and the research component of a PhD are just about orthogonal. By definition, the PE license certifies competence in applying the well-known. Conversely, the PE license does not certify competence in any of the academic skills, nor does it certify that its holder has made any contribution to knowledge, or has any interest in doing so. Perhaps the idea of "equivalence" in this context should be assumed to refer to pay scales rather than academic wherewithal.

A bit more reasonably, the aforementioned Derek Price equates the publication of a single peer-reviewed journal paper with the attainment of a PhD: [12]

> *Now, the PhD and the editorial standards of learned periodical publications are things that we have done our best to keep constant. It is therefore reasonable to identify the minimum effort of writing a single scientific paper with that demanded by the "sheepskin gateway" to the road of research. Although it is agreed that these things do not coincide, since some PhDs never publish even their theses, whereas many authors are not doctors, yet at worst they should differ by some reasonably constant ratio not too far from unity* [perhaps 1.6, as suggested implicitly by Hagan's work].

Another thought comes from *Sigma Xi, The Scientific Research Honor Society*. Their criteria for full membership include:[13]

> *An individual who has shown noteworthy achievement as an original investigator in a field of pure or applied science is eligible for election to Full Membership. This noteworthy achievement must be evidenced by publication as the primary author (defined in the manner appropriate to the discipline) on at least two*

different articles published in a refereed journal, patents, or refereed monographs. Dissertations and theses alone are not considered sufficient for demonstration of this achievement and must be accompanied by at least two other publications.

A candidate for membership in *Sigma Xi* who presents two first-author papers has smooth sailing, whereas a hypothetical candidate founders who presents only the 1.6 sole-author papers that Hagen finds to be the effective content of a typical dissertation. In fact, the bylaws and policy of *Sigma Xi* explicitly state that a graduate degree alone is neither necessary nor sufficient to qualify its recipient for full membership, nor is a dissertation accepted as evidence of "noteworthy achievement" (their term).[14] Thus, although not explicitly stated, it may be credibly inferred that *Sigma Xi* considers the publication of two legitimate, first-author, peer-reviewed papers to be a more noteworthy achievement than a doctoral dissertation.

A different statement of equivalence has been proposed by the University Corporation for Atmospheric Research, although the various thresholds are subjective, and ten years of experience seems excessive: [15]

". . . we suggest the following three requirements be considered an alternative to a PhD degree for the purpose of a Project Scientist (or Scientist) appointment at any level:

1. A Master's degree and experience past the Masters level that has led to published research (which might typically extend over a 10-year period);

2. Thematic development of some area of research to a level comparable to that expected in a PhD research project; and

3. Demonstrated expertise and general experience comparable to that expected from PhD course work."

Finally, the widespread acceptance of the three-paper stapler dissertation suggests strongly that a discipline-appropriate master's degree and three legitimate, *extramuros,* first-author papers in peer-reviewed journals are convincing evidence of having crossed the doctoral threshold in science or engineering. These encompass the fundamental aspects of a traditionally earned doctorate: The master's degree provides the coursework component. The three published, peer-reviewed, first-author (or two sole-author) papers are at least the equal of a typical dissertation, which has an effective content of 1.6 sole-author papers. The papers are legitimate contributions to knowledge; they demonstrate mastery of the tools and skills needed to conduct research; and they demonstrate the author's ability to argue logically, in writing, from premises to conclusions in an articulate way. Moreover, since the papers are first-author works (and, *a fortiori*, in the case of sole-author works), they demonstrate the ability to conduct research independently, which may be dubious in the case of dissertations and papers authored under faculty supervision in a university.

In this interpretation, however, the papers must have subject-matter cohesion among themselves as a group, and must offer original contributions to systematic knowledge supported by rational warrant. They cannot be tutorials, surveys, literature reviews, embellished product literature, simple reports of observations, opinion pieces, or any of the like. The principle behind this stipulation is essentially a modern paraphrase of Francis Bacon's thoughts in 1605 on the various works of the human mentality. According to Bacon: [16]

> *"The parts of human learning have reference to the three parts of man's understanding – History to his Memory, Poesy to his Imagination, and Philosophy to his Reason. And of these three, the highest is Reason, which leadeth the mind to the knowledge of causes; next is Memory, which furnishith the mind with the store of things past; and last of all is Imagination, which shapes and feigns things, but is least able to ascertain truth . . . Philosophy, by discovering causes, gives power, and therefore holds the place of highest honor among the three."*

Needed: Credentials for Accomplishments Outside the University

When applying for positions in a university setting, academics offer their *curricula vitae (c.v.)*. These are often lengthy documents. In contrast, those who apply for positions outside academia typically offer a comparatively brief résumé. A common benchmark for résumés is "one page, per ten years of experience." Folk wisdom holds that human resource (HR) departments devote less than one minute to examining an incoming résumé – assuming that it even survives an obligatory pass through pre-screening software – before deciding whether to circulate it among hiring managers.

Unfortunately, HR departments and pre-screening software are not able to determine which sets of alternative accomplishments are the equivalent of a doctorate, and which not. They need to rely on credentials. In the United States, credentials for accomplishments and skills of an advanced intellectual nature are granted almost exclusively by universities. This is one of their core responsibilities. At present, however, American universities are not fulfilling this responsibility for those who work in research outside academia – there are no credentials available to those who lack a formal doctorate but cross the same thresholds of expertise and accomplishment. Thus, candidates may be denied consideration for positions they are demonstrably capable of filling, based simply on the lack of arbitrary credentials.

Unlike universities in the United States, universities in Australia, France, Great Britain, Germany, and many other places offer credentials in recognition of expertise acquired and applied outside their walls; *i.e., extramuros* accomplishments. These may be called PhDs "by *prior* publication" or "*retrospective* PhDs." Britain's Cambridge University, for example, offers doctorates based on coherent compilations of journal papers – stapler dissertations – written later in life, subject to *viva voce.* Most British schools that offer this path to the doctorate, however, restrict eligibility to their own graduates, faculty, and staff, as does Cambridge. Along the same vein, the *Loi de Modernisation Sociale* of 17

January 2002 authorized all French universities to grant degrees, including doctorates, based on expertise acquired outside the university, subject to *viva voce* conducted by a jury of academics: *Validation des Acquis de l'Experience* (VAE). The internationally famous *Sorbonne*, for example, offers doctorates in this way (and also, of course, in the traditional way).

American universities do not provide these kinds of opportunities. Why not? Learning and accomplishment do not necessarily stop on commencement day, and competent mentoring of less-experienced researchers takes place outside the university as well as within. A cynic might answer by noting that today's American universities depend heavily on the inexpensive, but highly skilled, labor provided by in-house graduate students, and on tuition paid by foreign nationals.

This is not to suggest that any university should award doctoral degrees for "life experience" or "work experience" in the manner of a diploma mill. Rather, credentials should be offered by legitimate universities, as offered in France and Great Britain, for – and only for – work completed externally that meets *exactly the same standard* required for work completed within the university, *i.e.*, for crossing the same threshold. This is entirely feasible in the case of doctorates, given the abrupt change from course work to research upon completion of a master's degree, and the vetting of peer-review.

Limitations

Any argument like the one outlined here clearly has its limitations. Someone earning a doctorate in the traditional way obviously has a different experience than someone developing an *extramuros* portfolio. Consequently, the traditional doctorate and the portfolio approach cannot be exactly equivalent.

For instance, the *extramuros* person working in a commercial research laboratory is not immersed in the academic environment, and likely does not develop the folkways and mores of that culture, or close ties with its senior faculty members, or experience writing grant proposals, or experience teaching undergraduates. Further, accruing a portfolio does not demonstrate the same dogged level of commitment to scholarly activity shown by the successful pursuit of a traditional PhD.

The aforementioned elements of the traditionally-earned doctorate that are missing from the portfolio, however, have little importance outside academia. Some of these elements – for example immersion in academic folkways and mores – may be more of a liability than an asset outside the university, as the traditional *intramuros* doctoral student often lacks any contact with "the real world," and likely has not developed close ties with its rather different people and culture.

Consequently, in this context, the role of the *extramuros* portfolio as an alternative to the traditionally-earned doctorate is stronger outside academia than inside. Thus, the notion of equivalence here refers to indicators of ability and accomplishment, rather than across-the-board equivalence in a pedantic way. But in the sense of Abraham Maslow's

idea of self-actualization, the two approaches are indeed equivalent, whether the *extramuros* portfolio ultimately leads to a formal academic degree, or not.

Concluding Remarks

For good reason, the PhD is *sine qua non* for those intent on a tenure-track career in academia. At present, it seems that no accomplishment short of a Nobel Prize or a Fields Medal will be recognized. This notwithstanding, a discipline-appropriate master's degree, a significant accumulation of relevant experience, and two sole-author or three first-author papers published in legitimate journals arguably demonstrate at least the equivalent ability, knowledge, and accomplishment that a traditionally earned doctorate represents. Nevertheless, formal credentials, rather than their equivalents, are important in our Mandarin culture. American universities need to bring all of this together, and join their twenty-first-century foreign cousins who offer recognition and credentials by granting doctorates for equivalent learning and accomplishment outside their walls.

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[1] *University Catalog 2024-2025;* catalog.ncsu.edu.graduate/engineering/electrical-engineering/; the author of the present paper relies on the official catalog because he has no special knowledge of the program at NCSU, other than knowledge gained as a graduate student more than 50 years ago, and as an instructor in ECE 1994-1995, and in mathematics 1979-1983.

[2] Derek J. De Sola Price; *Little Science, Big Science*, Columbia University Press (1963); p. 43

[3] A. J. Lotka; "The frequency distribution of scientific productivity," *Journal of the Washington Academy of Sciences*, vol. 16 (1926), p. 317

[4] Price's account of Lotka's Law is not internally consistent. See: David Rand Irvin; "Lotka's Bibliometric Inverse-Power Law: Calibrating the Model and Exploring a Common Conceptual Error;" researchers.one/articles/24.07.00004 (2024)

[5] *Ibid.* The infinite sum is the Riemann Zeta function, $\zeta(a)$, which converges for all real $a > 1$. For $a = 2$ (inverse squares, as originally observed by Lotka), finding the sum is traditionally known as the "Basel problem." Leonhard Euler, in 1735, was the first to show that the sum converges, remarkably, to $\pi^2/6$, i.e., $\Sigma\ (1/n^2) = \pi^2/6$, which is approximately 1.64

[6] John P. Conley and Ali Sina Önder; "The Research Productivity of New PhD's in Economics: The Surprisingly High Non-Success of the Successful," *Journal of Economic Perspectives*, Vol. 28, No. 3 (Summer 2014), pp.205-216

[7] D. A. Gilman; "The Dissertation as a Terminal Exercise in Scholarly Activity," *Contemporary Education*, vol. XLV, no. 4 (Summer 1974), pp. 309-312

[8] R. Boice and F. Jones; "Why Academicians Don't Write," *Journal of Higher Education*, vol. 55, no. 5 (Sept/Oct 1984), pp. 567-582

[9] The findings of artificial intelligence can be suspect, of course, but in this case all three AI programs provided credible references when challenged.

[10] Nils T. Hagan; “Deconstructing doctoral dissertations: how many papers does it take to make a PhD?” *Scientometrics* (2010) 85:567-579

[11] See, for example, *Degrees in Specific Fields that CUNY Colleges May Accept in Lieu of the PhD*; https://www.cuny.edu/wp-content/uploads/sites/4/page-assets/academics/academic-programs/academic-program-resources/faculty-appointments/Degree-Equivalencies-2021-22.pdf (2021)

[12] *op cit., Price,* p. 52

[13] “Becoming a Member,” *Sigma Xi, The Scientific Research Honor Society*, https://www.sigmaxi.org/members/becoming-a-member (2024)

[14] Bylaws of *Sigma Xi*, 25 Oct 2021, line 43; “Membership Policy and Qualifications,” Updated March 2017; https://www.sigmaxi.org/docs/default-source/members-documents/join-nominate/cqmclarificationpolicy_dec19.pdf?sfvrsn=ab02bc58_2#:~:text=scientific%20publications%20(see%20above)%20resulting,the%20proceedings%20are%20peer%2Dreviewed

[15] *Associate and Project Scientist Review Committee – Final Report*, University Corporation for Atmospheric Research (10 July 2002), p. 7; search site *ucar.edu*

[16] Francis Bacon, *Of Proficience and Advancement of Learning Divine and Human*, Book II, Sections I and II (1605)