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The role of early-career university prestige stratification on the future academic performance of scholars.*

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Abstract

Prestige and mobility are important aspects of academic life that play a critical role during early-career. After PhD graduation scholars have to compete for positions in the labour market. Unfortunately, many of them have few research products such that their inherent ability and skills remain mostly unobserved for hiring committees. Institutional prestige in this context is a key mechanism that signals the quality of candidates, and many studies have shown that a "good" affiliation can confer many opportunities for future career development. We know little, however, about how changes of scholar's institutional prestige during early-career relate to future academic performance. In this paper, we use an algorithm to rank universities based on hiring networks in Mexico. We distinguish three groups of scholars that move *Up*, *Down* or *Stay* in the prestige hierarchy between PhD graduation and first job. After controlling for individual characteristics by matching scholars with equal training or the same first job institution, we find that scholars hired by their existing faculty sustain higher performance over their career in comparison to other groups. Interestingly, we find that scholars that move up the hierarchy exhibit, on average, lower academic performance than the other groups. We argue that the negative relation between upward ranking mobility and performance is related to the difficulties in changing research teams at an early-career stage and to the so-called "big-fish-small-pond" effect. We observe a high stratification of universities by prestige and a negative association between mobility and performance that can hinder the flows of knowledge throughout the science system.

Keywords: University prestige stratification, University ranking, Academic performance, Early career mobility, Faculty hiring network, PhD job market, Developing countries, Mexico.

JEL Codes: D7, I2, J15, O3, Z13

1 Introduction

Early-career in academia typically starts with the conclusion of doctoral studies lasts up to 5 years after the first job, has large consequences for future career development (Bazeley, 2003). During these early years, scholars need to learn how to assess relevance in a body of knowledge, build research skills and capabilities, engage with a research community and acquire sufficient expertize to conduct independent research for the coming years (Laudel & Gläser, 2008). At the same time, for universities, forming and hiring PhD graduates

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is essential for their competitiveness. Young scholars that stay in academia will turn into lecturers, senior researchers and professors that will drive knowledge production and fill teaching positions of universities over a long period.

After PhD graduation, scholars search for positions in the academic labour market and rank universities according to level of disciplinary specialization, access to resources and potential collaborators affiliated into faculties. Unfortunately, doctorate graduates usually have few research outputs and their skills and ability remain mostly unobserved. University hiring committees need to evaluate the research capabilities and disciplinary expertise of job-candidates, but in the absence of a publication record they rely on other signals of quality. Institutional prestige is an embodiment of patterns of academic excellence attached to universities and graduates and is a key mechanism to alleviate the asymmetric information between universities and candidates. Universities are thus motivated to hire PhD graduates with the highest prestige possible and candidates would like to graduate and work in the most prestigious faculties.

Hiring decisions in the academic labour market are pairwise evaluations of the quality between candidates and universities. This pairwise assessment can be used to extract information about the distribution of prestige of a higher education system (Clauset, Arbesman, & Larremore, 2015). Based on this idea, we develop an algorithm to disentangle the prestige order emergent from PhD hiring networks to rank universities (Cowan & Rossello, 2018). Using hiring networks to rank universities can overcome many of the shortcomings of bibliometric and survey-based measures (Barnett, Danowski, Feeley, & Stalker, 2010), which are discussed them in Section 2.3. Moreover, well-known university ranking systems, such as the Times Higher Education Supplement or the Shanghai Jiao Tong University are more effective for a comparison of elite institutions (Marginson & van der Wende, 2007) rather than the distribution of university prestige for institutions outside North America and Europe.

The literature on institutional prestige has typically looked at the relation between prestige from PhD granting university on future academic placement (Crane, 1970; Long, Allison, & McGinnis, 1979; Debackere & Rappa, 1995; Bedeian, Cavazos, Hunt, & Jauch, 2010; Lawson & Shibayama, 2015). However, these studies have been conducted in top-tier institutions and we know very little about how university prestige stratification affects labour market mobility and correlates with future academic performance outside the elite higher education systems. Much of the evidence accumulated so far indicates that prestige from the PhD institution increases the chance of getting further prestigious appointments. Some studies even argue that institutional prestige from the PhD is more important than research outputs prior to the first-job appointment. However, these results are to a certain extent expected, since science systems are well-known to exhibit patterns of cumulative advantage or what is termed as the *Matthew-effect*, where a “good” initial affiliation is likely to be preceded by other prestigious appointments and higher academic performance.

This pattern, however, seems to be more complex and nuanced. A previous analysis of university prestige stratification in South African reveals that in the long-run scholars that move up in the prestige hierarchy exhibit lower academic performance in comparison to those who keep their position in the hierarchy (Cowan & Rossello, 2018). After graduation scholars can be hired by their same faculty or migrate to other institutions. On the one hand, if they are hired by their faculty, researchers keep their current social capital and hold their position in the prestige hierarchy. On the other, if they move to a different faculty they change their prestige in two ways: they can move higher in the hierarchy to more prestigious universities, or alternatively, they can get an appointment in a less prestigious institution, moving down the hierarchy. Analysing these prestige changes rather than solely the effect of the PhD granting institution can offer deeper insights about how university prestige stratification relates to early-career and academic performance.

This paper focuses on how prestige differentials in the transition between PhD and first-job relate to the future academic performance of scholars. We use a sample of Mexican researchers from hard science that completed their doctoral studies between 1992 and 2016. First, we analyze the information contained in hiring networks of the Mexican PhD labour market to produce a ranking of universities by prestige. We then test the relationship between changes in prestige and academic performance using a stochastic analysis to compare the academic performance of matched pairs of individuals that exhibited different prestige changes during this transition. Given the potentially large implications of changes in prestige during this transition for future academic career development, we compare their performance in the short, medium and long-run.

Overall, we find that the Mexican university system is highly stratified where the most prestigious institutions exchange their PhD graduates mostly between themselves. This confirms previous results available mostly from more developed settings (Burris, 2004; Barnett et al., 2010; Clauset et al., 2015). Moreover, internal hiring is concentrated within 10 universities which could promote, on the one hand, higher levels of specialization and targeted allocation of resources. On the other hand, it can also reveal a structural problem in the science system, a "lock-in", where researchers are trained and hired by elite institutions and flows of knowledge are reduced through the national science system.

We have two main findings, firstly we discover that PhD candidates that are hired by their faculty after graduation exhibit higher academic performance throughout their careers than those who move up or down the prestige hierarchy (We discuss this apparent paradox in the discussion section). Secondly, we find that those PhD graduates that move down the university hierarchy perform better than those going up. On the one hand, when we hold PhD institution constant, those hired in less prestigious universities (downward mobility), perform better than those that get positions at higher ranked institutions which suggests that upward mobility is negatively associated with academic performance. One the other hand, holding first-job constant, those moving down from more prestigious institutions perform better than those moving up from less prestigious PhD institutions which underlines the importance of PhD training on performance.

2 Literature Review

2.1 University stratification by prestige

Davis (1942) in his analysis of social stratification, argues that prestige is the individual value attached to a given status, position or combination of the two and stratification is the unequal evaluation of different positions. He associates the value of prestige with the expectations of the role or functions of a certain position as perceived by society, such that some positions have higher expectations than others. Abbott and Barlow (1972) build upon this framework to explain the mechanism through which stratification explains prestige differentials across universities in a higher education system. They argue that universities are similar to complex organisations because they produce identifiable outputs that are functional for society or a certain group (e.g., students, researchers or academic communities). Over time the perceived quality of contributions is regarded as the embodiment of patterns of excellence that sort universities by prestige. These hierarchies create stratification in the higher education system that give rise to inequalities in the distribution of prestige across academic institutions.

Prestige from this functional perspective is a consequence of the social contributions of a university, such as forming human capital, conducting research to expand knowledge frontier and, arguably, supporting innovation more actively[1]. In order to deliver these social goals efficiently, universities compete for inputs, such as funding, grants and students, and are expected to deliver products and services, such as education, graduates and research outputs (Cohn, Rhine, & Santos, 1989). The structure in which universities operate is similar to a competitive market (Dill, 1997). However, universities are different from profit-seeking organizations because they do not seek exclusively to maximize profits or to minimize costs and their behaviour seems to be driven to a large extent by the goal of achieving prestige, status and quality (Breneman, 1982; Dill, 1997; Garvin, 1980; Geiger, 2004; van Vught, 2008). Another characteristic of the higher education market is that it operates imperfectly since the quality of education and other university products are not completely reflected by prices (Winston, 1999; van Vught, 2008). In other words, there are large differences in the quality of education and research products across universities with similar tuition, fees or research costs. Since prices are not very informative of the value of higher education outputs, university prestige can play an important role as a signal mechanism of academic excellence. Here prestige is an *attribute* of a university that serves as a signalling mechanism because it reflects quality assessment of past university

[1] There is an ongoing debate about the role of universities performing innovation activities (Etzkowitz, Webster, Gebhardt, & Terra, 2000).

contributions: teaching, knowledge production and in general the performance of graduates and scholars.

Because the value of prestige is the result of distinguished endeavours, it is expected that *meritocratic selectivity*[2] is the main mechanism that describes the accumulation of prestige. In other words, the accretion of prestige is related to the degree to which scholars believe in, and recognize value in the work of other peers. Scholars, faculties and academic institutions thus acquire prestige through the recognition of quality in the work as perceived by the academic community. Over time, it is possible that the distribution of prestige and its corresponding inequalities become stable. The persistence of prestige is likely related to what has been coined the *Matthew-effect* in science because as universities acquire prestige they move higher in the academic hierarchy and the power from their position can confer them a preferential advantage over resources and inputs of their production function. Prestige also has a *structural* property, since the attribute of value attached to each university derives a position in the institutional hierarchy. Here, stratification in the higher education system implies that due to the inequalities in the distribution of prestige, there are potentially large differences in the attitudinal value attached to universities. Thus high stratification can have consequences for higher education systems because few universities benefit from their position in the hierarchy. At the same time, the gains of the position rely on a certain level of inequality because there will be no inherent value from their place in the hierarchy if there is a uniform distribution of prestige across universities.

An alternative approach defines university prestige not only as attitudinal or as a consequence of academic excellence, but as a *resource* in itself. Hence, its accumulation can determine the competitiveness of academic institutions. Abbott and Barlow (1972) argue that prestige as a resource is another mechanism that can explain stratification since the magnitude of resources or inputs controlled by a university can determine their capacity to perform effectively. From this perspective, universities can compete for resources, and given that prestige is presented as a form of scare resource, the behaviour of universities is also explained as a function of its accumulation. For instance, Overton-de Klerk and Sienaert (2016) argue that prestige is the brand equity of universities in knowledge-based economies and propose that the accumulation of prestige is explained by a process in which research excellence increases the ranking, global reputation and, ultimately, the prestige of universities. However, it is not clear if research excellence is the main determinant of prestige nor which mix of outputs - i.e. graduates, research, innovation - will yield the highest return of prestige. Nevertheless, what is clear is that the process of prestige generation happens through the interaction between scholars and universities because, in addition to individual capacities, academic institutions also provide inputs, such as funding, equipment, training and networks. For instance, Burris (2004) presents an alternative explanation

[2] There are well-known biases that suggest that success in academia is not exclusively explained by merit (Ginther & Hayes, 2003; Ginther & Kahn, 2004).

of stratification where prestige is not only an attribute of a university or a faculty but the result of the position of academic institutions in hierarchical networks. Here prestige is a specific type of resource or *social capital* that is generated mainly through the interaction and exchange of doctorate graduates between academic institutions.

The market for higher education is peculiar because students are both the customers and the inputs of the production function of universities (Winston, 1999). Students are buyers of higher education services, but it is the performance of students and scholars that drive the recognition of universities. Since the quality of human capital determines their competitiveness, universities can limit access to students, PhD candidates, researchers or scholars in general, that can uphold or increase their prestige. Similarly, from the side of the scholars, there is also consistent evidence from different higher education markets that the general prestige of a university, academic program or department are key determinants in their selection of university (Hayes, 1989; Moogan, Baron, & Harris, 1999; Soutar & Turner, 2002; Veloutsou, Lewis, & Paton, 2004; Simões & Soares, 2010). Scholars thus base their choice of institutional affiliation on the information that they possess about the distribution of prestige. That is, if academic institutions and scholars seek to maximize their prestige, as previous studies suggest, then the ranking of academic institutions will have an effect on the mobility and labour market of scholars. As universities gain prestige and move up in the hierarchy, their demand increases and openness reduces, for instance, by restricting the access to candidates with specific backgroundS or skills, thus creating a competitive market for scholars.

2.2 University prestige on academic mobility and performance

The relationship between institutional prestige and mobility in the academic labour market has been addressed in the literature. In particular, there is a special interest in understanding how prestige of the PhD-granting institution affects placement in the labour market for several reasons. Early-career for scholars is important not only because the completion of doctoral studies usually marks the beginning of an academic career (Bazeley, 2003), but also because the transition between the PhD and the first academic position is a stressful yet critical passage that affects the development of a long term career in academia (Laudel & Gläser, 2008). This passage is also relevant for universities since hiring new scholars determines their quality of human capital and competitiveness. Nevertheless, hiring at this stage is a difficult task because PhD graduates usually have few research products and universities usually possess little information about the inherent knowledge and skills of candidates.

Since the quality of early-career candidates remains mostly unobserved, the prestige of the PhD institution plays a crucial role in signalling the inherent ability and skills of young scholars. This mechanism has been tested in a large body of works that in general show a positive relationship between the prestige of the PhD granting institution and future employment (Crane, 1970; Debackere & Rappa, 1995; Bedeian et al., 2010; Lawson & Shibayama, 2015).[3] PhD graduates from prestigious institutions tend to get better job offers and not surprisingly they have a competitive advantage in the academic labour market comparison to graduates from lower-tier universities. The evidence accumulated from these studies suggests that prestige from the PhD institution function as a key mechanism to alleviate the asymmetry of information between candidates and hiring faculties. The opportunities that a "good" affiliation can confer are clearer in early-career development but there is also some evidence that this effect can still be present in the long-run (Oyer, 2008; Bedeian et al., 2010). Hence, prestigious appointments at early academic career can provide knowledge, networks and resources that boost significantly the career of young scholars. Some studies even argue that institutional prestige from PhD granting institutions is more important than the researcher's productivity for obtaining the first job (Long et al., 1979; Allison & Long, 1990; Baldi, 1995).

Another group of studies pay attention to how changes of institutional prestige relate to academic performance and academic achievement of scholars. The study of Oyer (2008) uses a longitudinal sample to estimate how changes of institutional prestige affect the academic performance of economists. He shows that even after controlling for proxies of individual-level ability, that early academic prestige positively correlates with academic performance measured by publication productivity. Moreover, he shows that scholars in general move down the prestige ranking over their careers possibly because high ranked universities produce a big percentage of the total graduates that later move to lower ranked universities. Using a sample from the financial literature, Chan, Chen, and Steiner (2002) show that upward ranking mobility is a rare event and that on average scholars that move up the ranking produce twice as many publications compared with average production of scholars from destination universities. He furthers shows that after controlling for ability using publication productivity, the rank of the PhD grading institution predicts upward ranking mobility through their academic careers. The study of Azoulay, Stuart, and Wang (2014) take an alternative approach, they compare academic performance of scholars before and after upward mobility given by a prestigious academic recognition. They find that gains from upward ranking mobility have a lower effect on scholars that had above average citations than on scholars with low or below average citations. In general, these studies suggest that upward ranking mobility is associated with higher academic performance, but this is not always the case. A closer look at how prestige differentials in the passage between PhD graduation and first job relate to academic performance Cowan and Rossello (2018) shows that scholars that are hired by their faculty after PhD graduation and maintain their prestige exhibit on average higher academic performance in comparison to scholars that move up the in the prestige rank. Furthermore, the vast majority

[3] This hypothesis has been tested in large range disciplines from both social and hard sciences.

of research on institutional prestige has been conducted in higher education systems from the U.S. and we need more evidence from hierarchies of higher education in less developed countries.

2.3 Measuring University prestige

There are at least three main approaches for measuring university prestige, but in general all methods have a scale and a corresponding ranking system. The essential aspect of any ranking system is that each rung of a scale should correspond to the position of a university in a certain prestige-based hierarchy. Abbott and Barlow (1972) argue that if there is a distributive system that assigns prestige to academic institutions proportionally to their contributions to society, then a ranking system should be based on objective outputs. For instance, Debackere and Rappa (1995) use bibliographic records to calculate the prestige rankings for universities in the top-twenty departments of neuroscience by adding their citations. Similarly, Oyer (2008) uses the methodology proposed by Kalaitzidakis, Mamuneas, and Stengos (2003) to rank universities based on the contribution of universities to the top thirty journals in economics selected by their normalised citation index. Chan et al. (2002) take a similar approach and use the number of pages produced by a university faculty in top journals to rank universities.

Objective measurements have clear advantages, for instance, the International Ranking Expert Group (IREG)[4] has a clear preference for indicators that: 1) reflect the quality of academic institutions; 2) are based on outputs rather than inputs; 3) assign stable weights to measure the relative importance of each indicator. However, the selection of indicators in (2) is a challenge since some of the outputs are also inputs in the production function of universities such as PhD graduates and researchers. In addition, the assignment of weights in (3) to output indications, can be problematic since it is not clear which mix of outputs, graduates-research-innovation, reflect better the true distribution of prestige. For instance, while ranking systems based on bibliometric indicators pay attention to research outputs, they overlook the production of graduates and other relevant measurements of academic excellence. For instance, Buela-Casal et al. (2011) and Buela-Casal et al. (2012) assess the higher education system in Spain using a mix of output indicators to rank universities based on indexed journal publications, the number of full-time researchers, number of R&D projects, PhD graduates, scholarships and patents. Additionally, scholars are well-known to work in silos or disciplines, that have different practices and ways of validating their work, for instance, a patent can have a greater contribution to prestige in applied sciences but a less perceived value in social sciences and humanities. Another issue is that academic prestige seems to be persistent and current levels of academic performance can have a low or no effect in predicting the future perception of university prestige (Burris,

[4] IREG, found by UNESCO European Centre for Higher Education (UNESCO-CEPES), revise regularly the *Berlin Principles*, which are a general philosophy and recommendations for rankings institutions of higher education.

2004).

Another way of building ranking systems is using subjective measurements that rather than only focusing on university outputs, attempt to capture the peers' perception of academic prestige. For instance, Abbott and Barlow (1972) use a survey of graduate faculty to rank universities in 29 disciplines with an ordinal response scale of five levels. However, a main problem with rankings based on subjective measurements is that they assume that scholars are unbiased of their current affiliation and past experiences within the very system they are evaluating (Fogarty & Saftner, 1993). Another issue with subjective measurements is that scholars tend to have partial information of the status of universities across the ranking that make the use of subjective measures of ranking weak. This is because, as pointed out by Cowan and Rossello (2018), the awareness of universities may be localized, that is, scholars usually have more knowledge about institutions that are closer in the prestige hierarchy to their own affiliation universities. For instance, institutions that are closer in rank are likely to compete for the same resources (projects and grants) and publish articles in similarly ranked academic journals.

A relatively new framework for measuring prestige is based on the idea that the distribution of prestige is shaped by a social process in which scholars recognize quality in their work and also cross-validate institutions by their interactions. In particular, we follow the study of Clauset et al. (2015) that developed a ranking to approximate institutional prestige based on movements in the academic labour market; and in particular, the study of Cowan and Rossello (2018) who analyze the effect of prestige university stratification on academic performance in the context of the South African science system. We argue that if scholars and universities seek to maximize their prestige, then movements in the labour market contain valuable information about how they judge each other's quality. Therefore, using this information has the main advantage of approximating the distribution of prestige by taking into account the pairwise assessment of quality between PhD graduates and universities directly from movements in the academic labour market. Moreover, academic communities in developing settings can have other means of validating their work in addition to the publication of research in high impact factor journals. Therefore this approach is better suited to capture the hierarchies of universities in developing countries.

3 Data

We use data from the National Council of Science and Technology (CONACYT) from Mexico. Our data derives from the *National System of Researchers* (NSR), the most important science policy that aims to increase the productivity, quality and competitiveness of Mexican researchers. This policy started in 1985 as a result of concerns about the performance and technological capabilities of the science system and due to pressure from Mexican researchers whose income was reduced by inflation and budget cuts. The policy has evolved through the years (Reyes Ruiz & Suriñach, 2015), but in general its structure has not changed substantially.

Researchers apply to the NSR with their curriculum vitae and are assigned to one of seven different research disciplines. In order to evaluate their academic performance the NSR assigns commissions of prominent researchers for each discipline that assess the performance of researchers following a peer review process (described in the Appendix C). A peer review evaluation has clear advantages over bibliometric measurements of performance since they encompass a more holistic academic evaluation that takes into account the validation practices of each discipline for this country. The evaluation systematizes the performance of researchers across disciplines in 5 ordered categories that correspond to different rates of academic performance that we use to measure individual academic performance.

In the field of Social Sciences and Humanities schools of thought can constrain in the PhD job-market. In order to alleviate this issue, we exclude from the analysis social sciences and humanities, and we keep only *hard sciences*.[5] The sample has *898* scholars that received their PhD diplomas and were hired in Mexican universities between 1992 and 2016 (25 years). Our analysis includes 36 Mexican institutions[6] and data are *longitudinal* and have records of academic performance of scholars along with individual level controls: *gender*, *discipline*, *graduation year* and *evaluation year*.

4 Interactive Prestige Ranking

Given the shortcomings of objective and subjective approaches to approximate the distribution of prestige, we employ an interactive ranking based on hiring networks of the Mexican science system. We define the social space of the academic labour market as a set of vertices (universities) $v \in V$, in total $|V| = n$ institutions, connected by a set of edges $e \in E$ that represent movements in the job-market. The PhD to first-job hiring network $G = (V, E)$ is a weighted directed adjacency matrix A presented in Table 2, whose diagonal elements capture *inbreeding* processes (PhDs that are trained and hired by their faculty) and off-diagonal elements movements of graduates from university i to their first academic job in university j. The flows of hiring and placement of scholars are *out-strength*: $str^{-}(v) = \sum_j A_{ij}$; and the *in-strength*: $str^{+}(v) = \sum_i A_{ij}$ of the network respectively.

We expect if universities and PhD graduates seek to maximize their prestige[7], then movements in the

[5] We include the CONACYT Reseach Areas: I, II, III, VI and VII. Respectively, Physics-Mathematics and Earth Sciences, Biology Chemistry and Life Sciences, Medicine and Health Sciences, Biotechnology and Agricultural Sciences, and Engineering. Details are in Appendix C.

[6] The list of institutions is presented in the Appendix A

[7] Our main assumption is that on average the mobility of scholars and hiring processes are driven by prestige maximisation and not by other idiosyncratic reasons such as geographical location and recruiting not based on merit.

academic labour market contain an emergent ordering of how universities and PhD graduates perceive each other's quality. Academic institutions increase their prestige if they hire PhD graduates from other universities of higher status. Similarly, PhD students are interested in graduating from universities of the highest status possible. If academic institutions perfectly satisfy their desire, it would be possible to order universities (the rows and columns of the adjacency matrix A), such that PhD graduates can only move down the ordering. In this scenario, the set of universities V has a unique order o^* or *n-tuples* and the matrix A is defined as an *upper triangular matrix*[8] when then sum of rows have a global maximum score s^*.

$$s^* = max \sum_i \sum_{j>i} A_{ij} \tag{1}$$

The labour market of PhD graduates departs from this *ideal* scenario if universities hire graduates from lower ranked institutions or PhD candidates get appointments at universities of higher prestige. Nevertheless, if on average universities maximize their prestige, there is a set of orders ($n-tuples$ that sort columns and rows) of A that gets closer to s^*. The proposed solution is to approach the underlying hierarchies in distribution of prestige by applying the heuristic algorithm proposed by Cowan and Rossello (2018) that calculates scores $S = \{s_1, s_2, \ldots, s_k\}$ from Equation 1 for a set of *n-tuples* $O = \{o_1, o_2, \ldots, o_k\}$ to find a set $Q = \{o_k \in O \mid s_k \approx s^*\}$ of orders that reach the highest scores. From this set of highest scores Q, they define a mapping function $R : v \in V \to o_k \in O$, that results in a set of orders whose elements are $r_k \subset o_k$ for each university $R(v) = \{r_1, r_2, \ldots, r_k\}$. The *rank* of each university is defined as the average of the elements in each set $R(v)$.[9]

$$R_v = k^{-1} \sum_{i=1}^{k} r_i \tag{2}$$

A key assumption of this algorithm is that the underlying hierarchy of prestige is captured by a single adjacency matrix A that constitutes all labour market movements over an interval of time. This assumption is consistent previous evidence that show persistence of prestige over the career of scholars and cumulative advantage of universities with higher endowments of social capital. However, because it is not clear if the underlying hierarchies are persistent over time in a less developed higher education system, we relax this assumption by adopting a *dynamic* computation of the algorithm. The proposed variation iterates the previous algorithm over closed intervals, $t = [y - \Delta, y + \Delta]$, of time centred around the PhD graduation year y, with fixed windows of $\Delta = 3$ years.[10] After the computation of the ranking, we distinguish between three

[8] A square matrix in which all entries below the main diagonal are zero.

[9] The details of the procedure are described the Algorithm 1 from Appendix B.

[10] The number of universities is very small in early years of the sample their analogous adjacency matrices yield trivial orders of small length. To overcome this, we aggregated the first years of the sample up to the year 2000.

groups of scholars, *Up*, *Down* and *Stay*, that exhibited different changes in the prestige during the transition between PhD graduation and first job in the following way. We calculate the difference between the rank of the PhD (R_i) and the rank of the first job institution (R_j), which is $\Delta R = R_i - R_j$ for each researcher in the sample. The group of scholars that move *Up* in the hierarchy are those for which $\Delta R > 0$, the group that move *Down* are those that have $\Delta R < 0$ and scholars who are hired by their faculty have $\Delta R = 0$.

5 Prestige Ranking Results

Table 1 outputs the ranking of Mexican universities using the dynamic ranking of 3 years. The dynamic computation of the ranking is robust against potential changes in the distribution of prestige across time. However, not all institutions are present across t intervals, for instance, more recent universities are not listed in the early years of the sample. Hence, the computation of the scores presented in Table 1 is given by the average score of each university i over t intervals of time, given that $i \in t$.

Table 1: Ranking Mexican Universities 1992-2016 for Hard Sciences.

Tier 1	Tier 2	Tier 3	Tier 4
1. CINVESTAV[a]	10. UAM	19. BUAP	28. TEC
(2.5294)	(2.684)	(3.203)	(4.8494)
2. CICESE	11. UAEM	20. UASLP	29. UDG
(2.6497)	(4.0295)	(3.5339)	(3.9136)
3. UNAM	12. INECOL	21. CIMAV	30. UGTO
(1.3432)	(4.3667)	(4.7517)	(3.8549)
4. CINVESTAV[b]	13. IBERO	22. IPN	31. IMSS
(2.0916)	(7.3052)	(3.0192)	(3.7836)
5. IMP	14. CICY	23. UV	32. UNISON
(2.4086)	(4.641)	(4.778)	(5.8237)
6. ECOSUR	15. CIO	24. UADY	33. UMICH
(3.0022)	(4.8308)	(6.7742)	(4.8774)
7. IPICYT	16. COLPOS	25. UAEM	34. UAEH
(4.5405)	(4.937)	(3.8454)	(4.6305)
8. CIBINOR	17. CIQA	26. UCOL	35. UANL
(4.8267)	(6.7092)	(4.6986)	(3.8814)
9. INAOE	18. CIAD	27. UAQ	36. TECNM
(4.3645)	(6.5083)	(6.3504)	(3.2274)

[a] Zacatenco unit.
[b] All units but Zacatenco.
(*) Brackets correspond to standard deviations.
Full names of universities are listed in Appendix A.

Table 2 presents a aggregate adjacency matrix to illustrate the PhD to first job dynamics present across the sample. With respect to movement in the prestige hierarchy, Table 3 shows how the different prestige movements from PhD to first-job are distributed over the prestige hierarchy. We find a high level of strat-

Table 2: PhD to First-Job Mexican Faculty Hiring Matrix 1992-2016 for Hard Sciences.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1. CINVESTAV[a]	0	0	2	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2. CICESE	0	5	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0
3. UNAM	0	1	178	10	3	2	2	2	2	13	11	3	0	2	1	0	1	2	7	2	1	30	4	0	4	1	3	7	6	5	0	2	6	10	2	4
4. CINVESTAV[b]	0	1	9	22	1	0	0	0	0	0	1	1	0	4	0	0	0	2	4	6	2	12	1	1	1	5	0	1	4	5	2	2	3	2	5	2
5. IMP	0	0	2	0	16	0	0	0	0	0	3	0	0	1	0	0	0	0	1	1	0	5	2	0	0	0	0	1	1	0	0	0	1	0	0	2
6. ECOSUR	0	0	2	0	0	2	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7. IPICYT	0	0	2	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	3	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0
8. CIBINOR	0	1	1	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
9. INAOE	0	0	2	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	2	0	0	0	0	0	0	1
10. UAM	0	0	4	1	0	0	0	0	0	16	0	0	0	0	0	1	0	0	2	2	0	5	1	0	1	0	0	0	0	0	0	0	2	1	0	0
11. UAEM	0	0	7	0	1	0	0	0	0	1	7	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	1	0	0	0	0	0	0	1
12. INECOL	0	0	1	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
13. IBERO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
14. CICY	0	0	2	3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	2
15. CIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0
16. COLPOS	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17. CIQA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
18. CIAD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	1
19. BUAP	1	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	9	1	0	2	1	0	0	0	0	0	0	0	0	0	1	1	0	0
20. UASLP	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	9	0	0	1	0	1	0	0	0	1	1	0	0	0	1	1	0
21. CIMAV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
22. IPN	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	2	0	1	2	1	1
23. UV	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	2
24. UADY	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
25. UAEM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1
26. UCOL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1
27. UAQ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1
28. TEC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	1
29. UDG	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	1	0	0	0	0	1
30. UGTO	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	3	0	0	0	0	0	0
31. IMSS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0
32. UNISON	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0
33. UMICH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
34. UAEH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
35. UANL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	6	0
36. TECNM	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

Entries in the matrix correspond to the number of PhD graduates from university i hired by university j for their first-job. Full names of universities are listed in Appendix A.

Table 3: Prestige movements per university prestige 1992-2016

	down	stay	up	tot %
PhD Tier 1	304	283	17	68 %
PhD Tier 2	54	49	22	14 %
PhD Tier 3	38	48	12	10 %
PhD Tier 4	10	47	14	8 %
Job Tier 1	49	283	46	42 %
Job Tier 2	64	49	13	14 %
Job Tier 3	144	48	2	22 %
Job Tier 4	149	47	4	22 %

ification in the Mexican university system, with 68% of PhD graduates produced in the 10 top prestigious universities and nearly half of these hired (in these institutions) as their first-job.

6 Matched Pairs Analysis

In this section, we compare how changes of institutional prestige in the transition from PhD graduation to the first-job relates to future academic performance. To compare academic performance we match pairs of scholars in the three groups, *Up*, *Down* and *Stay*, holding constant individual characteristics and placement or hiring institution. Holding constant the PhD granting institution allows us to compare how changes in prestige relate to academic performance irrespective of training. Similarly, matching scholars by their first-job produces insights into how movements of prestige affect scholars with the same first appointment in the labour market. Because we expect that changes in prestige during early-career can have consequences for future development, we match and compare the performance between groups after PhD graduation in *short (Up to 2 years), medium (3-5 years) and long-run (6-25 years).*

We use a re-sampling technique to randomly generate $n = 1000$ bootstrap samples of size s for each group $g = \{Down, Stay, Up\}$. We further pair scholars between groups holding constant their individual characteristics: *gender, age, discipline and graduation year.* In order to compare their performance, we estimate the proportion of pairs, $p^* = (p_1, p_2, \ldots, p_n)$, in which one group g^α receives a higher NSR level than the other (group) g^β.

$$p_n^\alpha = s^{-1} \sum_{i=1}^{s} I(g_i^\beta < g_i^\alpha) \tag{3}$$

$$I(g_i^\beta < g_i^\alpha) = \begin{cases} 1, & \text{if } g_i^\beta < g_i^\alpha \\ 0, & \text{Otherwise.} \end{cases}$$

For each comparison *Up vs Stay*, *Down vs Stay* and *Up vs Stay*, we estimate two p^* for each group and construct their $F(p^*)$ cumulative empirical distribution function *(CEDF)*. To assess the performance of one group over the other we test for first order stochastic dominance (Levy, 1992). This test implies higher performance of g^α over g^β if $F(p^\alpha) \leq F(p^\beta)$ for all p^*.[11] We compare the two CEDFs by using a Kolmogorov–Smirnov test (*KS test*). First we run a *two-sided* test that specifies a null hypothesis, H_{01} : $F(p^\alpha) = F(p^\beta)$, that the two CEDF are drawn from the same distribution. Rejecting the null hypothesis H_{01} provides evidence that the relationship between academic performance and changes in prestige is statistically different between the two groups. If the H_{01} is rejected we conduct a *one-sided* test, here the null is $H_{02} : F(p^\alpha) \geq F(p^\beta)$ that the distribution function of $F(p^\alpha)$ is equal to or not less than $F(p^\beta)$. Rejecting the null implies that we find evidence to infer that $F(p^\alpha)$ stichastically dominates $F(p^\beta)$, in other words,

[11] Graphically this is inspected if $F(p^\alpha)$ lies below and to the right of $F(p^\beta)$.

that the increase in academic performance associated with a change of prestige from group g^{α} is statistically different from g^{β}.

7 Matched Pairs Results

In this section we present graphically the CEDF of the proportion in which one group received a higher NSR rating than the other. We compare Up vs. Stay, Down vs. Stay, and Up vs. Down in the short, medium and long-run. The changes in prestige of the groups are the output of the dynamic computation of the interactive ranking with a moving time window of 3 years[12] [13]. Results using the static rank are in Appendix D. In each comparison CEDFs are different and one group always stochastically dominates the other. Results of the KS-test of H_{01} and H_{02} are in Appendix E. We find consistent results both using the dynamic and the static rank. The similarities between both results do not necessarily suggest that the distribution of prestige is stationary but rather that the association between changes in prestige during early career and academic performance are consistent, irrespective of changes in the hierarchy. The static rank captures the structure of prestige that arises as a result of all the labour market movements in our sample. But the dynamic rank captures the distribution of prestige at several points in time and is more robust against potential changes in the underlying hierarchy of universities over the career of scholars.

Figure 1 shows the comparison between the performance of pairs of scholars that *Stay* and move *Up* the hierarchy. We look at the NSR performance of scholars with the same characteristics who are hired by their faculty after PhD graduation versus scholars that move upward in the prestige hierarchy during their first job. Figures on the left-hand side match scholars with the same PhD institution and figures on the right-hand side control for the first-job institution. In this way, we compare scholar with same PhD (or first-job) institution but different movements in the prestige hierarchy to control for PhD (or first-job) training. In both cases, the CEDF of $Stay > Up$ (solid lines), is located below that of $Up > Stay$ (dashed lines) implying that the *Stay* group stochastically dominates the *Up* group. This suggests, on the one hand, that scholars with the same PhD (left-plots) who are hired by their faculty after PhD graduation have on average a better NSF level of performance than the group that move to more prestigious positions. On the other hand, looking at scholars with the same first-job (right-plots) we find that those hired internally have on average higher performance than those moving up from less prestigious PhDs. In other words, the proportion of scholars that have higher academic performance is bigger in the *Stay* group in comparison to the *Up* group. These results suggest that scholars that manage to secure positions at their faculty after graduation demonstrate

[12] Details on the dynamic rank computation are in section 4.

[13] We execute the algorithm with a time window of $\Delta = 3$ and run robustness checks using other time ranges ($\Delta = 5$ and $\Delta = 8$) and our results are consistent.

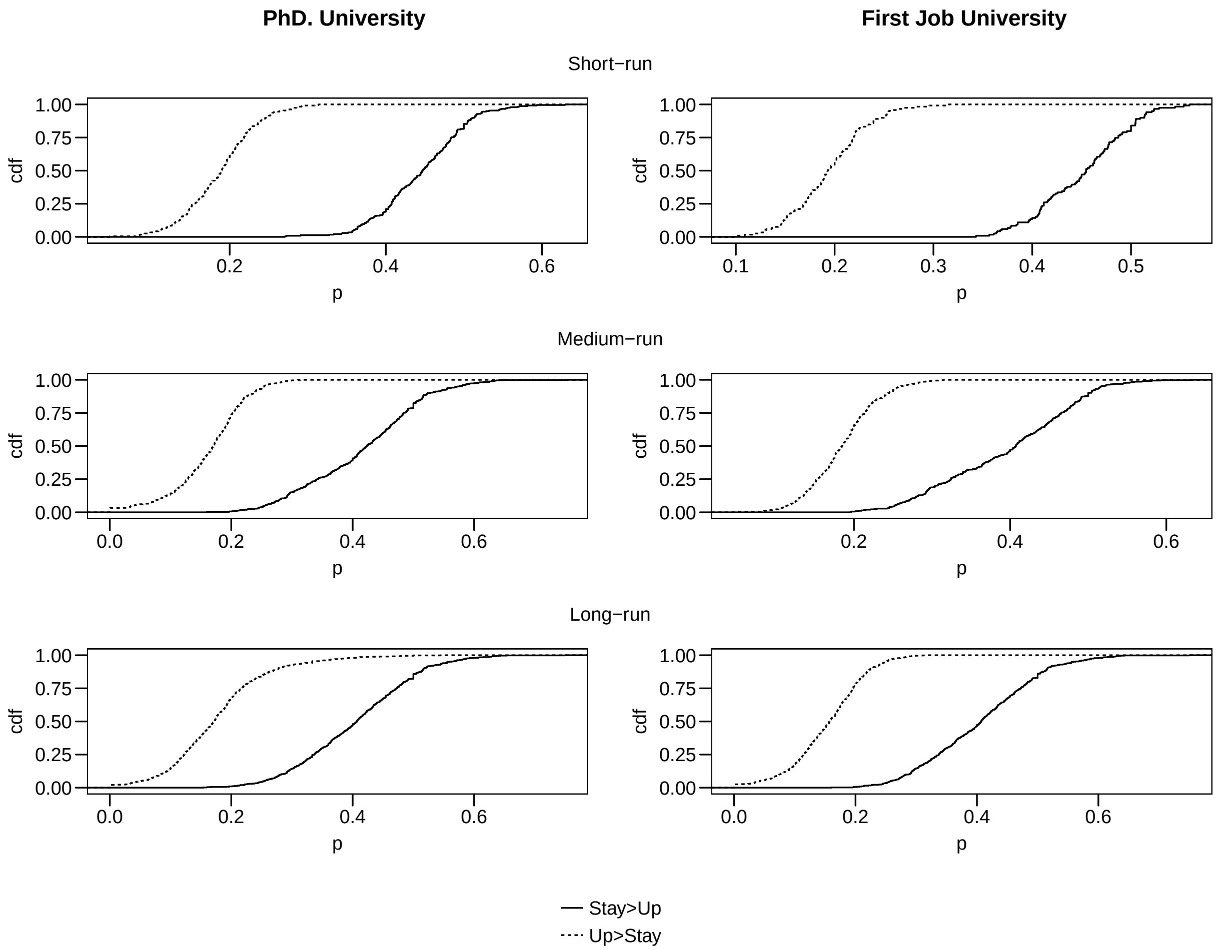

Figure 1: Up versus Stay comparison. The solid curves are CEDFs of the proportion of pairs in which $R_{Stay} > R_{Up}$. Dotted curves are CEDFs for $R_{Up} > R_{Stay}$. Pairs matched by gender, age, discipline, graduation years, and same PhD university (left), or same first-job university (right). From top to bottom: short-run (Up to 2 years), medium-run (3-5 years), and long-run (6-25 years) after PhD graduation.

higher NSR levels of performance than those who migrate to upper ranked institutions.

Figure 2 shows the results of the comparison between the *Down* and *Stay* groups. In this case, we compare scholars that take academic positions in their faculties after graduation and PhD graduates that move down the ranking during their first job. We find that the CEDF $Stay > Down$ stochastically dominates $Down > Stay$, and these results are unvarying if we keep constant their PhD or first-job institution. In line with our previous results, plots on the left-hand side show that scholars with the same PhD training that move down to a less prestigious institution in their first-job tend to have a lower NSR rating than those who stay in the university granting their PhD. Similarly, plots on the right-hand side compare scholars with the same first-job and indicate that those hired internally (stay), have a higher performance than those moving down from more prestigious PhDs.

Finally, in Figure 3 we compare groups of scholars who experience upward and downward prestige mo-

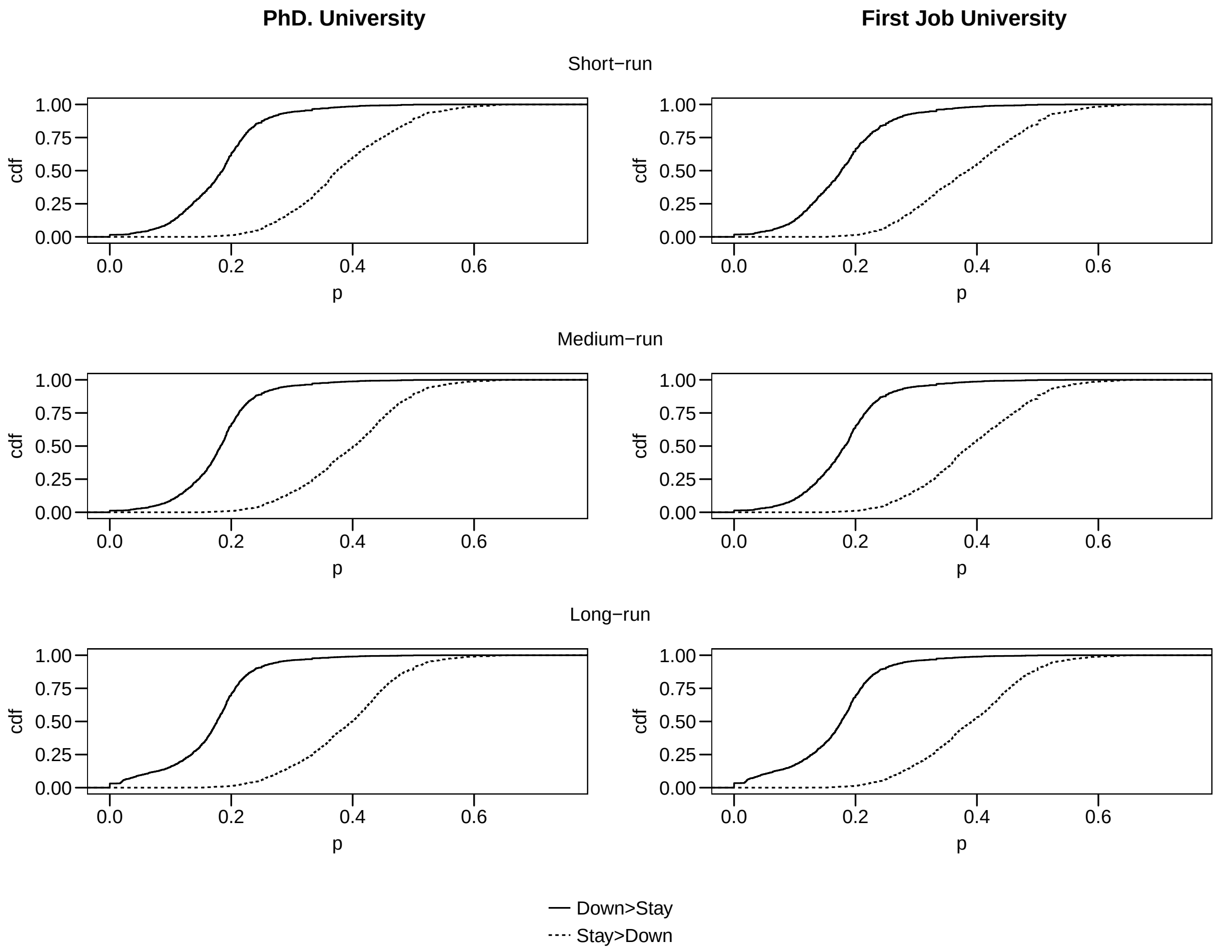

Figure 2: Down versus Stay comparison. The solid curves are CEDFs of the proportion of pairs in which $R_{Down} > R_{Stay}$. Dotted curves are CEDFs for $R_{Stay} > R_{Down}$. Pairs matched by gender, age, discipline, graduation years, and same PhD university (left), or same first-job university (right). From top to bottom: short-run (Up to 2 years), medium-run (3-5 years), and long-run (6-25 years) after PhD graduation.

bility. The CEDF of the proportions of scholars' performance where $Down > Up$ stochastically dominate $Up > Down$, display that scholars who experience downward prestige mobility sustain higher performance over their career than those experiencing upward mobility. These results are mostly unchanged when we allow ranking variation during the first job but keep constant the PhD institutions (left-plots) and also when we hold constant their first-job university (right-plots) to control for their PhD training. In the first case matching pairs of scholars with the same PhD, we find that those moving down the hierarchy have higher performance than those moving up to more prestigious first job institutions. The second pairing of scholars with the same first job but different PhDs institution, we find that those coming from more prestigious PhDs (down) have a higher NSI rating on average than those moving up from less prestigious PhD institutions.

These results seem counter-intuitive at first glance since most studies have associated upward ranking mobility with higher academic performance (holding PhD institution constant). What is most interesting is

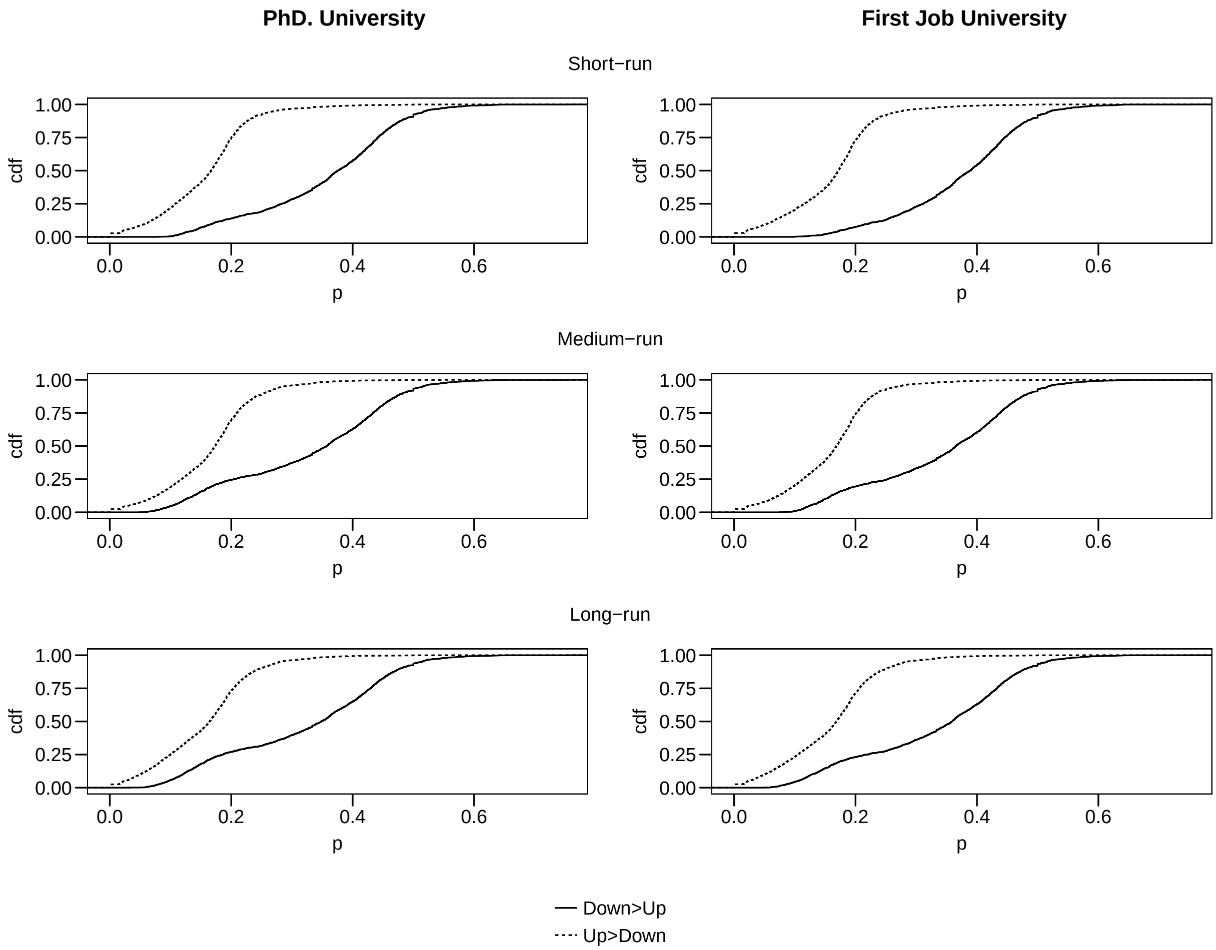

Figure 3: Down versus Stay comparison. The solid curves are CEDFs of the proportion of pairs in which $R_{Down} > R_{Stay}$. Dotted curves are CEDFs for $R_{Stay} > R_{Down}$. Pairs matched by gender, age, discipline, graduation years, and same PhD university (left), or same first-job university (right). From top to bottom: short-run (Up to 2 years), medium-run (3-5 years), and long-run (6-25 years) after PhD graduation.

that this pattern is maintained through the career of scholars, for both estimations using a dynamic rank (Figure 3) and static rank (Appendix D); nevertheless these findings require further scrutiny. Moreover, we should consider that those that start high in the hierarchy have few options to move up the ranking and they are more likely to move down, while the opposite is true for those low in the prestige hierarchy. This implies that those moving up (down) are more likely to have PhDs in less (more) prestigious institutions.

7.1 Regression Analysis: Ordinal Logistic Regression

In this final sub-section we undertake a regression analysis that complements the stochastic analysis. A full econometric analysis is beyond the scope of this paper, with the aim of this sub-section simply being to consider whether the correlations that we identified in the stochastic analysis above can be found in an alternative framework. The approach adopted involves considering the relationship between changes in prestige and academic performance using an *Ordinal Logistic Regression*. The dependent variable in this framework is an ordinal categorical variable y with $j \in J$ levels. The ordinal logistic model for y can be derived from a latent variable model, with the latent variable, y^* being determined by

$$y^* = X\beta + \epsilon$$

where X is a matrix of co-variates (excluding a constant) independent of the errors $E[\epsilon|X] \sim \mathcal{N}(0, \sigma^2)$. Letting $\alpha_1 < \alpha_2 < ... < \alpha_J$ be unknown threshold parameters, we can define:

$$y = \begin{cases} 0, & \text{if } y^* \leq \alpha_1 \\ 1, & \text{if if } \alpha_1 \leq y^* \leq \alpha_2 \\ \vdots & \\ J, & \text{if } y^* > \alpha_J \end{cases}$$

This means that there are *J-1* cutoffs to consider. The response probability for each outcome provides us with the conditional distribution of y given X, i.e.,

$$P(y = 0|X) = P(y^* \leq \alpha_1|x) = P(X\beta + \epsilon \leq \alpha_1|X) = \Lambda(\alpha_1 - X\beta)$$

$$P(y = 1|X) = P(\alpha_1 < y^* \leq \alpha_2|X) = \Lambda(\alpha_2 - X\beta) - \Lambda(\alpha_1 - X\beta)$$

$$\vdots$$

$$P(y = J - 1|X) = P(\alpha_J - 1 < y^* \leq \alpha_J|X) = \Lambda(\alpha_J - X\beta) - \Lambda(\alpha_J - 1 - X\beta)$$

$$P(y = J|X) = P(y^* > \alpha_J|X) = 1 - \Lambda(\alpha_J - X\beta)$$

with Λ being the logit function. It should be remembered that, in general, we are not interested in the estimated β's, which refer to the impact of a variable on the latent variable, but instead on the response probabilities, i.e. $P(y = j|X)$.

In our case, the dependent variable is an ordinal categorical variable that takes on five potential values, and in particular the five levels of academic performance of researchers from the peer review evaluation that was discussed in Section 3. As explanatory variables we include in our model controls for the prestige of PhD institution, age, gender, year of PhD graduation and discipline of scholars, the definitions of which are again described in the data section above. Our main explanatory variables are dummy variables indicating whether the individual moved up, moved down or remained in the same institute following PhD graduation.

In Table 4 we report results from a number of specifications of our ordinal logistic regression. Of particular interest to us are the results in Models 2 and 3, which include the dummy variables for individuals that move up or stay in the same institution. Results from these two models suggest a positive and significant association between future performance and scholars that are hired by their own institute after their PhD in comparison to those who move down. Given the lack of a significant relationship between moving up and performance, the results also suggest that scholars that remain in the same institute after completing their PhD also perform better than those that move up.

As already discussed, the coefficients reported in Table 4 are not particularly informative. Instead, therefore, we report in Table 5 the odds ratios for Model 3. The odds ratio for the variable *Stay* indicates that staying in the same institution (i.e. Stay = 1) increases the odds of being in category 5 (i.e. the highest performance category) versus being in the other four categories combined by a factor of 1.42. The results thus support the results found above, suggesting that remaining in the same institute after graduation has beneficial effects for future performance, with this effect being robust to the inclusion of a number of individual specific controls. The odds ratios for the other variables can be interpreted in a similar fashion. For PhD graduates from the *Top-10* institutions, the odds of having top performance increases by a factor of 1.683, with graduates from these institutes reporting a better chance of achieving higher levels of academic performance in comparison to universities down the hierarchy. In terms of the remaining variables, we find some evidence to suggest that the odds of achieving top performance is higher for males in the sample, with a reduction in the odds observed for graduates in disciplines II, III and VI, that correspond to Biology, Chemistry and Life Sciences; Medicine and Health Sciences and Biotechnology and Agricultural Sciences.

Table 4: Ordinal logistic regression: changes of prestige on academic performance.

	Model 1	Model 2	Model 3
PhD-Top-10	0.40860		0.52041^{*}
	(0.23103)		(0.23784)
PhD-Top-20	−0.04998		−0.07218
	(0.19665)		(0.19566)
PhD-Top-30	0.09305		0.07570
	(0.15779)		(0.15924)
Up		0.01439	0.19335
		(0.21731)	(0.23386)
Stay		0.30306^{*}	0.34912^{**}
		(0.11890)	(0.12012)
Male	0.37390^{**}	0.40277^{***}	0.40828^{***}
	(0.11388)	(0.11260)	(0.11415)
Age	0.01767	0.01921	0.01764
	(0.01365)	(0.01383)	(0.01385)
Discipline II	−0.19528	−0.17127	−0.17966
	(0.15857)	(0.15540)	(0.15630)
Discipline III	−0.45132	−0.53938	−0.46020
	(0.31462)	(0.30761)	(0.31410)
Discipline VI	-0.56758^{**}	-0.57312^{**}	-0.55852^{**}
	(0.21150)	(0.20922)	(0.21395)
Discipline VII	0.05683	0.04987	0.08791
	(0.17391)	(0.17424)	(0.17439)
AIC	9982.40999	9972.24112	9954.94310
BIC	10247.63255	10230.99483	10233.10335
Log Likelihood	-4950.20500	-4946.12056	-4934.47155
Deviance	9900.40999	9892.24112	9868.94310
Num. obs.	4764	4764	4764

Clustered standard errors (individual): $^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$

Table 5: Odds ratios Model 3 with confidence Intervals

	Δ Odd ratio	2.5 %	97.5 %
PhD-Top-10	1.683	1.263	2.240
PhD-Top-20	0.930	0.735	1.177
PhD-Top-30	1.079	0.899	1.294
Up	1.213	0.952	1.549
Stay	1.418	1.255	1.602
Male	1.504	1.338	1.691
Age	1.018	1.005	1.031
Discipline II	0.836	0.713	0.978
Discipline III	0.631	0.486	0.820
Discipline VI	0.572	0.461	0.708
Discipline VII	1.092	0.906	1.316

8 Discussion and Conclusion

Many studies show a positive association between the prestige of the PhD university and the future placement of scholars in the academic labour market (Crane, 1970; Long et al., 1979; Debackere & Rappa, 1995; Bedeian et al., 2010; Lawson & Shibayama, 2015). However, few studies pay attention to how changes in prestige from PhD to first-job relate to academic performance, especially in the medium and long-run. Our work, to our knowledge, is the first that studies university stratification in the Mexican higher education system by adopting an interactive ranking based on the PhD hiring networks. The majority of studies have looked mostly at university systems in the U.S, where mobility after the PhD tends to be high because universities have hiring practices that prevent them from hiring their own graduates immediately after the PhD.

Our first main finding indicates that those PhD candidates that are hired by their faculty after graduation exhibit sustained higher NSR levels of academic performance throughout their careers than those who experience changes of prestige. Those hired internally have a sustained higher performance throughout their career in comparison to those moving (no matter how in the hierarchy). One implication of this finding is that the academic labour market works better when hiring is internal. Faculties are capable of distinguishing potential from their PhD graduates and those who are hired will perform better through their careers. The second main finding is that those PhD graduates that move down the university hierarchy perform on average better than those going up. On the one hand, when we hold PhD institution constant, those hired in less prestigious universities (downward mobility), perform better than those that get positions at higher ranked institutions which suggests that upward mobility is negatively associated with academic performance. On the other hand, holding first-job constant, those moving down from more prestigious institutions perform better than those moving up from less prestigious PhD institutions. This underlines the importance of PhD training on performance.

Our findings in general suggest that there is a negative relation between mobility during early-career and academic performance. Moreover, when we decompose mobility looking at prestige differentials between PhD and first-job institution, we find that scholars that *Stay* or move *Down* the hierarchy remain mostly in first-tier (top 10) institutions. Those moving *Up* the hierarchy, get their PhD degree mostly from second-tier (bottom 30) institutions but move to first-tier institutions with their first job. This is an expected result in the light that those graduating from prestigious universities have fewer possibilities to move higher in the hierarchy. Our results of the matched pairs analysis provide evidence of the same association of prestige movements and performance in the short-, medium- and long-run. Further comparing those moving up with those moving down the hierarchy we find that those moving down have sustained higher performance than those moving up. These patterns suggest, on the one hand, that, given the same PhD institution, those moving down the hierarchy perform better than those moving up into more prestigious first-job institutions. On the other hand, that prestige during the PhD training years positively relates to performance. Given the same first-job, those performing better are those with more prestigious PhDs.

The reasons why promising scholars who move upwards in the prestige hierarchy after PhD have lower performance than their colleagues (with the same PhD) that stay or move downwards in prestige are interesting and require further investigation. This is true in particular for those who make large movements in prestige from the PhD to the first-job, from second-tier to top-tier institutions. Second-tier universities at the periphery of the global science frontier may have competitive advantages in specialising in niche research, where publication, citations, and visibility can work differently and payoff after many decades. So scholars experiencing upward mobility from second-tier to top-tier institutions may be specialised in niche areas where the evaluation of the scientific contribution can be difficult and disputable. Another explanation can be related to the social aspect of doing research. In the fields of Science Engineering and Technology, team-work is crucial, such that moving at an early stage implies changing teams. Especially in emerging countries, laboratories and facilities in universities are limited and research teams have to allocate space and materials among themselves and decide the lines of research to follow in the next years. At the beginning of a career, to enter these dynamics as an outsider is not always easy. In such cases, other psychological considerations may play a role. A young graduate from a second-tier university moving to a first-tier may be perceived as an outsider and face high levels of pressure. Related to this, the literature on psychology refers to the so-called "big-fish-small-pond" effect where moving from an environment where one is considered a high achiever to one where the others have similar high (lower) performance is detrimental (beneficial) on both self-perception and performance (Marsh & Hau, 2003; Werts & Watley, 1969; Astin, 1969; Marsh et al., 2008). In line with this literature, scholars that graduate from prestigious universities and move down the hierarchy may have higher self-perception in comparison to those moving up which could explain the differences in performance.

Similarly to the higher education system in the U.S. and other developed economies, we find a large stratification in the Mexican university system but low mobility (around 50% of PhD graduates are hired by their faculty), with a few prestigious institutions (around 10) producing the majority of PhD graduates that are subsequently mostly hired in these same institutions. A high concentration of prominent scholars in a few academic institutions reveals large inequalities in the distribution of prestige. The stratification of higher education could promote higher levels of specialization with a targeted allocation of resources. On the other hand, it can also reveal a structural problem in the science system, a "lock-in", where researchers are trained and hired by elite institutions and flows of knowledge are reduced throughout the national science system.

Appendices

A Faculty Hiring Matrix Names

	ABBREVIATION	NAMES
1	CINVESTAV(ZACATENCO)	CENTRO DE INVESTIGACION Y DE ESTUDIOS AVANZADOS DEL I.P.N. - UNIDAD ZACATENCO
2	CICESE	CENTRO DE INVESTIGACION CIENTIFICA Y DE EDUCACION SUPERIOR DE ENSENADA
3	UNAM	UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
4	CINVESTAV(OTHERS)	CENTRO DE INVESTIGACION Y DE ESTUDIOS AVANZADOS DEL INSTITUTO POLITECNICO NACIONAL
5	IMP	INSTITUTO MEXICANO DEL PETROLEO
6	ECOSUR	EL COLEGIO DE LA FRONTERA SUR
7	IPICYT	INSTITUTO POTOSINO DE INVESTIGACION CIENTIFICA Y TECNOLOGICA AC
8	CIBINOR	CENTRO DE INVESTIGACIONES BIOLOGICAS DEL NOROESTE SC
9	INAOE	INSTITUTO NACIONAL DE ASTROFISICA OPTICA Y ELECTRONICA
10	UAM	UNIVERSIDAD AUTONOMA METROPOLITANA
11	UAEM	UNIVERSIDAD AUTONOMA DEL ESTADO DE MORELOS
12	INECOL	INSTITUTO DE ECOLOGIA, A.C
13	IBERO	UNIVERSIDAD IBEROAMERICANA AC
14	CICY	CENTRO DE INVESTIGACION CIENTIFICA DE YUCATAN AC
15	CIO	CENTRO DE INVESTIGACIONES EN OPTICA AC
16	COLPOS	COLEGIO DE POSTGRADUADOS
17	CIQA	CENTRO DE INVESTIGACION EN QUIMICA APLICADA, A.C
18	CIAD	CENTRO DE INVESTIGACION EN ALIMENTACION Y DESARROLLO AC
19	BUAP	BENEMERITA UNIVERSIDAD AUTONOMA DE PUEBLA
20	UASLP	UNIVERSIDAD AUTONOMA DE SAN LUIS POTOSI
21	CIMAV	CENTRO DE INVESTIGACION EN MATERIALES AVANZADOS SC
22	IPN	INSTITUTO POLITECNICO NACIONAL
23	UV	UNIVERSIDAD VERACRUZANA
24	UADY	UNIVERSIDAD AUTONOMA DE YUCATAN
25	UAEM	UNIVERSIDAD AUTONOMA DEL ESTADO DE MEXICO
26	UCOL	UNIVERSIDAD DE COLIMA
27	UAQ	UNIVERSIDAD AUTONOMA DE QUERETARO
28	TEC	INSTITUTO TECNOLOGICO Y DE ESTUDIOS SUPERIORES DE MONTERREY
29	UDG	UNIVERSIDAD DE GUADALAJARA
30	UGTO	UNIVERSIDAD DE GUANAJUATO
31	IMSS	INSTITUTO MEXICANO DEL SEGURO SOCIAL
32	UNISON	UNIVERSIDAD DE SONORA
33	UMICH	UNIVERSIDAD MICHOACANA DE SAN NICOLAS DE HIDALGO
34	UAEH	UNIVERSIDAD AUTONOMA DEL ESTADO DE HIDALGO
35	UANL	UNIVERSIDAD AUTONOMA DE NUEVO LEON
36	TECNM	TECNOLOGICO NACIONAL DE MEXICO

B Prestige Ranking Algorithm by Cowan and Rossello (2018)

```
/* Input:  A:= weighted directed Adjacency Matrix with zero entries in the main
   diagonal.                                                                  */
sk:= A top-score defined with an arbitrary small initial value;
S:= An empty vector of max scores;
O:= An empty matrix of orders with u columns;
for i = 0 to n do
    o0:= Generate a random n-tuple of length u;
    M:= Sort the matrix A by o0;
    s0:= Compute current score by adding the upper triangular elements of M by row;
    /* Local Search                                                           */
    for i = 0 to n do
        o1:= Swap randomly two elements of o0;
        M:= Sort the matrix M by o1;
        s1:= Compute swap score by adding the upper triangular elements of M by row;
        if s1 ⩾ s0 then
            M:= Sort the matrix A by o1;
            sk:= Update the top-score by s1;
        end if
    end for
    dif:= Compute difference between s1 and sk;
    if dif > 0 then
        sk:= Update the top-score by s1;
        S:= Add the current score sk as an element of S ;
        O:= Add a row of orders given by s1 ;
    end if
end for
/* Output1:  S:= A set of highest scores                                      */
/* Output2:  O:= A matrix of orders for each element in S                     */
```

Algorithm 1: Prestige Ranking Algorithm by Cowan and Rossello (2018).

C NSR: Disciplines, Evaluation and Commissions

Disciplines

Area I	Physics-Mathematics and Earth Sciences
Area II	Biology, Chemistry, Life Sciences
Area III	Medicine and Health Sciences
Area IV	Humanities and Behavioural Sciences
Area V	Social Sciences
Area VI	Biotechnology and Agricultural Sciences
Area VII	Engineering

Commissions

The members of the "Evaluation Commission" are designated by the "Council of Approval", the highest authority in the "National System of Researchers" (NSR). Once the Evaluation Commission is designated and formalised it will run for a period of 3 years. The Evaluation Commission has the obligation to review applications of new and incumbent members of the NSR.

Evaluation

The "Evaluation Commission" reviews each application assessing both the quality and the quantity of the research output. Each application is evaluated by at least two members of the commission. The evaluation takes into consideration primarily the research output, but also human capital formation (number of supervisions) and linkages with industry and the public sector, updates in study plans and publication of dissemination articles. The research output include: Articles, Books, Book Chapters, Patents, Technological Developments, Innovations and Transfers of Technology.

Levels of Rewards:

- SNI Candidates[14]: Granted for 3 years, with the possibility of 2 years of extension.

- Level I: Granted for 3 years the first time, and every 4 years in the following periods.

- Level II: Granted for 4 years the first time, and every 5 years in the following periods.

- Level III: Granted for 5 years the first and second time, and every 10 years in the following periods.

- Emeritus Professors: Candidates must have 65 years of more, and have accumulated at least three periods of level III distinction (15 years) without interruption.

[14]Applicants can only receive this distinction one time.

D Results Static Rank

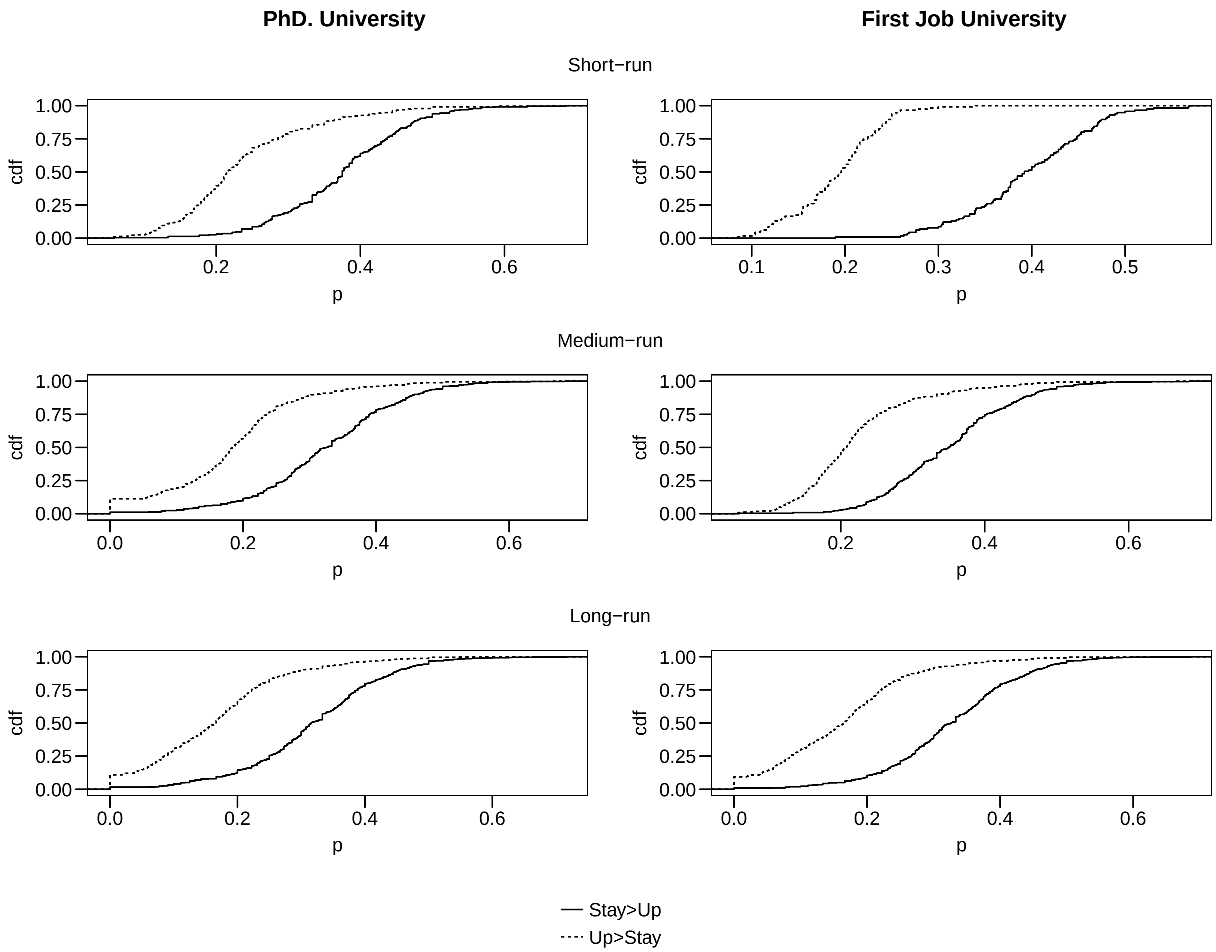

Figure 4: Stochastic Analysis of **Up vs Stay**.

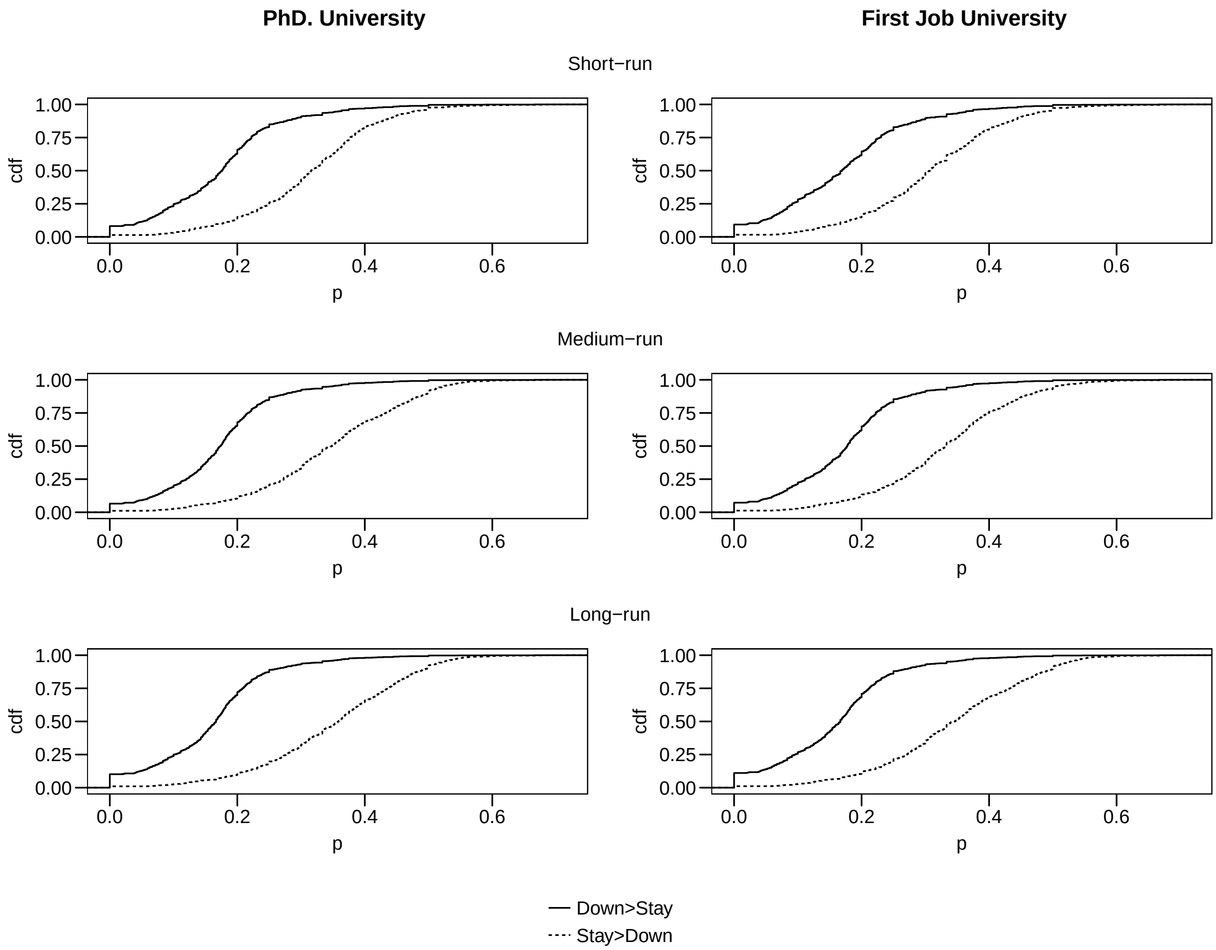

Figure 5: Stochastic Analysis of **Stay vs Down**.

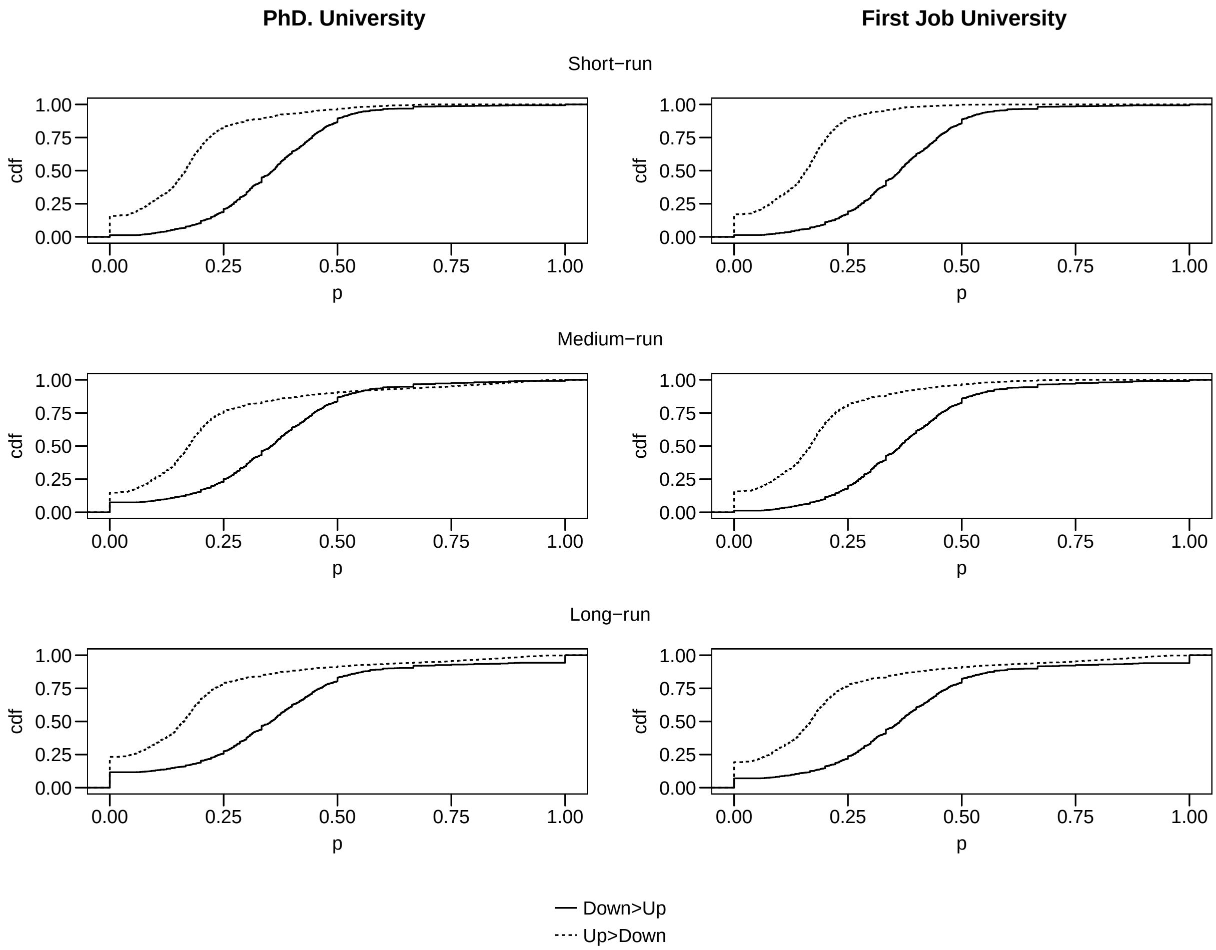

Figure 6: Stochastic Analysis of **Stay vs Down**.

E KS-Test Results

Table 6: KS-Test Results for Phd and First-job Matches.

PhD Matches

$Null : H_0$	Short-run	Med-run	Long-run
$F(p^{Up}) = F(p^{Stay})$	D=0.9874; pvalue=0	D=0.9097; pvalue=0	D=0.8165; pvalue=0
$F(p^{Up}) \leq F(p^{Stay})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Up}) \geq F(p^{Stay})$	D=0.9874; pvalue=0	D=0.9097; pvalue=0	D=0.8165; pvalue=0
$F(p^{Down}) = F(p^{Stay})$	D=0.812; pvalue=0	D=0.8487; pvalue=0	D=0.8564; pvalue=0
$F(p^{Down}) \leq F(p^{Stay})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Down}) \geq F(p^{Stay})$	D=0.812; pvalue=0	D=0.8487; pvalue=0	D=0.8564; pvalue=0
$F(p^{Up}) = F(p^{Down})$	D=0.7353; pvalue=0	D=0.6077; pvalue=0	D=0.5924; pvalue=0
$F(p^{Up}) \leq F(p^{Down})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Up}) \geq F(p^{Down})$	D=0.7353; pvalue=0	D=0.6077; pvalue=0	D=0.5924; pvalue=0

First-Job Matches

$Null : H_0$	Short-run	Med-run	Long-run
$F(p^{Up}) = F(p^{Stay})$	D=0.9227; pvalue=0	D=0.888; pvalue=0	D=0.9227; pvalue=0
$F(p^{Up}) \leq F(p^{Stay})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Up}) \geq F(p^{Stay})$	D=0.9227; pvalue=0	D=0.888; pvalue=0	D=0.9227; pvalue=0
$F(p^{Down}) = F(p^{Stay})$	D=0.8434; pvalue=0	D=0.8319; pvalue=0	D=0.8434; pvalue=0
$F(p^{Down}) \leq F(p^{Stay})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Down}) \geq F(p^{Stay})$	D=0.8434; pvalue=0	D=0.8319; pvalue=0	D=0.8434; pvalue=0
$F(p^{Up}) = F(p^{Down})$	D=0.6273; pvalue=0	D=0.6835; pvalue=0	D=0.6273; pvalue=0
$F(p^{Up}) \leq F(p^{Down})$	D=0; pvalue=1	D=0; pvalue=1	D=0; pvalue=1
$F(p^{Up}) \geq F(p^{Down})$	D=0.6273; pvalue=0	D=0.6835; pvalue=0	D=0.6273; pvalue=0

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