Adverse Selection and the Brain Drain*

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June 10, 2009

Abstract

We identify adverse selection by exploiting a unique institutional feature of the Ethiopian physician labor market, which allocates some new doctors randomly to their first jobs through a lottery mechanism, while others seek employment through the market, which matches better graduates to better jobs. We find evidence of adverse selection among lottery participants later in their careers, who cannot credibly use their first (randomly assigned) job as a signal of ability. Our estimates suggest that about two-thirds of the most able lottery participants subsequently exit the Ethiopian medical profession, accounting for as much as one third of physician brain drain.

*The survey for this study was financed by a grant from the Bill and Melinda Gates Foundation and Norad, administered through the World Bank. We thank Dr Tedros, Dr Kebede and Dr Nejmudin of the Ministry of Health, and the Government of Ethiopia. We are grateful to Dr. Aklilu Kidanu for providing invaluable assistance to the authors, and for leading the survey team of the Miz-Hasab Reserach Center in Addis Ababa. We also thank Kara Hanson, Christopher H. Herbst, Kenneth Leonard, Magnus Lindelow, John Micklewright, Gebreselassie Okubagzhi, Pieter Serneels, Agnes Soucat, Kate Tulenko, seminar audiences at the Center for Global Development, Georgetown Unviersity, UQAM, and the World Bank, and participants at the European Economics Association (2008) and NEUDC (2008) meetings for comments and assistance. The opinions expressed in the paper are those of the authors and do not reflect the position of the Government of Ethiopia or the World Bank Group.

1 Introduction

Following the early contributions of Akerlof (1970) and Spence (1973), the potential for information asymmetries to have sizeable labor market effects on wages and employment dynamics has been well recognized. The empirical content of these models has, however, been more difficult to identify, in part because reasonable counterfactual employment relations that do not suffer from asymmetric information are usually absent. This paper provides what we believe is one of the first empirical estimations of the economic inefficiency that lies at the heart of the lemons model of the labor market – the un- or under-employment of high skilled labor due to adverse selection.

We are able to identify exit of high skilled labor attributable to an asymmetry of information by exploiting a unique feature of the market for graduating physicians in Ethiopia under which some new graduates find their first jobs through the market, while others are allocated to their first placements through a lottery mechanism. Later in their careers, the market uses the employment history of doctors in the first group as an informative indicator of quality, and those with higher ability are rewarded. The lottery, on the other hand, tends to obfuscate information about physician quality, precisely because the characteristics of first jobs provide no information about worker quality. In this context, we develop a model of adverse selection-induced exit and test it by comparing the labor market outcomes of workers in each of the two groups, using newly collected data on Ethiopian physicians and nurses.

First, among physicians who did not participate in the lottery at graduation, we find substantial returns to ability (as proxied by self-reported performance in medical school), both in their first and later jobs. In contrast, the wage and specialization differences between high and low ability physicians are much smaller among former lottery participants. Similarly, in comparing the age distributions of former lottery participants and non-participants, we find that non-participants remain in the profession considerably longer. Further, exploring differential changes in the ability distribution over time in the two groups, we find that exit from the labor market among former lottery-participants is concentrated among those of high ability. We undertake several robustness tests using information on nurses' wage profiles that further support our findings.

The economic impact of our findings is sizeable. Based on our identifying assumptions, which provide a likely lower bound, we find that adverse selection-induced exit accounts for the loss of about two-thirds of high skilled physicians among former lottery participants, or about 10 percent of the current physician labor-force as a whole. While we do not observe the current activities of these exiters, many are likely to have migrated overseas. Indeed, Clemens and Pettersson (2007) estimate that fully 30% of practicing Ethiopian physicians currently work abroad. Thus roughly one-third of this "physician brain drain" could be attributable to adverse selection, itself an outcome of the lottery policy.

The policy-induced labor market distortions we identify in this paper provide compelling evidence that physician migration levels are inefficiently high. The brain drain represents a real efficiency loss, as high skilled workers flow to less-preferred outside options when they cannot effectively distinguish themselves from lower productivity labor. Although we do not observe the labor market choices of those who leave the domestic medical profession, administrative and anecdotal evidence suggests that many of them migrate overseas. This paper empirically verifies that adverse selection can be a contributing factor to such migration. As such, our evidence is also important for understanding the migration of highly skilled individuals from developing countries more generally, which may not only be driven by wage differentials and other differences in opportunities (Pritchett, 2006), but may also depend importantly on the efficiency with which domestic labor markets operate.

The findings of this paper complement other papers that have explored the empirical content of one or more predictions of Akerlof and Spence. For example, Gibbons and Katz (1991) provided early empirical evidence on the effects of information on labor market outcomes in a model in which lay-off decisions serve as a signal of worker quality, arguing that the market could infer the (low) productivity of laid-off workers, but not that of workers who lost their jobs in plant closings. It is also consistent with increasing evidence that initial labor market conditions have long-lasting effects on worker's careers (e.g. Beaudry and Dinardo, 1991; Devereux and Hart, 2006; Oreopoulos et al., 2006).

A growing number of papers have empirically tested for the presence of adverse selection in other, non-labor, markets. Chiappori and Salanie (2000) use motor vehicle insurance data in France to test for adverse selection by estimating the extent to which coverage choice is correlated with accident events. Using a variety of specifications, they cannot reject the null of conditional independence between these two variables, and conclude that the market does not appear to suffer from adverse selection.

An alternative approach to testing for adverse selection is to identify environments that exhibit some institutional heterogeneity, across which adverse selection pressures are likely to differ. The basic feature of these examples is that sellers are differentiated along two dimensions: an unobservable quality dimension that determines the underlying value of the trade, and an observable dimension that might, in equilibrium, provide a (sometimes exogenous) signal of quality. The Ethiopian physician labor market sharesexhibits thise bifurcated structure: sellers in this market – i.e., physicians who have completed their first assignment – are differentiated by quality on the one hand, and by whether they got their first job through the lottery mechanism on the other.

Other papers that exploit such institutional features include, for example, Chezum and Wimmer (1997), who study the market for thoroughbred yearlings, and distinguish between two types of sellers. They find that sellers who race their own horses, and who would therefore be expected to sell only animals of low quality, receive lower prices for otherwise similar horses than breeders, who tend to sell all their stock. Similarly, Anagol (2009) provides evidence of adverse selection in the market for cows in India by comparing prices and trade volumes of cows at different points in their reproductive cycle. In particular, cows that are not currently producing milk, and whose quality is thus difficult to discern, fetch a lower price and tend to be withheld from the market. In addition he shows that price differences between sellers of cows at different points in the cycle narrow in the presence of community-wide shocks, as those with "dry" animals are forced to sell.

A similar analysis of the used car market is performed by Genesove (1993), who differentiates between used car dealers and new car dealers. Greenwald and Glasspiegel (1983) examine the 19th century slave market in New Orleans, and find that prices paid for slaves who were brought from the old South are higher than for similar slaves sold locally.

The next section briefly provides contextual information on the Ethiopian physician labor market. Section 3 outlines our model of alternative labor allocation mechanisms, and the decision of graduates to exit the lottery. We present our data and empirical methodology in Section 4, and our main results in Section 5. Section 6 includes a number of robustness checks, and we draw conclusions in Section 7.

2 Background and context

The number and geographical distribution of health workers in Ethiopia is difficult to estimate. However, data from the Ministry of Health (2005) suggest that perhaps half of the country's physicians live and work in Addis Ababa (World Bank, 2008), the capital, which is home to just five percent of the population. In Addis Ababa, on average physicians earn close to \$500 per month in the private sector and \$250 per month in the public sector, while outside of the capital they earn only about \$180 (World Bank, 2008). Attracting doctors to rural areas has proven increasingly difficult in recent years, both with the steady growth of the private sector, most notably in the capital, and the implementation of a radical decentralization program across all areas of the public sector.

The primary vehicle by which the supply of rural health workers is maintained is a national clearing house. Each year recently graduated physicians are assigned to jobs through a national lottery. Under the lottery, which is officially mandatory although in practice optional, a participant is randomly assigned to one of the twelve administrative regions of the country. As we will show below, the available information indicates that the lottery assignment is indeed random. Job assignments at the regional level are determined by the relevant regional health bureau (Lindelow et al., 2005). Assigned workers are usually expected to serve a fixed number of years before being "released" and are free to search for a job in the public, private, or NGO sectors.[1]

National clearing houses for entry level physicians are also common in other countries. For example, in the United States, the market for almost all entry level positions (called residencies) for new doctors is mediated by a clearinghouse called the National Resident Matching Program (NRMP). Applicants and employers submit rank order lists representing their preferences, which are then used by the clearinghouse to centrally determine a match between applicants and employers (Niederle and Roth, 2007,.Roth, 2008). Unlike the NRMP, the Ethiopian lottery system does not seek to explicitly match employer and physician preferences, at least not with respect to the regional location of job assignments.

Figure 1 shows the shares of physicians and nurses in our survey (details of which are reported below) who participated in the lottery, over time. The average physician participation rate in our sample is 57%, although there has been a sharp fall in recent years. On the other hand, the relatively constant observed participation rate (even a drop among the oldest cohorts) is inconsistent with widely reported historical trends, which suggest that it has become increasingly easy to exit the lottery over the last 20 years. Indeed, the growth of the private sector, and the enhanced competition between decentralized regional authorities, both offer stronger incentives for graduates to circumvent the lottery.

FIGURE 1 GOES HERE

3 A model of physician labor market dynamics

In this section we develop a two-period model of the physician labor market in which graduating physicians are of heterogeneous ability, and facilities are of heterogeneous quality. In our theory, we follow Waldman (1984) and develop a simple model in which the quality of the worker's first job provides a valuable signal of underlying productivity to future employers for physicians initially assigned by the market. However, because the lottery allocates jobs randomly, underlying worker ability cannot be inferred to the same extent among lottery participants, even in the long-run. The resulting information asymmetry leads to wage pooling among those who participated in the lottery and, given the relatively attractive outside

[1] The terminology suggests that rural work is akin to a prison sentence. The maximum number of health workers assigned to each region is decided before October by a 3-person committee at the Ministry of Health, on the basis of the official requests for health workers sent by each region.

options available to highly-trained physicians, can lead to adverse selection as those with the highest skills exit the profession.

For simplicity, we assume there are matching (in-)efficiencies in the first period only, and that later on a given individual's labor productivity is independent of the facility in which he works.[2] Each physician's productivity is known by the market in the first period, but in the second period we allow for the possibility that it is not directly observable - that is, the market might "forget". We first outline a model in which labor is allocated by the market in both periods, and then describe the outcome when it is allocated randomly through the physician lottery mechanism in period 1, and by the market in period 2.

Finally, we model the decision by individual graduates to exit the lottery upon graduation, and provide a number of specific examples of that selection process. We use these models to draw empirical implications regarding the comparison of equilibirum wage and compensation profiles and labor market exit rates among physicians who participated in the lottery and those who did not, and to motivate the identifying assumptions we use in our empirical work.

3.1 Market allocations

We let $\theta \in [0,1]$ denote an individual graduate's class rank, and assume that this is an informative signal of his underlying ability, η. Specifically, we let

$$\eta = \theta + \varepsilon,$$

where ε is a random variable independent of θ and uniformly distributed on $[-\delta, \delta]$, for some $\delta \geq 0$. There are two types of medical facilities: half of the jobs are in facilities of high quality, ϕ_H, and half are in facilities of low quality, ϕ_L. Graduating physicians have no outside options in period 1. We further assume that in the first period, the output or surplus generated by a physician-facility match, $y(\eta, \phi)$, exhibits supermodularity, that is $\partial^2 y / \partial\eta\partial\phi > 0$. The allocation of labor is represented by the matching function $p(\eta)$, the probability that a physician with ability η lands a high quality job. Efficient matching obtains when

$$p(\eta) = \begin{cases} 0 & \text{if } \eta < 1/2 \\ 1 & \text{if } \eta \geq 1/2 \end{cases} \tag{1}$$

If $\delta = 0$, so $\eta \equiv \theta$, then the relationship between class rank and job, $p(\theta)$, has the same

[2]Matching could be included in period 2, but would only complicate the model. We include it in period 1 to introduce a correlation between worker ability and observable facility characteristics.

form,

$$p(\theta) = \begin{cases} 0 & \text{if } \theta < 1/2 \\ 1 & \text{if } \theta \geq 1/2 \end{cases} . \tag{2}$$

In this case, assuming efficient matching, the ability distribution of individuals who get jobs in high quality facilities is uniform on $[1/2, 1]$ with mean $\mu_H = 3/4$, and that of those who get jobs in low quality facilities is uniform on $[0, 1/2]$, with mean $\mu_L = 1/4$.

On the other hand, if $\delta > 0$, then an individual is efficiently matched to a high quality job if and only if $\varepsilon \geq 1/2 - \theta$. The matching function $p(\theta; \delta)$ is then

$$p(\theta; \delta) = \begin{cases} 0 & \text{if } \theta < 1/2 - \delta \\ \frac{1}{2} + \frac{(\theta - 1/2)}{2\delta} & \text{if } 1/2 - \delta < \theta < 1/2 + \delta \\ 1 & \text{if } \theta \geq 1/2 + \delta \end{cases} .$$

As class rank becomes a noisier signal of ability, the range of lower ranked individuals, some of whom are matched with high quality jobs in period 1, expands, as does the share of higher ranked graduates who are matched with low quality jobs. The mean ranks of individuals with jobs at high and low quality facilities are, respectively,

$$\mu_H(\delta) = \int_0^1 \theta p(\theta; \delta) d\theta \bigg/ \int_0^1 p(\theta; \delta) d\theta,$$

and

$$\mu_L(\delta) = \int_0^1 \theta [1 - p(\theta; \delta)] d\theta \bigg/ \int_0^1 [1 - p(\theta; \delta)] d\theta.$$

As ε has mean zero, these also measure mean abilities. A positive value of δ reflects the empirical dispersion of ranks across both high and low quality jobs. However, to simplify the theory, and without loss, we concentrate on the case of $\delta = 0$ from now on.

In the second period, we simplify our analysis further by assuming the production function is no longer supermodular, and the output of a worker is a function only of his ability, and not the match. We normalize $y(\theta, \phi) = \theta$. Potential employers can observe the identity, and hence quality, of the facility in which each worker had his first job. Each physician has an outside option in period 2, the value of which, $r(\theta)$, is increasing in his ability θ, with $r(\theta) < \theta$ for all θ.

If worker ability is directly observable by potential employers in period 2, then in a competitive labor market individuals would be paid their productivity and they would all work in the health sector, forgoing their outside options. On the other hand, if worker ability is no longer directly observable in period 2, employers use the quality of the worker's first job as a signal of his ability. In this case, wages can vary by employment history (i.e., quality of the first job), but not directly by worker productivity. A wage w offered to workers whose first job was in a facility of quality ϕ_L or ϕ_H will be accepted by all such workers for whom $w \geq r(\theta)$. Let $I(\theta, w)$ be an indicator function equal to one if $w \geq r(\theta)$ and zero otherwise. Then the mean ability of workers who had a high quality job and who accept the new job is

$$\nu_H(w) = \int_0^1 \theta p(\theta) I(\theta, w)\theta \Big/ \int_0^1 p(\theta) I(\theta, w) d\theta.$$

Similarly, the mean ability of workers who had a low quality job and who accept a new job at wage w is

$$\nu_L(w) = \int_0^1 \theta(1 - p(\theta)) I(\theta, w)\theta \Big/ \int_0^1 (1 - p(\theta)) I(\theta, w) d\theta.$$

An equilibrium in this pair of labor markets is a pair of wages (w_L^*, w_H^*) such that

$$\nu_L(w_L^*) = w_L^*$$

and

$$\nu_H(w_H^*) = w_H^*.$$

Within each labor market, the potential for adverse selection clearly exists, although of course labor market exit need not arise in equilibrium.

3.2 Lottery allocations

An alternative labor market institution is a lottery system, under which workers are allocated to jobs randomly in the first period. There are clear static inefficiencies with such an allocation mechanism when returns to matching exist. Although we think this is an important limitation of the lottery system, it is not our focus here.

When workers are assigned by lottery, the quality of the facility at which they hold their first jobs provides no information to future employers about their underlying ability. The probability of getting a job in a high quality facility under random allocation is constant across ability types, $p(\theta) = 1/2$ (assuming half the jobs are high quality). As above, if the market can observe ability in the second period, then labor will be paid according to its productivity, and the inefficiency of the lottery will be limited to the static losses associated with bad matches.

However, if worker ability is no longer observable in period 2, additional inefficiencies can arise. The market cannot use the identity and quality of the first job as an informative signal of worker productivity, so in our simple model *all* workers are indistinguishable, and must be paid the same wage. We maintain our assumption of an outside option with value $r(\theta)$, and observe that the average ability of workers accepting a job that pays a wage w is

$$\nu(w) = \int_0^1 \theta I(\theta, w)\theta \Big/ \int_0^1 I(\theta, w) d\theta.$$

An equilibrium in this market is a wage w^* such that

$$\nu(w^*) = w^*.$$

Again, adverse selection-induced exit may arise in equilibrium.

3.3 Lottery-induced adverse selection: an example

We propose that adverse selection will be more likely, or more severe, in period 2 if labor was allocated by lottery in period 1 than if it were allocated by the market. The intuition is that the market allocation mechanism provides information that narrows the effective distribution of types across which employers cannot distinguish in period 2. This narrower distribution means that high ability workers who had a high quality job early in their careers do not have their labor market options diluted by workers with very low abilities in period 2. Those who had low quality jobs early on similarly fall into a narrow distribution of types *ex post*. However, if workers are allocated jobs in period 1 through a lottery, those with the highest abilities must share their output with very low ability workers in equilibrium in period 2, and are thus more likely to exit the market. In this sub-section we present a numerical example which captures this intuition.

Consider two groups, lottery participants and non-participants, each with ability distributed uniformly on $[0, 1]$. In period 1, among non-participants, there is complete positive assortative matching, according to the matching function in (2). Lottery participants are randomly allocated to jobs in period 1.

In period 2, productivity is simply θ, and a worker of ability θ has an outside option of value $r(\theta) = \theta - 1/4$, independent of which labor market institution he participated in during period 1, and independent of the quality of his first job. Non-participants who had a low quality job in period 1 ($\theta \in [0, 1/2)$) constitute their own labor market, separate from the labor market populated by non-participants who started their careers with a high quality job ($\theta \in [1/2, 1]$), and separate from lottery participants ($\theta \in [0, 1]$).

Let $\overline{\theta}^{0,H}(w)$ be the mean ability of those non-participants who had a high quality job in period 1 who would accept a job at wage w in period 2. That is,

$$\overline{\theta}^{0,H}(w) = \begin{cases} 0 & \text{if } w < 1/4 \\ 3/8 + w/2 & \text{if } 1/4 < w < 3/4 \\ 3/4 & \text{if } w > 3/4 \end{cases}$$

as shown in Figure 2. The equilibrium wage in this labor market is $w^{0,H} = 3/4$, at point C. All workers (among non-participants who had a high quality job in period 1) accept a job at this wage, and there is no exit from the market.

FIGURE 2 GOES HERE

Similarly,

$$\overline{\theta}^{0,L}(w) = \begin{cases} 0 & \text{if } w < -1/4 \\ 1/8 + w/2 & \text{if } -1/4 < w < 1/4 \\ 1/4 & \text{if } w > 1/4 \end{cases}$$

is the mean ability of those non-participants who had a low quality job in period 1 who would accept a job at wage w in period 2. The equilibrium wage in this market is $w^{0,L} = 1/4$, at point A. Again, all workers (among non-participants who had a low quality job in period 1) accept a job at this wage, and there is no exit.

Finally, for former lottery participants, the mean ability of those willing to accept a job at wage w in period 2 is

$$\overline{\theta}^{1}(w) = \begin{cases} 0 & \text{if } w < -1/4 \\ 1/8 + w/2 & \text{if } -1/4 < w < 3/4 \\ 1/2 & \text{if } w > 3/4 \end{cases}.$$

As illustrated in Figure 2, the equilibrium wage rate in this market is the same as in the market for labor of non-participants who had a low quality job in period 1, at point A. However, in this equilibrium some workers exit the labor market: all workers in the market with ability greater than 1/2 will exit the market and take up their outside option. The signal carried forward to period 2 by those assigned to jobs through the market in period 1 facilitates efficient labor allocation in the latter period.

This specific example clearly does not constitute a general result, and depends on the distributions of types in each labor sub-market in period 2, the nature of outside options, and the informational features of the markets. The basic intuition we wish to illustrate with the example is that first period jobs, if informative, can act to segment the second period labor market in a way that improves efficiency, while random job allocation in period

1 can obfuscate information, thereby hampering the efficient operation of the labor market in period 2.

3.4 Lottery participation

Participation in the labor market lottery has been officially mandatory, but a significant share of doctors in our sample opted out of the allocation mechanism after graduating. In this section we suggest a number of simple examples of the selection process, and how it might have evolved over time. In general, as noted above, it is widely understood that it has become easier and/or more rewarding to exit the lottery over time. However, we emphasize that although in our empirical work we compare outcomes across lottery participants and non-participants, non-random selection into these groups does not present the kinds of identification problems that plague some other studies. For example, we do not compare average outcomes such as wage levels across groups, which may well depend on both observable and unobservable differences.

Instead, we assess the *ex post* operation of the two markets, when each consists of a group of heterogeneous workers. The validity of our comparison does not depend on the distributions of workers in each group being the same, or even on the distributions overlapping. However, in our data the distributions of participant and non-participant groups share a common support over observable characteristics. We discuss our specific identification assumptions further in Section 4.

Example A: A first example is that workers *randomly select* out of the lottery, or at least that they exit on the basis of some variable that is uncorrelated with those relevant to labor market outcomes. In this case, the distributions of ability types among lottery participants and non-participants are both uniform. We let σ_t denote the probability of exiting the lottery, and assume that as enforcement of lottery participation has waned, σ_t has increased over time.

Example B: The simplest form of non-random selection is a rule under which graduates with a sufficiently high rank exit the lottery system; they might, for example, be able to more easily find work immediately in the private sector. This rule is characterised by a critical rank θ_t, and a probability of participation given by

$$\sigma_t(\theta) = \begin{cases} 0 & \text{if} \quad \theta < \theta_t \\ 1 & \text{if} \quad \theta \geq \theta_t \end{cases} .$$

Relaxation over time of the requirement to participate in the lottery is associated with a fall in θ_t.

Example C: Alternatively, consider a selection rule in which individuals with sufficiently high rank randomly exit the lottery, and that while the probability of exiting increases over time, the critical rank above which graduates exit remains fixed. Thus,

$$\sigma_t(\theta) = \begin{cases} 0 & \text{if } \theta < \theta_0 \\ \sigma_t & \text{if } \theta \geq \theta_0 \end{cases}$$

for some fixed θ_0 and for σ_t increasing in t.

Example D: Finally, suppose higher ability graduates have more to gain by opting out of the lottery, but that each faces an idiosyncratic cost of doing so. Higher ability graduates are more likely to exit the lottery, although those with particularly high costs of doing so do not. And even the lowest ability doctors exit if the cost of doing so is small enough.

These examples illustrate a range of alternative ways in which the ability composition of lottery participants and non-participants might change over time, even in the absence of differences in exit rates. In our data, we observe the effects of such changes, in addition to the impact of subsequent exit from the market. This combined effect is in turn composed of the impact of secular trends in labor market opportunities for all physicians, and the impact of adverse selection, if it exists. Our empirical challenge is to identify the latter effect when we observe only the aggregate effect of all three sources of selection into, and out of, the two groups.

4 Data and empirical strategy

4.1 Sampling methodology

In late 2006, detailed data on a random sample of 219 physicians and 642 nurses in Ethiopia was collected by an experienced survey firm based in Addis Ababa.[3] Our sampling strategy aimed at obtaining representative samples from three of Ethiopia's twelve regions – the capital city of Addis Ababa, and the predominantly rural regions of Tigray and Southern Nations and Nationalities Peoples' Republic (SNNPR).[4] Addis is a city of about 3 million people and is located in the central highlands. Tigray has a population of about 4 million

[3] The Miz-Hasab Research Center.

[4] Cost considerations, in a large country with poor communications and transportation infrastructure, limited the geographical scope of the survey to three regions.

people and lies in the north of the country, bordering Eritrea, while SNNPR, with a population of 14 million lies to the south west of Addis. Our sample is representative within these geographic areas. Other regions, such as Oromia, which surrounds Addis Ababa, and Amhara are larger (with 26 and 19 million residents respectively) and less remote, at least in terms of direct distance measures, but we have no reason to expect this to have introduced systematic biases in our estimates.

Because of the small number of health workers outside Addis Ababa, we sought to interview all physicians in Tigray and SNNPR. We visited all 23 public hospitals in the two regions, there generally being no physicians in non-hospital health facilities and, at the time of the survey, no private hospitals outside the capital. On the other hand, only about one third of physicians in Addis were included in our sample. The Addis sample was drawn by first randomly sampling facilities of various types (hospitals, health centers, clinics, etc.) with sampling weights corresponding to the estimated proportion of physicians working in each type, and subsequently interviewing all physicians at the sampled facilities. In all, we administered the survey to 219 physicians working in hospitals, health centers, and clinics. A summary of our physician sample is provided in table 1.

Amongst physicians, the interview response rate was 86% in Tigray. Non-response arose because one sampled facility no longer existed, and one was inaccessible for security reasons. The response rate was lower in SNNPR and Addis Ababa - 58% and 66% respectively. However, excluding physicians on leave, the response rate was considerably higher. In SNNPR, nine out of ten of the physicians listed as being employed but not interviewed were on leave, implying an effective response rate of around 90%. In Addis, the response rate was 79% at both public and private facilities, excluding planned leave.

As described in detail below, our empirical strategy compares labor market outcomes of lottery participants and non-participants across age cohorts. Our estimates of adverse selection among participants would be biased upwards if non-response rates were higher among that group than among non-participants. However we see no reason for response to be correlated with lottery status in this way. Indeed, we show below that slightly more non-participants found their first job in Addis Ababa, where response rates are lowest, suggesting that, if anything, our results underestimate the extent of adverse selection. Finally, it is reasonable to believe that non-response rates increase with individuals' opportunity cost of time, and since lottery participants, especially those of high ability, report lower wages than non-participants, we expect response rates to be higher among the former.

4.2 Description of Data

Tables 2, 3, and 4 present basic demographic and employment comparisons between lottery participants and non-participants. Fifty-nine percent of our sample of physicians reported that they participated in the lottery after graduating. More precisely, 59% reported that they formally entered the lottery, and that the first job they took was assigned under the lottery. Of course, simple differences in means are likely to mask important underlying patterns. On the other hand, even at this level of aggregation we find some suggestive evidence that lottery non-participants are better matched in their first jobs, and that adverse selection among lottery participants may be at play.

To start, the facility-level data in table 2 do not suggest obvious differences between where members of the two groups currently work; there are no significant differences in facility size, as measured by inpatient and outpatient care capacity, nor in measures of remoteness. The demographic data in table 3 on the other hand, do show some significant differences, most notably in age, with non-participants on average four years older than participants, a significant difference. This is consistent with our model of adverse selection, wherein older lottery participants have left the profession over time.[5] On the other hand, there is no significant difference between groups in terms of sex, family size (as measured by the number of siblings), or the likelihood of having a relative who is a health worker.

With regards to ability, medical training and employment characteristics, Table 4 first shows that non-participants are on average slightly better ranked, although not significantly so [6], and are significantly less likely to have had their training sponsored by the federal government (57% versus 82%), supporting the idea that it is more difficult for some physicians to leave the lottery than for others. The table also provides some evidence that the first job match among lottery participants is of lower quality than among non-participants. About one-fifth of lottery non-participants got their first job in the capital, while only 10 percent of participants did (p-value of the difference is 0.103). Further, limiting the sample to the 116 doctors at least 5 years out of medical school, non-participants spent on average 5.4 years in their first job, compared with 3.8 years among former lottery participants. This difference is not significant (p-value = 0.17) but this small sample provides limited power to detect differences.

Finally, the table reports higher average monthly salaries and total incomes among non-participants ($320 and $359, respectively) than among participants ($271 and $303, respec-

[5]We confirm in our empirical work below that it is the higher ability workers who leave.

[6]Respondents were asked to report their class rank in medical school, with rank numbers representing quintiles. None of the physicians reported being in the bottom two quintiles (ranks 4 and 5). The distribution was 21%, 43%, and 36%, respectively, over the ranks 3 [41-60%], 2 [61-80%], and 1 [81-100%].

tively), although these differences are not significant. The earnings gap grows, however, with experience[7], which is consistent with the bottom row showing that non-participants are considerably more likely to be specialized (42% versus 18%). Lastly, note that non-participants are no more likely to work in the private sector (37% versus 38% for participants) or to hold more than one job (15% versus 21% for participants).

4.3 Empirical strategy

Our primary goal is to test the idea that allocating graduate physician labor by lottery leads to adverse selection in subsequent periods. To do this we compare labor market outcomes such as wages and specialization for lottery participants and non-participants. Endogenous selection out of the lottery at the time of graduation means that we cannot be sure that these two groups are, or in the absence of subsequent exit would have been, the same. However, we can still analyze the dynamics over time within each group (lottery participant and non-participant) by comparing characteristics of recent graduates with older cohorts, and use differences in experience and ability dynamics across the two groups to test for adverse selection among the former. Furthermore, the widely reported claim that over the last 20-30 years it has become increasingly easy, and increasingly attractive, to opt out of the lottery allows us to test for the robustness of our findings by making more precise predictions about how dynamics across the two groups should have evolved in the absence of adverse selection.

We observe that if the selection process by which individuals opt out of the lottery had not changed over time, then the distributions of ability of participants and non-participants would be the same for members of both older and younger cohorts. Any observed actual differences in the distributions across cohorts would then reflect different patterns of exit from the physician labor market. Under the weaker assumption that the ability distributions of lottery participants and non-participants at graduation have not converged over time (in a sense we make precise below), observed differences in ability distributions provide a lower bound on the extent of exit of high ability lottery participants from the market.

In a regression context, the coefficient on the interaction between experience and lottery participation in an equation predicting medical school rank provides us with such an estimate. We refine this difference-in-difference approach further by restricting our sample to doctors who are not in the first few years of their careers, and by comparing the results with estimates of a similar specification applied to data on nurses. Our precise identifying assumptions are discussed in detail in the next section.

[7] Limiting the sample to those at least 5 years out of medical school, salaries and incomes among non-participants are \$80 and \$104 higher, with p-values of 0.14 and 0.10, respectively.

5 Results

5.1 First job allocations

We first examine the operation of the labor market for newly graduated physicians. Our theory proposes that good doctors are matched to good jobs by the market, but not through the lottery since the allocation is random. Our measure of graduate quality is self-reported class rank. Job or facility quality is proxied by location in the capital city, Addis Ababa. Table 5 reports estimated coefficients of a linear probability model of location of first job on class rank and a number of other covariates.[8] Columns I through III are for lottery participants, and IV and V are for non-participants. Specifications I, IV, and V use the actual location of the first job as the dependent variable, while columns II and III use the initially assigned location of lottery participants. While 90% of all lottery physicians were first assigned to one of the rural regions, only 1.8% of these (i.e., 2 people) did not take up the rural position but found work directly in Addis.

TABLE 5 GOES HERE.

Among lottery participants, class rank is not correlated with being assigned to a first job in Addis Ababa, suggesting that with respect to this variable, assignment is random. Being connected to the medical profession through parents or other relatives also has no discernible effect. Having his studies sponsored by a regional authority reduces a graduate's chance of being assigned to Addis, but this may reflect an informal two-stage lottery process wherein some students are assigned first to the sponsoring region, and then by lottery to a job there. Finally, men are less likely to be assigned to the capital than women. Since postings can be refused for health reasons or family related considerations (Lindelow et al., 2005), this may reflect the possibility that some women who face issues of physical security and joint career decisions are assigned with higher probability to Addis Ababa.

Among non-participants, the pattern is reversed, with class rank as well as family connections to the medical profession being signficant determinants of rural assignment; for non-participants both what you know, and who you know, seem to matter. In particular, being in the bottom third of the class reduces a graduate's chance of finding a job in Addis Ababa by 25 percentage points relative to first ranked non-participant graduates. Having a parent in the profession also reduces this probability, perhaps because such graduates

[8] Linear probability estimation is employed instead of probit maximum likelihood since there are a few instances where probit estimations are forced to drop several observations. For example, in the lottery sample, there are 3 healthworkers whose parents were also health workers. Because all three work outside Addis, these are dropped in probit estimations.

tend to join a family practice in rural areas, but having a non-parental relative increases it. These results support our hypothesis that some matching of talent to jobs occurs through the market, but that the lottery is random with respect to ability.

5.2 Long-term wage structure

If information on worker quality is publicly observable then a physician's first job does not provide valuable information to future employers. In this case, the relationship between ability and current wages should be the similar for lottery participants and non-participants. On the other hand, if the lottery obfuscates worker quality information, then we expect that the wage distribution will be more narrow across ability differences among lottery participants than among non-participants. Figure 3, which shows the raw wage distribution by rank separately for lottery and non-lottery physicians, provides suggestive evidence to this effect.

FIGURE 3 GOES HERE.

First, note that the graph shows that physicians who were third ranked students currently earn virtually the same whether they were initially in the lottery or not. Among second rank ones, non-participants earn slightly more, but not much. However, there is a large difference among first ranked physicians, with non-participant physicians earning 39% more on average than lottery participants. Table 6 explores this in a regression context predicting log wages using interactions between class rank and lottery participation among the sub-sample of physicians who are at least 2 years out of medical school. Here, third rank is the left out category to highlight the focus on first rank dynamics.

TABLE 6 GOES HERE.

The table first shows that there is not enough power to include a dummy for lottery participation and its interaction with dummies for rank 1 and rank 2, none of which are significant (column I). Restricting the effect of lottery participation to be zero for third ranked physicians (consistent with Figure 3), the coefficient estimates on the interaction terms both fall just outside the significance range (column II). Combining first and second rank in their interaction with lottery participation, column III shows that first ranked physicians earn 48% more than third ranked physicians outside the lottery, but only 24% more inside the lottery (a combination of the direct and interaction effect), a difference in the ability driven earnings gaps of 24 percentage points. This is consistent with relatively undifferentiated wages among physicians who participated in the lottery.

Further, suppose that in a well-functioning labor market the returns to experience are higher for higher ability individuals, perhaps because they both are able to learn more, and are given jobs in which they can learn more. If this is the case, we would expect the wage gap between 1st and 3rd ranked physicians in the non-participant group relative to the same gap between 1st and 3rd ranked physicians among lottery participants to increase over time with experience. To verify this, column IV reports results restricted to individuals in our sample with 5 or more years of experience. Despite a much smaller sample (109 observations), the results are indeed stronger than before. Whereas before the wage gap between first and third ranked physicians was 24 percentage points greater among non-participants, among the restricted, more experienced sample, this difference has grown to 37 percentage points.

Finally, it is conceivable that an omitted variable could bias our wage pooling results, for instance if it acted both to increase wages and to induce individuals to opt out of the lottery. However we believe this is unlikely for two reasons. First, if this were the case, then one would expect third ranked physicians to also earn more outside the lottery, which is not the case. And second, if there is no wage pooling inside the lottery, one would expect second ranked students inside the lottery to earn more than third ranked students inside the lottery.

5.3 Exit from the physician labor market

The first indication that physician exit is more pronounced among lottery participants is found by comparing the mean ages of lottery participants and non-participants. If lottery participation had remained stable over time, we would expect mean ages to be similar in the absence of exit. If, on the other hand, opting out of the lottery has become easier over time as we believe to be empirically the case, then in the absence of differential exit, we would expect the mean age of lottery participants to be higher than that of non-participants, and more generally the age structure of lottery participants to exhibit first order stochastic dominance over that of non-participants. However, while Table 3 shows that the mean ages of the two groups differ significantly, lottery participants are more than four years *younger* than non-participants. Table 7 explores this age difference in more detail, first limiting the sample to physicians with more than two years experience (column I), more than five years experience (column II), and more than five years experience but with outliers older than 70 years removed (column III). These results clearly show that the age gap between lottery and non-lottery participants is increasing over time, and not particularly sensitive to outliers.

TABLE 7 GOES HERE.

In fact, panel (a) of Figure 4, which presents non-parametric estimates of the cumulative age distributions of physicians in both groups, clearly shows that the cdf of non-participants is displaced to the right. For future reference, we also present the corresponding cdfs for nurses, which show no such dominance properties.

FIGURE 4 GOES HERE.

In sum, this evidence suggests that doctors who started in the lottery have subsequently been more likely to exit the labor force than non-participants. If exit has been particularly acute among *high* ability lottery participants, we should expect the quality of the remaining older former lottery participants to be relatively low. To investigate this, we run the following regression:

$$y_i = \alpha + \beta_1 L_i + \beta_2 L_i \exp_i + \beta_3 \exp_i + \beta_4 \exp_i^2 + \varepsilon_i, \tag{3}$$

where y_i is our measure of physician ability, L_i is a dummy for lottery participation, and $\exp_i$ is years of experience.

To illustrate our identification strategy, suppose we were to divide our sample into two age groups with experience levels $\exp_i = 0, 1$. Suppose also that there has been neither exit nor any change in lottery participation rates. Then, we should observe the same difference in average ability between the lottery participant group and the non-participant group among the experienced ($\exp_i = 1$) physicians as among the inexperienced ($\exp_i = 0$) physicians. If, however, experienced high ability lottery physicians have been exiting the profession (and thus our sample), then we should expect lottery physician ability in our sample to decline with experience relative to non-participants. For β_2, the simple double difference estimator, to provide an unbiased estimate of the rate of exit, the corresponding identifying assumption is that the change in ability over time (from earlier graduates to recent graduates) among non-participants is a good proxy for the change over time in ability that would have occured among lottery participants *in the absence* of high ability exit among the earlier graduates. However, in our case, this assumption may not hold since we also expect differences in relative ability to have changed over time due to changes in the rate and pattern of selection out of the lottery. Fortunately, as shown below, under reasonable assumptions about changes in the selection process, ability differences between lottery participants and non-participants due to the participation decision will have remained constant, or at worst diverged in the opposite direction of divergence due to exit.

Our identifiying assumption is illustrated in Figure 5. In terms of the figure, we seek to estimate the distance $C - C'$, but face the problem that point C is not observed. Suppose also that at the time of the survey there had been no exit from the young cohort. Then the difference we wish to estimate satisfies

$$\Delta = C - C' = (A - C') - (A - C) \geq (A - C') - (B - D).$$

The right hand side is identified, and provides a lower bound on the effect of differential exit rates from lottery participants in the older cohort on observed ability. Note that if the younger cohort of lottery participants had suffered exit that had resulted in lower mean ability levels, then Δ would be a weaker lower bound on the actual effect we wish to estimate.[9] Applied to the regression (3), β_2 represents a lower bound on the deterioration in the ability of the pool of lottery participants that can be attributed to high ability exit.

FIGURE 5 GOES HERE

The validity of our identifying assumption depends on the nature of the process by which graduates have decided to opt out of the lottery, and how that process has changed over time. The suggestive dynamics discussed in section 3.4 provide theoretical support for our assumption. In Example A, the mean ability of each group (lottery participants and non-participants) prior to any exit remains constant over time, and the difference between them is zero; in Example B, the mean ability in each group falls over time, but the difference remains constant; in Example C, the mean ability of non-participants remains constant, but that of participants falls, so the difference increases. Linear combinations of these special cases would similarly yield changes in lottery participation that satisfied our identifying assumption. The validity of our assumption under more general dynamics, as in Example D, is more difficult to assess. For example, if only the brightest of the older physicians had exited the lottery, as in Example B, but young doctors exit randomly (Example A), then the ability levels of lottery participants and non-participants could converge over time. However, if the qualitative nature of the selection mechanism remains fixed, then we believe our assumption is reasonable.

TABLE 8 GOES HERE.

Table 8 reports estimates of equation (3) for two alternative definitions of the dependent variable measuring ability. In column I, class rank is coded as 1 for those in the top 20 percent, 2 for the next 20%, and 3 for the middle 20%. The coefficient on the interaction between experience and lottery participation is positive and significant; average ability levels

[9] All our evidence suggests that the lowest ability doctors have *not* been exiting at higher rates than those with high ability.

fall quicker (i.e. higher value of rank) with experience among lottery participants than among non-participants. Column II reports similar results of a linear probability model that are more easily interpretable: the share of lottery participants who are first ranked is 20 percentage points lower after 10 years of experience. This is a large effect, given that the share of new lottery graduates of first rank is only 0.30. Thus as many as two-thirds of higher ranked lottery participants appear to have quit the domestic physician labor market, or about 10 percent of all physicians. This is about one-third of the estimated 30% of Ethiopian-trained physicians who currently work outside the country.

6 Robustness checks

In this section we present several robustness checks using alternative outcome variables and a variety of different specifications. To begin, Table 9 reports results obtained from a linear probability model in which specialized training is estimated as a function of class rank and its interaction with lottery participation. As in the wage equation of Table 6, we find evidence of compression of this measure of reward for individuals who participated in the lottery. First, there are no significant differences in specialization rates between 2nd and 3rd ranked physicians, neither among lottery participants, nor non-participants, nor between them. However, whereas 1st ranked lottery participants are 13 percentage points more likely to be specialized than 2nd and 3rd ranked physicians, 1st ranked non-participants are 40 percentage points more likely to be specialized than their 2nd and 3rd ranked colleagues (lottery or non-participants).

TABLE 9 GOES HERE.

We provide further support for our exit results by comparing the experiences of physicians with those of nurses, of whom a random sample of 642 from the three regions were interviewed as part of the survey. Among nurses at least two years out of medical school, 38% participated in the lottery. Comparisons between physicians and nurses are informative under the assumption that (i) changes over time in the patterns of selection out of the lottery by graduating nurses have been similar to those of graduating doctors, and that (ii) any subsequent exit that has occurred among nurses is the same for nurses who participated in the lottery and those who did not.

Part (ii) of this identifying assumption rules out different adverse selection dynamics for lottery participating nurses and non-participants, motivated by the idea that outside options for nurses are generally much less attractive than for doctors. In this case, the double difference of average ability levels for old and young nurses reflects the divergence over time, if any, in the ability composition of lottery participants and non-participants at graduation. Part (i) of the assumption implies that the resulting triple difference – i.e., the difference in the double differences estimated for doctors and nurses – provides an estimate of the impact of adverse selection in the physician labor market.

We first observe that wage profiles of nurses are flat with respect to quality, both among the lottery participant and non-participant groups; while nurses self-reported school rank levels are nearly uniformly distributed across ranks 1, 2, and 3, those with a higher rank, both inside the lottery and outside, do not earn a salary premium. Only experience matters for salaries.[10] Table 10 further shows that lottery participation does not predict nurse age, which is consistent with our expectation that exit rates do not vary significantly between lottery participants and non-participants.

TABLE 10 GOES HERE.

Still, as with physicians, changes in lottery participation rates by ability could possibly generate differences in average ability levels over time. Average lottery participation rates among surveyed nurses were greater than 50% until at least 1996, but then dropped to a third, and to less than 1 in 6 after 2004. Physicians experienced a similar decline, although it started later (after 2000). However, in contrast to Table 3, Table 11 shows that for nurses neither lottery participation nor its interaction with experience are correlated with either of our measures of class rank. In other words, there is no evidence that changes in the rate of lottery participation induced changes in the average ability differences over time between lottery and non-participant nurses, so the double difference estimator of average ability differences between the two groups is effectively zero. This suggests that our estimate of the effect of adverse selection on the ability composition of the physician labor market is unbiased and that the ability divergence observed among physicians is due to exit and not due to changes in selection into the lottery.

TABLE 11 GOES HERE.

7 Conclusion

In this paper we have presented evidence of adverse selection in the market for experienced physician labor in Ethiopia. By comparing the labor market outcomes of physicians who got their first jobs through alternative institutional mechanisms, we have identified exit of some of the highest quality doctors from the profession, and found that they account for

[10] Results available upon request.

up to one-third of the estimated medical brain drain experienced by the country. We have argued that those who got their first jobs through the government's lottery program were subsequently unable to signal their quality to the market, creating the conditions of asymmetric information under which adverse selection can arise. Indeed, among these doctors, both wage and specialization returns to ability are lower, job tenure is shorter, and exit is concentrated among those of higher reported ability. We confirm these results by comparing the performance of the physician labor market with that of the market for nurses, which shares a similar bifurcated structure, but in which the return to ability is flat for all workers, regardless of lottery participation.

At a general level, our analysis illustrates that short-term inefficiencies can be associated with important long-term consequences. Thus randomly allocated labor is inevitably inefficiently matched to jobs, implying a short-term cost; but by obfuscating information about worker quality, the lottery also compromises the long-term performance of the labor market. Our model and results suggest this dynamic loss can be first order.

Finally, our results provide one of the few rigorous arguments against the "brain-drain" of high skilled workers from poor countries. If such migration is in response to real productivity differentials, it is difficult to argue that it should be constrained. However, in this case it derives at least in part from policy choices that, while well-intentioned, introduce long-term distortions into the local labor market, and drive the best physicians out of the profession and/or the country. Doctors may be more effectively attracted to work in remote locations by the provision of explicit financial or in-kind incentives. While these may exhibit higher up-front costs, our estimates of subsequent labor market effects of the lottery system suggest that the reduction in future costs associated with adverse selection are an important offsetting consideration.

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9 Tables

	Addis Ababa	SNNPR	Tigray	Total
FACILITIES	39	21	17	77
Hospitals	3	12	11	26
Health centers and clinics	36	9	6	51
PHYSICIANS	91	72	56	219

Table 1: Facilities and physicians surveyed

	Lottery Participants	Non-Participants
Number inpatient beds	65.8	68.7
	(24.0)	(21.8)
Number outpatients	105.9	99.3
	(15.4)	(16.8)
Hours travel to Addis	10.5	14.4
	(4.1)	(8.2)
Hours travel to regional capital	2.8	2.5
	(0.7)	(0.7)

Statistics are calculated using frequency weights corresponding to total number of doctors by region working in (1) public hospitals, (2) private hospitals, (3) government health centers, and (4) private, NGO, or missionary clinics

Table 2: Facility characteristics

	Lottery Participants	Non-Participants
DEMOGRAPHICS		
Share female (%)	17.8	17.2
Share married (%)	50.5	64.0
Age (years)	34.5	38.7
	(0.89)	(1.62)
Number of siblings	6.3	6.4
	(0.27)	(0.29)
Number of children	0.83	1.30
	(0.12)	(0.22)
FAMILY CONNECTIONS TO PROFESSION (%)		
Parents health workers	1.8	1.8
Birth order	2.81	3.45
	(0.19)	(0.27)
Siblings health workers	17.8	18.5
Other family health workers	16.0	22.2

Table 3: Demographic and economic characteristics of sampled health workers

	Lottery Participants	Non-Participants
MEDICAL TRAINING AND FIRST JOB		
Medical school rank (1=top 20%,2=top 40%,etc)	1.88	1.72
	(0.09)	(0.10)
Federal sponsor medical school (%)	81.8	57.4
First assignment in Addis Ababa (%)	10.5	20.5
Duration (yrs) of first job (among sample 5+ years out)	3.81	5.39
	(0.40)	(0.99)
CURRENT INCOME		
Salary (US$)	271.0	320.3
	(22.4)	(33.9)
Total income (US$)	303.6	358.9
	(27.4)	(35.1)
Housing allowance (%)	19.3	17.0
CURRENT JOB CHARACTERISTICS (%)		
Primary job in the private sector	38.2	37.1
Holds more than one job	21.2	15.1
Specialist	17.5	42.3

Table 4: Incomes and assets of sampled health workers

	Lottery Participants			Non-Participants	
	I	II	III	IV	V
2nd ranked student	0.094	0.063		-0.176~	-0.210~
	(0.079)	(0.070)		(0.117)	(0.134)
3rd ranked student	0.038	0.045		-0.304*	-0.250**
	(0.102)	(0.103)		(0.151)	(0.124)
Parents health workers	-0.007	-0.001		-0.348*	-0.261**
	(0.087)	(0.082)		(0.195)	(0.120)
Other relatives health workers	0.055	0.082		0.265**	0.303***
	(0.107)	(0.107)		(0.129)	(0.106)
Sponsor: regional authorities	-0.180***	-0.161**	-0.125**	0.024	
	(0.064)	(0.065)	(0.058)	(0.100)	
Sponsor: private/foreign government	0.136	0.103	0.087	0.017	
	(0.111)	(0.096)	(0.088)	(0.165)	
Male (=1)	-0.250***	-0.256***	-0.262***	-0.126	
	(0.086)	(0.087)	(0.083)	(0.175)	
Years experience	0.004	0.001		-0.007	
	(0.018)	(0.016)		(0.019)	
Years experience squared	-0.000	-0.000		0.000	
	(0.001)	(0.001)		(0.001)	
Order of birth	0.001	0.006		0.035	
	(0.015)	(0.014)		(0.029)	
Number of siblings	0.010	0.009		-0.024	
	(0.017)	(0.017)		(0.032)	
Observations	122	122	122	85	85
R-squared	0.1577	0.1764	0.1341	0.2244	0.1916

Notes: Linear probability model. In columns I, IV, and V the dependent variable is the actual location of the first job (Addis=1), while in columns II and III it is the location of the first job as *assigned* under the lottery. Standard errors corrected for clustering at facility level. P-values: *** 1%, ** 5%, * 10%, ~15%.

Table 5: Predicting assignment to Addis Ababa in first job after medical school

	Log current salary			
	I	II	III	IV
1st ranked student	0.421**	0.505***	0.476***	0.373*
	(0.178)	(0.155)	(0.137)	(0.190)
2nd ranked student	0.067	0.153	0.178~	0.040
	(0.156)	(0.130)	(0.125)	(0.152)
1st ranked x lottery	-0.182	-0.291		-0.359*
	(0.214)	(0.193)		(0.201)
2nd ranked x lottery	-0.082	-0.196		-0.182
	(0.207)	(0.139)		(0.126)
1st and 2nd ranked			-0.240*	
x lottery			(0.121)	
Lottery	-0.116			
	(0.169)			
Parents healthworkers	-0.332	-0.344	-0.324	-0.848***
	(0.293)	(0.286)	(0.258)	(0.159)
Other relatives	0.061	0.064	0.067	0.146
healthworkers	(0.130)	(0.129)	(0.127)	(0.118)
Years experience	0.061***	0.058***	0.058***	0.018
	(0.020)	(0.019)	(0.019)	(0.021)
Years experience^2	-0.002***	-0.001***	-0.001***	-0.001
	(0.001)	(0.001)	(0.001)	(0.000)
Sponsor:	-0.310*	-0.304*	-0.311*	-0.755***
regional authority	(0.165)	(0.164)	(0.163)	(0.164)
Sponsor:	-0.167	-0.158	-0.156	-0.258**
private/foreign govt.	(0.115)	(0.115)	(0.116)	(0.125)
Order of birth	0.066**	0.068**	0.070**	0.101***
	(0.028)	(0.028)	(0.027)	(0.026)
Number of siblings	-0.020	-0.020	-0.022	-0.024
	(0.019)	(0.018)	(0.019)	(0.017)
Observations	203	203	203	109
R-squared	0.2823	0.2810	0.2799	0.4090

Notes: Estimations I, II, III exclude physicians who were less than two years out of medical school. IV is limited to physicians at least 5 years out.
OLS estimations with standard errors corrected for clustering at facility level.
p-values: *** 1%,** 5%, * 10%.

Table 6: Wage evidence of adverse selection among lottery participants

Age (years)	I	II	III
Lottery participation	-5.241***	-8.236***	-6.696***
	(1.792)	(2.102)	(1.900)
Number of observations	210	116	114
R-squared	0.0610	0.1768	0.1458

Notes: Robust standard errors clustered at the facility level. Estimation I excludes physicians who were less than two years out of medical school. II, III excludes physicians less than 5 years out. III excludes physicians older than 70. *p*-values: ***1%, **5%,* 10%, ~15%.

Table 7: Differences in mean age of lottery participants and non-participants as evidence of adverse selection among the former

Physician rank	I	II
Lottery participation	0.153	-0.065
	(0.139)	(0.201)
Lottery participation x Experience	-0.020*	0.022*
	(0.010)	(0.013)
Experience	0.034*	-0.060**
	(0.018)	(0.025)
Experience^2	-0.0008	0.002**
	(0.0005)	(0.001)
Number of observations	209	209
R-squared	0.0252	0.0319

Notes: I is a linear probability model predicting first rank; dependent variable in II is actual rank 1, 2, or 3. Robust standard errors clustered at the facility level. *p*-values: ***1%, **5%,* 10% Estimations exclude physicians who were less than two years out of medical school.

Table 8: Impact of lottery participation on class rank

	Physician specialized
1st ranked student	0.404***
	(0.142)
2nd ranked student	0.095
	(0.154)
1st ranked x lottery	-0.263*
	(0.158)
2nd ranked x lottery	-0.035
	(0.189)
Lottery	-0.150
	(0.130)
Parents healthworkers	-0.163
	(0.281)
Other relatives healthworkers	-0.178**
	(0.068)
Years experience	0.014
	(0.013)
Years experience^2	-0.000
	0.000
Sponsor: regional authority	-0.198*
	(0.101)
Sponsor: private/foreign govt.	-0.058
	(0.107)
Order of birth	0.056***
	(0.018)
Number of siblings	-0.038***
	(0.013)
Observations	207
R-squared	0.2763

Notes: Linear probability estimation with robust std errors clusterd on facility level. Excludes physicians who were less than two years out of medical school. p-values: *** 1%,** 5%, * 10%

Table 9: Specialization evidence of adverse selection among lottery participants

Nurse age (years)	I	II
Lottery participation	0.667	-0.315
	(0.808)	(1.358)
Number of observations	581	257
R-squared	0.0012	0.0003

Notes: OLS estimation with robust standard errors clustered at the facility level.
I and II exclude nurses who were less than two and five years out of nursing school.
p-values: ***1%, **5%,* 10%

Table 10: Attrition evidence of adverse selection of lottery participants among nurses

Nurse rank	I	II
Lottery participation	-0.040	0.101
	(0.068)	(0.113)
Lottery participation x Experience	-0.007	0.008
	(0.006)	(0.009)
Experience	0.008	-0.024**
	(0.008)	(0.011)
Experience^2	-0.000	0.000
	(0.000)	(0.000)
Number of observations	581	581
R-squared	0.015	0.018

Notes: Specification I: 1st rank=1, other ranks=0; Specification II: 1st rank=1, 2nd rank=2, 3rd rank=3. Robust standard errors clustered at the facility level. OLS estimation excludes nurses who were less than two years out of medical school. *p*-values: ***1%, **5%,* 10%

Table 11: Impact of lottery participation on class rank - nurses

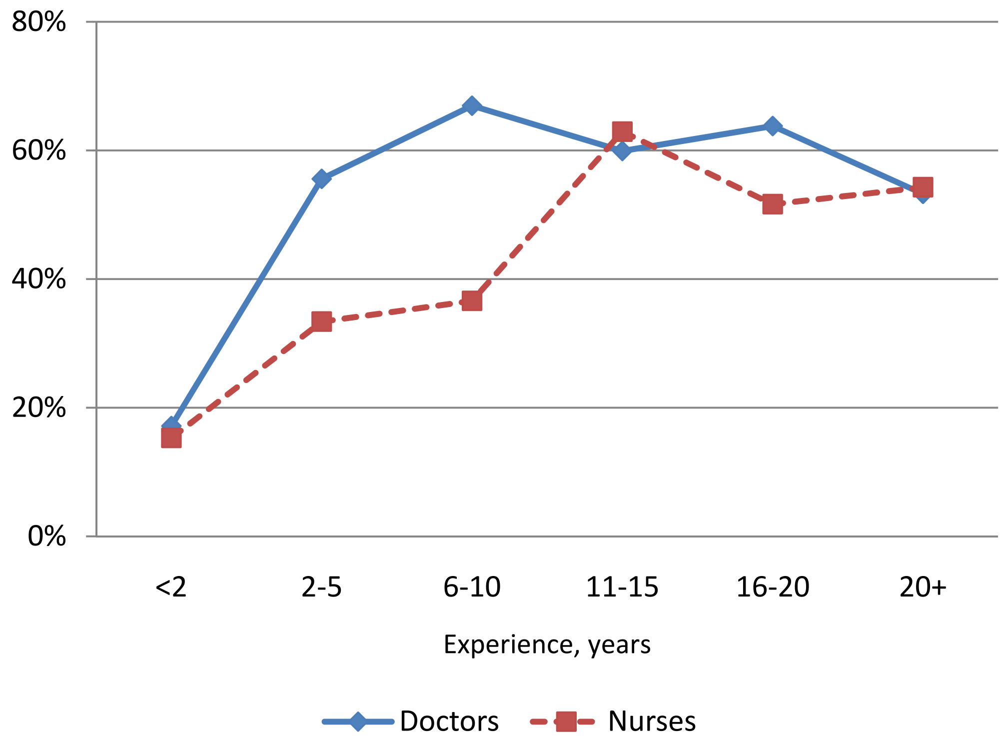


Figure 1: Lottery participation rates by experience

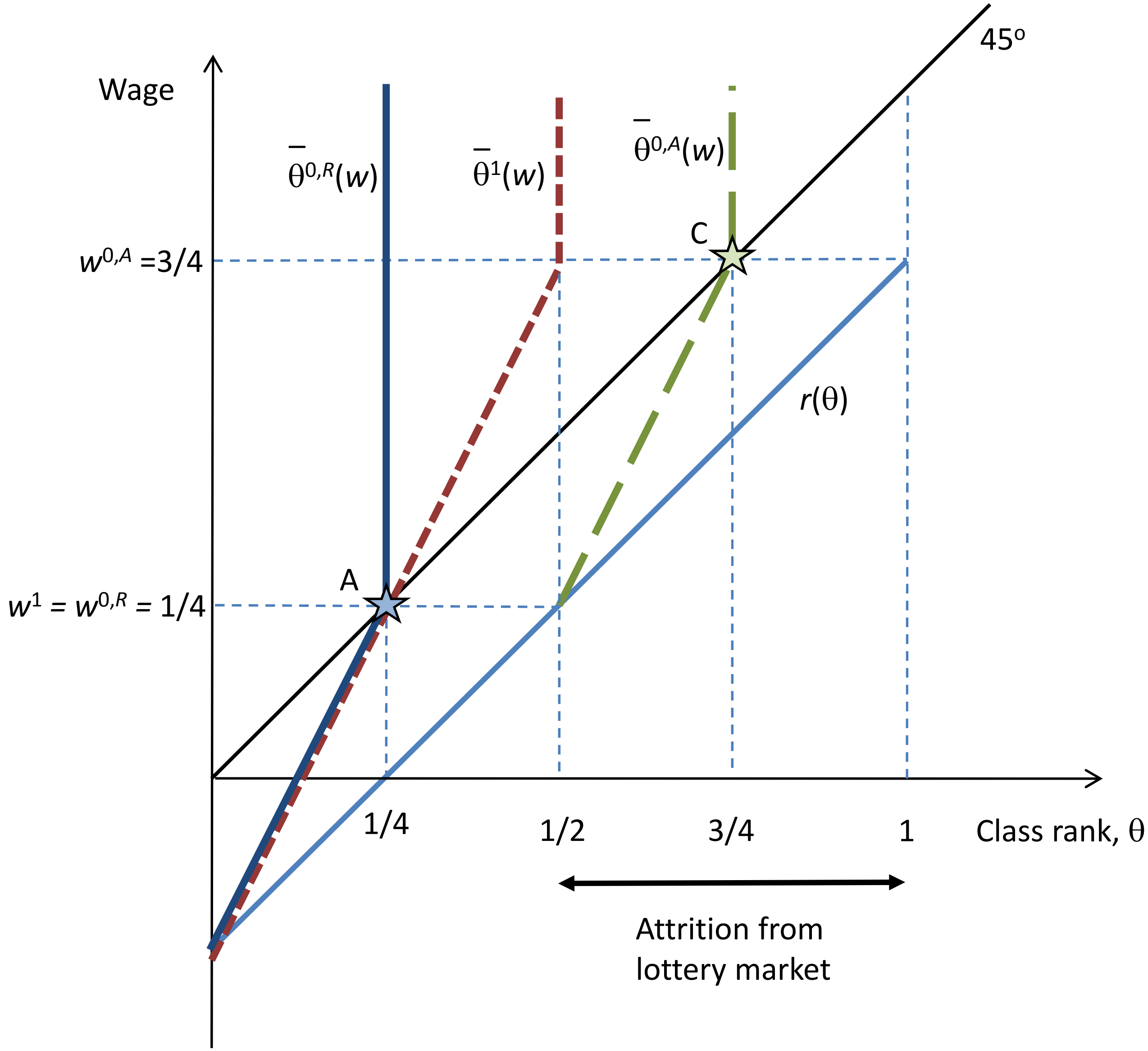


Figure 2: Lottery non-participants suffer no adverse selection in period 2, while all high ranked lottery participants exit the market.

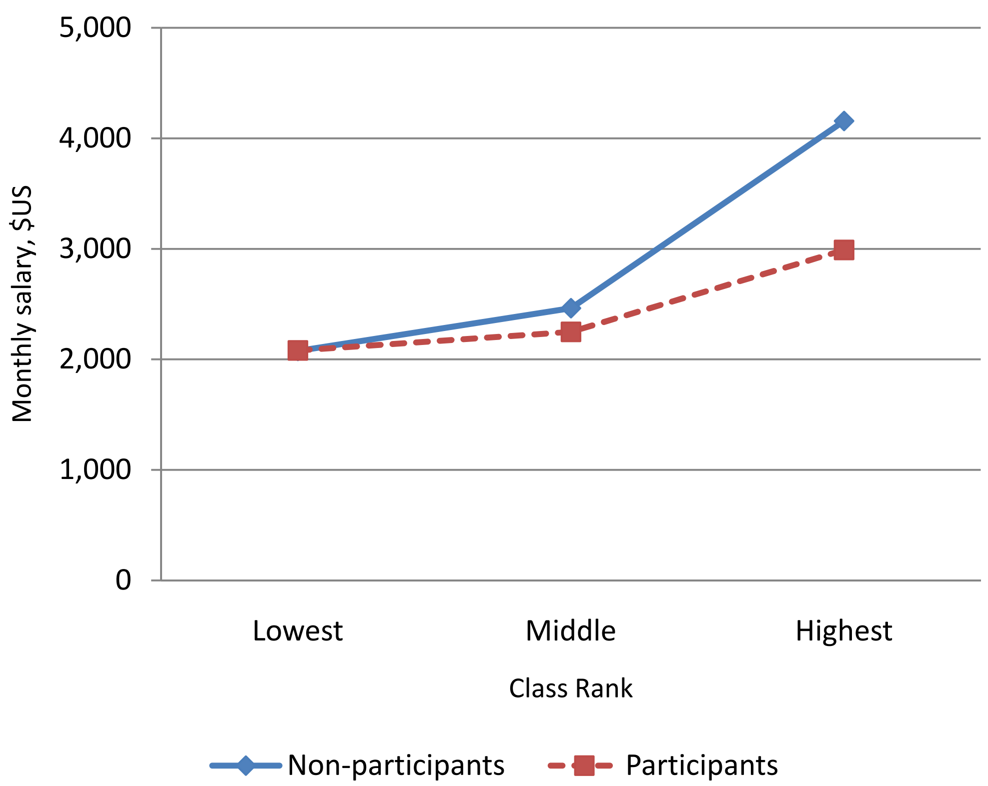
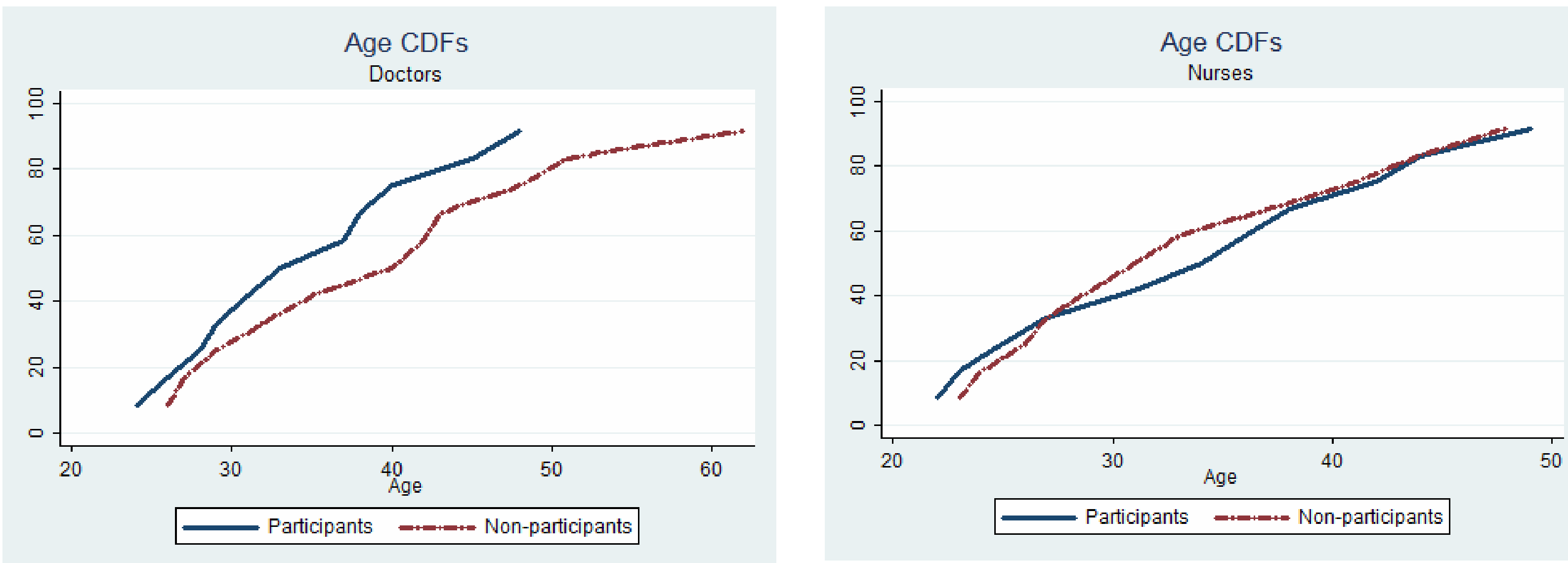


Figure 3: Monthly wages, by rank and lottery participation



(a) (b)

Figure 4: Non-parametric estimates of the cumulative age distributions of lottery participants (solid line) and non-participants (dashed line). (a) doctors, and (b) nurses.

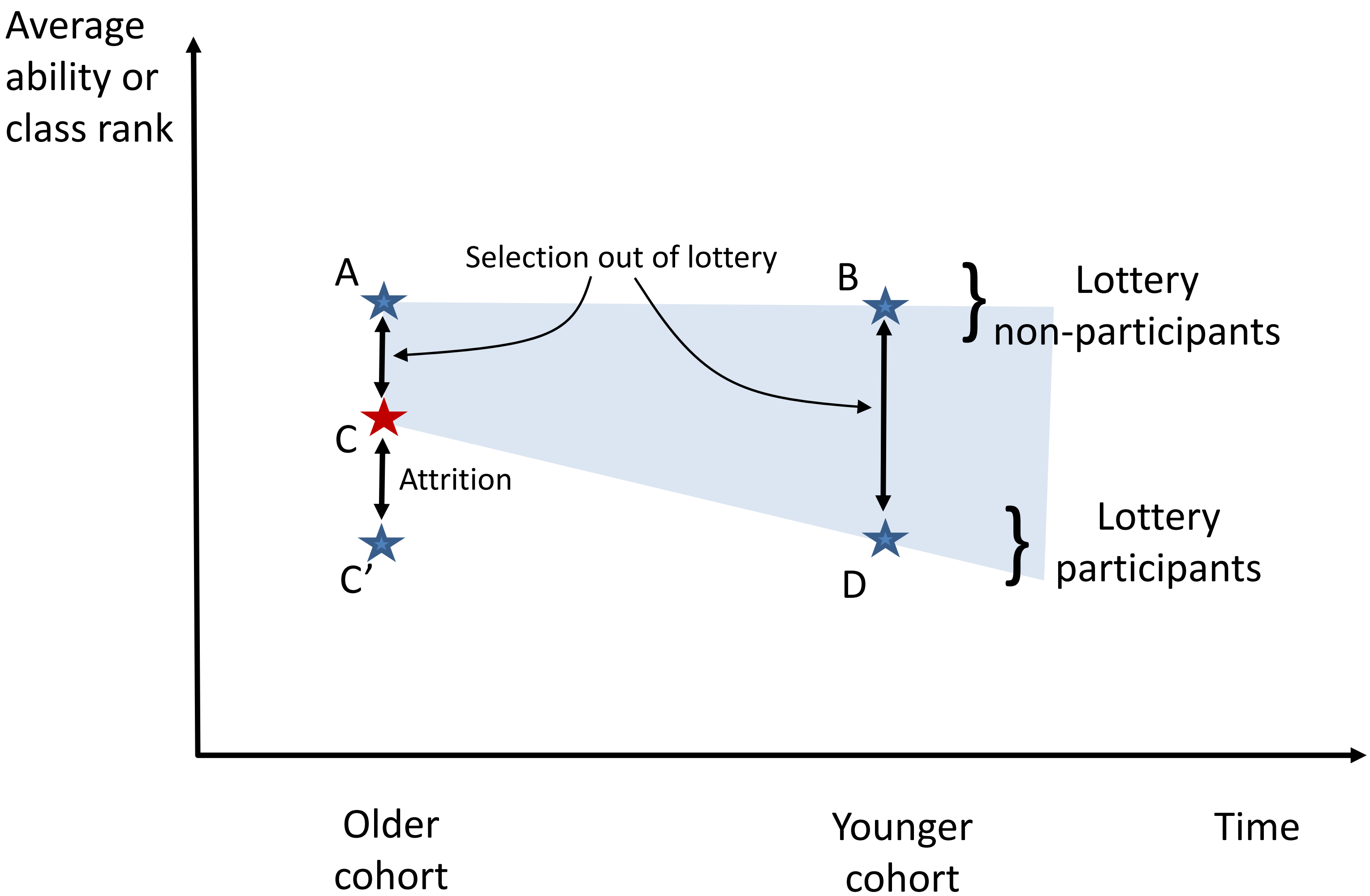


Figure 5: Lottery participation decisions and labor market attrition