The return to medical school in a regulated labor market: Evidence from admission lotteries*

Nadine Ketel[†] Edwin Leuven[‡] Hessel Oosterbeek[§]

Bas van der Klaauw[¶]

Abstract

Many countries restrict the supply of doctors by centrally fixing the number of places in medical schools. This is likely to create a monopoly rent for doctors. We estimate the size of this rent by exploiting that admittance to medical school in the Netherlands is determined by a lottery. We find that doctors earn at least 20 percent more than people who end up in the next-best occupation. Estimated earnings profiles suggest that the difference is much larger in the long-run: 21 years after participating in the first lottery the earnings difference is more than 60 percent. Only a small part of this difference can be attributed to differences in working hours and human capital investments. The size of the rent does not vary with gender, but is higher for applicants with a higher GPA in secondary education.

JEL-codes: J44; I18; I23; C36

Keywords: Medical school, returns to education, occupational licensing, random assignment

*This version: March 2012. We gratefully acknowledge valuable comments from Maarten Lindeboom, Dinand Webbink and seminar participants in Amsterdam and Toulouse.

[†]VU University Amsterdam; University of Amsterdam; Tinbergen Institute

[‡]University of Oslo. Also affiliated with CEPR, CESifo, IZA and Statistics Norway.

[§]University of Amsterdam; Tinbergen Institute; TIER

[¶]VU University Amsterdam; Tinbergen Institute; CEPR; IZA

1 Introduction

Many countries restrict the supply of doctors by centrally fixing the number of places in medical schools (Simoens and Hurst, 2006). This might result in a monopoly rent with doctors' earnings exceeding their reservation earnings to enter the profession. This paper addresses the question by how much doctors' earnings – and thereby health expenditures – can be reduced without reducing the effective supply of doctors. This deals with the earnings elasticity of entry into the medical profession. Earlier studies looked at the labor supply elasticity of doctors at the intensive (hours) margin (Baltagi et al., 2005; Noether, 1986; Rizzo and Blumenthal, 1994; Showalter and Thurston, 1997; Sloan, 1975). The extensive margin of doctors' labor supply has not been examined before.

The ideal research design would be to exploit exogenous variation in future renumeration of potential doctors. Future earnings prospects should differ between similar groups of potential doctors, who should also have the same earnings prospects in alternative occupations. It is hard to think of a source of variation that accomplishes this. An experimental design is most likely impossible, and, for example, differences in tax rates or regional variations in renumeration either do not provide sufficient variation in earnings prospects, affect also earnings in alternative occupations, or affect selective groups.

In this paper we exploit the limited number of places in Dutch medical schools, which are assigned to applicants through admission lotteries. We use administrative data from the admission lotteries in the years 1988 to 1999, and of applicants' subsequent study career from the Dutch student registry. This information is merged at the individual level with data on labor market outcomes from Statistics Netherlands. These data cover the entire population and are from the administrative records of municipalities, tax authorities and social insurance administrations. The labor market data cover the period 1999 to 2009, implying that for the cohort that applied for the first time to medical school in 1988, labor market information is available up to 21 years after their first application. Using these data we estimate returns to medical school and thus from entering the medical profession (compared to the next-best occupation). The admission lotteries allow us to deal with (self-)selection bias. We present separate estimates for each year since the first application thereby constructing synthetic experience-earnings profiles.

Also in the absence of the supply restriction, earnings as a doctor may, however, differ from earnings in the next-best occupation. Two reasons are often mentioned. First, the investments in human capital differ. Becoming a doctor requires, on average, more years of education than necessary to enter other occupations. Because we observe the entire earnings profile since first applying for medical school and tuition fees are known, we deal with differences in human capital investments. Second, job characteristics differ between professions, for example, doctors often claim to work long hours. We examine this possible explanation for the earnings differential.

The main empirical complication is that losers of admission lotteries are allowed to reapply the next year, and not all lottery winners actually complete medical school. We use the outcome of an individual's first lottery as instrumental variable for completing medical school. Winning the first lottery increases the probability to complete medical school by around 40 percentage points, and this effect is highly significant.

The earnings increase of working as a doctor instead of in the next-best occupation is substantial. There is no single year after graduation in which the return is less than 20 percent. Moreover, the earnings profiles indicate that the return increases with experience. Twenty one years after the first lottery doctors have, on average, more than 60 percent higher earnings. The returns are very similar for men and women, although in absolute terms men earn more than women. The returns to medical school are higher for individuals with a higher ability, measured by high-school GPA: Applicants with a GPA in the top 20 percent of the GPA-distribution have a 50 percent larger earnings gain than applicants with a GPA in the bottom 30 percent in that distribution. These large earnings differences can not be attributed to differences in working hours. While doctors work longer hours than non-doctors, this difference is modest. In the first four years of their career doctors work 200 to 300 hours more on an annual basis, after these first four years this difference is in the vicinity of 100 hours per year. There is also no evidence that doctors are more restricted in their private life. In 2010, doctors are 8 percentage points more likely to be married and 5 percentage points more likely to have children.

The instrumental variable approach implies that we identify average treatment effects for compliers (Imbens and Angrist, 1994). The compliers are applicants who complete medical school if they win the first lottery, and who do not complete medical school if they lose the first lottery. Not completing medical school after losing the first lottery can result from not reapplying or from losing subsequent lotteries. Since we also have information about participation and outcomes of subsequent lotteries, we can further characterize the compliers. In particular, we can identify separately the earnings gain for compliers who do not reapply when they lose the first lottery, and for compliers who reapply when they lose the first lottery but also lose subsequent lotteries. The empirical results show that the earnings returns are largest for the first type of compliers.

A possible confounding factor is that the disappointment of losing the first lottery has a direct effect on earnings in the next-best occupation. We also report results from admission lotteries for other university studies, which do not license people to work in a specific occupation. For these studies we find no earnings difference between winners and losers of the first lottery. This suggests that the disappointment of losing a admission lottery does not reduce future earnings.

The very substantial monopoly rent for doctors questions the desirability of a quota in combination with the low and uniform tuition fees charged by Dutch universities. Completely releasing the quota will initially almost double the inflow and outflow of medical schools, which requires a large expansion of the capacity of medical schools. The extra supply of doctors should eventually eliminate the monopoly rent, but our estimates are uninformative about the extra supply needed to achieve that. Alternatively, the government can increase tuition fees for medical schools such that fewer students apply and an extreme capacity increase is not necessary. However, not all people in the medical profession become specialist, who have the highest earnings. The increase in tuition fee should not be so high that medical school will only be affordable for students who want to become a medical specialist. But medical specialists follow special longer education tracks. It seems feasible to extract the high rents of specialists by charging substantial tuition fees for these tracks.

The size of monopoly rents due to regulation of the market of doctors has been studied before. Friedman and Kuznets (1954) quantify this rent for the US in the 1950s, by comparing earnings of doctors and dentists, for whom at the time entry was much less restrictive. They claim that 16.5 percent of doctors' earnings is due to "barriers to entry". They acknowledge that part of the observed earnings difference may reflect ability differences. Burstein and Cromwell (1985) find that the difference in income between doctors, on the one hand, and dentists and lawyers on the other was 35 percent and 139 percent, respectively, in 1978-80. More recently, Anderson et al. (2000) show that doctors in states in the US with higher entry barriers due to stricter regulations earn significantly higher incomes. Finally, Kugler and Sauer (2005) measure the effects of licensing by exploiting a retraining assignment rule for immigrant doctors in Israel. They find that immigrant doctors have mean monthly earnings that are 180 percent to 340 percent higher when they obtain a license. These returns apply to the special group (immigrants who have at least 20 years of experience as a doctor).

The remainder of this paper is organized as follows. The next section provides further details about the institutional context and the admission lottery to medical school. Section 3 describes the data used in this paper. Section 4 discusses the empirical model and the identification. Section 5 presents the estimation results. Section 6 discusses the interpretation of our results in terms of characterizing the compliers. Section 7 concludes.

2 Background and institutional context

2.1 The Dutch health care system[1]

Compared to other OECD countries, the Dutch health care system ranks high in terms of outcomes. In 2009, life expectancy at birth was 80.6, above the OECD average of 79.5 but somewhat below Japan which is the highest with 83.0. Also the percentage of adults reporting to be in good health is in the Netherlands (78.5 percent) above the OECD average (69.1 percent), but below the highest percentage in Switzerland (86.7 percentage).

The number of practicing doctors in the Netherlands is 2.9 per 1000 inhabitants, while

[1] The information in this subsection comes from OECD (2010).

this is 3.1 in the OECD. Also the division amongst general practitioners, specialists and other doctors in the Netherlands is close to the OECD average, at 25.9 percent, 61.4 percent and 12.7 percent, respectively. The same holds for the number of medical graduates; in 2009, 9.9 per 100,000 population. In terms of remuneration general practitioners in the Netherlands earn 1.7 or 3.5 times the average income depending on whether they are salaried or self-employed. Self-employed GP's in the UK, Ireland, Germany and Canada have comparable relative remuneration rates. Specialists in the Netherlands are well paid at 5.5 times the average income. There is no other country where this ratio is so high, although also in several other countries (including Australia, Austria, Canada, Ireland and Germany) this ratio exceeds 4.

2.2 Medical schools in the Netherlands

In the Netherlands students choose their field as soon as they enter university, unlike, for example, the US where students specialize later. Graduates from the pre-university track in high school can enroll in all fields at all universities.[2] Universities have to accept all applicants. However, some fields have a quota, implying that only a fixed number of students is admitted.

The quota for medical schools was introduced in 1976. Initially, the argument for the quota was to ensure the quality of the study program in a time of increasing numbers of applicants. More recently, the arguments in favor of the quota are threefold (RVZ, 2010). First, since university education is largely publicly funded and medical school is much more expensive than the average study, it is considered a waste of resources to educate doctors for whom there is no employment as a doctor. Second, the teaching capacity of medical schools is limited. Finally, there may be supplier induced demand (Hurley (2000)), implying that educating more doctors will increase the number of medical interventions.

The minister of education decides about the size of the quota. Until 1993 the annual quota was fixed at 1458 students. From 1993 to 1995 it was gradually expanded to 1815 students in 1995. In the years relevant for this study it remained at this level. The

[2]In the Netherlands students are tracked into different levels when they enter high school at age 12. Only the highest of three levels ensures direct admittance to university.

Table 1. Lottery categories

Category	GPA	Share	Weight
A	$GPA \geq 8.5$	0.02	2.00
B	$8.0 \leq GPA < 8.5$	0.06	1.50
C	$7.5 \leq GPA < 8.0$	0.09	1.25
D	$7.0 \leq GPA < 7.5$	0.21	1.00
E	$6.5 \leq GPA < 7.0$	0.22	0.80
F	$GPA < 6.5$	0.29	0.67

Notes: GPA is grade point average on the final exams in high school. Share is the share of applicants in the different categories that applied for the lotteries in the years 1988-1999. Weight indicates the relative probability of being admitted.

minister bases the size of the quota on the number of places in specialization tracks, which is determined by the associations of specialists. For example, the association of neurologists decides how many places there are for specialization tracks in neurology.

If the number of applicants for medical schools exceeds the quota (which has always been the case), a lottery determines who is admitted.[3] Rejected applicants are allowed to reapply in the next year, and until 1999 they could do this as often as they wanted.[4] We observe that 69 percent of the rejected first-time applicants in our sample reapply a second time.

The lottery is weighted such that students with a higher GPA on secondary school exams have a higher probability of being admitted.[5] High school exams are nationwide and externally graded on a scale from one to ten, where six and above indicates a pass. Table 1 shows which GPA intervals are assigned to which lottery groups - labelled A to F -, together with the shares of applicants in each category.[6] The final column indicates the weights in the lottery. This weight determines the ratio of places assigned to a category over the number of applicants in this category relative to category D. Hence, someone in

[3]Since 2000, medical schools are allowed to admit at most 50 percent of the students using their own criteria. Medical schools have have made increasing use of this, and selection is often based on motivation and previous experience.

[4]In our data, the maximum number of applications of one individual is nine. In 1999, the maximum number of applications was limited to three.

[5]Graduating from high school requires an exam in seven subjects. Applicants for medical school should have included biology, chemistry, physics and math among these subjects and should have passed these subjects.

[6]Additionally, there are categories G and H for students who did not participate in the nationwide high school exams, such as foreign students. These categories, which contain less than 10 percent of the applicants, are excluded from the analysis.

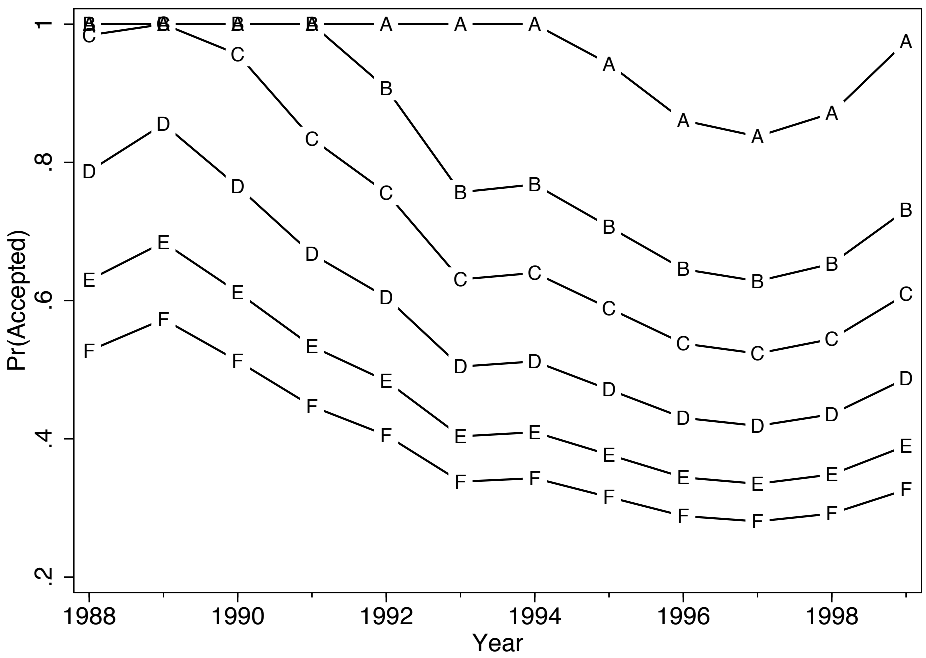


Figure 1. Probability of being admitted by year of application

category A has a twice as high probability of being admitted than someone in category D.[7]

Figure 1 shows for the years in our data the total numbers of applicants (first time and later) and the admitted rates by lottery category. In most years, there is only a relatively small number of applicants in categories A and B, who are almost certainly admitted. The majority of applicants are in categories C to F, for which the admittance rates ranges from 35 to 60 percent. Since applicants can participate in multiple lotteries, eventually almost 72 percent of all first-time applicants between 1988 and 1999 are admitted.[8]

The program of medical schools consists of different phases. After completing four years of mainly theoretical education students receive their undergraduate diploma. To enter the labor market for medical doctors, two more years of practical training is required. After that, students can choose to specialize. The specialization for a general practitioner

[7] In case the number of available places in a category exceeds the number of applicants, all applicants in that category are admitted.

[8] The admission lottery is centrally executed. Applicants are allowed to list their first three preferred medical schools. After the result from the lottery is known, admitted students are divided over the medical schools taking account of their preferences where possible. In the Netherlands, eight universities have a medical school, which offer programs which are similar in content and quality. Universities are publicly funded and the nationwide tuition fee is low and fixed by the government. There are no private institutes offering the same education.

takes three additional years while the most advanced specializations such as neurologist, cardiologist or surgeon require an additional four to six years of training. In order to get a place in one of the medical specializations it is common to first get a PhD degree. In total, the complete medical study takes between six and 15 years.

During the first six years students are entitled to the same general study allowance that all Dutch students receive and students pay a tuition feeof around 1000 euro (at that time). During the PhD or specialization track students are not charged a tuition fee. Instead, they have a formal employment contract and receive a salary.

A medical specialist can either become an employee of a hospital or can join a partnership, which is a joint venture of self-employed individuals. Members of a partnership are considered to be self-employed and are taxed as such. The hospital buys the services of these partnerships of medical specialists.

Doctors with a non-Dutch diploma can practice in the Netherlands if their diploma is recognized by the Dutch registration authority. Non-EU citizens have to pass a language test and a medical ability test. They often have to follow a number of years of additional training, depending on the assessment of their diploma. The language tests are a considerable barrier; in the years 2005-2009 only one quarter of the participants passed the test (Herfs, 2009). For EU-citizens the Dutch government is not allowed to demand a language requirement, but employers can. In practice, many employers ask a candidate to pass the same language test as the non-EU citizens.

3 Data

3.1 Data sources and sample

The data used in this paper come from two sources. The first source are the administrative records from the agency (DUO) that registers enrollment of all Dutch students in higher education and that conducts the lottery. So, we observe all applicants for medical school together with their lottery category and the outcomes of the lotteries. Furthermore, we know the actual study choices of all lottery applicants, winners and losers. Information on study progress is also available as the agency registers when and whether students successfully complete certain stages.

Between 1987 and 2004, almost 50,000 persons applied at least once to medical school. Because we are interested in the full history of lottery participation, we exclude from the data individuals who participated in the lottery in 1987. For that year, we cannot observe if participation in the lottery is preceded by losing previous year's lottery. The data show that people very rarely skip lottery years. But if someone applied in 1986 and next in 1988 (so skipped 1987), we would mistakenly consider the lottery participation in 1988 as start of the application history. To further minimize the number of mistakes, we exclude applicants that are older than 20 at the time that we observe their first application.[9]Since 2000, universities are allowed to admit some students using their own criteria. Therefore, we exclude all applicants that applied for the first time after 1999. Finally, participants in category A are excluded since almost all of them are eventually admitted to medical school. This leaves us with 25,551 observations.

Using social security numbers, the information from DUO is merged to the individual records of all Dutch citizens kept by Statistics Netherlands. We lose 60 observations, who do not have a valid social security number and cannot be matched. These individuals are evenly distributed among the winners and losers of the first lottery (p-value of equality is 0.18). The records of Statistics Netherlands include information from municipalities, tax authorities and social insurance administrations and contain detailed information on earnings from various sources and on characteristics such as age, gender, ethnicity and marital status. All inhabitants of the Netherlands are registered at a municipality, which implies that if a person is not in our data in a particular year, this person did not live in the Netherlands in that year. Finally we have records from the BIG-register, that registers all healthcare professionals in the Netherlands. This register provides information regarding the care provider's qualifications and entitlement to practice. Data from the Statistics Netherlands records are available for the years 1999 to 2009.

[9]In the Netherlands children finish high school at the age of 18, so if they applied in 1985, skipped the 1986 and 1987 lottery and applied again in 1988 they will be older than 20 once we observe their first application

Table 2. Descriptive statistics

	Winners first lottery	Losers first lottery
	Mean	Mean
Personal characteristics		
Female	0.58	0.58
Age at date of first application	18.3	18.3
Non-western immigrant	0.08	0.08
GPA high school exams	7.06	6.79
Study enrollment and completion		
Enrolled in medical school	0.94	0.45
Completed medical school	0.79	0.38
Enrolled in study program in NL	0.99	0.95
Completed study program in NL	0.90	0.80
Labor market outcomes		
Mean monthly earnings 1999-2009	3013	2188
Mean hours worked 2006-2009	1755	1685
Mean hourly earnings 2006-2009	31.0	24.0
Works part time 2009	0.18	0.20
Ever any benefits	0.27	0.28
Household composition		
Married in 2010	0.51	0.45
Children in 2010	0.60	0.51
Number of observations	13,672	11,819

3.2 Descriptive statistics

Table 2 presents descriptive statistics separately for winners and losers of the the first lottery.[10] The first part of the table provides information on personal characteristics. The majority of the applicants is female and the percentage of women is similar among winners and losers. The average age at the date of first application is 18.3, which indicates that most applicants apply directly after finishing high school. In the Netherlands the nominal age at the end of high school is 18. The mean GPA of lottery winners is higher than of lottery losers, which reflects that GPA is used to determine the weight in the lottery.

Next, the table presents summary statistics on study enrollment and completion. The outcome of the first lottery is associated with a 50 percentage point increase in enrollment

[10] When there can be no confusion we sometimes refer to winners and losers of the first lottery in which they participated as "lottery winner" and "lottery loser".

into medical school. Not everyone who wins the first lottery actually enrolls in medical school; 6 percent of the winners of the first lottery does not. Of the losers of the first lottery 45 percent enrolls in medical school (after winning a subsequent lottery). Of the winners who enroll, 79 percent complete medical school, and for the losers this is 84 percent.

For the interpretation of the estimated returns to medical school it is important to know which alternatives the lottery losers opted for. The majority of the lottery losers attends a study program in the Netherlands. Only 5 percent of the lottery losers never register for higher education in the Netherlands. These individuals may not have enrolled in any study program. But, it is also possible that they enrolled in medical school in Belgium.[11] A degree from medical school in Belgium seems a close substitute for a degree from a Dutch medical school. However, individuals who studied in Belgium may lack the network, which might be useful to become a practicing medical specialist. In our empirical analyses we focus on the returns to a degree from a Dutch medical school. If a degree from a Belgium medical school is a very close substitute, our estimated returns will be a lower bound for the returns of any medical degree. But since it concerns at most only a small fraction of the losers, the downward bias will most likely be small if at all present. Of the lottery participants that do not enroll in medical school but do enroll for Dutch higher education 32% enrolls in a health related field. Other regularly chosen fields include Science (15%), Social and Behavioral Sciences (15%), Engineering (10%) and Economics (9%). The most frequently chosen other studies of lottery participants who do not enroll in medical school are psychology (9.5 percent), law (6.3 percent) and pharmaceutical sciences (5.4 percent).

Lottery losers are 10 percentage points less likely to complete a study program. Several factors may explain this. First, lottery losers can have wasted time by participating in multiple lotteries and may thus still be actively studying. Second, if lottery losers may be less motivated when being enrolled in an alternative study program, which decreases the probability of completing. Third, medical school has much lower dropout rates than other

[11]Belgium does not have a quota like the Netherlands. Applicants have to pass an entry exam in order to be allowed into medical school.

study programs. It is often argued that this is the consequence of the intensity of the study program at medical school (more workgroup classes and fewer exams). Finally, lottery losers have, on average, lower ability (GPA), which can explain their lower graduation rate. This final explanation is supported by results from a regression of having a diploma on GPA.

We focus on the following labor market outcomes: earnings, working hours, earnings per hour and collecting benefits. Earnings are measured as the sum of before-tax income from employment, income as a self-employed, income from abroad and other income from labor. Earnings are observed per year, which we divide by 12 to obtain monthly earnings. Using the Consumer Price Index for the Netherlands all amounts are converted to 2010 euros. Earnings are set equal to zero for people who live in the Netherlands and have no income from labor.[12] This includes students who have no earnings from a side-job. Table 2 shows that mean earnings are around 38 percent higher for winners than for losers.

Information on the number of hours worked is only available for 2006 to 2009 and only for employed workers. For the self-employed we assume a full-time job (1872 hours per year).[13] Average working hours are close to 1700, but winners work approximately 4% more hours than losers. This difference is not sufficient to equalize earnings per hour; these are about 29 percent higher for the winners. A part-time job is defined as working less than 1500 hours per year. Among both the winners and the losers, about 27 percent ever received any kind of social insurance benefits (welfare, unemployment and disability insurance) in the period 1999-2009.

Finally, the bottom part of the table shows descriptives for the household situation in 2010. Winners of the lottery are more likely to be married and to have at least one child.

[12]The share of people that live abroad increases over time and is 5 percent in 2008, this share is the same for winners and losers.

[13]In case a person has income both from employment and from self-employment we take: hours worked= hours from employment + (income from self-employment/total income) * 1872 hours.

4 Empirical approach

We are interested in the effect of working as a doctor on labor market outcomes. Our data do, however, not contain information about people's actual profession. But since the only way to be licensed as a doctor is by obtaining a medical degree, we use completion of medical school as indicator of working as a doctor. We assume a linear relationship between the labor market outcome of individual i in year t who applied for the first time to medical school in year τ ($Y_{it\tau}$) and completion of medical school:

$$Y_{it\tau} = \alpha_t + \gamma_{t-\tau} + \delta_{t-\tau} MS_i + X_i\beta + LC_{i\tau} + U_{it\tau} \tag{1}$$

where $t - \tau$ indicates the number of years elapsed between the year of the first lottery and the year in which the outcome is observed. MS_i is a dummy variable which is equal to one if individual i completed medical school, zero otherwise. X_i is a vector of controls including gender, ethnicity and age at first lottery, and $LC_{i\tau}$ is the interaction between lottery category and year of first lottery. α_t and $\gamma_{t-\tau}$ are fixed effects for year in which the outcome is observed and the number of years since the first application. $U_{it\tau}$ is the error term. The parameters of interest are $\delta_{t-\tau}$ which describe the returns to completing medical school $t - \tau$ years after first applying. We estimate equation (1) separately for each number of years since the first lottery ($t - \tau$).

Even in the sample of applicants for medical school, completion of medical school is potentially endogenous. As shown in the previous subsection, not all admitted student actually complete medical school, and after losing a lottery some people decide to reapply in subsequent years. Therefore, we instrument MS_i with the result (0/1) of the first lottery (LR_{1i}) in which someone participated. We estimate a first-stage equation of the form:

$$MS_i = \kappa + \lambda LR_{1i} + X_i\theta + LC_{i\tau} + V_i \tag{2}$$

The identifying assumption for $\delta_{t-\tau}$ to be the causal effect of completing medical school on labor market outcome Y is that conditional on X and LC the result in the first lottery is mean independent of U: $E(LR_1 \cdot U|X, LC) = 0$. Recall that in each year within each lottery category all individuals have the same probability of being admitted. This conditional random assignment guarantees that the mean independence assumption holds as long as the specification includes interactions between years and lottery categories.

In equation (2) the parameter λ reflects the difference in the completion rates of medical school between losers and winners of the first lottery. It will not be equal to 1 for three reasons. First, some winners of the first lottery decide not to enroll in medical school. Second, a share of those who win and enroll do not complete medical school. And third, people who lost the first lottery can still obtain a medical degree if they win one of the later lotteries. An interpretation of λ is that it describes the share of compliers in the data. Compliers are applicants for whom completion of medical school is determined by the result of the first lottery. In Section 6 we elaborate further on the definition of the compliers and the interpretation of the estimates from this model.

By estimating equation (1) separately for different years since the first lottery, we obtain a picture of the evolvement of the earnings differential during the first 21 years after the first lottery. This period also captures the longer study duration in medical schools compared to alternative studies, and thereby an estimate of the opportunity costs of the longer investment in human capital.

5 Results

5.1 Main findings

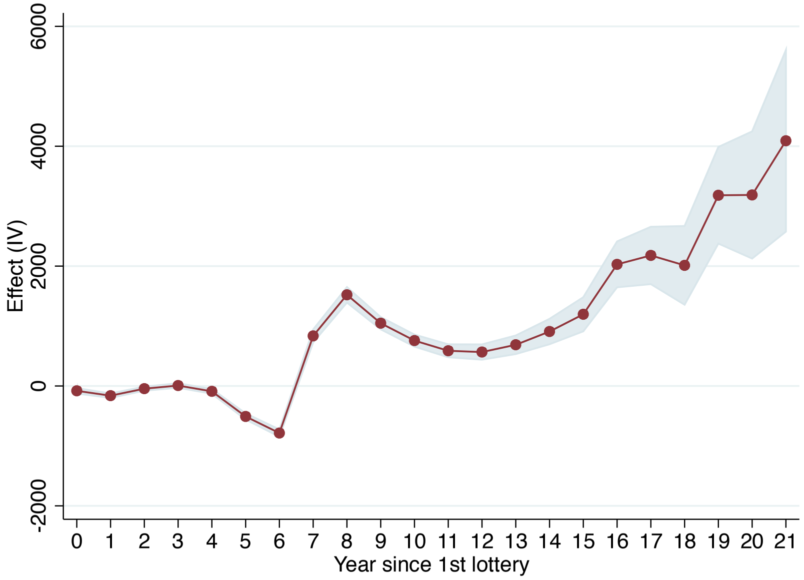
Table A2 presents the instrumental variable estimates of the effect of completing medical school on labor market outcomes by year after the first lottery ($t-\tau$). The second column reports the number of observations in each regression and shows how this number varies across rows. The final row (1) is only based on 2009-earnings information of people who first applied in 1988. The penultimate row is based on 2009-earnings information of people who first applied in 1989 and on 2008-earnings information of people who first applied in 1988, and so on. Because the admission data end in the same year in which the earnings data start (1999), also the estimates in the first row are based on only a single cohort.

The third column reports first stage estimates for the subsamples that are differentiated by year since first lottery. All these estimates are highly significant (the F-statistic is never below 200) and are all close to 0.40.

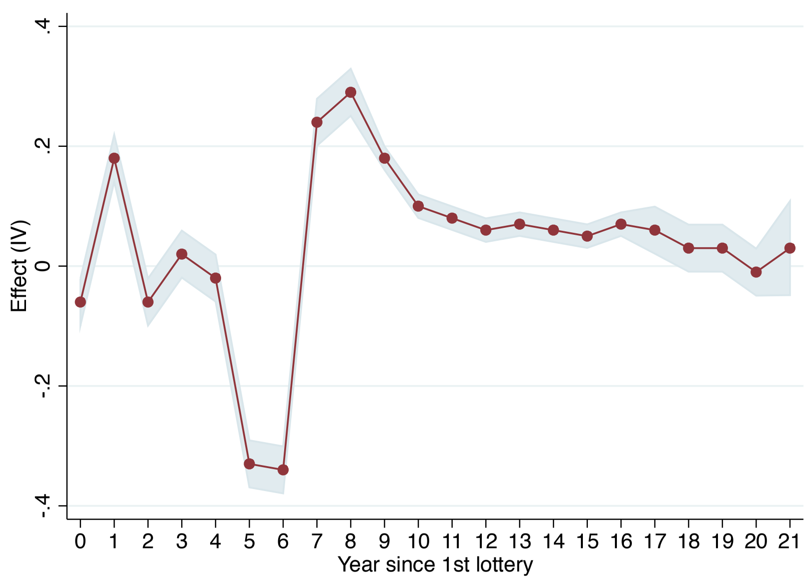
The fourth column reports the effect of completing medical school on monthly earnings. During the first six years after the first lottery, the effect is negative. In the first four years the reduction is modest, and due to students who are not in medical school having more often a small job while studying and some people not admitted who decide to work rather than studying. In the fifth and the sixth year after first applying the reduction in earnings is substantial. This reflects that most alternative studies have a shorter duration than the six years required for medical school. Individuals who do not attend medical school enter the labor market earlier and start receiving income earlier than individuals attending medical school. These negative earnings effects in the fifth and sixth years express the larger investment in human capital of people who obtain the license to practice as a doctor.

The picture reverses from the seventh years onwards. This is also students from medical school have graduated, and start earning, either on the labor market, or while working in a specialization track. From then on the returns to medical school are always positive and significant. In years seven to ten after the first lottery the pattern of this earnings differential is somewhat erratic, with 1500 euro per month difference in the eighth year which reduces to less than half of that in the tenth year. From the tenth year onwards, the pattern is clearer, the difference gradually increases and amounts to almost 4100 euro per month in the twenty-first year. Even for a high discount rate of, say, 10%, the present value of the net earnings gain during the period of 21 years exceeds 30,000 euro. At a more moderate discount rate of 4%, the gain during this period is close to 100,000 euro.

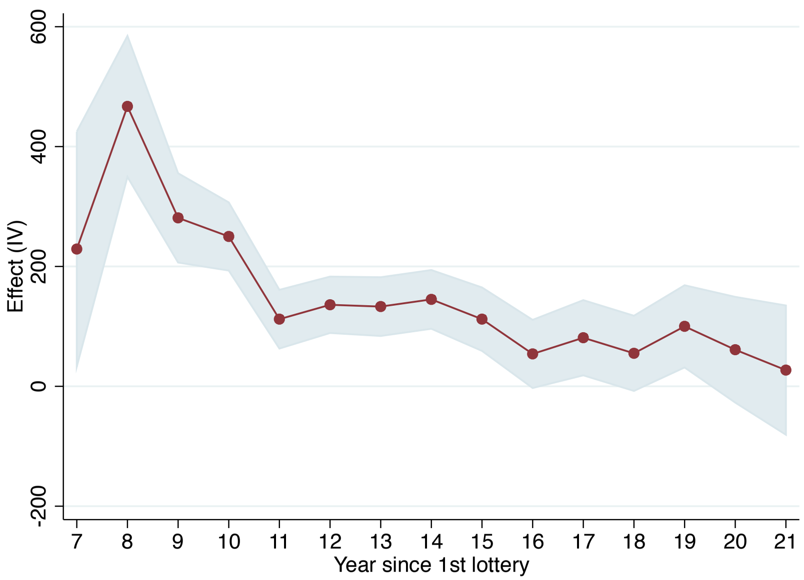
Figure 3 uses the estimated model to show the predicted earnings profiles with an without completing medical school for an average individual. This implies that for both $MS = 0$ and $MS = 1$, we compute the expected earnings according to



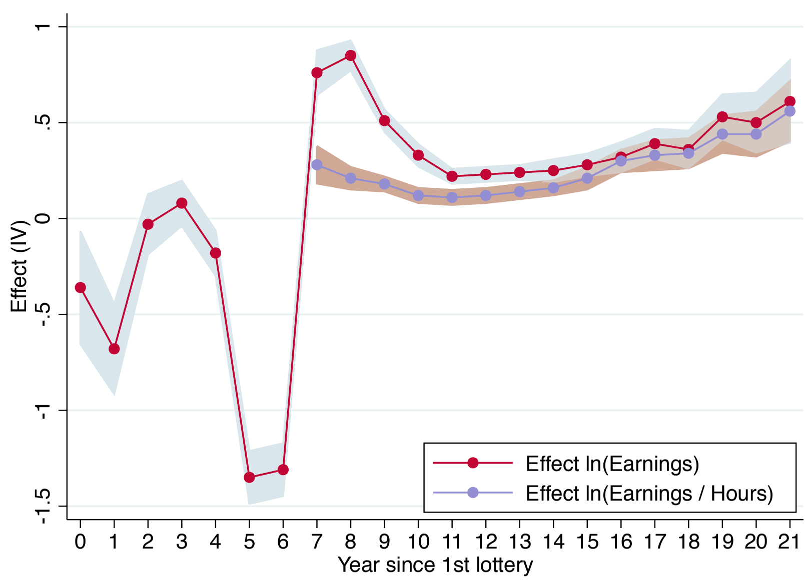
(a) Earnings



(b) I[Earnings>Subsistence Level]



(c) Hours



(d) ln(Hourly Earnings)

Figure 2. Instrumental variable estimates of the effects of completing medical school on labor market outcomes $t - \tau$ years after first applying

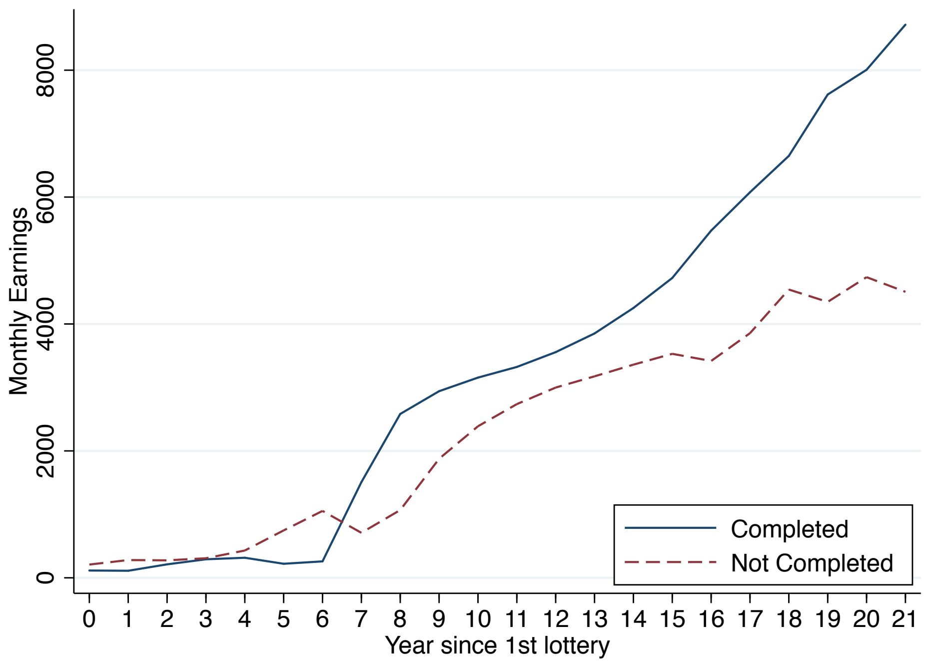


Figure 3. Predicted earnings, completed or not completed

$$\hat{Y_{t-\tau}} = \hat{\alpha}_t + \hat{\gamma}_{t-\tau} + \hat{\delta}_{t-\tau}MS + \bar{X}\hat{\beta} + \bar{LC}$$

where $\bar{X}$ and $\bar{LC}$ are the sample means within our sample. The figure clearly expresses that while being in medical school students earn less than if they would have attended another study, and this difference is erratic shortly before the end of the nominal duration of medical school.

Column (5) shows results where a dummy for having earnings above the level of welfare benefits is the dependent variable. In the fifth and sixth year after the first lottery, students in medical school are less likely to have positive earnings than those not in medical school. But just as with the level of earnings, the sign reverses in the seventh year after the first lottery. The effect is particularly large in seven to nine after the first lottery, which suggests that a large share of the students from medical school find work immediately after graduating. For ten year onwards, relative to a base of 0.xx, medical school graduates are around four percentage points more likely to have positive earnings than other students. Conditional on having positive earnings, column (6) shows results for the effect of completion of medical school on log earnings. The observed pattern is very similar to the pattern for the level of earnings (which includes zeros) in column (4). During the first six years after the lottery, medical school graduates have lower log earnings than not admitted students and this reverses in the seventh year. Until the tenth year the pattern is a bit erratic, but from the eleventh year onwards, the gain for winners steadily increases, up to 0.61 in the last year covered by the data.

Part of the large earnings gain for winning compliers may be attributable to longer working hours. Column (7) reports IV estimates where the number of working hours per year is the dependent variable. Information about hours is only available for the years 2006 until 2009, and therefore only for the seventh to twenty-first year after the first lottery. The results reveal that winning compliers only work more hours per year than losing compliers during the first four years after finishing the initial phase of their study. During these four years winning compliers work a total of 1200 hours more than losing compliers. The average number of working hours during these four years together is around 5750 hours, so that winning compliers work around 20 percent more than losing compliers. After these first four years winners work about 100 hours more per year than losers. Compared to a baseline of 1600 hours this is a 6 percent difference. Differences in working hours can therefore not explain the large earnings gain to completion of medical school. This is confirmed by the results in the final column where log earnings per hour is the dependent variable. From the eleventh year onwards the gain in the log of per hour earnings steadily increases to 0.56.

Using the results from Table A2 we can calculate the lifetime benefits of completing a medical degree. For the first 21 year the estimated differences are used so this takes account of the longer education period for doctors and of the two years of unpaid residencies. We assume that in addition to the 21 years since the first lottery that were already estimated, an average career lasts another 24 more years. The earnings difference for the years 22-45 is set at the level of 21 years after the first lottery. Since the earnings differences are still increasing in the last observation years this is likely to provide a conservative estimate of lifetime rents. Net present values of the lifetime rent are calculated for discount rates equal to 2%, 4% and 6%. Table 3 presents the results.

Table 3. Discounted lifetime rents

Discount rate	All	Men	Women
0.02	810,618	810,217	775,182
0.04	471,207	469,784	453,011
0.06	285,069	282,974	275,996

Notes: Figures assume that the earnings difference for 22-45 years after the first lottery remains at the level of the earnings difference at 21 years after the first lottery. The entries represent discounted earnings at the time of participating in the first lottery. The estimated lifetime rents are for a representative individual.

Table 4. Other outcomes

	All	Men	Women
Children in 2010	0.08 (0.02)***	0.12 (0.02)***	0.05 (0.02)**
Married in 2010	0.05 (0.02)***	0.09 (0.03)***	0.02 (0.02)
Works part-time 2009	-0.07 (0.01)***	-0.06 (0.02)***	-0.08 (0.02)
Ever state benefits	-0.04 (0.02)***	-0.10 (0.02)***	0.01 (0.02)

Notes: Standard errors in parentheses. Total number of individuals is 25,491. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Every cell in this column represents a separate regression, which include controls for gender (in the first column), ethnicity, age in the first lottery year, lottery category, year of first lottery and interaction terms of the year of first lottery and lottery category

Other outcomes Table A2 shows that with the exception of the first few years of their career, doctors do not work longer hours than others. We now inquire whether the high earnings of doctors come at the cost of other outcomes. In Table 4 we look at the impact of completion of medical school on having children, being married, working part-time (at most 30 hours per week) and ever receiving state benefits. The first column pertains to the whole sample, while the second and third columns report results separately for men and women.[14] The results show that doctors never do worse in terms of these outcomes; they do not have fewer children, they are more likely to be married, they more often work part-time and they are less likely to have ever received state benefits. Results by gender show that male doctors score significantly different on all these variables than male non-doctors, while for women all these outcomes are identical for doctors and non-doctors. In short, doctors' household situation does not suffer from their occupation.

[14]In the next subsection we report effects on labor market outcomes by gender.

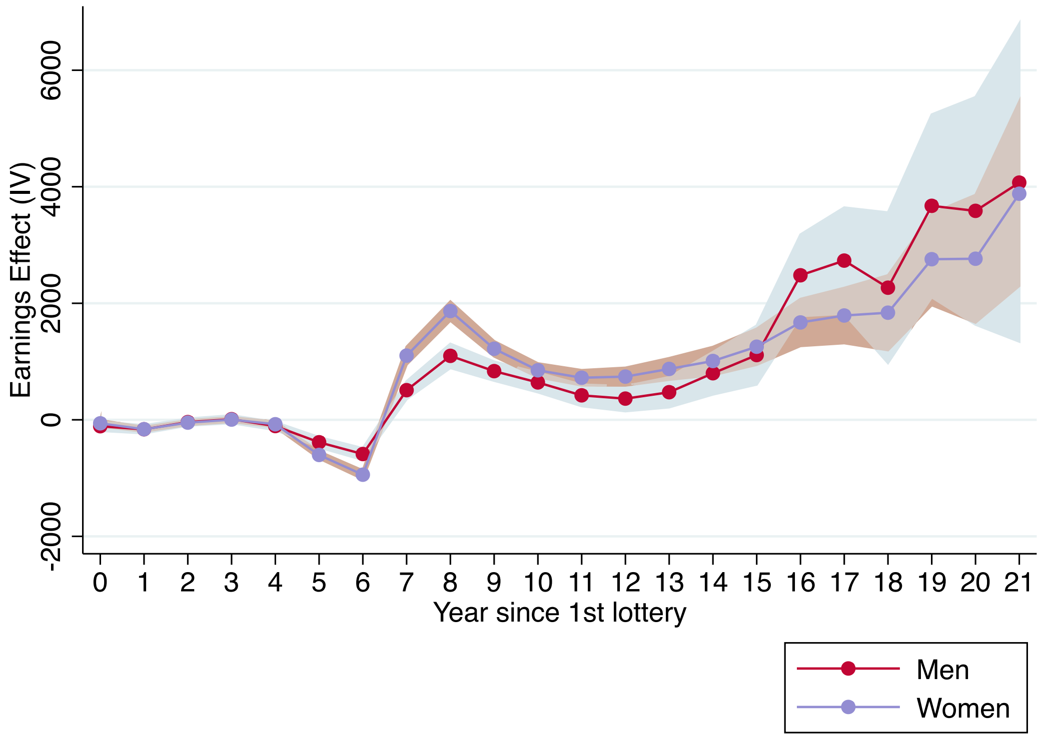
5.2 Heterogenous treatment effects

We now turn to the heterogeneity of treatment effects. We first examine whether treatment effects differ between men and women. As Table 2 reveals, a majority of the applicants for medical school is female. While of all university students in the Netherlands less than half is female during the period 1988-1999, this is 58 percent in medical schools. This justifies the question whether women have a comparative advantage in medical school. Next we investigate whether treatment effects differ by ability. As described in Section 2 the admission lottery uses weights based on applicants' GPA on secondary school exams. Applicants with a higher GPA have a higher chance to be admitted. This system of a weighted admission lottery warrants the question whether this allocates the available places efficiently.

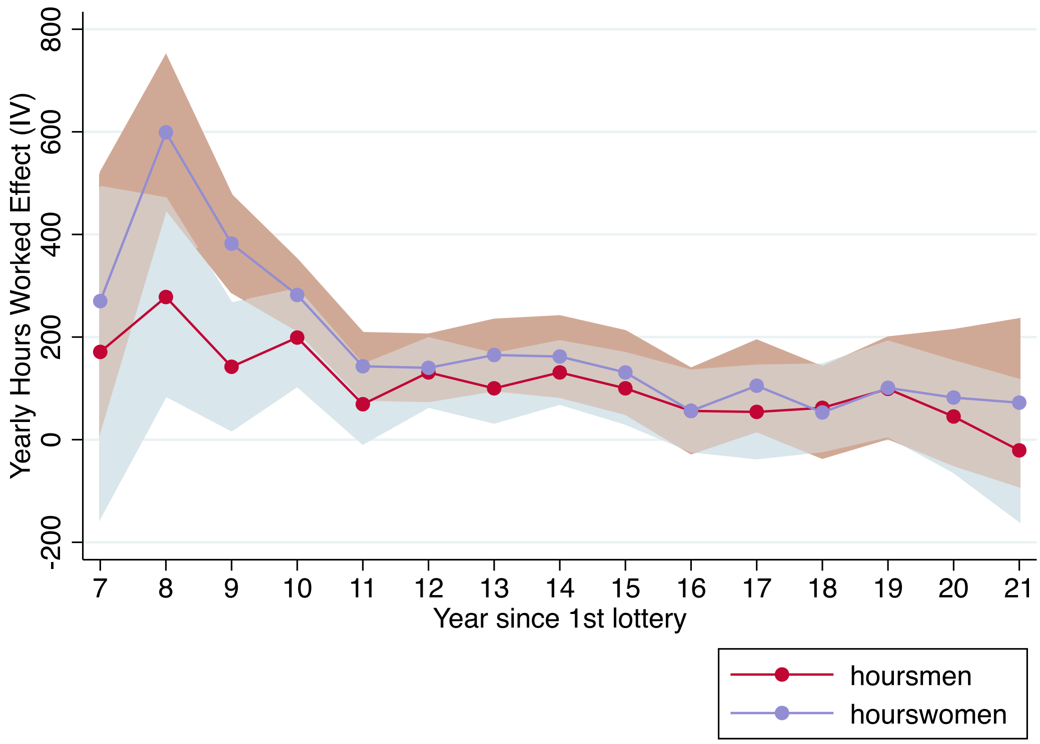
By gender The first two columns of Table A3 show estimates of the earnings gain separately for men and women. Until the sixth year both men and women experience an earnings loss when completing medical school. This loss is very similar across the sexes. In years 7 to 14, the gain is much larger for women than for men, but from year 15 onwards men seem to catch up and in the last year the gain of completing medical school is even slightly larger for men than for women. This suggests that male doctors more often choose for long specialization tracks than female doctors. Figure 5 shows gender-specific predicted earnings profiles with and without completed medical school. This reveals that female doctors earn more or less the same as male non-doctors, and that doctors earn more than non-doctors of the same sex.

The final two columns in Table A3 shows that from the seventh to the tenth year after the first lottery, doctors work longer hours than non-doctors of the same sex. The difference is larger for women than for men. These effects on hours disappear after the tenth year, and a bit further in their career male doctors even work fewer hours than male non-doctors.

By ability The lottery gives higher chances to be admitted to applicants with higher GPA on their secondary school exams. This warrants the question whether there is a difference



(a) Earnings



(b) Hours

Figure 4. IV estimates of effects of medical school completion on earnings and hours, by year since first lottery and gender

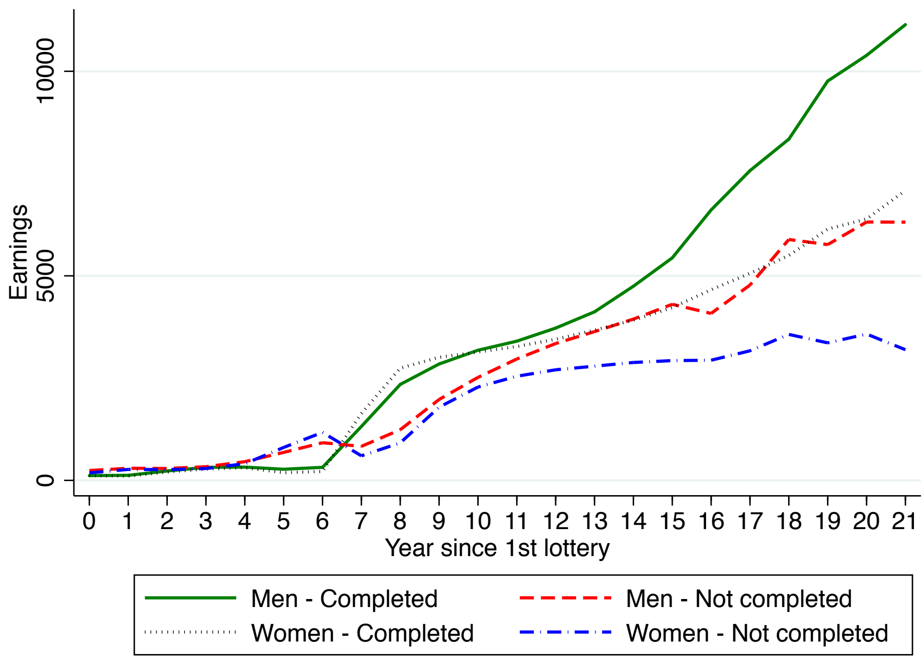


Figure 5. Predicted earnings, gender differences

in earnings gain between people with different GPA's. To examine this, we estimated earnings gains by year after first lottery separately for lottery categories B to F.[15] Table A4 reports the results. The estimates for categories B, C and D are not very precise due to small sample sizes. By and large, however, the estimates show that the earnings gain to completion of medical school increases with average GPA. This is most clearly seen in the bottom row which reports the net present values of the earnings streams from zero to 20 years after the first lottery. This uses a discount rate of 4%. For applicants in categories B and C the net present value after 20 years is slightly larger than 100,000 euros. Winning compliers from categories D and E have a gain from almost 85,000 euros, while those from category F receive a gain of 70,000 euros. Hence, while the gain in net present value is substantial for all categories, winning compliers with GPA's above 7.5 benefit around 50 percent more than winning compliers with a GPA below 6.5. If earnings reflect productivity accurately and if applicants' GPA's do not respond to changes in the chances to be admitted, wealth would increase from admission on the basis of merit alone, without a lottery.

[15]Category A is omitted since there are too few losers from this category.

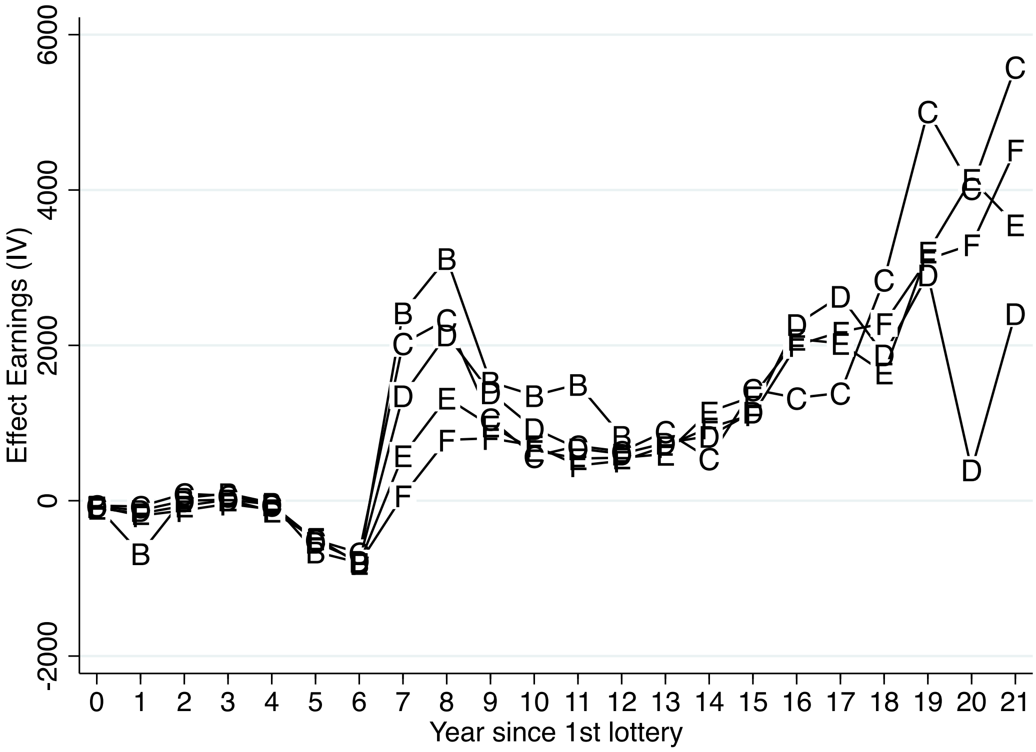


Figure 6. IV estimates of effects of medical school completion on earnings, by year since first lottery and lottery category

6 Interpretation

6.1 Degrees of compliance

In this section we provide some interpretation to the estimated returns to medical school presented in the previous section. As we already stressed before, using the instrumental variable approach identifies the average treatment effect of completing medical school for applicants who comply to the result of the first lottery. Below we characterize these compliers in more detail. Following(Imbens and Angrist, 1994), the Wald estimator can be expressed in terms of potential outcomes as:

$$\frac{E[Y|LR_1 = 1] - E[Y|LR_1 = 0]}{P(MS = 1|LR_1 = 1) - P(MS = 1|LR_1 = 0)} = E[Y(1) - Y(0)|MS(LR_1 = 1) - MS(LR_1 = 0) = 1] \quad (3)$$

where$Y(1)$ and $Y(0)$ are potential outcomes with and without completing medical school, respectively, and $MS()$ is an indicator for whether medical school is completed or not if the expression in parentheses holds.

Compliers complete medical school when being admitted in the first lottery, and do not complete medical school when not being admitted in the first lottery. The latter implies that an applicant either does not reapply after losing the first lottery, reapply one or more times and always lost (or won but did not complete medical school). The first group, whom we refer to as "first degree" compliers seems to meet the concept of compliance closer than re-applicants who only comply with the result of the first lottery because they loose subsequent lotteries. Depending on the number of lotteries in which applicants participate, we refer to them as "second degree" compliers, "third degree" compliers, and so on. The more often someone reapplies, the closer s/he is to an always-taker. Since we have information about subsequent lotteries, we can separately identify the earnings effects for different groups of compliers.

We simplify the analysis to five types of applicants: first, second, third degree compliers, never takers and always takers. Always-takers are people who participate in at least four lotteries. It is straightforward to extend the analysis to more groups of compliers, and as will become clear below defining always takers as people who intend to participate in four or more lotteries does not affect the average returns for the other groups of compliers. Never takers are people who do not complete medical school irrespective of the result of the lotteries. Defiers are excluded. We first want to identify the shares of the five groups from our data. Let L_k be a dummy variable indicating whether a person applies for the k^{th} lottery; 1 if yes, otherwise 0. LR_k is a dummy variable indicating whether a person won the k^{th} lottery (conditional on participating); 1 if yes, otherwise 0.

Let C_N be a stochastic variable indicating whether the person is a never taker. A never taker is an applicant, who will not complete medical school when being admitted:

$$\Pr(C_N = 1) = \Pr(MS = 0|LR_1 = 1)$$

Next, let C_k be a stochastic variable describing whether the person is a k^{th} degree complier. A first-degree complier does not reapply after losing the first lottery, and completes medical school when being admitted in the first lottery:

$$\Pr(C_1 = 1) = \Pr(L_2 = 0|LR_1 = 0)(1 - \Pr(C_N = 1))$$

Similarly, we consider the second-degree and third-degree compliers:

$$\Pr(C_2 = 1) = \Pr(L_3 = 0|LR_2 = 0, L_2 = 1)(1 - \Pr(C_N = 1)) \Pr(L_2 = 1|LR_1 = 0)$$

$$\Pr(C_3 = 1) = \Pr(L_4 = 0|LR_3 = 0, L_3 = 1)(1 - \Pr(C_N = 1)) \Pr(L_3 = 1|LR_1 = 0, LR_2 = 0)$$

Finally, let C_A be a stochastic variable indicating whether the person is an always taker. Given that we already characterized the four other groups, the probability of being an always taker is:

$$\Pr(C_A = 1) = 1 - \Pr(C_3 = 1) - \Pr(C_2 = 1) - \Pr(C_1 = 1) - \Pr(C_N = 1)$$

For tractability we impose that the probability of being a never taker is the same in every lottery, which is consistent with our data. In each lottery the fraction of admitted students that does not complete medical school is very similar (see fn.16).

Next, we consider the probability of being a complier in our empirical analyses, which are individuals for which the outcome of the first lottery decides whether or not to complete medical school. This holds for first-degree compliers, and second-degree and third-degree complier who loose all subsequent lotteries after the first lottery:

$$\Pr[MS(LR_1 = 1) - MS(LR_1 = 0) = 1] =$$
$$P(C_1 = 1) + P(C_2 = 1)P(LR_2 = 0) + P(C_3 = 1)P(LR_2 = 0)P(LR_3 = 0)$$

Using this characterization of the compliers in our estimations, we can then rewrite the right hand-side of equation (3) as a weighted average of the potential outcomes for the different groups of compliers:

$$\frac{E[Y|LR_1=1]-E[Y|LR_1=0]}{P(MS=1|LR_1=1)-P(MS=1|LR_1=0)} =$$
$$(E[Y(1)-Y(0)|C_1=1]P[C_1=1]$$
$$+E[Y(1)-Y(0)|C_2=1]P[C_2=1]P[LR_2=0]$$
$$+E[Y(1)-Y(0)|C_3=1]P[C_3=1]P[LR_2=0]P[LR_3=0])/$$
$$(P[C_1=1]+P[C_2=1]P[LR_2=0]+P[C_3=1]P[LR_2=0]P[LR_3=0]) \quad (4)$$

We now restrict the sample to people who lost the first lottery and applied for the second lottery. For this group of individuals, the result of the second lottery is random (conditional of the lottery category). Again using instrumental variables estimation, we can estimate for the compliers to the result of the second lottery the average treatment effect of completing medical school. This group of compliers to the result of the second lottery consists of second and third-degree compliers. Recall that first-degree compliers never get to the second lottery.

The Wald estimate using applicants to the second lottery can be expressed as a weighted average potential outcomes of second and third degree compliers as follows:

$$\frac{E[Y|LR_2=1]-E[Y|LR_2=0]}{P(MS=1|LR_2=1)-P(MS=1|LR_2=0)} =$$
$$(E[Y(1)-Y(0)|C_2=1]P[C_2=1]$$
$$+E[Y(1)-Y(0)|C_3=1]P[C_3=1]P[LR_3=0])/$$
$$(P[C_2=1]+P[C_3=1]P[LR_3=0]) \quad (5)$$

Repeating the instrumental variables estimation for applicants to the third lottery gives the average treatment effect for compliers to the result of the third lottery. This group only consists of third degree compliers, which gives the following expression:

$$\frac{E[Y|LR_3=1]-E[Y|LR_3=0]}{P(MS=1|LR_3=1)-P(MS=1|LR_3=0)} = E[Y(1)-Y(0)|C_3=1] \quad (6)$$

With the estimate of the average treatment effect for third degree compliers in equation (6) and estimates of the shares of second and third degree compliers, we can back out the average treatment effect for second degree compliers from equation (5). Likewise, with estimates of the average treatment effects of third and second degree compliers and of the shares of first, second and third degree compliers, we recover the average treatment effect for first degree compliers from equation (4).

The first three columns in Table A5 report IV estimates of the effect of completion of medical school on earnings by year since first lottery using the result of the first, second and third lotteries as instrument. The results in the first column repeat those from column (4) in Table A2, the results in the second column are obtained when restricting the sample to people who lost the first lottery and apply to the second. Likewise the results in the third column are obtained when restricting the sample to people who lost the first and second lotteries and apply to the third. The results in the third column pertain to third degree compliers. Using the procedure outlined above, the final two columns present estimates of the earnings gains for first and second degree compliers.[16] For some years after the first lottery, the numbers of observations are rather small and the estimates imprecise, but for the years with enough observations the pattern seems clear. The earnings gain for first degree compliers is larger than for second degree compliers, which in turn is larger than that of third degree compliers. As summary statistics we report in the final row of the table, the net present values of the gains from 5 to 20 years after the first lottery, using a discount rate of 4%. We only start at the fifth year because almost everyone (treated and controls) are in full-time education during the first four years after the first lottery, so any differences are due to small variations in earnings in side jobs. Including the first four years would give strange results due to the large but very imprecise earnings gain in the year of the first application in the third column.

[16]The shares of the different groups are: 0.244 for first degree compliers, 0.232 for second degree compliers, 0.211 for third degree compliers, 0.108 for always-takers, and 0.205 for never-takers. The share of never takers in the first lottery equals 0.XXX, in the second lottery 0.XXX and in the third lottey 0.XXX. The probability to lose the first lottery ($\Pr(LR_1 = 0)$) equals 0.453. For the second and third lotteries these probabilities are 0.537 and 0.566, respectively.

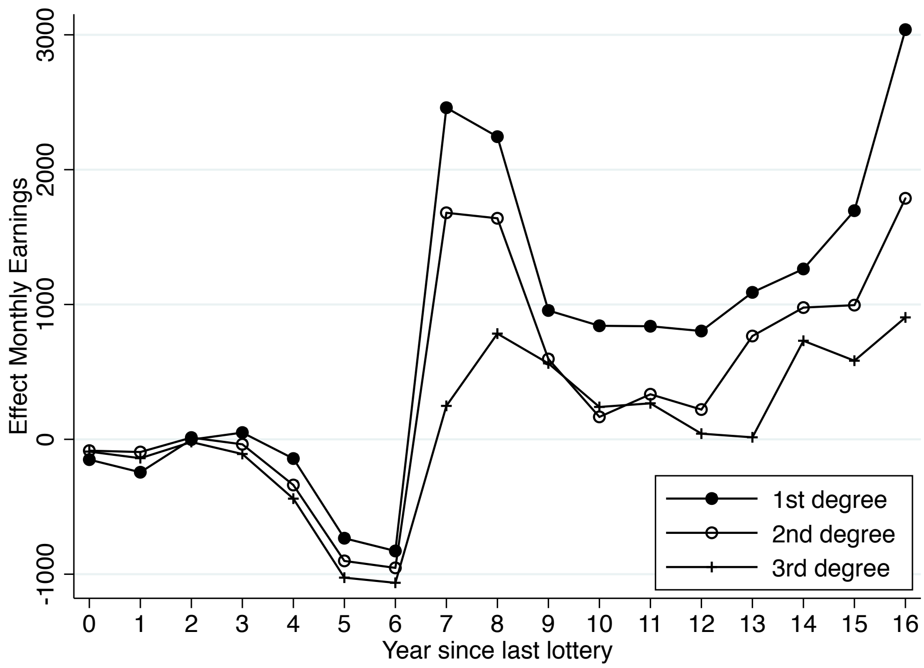


Figure 7. Estimates of effects of medical school completion on earnings for different lotteries and degrees of compliers, by year since first lottery

6.2 Validity of the instrument

We use the result of the first lottery as instrumental variable to estimate the effects of completing medical school. In Table A2 we have shown already that this instrument has a strong impact on the endogenous variable. Above we argued that the exclusion restriction holds by virtue of the randomization of the lottery. The exclusion restriction does not hold, however, when lottery losers are disappointed and therefore do worse, or that people do worse when they can not follow the study of their first choice. This may lead to an overestimation of the monopoly rent obtained upon completion of medical school. To assess the importance of this mechanism, we analyze data from people who participated in the admission lottery for international business studies. Since this study does not give a license to enter a regulated labor market, we assume that this admission to this study does not generate a monopoly rent and that any earnings difference between winning and losing compliers to the result of the lottery can mainly be attributed to disappointment of losers and/or losers being less motivated for the study of their second choice. Results are presented in Table XX.

While we acknowledge that there can be differences in the level of disappointment between losing the lottery for medical school and the lottery to study international business studies, the estimates are still informative.

7 Conclusion

The results of this paper provide evidence for the existence of a substantial monopoly rent for doctors. This calls the desirability of a quota in combination with low tuition fees into question. According to the results, at least 20 percent of doctors' earnings consist of a rent. This rent is defined relative to the next-best option of applicants for medical school; without a license to work as a doctor the same people would have earned at least 20 percent less. Furthermore, the estimated wage profiles suggest that the gain is even (much) higher in the long run: twenty years after participating in the first lottery the earnings difference has increased up to 50 percent. Only a small part of this earnings difference can be attributed to differences in working hours or a longer investment in human capital. Releasing the quota might reduce the rents of doctors. If we assume that wages in the applicant's next-best option are not influenced by a release of the quota such a release can reduce doctors' earnings to at most the level in their next-best option.[17]

Releasing the quota is costly in a situation in which the government heavily subsidizes tuition fees, as is currently the case in the Netherlands. The costs of a medicine study are much higher than the costs of other study programs. Over the course of the whole study the costs of a medicine student are estimated to be at least 167,000 euros compared to an average amount of 55,000 euros for a study program of a comparable level (Houkes-Hommes, 2009).[18] Students pay only a tuition fee of around 1000 euros per year, which is not differentiated across studies. Furthermore, the majority of the medical students starts a specialization track after finishing medical school. The costs of a specialization

[17]Earnings levels in applicants' next-best option will be affected if releasing the quota significantly reduces labor supply in these sectors. In most alternative fields in which rejected medicine applicants apply they form only a small proportion of the total amount of students (for example law or psychology), so this is not likely to be the case.

[18]Part of the difference in costs reflects the fact that the study of medicine takes longer than the alternative study programs.

track are completely born by the government and range from 40,000-145,000 euro.[19]

The coexistence of high private benefits and high social costs raise the question whether a larger part of the costs should be shifted to the students. We see that even under the conservative assumptions underlying Table 3, there is sufficient scope for medical school students to pay a larger share of their education costs. This would allow the government to increase the number of available places without increasing public expenditures. At the same time higher costs can reduce the number of applicants for medical school. An increase in the supply of doctors and the resulting reduction of their earnings will also reduce the number of applicants.

References

Anderson, G. M., Halcoussis, D., Johnston, L., and Lowenberg, A. D. (2000). Regulatory barriers to entry in the healthcare industry: The case of alternative medicine. *The Quarterly Review of Economics and Finance*, 40(4):485–502.

Baltagi, B. H., Bratberg, E., and Holma, T. H. (2005). A panel data study of physiciansÕ labor supply: the case of Norway. *Health Economics*, 14:1035–1045.

Burstein, P. L. and Cromwell, J. (1985). Relative incomes and rates of return for U.S. physicians. *Journal of Health Economics*, 4(1):63 – 78.

Friedman, M. and Kuznets, S. (1954). *Income from Independent Professional Practice*. NBER Books. National Bureau of Economic Research, Inc.

Herfs, P. (2009). International medical graduates in the Netherlands. Phd-dissertation, Utrecht University.

Houkes-Hommes, A. (2009). De kosten van verruimen of loslaten van de numerus fixus. Report, SEO.

[19]The specialization tracks for medicine are an exception among other post-graduate programs; in most cases the government does not bear the (full) costs of post-graduate education.

Hurley, J. (2000). An overview of the normative economics of the health sector. In Culyer, A. J. and Newhouse, J. P., editors, *Handbook of Health Economics*, volume 1A. Elsevier.

Imbens, G. W. and Angrist, J. D. (1994). Identification and estimation of local average treatment effects. *Econometrica*, 62(2):467–475.

Kugler, A. D. and Sauer, R. M. (2005). Doctors without borders? Relicensing requirements and negative selection in the market for physicians. *Journal of Labor Economics*, 23(3):437–466.

Noether, M. (1986). The growing supply of physicians: has the market become more competitive? *Journal of Labor Economics*, 4:503–537.

OECD (2010). *Health at a glance 2010*. OECD, Paris.

Rizzo, J. and Blumenthal, D. (1994). Physician labor supply: Do income effects matter? *Journal of Health Economics*, 13:433–453.

RVZ (2010). Numerus fixus geneeskunde: Loslaten of vasthouden. Report, Raad van Gezondheid (RVZ).

Showalter, M. and Thurston, N. (1997). Taxes and labor supply of high-income physicians. *Journal of Public Economics*, 66:73–97.

Simoens, S. and Hurst, J. (2006). The supply of physician services in OECD countries. OECD Health Working Papers 21, OECD Publishing.

Sloan, F. (1975). Physician supply behavior in the short run. *Industrial and Labor Relations Review*, 28:549–569.

A Results Tables

Table A1. Fraction p admitted and number of applicants N by year and lottery category

	A		B		C		D		E		F		Total	
Year	p	N	p	N	p	N	p	N	p	N	p	N	p	N
1988	1.00	29	1.00	96	0.89	179	0.75	495	0.62	537	0.54	749	0.67	2085
1989	1.00	30	1.00	84	0.96	158	0.80	429	0.66	531	0.58	697	0.71	1929
1990	1.00	36	1.00	111	0.87	194	0.71	468	0.59	571	0.51	746	0.64	2126
1991	1.00	41	0.89	130	0.76	201	0.63	547	0.50	649	0.43	881	0.56	2449
1992	1.00	51	0.84	113	0.72	235	0.59	600	0.48	689	0.42	1036	0.53	2724
1993	0.93	44	0.72	167	0.62	241	0.51	702	0.41	847	0.36	1299	0.45	3300
1994	0.89	61	0.69	208	0.58	389	0.48	905	0.39	1034	0.33	1331	0.43	3928
1995	0.80	88	0.62	265	0.51	430	0.41	982	0.34	1024	0.31	1402	0.39	4191
1996	0.74	97	0.58	283	0.48	494	0.39	1084	0.32	1119	0.27	1496	0.36	4573
1997	0.72	117	0.54	310	0.45	498	0.37	1114	0.31	1129	0.26	1486	0.35	4654
1998	0.75	106	0.56	332	0.50	492	0.39	1121	0.32	1041	0.28	1325	0.37	4417
1999	1.00	87	1.00	341	0.52	421	0.42	1025	0.33	898	0.29	1146	0.43	3918
Total	0.86	787	0.73	2440	0.59	3932	0.49	9472	0.41	10,069	0.36	13,594	0.46	40,294

Table A2. Instrumental variable estimates of the effects of completing medical school on labor market outcomes $t-\tau$ years after first applying

$t-\tau$ (1)	N (2)	1st stage (3)	Earnings (4)	Positive earnings (5)	log(Earnings) (6)	Hours (7)	log(Earnings/hr) (8)
0	2159	0.36 (0.02)***	−81 (23)***	-0.06 (0.02)***	-0.36 (0.15)**		
1	4607	0.36 (0.01)***	−162 (19)***	0.18 (0.02)***	-0.68 (0.12)***		
2	7167	0.37 (0.01)***	−45 (17)***	-0.06 (0.02)***	-0.03 (0.08)		
3	9885	0.38 (0.01)***	7 (19)	0.02 (0.02)	0.08 (0.06)		
4	12438	0.39 (0.01)***	−90 (20)***	-0.02 (0.02)	-0.18 (0.06)***		
5	14952	0.39 (0.01)***	−509 (26)***	-0.33 (0.02)***	-1.35 (0.07)***		
6	17154	0.39 (0.01)***	−786 (31)***	-0.34 (0.02)***	-1.31 (0.07)***		
7	18946	0.38 (0.01)***	835 (55)***	0.24 (0.02)***	0.76 (0.06)***	229 (100)**	0.28 (0.05)***
8	20705	0.38 (0.01)***	1521 (66)***	0.29 (0.02)***	0.85 (0.04)***	467 (60)***	0.21 (0.03)***
9	22185	0.38 (0.01)***	1047 (52)***	0.18 (0.01)***	0.51 (0.03)***	281 (38)***	0.18 (0.02)***
10	23485	0.38 (0.01)***	757 (51)***	0.10 (0.01)***	0.33 (0.03)***	250 (29)***	0.12 (0.02)***
11	22762	0.39 (0.01)***	587 (55)***	0.08 (0.01)***	0.22 (0.02)***	112 (25)***	0.11 (0.02)***
12	20244	0.39 (0.01)***	566 (65)***	0.06 (0.01)***	0.23 (0.02)***	136 (24)***	0.12 (0.02)***
13	17681	0.39 (0.01)***	687 (79)***	0.07 (0.01)***	0.24 (0.02)***	133 (25)***	0.14 (0.02)***
14	14980	0.39 (0.01)***	908 (108)***	0.06 (0.01)***	0.25 (0.03)***	145 (25)***	0.16 (0.02)***
15	12494	0.38 (0.01)***	1196 (145)***	0.05 (0.01)***	0.28 (0.03)***	112 (27)***	0.21 (0.03)***
16	10012	0.39 (0.01)***	2029 (195)***	0.07 (0.01)***	0.32 (0.04)***	54 (29)*	0.30 (0.03)***
17	7866	0.39 (0.01)***	2178 (244)***	0.06 (0.02)***	0.39 (0.04)***	81 (32)**	0.33 (0.04)***
18	6100	0.40 (0.01)***	2012 (335)***	0.03 (0.02)	0.36 (0.05)***	55 (32)*	0.34 (0.04)***
19	4329	0.41 (0.02)***	3182 (411)***	0.03 (0.02)	0.53 (0.06)***	100 (35)***	0.44 (0.05)***
20	2805	0.41 (0.02)***	3187 (541)***	-0.01 (0.02)	0.50 (0.08)***	61 (45)	0.44 (0.06)***
21	1436	0.45 (0.03)***	4091 (773)***	0.03 (0.04)	0.61 (0.11)***	27 (55)	0.56 (0.08)***

Notes: Standard errors in parentheses. Total number of individuals is 25,491. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Every cell in this column represents a separate regression, which include controls for gender, ethnicity, age in the first lottery year, lottery category, year of first lottery and interaction terms of the year of first lottery and lottery category.

Table A3. IV estimates of effects of medical school completion on earnings and hours, by year since first lottery and gender

	Earnings		Hours	
$t - \tau$	Men	Women	Men	Women
0	−111 (40)***	−61 (27)**		
1	−163 (35)***	−162 (20)***		
2	−40 (30)	−49 (20)**		
3	10 (34)	3 (20)		
4	−108 (34)***	−77 (24)***		
5	−386 (45)***	−604 (31)***		
6	−588 (51)***	−943 (38)***		
7	508 (78)***	1101 (78)***	171 (164)	270 (127)**
8	1097 (106)***	1867 (84)***	278 (98)***	599 (76)***
9	835 (84)***	1219 (67)***	142 (63)**	382 (48)***
10	641 (86)***	850 (61)***	199 (48)***	282 (35)***
11	419 (94)***	722 (67)***	69 (39)*	143 (33)***
12	363 (110)***	741 (78)***	131 (34)***	140 (33)***
13	473 (132)***	873 (95)***	100 (34)***	165 (35)***
14	799 (186)***	1009 (124)***	131 (31)***	162 (40)***
15	1111 (258)***	1254 (158)***	100 (35)***	131 (41)***
16	2480 (357)***	1671 (206)***	56 (40)	56 (42)
17	2732 (465)***	1790 (242)***	54 (46)	105 (45)**
18	2267 (659)***	1838 (328)***	62 (43)	53 (45)
19	3672 (800)***	2756 (402)***	99 (47)**	101 (50)**
20	3586 (996)***	2764 (559)***	45 (55)	82 (67)
21	4071 (1392)	3880 (807)***	−21 (70)	72 (83)

Notes: Standard errors in parentheses. Total number of individuals is 25,491. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Every cell in this column represents a separate regression, which include controls for ethnicity, age in the first lottery year, lottery category, year of first lottery and interaction terms of the year of first lottery and lottery category.

Table A4. IV estimates of effects of medical school completion on earnings and hours, by year since first lottery and lottery category

$t-\tau$	B	C	D	E	F
0	−66 (112)	−64 (67)	−74 (36)**	−95 (36)***	−76 (50)
1	−680 (327)**	−74 (55)	−124 (33)***	−164 (33)***	−192 (37)***
2	35 (86)	90 (49)*	−1 (32)	−66 (32)**	−125 (33)***
3	93 (120)	64 (45)	14 (32)	12 (31)	−41 (40)
4	−30 (103)	−53 (56)	−50 (36)	−132 (36)***	−112 (41)***
5	−658 (136)***	−504 (77)***	−532 (53)***	−490 (50)***	−481 (47)***
6	−800 (157)***	−673 (103)***	−777 (63)***	−806 (53)***	−806 (56)***
7	2421 (397)***	2026 (240)***	1354 (118)***	582 (98)***	66 (85)
8	3120 (434)***	2331 (237)***	2137 (125)***	1323 (143)***	783 (100)***
9	1529 (327)***	1053 (176)***	1392 (105)***	965 (96)***	803 (90)***
10	1355 (327)***	573 (166)***	930 (101)***	649 (94)***	711 (88)***
11	1499 (374)***	705 (196)***	671 (109)***	543 (110)***	453 (88)***
12	831 (446)*	634 (239)***	603 (132)***	553 (125)***	513 (102)***
13	452 (669)	892 (300)***	743 (173)***	600 (135)***	700 (124)***
14	−435 (1114)	544 (447)	831 (241)***	1145 (195)***	940 (156)***
15	447 (1506)	1433 (711)**	1143 (334)***	1341 (260)***	1109 (205)***
16	1273 (2305)	1323 (1041)	2271 (469)***	2081 (324)***	2001 (284)***
17	925 (9923)	1387 (1008)	2634 (644)***	2027 (426)***	2173 (338)***
18		2845 (1272)**	1880 (836)**	1647 (690)**	2283 (417)***
19		5013 (1332)***	2910 (1344)**	3204 (678)***	3109 (541)***
20		4023 (2778)	400 (1983)	4140 (928)***	3298 (660)***
21		5585 (4464)	2411 (3290)	3555 (1061)***	4518 (962)***
$NPV(r=0.04)$					

Table A5. Estimates of effects of medical school completion on earnings for different lotteries and degrees of compliers, by year since first lottery

	Lottery 1		Lottery 2		Lottery 3		1st degree	2nd degree
$t-\tau$	N	IV	N	IV	N	IV	compliers	compliers
0	2159	−81 (23)∗∗∗	879	−3 (32)	280	−42 (49)	-151	18
1	4607	−162 (19)∗∗∗	1966	−70 (29)∗∗∗	674	−44 (43)	-244	-84
2	7167	−45 (17)∗∗∗	3161	−93 (22)∗∗∗	1152	−91 (38)∗∗	-2	-94
3	9885	7 (19)	4484	−41 (22)∗∗	1736	−140 (35)∗∗∗	50	13
4	12438	−90 (20)∗∗∗	5687	−31 (24)	2247	−20 (35)	-143	-37
5	14952	−509 (26)∗∗∗	6777	−258 (34)∗∗∗	2693	−109 (65)∗	-734	-339
6	17154	−786 (31)∗∗∗	7730	−739 (36)∗∗∗	3056	−440 (54)∗∗∗	-828	-902
7	18946	835 (55)∗∗∗	8357	−979 (45)∗∗∗	3282	−1026 (64)∗∗∗	2459	-953
8	20705	1521 (66)∗∗∗	8898	713 (99)∗∗∗	3429	−1064 (82)∗∗∗	2245	1680
9	22185	1047 (52)∗∗∗	9196	1149 (77)∗∗∗	3482	248 (119)∗∗	956	1639
10	23485	757 (51)∗∗∗	9398	662 (70)∗∗∗	3501	784 (122)∗∗∗	842	596
11	22762	587 (55)∗∗∗	8760	306 (74)∗∗∗	3258	563 (124)∗∗∗	839	166
12	20244	566 (65)∗∗∗	7649	301 (85)∗∗∗	2843	240 (133)∗	803	334
13	17681	687 (79)∗∗∗	6449	237 (104)∗∗	2363	267 (149)∗	1090	221
14	14980	908 (108)∗∗∗	5137	511 (149)∗∗∗	1783	42 (216)	1263	766
15	12494	1196 (145)∗∗∗	3987	638 (214)∗∗∗	1293	15 (320)	1696	977
16	10012	2029 (195)∗∗∗	2932	902 (275)∗∗∗	865	731 (440)	3038	995
17	7866	2178 (244)∗∗∗	2004	1363 (385)∗∗∗	519	583 (660)	2908	1788
18	6100	2012 (335)∗∗∗	1386	1595 (570)∗∗∗	300	904 (994)	2385	1971
19	4329	3182 (411)∗∗∗	838	1068 (927)	150	−2846 (1858)	5075	3198
20	2805	3187 (541)∗∗∗	502	1540 (1133)	80	−398 (3063)	4662	2595
21	1436	4091 (773)∗∗∗	255	2239 (1689)				
$NPV(0-20)$						−15464	182729	89454