The Role of Trade in Structural Transformation

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Introduction

- High agricultural productivity growth is typically considered a necessary condition for the start of industrialization and growth. Schultz (1953); Gollin, Parente, Rogerson (2007).

- Goal of the paper:
  - Can international trade in agricultural good accelerate transition process of countries with low agricultural productivity?
  - What is the quantitative effect of trade on the structural transformation of net agricultural importers?

- Main idea:
  - Under autarky, because of need to feed population:
    - Low agricultural productivity $\Rightarrow$ Large agricultural sector, low aggregate productivity.
  - Under international trade:
    - Low agricultural productivity $\Rightarrow$ Food imports from abroad, faster structural transformation.
Main Contributions

- Related literature:
  - Structural transformation in an open economy: Matsuyama (1992, 2009); Stokey (2001); Yi and Zhang (2010).

- Main contributions of this paper:
  - Introduce trade into two-sector neo-classical growth model.
  - Show model is able to replicate structural transformation data:
  - Quantitatively evaluate role of trade in the transformation of:
    - United Kingdom,
    - South Korea.
Outline of the presentation

1. Introduction
2. Structural transformation model
3. Model simulation, numerical results
4. Implications for low-development countries
5. Conclusion
Motivation: income and agriculture size

- Structural transformation is a key element of the development process: poor countries have much larger agricultural sectors than rich ones.
Evidence for US, UK, S. Korea

- Transformation experienced at very different points in time:
  - United States: Transition during 19th and 20th century.
  - United Kingdom: Transition earlier than in the US.
  - South Korea: Transition 2nd half 20th century, much faster.
Evidence for US, UK, S. Korea

- Controlling for income, size agricultural sector similar in US and Korea; much smaller in UK.

[Graph showing the relationship between log GDP per capita and agricultural employment share for different years in US, UK, and S. Korea.]
Main Results: United Kingdom

- Trade very important for United Kingdom’s early transformation:
  - In 1800, 80% empl in agr under autarky instead of 35% under trade.

- Trade had very large effects on income growth and welfare:
  - Gain in welfare equivalent to 5.5% increase in consumption exp.
Main Results: South Korea

- In South Korea, positive but smaller effects of trade in transformation.
  - Initial agricultural employment 70% instead of 63%.

- If no agr protection, faster transition and larger effects of trade:
  - Agricultural employment below 10% in 1979 instead of 2002.
  - Gain in welfare equivalent to 5.4% increase in consumption exp.
Model Description

- **Two Sectors:**
  - Agricultural good (consumption).
  - Nonagricultural good (consumption and investment).

- **Production functions:**
  - Agricultural sector inputs: land (fixed), capital, labor.
  - Nonagricultural sector inputs: capital, labor.
  - Exogenous technology growth; different rates across sectors.

- **Preferences:**
  - Low income elasticity agricultural good.
  - Low price elasticity agricultural good.

- **Environment:**
  - Perfect competition.
  - Perfect input mobility.
Technology Description

- Production functions:
  - Nonagricultural sector:
    \[ Y_n = A_n (K_n)^\alpha (N_n)^{1-\alpha} \]
  - Agricultural sector:
    \[ Y_a = A_a (K_a)^\eta (N_a)^\beta (L)^{1-\eta-\beta} \]
  - Exogenous technological change:
    \[ \frac{\dot{A}_n}{A_n} \equiv \gamma_n, \quad \frac{\dot{A}_a}{A_a} \equiv \gamma_a \]
- Capital accumulation:
  \[ \dot{K} = (Y_n - C_n) - \delta K \]
Preferences Description

- Preferences:

\[ U(t) = \int_t^\infty e^{-\rho s} N(s) u(c_a, c_n) \, ds \]

\[ u(c_a, c_n) = \log(c_n) + \begin{cases} 
\mu_0 \log\left(\frac{c_a - c_a}{c_n}\right) & \text{if } c_a \leq c_a^* \\
B + \mu_1 \log\left(\frac{c_a - c_a^* - A}{c_n}\right) & \text{if } c_a > c_a^* 
\end{cases} \]

\[ A = \frac{\mu_1}{\mu_0} \left(c_a^* - c_a\right) \] to get differentiability at \( c_a^* \).

\[ B = \mu_0 \log\left(c_a^* - c_a\right) - \mu_1 \log\left(\frac{\mu_1}{\mu_0} \left(c_a^* - c_a\right)\right) \] to get continuity at \( c_a^* \).

Utility at different levels of agricultural consumption

Agricultural good expenditure share

ParameterValues:

- \( c_a = 100 \)
- \( c_a^* = 150 \)
Main mechanisms

- Agents optimization:
  - Firms choose capital, labor, and land demand to maximize profits.
  - Households choose savings, consumption, allocation of labor and capital to maximize intertemporal welfare.

- Market clearing:
  - Under autarky, domestic supply = domestic demand.
  - Under trade, imports = exports (labor, capital not mobile).

- Main mechanisms leading to structural transformation:
  - Technological change + capital accumulation $\Rightarrow$ income $\uparrow \Rightarrow$ agricultural consumption share $\downarrow$.
  - Structural transformation in a closed economy:
    - Agricultural consumption share $\downarrow \Rightarrow$ agricultural employment share $\downarrow$.
  - Structural transformation in an open economy:
    - If international price agricultural good $<$ domestic price, trade $\Rightarrow$ agricultural imports $\uparrow$, agricultural employment $\downarrow$. 
Equilibrium analysis

- If population growth not "too high" relative to TFP growth,

\[ \frac{\eta}{1 - \alpha} \gamma_n + \gamma_a - (1 - \eta - \beta) \nu > 0, \]

the economy behaves asymptotically as if homothetic preferences:

\[ u(c_a, c_n) = \mu_1 \log(c_a) + \log(c_n). \]

- Then, for any initial condition, the economy converges asymptotically to the homothetic preferences Balanced Growth Path.

- **Closed economy BGP:**
  - Positive and constant employment shares in both sectors.
  - Constant (not necessarily equal) growth rates of all other variables.

- **Small open economy:**
  - Specialization in agriculture if agricultural price "high enough".
  - BGP growth rates depend on sectoral composition:
    - If growth rate agricultural price "high enough", agricultural specialization.
    - If not, non-agricultural specialization.
Simulations

1. Parameter values specified.

2. Exogenous variables specified:
   - United States: $A_a, A_n, N$.
   - United Kingdom: $A_a, A_n, N, p_a/p_n$.
   - South Korea: $A_a, A_n, N, p_a/p_n, t_a, \sigma_a$.

3. Initial capital stock taken from the data.

4. Simulation results compared with the data.
   - United Kingdom: 1800 - 1900.

5. Counterfactual experiments:
   - United States: different initial productivity.
   - United Kingdom: autarky.
   - South Korea: autarky, free trade (no agricultural policy).
## Parameter Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$ Capital share nonagr sector</td>
<td>1/3</td>
<td>standard</td>
</tr>
<tr>
<td>$\eta$ Capital share agr sector</td>
<td>0.1</td>
<td>Korea Development Institute</td>
</tr>
<tr>
<td>$\beta$ Labor share agr sector</td>
<td>0.5</td>
<td>Korea Development Institute</td>
</tr>
<tr>
<td>$\delta$ Capital depreciation rate</td>
<td>0.10</td>
<td>Christensen, Jorgenson (1995)</td>
</tr>
<tr>
<td>$\rho$ Intertemporal discount</td>
<td>0.06</td>
<td>To match SS capital US</td>
</tr>
<tr>
<td>$\mu_0$ Agr good initial weight</td>
<td>0.5</td>
<td>To match Korea cons data</td>
</tr>
<tr>
<td>$\mu_1$ Agr good weight</td>
<td>0.01</td>
<td>To match SS agr empl US</td>
</tr>
<tr>
<td>$c_a^* / c_a$ Agr cons threshold</td>
<td>1.5</td>
<td>To match Korea cons data</td>
</tr>
<tr>
<td>$c_a$ Agr subsistence level</td>
<td>60%</td>
<td>To match US cons data</td>
</tr>
<tr>
<td>(as % initial agr cons)</td>
<td>85%</td>
<td>To match Korea cons data</td>
</tr>
<tr>
<td></td>
<td>91%</td>
<td>To match UK cons data</td>
</tr>
</tbody>
</table>
United States Baseline Simulation

Fraction of Employment in Agricultural Sector

- Model
- Kendrick Data
- NIPA data

Exogenous Variables
United States Simulations: changes in initial TFP

Initial Agricultural Productivity

- $A_a(0)=100$ (Baseline)
- $A_a(0)=50$

Initial Nonagricultural Productivity

- $A_n(0)=100$ (Baseline)
- $A_n(0)=50$
United Kingdom Baseline Simulation

Exogenous Variables
Policy experiment: Autarky

Relative price agricultural good

Agricultural Sector Employment Share

Agricultural Good Consumption

Nonagricultural Good Consumption (in logs)

Results Summary
South Korea Baseline Simulation

Agricultural consumption per capita

Agricultural production per capita

Nonagricultural production per capita (in logs)

Aggregate capital stock (in logs)
Policy experiment 1: Autarky

Relative price agricultural good

Agricultural Sector Employment Share

Agricultural Good Consumption

Nonagricultural Good Consumption (in logs)
Policy experiment 2: No Agricultural Policy

Agricultural Good Imports

Agricultural Sector Employment Share

Agricultural Good Consumption

Nonagricultural Good Consumption (in logs)

Results Summary
Results Summary

- **Real income growth:**

<table>
<thead>
<tr>
<th>Country</th>
<th>Autarky</th>
<th>Baseline</th>
<th>No agr policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>1.28%</td>
<td>1.44%</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>4.5%</td>
<td>4.71%</td>
<td>5.47%</td>
</tr>
</tbody>
</table>

- **Intertemporal Welfare gain with respect to Autarky:**
  (in terms of annual consumption expenditures)

<table>
<thead>
<tr>
<th>Country</th>
<th>Baseline</th>
<th>No agr policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>5.5%</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>0.4%</td>
<td>5.4%</td>
</tr>
</tbody>
</table>
International evidence. Agricultural and non-agricultural productivity

- Poor countries are particularly unproductive in agriculture:

![Graph showing the ratio of non-agricultural and agricultural output per worker to US output for various countries.](image-url)
International evidence. Agricultural relative price

- The relative price of agricultural goods is higher in poor countries:

![Graph showing the relative price of agricultural goods across different countries, with a 2D scatter plot.]
Implications for Low-Development Countries

- There seem to be important potential benefits from agricultural imports for many poor countries:

<table>
<thead>
<tr>
<th>Year: 1985</th>
<th>Ratio 10th - 90th percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Employment Share</td>
<td>0.85/0.05</td>
</tr>
<tr>
<td>Aggregate labor productivity</td>
<td>1/30</td>
</tr>
<tr>
<td>Agriculture labor productivity</td>
<td>1/50</td>
</tr>
<tr>
<td>Relative price agricultural good</td>
<td>2</td>
</tr>
</tbody>
</table>

- Agricultural trade flows very low in poor countries, but they are more food importers than rich countries. (World Bank, year 2004-05)

<table>
<thead>
<tr>
<th></th>
<th>Net Food Exporters</th>
<th>Net food Importers</th>
<th># Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial</td>
<td>39%</td>
<td>61%</td>
<td>33</td>
</tr>
<tr>
<td>Middle-income</td>
<td>34%</td>
<td>66%</td>
<td>105</td>
</tr>
<tr>
<td>Low income</td>
<td>28%</td>
<td>72%</td>
<td>58</td>
</tr>
</tbody>
</table>
Conclusion

- Results summary:
  - Large effects of trade in United Kingdom.
  - Positive but smaller effects of trade in South Korea.
  - Trade effects in South Korea much larger if no agriculture protection.

- Policy implications:
  Important welfare gains from eliminating agricultural protection policies.

- Future extensions:
  - Robustness analysis (functional forms, parameter values).
  - Study potential benefits of agricultural trade for low-development countries.
  - Examine relation land quality and income for closed and open economies.
APPENDIX
Appendix. Related Literature

Why countries experience structural transformation:

- Differences in goods’ income elasticities: Kongsamut et al. (2001).

Structural Transformation in a Closed Economy:


Structural Transformation in an Open Economy:

Matsuyama (1992, 2009); Stokey (2001); Echevarria (2007); Stefanski (2010); Ungor (2010); Deardorf, Park (2010); Yi and Zhang (2010); Betts and Verma (2011); Choi and Ma (2011); Tombe (2011).

Agricultural vs Nonagricultural productivity:

Caselli (2005); Cordoba and Ripoll (2006); Vollrath (2008); Lagakos and Waugh (2009).

East Asian countries growth episodes:

Young (1992, 1995); Hsieh (2002); Connolly and Yi (2009).
Appendix. Empirical evidence

- Structural transformation experienced by countries at different points in time.
Appendix. Empirical evidence

- Structural transformation process closely related to income growth.
Appendix. Empirical evidence

Also, at a given point in time, negative relation between income and size agriculture across countries:
Appendix. Empirical evidence

- Relationship between income and agricultural sector size less strong for open economies:

![Graph showing the relationship between agricultural employment share and log GDP per capita for 25% least and most open economies.](image)

- R-squared for 25% least open economies = 0.7
- R-squared for 25% most open economies = 0.45
Appendix. Empirical evidence

- Poor countries more likely to be food exporters than rich ones (World Bank, year 2004-05):

<table>
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</table>

Food net exports over total income (1995-2005) vs. Log GDP per capita - year 2000
Appendix. Closed Economy Equilibrium

Households’ optimization:

$$\max \{c_s, n_s, k_s, \} \int_0^\infty e^{-(\rho - \nu)t} u(c_a, c_n) dt$$

s.t.

$$\dot{k} = w + p_l L e^{-\nu t} + (r - \delta - \nu) k - q c_a - c_n$$

Firms’ optimization:

$$\max_{k_a, n_a} \left\{ q A_a (k_a) ^{\eta} (n_a) ^{\beta} (L e^{-\nu t})^{1-\eta-\beta} - r k_a - w n_a - p_l L e^{-\nu t} \right\}$$
Appendix. Closed economy equilibrium conditions

- Consumers’ optimization conditions:

\[ \dot{c}_n = c_n (r - \delta - \rho) \]

\[ c_a = \begin{cases} 
\frac{c_a + \mu_0 \frac{c_n}{q}}{c^*_a - A + \mu_1 \frac{c_n}{q}} & \text{if } c_a + \mu_0 \frac{c_n}{q} \leq c^*_a \\
\frac{c^*_a}{c^*_a} & \text{else}
\end{cases} \]

- Firms’ optimization conditions:

\[ r(t) = q \eta A_a (k_a)^{\eta-1} (n_a)^{\beta} (Le^{-\nu t})^{1-\eta-\beta} = \alpha A_n (k_n)^{\alpha-1} (n_n)^{1-\alpha} \]

\[ w(t) = q \beta A_a (k_a)^{\eta} (n_a)^{\beta-1} (Le^{-\nu t})^{1-\eta-\beta} = (1 - \alpha) A_n (k_n)^{\alpha} (n_n)^{-\alpha} \]

- Market clearing:

\[ y_a = c_a, \quad y_n = \dot{k} + (\delta + \nu) k + c_n \]

\[ k_a + k_n = k, \quad n_a + n_n = 1 \]
Appendix. Closed Economy Equilibrium

\[ u(c_a, c_n) = \mu_1 \log(c_a) + \log(c_n) \]  \hspace{1cm} (1)

\[ u(c_a, c_n) = \log(c_n) + \begin{cases} 
\mu_0 \log(c_a - c_a) & \text{if } c_a \leq c_a^* \\
B + \mu_1 \log(c_a - c_a^* - A) & \text{if } c_a > c_a^*
\end{cases} \]  \hspace{1cm} (2)

- If preferences as in equation (1), economy converges asymptotically to BGP.

- If preferences as in equation (2), equilibrium system converges to the equilibrium system for preferences (1), as long as

\[ \frac{\eta}{1 - \alpha} \gamma_n + \gamma_a - (1 - \eta - \beta) \nu > 0 \]  \hspace{1cm} (3)

- For any initial condition, economy converges asymptotically to BGP of preferences (1).
Appendix. Closed economy BGP growth rates

\[ \lim_{t \to \infty} \left\{ \frac{s_e'(t)}{s_e(t)} \right\} = 0, \quad \text{where } s_e \equiv \frac{Na}{N} \]

\[ \lim_{t \to \infty} \left\{ \frac{s_k'(t)}{s_k(t)} \right\} = 0, \quad \text{where } s_k \equiv \frac{Ka}{K} \]

\[ \lim_{t \to \infty} \left\{ \frac{k(t)}{k(t)} \right\} = \lim_{t \to \infty} \left\{ \frac{c_n'(t)}{c_n(t)} \right\} = \frac{1}{1 - \alpha} \gamma_n \]

\[ \lim_{t \to \infty} \left\{ \frac{q(t)}{q(t)} \right\} = \frac{1 - \eta}{1 - \alpha} \gamma_n + (1 - \eta - \beta) \nu - \gamma_a \]

\[ \lim_{t \to \infty} \left\{ \frac{c_a'(t)}{c_a(t)} \right\} = \gamma_a + \frac{\eta}{1 - \alpha} \gamma_n - (1 - \eta - \beta) \nu \]
Appendix. Autarky equilibrium analysis

- Structural transformation under autarky:
  - Evolution of fraction of employment in agricultural sector:

\[
\frac{n_a}{1-n_a} = \mu \frac{\beta}{1-\alpha} \frac{\frac{c_n}{y_n}}{1 - \frac{c_a-A}{c_a}}
\]

- If \(\frac{c_n}{y_n}\) constant, as \(c_a\) increases

\[
\frac{c_a-A}{c_a} \downarrow \Rightarrow s_e \downarrow
\]

- Evolution of agricultural good relative price:

\[
q = \Phi \frac{A_n}{A_a} (Le^{-vt})^{\eta+\beta-1} k^{\alpha-\eta} \left(\frac{n_a}{1-\eta} - \frac{\eta}{\beta} \frac{n_a}{\left(\frac{\beta}{\eta} - n_a \left(\frac{\beta}{\eta} - \frac{1-\alpha}{\alpha}\right)\right)}\right)^{\alpha-\eta}
\]

- Structural transformation has negative effect on agricultural price:

\(n_a \downarrow \Rightarrow q \downarrow\)

- Other variables also affect agricultural price:

\[
\frac{A_n}{A_a} \uparrow \Rightarrow q \uparrow, \; k \uparrow \Rightarrow q \uparrow, \; Le^{-vt} \downarrow \Rightarrow q \uparrow
\]
Appendix. Open Economy Equilibrium

- **Market clearing conditions:**

\[
\begin{align*}
y_a &= c_a + x_a \\
y_n &= \dot{k} + (\delta + \nu)k + c_n + x_n \\
k_a + k_n &= k \\
na + nn &= 1
\end{align*}
\]

- **Balanced trade:**

\[
qx_a + x_n = 0 \quad \forall t
\]

- **Small open economy:**

\[
q \text{ exogenous, with } \frac{\dot{q}}{q} \equiv \gamma_q
\]
Appendix. Open Economy Equilibrium

- Specialization in the short run:
  - If \( q(t) \) is ”high enough”, specialization in agricultural good:

\[
q > \lim_{s_e \to 1, s_k \to 1} \left\{ \frac{\alpha A_n ((1 - s_k) k)^{\alpha-1} ((1 - s_e))^{1-\alpha}}{\eta A_a (s_k k)^{\eta-1} (s_e)^{\beta} N^{\eta+\beta-1}} \right\}
\]

\[
= \Theta \frac{A_n}{A_a} N^{1-\eta-\beta} k^{\alpha-\eta}
\]

- Specialization in nonagricultural good not possible in the short run:

\[
q \not\approx \lim_{s_e \to 0, s_k \to 0} \left\{ \frac{\alpha A_n ((1 - s_k) k)^{\alpha-1} ((1 - s_e))^{1-\alpha}}{\eta A_a (s_k k)^{\eta-1} (s_e)^{\beta} N^{\eta+\beta-1}} \right\}
\]

\[
= \Psi \frac{A_n}{A_a} N^{1-\eta-\beta} k^{\alpha-\eta} \left( \lim_{s_e \to 0} s_e^{1-\eta-\beta} \right)
\]
Appendix. Open Economy Equilibrium

- As before, if condition (3) is satisfied, convergence to BGP of (1).

- Specialization in the long run:
  
  - If $\gamma_q = (1 - \eta - \beta) \nu + \frac{1-\eta}{1-\alpha} \gamma_n - \gamma_a$, no specialization.

  - If $\gamma_q < (1 - \eta - \beta) \nu + \frac{1-\eta}{1-\alpha} \gamma_n - \gamma_a$

    \[
    \lim_{t \to \infty} \left\{ n_a(t) \right\} = \lim_{t \to \infty} \left\{ \frac{k_a(t)}{k(t)} \right\} = 0
    \]

  - If $\gamma_q > (1 - \eta - \beta) \nu + \frac{1-\eta}{1-\alpha} \gamma_n - \gamma_a$

    \[
    \lim_{t \to \infty} \left\{ n_a(t) \right\} = \lim_{t \to \infty} \left\{ \frac{k_a(t)}{k(t)} \right\} = 1
    \]
Appendix. Open economy BGP growth rates

- If $\gamma_q \leq (1 - \eta - \beta) \nu + (1 - \eta) \gamma_n - \beta \gamma_a$ (and $q$ not ”too high”):

$$
\lim_{t \to \infty} \left\{ \frac{\dot{k}(t)}{k(t)} \right\} = \lim_{t \to \infty} \left\{ \frac{\dot{c}_n(t)}{c_n(t)} \right\} = \frac{1}{1 - \alpha} \gamma_n
$$

$$
\lim_{t \to \infty} \left\{ \frac{\dot{c}_a(t)}{c_a(t)} \right\} = \frac{1}{1 - \alpha} \gamma_n - \gamma_q
$$

- If $\gamma_q > (1 - \eta - \beta) \nu + (1 - \eta) \gamma_n - \beta \gamma_a$ (or $q$ ”high enough”):

$$
\lim_{t \to \infty} \left\{ \frac{\dot{k}(t)}{k(t)} \right\} = \lim_{t \to \infty} \left\{ \frac{\dot{c}_n(t)}{c_n(t)} \right\} = \frac{1}{1 - \eta} \gamma_a + \frac{1}{1 - \eta} \gamma_q - \frac{1 - \eta - \beta}{1 - \eta} \nu
$$

$$
\lim_{t \to \infty} \left\{ \frac{\dot{c}_a(t)}{c_a(t)} \right\} = \frac{1}{1 - \eta} \gamma_a + \frac{\eta}{1 - \eta} \gamma_q - \frac{1 - \eta - \beta}{1 - \eta} \nu
$$
Comparison subsistence levels

- If good \( a \) is tradable and country \( i \) imports it from country \( j \), then

\[
E(t) P^i_a(t) = P^j_a(t) (1 + \tau^i_a(t)) (1 + d^i_a(t))
\]

where \( E \) is the exchange rate, \( \tau \) the import tariff, and \( d \) the transport cost.

- Using this, possible to compare \( c_a \) for the three countries:
  
  **Comparison United States, South Korea:**

\[
\frac{P^{us}_a(1990) c^{sk}_a}{P^{us}_a(1990) c^{us}_a} = \frac{E(1990) P^{us}_a(1990)}{(1 + \tau^{sk}_a(1990))(1 + d^{sk}_a(1990)) c^{sk}_a} = \frac{1.47}{(1 + d^{sk}_a(1990))}
\]

⇒ If transportation cost equal to 47%, then the two subsistence levels are equivalent.

**Comparison United States, United Kingdom:**

\[
\frac{P^{us}_a(1900) c^{uk}_a}{P^{us}_a(1900) c^{us}_a} = \frac{E(1900) P^{us}_a(1900)}{(1 + \tau^{uk}_a(1900))(1 + d^{uk}_a(1900)) c^{sk}_a} = \frac{0.52}{(1 + d^{uk}_a(1900))}
\]

⇒ Even if no import tariffs and no transportation costs, value subsistence level in UK lower than in US!
## Appendix. United States Exogenous Variables

<table>
<thead>
<tr>
<th>Description</th>
<th>Sample period growth</th>
<th>Future growth</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\nu$ Population growth</td>
<td>Smoothed data (0.018 - 0.009)</td>
<td>0.01</td>
<td>Kendrick (1961) NIPA</td>
</tr>
<tr>
<td>$\gamma_a$ Agr TFP growth</td>
<td>Smoothed data (0.005 - 0.06)</td>
<td>0.06</td>
<td>Kendrick (1961) NIPA</td>
</tr>
<tr>
<td>$\gamma_n$ Nona TFP growth</td>
<td>Smoothed data (0.002 - 0.015)</td>
<td>0.015</td>
<td>Kendrick (1961) NIPA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Value</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K (0)$ Initial capital stock</td>
<td>$\frac{K}{Y_n} = 2.03$ in 1890</td>
<td>Kendrick (1961)</td>
</tr>
</tbody>
</table>
Appendix. United States Data

US Net Agricultural Exports over Agricultural Production
Appendix. South Korea Data

Why study South Korea?

<table>
<thead>
<tr>
<th>Year</th>
<th>Agr emp %</th>
<th>GDP capita (Korea / US) %</th>
<th>Openess (X+M)/GDP</th>
<th>Agr imports (over Agr GDP) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955</td>
<td>80 (approx)</td>
<td>11.3</td>
<td>11.6%</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>58.5</td>
<td>11.1</td>
<td>24.22%</td>
<td>7.8</td>
</tr>
<tr>
<td>1975</td>
<td>45.7</td>
<td>17.9</td>
<td>62%</td>
<td>19.6</td>
</tr>
<tr>
<td>1985</td>
<td>24.9</td>
<td>25.2</td>
<td>64.4%</td>
<td>17.2</td>
</tr>
<tr>
<td>1995</td>
<td>11.8</td>
<td>45.4</td>
<td>58.7%</td>
<td>18.5</td>
</tr>
<tr>
<td>2004</td>
<td>8.1</td>
<td>51</td>
<td>84%</td>
<td>24.1</td>
</tr>
</tbody>
</table>
Appendix. South Korea exogenous variables

- **Agricultural policy variables:**
  - Import tariff (iceberg-cost type): $t_a$
  - Production subsidy: $\sigma_a$
  - Lump-sum tax to households: $\tau$
  - Balanced government budget constraint: $\sigma_a q y_a = \tau$

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_a$</td>
<td>Agr prod subsidy</td>
<td>0 (1963 - 1972)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10% (1973 - 2007)</td>
</tr>
<tr>
<td>$t_a$</td>
<td>Agr import tariff</td>
<td>USDA (1990: 104%)</td>
</tr>
</tbody>
</table>
## Appendix. South Korea exogenous variables

<table>
<thead>
<tr>
<th>Description</th>
<th>Sample period growth</th>
<th>Future growth</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \nu ) Population growth</td>
<td>Smoothened data ((0.025, 0.005))</td>
<td>0.005</td>
<td>Bank of Korea</td>
</tr>
<tr>
<td>( \gamma_q ) Rel agr price growth</td>
<td>( \frac{P_a Y_a}{Y_a} / \frac{P_n Y_n}{Y_n} ) smoothed ((-0.012, 0.023))</td>
<td>-0.0216</td>
<td>Bank of Korea</td>
</tr>
<tr>
<td>( \gamma_a ) Agr TFP growth</td>
<td>0.032</td>
<td>0.032</td>
<td>To match ( n_a )</td>
</tr>
<tr>
<td>( \gamma_n ) Nonagr TFP growth</td>
<td>0.021</td>
<td>0.021</td>
<td>To match ( n_a )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( K (0) ) Initial capital stock</td>
<td>( \frac{K}{Y_n} = 2.87 ) in 1963</td>
<td>Korea Development Institute</td>
</tr>
</tbody>
</table>
Appendix. South Korea exogenous variables

Relative price agricultural good

Agricultural Sector TFP

Nonagricultural Sector TFP
Appendix. South Korea Data

Exports minus Imports over GDP


-0.2
-0.15
-0.1
-0.05
0
0.05
0.1
0.15

Exports minus Imports over GDP
## Appendix. South Korea Policy experiments results

- Sample period results (1963-2007):

<table>
<thead>
<tr>
<th>% Avg. change (w.r.t. Baseline)</th>
<th>$q$</th>
<th>$n_a$</th>
<th>$c_n$</th>
<th>$c_a$</th>
<th>$k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autarky</td>
<td>16.5</td>
<td>21</td>
<td>0.3</td>
<td>-1.1</td>
<td>-3.5</td>
</tr>
<tr>
<td>No subsidy</td>
<td>0</td>
<td>-17</td>
<td>0.65</td>
<td>0.04</td>
<td>2.8</td>
</tr>
<tr>
<td>No subs</td>
<td>-42</td>
<td>-73</td>
<td>10.9</td>
<td>5.5</td>
<td>12.1</td>
</tr>
</tbody>
</table>

- Real income growth:

<table>
<thead>
<tr>
<th></th>
<th>Autarky</th>
<th>Baseline</th>
<th>No subsidy</th>
<th>No ag policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real income</td>
<td>4.5%</td>
<td>4.71%</td>
<td>4.72%</td>
<td>5.47%</td>
</tr>
</tbody>
</table>

- Intertemporal Welfare gain with respect to Autarky:
  (in terms of annual consumption expenditures)

<table>
<thead>
<tr>
<th></th>
<th>Autarky</th>
<th>Baseline</th>
<th>No subsidy</th>
<th>No ag policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welfare gain</td>
<td>0</td>
<td>0.4%</td>
<td>0.45%</td>
<td>5.4%</td>
</tr>
</tbody>
</table>
### Appendix. United Kingdom Exogenous Variables

<table>
<thead>
<tr>
<th>Description</th>
<th>Sample period growth</th>
<th>Future growth</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population growth</td>
<td>Smoothed data (0.016, 0.08)</td>
<td>0.01</td>
<td>Mitchell (1962) Maddison (2003)</td>
</tr>
<tr>
<td>Rel agr price growth</td>
<td>Smoothed data (-0.0043)</td>
<td>-0.0043</td>
<td>Mitchell (1962) Deane,Cole (1969)</td>
</tr>
<tr>
<td>Agr TFP growth</td>
<td>0.0125</td>
<td>0.0125</td>
<td>To match $n_a$</td>
</tr>
<tr>
<td>Nonagr TFP growth</td>
<td>0.0065</td>
<td>0.0065</td>
<td>To match $n_a$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K$ (0) Initial capital stock</td>
<td>$\frac{K}{Y_n} = 2.52$ in 1800</td>
<td>Feinstein (1988)</td>
</tr>
</tbody>
</table>
Appendix. United Kingdom Exogenous Variables

Agricultural relative price
Simulation Exogenous Variable
Data

Total Population
Simulation Exogenous Variable
Measured Data

Agricultural Sector TFP
Simulation Exogenous Variable
Measured Data

Nonagricultural Sector TFP
Simulation Exogenous Variable
Measured Data
Appendix. United Kingdom Policy experiment results

- Sample period results (1800-1900):

<table>
<thead>
<tr>
<th>% Avg. change (w.r.t. baseline)</th>
<th>q</th>
<th>n_a</th>
<th>c_n</th>
<th>c_a</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autarky</td>
<td>45.8</td>
<td>155.7</td>
<td>-10.5</td>
<td>-5.4</td>
<td>-20.8</td>
</tr>
</tbody>
</table>

- Real Income Growth:

<table>
<thead>
<tr>
<th></th>
<th>Autarky</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real Income Growth:</td>
<td>1.28%</td>
<td>1.44%</td>
</tr>
</tbody>
</table>

- Intertemporal Welfare gain with respect to Autarky: (in terms of consumption expenditures)

<table>
<thead>
<tr>
<th></th>
<th>Autarky</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intertemporal Welfare gain</td>
<td>0</td>
<td>5.5%</td>
</tr>
</tbody>
</table>
Appendix. Alternative preferences simulations

- Household preferences:
  \[
  \int_0^\infty e^{-\rho t} N(t) u(c_a(t), c_n(t)) dt \\
  u(c_a, c_n) = \mu \sigma \frac{(c_a - c_a)^{1-\sigma}}{1 - \sigma} + \log(c_n)
  \]

- Simulation parameter values:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\mu) Agr good weight</td>
<td>47</td>
<td>to match (c_a) data</td>
</tr>
<tr>
<td>(\sigma) Agr subsistence level</td>
<td>7.75</td>
<td>to match (c_a) data</td>
</tr>
<tr>
<td>(c_a) Agr cons threshold</td>
<td>35% agr cons 1963</td>
<td>to match (c_a) data</td>
</tr>
</tbody>
</table>

- Sample period results (1963-2007): comparison S. Korea simulations

<table>
<thead>
<tr>
<th></th>
<th>Growth %</th>
<th>(q) %</th>
<th>(s_e) %</th>
<th>(c_n) %</th>
<th>(c_a) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autarky</td>
<td>6.4</td>
<td>19.8</td>
<td>22.1</td>
<td>-0.1</td>
<td>-1.7</td>
</tr>
<tr>
<td>No subsidy</td>
<td>5.8</td>
<td>0</td>
<td>-21</td>
<td>0.1</td>
<td>0.09</td>
</tr>
<tr>
<td>No subs No tariff</td>
<td>5.5</td>
<td>-44</td>
<td>-76</td>
<td>13.18</td>
<td>7.45</td>
</tr>
</tbody>
</table>
Appendix. Alternative preferences simulations

- Fraction of Employment in Agricultural Sector
- Agricultural consumption per capita
- Agricultural production per capita
- Aggregate capital stock (in logs)