

Economic Growth and Income Disparity

ECO 305: Intermediate Macroeconomics

Goals

1 / 14

Explore multiple growth theories to explain...

- 1 Income disparities: Why do some countries never catch up to more developed countries
- 2 Poverty traps: Why some impoverished countries grow slowly

Reading and Exercises

2 / 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on Thursday

Reading and Exercises

2 / 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on Thursday

Reading and Exercises

2 / 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- Homework/Exercise due Thursday 11:59 PM. We will work together in class on Thursday

Reading and Exercises

2 / 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on Thursday

Differences in Access to Technology

3 / 14

- Not all countries may have the same total factor productivity
- Implementing new technologies may require high levels of existing infrastructure (eg: factories, internet connectivity, etc.)
- Countries with low levels of capital stock may have limited access to technologies
- Countries with low k may also have low z

Differences in Access to Technology

3 / 14

- Not all countries may have the same total factor productivity
- Implementing new technologies may require high levels of existing infrastructure (eg: factories, internet connectivity, etc.)
- Countries with low levels of capital stock may have limited access to technologies
- Countries with low k may also have low z

Differences in Access to Technology

3 / 14

- Not all countries may have the same total factor productivity
- Implementing new technologies may require high levels of existing infrastructure (eg: factories, internet connectivity, etc.)
- Countries with low levels of capital stock may have limited access to technologies
- Countries with low k may also have low z

Differences in Access to Technology

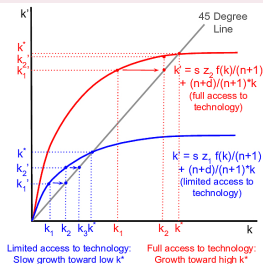
3 / 14

- Not all countries may have the same total factor productivity
- Implementing new technologies may require high levels of existing infrastructure (eg: factories, internet connectivity, etc.)
- Countries with low levels of capital stock may have limited access to technologies
- Countries with low k may also have low z

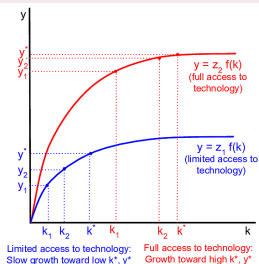
Differences in Access to Technology

4 / 14

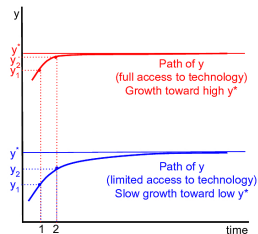
Capital Evolution



Output Growth



Time Path for Output



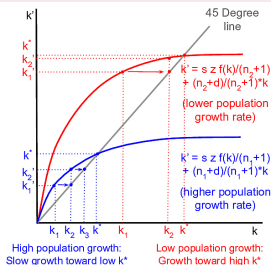
Result for countries with low capital stock & low access to tech

- Grow at slow rates
- Converge at low levels of capital stock per worker
- Converge at low levels of real GDP per capita

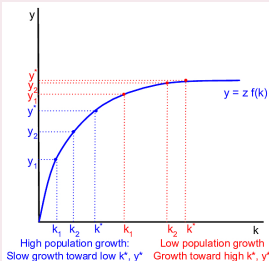
Differences in Population Growth Rates

5 / 14

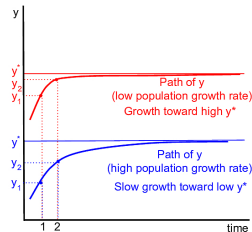
Capital Evolution



Output Growth



Time Path for Output



Result for countries with low capital stock & high population growth

- Grow at slow rates
- Converge at low levels of capital stock per worker
- Converge at low levels of real GDP per capita

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

Increasing Marginal Product of Capital

6 / 14

- Typical assumption of **diminishing returns**: As capital stock increases, the marginal product of capital decreases
- At lowest levels of capital stock, increasing marginal product of capital is possible
- Positive externalities to capital production: When infrastructure and markets are small to non-existent in lesser-developed countries, new firms and new capital help productivity of other firms.
 - Example: a single factory would be more productive if there was a shipping and warehousing company to ship products and supplies.
- Small companies, small facilities, may take advantage of economies of scale
 - Eventually companies may get large enough and diminishing returns sets in
- Likely possibility for small lesser-developed economies, not likely at an aggregate level for highly-developed economies

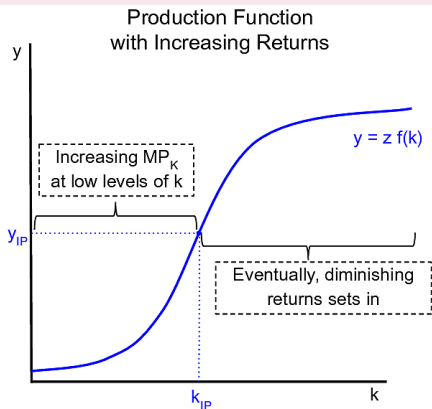
Production Function with Increasing Returns

7 / 14

Increasing Returns

- Increasing MP_K at low levels of capital stock per worker
- Eventually, diminishing returns sets in after k_{IP}

Production Function



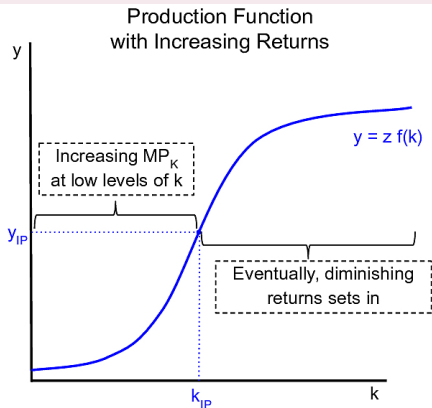
Production Function with Increasing Returns

7 / 14

Increasing Returns

- Increasing MP_K at low levels of capital stock per worker
- Eventually, diminishing returns sets in after k_{IP}

Production Function



Multiple Steady States with Increasing Returns

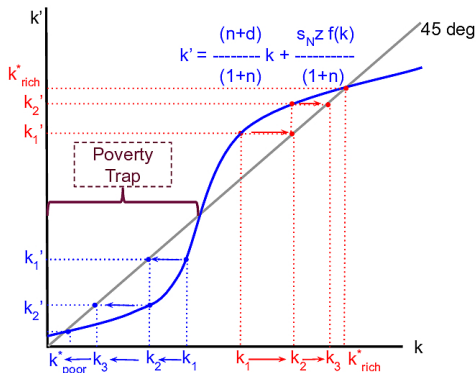
8 / 14

Increasing Returns

- When k is low and below intersection with 45-deg line, economy shrinks, converges to impoverished levels
- When k is higher and above intersection, economy grows, converges to developed levels
- Case for government assistance is when k is in poverty trap

Capital Evolution

Capital Evolution with Increasing Returns



Multiple Steady States with Increasing Returns

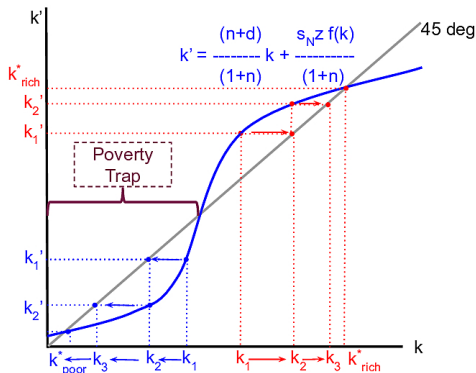
8 / 14

Increasing Returns

- When k is low and below intersection with 45-deg line, economy shrinks, converges to impoverished levels
- When k is higher and above intersection, economy grows, converges to developed levels
- Case for government assistance is when k is in poverty trap

Capital Evolution

Capital Evolution with Increasing Returns



Multiple Steady States with Increasing Returns

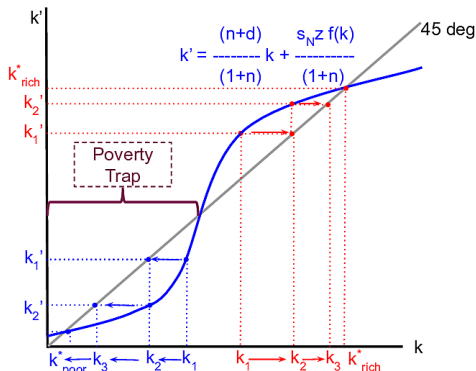
8 / 14

Increasing Returns

- When k is low and below intersection with 45-deg line, economy shrinks, converges to impoverished levels
- When k is higher and above intersection, economy grows, converges to developed levels
- Case for government assistance is when k is in poverty trap

Capital Evolution

Capital Evolution with Increasing Returns



Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Human Capital Properties

9 / 14

- Human capital is a factor of production we have ignored so far
- **Human capital:** knowledge and skills of workers that can be used in the production of goods and services
- Argued that human capital does not exhibit diminishing returns
 - Knowledge accumulation is **non-rivalrous**. One person learning something doesn't diminish or prevent another person from learning something.
 - Knowledgeable workers can have **positive externalities**. Not only is a knowledgeable worker more productive, other co-workers may benefit and be more productive
 - Acquiring and sharing knowledge gets easier as it grows. Example: Calculus, and you're no Isaac Newton.

Increasing Returns to Human Capital

10 / 14

Being knowledgeable not only improves your own productivity and opportunities, it **also makes it easier for your peers and co-workers to acquire acquire knowledge.**



<https://www.youtube.com/watch?v=U5wfxjmlwtE>

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded. forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded. forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

11/ 14

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

Human Capital Accumulation

- Let human capital per worker evolve according to:

$$h' = (1 - d)h + buh$$

- h : average level of human capital per worker
 - $d \in (0, 1)$ depreciation rate of human capital
 - $u \in (0, 1)$ fraction of time spent with training and education
 - $b > 0$: measure of efficiency/effectiveness of training and education
- Some algebra shows...

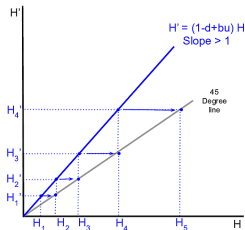
$$h' = (1 - d + bu)h$$

- Coefficient on h is greater than 1.0 when...
- $bu > d$: Effectiveness and time spent on training/education outweigh forgetting stuff.
- When coefficient > 1 , $h' > h$ always, human capital grows unbounded, forever

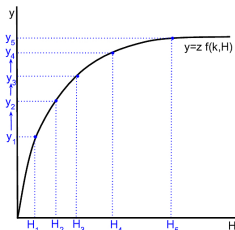
Human Capital and Output Growth

12/ 14

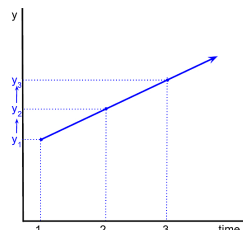
Human Capital



Output Growth



Time Path for Output



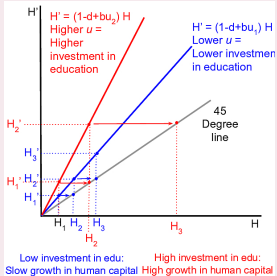
Result for human capital and output growth

- Human capital grows unbounded
- Even with diminishing returns, real GDP per capita grows unbounded with human capital
- There is no convergence: Countries with lower levels of human capital can grow, but still remain behind others with higher levels of human capital

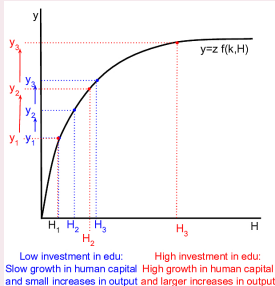
Human Capital and Output Growth

13/ 14

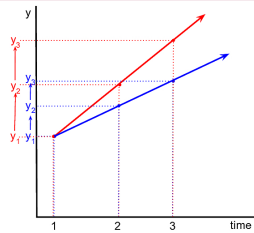
Human Capital



Output Growth



Time Path for Output



Result for human capital and output growth

- Even when initial levels of human capital & output are the same
- More investment in human capital leads to permanently faster growth
- Growth paths diverge (no convergence)

Reading and Exercises

14/ 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on

Reading and Exercises

14/ 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on

Reading and Exercises

14/ 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- Homework/Exercise due Thursday 11:59 PM. We will work together in class on

Reading and Exercises

14/ 14

- Chapter 8, pp. 281-290: Using the Solow growth model to explain international differences in income per capita
- Chapter 8, pp. 290-300: Endogenous growth model with human capital accumulation
- **Canvas Quiz due Wed 11:59 PM.**
Multiple-choice, 10 questions, unlimited attempts allowed, only best score counts
- **Homework/Exercise due Thursday 11:59 PM.** We will work together in class on