Abbreviations used in the model solution:

- **Weil:** David N. Weil, 2013. "Economic Growth", Pearson International Edition, 3rd Edition
- **PRLB:** Dwight H. Perkins, Steven Radelet, David L. Lindauer and Steven A. Block, 2013. "Economics of Development", 7th edition, W.W. Norton & Company.
- **Ray:** Debraj Ray, 1998, “Development Economics”, Princeton University Press

Problem A

Please provide short answers to the following questions and statements:

1. Please provide an argument for why income inequality may affect growth and future income levels negatively.

This question draws on Weil ch. 13.

Weil describes several channels for why income inequality may be harmful to growth. Here, a model answer using redistribution is provided:
High levels of inequality can lead to a high demand for taxes and transfers that aim to decrease inequality. Taxes can reduce efficiency because they distort incentives; in particular, they reduce labour supply. Further, tax-payers may take costly actions to try to avoid paying taxes. Both channels reduce economic efficiency, and reduces income levels.

2. Please explain the difference between gross and the net enrollment rates. How can gross enrollment rates be above 100%?

This question draws on PRLB ch. 8.

The gross enrollment rate measures the number of students enrolled at a given grade, divided by the number of students who are enrollable, i.e., who are of the age that is expected to be enrolled in that grade. However, due to grade repetition, the number of students enrolled may be higher than the number of enrollable students. This can lead to gross enrollment rates above 100%.

The net enrollment rate measures the number of students enrolled at a given grade *who are enrollable*, divided by the number of students who are enrollable. The net enrollment rate is always smaller or equal to 100%.

3. Please explain briefly how poverty is estimated using the Food Energy Intake (FEI) method of estimating poverty lines.

This question draws on Ravallion (1998).

The food energy intake method (FEI) uses an “engel curve for calories”, i.e., a function fitted to data that describes how food-energy intake measured in calories per day depends on income (or expenditure). This is combined with a nutritional anchor, i.e., the number of calories per day required to be considered non-poor.

The poverty line is determined as the income level at which the nutritional anchor is achieved using the fitted function.

4. Please briefly discuss some disadvantages of the Food Energy Intake (FEI) method.

This question draws on Ravallion (1998).

The cost of acquiring the nutritional anchor will vary with tastes, prices and which goods are publicly provided. One example is that urban non-food prices are often lower than rural non-food prices, which, due to substitution effects in consumption, leads to a higher FEI poverty line, since urban households purchase more non-food items before they reach the nutritional anchor.

5. Please describe briefly what a randomized control trial (RCT) is and discuss what the main advantage of using RCTs in development economics is.

This question draws on PRLB ch. 8 and Barret and Carter (2010).

A randomized control trial (RCT) is a way of using experiments with random assignment of treatment. A prototypical RCT randomizes a study group into a treatment group and a control group. Only the treatment group gets the treatment, and since assignment is random, any differences between the treatment and the control group can be attributed to the treatment.

The main benefit of an RCT is exactly that it can provide clean identification of causal effects.

6. Please discuss the following claim: In terms of economic growth, there exists an optimal level for the annual average temperature.

This question draws on Burke et al. (2015).

The concept of an optimal level of annual temperature is central to Burke et al. (2015). The authors argue that many micro-level variables (e.g. labour supply, crop yields etc.) react negatively to higher prices, often with a "kinked" reaction curve where the decrease sets in at a temperature of 20-30 degrees Celsius. Combined with a distribution of temperatures experienced in given years, this leads to an inverted-U curve of the effect of temperature on production (or growth).

Burke et al. test this using regressions and find that there does indeed appear to be an optimal annual average temperature across countries. This is quite consistent across rich and poor countries as well as in different time periods.

7. Please explain how the relationship between wages and nutrition can lead to low-level equilibria in labour markets in very poor countries.

This question draws on Ray ch. 13.

The student may use a figure like Ray's figure 13.5 to support the answer of this question.

This can occur in the presence of an "S-shaped" capacity curve (such as Ray's figure 13.3) and a piece rate for work. The capacity curve may be S-shaped because work capacity only increases a little for low nutritional intakes (i.e. when incomes are low) because a certain amount of calories is needed to maintain the body's resting metabolism. This is followed by a rapid increase in work capacity for higher levels of income after the body's resting metabolism needs are covered. This is again followed by a flat part of the curve. The piece wage rate corresponds to a linear function in income-work capacity space.

An equilibrium occurs when work capacity for a given amount of income is equal to the income received for a given amount of work. If the piece rate is sufficiently low (corresponding to a steep line in the income-work capacity space), there is no high-level equilibrium possible (i.e. an equilibrium at income levels above the steep part of the S-shaped capacity curve), and workers end up in a low-level equilibrium where income and work capacity are both low.

Problem B Human capital

1. A version of The Solow model using standard notation is given by equations (1) and (2). Please explain the economic intuition behind the equations and the variables used. Please be as precise as you can.

$$Y = AK^{\alpha}(hL)^{1-\alpha} \qquad (1)$$

$$\Delta K = \gamma Y - \delta K \qquad (2)$$

This question draws on Weil ch. 3 and 6.

Equation 1 is a Cobb-Douglas macro production function. It states that total production (Y) is a function of total factor productivity (A), the capital stock (K), the labour force (L) augmented by the average level of human capital (h). α is a parameter describing the share of income that accrues to capital.

Equation 2 is an accounting equation for the development of the capital stock. It states that the change in capital stock is equal to total savings, which are a fraction (γ) of total production, from which depreciation of the existing capital stock is subtracted at a depreciation rate of δ.

2. Please derive an expression for the steady-state level of income per capita. How will steady-state income per capita change if human capital increases by 10%?

This question draws on Weil ch. 6.

Income per capita is given as $y = \frac{Y}{L} = \frac{AK^{\alpha}(hL)^{1-\alpha}}{L} = Ah^{1-\alpha}\left(\frac{K}{L}\right)^{\alpha} = Ah^{1-\alpha}k^{\alpha}$, using equation 1 and defining $k \equiv \frac{K}{L}$ and $y \equiv \frac{Y}{L}$.
The steady state is achieved when $\Delta K = \Delta k = 0$. This implies that
$\gamma y = \delta k \Rightarrow$
$\gamma A h^{1-\alpha} k^{\alpha} = \delta k \Rightarrow$

$k = \left(\frac{\gamma A h^{1-\alpha}}{\delta}\right)^{\frac{1}{1-\alpha}}$

The steady state level of income is therefore given as

$$y^{ss} = Ah^{1-\alpha}\left(\frac{\gamma A h^{1-\alpha}}{\delta}\right)^{\frac{\alpha}{1-\alpha}} = A^{\frac{1}{1-\alpha}} * h * \left(\frac{\gamma A}{\delta}\right)^{\frac{\alpha}{1-\alpha}}$$

From this expression, it is clear that a 10% increase in h will lead to a 10% increase in steady state income per capita.

3. Please discuss how high levels of inequality can affect the accumulation of human capital negatively and reduce efficiency.

This question draws on Weil ch. 13.

Weil outlines a model that can lead to this outcome. We assume that human capital is not transferrable and that there is decreasing marginal product to investments in human capital. On the other hand, the marginal product of physical capital is constant for any one person. Allocative efficiency is achieved when investments in human capital take place up until the point where the marginal product of human capital investments dips below the marginal product of investments in physical capital, after which only physical capital investments take place.

However, if there is inequality and the poor are credit constrained, they may not be able to invest in enough human capital to ensure an efficient outcome.

4. Human capital accumulates through education. The return to schooling is often measured using a "mincerian wage regression" on a cross section of individuals (i) like the one given in equation (3). β_1 is a measure of the semi-elasticity of wages (E_i) with respect to years schooling (S_i). exp_i is a measure of experience. Please discuss potential drawbacks to using this method and explain how "Second generation estimates" can be seen as an attempt to address these issues.

$$lnE_i = \alpha + \beta_1 S_i + \beta_2 \exp_i + \beta_3 \exp_i^2 \qquad (3)$$

This question draws on PRLB ch. 8.

The main drawback with using (3) to estimate returns to schooling is that there may be self-selection into who gets schooling. If higher-skilled individuals are more likely to attend school (because the return to schooling is higher), and higher-skilled individuals will also achieve higher wages on average, conditional on their schooling level, we end up attributing part of the premium on skills to schooling. The skill level of an individual cannot be directly observed, so it is not possible to control for it by adding an extra control variable to (3).

Second generation estimates attempt to address this issue of endogeneity by exploiting random variation in who gets schooling. One way of doing this is to exploit natural experiments. An example of this could be the school construction programme in Indonesia used by Duflo (2001)[1].

5. Another part of human capital is health. As figure 1, which is taken from Weil (2013) , illustrates, there is a clear correlation between life expectancy and GDP per capita. Please discuss:
    a. Is life expectancy a satisfactory indicator of health?
    b. Is it reasonable to infer that the causal mechanism behind the correlation in figure 1 is that high levels of income causes high levels of life expectancy?

This question draws on PRLB ch. 9 and Weil ch. 6.1.

@a: Life expectancy is a summary statistic that gives a snapshot of the health of a country in a single number. However, it does not give the full picture. First, life expectancy does not fully capture morbidity, i.e. rates of disease and illness. Second, health is not only the absence of disease and death, but rather a more comprehensive concept that can include mental, physical and social well-being (cf. the WHO definition PRLB references on p. 302). To conclude, life expectancy is not a sufficient indicator of health.

@b: Income can affect health positively, e.g., through better access to health inputs. However, health can also affect income positively. For instance, better nutrition and a higher caloric intake increases work capacity. In general, healthy workers are more productive. Therefore, there may also be some degree of reverse causality, i.e., that higher levels of health (measured by life expectancy) cause higher levels of income.

Problem C Agriculture

1. An important factor in agricultural production is land. However, ownership of land is unequally distributed. Assume that farm production exhibits constant returns to scale. In this situation, landowners will want to either hire labour or rent out land to increase productivity. Please give examples of circumstances under which:
    a. Hiring of labour may be preferred to renting of land
    b. Renting of land may be preferred to hiring of labour

This question draws on Ray ch. 11.

Two examples are given below, although Ray also discusses other circumstances that fit the question.

@a: If would-be renters of land are risk averse, they may prefer to be hired as labour for a fixed wage, thus eliminating variation in income under e.g., good or bad harvests. If the land-owners are risk-neutral, they can set the wage such that expected incomes are unchanged, thus making the land-owner indifferent to renting out land or hiring labour. Note that if insurance markets work perfectly, the would-

[1] Duflo, E. (2001). Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment. *American economic review*, *91*(4), 795-813, referenced in PRLB ch. 8.

be renter may instead rent land and insure against bad outcomes. Often, however, there is a compounding failure in the insurance market for harvest outcomes.

@b: If the tasks that must be carried out are difficult to monitor, supervision costs can be an extra cost for the land-owner, who hires labour, compared to the land-owner who rents out land.

2. Part of the existing literature finds that smaller farms appear to have higher productivity than larger farms, when productivity is measured as output per acre. Please discuss why this situation may arise.

This question draws on Ray ch. 12.

Ray discusses several reasons, including:

- A market failure in the credit market or insurance market combined with risk averse tenants mean that an efficient contract cannot be achieved. If hiring of labour is problematic due to e.g. supervision costs, it may be possible to achieve a higher input of effective labour per acre when farms are owner-operated, which will be the case with small farms.
- If there is unemployment, the accepted wage rate on the owner-operated farm (where employment is certain), will be lower than the accepted wage rate as hired labour (where there is a risk of unemployment) to equalize expected wages. This means, that the marginal product of labour will be lower on the owner-operated farm, which in turn implies a higher labour input per acre.

An important connection between the agricultural sector and the rest of the economy works through the labour market. Consider the canonical Lewis two-sector model, with a single change, namely that social norms dictate that the agricultural wage should not be less than the average product of labour in the agricultural sector.

3. What does the labour supply curve of the industrial sector look like? Please illustrate the effects as demand for labour in the modern sector increases and compare with the effects of the same increase in the standard Lewis two-sector model. Please illustrate your answer with relevant graphs.

This question draws on PRLB ch. 16.

In the canonical Lewis two-sector model, the labour supply curve in the modern sector is perfectly elastic (flat) for a while. This is because the wage required for workers to take a job in the modern sector must make them indifferent between working in the agricultural sector, and working in the modern sector. In the modern sector, the wage is a markup over the agricultural wage to take account of e.g. the nature of the work or moving costs. In the agricultural sector, the wage is equal to the minimum wage when the marginal product of labour (MPL) is below the minimum wage, and equal to MPL when MPL is above the minimum wage.

If the agricultural wage is instead set equal to the average product of labour, the agricultural wage will be increasing from the beginning, even when MPL is zero. This means that the modern sector faces an upward-sloping supply curve.

As demand for labour in the modern sector increases, this will lead to an increase in the wage rate from the get-go. This is different from the canonical model, where the modern sector can for a while draw on a pool of "surplus" labour from the agricultural sector without increasing the modern sector wage rate.

The students can use a modified version of PRLB figure 16-5 b and 16-5 c to illustrate the points made above.

4. What are the effects of a population increase in this model? Please compare to the effects of the standard Lewis two-sector model. Assume that the modern sector labour demand is such that the agricultural marginal product of labour is zero.

This question draws on PRLB 16.

An increase in the labour force does not increase agricultural production, since the economy was already at the point where agricultural MPL is zero.

In the standard Lewis model, an increase in the labour force does not affect the agricultural minimum wage. This means that the modern sector labour demand is unchanged. The entirety of the population increase will therefore be relegated to working in the agricultural sector, but at an MPL of zero.

In the modified Lewis model, the increase in the agricultural labour force will reduce the average product of labour, which shifts the modern sector labour supply curve down. This will lead to a decrease in the modern sector wage and an offsetting increase in modern sector employment.