Business Cycles during Structural Change: 
Arthur Lewis’ Theory from a Neoclassical Perspective

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June 1, 2022
US (left) & China (right): GDP vs. Total Employment

(a) USA

(b) China

Real GDP
Total employment
China: Agr-NonAgr Reallocation over the Business Cycle

Agriculture’s share in total employment (%) over the years from 1980 to 2010.
USA: Agr.-Nonagr. Reallocation over the Business Cycle

Agriculture’s share in total employment (%)
Purpose of the Paper

- Unified theory of business cycles and structural transformation

**Structural transformation:**

1. Reallocation of labor away of Agr as capital accumulates
2. Modernization of Agr: As workers leave Agr, labor productivity gap NonAgr-vs-Agr ↓ and labor share in Agr ↓

**Business cycles change during structural change. Poor countries have:**

1. Acyclical and smooth labor supply
2. Strong labor reallocation between Agr and NonAgr
3. Labor productivity in Agr ↑ in booms (also relative to NonAgr)

**Goals:**

1. Propose a theory quantitatively consistent with both structural transformation and business cycles
2. Match China-US (and cross-country) patterns
3. Novel framework to analyze fluctuations during transition
Modernization of Agriculture: KY ratio

(a) Relative K/Y ratio (farm/total)

(b) Relative K/Y ratio (agriculture/total)

Year

Agriculture's share in total employment (%)
Define Productivity Gap as the ratio of the Average Productivity of Labor (APL) in NonAgr vs. Agr

\[
\text{Prod. Gap} \equiv \frac{\text{Value Added per Worker in NonAgr}}{\text{Value Added per Worker in Agr}}
\]
Modernization of Agric.: Productivity Gap

(a) Productivity gap (nonfarm/farm)

(b) Productivity gap (nonagric./agric.)

Agriculture’s share in total employment (%)

Year 1940 1960 1980 2000

Productivity gap (nonfarm/farm)

0.5 1 1.5 2 2.5 3 3.5 4

0 5 10 15 20 25 30

Fitted line
Modernization is accompanied by transformations in the nature of business cycle fluctuations.

Consider HP Filtered or First-Differenced data:

<table>
<thead>
<tr>
<th></th>
<th>Large Agriculture (poor country)</th>
<th>Small Agriculture (rich country)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment-GDP correlation</td>
<td>acyclical</td>
<td>procyclical</td>
</tr>
<tr>
<td>corr(agr. empl.,nonagr empl.)</td>
<td>negative</td>
<td>≈ 0</td>
</tr>
<tr>
<td>Labor productivity gap</td>
<td>countercyclical</td>
<td>acyclical</td>
</tr>
</tbody>
</table>

Figure: X-axis: avg. agr. empl. share. Y-axis: (a) corr. empl.-GDP; (b) corr. nonag-ag employment; (c) cyclicality APL ratio; (d) rel. empl. volatility.
DO WE NEED A NEW THEORY?
Consider a two-sector neoclassical benchmark
Cobb-Douglas production function in each sector

\[ Y^M = Z^M \times \left( K^M \right)^{1-\alpha} \left( L^M \right)^{\alpha} \quad \text{and} \quad Y^G = Z^G \times \left( K^G \right)^{1-\beta} \left( L^G \right)^{\beta} \]

which implies constant factor shares:

\[ \frac{wL^M}{P^M Y^M} = \alpha \quad \text{and} \quad \frac{wL^G}{P^G Y^G} = \beta \]

So, the productivity gap is

\[ \frac{P^M Y^M}{L^M} / \frac{P^G Y^G}{L^G} = \frac{\beta}{\alpha} \]

Counterfactual!

Structural transformation is driven by two forces:
- exogenous differential technical progress,
- endogenous capital deepening.

Extend Acemoglu-Guerreri to incorporate a “rural Lewis sector.”

Agr goods are produced using two different technologies
1. Modern (neoclassical) sector using labor, capital, and land;
2. Traditional sector with no capital.
Literature

- **Structural Changes**

- **Business Cycle**

- **Development**
  - Lewis (1954); Harris and Todaro (1970); Hansen-Prescott (2002); Parente, Rogerson, and Wright (2000); Gollin, Lagakos, and Waugh (2014)
THE MODEL
The final good is produced competitively

It combines Agr and NonAgr goods, with elast. of subst. $\varepsilon$

$$Y = F \left( Y^G, Y^M \right) = \left[ \gamma \left( Y^G \right)^{\varepsilon-1} + (1 - \gamma) \left( Y^M \right)^{\varepsilon-1} \right]^{\frac{\varepsilon}{\varepsilon-1}}.$$

Can be interpreted as a preference aggregator.

Extension: nonhomothetic (Stone Geary) preferences:

- Agr good as “necessity” in consumption.

Study both $\varepsilon > 1$ and $\varepsilon < 1$

- (although estimation suggests $\varepsilon > 1$)
Production Function in NonAgr sector:

\[ Y^M = (K^M)^{1-\alpha} (Z^M N^M)^\alpha \]

Agr is produced in two ways: modern (AM) and traditional (S) technology with an elasticity of substitution \( \omega > 1 \):

\[ Y^G = \left[ (Y^{AM})^{\frac{\omega-1}{\omega}} + (Y^S)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}, \]

where

\[ Y^{AM} = (K^{AM})^{1-\beta} (Z^{AM} N^{AM})^\beta, \]
\[ Y^S = Z^S N^S. \]

- Assume \( \beta > \alpha \) (M more capital intensive than AM)
- Later (estimation): allow land in agriculture
TFP grows at a constant rate in each sector

Only one friction:

- an exogenous time-invariant wedge (a "tax" on nonagr employment) that keeps marginal productivity higher in urban than in rural sector;
- stand-in for a variety of institutional frictions inducing rural overpopulation;
- does not matter for the theory, matters for quantitative results.
The Recursive Competitive Equilibrium is equivalent to the solution to the following distorted social planner’s problem

\[
\max_{K^M, K^{AM}, N^M, N^{AM}, N^S, c} \int_0^\infty e^{-(\rho-n)t} \times \log(c_t) \, dt
\]

subject to the resource constraints

\[
\dot{K}_t = F\left(Y^M_t, Y^G_t\right) - \delta K_t - cN_t - \tau \bar{W}_t N^M_t + Tr_t,
\]

\[
K_t = K^M_t + K^{AM}_t,
\]

\[
N_t = N^M_t + N^{AM}_t + N^S_t,
\]

given exogenous law of motions for TFPs, and initial conditions.

We later augment it with endogenous labor supply and shocks.
Static Equilibrium

- Static efficiency: equate MPL and MPK across sectors.
- Let:

\[ \chi \equiv \frac{K}{L} \text{ (endogenous state variable)} \]
\[ \kappa \equiv \frac{K^M}{K} \text{ (share of capital in Nonagr)} \]
\[ \nu \equiv \frac{(Y^{AM})^{\omega^{-1}}}{(Y^{AM})^{\omega^{-1}} + (Y^{S})^{\omega^{-1}}} \text{ (Agr modernization)} \]

- \( \kappa (\chi, Z) \) and \( \nu (\chi, Z) \) are sufficient for characterization.
- Pin down employment in the three sectors.
- RESULT: for \( \omega \) close to \( \varepsilon > 1 \): \( \partial \kappa / \partial \chi > 0 \) and \( \partial \nu / \partial \chi > 0 \).
Monotone dynamics is not a robust feature.

Consider a “Lewis model” ($\omega \to \infty$ and $\varepsilon > 1$) driven by capital accumulation.

Three stages of economic growth:

1. Early Lewis: no modern agriculture ($\nu = 0, \kappa = 1$);
2. Advanced Lewis: modernization of agriculture ($\nu \uparrow, \kappa \downarrow, N^S \downarrow$).
3. Neoclassical: demise of agriculture ($\kappa \uparrow$ and $\kappa \to 1$) and further modernization of agriculture ($\nu \to 1$).
Static Equilibrium (Lewis)

(a) Share of labor in each sector
- Nonagric’s share in total employment (%)
- Modern agric.’s share in total employment (%)
- Traditional agric.’s share in total employment (%)

(b) Factor prices
- Wage rate
- Rental rate of capital

(c) Productivity gap

(d) Relative K-Y ratio in agriculture to nonagriculture
- Relative K-Y ratio (Agr./Nonagr.)

Business Cycle during Structural Change
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Sufficient conditions: suppose $\omega > 1$ and

$$\varepsilon > 1, \quad g^M \geq g^{AM} \geq g^S.$$ 

[or, alternatively, $\varepsilon < 1$ and $g^{AM} \geq g^M \geq g^S$] 

... then the dynamic equilibrium converges to unique ABGP where

$$\kappa_t \to 1, \quad \nu \to 1,$$

$$\frac{\dot{c}_t}{c_t} \to g^M, \quad \frac{\dot{\chi}_t}{\chi_t} \to g^M.$$ 

Note: labor and capital accumulation in agriculture can be positive in the ABGP, but it goes to zero as a share of total GDP.
What should we believe about elasticities $\omega$ and $\varepsilon$?

- $\omega > 1$ seems plausible (in Lewis, $\omega \rightarrow \infty$).
- What about $\varepsilon$?
  - Herrendorf et al. (2013), Comin et al. (2018), etc. argue $\varepsilon < 1$
  - Foster and Rosenzweig (2004), Moscona (2018) argue $\varepsilon > 1$
Relative price (non-agr./agr.) vs. agricultural employment share: CHINA vs. USA

China NBS data

USA (Alvarez-Cuadrado & Poschke, 2011)
QUANTITATIVE ANALYSIS
Quantitative Model

- Discrete time.
- Persistent shocks to the three TFPs.
- Endogenous labor supply (pref. for leisure).
- Land in (modern) agriculture.
- First estimate the deterministic model to match structural change.
- Then, estimate stochastic processes for TFPs.
- Finally, simulate the stochastic model and compare business cycle statistics.
Model Estimation: SMM (for China)

- 8 parameters are calibrated outside the model
  - $n = 1.4\%$, $\delta = 5\%$, $(1 + \rho)^{-1} = 0.96$, $\alpha = 0.50$, $Y_{1985} = 1$, $\tau = 0.64$, $\theta = 0.76$, $g_M = 6.4\%$

- 10 parameters are estimated by SMM to match 19 moments (China 1985-2012):
  - (i) the share of agricultural employment in total employment;
  - (ii) the share of capital in agriculture relative to the total capital stock;
  - (iii) the ratio of real output in agriculture to total GDP;
  - (iv) the relative value added share of agriculture, evaluated at current prices (i.e., the expenditure share of agricultural goods);
  - (v) the capital/output ratio;
  - (vi) the productivity gap between agriculture and nonagriculture (adjusted for rural-urban wage differences).
### Estimated Parameters (SMM)

<table>
<thead>
<tr>
<th>Estimated Parameters</th>
<th>Benchmark $\varepsilon \leq \omega$</th>
<th>Unconstrained Estim.</th>
<th>Robustness $\varepsilon = 0.5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{c}$</td>
<td>Subsist. level in food cons.</td>
<td>$-$</td>
<td>$-$</td>
</tr>
<tr>
<td>$\varepsilon$</td>
<td>ES btw agric. and nonagric. cons.</td>
<td>4.07</td>
<td>6.70</td>
</tr>
<tr>
<td>$\omega$</td>
<td>ES btw modern and trad. agr.</td>
<td>4.07</td>
<td>1.40</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>weight on agric. goods</td>
<td>0.52</td>
<td>0.58</td>
</tr>
<tr>
<td>$1 - \beta - \beta_T$</td>
<td>capital's income share in modern agr.</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>$\beta$</td>
<td>labor's income share in modern-agric.</td>
<td>0.17</td>
<td>0.35</td>
</tr>
<tr>
<td>$g$</td>
<td>TFP growth rate in total agric.</td>
<td>6.0%</td>
<td>6.2%</td>
</tr>
<tr>
<td>$g^S$</td>
<td>TFP growth rate in trad. sector</td>
<td>4.7%</td>
<td>1.3%</td>
</tr>
<tr>
<td>$Z_{1985}$</td>
<td>initial TFP level in trad. agr.</td>
<td>1.74</td>
<td>1.97</td>
</tr>
<tr>
<td>$Z_{AM}^M$</td>
<td>initial TFP level in modern-agr.</td>
<td>0.92</td>
<td>1.29</td>
</tr>
<tr>
<td>$Z_{1985}$</td>
<td>initial TFP level in nonagr.</td>
<td>2.62</td>
<td>2.84</td>
</tr>
<tr>
<td>$J$-statistic</td>
<td>0.808</td>
<td>0.491</td>
<td>1.008</td>
</tr>
</tbody>
</table>

**Table:** Estimated parameters.
Model Fit 1: Decline of Agricultural Sector

- **Employment share of agricultural sector**
- **Capital share of agricultural sector**
- **Real output ratio agriculture/nonagriculture**
- **Expenditure ratio agriculture/nonagriculture**
Model Fit 2: GDP growth, Prod. Gap, K/Y Ratio

Index of real GDP (log)

Aggregate capital-output ratio

Log of productivity gap nonagriculture/agriculture
Trajectories: Traditional Agr Share in Agr

![Graphs showing employment, value added, and relative KY ratio over time.](image)

- Employment in traditional agriculture/Total employment in agriculture
- Value added in modern agriculture/Total agricultural value added
- Relative KY ratio in agriculture to nonagriculture
QUANTITATIVE ANALYSIS: BUSINESS CYCLE DURING STRUCTURAL CHANGE
Estimate joint TFP process

- Observed sectoral TFP sequence $\tilde{z}_t^j = \log \left( Z_t^j \right) - \log \left( Z_t^j \right)$, where $\bar{Z}_t^j$ is the deterministic trend for $j \in \{ M, AM, S \}$
- $\tilde{z}_t^j$ consists of two parts: the true TFP level $z_t^j$ and an i.i.d. measurement error $\zeta_t^j$
- $z_t^j$ follows an autoregressive VAR(1) process, $z_t^j = \phi^j z_{t-1}^j + \epsilon_t^j$

<table>
<thead>
<tr>
<th>$j$</th>
<th>$\phi^j$</th>
<th>$\sigma(\epsilon_t^j)$</th>
<th>$\sigma(\zeta_t^j)$</th>
<th>corr($\epsilon_t^j, \epsilon_t^M$)</th>
<th>corr($\epsilon_t^j, \epsilon_t^{AM}$)</th>
<th>corr($\epsilon_t^j, \epsilon_t^S$)</th>
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<tbody>
<tr>
<td>$M$</td>
<td>0.70</td>
<td>0.0182</td>
<td>6.0e-04</td>
<td>1</td>
<td>0.631</td>
<td>-0.389</td>
</tr>
<tr>
<td>$AM$</td>
<td>0.51</td>
<td>0.0489</td>
<td>0.0042</td>
<td>0.631</td>
<td>1</td>
<td>-0.745</td>
</tr>
<tr>
<td>$S$</td>
<td>0.51</td>
<td>0.0480</td>
<td>0.0295</td>
<td>-0.389</td>
<td>-0.745</td>
<td>1</td>
</tr>
</tbody>
</table>

Table: The estimated TFP process
Impulse-Resp. of Employment to NonAgr TFP Shock

Employment after Nonagriculture Shock

- Total
- Nonagriculture
- Modern agriculture
- Traditional agriculture

Period
Percent
Productivity Gap and Kappa after Nonagriculture Shock

- Productivity gap
- Kappa

Imp.-Resp. of Prod. Gap to Nonagr TFP Shock
Productivity Gap and Kappa after Modern Agri. Shock

- **Productivity gap**
- **Kappa**
## Business Cycle Statistics: China data vs. model

### A. China, 1985-2012

<table>
<thead>
<tr>
<th></th>
<th>( c )</th>
<th>( i )</th>
<th>( y^G )</th>
<th>( y^M )</th>
<th>( P^G \frac{y^G}{P} )</th>
<th>( P^M \frac{y^M}{P} )</th>
<th>( APL^G_{APL^M} )</th>
<th>( n^G )</th>
<th>( n^M )</th>
<th>( n )</th>
</tr>
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<tbody>
<tr>
<td>( \text{std}(x) ) / ( \text{std}(y) )</td>
<td>0.99</td>
<td>3.53</td>
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<td>1.21</td>
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<td>1.04</td>
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<td>( \text{corr}(x, y) )</td>
<td>0.70</td>
<td>0.65</td>
<td>-0.11</td>
<td>0.99</td>
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<td>-0.76</td>
<td>0.62</td>
<td>1.00</td>
<td>-0.93</td>
<td>0.18</td>
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<tr>
<td>( \text{corr}(x, n^M) )</td>
<td>0.64</td>
<td>0.65</td>
<td>-0.14</td>
<td>0.85</td>
<td>0.01</td>
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<td>( \text{corr}(x, y) )</td>
<td>0.75</td>
<td>0.99</td>
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<td>( \text{corr}(x, n^G) )</td>
<td>-0.31</td>
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\( \text{std}(y) = 1.7\% \)
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<td>0.80</td>
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</tr>
<tr>
<td>corr($x$, $n^M$)</td>
<td>0.42</td>
<td>0.75</td>
<td>-0.79</td>
<td>0.91</td>
<td>-0.70</td>
<td>0.89</td>
<td>-0.87</td>
<td>-0.90</td>
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<td>-0.68</td>
</tr>
<tr>
<td></td>
<td>(c)</td>
<td>(i)</td>
<td>(y^G)</td>
<td>(y^M)</td>
<td>(\frac{P^G y^G}{p})</td>
<td>(\frac{P^M y^M}{p})</td>
<td>(\frac{APL^G}{APLM})</td>
<td>(n^G)</td>
<td>(n^M)</td>
<td>(n)</td>
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<tr>
<td>A. China, 1985-2012</td>
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<tr>
<td>(\frac{std(x)}{std(y)})</td>
<td>0.99</td>
<td>3.53</td>
<td>0.40</td>
<td>1.21</td>
<td>1.64</td>
<td>1.34</td>
<td>2.17</td>
<td>1.00</td>
<td>1.04</td>
<td>0.10</td>
</tr>
<tr>
<td>(corr(x, y))</td>
<td>0.70</td>
<td>0.65</td>
<td>-0.11</td>
<td>0.99</td>
<td>0.06</td>
<td>0.95</td>
<td>-0.48</td>
<td>-0.78</td>
<td>0.83</td>
<td>-0.23</td>
</tr>
<tr>
<td>(corr(x, n^G))</td>
<td>-0.67</td>
<td>-0.61</td>
<td>0.10</td>
<td>-0.79</td>
<td>-0.01</td>
<td>-0.76</td>
<td>0.62</td>
<td>1.00</td>
<td>-0.93</td>
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<tr>
<td>(corr(x, n^M))</td>
<td>0.64</td>
<td>0.65</td>
<td>-0.14</td>
<td>0.85</td>
<td>0.01</td>
<td>0.82</td>
<td>-0.65</td>
<td>-0.93</td>
<td>1.00</td>
<td>-0.01</td>
</tr>
<tr>
<td>B. Benchmark</td>
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<tr>
<td>(\frac{std(x)}{std(y)})</td>
<td>0.24</td>
<td>2.50</td>
<td>2.09</td>
<td>1.43</td>
<td>1.53</td>
<td>1.30</td>
<td>2.58</td>
<td>3.28</td>
<td>1.52</td>
<td>0.51</td>
</tr>
<tr>
<td>(corr(x, y))</td>
<td>0.75</td>
<td>0.99</td>
<td>-0.29</td>
<td>0.94</td>
<td>-0.15</td>
<td>0.96</td>
<td>-0.58</td>
<td>-0.56</td>
<td>0.74</td>
<td>-0.08</td>
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<tr>
<td>(corr(x, n^G))</td>
<td>-0.31</td>
<td>-0.56</td>
<td>0.86</td>
<td>-0.74</td>
<td>0.80</td>
<td>-0.71</td>
<td>0.96</td>
<td>1</td>
<td>-0.90</td>
<td>0.81</td>
</tr>
<tr>
<td>(corr(x, n^M))</td>
<td>0.42</td>
<td>0.75</td>
<td>-0.79</td>
<td>0.91</td>
<td>-0.70</td>
<td>0.89</td>
<td>-0.87</td>
<td>-0.90</td>
<td>1</td>
<td>-0.68</td>
</tr>
</tbody>
</table>

\(std(y) = 1.7\%\)
Employment: From Acyclical to Procyclical

Richer countries (lower share of employment in agriculture) to the left
Employment Agr-NonAgr Turns Less (Neg.) Correlated
Richer countries (lower share of employment in agriculture) to the left
Prod Gap (Nonag/Ag) Becomes Less Countercyclical

Richer countries (lower share of employment in agriculture) to the left
Robustness analysis

- Modify TFP process for traditional sector
  - assume same persistence, $\phi^S = \phi^{AM}$
  - common shock to entire agric. sector
- Capital adjustment costs
- Cobb-Douglas preferences ($\varepsilon = 1$ and large subsistence level in food)
Conclusion

- We document how business cycle features changes throughout development
  - China vs. US
  - A cross section of countries
- Provide unified theoretical framework to account for business cycles and structural change
- Estimate model to match structural transformation in China
  - Model is broadly consistent with business cycle properties of China
- As productivity grows and capital accumulates, business cycles become more similar to those of the US
ADDITIONAL MATERIAL
Business cycles in developing countries

- Sectoral comovement

- Cross-country business cycle differences
  - Rogerson (1991): movement out of Agriculture in the US has been concentrated during upturns in economic activity, whereas the movement of workers out of manufacturing has been concentrated during downturns.
  - Da-Rocha and Restuccia (2006) focus on the role of Agriculture. We provide new evidence and a model with structural change
  - Aguiar and Gopinath (2007): emphasize trend shocks

China:

- Zhang, Rozelle, and Huang (2001); in the early 1990’s the layoffs increased and hiring slowed. Those who lost their jobs returned to the Agricultural sector.
Structural change

- Driving force: differential technical change and capital deepening
- China: Cheremukhin et. al. (2015),

Dual labor market:

- Lewis (1954), Harris and Todaro (1970)
In absence of shocks, the deterministic equilibrium is characterized by the following systems of differential equations w.r.t. \((c, \nu^A, \kappa^M, \chi)\) where

\[
\kappa^M \equiv \frac{K^M}{K}, \nu^A \equiv \zeta \frac{(Y^A)^{\omega-1}}{(Y^A)^{\omega}}, \chi \equiv \frac{K}{N},
\]

\[
\frac{\dot{c}}{c} = \frac{1}{1 + \theta (\sigma - 1)} \times \left[ \frac{1}{\kappa_t} (1 - \gamma) (1 - \alpha_M) \times (\kappa_t^{-\alpha_M} (Z_t^M \nu_t^M)^{\alpha_M} \chi_t^{-\alpha_M} - \delta - \rho) \right]
\]

\[
\frac{\dot{\chi}_t}{\chi_t} = \eta_t \left( Z_t^M \right)^{\alpha_M} \left( \kappa_t^{-\alpha_M} \right) \left( \nu_t^M \right)^{\alpha_M} \chi_t^{-\alpha_M} - \delta - c \chi_t^{-1} - n,
\]
Deterministic Dynamic Systems (Constant $h$)

\[
\frac{\dot{k}_t^M}{k_t^M} = \left(1 - k_t^M\right) \left(\frac{\left(\alpha_M g^M - \alpha_A g^A + (\alpha_A - \alpha_M) \frac{\dot{\chi}_t}{\chi_t}\right) + \frac{1}{\omega-1} - \frac{(\alpha_A - \alpha_M) (1 - v_t^M)}{\alpha_A v^A + 1 - v_t^A}}{\frac{1}{\epsilon-1} + (\alpha_A - \alpha_M) \left(k_t^M - v_t^M\right)}\right),
\]

\[
\frac{\dot{v}_t^A}{v_t^A} = \left(1 - v_t^A\right) \left(\frac{\alpha_A g^A - g^S + (1 - \alpha_A) \left(\frac{\dot{\chi}_t}{\chi_t} - \frac{\dot{k}_t^M}{k_t^M} \frac{k_t^M - v_t^M}{1 - k_t^M}\right)}{\frac{1}{\omega-1} + \frac{(1 - v_t^A)(1 - \alpha_A)(1 - v_t^M)}{\alpha_A v_t^A + 1 - v_t^A}}\right),
\]

\[
\frac{Z_t^M}{Z_t^M} = g^M, \quad \frac{Z_t^A}{Z_t^A} = g^A, \quad \frac{Z_t^S}{Z_t^S} = g^S,
\]
...where

\[
\eta_t \equiv (1 - \gamma)^{\frac{\varepsilon}{\varepsilon-1}} \left( 1 + \frac{1 - \alpha_M}{1 - \alpha_A} \frac{1 - \kappa_t^M}{\kappa_t^M} \frac{1}{\nu_t^A} \right)^{\frac{\varepsilon}{\varepsilon-1}},
\]

\[
\nu_t^M = \left( 1 + \frac{1 - \kappa_t^M}{\kappa_t^M} \frac{1 - \alpha_M}{1 - \alpha_A} \left( \frac{\alpha_A}{\alpha_M} + \frac{1}{\alpha_M} \frac{1 - \nu_t^A}{\nu_t^A} \right) \right)^{-1},
\]

\[
\nu_t^A = \frac{1}{1 - \tau} \frac{1 - \kappa_t^M}{\kappa_t^M} \frac{1 - \alpha_M}{1 - \alpha_A} \frac{\alpha_A}{\alpha_M} \nu_t^M.
\]
### Table: Business Cycle Statistics: Model vs Data

<table>
<thead>
<tr>
<th>FIRST DIFF</th>
<th>HOMOTH</th>
<th>$x =$</th>
<th>$c$</th>
<th>$i$</th>
<th>$p^G y^G$</th>
<th>$p^M y^M$</th>
<th>PrGap</th>
<th>$n^G$</th>
<th>$n^M$</th>
<th>$n$</th>
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<tbody>
<tr>
<td>A. FD- Filtered China Data: $std(y) = 2.4%$</td>
<td></td>
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<tr>
<td>$std(x)$</td>
<td>1.27</td>
<td>3.34</td>
<td>1.82</td>
<td>1.31</td>
<td>2.32</td>
<td>1.00</td>
<td>0.76</td>
<td>0.30</td>
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<tr>
<td>$std(y)$</td>
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<tr>
<td>$corr(x, y)$</td>
<td>0.57</td>
<td>0.63</td>
<td>0.12</td>
<td>0.93</td>
<td>-0.09</td>
<td>-0.57</td>
<td>0.66</td>
<td>-0.25</td>
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<tr>
<td>$corr(x, n^G)$</td>
<td>-0.74</td>
<td>-0.34</td>
<td>-0.38</td>
<td>-0.38</td>
<td>0.35</td>
<td>1.00</td>
<td>-0.50</td>
<td>0.71</td>
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<tr>
<td>$corr(x, n^M)$</td>
<td>0.32</td>
<td>0.37</td>
<td>0.40</td>
<td>0.53</td>
<td>-0.52</td>
<td>-0.50</td>
<td>1.00</td>
<td>0.19</td>
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<tr>
<td>B. FD- Filtered Model, $std(y) = 2.6%$</td>
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<td>$std(x)$</td>
<td>0.30</td>
<td>2.36</td>
<td>1.11</td>
<td>1.25</td>
<td>0.72</td>
<td>1.10</td>
<td>1.27</td>
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<tr>
<td>$std(y)$</td>
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<td>$corr(x, y)$</td>
<td>0.80</td>
<td>0.99</td>
<td>0.24</td>
<td>0.95</td>
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<td>0.69</td>
<td>0.18</td>
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<tr>
<td>$corr(x, n^G)$</td>
<td>-0.22</td>
<td>-0.27</td>
<td>0.80</td>
<td>-0.51</td>
<td>0.79</td>
<td>1</td>
<td>-0.78</td>
<td>0.75</td>
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<tr>
<td>$corr(x, n^M)$</td>
<td>0.55</td>
<td>0.66</td>
<td>-0.40</td>
<td>0.88</td>
<td>-0.81</td>
<td>-0.78</td>
<td>1.00</td>
<td>-0.52</td>
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</tbody>
</table>
Labor’s Income Share in non-farm/farm sector

Figure: The Figure plots the labor’s income share in farm/non-farm sectors in the USA. The labor’s income share is defined as the compensation of employees divided by the value-added output minus proprietor’s income.
Rel. Price of non-farm/farm output in the US

USA (Alvarez-Cuadrado & Poschke, 2011)

Figure: The Figure is from the Figure 1 in Alvarez-Cuadrado and Poschke (2011, AEJ Macro). It plots the share of employment in agriculture and the relative price of manufactures to agricultural goods in the US 1790/1800-2000. Note that the value-added price index is not available for such a long period, they use producer prices and wholesale prices of all commodities versus farm products in the US.
Consider increase in agricultural TFP: $Z^{AM} \uparrow$ and $Z^S \uparrow$

$\varepsilon > 1$: shock $Z^{AM} \uparrow$ and $Z^S \uparrow$ *reverses* structural change: $N^M \downarrow$
(workers go from manufacturing to agriculture when agriculture becomes more productive)

$\varepsilon < 1$: shock $Z^{AM} \uparrow$ or $Z^S \uparrow$ *accelerates* structural change: $N^M \uparrow$
(workers leave countryside and move to manufacturing when agriculture becomes more productive)
TFP Shock & Structural Change: High vs. Low epsilon

Relative agric. employment $\epsilon > 1$

Relative agric. employment $\epsilon < 1$
Figure: The Figure plots the share of employment in agriculture and the relative price of non-agricultural goods to agricultural goods in CHINA 1978-2012. The relative price is calculated as non-agricultural output deflator divided by the agricultural output deflator.
Figure: The Figure is from the Left panel of Figure 4 in Alvarez-Cuadrado and Poschke (2011, AEJ Macro). Countries include CAN, UK, NLD, BEL, FRA, GER, JPN, FIN, KOR, ESP.
Rel. Price of non-farm/farm output (Pre-WWII)

Figure: The Figure is based on the Left panel of Figure 4 in Alvarez-Cuadrado and Poschke (2011, AEJ Macro). Countries include CAN, UK, NLD, BEL, FRA, GER, JPN, FIN, KOR, ESP.