Trade, Structural Transformation and Growth in China

Pedro Cavalcanti Ferreira
Fundação Getulio Vargas
China growth performance in the recent years is an (almost) unique growth experience;

China went from a long period of stagnation to one of extremely fast growth;

For instance, if we extrapolate the trends of the previous decade, in 16 years China will overtake Japan in per capita terms. 16 years ago, per capita GDP of China was less than 15% of that of Japan.
One interpretation: until 1979 the country was living under a "Malthusian trap", with stagnation or extremely slow growth.

After 1980 the country experiences "Modern Growth": fast growth and convergence.

Compatible with "Barriers to Riches" theory (Parente and Prescott, 2000): institutional or political barriers prevent growth.

Compatible with "Modern Growth" theories (e.g.: Hansen and Prescott (2002), Galor and Weil (2002)): industrial revolution in China.
At the same time of growth acceleration one observes:

1. Increase of international trade: exports + imports went from less than 9\% of GDP in the seventies to more than 60\% today.

2. High and non-decreasing return to capital, as opposed to other miracles such as South Korea and Japan.

3. Structural transformation: labor reallocation from agricultural sector to non-agricultural sectors and fast decrease of the share of the former in total value added.
Introduction

- Trade allows shift of resources from agriculture (low productivity sector) to industry (high productivity sector);
- Without trade limit of growth would be given by domestic supply of food and raw material;
- That is Pomeranz (2000)’s and O´Rourke and Williamson (2005)’s explanation of why Industrial Revolution was in UK and not China: not (only) institutions but trade.
In UK, cheap supply from colonies and ex-colonies allowed specialization in manufactures and the release of resources from agriculture.

If British industry had been forced to source its raw materials domestically - rather than import them - prices would explode, as expanding levels of demand would be restricted by domestic land endowment.

In China there was no such alternatives at low cost at that time.

Not any more.
In the next section we present some stylized facts that will guide our modelling.

We next develop a growth model calibrated to China.

In this model the expansion of international trade takes place at about the same time that technology growth in the agricultural and manufacture sectors accelerates;

This allows the economy to transit from stagnation to growth. In technical terms: from a Malthusian two-sectors model to a dynamic Heckscher-Ohlin economy.
Simulations of the model are able to replicate some of the main facts of China recent development: labor reallocation, growth acceleration, the fast increase of investment and investment rate and the fall of the relative price of agricultural goods.

Without trade, the model cannot reproduce most of the observed facts and transition is excessively slow.
### Growth Miracles

<table>
<thead>
<tr>
<th>Country</th>
<th>Region</th>
<th>Start</th>
<th>Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPN</td>
<td>East Asia</td>
<td>1950</td>
<td>7.54%</td>
</tr>
<tr>
<td>BWA</td>
<td>Africa</td>
<td>1963</td>
<td>7.29%</td>
</tr>
<tr>
<td>CHI</td>
<td>East Asia</td>
<td>1980</td>
<td>7.16%</td>
</tr>
<tr>
<td>TWN</td>
<td>East Asia</td>
<td>1961</td>
<td>7.05%</td>
</tr>
<tr>
<td>KOR</td>
<td>East Asia</td>
<td>1970</td>
<td>6.74%</td>
</tr>
<tr>
<td>HKG</td>
<td>East Asia</td>
<td>1960</td>
<td>6.29%</td>
</tr>
<tr>
<td>SGP</td>
<td>East Asia</td>
<td>1963</td>
<td>6.19%</td>
</tr>
<tr>
<td>THA</td>
<td>East Asia</td>
<td>1970</td>
<td>5.42%</td>
</tr>
<tr>
<td>MYS</td>
<td>East Asia</td>
<td>1958</td>
<td>5.02%</td>
</tr>
<tr>
<td>BRA</td>
<td>Latin America</td>
<td>1953</td>
<td>4.94%</td>
</tr>
<tr>
<td>IDN</td>
<td>East Asia</td>
<td>1965</td>
<td>4.71%</td>
</tr>
</tbody>
</table>

source: Prichett (2010)
China in even more impressive if we nail growth turning points:

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>PERIOD</th>
<th>GROWTH RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1950-1991</td>
<td>5.85%</td>
</tr>
<tr>
<td>Korea Rep</td>
<td>1966-2008</td>
<td>6.01%</td>
</tr>
<tr>
<td>China 1</td>
<td>1990-2008</td>
<td>7.11%</td>
</tr>
<tr>
<td>China 2</td>
<td>1998-2008</td>
<td>8.09%</td>
</tr>
<tr>
<td>Brazil</td>
<td>1951-1979</td>
<td>3.77%</td>
</tr>
<tr>
<td>India</td>
<td>1987-2008</td>
<td>4.63%</td>
</tr>
<tr>
<td>India 2</td>
<td>2000-2008</td>
<td>5.66%</td>
</tr>
</tbody>
</table>
Facts: growth rates

- Distance to leaders still very large, but catching up
Facts: growth and relative productivity

- Distance to leaders still very large, but catching up: from 3% to almost 20% of U.S. labor productivity
Facts: growth and relative productivity

China, Per Capita GDP

China, Per Capita GDP

*Malthus*  "Modern Growth"
Facts: TFP

- From 20% of US TFP in 1980 to 60% in 2007 (3.9%/year)
Facts: high and stable return to capital

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>0.15</td>
<td>0.16</td>
<td>0.18</td>
<td>0.19</td>
<td>0.22</td>
<td>0.19</td>
<td>0.22</td>
</tr>
<tr>
<td>Japan</td>
<td>0.19</td>
<td>0.20</td>
<td>0.12</td>
<td>0.11</td>
<td>0.09</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Korea Rep</td>
<td>0.23</td>
<td>0.27</td>
<td>0.18</td>
<td>0.17</td>
<td>0.14</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>USA</td>
<td>0.22</td>
<td>0.21</td>
<td>0.19</td>
<td>0.19</td>
<td>0.18</td>
<td>0.18</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Source: PWT 6.3
Facts: high and stable return to capital

Source: Bai, Hisie and Qian (2006)
So fast accumulation but no decrease in marginal return to capital: compatible with growth theory with trade and sector reallocation (as in Ventura (1997) and Ferreira and Trejos (2007)).

Trade allows the release of resources from low to high productivity sectors: hence constant marginal productivity of capital in an interval.

In this case holds a result analogous to the Factor Price Equalization Theorem, which states that equilibrium marginal returns of capital and labor are not sensitive to variations in the factor endowment.
Facts: growth in trade

- Growth in International Trade coincides with "modern growth"
Facts: structural transformation

Value Added per Sector, China (% Total)

- Agriculture
- Services
- Industry
Employment share of Agriculture went from around 80% in 1960, to 71% in 1978, 60% in 1990 and less than 50% around 2003 (Dekle and Vandenbroucke (2006))

Still way higher than in other "miracles" and rural population still the majority.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>16,0</td>
<td>17,4</td>
<td>19,6</td>
<td>27,4</td>
<td>35,8</td>
<td>43,1</td>
</tr>
<tr>
<td>Japan</td>
<td>43,1</td>
<td>53,2</td>
<td>59,6</td>
<td>63,1</td>
<td>65,2</td>
<td>66,5</td>
</tr>
<tr>
<td>Korea Rep.</td>
<td>27,7</td>
<td>40,7</td>
<td>56,7</td>
<td>73,8</td>
<td>79,6</td>
<td>81,5</td>
</tr>
<tr>
<td>United States</td>
<td>70,0</td>
<td>73,6</td>
<td>73,7</td>
<td>75,3</td>
<td>79,1</td>
<td>81,7</td>
</tr>
<tr>
<td>Brazil</td>
<td>44,9</td>
<td>55,8</td>
<td>67,4</td>
<td>64,8</td>
<td>81,2</td>
<td>85,6</td>
</tr>
</tbody>
</table>

Source: WDI, 2009
Facts: summary

1. Stagnation until 1980 and then fast ("modern") growth.
2. High productivity growth and high capital accumulation.
3. As opposed to other miracles episodes, return to capital is not falling.
4. Boost in trade coincides with growth period.
5. Structural transformation coincides with the increase of international trade, but still a lot of ground to go.
Model is a two-goods and two-sectors version of the overlapping generation model.

At early stages of development, the technology in the manufacturing sector - that uses capital and labor as factors of production- is very incipient and international trade is not relevant.

Most resources are allocated in the agricultural sector - that uses capital, labor and land - and technological progress in the sector determines output growth.

Given that technological growth is low in the sector, economy is stuck in a "Malthusian trap", with no growth in per capita terms.
The model

- At certain moment there is a structural break in the technological progress in both sectors and, after that, the economy opens to trade.
- Resources are transferred from the low productivity agricultural sector to high productivity manufacturing sector.
- This trigger economic ("modern") growth.
The model

- This reallocation of factors will be very slow or bounded if the economy is not open to international trade, since income growth would have caused a disequilibrium in the market of agricultural goods, raising its relative price.
- However, trade will allow the economy to balance the agricultural market through importation.
- Relative prices are now set in the international market.
The model: Technology

- Agricultural sector

\[ Y_A = \gamma_{t-t_0}^{\phi} K_{At}^\mu N_{At}^{1-\phi-\mu} \]

- Manufacturing (non-agriculture) sector

\[ Y_M = \gamma_{t-t_0}^{\theta} K_{Mt}^\theta N_{Mt}^{1-\theta} \]

where \( L \) is the fixed supply of land

- firm’s problem in agriculture:

\[ \text{Maximize } Y_{At} - r_{Kt} K_{At} - w_t N_{At} - r_{Lt} L_t \]

- firm’s problem in manufacture:

\[ \text{Maximize } P_t Y_{Mt} - r_{Kt} K_{Mt} - w_t N_{Mt} \]
The model: Preferences

- An agent of generation $t$ chooses consumptions $(c^y_{At}, c^y_{Mt})$ when she is young and $(c^o_{At+t}, c^o_{Mt+1})$ when she is old and investment $k_{t+1}$ and $l_{t+1}$ in order to maximize:

$$\alpha \ln(c^y_{At} - \underline{c}) + (1 - \alpha) \ln c^y_{Mt} + \beta [\alpha \ln c^o_{At+1} + (1 - \alpha) \ln c^o_{Mt+1}]$$

subject to:

$$c^y_{At} + P_t c^y_{Mt} + k_{t+1} + q_t l_{t+1} = w_t$$

$$c^o_{At+1} + P_{t+1} c^o_{Mt+1} = r_{Kt+1} k_{t+1} + (r_{Lt+1} + q_{t+1}) l_{t+1}$$

where $\underline{c}$ is a minimum level of consumption for the good $A$. 

Ferreira () China and Trade 26 / 43
Equilibrium

- The Chinese development is interpreted as a transition from a closed Malthus economy (where per capita income is stagnant) to a small open economy with sustained growth.
- In the Malthus/closed economy, market-clearing conditions have to be satisfied at every period.
- In the open economy model, prices are set in the international market.
Equilibrium: closed economy

Given $K_t$, $N_t$, $L$, the price of land $q_{t-1}$ and the population growth rate of $\frac{1}{\gamma - \phi - \mu}$, an equilibrium trajectory for the Malthus economy is given by a set of input allocations $(K_{A_t}^*, N_{A_t}^*) = (K_A^*, N_A^*)$ such that $\forall t < t_0$:

i) Factors are allocated optimally:

$$\frac{\mu}{(1 - \theta)} \frac{K_{A_t}}{N_{A_t}} = \frac{\phi}{\theta} \frac{(K_t - K_{A_t})}{(N_t - N_{A_t})}$$

where we are using $K_M = K - K_A$ and $N_M = N - N_A$.

ii) The market-clearing conditions are satisfied:

$$K_{t+1} = N_t k_{t+1} = N_t \frac{\beta}{1 + \beta} [w_t(K_A^*, N_A^*) - c] - q_t$$

where $N_t l_{t+1} = 1$. 
Equilibrium: closed economy

(ii) The market-clearing conditions are satisfied (cont.):

\[ N_t c_{At}^y(K_A^*, N_A^*) + N_{t-1} c_{At}^o(K_A^*, N_A^*) + N_t k_{t+1} = Y_{At} \]

\[ N_t c_{Mt}^y(K_A^*, N_A^*) + N_{t-1} c_{Mt}^o(K_A^*, N_A^*) = Y_{Mt} \]

(iii) The price of land is given by:

\[ q_t = r_{Kt}(K_A^*, N_A^*)q_{t-1} - r_{Lt}(K_A^*, N_A^*) \]

(iv) Relative price is given by:

\[ P_t(K_{At}, N_{At}) = \frac{\mu \gamma_t^t K_A^\phi N_{At}^{\mu-1}}{(1 - \theta) \gamma_M^t (K_t - K_{At})^\theta (N_t - N_{At})^{-\theta}} \]
Given $K_{t_0}, N_{t_0}, L$, the price of land $q_{t_0-1}$ and the international price $\bar{P}$, an equilibrium trajectory for the dynamic economy is given by a set of input allocations $(K_{At}^*, N_{At}^*)$ such that $\forall t \geq t_0$:

\( i) \ (K_{At}^*, N_{At}^*) \) is a solution of the following maximization problem:

\[
\begin{align*}
\max_{K_{At}, N_{At}} & \quad \gamma_t^A K_{At}^\phi N_{At}^\mu + P_t \gamma_M^t (K_t - K_{At})^\theta (N_t - N_{At})^{1-\theta} \\
\text{subject to:} & \quad \frac{\mu}{(1-\theta)} \frac{K_{At}}{N_{At}} = \frac{\phi (K_t - K_{At})}{\theta (N_t - N_{At})}
\end{align*}
\]  

(1)
ii) The aggregate capital and the price of land are given by the following law of motions:

\[
K_{t+1} = N_t k_{t+1} = N_t \frac{\beta}{1 + \beta} \left[ w_t(K^*_A, N^*_A) - c \right] - q_t
\]

\[
q_t = r_K(K^*_A, N^*_A) q_{t-1} - r_L(K^*_A, N^*_A)
\]
Results

- The model is calibrated to China before and after modern growth.
- By construction the country is stagnant until 1980.
- After 1980 we increase TFP growth in agriculture and manufacture.
- After 1985 we open the economy to trade.
- We also run contrafactual simulations in which China never opens to trade, everything else the same.
Results: structural transformation

Labor's share in the agricultural sector

- Model - closed Economy
- Model with international trade
- Data

Periods:

Values:
- 0.30
- 0.35
- 0.40
- 0.45
- 0.50
- 0.55
- 0.60
- 0.65
- 0.70
Results: growth acceleration

Output per capita - Model simulations

- Model without Trade
- Model with Trade
- Data
Results: growth acceleration

Aggregate Growth Rate (%) - Model Simulations

Periods

Closed Economy
Allowing International Trade

Ferreira ()
China and Trade
The model is able to replicate structural transformation observed in China, reproducing the reallocation of labor from the agricultural sector to the non-agriculture sector;

Simulations match very closely the increase in output per capita and the transition from stagnation to modern growth.

In the closed-economy model the reduction of the labor share in agriculture is too slow as compared to data and to the open-economy model.

Without trade the model estimates that output per capita would be less than one third of the observed, even increasing TFP growth.
Results: Investment Rate

Investment-Output Ratio

<table>
<thead>
<tr>
<th>Periods</th>
<th>Model with Trade</th>
<th>Model without Trade</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980-84</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-89</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990-94</td>
<td>0.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995-99</td>
<td>0.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000-04</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005-09</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Aggregate Investment - Model Simulations

- Closed economy
- Closed econ. and higher TFP agriculture growth
- Allowing international trade

Periods:
- 1975-79
- 1980-84
- 1985-89
- 1990-94
- 1995-99
- 2000-04
Results: relative prices

Relative Price of Agriculture

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ferreira ()

China and Trade
The model also replicates the increase of capital formation and the increase in investment ratio.

The model is able to match the fall of the relative price of agricultural goods observed in China in the period.

Model overestimates international trade:
- exports and imports simulated are 47% of GDP in the steady state.
- from 2005 to 2007 exports were 39% of GDP and imports 31%.
Results: return to capital

Return to Nonagricultural Capital

Model with Trade Data

Ferreira ()
China and Trade
Results: shortcomings

- Model underestimates return to capital, although simulated return is not falling;
- Model underestimates slightly growth and overestimates trade;
- Hence, TFP growth and trade gives us a lot, but not all;
- Possible reason: model lacks human capital and public-private firm dimension, which were very important to China development.
Conclusion:

- Institutional and policy changes in China in the last 30 years would not have generated the growth acceleration observed in the country without its aggressive commercial policy.
- However, imports are also a key factor: they allow fast reallocation of resources towards efficient sectors.
- The closed-economy model cannot reproduce the main development trends, because low productivity in the domestic agricultural sector puts a bound on growth. This is true even raising TFP growth in the sector.