This document provides a sketch of solutions to the exam. The provided solutions are intended as a guide to answering the questions, and are not meant as exhaustive. The written solutions would have to be worked out more completely.

This is the final exam for Economics of Education, Spring 2017. You have three hours to answer the following four questions. Draft your responses with an eye to clarity of exposition and structure as well as to showing your understanding of the concepts learned in class. Link the problem at hand to economic theory. You are free to make any reasonable assumptions that help you in answering, as long as you are specific and explicit.

Make sure to *pace yourself*. Also, you may choose to work on the questions in a *different order*: All questions can be answered independently.

Human Capital Policy in France

France is a country that ranks 19th in reading and 26th in Math on the PISA study of 2015, comparing performance of 15-year-olds in the OECD and partner countries, making it middle-of-the-pack.[1]

But France stands out when it comes to inequality of educational performance by parental background and immigrant status. Socio-economic status explains substantially more of the variation in PISA science test scores in France than in other countries. For example, the OECD reports that an increase of the socio-economic status by one standard deviation leads to a gain of 38 points in the OECD as a whole, but a full 57 points in France. This is the highest slope observed in the entire sample, and corresponds to more than a year of schooling. In France, the gap in science performance between students in the top and bottom quarters of socio-economic status is among the largest of countries participating in PISA. Immigrant students (first generation) score 87 points lower than non-immigrants in France, versus a 53-point-gap for the OECD average. The gap for second-generation immigrants is also substantially larger in France (50 vs 31 points).

The newly elected president Emmanuel Macron has made reducing inequality through educational investments one of his very specific campaign promises. Specifically, he suggests a drastic class-size reduction in certain disadvantaged schools. His program states

> *We will limit the class size to 12 students per teacher in grades CP and CE1 [ages 6 to 8] that are in* priority zones.

These *priority (education) zones* are particularly disadvantaged neighborhoods, selected roughly on economic and education criteria, such as parents' socioeconomic background, unemployment rate, fraction of students for whom French is a second language, fraction of students that had to repeat a grade, and parental education. Macron's program further states that

> *Teachers in these priority zones will receive a yearly net prime of 3000 euros. And they will be more experienced: By 2022, those teaching in priority zones will have at least 3 years of experience.*

[1] Sources: OECD (2016), *PISA 2015 Results (Volume I) - Excellence and Equity in Education*, PISA, OECD Publishing Paris; and OECD (2016), *Education at a Glance 2016: OECD INDICATORS*, OECD Publishing, Paris.

Questions

1. Use the classical Ben Porath human capital model to analyze Macron's policy suggestion. You may use the the optimal schooling allocation equation copied below.
   (1) Where would the proposal enter in this model? (Which variable would you use?)
   (2) What are the effects of this policy, within this model?
   (3) Would it reduce inequality?
   (4) Would the effect be homogenous (i.e., equal for all students)?
   (5) Which assumptions in Ben-Porath lead us to some conclusions that we would challenge when thinking of this particular example? (You may contrast it to Becker-Tomes.)

   The optimal share of time in schooling in period t by individual i is S_{it}^*:

$$S_{it}^* = \left[\frac{\beta_{t+1}}{\beta_t} \frac{\alpha}{1+\rho} \frac{1}{H_{it} + \gamma_t/\beta_t} \left(A_i H_{it} E_{it}\right)^{\alpha} \right]^{1/(1-\alpha)},$$

   where

   - β are the wage-returns to human capital,
   - H_{it} is i's human capital in period t,
   - A_i is personal initial learning ability,
   - E_{it} are public expenditures on schooling,
   - α is the parameter of the human capital production function, ρ is the discount rate, γ is the direct cost of schooling.

Solution:

- The policy proposal of more teachers per student (fewer students for each teacher) would enter as a higher E_{it}, greater public expenditures into the schooling process.
- The effects of this policy, in a first step, is to increase optimal schooling S_{it}^* for everyone that is affected by the policy, because E_{it} enters positively. More specifically,

$$\frac{\partial S_{it}^*}{\partial E} = \underbrace{\frac{\alpha}{1-\alpha}}_{+} \underbrace{\left[\frac{\beta_{t+1}}{\beta_t} \frac{\alpha}{1+\rho} \frac{1}{H_{it} + \gamma_t/\beta_t} \left(A_i H_{it}\right)^{\alpha} \right]^{\frac{1}{1-\alpha}}}_{+} \underbrace{E_{it}^{\frac{2\alpha-1}{1-\alpha}}}_{+},$$

  which is positive because A, H, and E are positive. Note that we are assuming in this setting that children are making their own optimal schooling decisions at possibly age 6, which is stretching the credibility slightly. Alternatively, one could think of a multi-period Ben-Porath model where higher early human capital measures (say, H_2 or H_3) generate a greater productivity of later investments. In this case, a different mechanism would produce the same result, that optimal schooling is higher.

- Following the greater schooling investments, adult human capital is higher for those who experienced the greater public investment through the class size decrease, and their earnings will be increased.
- To the extent that this is a targeted increase in public expenditures for some disadvantaged students - in the current model, this would appear as being targeted at low-A_i - it would be a policy that indeed reduces inequality. Note the difference to what we studied in class: there, we mainly discussed an equal increase in E_{it} that would *increase* inequality - see also the next point.
- The effect of this particular E_{it} increase is not homogenous, in two ways: It is obviously different between those who benefit from the class size reduction and those who do not. It is also not homogenous among the subgroup of students who experience the increase. As seen in the lectures, higher public expenditures increase the influence of ability on optimal schooling:

$$\frac{\partial^2 S_{it}^*}{\partial E \partial A} = \underbrace{\left(\frac{\alpha}{1-\alpha}\right)^2}_{+} \underbrace{\left[\frac{\beta_{t+1}}{\beta_t}\frac{\alpha}{1+\rho}\frac{1}{H_{it}+\gamma_t/\beta_t}H_{it}^{\alpha}\right]^{\frac{1}{1-\alpha}}}_{+} \underbrace{(A_i E_{it})^{\frac{2\alpha-1}{1-\alpha}}}_{+}$$

  That means that even in the schools that are part of the priority zones, the merely-poor-but-bright students benefit more than students who have low learning ability A_i or low initial human capital H_{it-1}. Targeting geographic areas or schools still does not preclude heterogeneous effects by initial ability.
- The main assumption in Ben-Porath that is difficult to defend, especially in a setting with very disadvantaged parents, is that of perfect capital markets that allow agents to smooth consumption between all periods. The result that the most-able benefit the most from higher public expenditures is possible because they can reduce their working time - and borrow to keep their consumption constant. If low-resource parents of high-ability children are credit constrained, they may not be able to increase investments as much. Furthermore, note that the formulation of Ben-Porath we have worked with always included a positive cross-derivative between public and private investments. More public investments made the private ones more productive. This may not necessarily hold in practice - if they are substitutes, we could even see reduction of private investments that (at least partially) offset the increase in public investments.

2. What does empirical evidence say about how effective we expect this class size reduction to be? Please describe also how the empirical evidence is established, and how that makes different types of studies more or less relevant to the case at hand.

Solution:

Generally, the evidence for class size reductions points to positive effects, but with a significant number of studies showing no effects. Overall, we cannot say without hesitation that the class size reduction will have an effect. But note the very different settings of the following papers - some of them are at a different age range than the one we're discussing in France, others are evaluating smaller ranges of reductions than the cutting in half suggested by Macron, etc.

- randomized experiments:
  - Evidence from Project Star shows improved performance in smaller classes. The age range is very relevant for our question, as it was on grades 1-4, but the smallest class was still larger than the 12 students suggested by Macron. Where Krueger (1999) showed positive effects throughout school, Krueger and Whitmore (2001) showed that by the end of high school, SAT scores were not significantly improved any longer. Yet, students from smaller classes were more likely to apply to college, particularly minority students. Therefore, students in France's special zones might benefit to a greater extent than non-disadvantaged students generally.
- natural experiments:
  - Hoxby (2000) uses cohort size variation and district rules to study "naturally occuring class size variation," and does not support a positive effect of smaller classes on test scores throughout middle school. The variation studied here is much smaller than the reduction to 12 students.
  - A similarly large reduction in size is studied by Angrist and Lavy (1999), through Maimonides' rule, that lets the number of students fall from 40 to 20. They find significant test score increases in 4th/5th grade for the smaller classes. Of course, 20 students are still more than 12.
- panel data:
  - Woessmann and West (2006) use international test scores on TIMSS, using cross-country variation. The data covers students that are much older than our question (13 years old). Few countries in the sample show significant effects of class size on math/science test scores. Instead, their discussion focuses on the role of teacher selection (through remuneration) that may influence how relevant class size is. Given that the suggested policy involves not only a class size reduction, but also a financial incentive to work at these schools and a selection on experience, possibly the class size reduction is no longer as necessary as with less-experienced teachers.

3. What other policies could have been used to improve the educational outcomes of these children in disadvantaged geographic areas? Describe them briefly and note

the evidence for their effectiveness.

Solution:

- Increase spending: on resources? Or instructional time?
  - very little evidence for a direct link between increasing financial resources and improved student outcomes
  - Instructional time has been shown to be a significant driver for educational outcomes - but we noted the embedded character of human capital that makes an un-limited increase in instruction time unlikely to work. This may be more relevant even for younger children, as those we are discussing here.
  - Lavy (2015) shows that especially girls, immigrants, and low-SES students benefit more from increased instruction time, using PISA test scores. While the age range of PISA is too old for our question, the heterogeneous effects of instruction time could indicate that students in the *special zones* could benefit more than advantaged students. In this sense, this policy could be very effective at reducing inequality.
- Select students - stratification. There may be an argument that disadvantaged students could be put into classes with high-achieving students, and learn better from this mixed setting. Jackson (2010), for example, showed that being with in high schools with higher-ability peers improves later performance. But most of the available evidence stems from university-level class-stratification experiments, and we do not know whether the same mechanisms apply to elementary school students. Furthermore, Carrell, Fullerton, and West are a cautionary tale for extrapolation of class stratification. Whereas their first study (2009) showed that low-achieving students benefit in terms of learning gains from being in a classroom (squadron, actually) with high-achieving students, and the high-achieving students do not suffer, their second (2011) experiment of extreme stratification failed to improve outcomes. The bi-modal distribution of very high and very low achieving students *only* in one class meant that there was less interaction than before, and thus the class-setting did not translate into actual common study time. If one wanted to mix classes with advantaged and disadvantaged students in the *special zones* in France, it could lead to a similar problem, if students do not actually learn together.
- Other: Evidence on school values / "high expectations". Charter schools that implement strong values that students (and their parents) have to subscribe to have been shown to significantly improve their students' learning achievements. Some of these have been evaluated in randomized experiments, others not.
  - Angrist et al (2010) evaluate KIPP, which is one example of the "high expectations" type of schools. Students' test scores of those who won an admission lottery were much higher than those who lost the lottery.

  - Dobbie and Fryer (2013) evaluate charter schools and show that while traditional input measures (including class size) are not significant drivers of student outcomes, other policies are important: frequent feedback, data use, high-dosage tutoring, increased instructional time, and high expectations. While some of this evaluation is not using the lottery, the data used includes many different schools.

- Select teachers. Some teachers are more effective than others. "Teacher value-added" has been shown to improve students' test scores significantly, and also has long-term effects on students' labor market outcomes. The suggested policy we are evaluating also includes teacher selection through financial incentives - so in that sense, the policy *is already* suggesting an additional component that has been shown to be economically meaningful.

- Focus on non-cognitive skills, as in the Perry Preschool project. These interventions have been shown to produce most long-run effects through their reduction of problem behavior and in fostering conscientiousness.

4. If we take Macron's education policy suggestion as an early human capital investment, what are the likely effects on crime?

   (1) Briefly describe the prediction from an empirical standpoint.

Solution:

- Lochner and Moretti (2004) exploit variation in state-specific compulsory schooling laws over time to induce variation in schooling which is uncorrelated with factors that directly affect criminal behavior (s.a. preferences or abilities). They show that schooling has a significant effect in reducing later imprisonment.

- The Perry Preschool Project uses a randomized controlled experiment that followed participants and control subjects 40 years later, and shows that an early schooling investment significantly reduced crime as adults.

- Both of these pieces of evidence are not exactly referring to class-size reductions at ages 6-8, but they speak to long-run effects of schooling on crime generally. The Perry study in particular shows the promising potential of early interventions in particularly disadvantaged populations to reduce their crime rates significantly.

   (2) *Extra credit:* Discuss the mechanisms through which the investment operates in Lochner's model that we studied. For reference, the optimality conditions from the first order conditions are given on the next page.

Optimality conditions in Lochner (2004):

Crime: $$\frac{\partial N(k_t, H_t, \theta)}{\partial k_t} = w_t H_t + \frac{\partial P(k_t)}{\partial k_t} \left[F + \beta \left\{V_{t+1}\left(H_{t+1}\right) - \Omega_{t+1}\left(H_{t+1}\right)\right\}\right]$$

H Investment: $$w_t H_t + \gamma = \beta \left[P(k_t)\Omega'_{t+1}(H_{t+1}) + (1 - P(k_t))V'_{t+1}(H_{t+1})\right] \cdot \frac{\partial f()}{\partial I_t}$$

where

- $N(k_t, H_t, \theta)$ is the benefit from engaging in crime for share k_t of the time,
- H_t is human capital at time t, and w_t its associated wage,
- $P(k_t)$ is the probability of incarceration, depending on crime time k_t, and F is the direct fine associated with incarceration.
- The value of all future periods is $\Omega_{t+1}\left(H_{t+1}\right)$ when incarcerated, and $V_{t+1}\left(H_{t+1}\right)$ when free.
- $f()$ is the production function of human capital, from $H_{t+1} = H_t + f(I_t, H_t, A)$.

Solution:

Lochner's model gives the clear prediction that individuals with higher human capital commit fewer crimes. The intuition behind this is that the cost of crime is increased (right hand side of first FOC), in two places: the opportunity cost of spending time on crimes has increased ($w_t H_t$), and the value of all future periods is higher out of prison than in prison (the value increase is greater for V_{t+1} than for Ω_{t+1}). Therefore, the share of time that is used for crime has to decrease.

Less time in crime (lower k) leads to a higher anticipated gain of investing in human capital (right hand side of second FOC), which may lead to an increased investment. This is uncertain, however, as higher human capital also raises the marginal (opportunity) cost of investment, as higher human capital means higher wages (left side of second FOC).