Structural Change and Growth in a NEG Model

Fabio Cerina
Francesco Mureddu

CRENoS and University of Cagliari
CRENoS and University of Cagliari

Presentation prepared for the XVI DEGIT Conference, Saint Petersburg, 8-9 September, 2011
Structural Change and Growth in a NEG Model

- Introduction
- Analytical Framework
- Equilibrium and Stability Analysis
- Growth Analysis
- Conclusions
The Literature and Our Contribution

- **Structural change**: economic development is associated with reallocation of resources from agriculture to non-agriculture sectors and, within the latter, from manufactures to services.

- **Demand based structural change**
  - Matsuyama (1992 JET); Kongsamut, Rebelo and Xie (2001 RES), Foellmi and Zweimuller (2008 JME), etc.
  - Murata (2008 JDE) introduces non-homothetic preferences in a static model of New Economic Geography: integration leads to demand-driven structural change and urbanization.

- **Supply based structural change**
  - Baumol (1967 JPE); Ngai and Pissarides (2007 AER); Acemoglu and Guerreri (2008 AER): difference in the growth rate of productivity between sectors.

- **Our model**: spatial (agglomeration and trade costs) and dynamic (endogenous growth); demand (non-homothetic utility) and supply (faster productivity in industry) approach.
What do we do?

- We introduce non-homothetic preferences in a footloose capital model à la Baldwin, Martin and Ottaviano (JEG 2001).

- The structural change mechanism, similar to Murata (2008), is led by a decline in transport costs which:
  - By enhancing consumers’ purchasing power, leads to *Engel’s law*: demand shift from agricultural to non-agricultural sectors.
  - By enlarging the extent of the market for non-agricultural goods, induces * Petty’s law*: labor reallocation from agriculture to non-agricultural activities.
  - By increasing the expenditure shares in manufacturing goods trade costs affects

1. the **equilibrium dynamics** of spatial allocation of firms
2. the **growth rate** of the economy
Main Results (1): spatial equilibrium dynamics

The possibility of growth enriches the spatial equilibrium dynamics with respect to Murata (2008)

- An additional agglomeration force, the Expenditure Shares Effect (Cerina and Mureddu (2011) JRS):
  - By HME, agglomeration leads to local higher real income
  - With NH utility demand shifts to industrial goods
  - Local profits increase and more incentive to invest

- Non-linearities and multiple equilibria
  - Very high trade costs: real income is so low that we are in a pre-industrial stage both regions
  - High trade costs: the two economies industrialize; symmetric equilibrium unique and stable
  - Low trade costs: multiple equilibria; two new interior (unstable) equilibria emerge; symmetric and CP allocations are both stable
  - Very low trade costs: no longer multiple equilibria and symmetric equilibrium looses its stability; catastrophic agglomeration
Main Results (2): Growth

- Growth is affected by the expenditure shares in industrial goods, which is usually assumed to be exogenous.
- Here, thanks to NH utility, expenditure shares in industrial goods are positively affected by an increase in real incomes.
- Trade costs and spatial allocation of firms affects real incomes.
  - A decline in trade costs increases real incomes, expenditure shares and then growth.
  - Alternative channel (CM 2011) through which integration boosts growth.
    - Different from comparative advantage, technology flows, efficiency gains.
    - Agglomeration is growth detrimental because it reduces the average expenditure shares in industrial goods.

- **Growth effects** of endogenous expenditure shares (versus level effects in Murata 2008).
Structural Change and Growth in a NEG Model

- Introduction
- Analytical Framework
- Equilibrium and Stability Analysis
- Growth Analysis
- Conclusions
The Economy

- 2 regions (N and S), 2 factors (K and L), 3 sectors (M, I and T)
- Regions are perfectly symmetric in terms of preferences, technology, labour endowment and trade costs
- Labour is immobile across regions but mobile across sectors
- T-good is freely traded, M-good is subject to iceberg cost
- M-sector is Dixit-Stiglitz and enjoys IRS (fixed unit of knowledge capital and variable cost $a_M$ in terms of labour)
  - One unit of $K$ is needed to start a new variety $n$, then $K + K^* = K^w = n + n^* = n^w$
- Capital is immobile: $n = K$ and $n^* = K^*$ firms’ profits should be spent locally
- By defining $s_n = \frac{n}{n^w}$ and $s_K = \frac{K}{K^w}$, we also have $s_n = s_K$
- T-sector produces under perfect competition and CRS: $T=L$
The Innovation Sector as the Engine of Growth

- Each region’s $K$ is produced by its $I$-sector:

$$\dot{K} = \frac{L_I}{a_I}, \quad F = w_I a_I$$

- To individual $I$-firms, the innovation cost $a_I$ is a parameter
- We have endogenous growth assuming that the labour unit requirements $a_I$ decline as the cumulative output rises
- Learning spillovers are assumed to be global so that:

$$a_I = \frac{1}{K^w}$$

- Since number of firms = capital units = varieties:

$$g \equiv \frac{\dot{K}}{K}; \quad g^* \equiv \frac{\dot{K}^*}{K^*}$$
Non-homothetic Preferences

- We have an infinite lively consumer that maximizes:
  \[ U = \int_{t=0}^{\infty} e^{-\rho t} \ln Q \, dt; \quad Q = (C_A)^{1-\mu} \left(n^{w^1-\sigma} C_M + \gamma \right)^\mu; \quad C_M = \left(\int_{i=0}^{K+K^*} c_i^{-\frac{1}{\sigma}} \, di \right)^{\frac{1}{1-1/\sigma}} \]

- \( \gamma \) is the non-homotheticity parameter: \( C_M \) is purchased only when expenditure reaches a certain threshold.

- We abstract from the love for variety (as Murata 2008).

- 3 stage optimization: 1) income between consumption and savings intertemporally; 2) consumption between the agricultural and the non-agricultural good intertemporally; 3) non-agricultural consumption between varieties.

- Our main focus is on the second stage.

\[
\max_{C_M, C_T} Q_t = (C_A)^{1-\mu} \left(n^{w^1-\sigma} C_M + \gamma \right)^\mu \\
\text{s.t.} \quad P_M C_M + p_A C_A = E
\]
Endogenous Expenditure Shares

The second-stage optimization process leads to the following:

\[
\frac{P_M C_M}{E} = m(s_K, \phi) = \max \left( \mu - (1 - \mu) \gamma \frac{(s_K + (1 - s_K) \phi) \frac{1}{1 - \sigma}}{L + \rho s_K}; 0 \right)
\]

\[
\frac{P^*_M C^*_M}{E^*} = m^*(s_K, \phi) = \max \left( \mu - (1 - \mu) \gamma \frac{(\phi s_K + (1 - s_K)) \frac{1}{1 - \sigma}}{L + \rho (1 - s_K)}; 0 \right)
\]

- **Endogenous expenditure shares**: they depend on firms’ allocation \(s_K\) and on the degree of integration \(\phi\)
- Industrial expenditure shares are negatively related to \(\gamma\)
- To have positive industrial expenditure shares, \(\gamma\) should not be too high and \(\phi\) should not be too low
Structural Change: Engel’s Law

- Integration (increase $\phi$) leads to Engel’s law: increase of expenditure shares in industrial goods, via reduction in price index

\[
\frac{\partial m(s_K, \phi)}{\partial \phi}, \frac{\partial m^*(s_K, \phi)}{\partial \phi} > 0
\]

- Agglomeration leads to Engel’s law but only in the more concentrated region: by HME, industrial goods becomes relatively cheaper in the north. Thus the expenditure shares increase in the north and decrease in the south

\[
\frac{\partial m(s_K, \phi)}{\partial s_K} > 0; \frac{\partial m^*(s_K, \phi)}{\partial s_K} < 0
\]
Structural Change: Petty’s Law

- Labour market clearing for industrial goods
  \[ L_M + L_M^* = \frac{\sigma - 1}{\sigma} (m(s_K, \phi)(L + \rho s_K) + m^*(s_K, \phi)(L + \rho(1 - s_K))) \]

- Integration pins down the manufacture price index in both regions thereby the labour share increases globally (Petty’s law)
  \[
  \frac{\partial (L_M + L_M^*)}{\partial \phi} = \frac{\sigma - 1}{\sigma} \left( \frac{\partial m(s_K, \phi)}{\partial \phi} (L + \rho s_K) + \frac{\partial m^*(s_K, \phi)}{\partial \phi} (L + \rho(1 - s_K)) \right)
  \]

- By HME integration let \( P_M \) decrease in the north thus labour shares increase in the north and decrease in the south
  \[
  \frac{\partial L_M}{\partial s_K} = \frac{1}{\sigma} \left( (1 - \mu) \gamma (s_K + (1 - s_K) \phi)^{1-\sigma} (1 - \phi) + \rho \mu (\sigma - 1) \right) > 0
  \]
  \[
  \frac{\partial L_M^*}{\partial s_K} = -\frac{1}{\sigma} \left( (1 - \mu) \gamma (\phi s_K + (1 - s_K))^{\frac{\sigma}{1-\sigma}} (1 - \phi) + \mu (\sigma - 1) \rho \right) < 0
  \]
The reduction in trade costs in the last century is dramatic
- Bairoch (1989): the transport cost as a % of production costs for a 800 kilometer trade shipment of manufactured iron goods fell from 27 % in 1830 to 6 % in 1910
- The average cost of moving a ton a mile has decreased ninefold in the last century (Glaeser and Kohlhase, 2004)
- Mokyr (1990) (technology); Chandler (1977) and Tedlow (1990) (vertical integration and innovation in delivery); Kelly (1997), McDonald and McMillen (2007) (deregulation)
- Murata (2008): real effects of trade-cost reduction
  - Hoover (1937): as transport costs decline, trade and local specialization develop and a new stratum of population starts to set and run simple village industries for the farmers
  - Stiglier (1951), Smith (1976) and Young (1928): reduction in trade costs increases the extent of the market
- We push this mechanism even further, by analyzing its implications in a dynamic economy
Structural Change and Growth in a NEG Model

- Introduction
- Analytical Framework
- Equilibrium and Stability Analysis
- Growth Analysis
- Conclusions
Equilibrium and Stability Analysis

- Pre-industrial economy
- New Agglomeration force: Expenditure share effect
- Non-linearities and multiple equilibria
- Stability map
Pre-industrial economy

- When real income is very low, there might be no demand for industrial goods: regional workforce is wholly allocated to the agricultural sector.
- Very high trade costs might be one cause of it

\[
\phi < \phi_I : m(s_K, \phi) = 0
\]

\[
\phi < \phi_I^* : m^*(s_K, \phi) = 0
\]

- Regions are symmetric so \(\phi_I = \phi_I^*\) and the industrial stage begins with a symmetric allocation. Hence

\[
m \left( \frac{1}{2}, \phi_I \right) = m^* \left( \frac{1}{2}, \phi_I \right) = \mu - 2(1 - \mu) \gamma \frac{\left(1+\phi_I\right)^{1-\sigma}}{2L + \rho} = 0
\]

- So that

\[
\phi_I = 2 \left( \frac{2(1 - \mu) \gamma}{\mu (2L + \rho)} \right)^{\sigma - 1} - 1
\]
In order for the symmetric equilibrium to be \textit{unstable}, agglomeration forces should be stronger than dispersion forces

\[
\frac{\partial f \left( \frac{1}{2}, \phi \right)}{\partial s_K} < 0 : \quad \left( \frac{1 - \phi}{1 + \phi} \right) - \frac{\partial s_E}{\partial s_K} - \frac{\partial m \left( \frac{1}{2}, \phi \right)}{2m \left( \frac{1}{2}, \phi \right)} < 0
\]

Market-Crowding \quad \text{Demand-Linked} \quad \text{Expenditure Share}

\[
\frac{\partial m \left( \frac{1}{2}, \phi \right)}{\partial s_K} / 2m \left( \frac{1}{2}, \phi \right)
\]

represents the \textit{expenditure share effects} induced by non-homotheticity: a firm investing in the North

\begin{itemize}
  \item increases Northern expenditure and lowers Northern prices\rightarrow
  \item increase Northern purchasing power\rightarrow
  \item increase Northern expenditure shares on industrial goods\rightarrow
  \item increases Northern relative profits\rightarrow
  \item creates further incentive to invest in the North
\end{itemize}
The Expenditure share Effect/2

\[
\frac{\partial f \left( \frac{1}{2}, \phi \right)}{\partial s_K} < 0 : \quad \frac{(1 - \phi)}{(1 + \phi)} - \frac{\partial s_E}{\partial s_K} - \frac{\partial m \left( \frac{1}{2}, \phi \right)}{\partial s_K} < 0
\]

- Market-Crowding
- Demand-Linked
- Expenditure Share

- \( \frac{\partial m \left( \frac{1}{2}, \phi \right)}{\partial s_K} = 0 \) when \( \gamma = 0 \) so that this force does not exist with exogenous expenditure shares.
- So agglomeration is reached for higher values of trade costs and the new force can be so strong that the symmetric equilibrium may be unstable even for prohibitive trade costs (\( \phi = 0 \)).
- That happens when \( \gamma \) is large enough (but still small enough to guarantee industrialization)
- Corollary: we can have catastrophic agglomeration even in case of capital mobility, that is the case when \( \frac{\partial s_E}{\partial s_K} = 0 \)
The decrease in trade costs might lead to the following stages of development and urbanization:

- **Stage 1**: \( \phi \in (0, \phi_I) \): pre-industrial economy with only agricultural production in both regions.
- **Stage 2**: \( \phi \in (\phi_I, \hat{\phi}) \): early industrial economy in both regions; the symmetric allocation is the unique and stable steady state.
- **Stage 3**: \( \phi \in (\hat{\phi}, \phi_B) \): intermediate industrial economy with multiple equilibria: symmetric and core-periphery equilibria are stable at the same time and there are two more interior instable equilibria.
- **Stage 4**: \( \phi \in (\phi_B, 1) \): the symmetric equilibrium loses its stability and the system evolves into a core-periphery pattern.

When \( \hat{\phi} < \phi_I < \phi_B \), stage 2 does not exist; when \( \hat{\phi} < \phi_B < \phi_I \), stage 2 and stage 3 do not exist and catastrophic agglomeration is activated for any value of trade costs.
Stability map when $\phi_I < \hat{\phi} < \phi_B$
Stability map when $\hat{\phi} < \phi_I < \phi_B$
Stability map when $\hat{\phi} < \phi_B < \phi_I$
Single Interior Equilibrium

Figure: The case of a single interior equilibrium
Multiple Equilibria

Figure: The case of multiple equilibria
The symmetric equilibrium loses its stability
Structural Change and Growth in a NEG Model

- Introduction
- Analytical Framework
- Equilibrium and Stability Analysis
- Growth Analysis
- Conclusions
Geography and Integration always matter for Growth

- Non-homotheticity activates an additional channel through which growth is affected by integration and location of economic activities.
  - In NEG models (with exogenous expenditure shares) firms’ location (positively) affects growth only with localized spillovers and integration affects growth only indirectly through its effect on firms’ location.

- Growth positively depends on the weighted average expenditure share devoted to industrial goods, which in our model is itself affected by integration (positively) and agglomeration of economic activities (negatively), hence

- *Integration is always growth enhancing and agglomeration is growth-detrimental*
Growth and Integration

- The growth rate is:

\[ g(s_K, \phi) = \frac{2L\mu - \rho(\sigma - \mu) - (1 - \mu)\gamma Z(s_K, \phi)}{\sigma} \]

- where \( g \) depends negatively on \( \gamma \) and:

\[ Z(s_K, \phi) = \left( (s_K + (1 - s_K)\phi)^{\frac{1}{1-\sigma}} + (1 - s_K + s_K \phi)^{\frac{1}{1-\sigma}} \right) \]

- with

\[ \frac{\partial g(s_K, \phi)}{\partial \phi} = - \frac{(1 - \mu)\gamma}{\sigma} \frac{\partial Z(s_K, \phi)}{\partial \phi} > 0 \]

- Growth effect of integration: a decrease in transport costs enhances aggregate expenditure share in industrial goods boosting growth
Growth and Firms’ Location

- The rate of growth can also be written as:
  \[ g(s_K, \phi) = \frac{m(s_K, \phi) E + m^*(s_K, \phi) E^* - \rho \sigma}{\sigma} \]

- Agglomeration is **bad** for growth:
  \[ \frac{\partial g}{\partial s_K} = \frac{1}{\sigma} \left[ m \left( \frac{\partial m/\partial s_K}{m} E + \rho \right) + m^* \left( \frac{\partial m^*/\partial s_K}{m^*} E^* - \rho \right) \right] < 0 \Leftrightarrow s_K > \frac{1}{2} \]

- "Decreasing returns on agglomeration": with non-homotheticity, Northern expenditure on industrial goods is increasing in \( s_K \) but at a decreasing rate.
- Hence, the **aggregate** expenditure on industrial goods is larger in symmetry and then, ceteris paribus, growth is faster
Agglomeration, Integration and Growth

- Integration and spatial concentration of firms has opposite effects on growth.
- However integration leads to spatial concentration so that - if the location effect is larger - a reduction in the degree of integration - by favoring dispersion - might boost growth.
- Then: which level of integration an hypothetical central planner controlling \( \phi \) will choose in order to maximize overall growth?
- More formally, the effective equilibrium growth rate will be:

\[
g \left( \frac{1}{2}, \phi \right) = \frac{2L \mu - \rho (\sigma - \mu) - (1 - \mu) \gamma Z \left( \frac{1}{2}, \phi \right)}{\sigma} \quad \text{for } \phi \leq \phi_B
\]

and:

\[
g (1, \phi) = \frac{2L \mu - \rho (\sigma - \mu) - (1 - \mu) \gamma Z (1, \phi)}{\sigma} \quad \text{for } \phi > \phi_B
\]

- When \( \phi \) is totally controlled by the government, it will always choose between the maximum level of integration in either regime, that is \( \phi = \phi_B \) or \( \phi = 1 \)
- but in this case \( g \left( \frac{1}{2}, \phi_B \right) < g (1, 1) \) so that the (positive) growth effect of integration is always higher than the (negative) growth effect of agglomeration.
Structural Change and Growth in a NEG Model

- Introduction
- Analytical Framework
- Equilibrium and Stability Analysis
- Growth Analysis
- Conclusions
Conclusions

- Models of agglomeration and growth have very different predictions once structural change is taken into account.
- Agglomeration dynamics
  - a new force of agglomeration appears
  - the latter introduces nonlinearity elements which leads to the emergence of multiple equilibria for some range of trade costs.
- Growth
  - Trade costs’ decline is growth-enhancing via increase in real income
  - Agglomeration is growth-detrimental as it reduces the aggregate expenditure in industrial goods.
Conclusions/2

- Main message: models of agglomeration and growth should not neglect the effect of trade costs and industry location on expenditure shares
- Otherwise they can suggest misleading policy implications:
  - "Integration always leads to agglomeration" (from Krugman 1991 onwards)
  - "Integration doesn’t have a direct influence on growth" (Baldwin, et. al. 2001, Baldwin and Martin 2004)
  - "Agglomeration is always good for growth when knowledge spillovers are localized" (Martin (1999), Baldwin, et. al. 2001, Baldwin and Martin 2004)
- Next step: test the empirical relevance of the main mechanism with some regressions or calibration exercises
THANK YOU!!!