Written Exam at the Department of Economics winter 2018-19

Advanced Development Economics – Macro aspects

Master's Course

December 19th , 2018

Solution guide

QUESTION A. The gender wage gap, fertility, and education.

Readings:

- Galor, Oded (2012), The Demographic Transition: Causes and Consequences. *Cliometrica* 6(1): 1-28.
- Andersen, Thomas B., Carl-Johan Dalgaard, and Pablo Selaya (2016), Climate and the Emergence of Global Income Differences. *Review of Economic Studies* 83(4): 1334-1363.
- Alesina, Alberto, Paula Giuliano and Nathan Nunn (2013). On the Origins of Gender Roles: Women and the Plough. *Quarterly Journal of Economics* 128(2): 469-530.
- Gershman, Boris (2017), Long-Run Development and the New Cultural Economics, Chapter 9 in "Demographic Change and Long-Run Development", Matteo Cervelatti and Uwe Sunde (eds.), Cambridge, MA: MIT Press.
- Nunn, Nathan (2012), Culture and the Historical Process. *Economic History of Developing Regions* 27(S1): 108-126.

A.1.

The solution to the typical household's optimization problem is:

$$(n^*, e^*) = \arg\max_{n,e} \left\{ \gamma \ln(y - [\tau^q w^M n + \tau^e yen]) + (1-\gamma)[\ln(n) + \ln(e) - \ln(e+g)] \right\}.$$

To find n^* and e^*, compute the first order conditions (FOCs), by setting the first derivatives of the objective function with respect to n and e equal to zero.

FOC with respect to n:

$$\frac{\gamma(\tau^q w^M + \tau^e ye)}{y - \tau^q w^M n - \tau^e yen} = \frac{1-\gamma}{n} \tag{1}$$

FOC with respect to e:

$$\frac{\gamma \tau^e yn}{y - [\tau^q w^M n + \tau^e yen]} = (1-\gamma)\left(\frac{1}{e} - \frac{1}{e+g}\right) \tag{2}$$

In order to find e^*, divide (1) by (2):

$$\begin{aligned}
\frac{\gamma(\tau^q w^M + \tau^e y e)}{\gamma \tau^e y n} &= \frac{\frac{1}{n}(1-\gamma)}{\left(\frac{1}{e} - \frac{1}{e+g}\right)(1-\gamma)} \\
\frac{\tau^q w^M + \tau^e y e}{\tau^e y n} &= \frac{\frac{1}{n}}{\frac{g}{e(e+g)}} \\
\frac{\tau^q w^M + \tau^e y e}{\tau^e y n} &= \frac{e(e+g)}{gn} \\
\frac{\tau^q w^M + \tau^e y e}{\tau^e y e} &= \frac{e+g}{g} \\
\frac{\tau^q w^M}{\tau^e y e} + 1 &= \frac{e}{g} + 1 \\
\frac{g\tau^q w^M}{\tau^e y} &= e^2 \\
e^* &= \left(\frac{g\tau^q w^M}{\tau^e y}\right)^{\frac{1}{2}} = \left(\frac{g\tau^q w^M}{\tau^e [w^M + w^F]}\right)^{\frac{1}{2}} = \left(\frac{g\tau^q}{\tau^e [1 + \frac{w^F}{w^M}]}\right)^{\frac{1}{2}}
\end{aligned}$$

In order to find n^*, first rearrange (1):

$$\begin{aligned}
\frac{n(\tau^q w^M + \tau^e y e)}{y - [\tau^q w^M n + \tau^e y e n]} &= \frac{1-\gamma}{\gamma} \\
\frac{\tau^q w^M n + \tau^e y e n}{y - [\tau^q w^M n + \tau^e y e n]} &= \frac{1-\gamma}{\gamma} \\
\frac{\gamma}{1-\gamma} &= \frac{y - [\tau^q w^M n + \tau^e y e n]}{\tau^q w^M n + \tau^e y e n} \\
\frac{\gamma}{1-\gamma} &= \frac{y}{\tau^q w^M n + \tau^e y e n} - 1 \\
\frac{1}{1-\gamma} &= \frac{y}{n(\tau^q w^M + \tau^e y e)} \\
n &= (1-\gamma) \cdot \frac{y}{\tau^q w^M + \tau^e y e} \\
n &= (1-\gamma) \cdot \frac{1}{\tau^q w^M / y + \tau^e e} \qquad (3)
\end{aligned}$$

and then replace e^* into (3):

$$\begin{aligned}
n^* &= (1-\gamma)\cdot\frac{1}{\frac{\tau^q w^M}{y}+\tau^e\left(\frac{g\tau^q w^M}{\tau^e y}\right)^{\frac{1}{2}}} \\
&= (1-\gamma)\cdot\frac{1}{\frac{\tau^q w^M}{y}+\left(\frac{g\tau^e\tau^q w^M}{y}\right)^{\frac{1}{2}}} \\
&= (1-\gamma)\cdot\frac{1}{\frac{\tau^q w^M}{w^M+w^F}+\left(\frac{g\tau^e\tau^q w^M}{w^M+w^F}\right)^{\frac{1}{2}}} \\
&= (1-\gamma)\cdot\frac{1}{\frac{\tau^q}{1+\frac{w^F}{w^M}}+\left(\frac{g\tau^e\tau^q}{1+\frac{w^F}{w^M}}\right)^{\frac{1}{2}}} \\
n^* &= (1-\gamma)\cdot\left[\frac{\tau^q}{1+\frac{w^F}{w^M}}+\left(\frac{g\tau^e\tau^q}{1+\frac{w^F}{w^M}}\right)^{\frac{1}{2}}\right]^{-1}
\end{aligned}$$

A.2.

From the solutions above, notice that

$$\frac{\partial e^*}{\partial g} > 0$$

and

$$\frac{\partial n^*}{\partial g} < 0.$$

That is, an increase in the rate of technological progress (g) decreases optimal fertility (n^*) and increases the optimal level of education (e^*) each child gets.

Interpretation:

An increase in the rate of technological progress increases the speed at which knowledge and skills get depreciated, and therefore it provides incentives for households to increase their education investments in their children. Given that the household income level and the time costs raising children do not change with technological progress, a higher level of education investments can be financed with a reduction in the total number of children per household to keep the budget in balance. That is, an increase in the rate of technological progress instigates a reallocation of resources away from *quantity* of children towards their *quality*. This illustrates the type of *quality-quantity* trade-off between fertility and education investments in children presented in Galor (2012) and Galor and Weil (1990).

A.3.

Historical evidence supports the idea that higher investments in education (*quality*) in pre-industrial periods were associated with reductions in fertility (*quantity*). Galor (2012) cites and presents evidence for different European countries around the end of the nineteenth century, that supports the idea that the historical rise in education and human capital formation was associated with reductions in fertility rates. For example, the significant increase in the proportion of children 6-14 attending schools that started around 1850 in England, was associated with a sharp decline in crude birth rates around 1880. Panel evidence for France, Germany, and England during 1870 and 2000 also supports the hypothesis that the increase in education and human capital formation had an adverse effect on fertility.

Related to the characteristics of climate and the emergence of historical global income differences, Andersen et al (2016) show that countries with a disease ecology that reduces the returns to the accumulation of knowledge and skills, embarked on a process of permanent fertility decline later than the rest, and also experienced slower growth in the level of schooling during the years that followed the decline in fertility

A.4.

The results above show that

$$\frac{\partial n^*}{\partial \left(\frac{w^F}{w^M}\right)} > 0$$

and

$$\frac{\partial e^*}{\partial \left(\frac{w^F}{w^M}\right)} < 0.$$

Therefore, a smaller wage gap $\frac{w^F}{w^M}$ reduces optimal fertility n^* and increases optimal investments in education e^*.

Interpretation:

To see the different forces at play, rewrite the budget constraint as

$$c + \tau^q w^M n + \tau^e (w^F + w^M) en = w^F + w^M.$$

For simplicity, assume that w^F stays constant while w^M increases. Hence, the household experiences a positive income effect. To identify how this extra income is allocated between n, e and c notice from the utility function that households consume a constant fraction γ of their income and use a fraction $(1-\gamma)$ for n and e.

With w^M increasing, the time opportunity cost of having children ($\tau^q w^M$) increases which provides incentives to reduce fertility. In net terms then, a reduction in the wage gap $\frac{w^F}{w^M}$ tends to reduce optimal fertility.

On the other hand, households increase their investments in education having more money available due to the positive income effect. This positive effect on education investments is reinforced by the incentives to reduce fertility, given that the combined effect reduces the total costs of education for the household. Therefore, in net terms, a reduction in the relative wage gap $\frac{w^F}{w^M}$ tends to increase investments in children's education.

A.5.

Galor (2012) observes that the rise in the demand for human capital triggered by higher technological progress gradually reduced the relative wage gap $\frac{w^F}{w^M}$, by increasing the wage of mothers – which in our model is captured by w^M, or the income of the parent who typically covers the time costs of raising children regardless of the level of investments in children's education. In that sense, a gradual reduction in the wage gap is likely to have reinforced the effects of faster technological progress on lower fertility, and also the incentives of families to increase investments in childrens' education.

In general, these results also suggest that, in a scenario where technological progress is not accompanied by reductions in the wage gap, or where technological progress is instead accompanied by increases in the wage gap, reductions in fertility, investments in childrens' education, and the associated increases in the level of prosperity, will tend to get postponed.

A.6.

The first graph shows the magnitude of the gap in earnings for men and women, before and after having a first child. In relationship to the model above, the first graph illustrates that the size of the $\frac{w^F}{w^M}$ gap is around 20% in the medium or long term in the Danish economy today.

The second graph shows that the long-term drop in earnings is more pronounced for women who had mothers working relatively less than their fathers. In that sense, this part looks at the *origins* of the wage gap between men and women – as compared to the questions in the exercise above, that look at the *consequences* of the wage gap between men and women.

More concretely, the second graph illustrates that differences in participation in the labor market between men and women are transmitted across generations, in particular from parents to their daughters. Given that in Denmark there are not formal institutional barriers to the participation of women in labor markets (and also given the tendency of women to be more educated than men), the graph points towards the role that cultural features may be playing to reduce women's participation in labor markets.

Alesina, Giuliano and Nunn (2012) study the historical origins of cultural attitudes about the appropriate role of women in society. They show a strong pattern of cultural persistence for gender norms – using historical data across countries, regions, and ethnic homelands across regions. Supporting Ester Boserup's (1970, Woman's Role in Economic Development) hypothesis, the authors also show that societies with tradi-

tionally lower participation of women in agriculture tend to have more unequal gender norms at present (measured by survey responses on attitudes towards female participation in the workplace, politics, and entrepreneurial activities).

Their final set of results shows that children of immigrants living in the US and Europe also tend to have less egalitarian beliefs about gender roles, if they are descendants of parents from regions with a traditionally lower participation of women in agriculture. This part emphasizes that the family is an important channel through which culture is transmitted.

In general, these results support the idea that culture plays an important role to understand important development outcomes. In particular, they illustrate the idea that culture affects the level of these outcomes, and also has explanatory power for the pattern of persistence that they typically exhibit (Gershman, 2017; Nunn, 2012).

QUESTION B. The State.

Readings:

- Acemoglu, Daron (2010), Chapter 4: Fundamental Determinants of Differences in Economic Performance, in "Introduction to Modern Economic Growth," Princeton University Press. Sections 4.1 and 4.3.
- Acemoglu, Daron, Jacob Moscona, and James A. Robinson (2016), State Capacity and American Technology: Evidence from the Nineteenth Century. *American Economic Review: Papers & Proceedings* 106(5): 61-67.
- Vries, Peer (2012), Public Finance in China and Britain in the Long Eighteenth Century. Department of Economic History, LSE, Working Papers No. 167/12.
- Acemoglu, Daron and James A. Robinson (2010), The Role of Institutions in Growth and Development. *Review of Economics and Institutions* 1(2): 1-33.

B.1.

The state plays an important role as a *fundamental* determinant of economic development because it shapes the way in which various *proximate* determinants development work. It does so by structuring the "rules of the game", or by giving form to the cluster of formal arrangements, regulations, laws, policies – the set of formal institutions – that influence the environment in which economic and political interactions happen in a society. In that way, the state impacts the dynamics of social, political and other outcomes related to the overall process of development (Acemoglu, 2010).

As concrete examples, the state influences the degree to which the rule of law prevails, the structure and protection of property rights, the presence and functioning of markets, and the contractual opportunities available to individuals, among many others. Through these *economic institutions*, the state affects for instance the sense of security that individuals have to engage in investments and economic transactions, and therefore it impacts a range of proximate factors that ultimately explain differences in prosperity across different societies (growth), and the way in which that prosperity is distributed within societies (inequality).

The state also affects *political institutions*. For example, it affects the form of government a society adopts; whether executive decision powers are allocated to a monarch, a parliament, a president or a prime minister; the way in which authorities are elected; the degree of autonomy of different regions within a society; the degree of bureaucratic centralization; the prevalence of a monopoly of violence, etc. Similar to economic institutions, these different political institutions structure incentives in political, social, and economic exchange within a society, and thereby affect the dynamics of economic activity and the distribution of resources.

Various examples in the course literature illustrate the capacity of the state to affect economic development in a medium and long term perspectives. One well discussed example is the separation of the Korean peninsula between North and South 60 years

ago. This event highlights that the creation of two states that differ in terms of how *inclusive* or *extractive* are their economic and political institutions, contributes to sustain marked differences in terms of economic development (see other cases in Acemoglu and Robinson, 2010).

A historical example discussed in Vries (2012) argues that the type of state and, in particular, the "big" government that England had before industrialization – characterized by high level of taxation, high government expenditures, a large navy, and a large ratio of fiscal debt to GDP – contributed to create a more embedded state among the population. Importantly, Vries argues that a big government also had a number of externalities that lead to important innovations, which ultimately gave England a comparative advantage to embark on a process of Industrial Revolution. For example, the large public debt instigated interest in devising mechanisms to facilitate participation of the population in politics, and also gave rise to significant financial innovations.

B.2.

Acemoglu, Moscona and Robinson (2016) argue that the presence and reach of the state, or its *infrastructural capacity* – measured in their study as the density of postal offices across US counties between 1804 and 1899 – can contribute to innovation at least via three channels.

First, it facilitates the flow of information and knowledge, which contributes to the spread of ideas and the creation of new ones. Second, if the flow of ideas is paired with policies of increased protection of property rights and ideas, a stronger infrastructural presence of the state also leads to faster innovation for "the more prosaic reason that it made patenting and securing intellectual property rights much easier" (Acemoglu *et al.*, 2016). Third, the presence of a post office is likely to be associated with a broader presence of the state, for example through regulation, or the provision of legal services, which have also the potential to contribute directly to innovation.

B.3.

We cannot give the baseline results in column 1 a causal interpretation immediately. The results show AMR's baseline results of a regression of the number of patents as the dependent variable, and contemporaneous levels and lags of the number of post offices in each county as the main regressors. As indicated in the notes to the table, all regressions control for size of each county population and a full set of county and year fixed effects.

Even though this control strategy ameliorates concerns of endogeneity due to ommited variables (for example the county fixed effects account for the idiosyncratic county characteristics that remain constant in time in each county, and the time fixed effects account for time-varying common shocks), we cannot rule out endogeneity due to *joint determination*, because of there might be important time-varying characteristics that are not included in the regression and that explain both the dynamics of patenting and innovation on one side, and postal offices expansion on the other side. For example, consider the pre-existing or initial levels of economic activity and human capital in

each county, which would tend to bias the coefficients of interest upwards. (A direct way to address this concern, is to include time-varying controls in the regression, as AMR do in column 2, where they include measures of manufacturing value in 1850, adult literacy rates in 1850, and others – all interacted with time fixed effects to allow for time-varying effects.)

We cannot rule out neither that the effects are tainted by endogeneity due to *reverse causality*. This may happen if, for example, more patenting and innovation activity in a given county increase the demand and the presence of additional postal offices in that county.

B.4.

Column 3 shows a regression where *leads* of the number of postal offices are included in the regression, in addition to contemporaneous levels, and *lags* of the number of postal offices. This specification allows for a *falsification test* of the hypothesis that the line of causality runs from postal offices to patenting, by comparing whether it is the opening of postal offices what is associated with patenting (that is, whether the *lagged* number of the postal offices number is significantly related to the number of patents), or whether the opening of postal offices follows the level of patenting (in which case the *leads* of the number of postal offices would be associated with the level of patenting.). The results show that the leads have small and noisily estimated coefficients in column 3, and that only the lags of the main regressor remain significant.

These results do not unambiguously establish causality. However, the entire table shows a fairly robust pattern of correlations that support the idea that the opening of postal offices was associated with higher patenting activity in the future, and therefore it supports the hypothesis and historical accounts mentioned in AMR's study, showing that the expansion of the presence and the capacity of the state to provide services contributed to the historical process of innovation in the US.

QUESTION C. Ruggedness and geography.

Readings:

- Nunn, Nathan and Diego Puga (2012), Ruggedness: The Blessing of Bad Geography in Africa. *Review of Economics and Statistics* 94(1): 20-36.
- Alesina, Alberto, Stelios Michalopoulos, and Elias Papaioannou (2016), Ethnic Inequality. *Journal of Political Economy* 124 (2): 428-488.
- Acemoglu, Daron (2010), Chapter 4: Fundamental Determinants of Differences in Economic Performance, in "Introduction to Modern Economic Growth," Princeton University Press. Sections 4.1 and 4.3.
- Nunn, Nathan (2014), Historical development. Chapter 7 in Handbook of Economic Growth, Volume 2A, 347-402.
- Dell, Melissa (2010), The Persistent Effects of Peru's Mining Mita. *Econometrica* 78(6): 1863-1903.
- Nunn, Nathan, and Leonard Wantchekon (2011), The Slave Trade and the Origins of Mistrust in Africa. *American Economic Review* 101(7): 3221-3252. (Optional reading, not in the required list of readings).

C.1.

Nunn and Puga's (2012) propose a plausible explanation to this paradox, by looking back into the history of slave trade in Africa.

As described by the authors, the trade of African slaves that took place between 1400 and 1900 led to the forced migration of over 18 million people. The process was also accompanied by death, fragmented societies, and collapsing political institutions.

This adverse environment naturally moved African people to make efforts to flee the slave trade. One can hypothesize that ruggedness could have played an important role there, by taking into account that the practice of enslavement took place through raids conducted by different groups, and therefore hills, caves, and cliff walls provided useful positions for establishing vigilance posts and hiding for those trying to escape.

At present, the geographic features associated to ruggedness of the landscape or the terrain (such as caves, hills, and cliff walls) are not likely to represent significant advantages for the creation of prosperity or the distribution of resources. In fact, they may add costs to the transport of goods, the irrigation of agricultural fields, or the construction of infrastructure, and ultimately to the advance of economic development.

If that is the case, as a general pattern, one should observe that regions with more rugged terrains today face higher costs to develop, vis-à-vis comparable regions with flatter terrains. But if Nunn and Puga's hypothesis is correct, the negative effect of ruggedness on economic development should be reduced in Africa, where ruggedness

had a historic indirect positive effect on development, by facilitating the escape from slavery and its negative consequences.

C.2.

A concern that arises almost immediately when interpreting the differential effect of ruggedness in Africa, is that it may be correlated with other geographical features. For instance, it is possible to imagine that the presence of hills and caves is correlated with the presence of mineral deposits that create net benefits in general, but negative effects in Africa. Consider for instance that ruggedness is correlated with the presence of diamond deposits, which increase income outside Africa, but decrease income within Africa – for example due to the presence of strongly extractive institutions. (Consider also Dell, 2010, which could help to build an interesting counter-example of the positive association between ruggedness and the production of minerals outside Africa). As another example, consider that rugged terrains tend to have lower soil quality, but that in Africa they tend to be fertile lands.

A similar case can be made for the disease environment. If rugged areas in Africa are less suitable environments for tropical pathogens than in the rest of the world, the differential effect of ruggedness in Africa may be confounded by the presence of a more favorable disease environment.

As a final example, one could imagine that rugged terrains are farther from oceans and navigable rivers, and therefore represent higher costs of integration to trade and markets in general, but that the opposite holds true within Africa.

The important part in these examples is that the effect of ruggedness may certainly be confounding the effect of another geographic (or climatic) factor, and one should be careful to control for those other factors in a regression analysis. However, an additional and very important point is that these potential geographic confounders should not only have a direct relationship with income and ruggedness to confound the differential effect of ruggedness in Africa, but also their own differential effect in that region.

Table 2 in Nunn and Puga's (2012) study presents a series of robustness checks in which all the above mentioned geographic potentially confounding characteristics are included one at the time (both in levels and interacted with the dummy variable for Africa, to capture the differential effect). Table 2 also presents in the last column a specification in which all the potential geographic confounders are included at the same time.

The results show a robust negative effect of ruggedness on income in general, and a robust differential positive effect of ruggedness in Africa. Looking at the results of column 5 (the richest specification), it is possible to see that one of the potentially confounding geographic characteristics also have direct and differential effects. Indeed, the presence of diamond deposits appears to have a positive effect on income in general, but a differential negative effect in Africa. The percentage of land in tropical areas and the average distance to oceans, appear to have a negative effect on income in general, but not a differentlial effect in Africa.

C.3.

Geographic and climatic factors can play the role of direct fundamental causes of differences in comparative development – for example via the direct effects of ruggedness on trade. At the same time, differences in geographic and climatic factors can also affect inequality. For example, Alesina, Michalopoulos, and Papaioannou (2016) show that inequality in geographic endowments between ethnic foster income inequality between, which that can increase social fragmentationand affect and have additional effects through that channel. However, importantly, geographic and climatic factors can also affect the way in which other fundamental factors operate.

The results in Nunn and Puga (2012) highlight both the direct effects of ruggedness (as an example of a geographic factor that acts as a fundamental cause of differences in economic development), and the historical effects that it had in relationship with the history of slaves trade in Africa. The latter can be interpreted as representing the reduced-form effects of ruggedness on cultural or institutional dimensions.

For example, ruggedness may have helped specific areas in Africa to be shielded from the side effects of slavery on ethnic divisions, and it concretely may have helped to reduce the degree of social fragmentation or to increase the general level of trust in strangers (as research published by Nunn and Wantchekon in 2011 shows).

Similarly, ruggedness may have affected the way in which different societies structured different institutions. For instance, by helping to avoid the collapse of pre-colonial institutions, ruggedness may have helped to preserve relatively less hierarchical, or relatively more democratic societies.

Importantly, given that the geography and climate features may have had these types of effects on fundamental characteristics associated to the cultural and institutional make-up of different societies, geography and climate also help to explain the strong pattern of *persistence* that we tend to observe in comparative development analyses.