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A decomposition of China's productivity through calibration of an endogenous growth model

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Background

The death of Communist leader Mao in 1976 led to the restructuring of the Chinese economy under the Four Modernization (agriculture, industry, science and technology, and defense) in late 1978, which paved the way for unprecedented growth in the Chinese economy.

How did this structural change so drastically effect the Chinese economic growth? Human capital and investment specific technology (IST) capture two fundamentally different sources of growth: human capital centers on the idea that human intellect and innovation are the driving force of growth, while IST focuses on the evolution of productivity of physical capital.

We show human capital and IST together play an essential role in explaining the Chinese economic growth.

Objectives

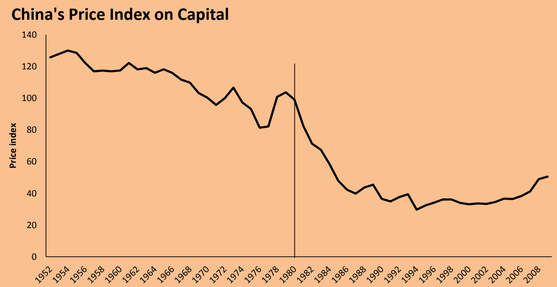
1) Use an endogenous growth model with human capital enhancing labor productivity in the production function and IST augmenting capital investment in the law of motion of capital to decompose the Chinese labor augmented productivity (LAP).
2) Based on the growth structure of LAP, we are able to more accurately project when the Chinese economy will surpass the U.S. economy.

Investment Specific Technology

IST (τ) describes the state of capital technology by formalizing the amount of output needed to produce one unit of capital. Growth in IST imply a new—more productive—vintage of capital and an improvement in the conversion technology.

The state of the technological is reflected in the price of capital. As technology advances, capital, particularly equipment, become less expensive.

Thus, IST is defined as: τ=*1/(price of capital)*. As seen below, China's price of capital has been falling steadily since the 1980s.



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Human Capital

For this study, we focus on education driven human capital. Namely, the better educated the labor force, the more productive are the laborers and the faster the knowledge stock grows.

During Mao's era, the Chinese education system was reorganized to follow a Soviet style system and aimed to bring education to the rural masses. However, because this education was viewed as inferior rural worker were hesitant to enroll. After Mao's Death, the Chinese education system was again reorganized to follows a Western style. Since then China's education rate has doubled.

Theory

Chinese Growth Decomposition

LAP: $A_t = Y_t^{1/(1-\alpha)} / \left(K_t^{\alpha/(1-\alpha)} h_t L_t\right)$

Human capital: $h_t = \exp(\psi \sigma_t)$

Law of Motion (K_t): $K_{t+1} = (1-\delta)K_t + \tau_t s Y_t$

Variable Definition

Y=GDP, K=Capital, A=Labor Augmenting Productivity, h=Human Capital, L=Labor, σ=Years of Schooling

Parameters

α=Capital Share Parameter, ψ=ReturnstoEducation, δ=Deprecation Rate, s=Savings

GDP Forecasting

Production: $Y_{it} = K_{it}^{\alpha} (A_{it} L_{it})^{1-\alpha}$, $i = 1(U.S.), 2(China)$

Law of Motion (K_{it}): $K_{i,t+1} = (1-\delta)K_{it} + \tau_{it} s Y_{it}$

Population Growth: $L_{i,t+1} = (1+g_{iL})L_{it}$

IST growth: $\tau_{i,t+1} = (1+g_{i\tau})\tau_{it}$

LAP Growth (US): $A_{1,t+1} = (1+g_{1A})A_{1t}$

Catch-up LAP Growth (China): $A_{2,t+1} = A_{2t} + g_{1A} A_{1t}^{\theta} A_{2t}^{1-\theta}$

where θ is the catch-up parameter and g_{ij} are the growth rates.

China's LAP follows a catch-up formation to account for non-balanced growth of the Chinese economy. As China's LAP approached that of the U.S., the Chinese LAP growth converges to the U.S. LAP growth rate.

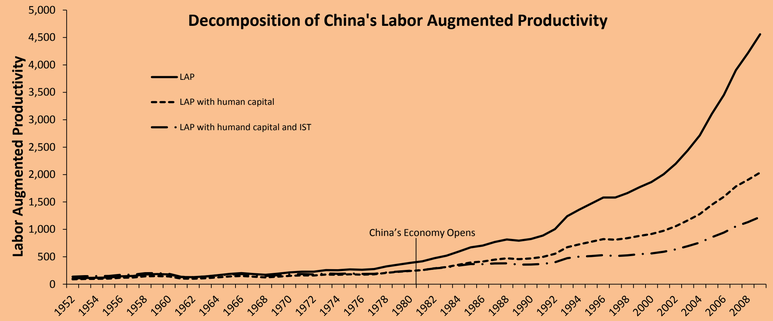
Data and Calibration

The model is calibrated using data for the period 1952-2009. Data for population, real GDP per worker, purchasing power parity (PPP), savings, and price of investment data were collected from the Penn World Tables. Data for average years of schooling came from Barro and Lee. The consumption of fixed capital to output was collected from the World Bank, and the physical capital share was calculated from data collected from the Bureau of Economic Analysis.

Results

Chinese Growth Decomposition

The Chinese LAP is broken down in three steps: 1) for the baseline, we calculate LAP using the growth model without human capital or IST, 2) we incorporate human capital into the production function and compare the structure of LAP to that in the first step, and 3) we combine both human capital and IST into the model and compare the growth structure to that in the previous two steps.



Decomposition of LAP

	Average for Period 1 (1952-1979)	Average for Period 2 (1980-2007)
LAP Step 1 ($)	196	1,666
LAP Step 2 ($)	143	829
LAP Step 3 ($)	174	550
% change: Step 1 vs. 2	-25.07	-46.72
% change: Step 1 vs. 3	-5.08	-60.16
% change: Step 2 vs. 3	25.32	-26.65

GDP Forecasting

We estimate that the Chinese GDP will surpass the U.S. GDP in 2022. The table below offers various years at which Chinese's GDP will over take the U.S. GDP based on sensitivity analysis for shocks to the labor growth rate, savings rate, and IST growth rate.

Sensitivity Analysis

Average Labor Growth Rate	5% Increase	5% Decrease
China (1.53%)	2021	2023
United States (1.19%)	2023	2021
Average Saving Rate	**5% Increase**	**5% Decrease**
China (24.67%)	2021	2023
United States (22.94%)	2019	2028
Average IST Growth Rate	**5% Increase**	**5% Decrease**
China (2.44%)	2022	2023
United States (0.51%)	2023	2021

Conclusions

- Human capital plays a central role in decomposition LAP, and the importance of this role has increased over time. Human capital accounts for 47% of LAP.
- IST: There is a pronounced divergence between LAP calculated from the growth model in step 2 and that calculated in step 3. China's capital vintage was stagnant before the Chinese economy opened. After 1979, the capital vintage dramatically improved and played a major role in explaining China's LAP growth. IST accounts for an additional 27% of LAP.
- The GDP Predictions are robust to reasonable economics shocks.