7. Structural Change.

References: Weil: Appendix to Chapter 10
Matsuyama, K., 1992, Agricultural Productivity, Comparative Advantage, and Long- Run Growth, *Journal of Economic Theory* 58, 317-334.

Structural Change: The change of relative importance of economic sectors over time:

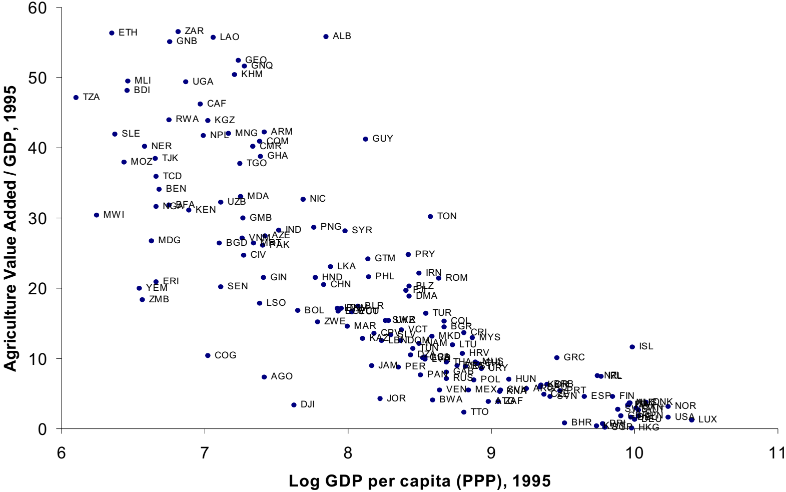
1. The rise of manufacturing at expense of agriculture: The Industrial Revolution.
2. The rise of the service sector at expense of manufacturing.

Here, we consider only 1. One of Kaldor's facts: The agricultural sector shrinks during development.

Structural Change

- is an important phenomenon in its own right.
- can help us to understand cross-country productivity (TFP) differences.

Structural change is one of the strongest regularities in macroeconomics...


Agriculture Value Added / GDP, 1995
Log GDP per capita (PPP), 1995
0
10
20
30
40
50
60
6
7
8
9
10
11
ETH
ZAR
GNB
LAO
ALB
GEO
GNQ
KHM
MLI
BDI
UGA
TZA
CAF
RWA
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SLE
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"Classical" Development Economics:

- lack of structural change is key to understand under-development (Rosenstein-Rhodan, Leibenstein)
- a big push is needed for economic take off
- emphasis on capital accumulation and foreign aid
- the "dual economy" (Lewis)

Nowadays:

- emphasis on TFP and "Deep Determinants"
- factor accumulation is important for growth but other factors have power *to prevent* growth:
  - weak institutions (property rights)
  - weak governance (corruption)
  - ...

Observe: structural change does not progress at an even pace everywhere:

EMPLOYMENT AND OUTPUT SHARES OF AGRICULTURE IN 1960, 1980 AND 1996

	Employment share (a)			*Output share (s)*			*Relative productivity*			*Sample sizes*		
	1960	*1980*	*1996*	*1960*	*1980*	*1996*	*1960*	*1980*	*1996*	*a*	*s*	*RLP*
Sub-Saharan Africa	0.88	0.76	0.71	0.39	0.30	0.37	11.8	8.7	6.1	19	16	16
East Asia and Pacific	0.62	0.39	0.17	0.29	0.19	0.08	3.4	3.3	2.8	10	8	7
South Asia	0.75	0.70	0.60	0.46	0.34	0.25	3.2	3.2	3.4	5	4	4
Latin America/Caribbean	0.53	0.36	0.23	0.23	0.12	0.09	3.8	3.4	2.2	20	18	18
High-income OECD	0.19	0.08	0.05	0.11	0.05	0.03	2.4	1.8	1.7	20	16	16

Key questions:

- Does the speed of structural change matter for productivity differentials?
- What drives this process?

Consider a 2-sector economy:

$$Y_1 = A_1 L_1, \qquad Y_2 = A_2 L_2$$

For simplicity the only factor is labor (no accumulation).

Aggregate output

$$Y = Y_1 + Y_2$$

Now, aggregate productivity (the Solow residual from growth accounting) is:

$$A = \frac{Y}{L} = \frac{A_1 L_1 + A_2 L_2}{L} = A_1 \left(\frac{L_1}{L} \right) + A_2 \frac{L_2}{L}$$

Observe:

- aggregate productivity is a *weighted* average of sectoral productivities.
- the weights are the labor shares.

Suppose there is no sectoral movement of labor. Productivity change:

$$\dot{A} = \frac{\dot{A}_1 L_1 + \dot{A}_2 L_2}{L}$$

Implying productivity growth:

$$\hat{A} = \frac{\dot{A}}{A} = \frac{\dot{A}_1 L_1 + \dot{A}_2 L_2}{AL} = \frac{\dot{A}_1 L_1 + \dot{A}_2 L_2}{Y}.$$

Using $L_i = Y_i / A_i$:

$$\hat{A} = \hat{A}_1 \frac{Y_1}{Y} + \hat{A}_2 \frac{Y_2}{Y}$$

Observe:

- aggregate productivity is a weighted average of sectoral productivities.
- the weights are the sectoral shares of output.

Example:

- Suppose sectoral productivity growth is identical world-wide.
  - 2% in sector 1 (non-agriculture)
  - 1% in sector 2 (agriculture).

Country 1 produces 90 percent of output in non-agriculture $\rightarrow$

$$\hat{A} = 0.02 \cdot 0.9 + 0.01 \cdot 0.1 = 1.9\%$$

Country 2 produces 50 percent of output in non-agriculture $\rightarrow$

$$\hat{A} = 0.02 \cdot 0.5 + 0.01 \cdot 0.5 = 1.5\%$$

The last example was not really appealing intellectually. Now, suppose

- same rate of TFP growth in both sectors
- ongoing structural change
- constant labor force $L \;\rightarrow\; -\dot{L}_1 = \dot{L}_2$

We compute the derivative w.r.t. time again:

$$\dot{A} = \frac{\dot{A}_1 L_1 + \dot{L}_1 A_1 + \dot{A}_2 L_2 + \dot{L}_2 A_2}{L} = \frac{\dot{A}_1 L_1 + \dot{A}_2 L_2 + (A_1 - A_2)\dot{L}_1}{L}.$$

And thus

$$\hat{A} = \hat{A}_1 \frac{Y_1}{Y} + \hat{A}_2 \frac{Y_2}{Y} + \frac{(A_1 - A_2)}{A} \frac{\dot{L}_1}{L}$$

Example: From our assumption that productivity growth is the same in both sectors, the first two terms are identical across countries. Now suppose:

- Sector 1 is three times as productive as sector 2: $A_1 = 1.5$, $A_2 = 0.5$
- Each year, one percent of the labor force moves from sector 2 to 1.
- Currently, $L_1 = L_2 = L/2 \;\rightarrow\; A = 1$.

$$\hat{A} = \frac{1.5 - 0.5}{1} \cdot 0.01 = 0.01.$$

Observe

- Productivity grows at 1 percent annually for structural change *only*.
- This phenomenon is only of temporary duration (why?).

Empirically, this issue is not so straightforward

- role of relative prices (demand)
- production function, factor aggregation
- data (shadow economy, family farms)

Recent studies (Dalgaard and Chanda, 2006) suggest: about half of cross-country variation of TFP differences can be attributed to compositional effects.

Conclusion:

- a kind of reconciliation between classical and modern schools of development theory
- TFP is key to economic growth
- Yet TFP growth it is itself to a large extent determined by sectoral factor allocation.

Yet, what determines sectoral TFP differences?

- geography (climate)?
- policy?
- institutions ? $\rightarrow$ more on these issues later.

What drives structural change? $\rightarrow$ some theory needed.

2 basic approaches:

1. industrial pull
2. agricultural push

we focus on the second (more consistent) idea.

A simple model (based on Matsuyama, 1992):

- 2 goods: agricultural, modern (industrial)
- price of agricultural goods normalized to one.
- p relative price of industrial goods
- 2 inputs, labor and land
- land is in fixed supply and used in agriculture only.

Production in agriculture:

$$Y_A = A L_A^{\alpha} Z^{1-\alpha}$$

with land Z.

All rents go to labor (no landlords, family managed farm) $\rightarrow$ wages equal the average product of labor

$$w_A = \frac{Y_A}{L_A} = A \left(\frac{Z}{L_A} \right)^{1-\alpha}.$$

Production in industrial sector (manufacturing):

$$Y_M = ML_M$$

with productivity M.
Implied wages:

$$w_M = p\frac{\partial Y_M}{\partial L_M} = pM$$

Suppose it is costless to move from agriculture to manufacturing and back. $\rightarrow$ wage equalization:

$$w_A = w_M = pM$$

[What if it were not costless? $\rightarrow$ dual economy, a further cause of productivity differentials. More on that later.]

Implied labor demand:

$$A\left(\frac{Z}{L_A}\right)^{1-\alpha} = pM$$

and with normalization $Z = 1$:

$$p = \frac{A}{M}L_A^{\alpha-1}. \tag{1}$$

Indirect supply function for agricultural goods.

Recall Engel's law:

- the relative share of income spent on food decreases with income.
- here we use a particular simple representation: households have to spend the amount $\bar{a}$ for food (constant demand).

Thus, market clearing for agriculture:

$$Y_A = AL_A^{\alpha} = \bar{a}L. \tag{2}$$

Market clearing for labor:

$$L_A + L_M = L \tag{3}$$

Model complete. Equations (1)-(3) pin down p, L_A and L_M.

From (1) and (2)

$$L_A = \left(\frac{\bar{a}L}{A}\right)^{1/\alpha} \tag{4}$$

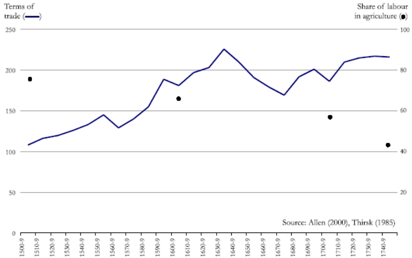
$$p = \frac{A}{M}\left(\frac{\bar{a}L}{A}\right)^{(\alpha-1)/\alpha} \tag{5}$$

and (3) pins down L_M.

Observe:

- increasing productivity (technological change) *in agriculture* propels structural change.
- productivity in manufacturing is not important.
- Mechanism: $A \uparrow$ and unchanged demand (generally, little changed demand) $\rightarrow$ excess supply of agricultural goods $\rightarrow p \uparrow$ labor moves from agriculture to manufacturing which reduces access supply.

Yet there is a little problem with these predictions, if history is a guide...



Agricultural terms of trade improved (p fell) during the early period of structural change in the U.K.

Simple (ad hoc) resolution:

- permanent technological progress in manufacturing.
- Matsuyama models this as learning-by-doing:

$$M_{t+1} - M_t = \delta Y_M = \delta \left(L - L_A \right)$$

- with M perpetually growing and A only occasionally changing, p can fall and we still see structural change.
- Nevertheless, productivity improvements in the A–Sector remain essential for structural change.

Still, the theory is somehow "too easy"...

- If every innovation in the A sector shifts labor, then why did it take us 15.000 years (since the Neolithic revolution) to start developing a manufacturing sector?
- And what about Africa? Has there been more or less no change of A?

Recently, researchers came up with some ideas. Most of them connect structural change with the fertility decision of households.

Basic idea: a toy model based on Strulik (2000):

1. element: recall

- W &E I
- Kremer's model

and suppose that population growth $\hat{L}$ follows a path of demographic transition: it is invertedly u-shaped in income per capita y

[Figure: path of $\hat{L}(y)$ reflecting the demographic transition]

2. element: assume perpetual technological change in agriculture (possibly at a very low rate): $\hat{A} > 0$.

Differentiate (4) logarithmically

$$\hat{L}_A = \frac{1}{\alpha}\left(\hat{L} - \hat{A}\right)$$

to see that there will be no structural change as long as $\hat{L} = \hat{A}$.

Income per capita equals wages, i.e. $y = p \cdot M$. Log-diff. w.r.t. time:

$$\hat{y} = \hat{p} + \hat{M}$$

And from (5)

$$\hat{p} = \hat{A} - \hat{M} - \frac{1-\alpha}{\alpha}\left(\hat{L} - \hat{A}\right)$$

Thus, income per capita grows at rate

$$\hat{y} = \hat{A} + \frac{1-\alpha}{\alpha}\hat{A} - \frac{1-\alpha}{\alpha}\hat{L}$$

This constitutes – since population growth depends on income – an ordinary 1st oder differential equation in y:

$$\hat{y} = \frac{1}{\alpha}\hat{A} - \frac{1-\alpha}{\alpha}\hat{L}(y).$$

Observe:

- There exists an equilibrium of constant y where $\hat{A} = (1-\alpha)\hat{L}$.
- The equilibrium is locally stable for $\partial\hat{L}/\partial y > 0$.

[Figure: locally stable and unstable equilibria]

Interpretation:

- Note that the model boils down to our standard Malthus model for $\hat{A} = 0$.
- For $\hat{A} > 0$: "neo-Malthusian" model.
- All potential income growth through technological change in agriculture is absorbed by population growth.

Now consider:

- an increase of $\hat{A}$ (mechanization of agriculture, motor tractor, harvester, chemical fertilizer, disease control,...) $\rightarrow$ $\hat{A}$–line shifts upwards
- and/or a change of fertility behavior $\rightarrow$ $\hat{L}$–curve shifts downwards.

$\rightarrow$ the neo-Malthusian equilibrium may cease to exist.

What happens then?

- After an initial phase of increasing population growth, $\hat{L}$ begins to decrease with y.
- Consequence: $\hat{y}$ is positive and rising.

With permanent income growth, constant food demand per head and decreasing population growth $\rightarrow$ structural change.

Formally

$$\hat{L}_A = \frac{1}{\alpha}\left(\hat{L} - \hat{A}\right) < 0.$$

i.e. the *relative* size of the agricultural sector goes to zero, industrialization.

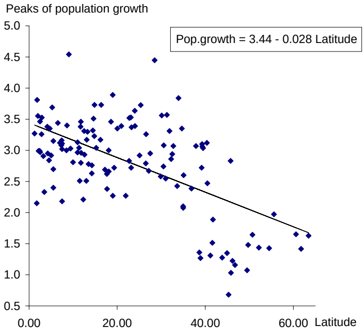
Now, what about Africa?

- Maybe population growth (mortality and fertility behavior) is different.
- The "population growth hump" peaks at higher $\hat{L}$

[Figure: Geographic location and population growth: effect on stagnation]

Empirically, this seems to be indeed the case:

Absolute Latitude and the Historical Peak of Population Growth for 128 Countries:



Yet why is fertility behavior different in the tropics?
i.e. Why does the human species multiply at higher rates at locations for which is it is less fit to live in? $\rightarrow$ ongoing research. Strulik (2007).