The role of technology, organisation, and demand in growth and income distribution

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Growth, divergence and structural change

World economies have experienced dramatic cross-country growth divergencies over the past two centuries (Maddison, 2003; Hulten, 2009).

Structural change leads to transformations of economies and societies. Examples from the industrial revolution

- Concentration in large capital intensive firms & firm size growth (Desmet and Parente, 2009),
- Increase in the number of goods available for final consumption (Berg, 2002),
- Closer involvement of science in technological change (**?**),
- Increased use of capital in agriculture and manufacturing and improvement in the technology embedded in machines (**?**),
- Urbanisation, income inequality and changes in social class composition (**?**)...

Structural change

Structural change involves many aspects of the economy

- "[...] complementary changes in various aspects of the economy, such as the *sector compositions of output and employment*, the *organization of industry*, the *financial system*, *income and wealth distribution*, *demography*, political *institutions*, and even the society's *value system*" (Matsuyama, 2008)
- "[...] a change in the structure of the economic system, that is, in its *components* and in their *interactions*. Components are [...] *particular goods or services*, and other activities and *institutions*, such as *technologies*, *types of knowledge*, *organizational forms* etc.**What does it mean for a system to be in equilibrium when its composition keeps changing due to the emergence of qualitatively different entities?** " (Saviotti and Gaffard, 2008)

Focus of this paper

Production technology

- The relevance of embedded capital technologies to productivity increase (Hulten, 1992; Greenwood et al., 1997)

Organisation of production

- The transformation following the capitalistic system: size, organisation, concentration, managerial role (von Tunzelmann, 1995; Desmet and Parente, 2009)

Composition of output

- Countries with higher income have larger variety of available goods (Funke and Ruhwedel, 2001; Economic Commission for Europe, 2004), and a more complex production/export structure (Hidalgo and Hausmann, 2009).
- Product variety is positively related to income and inequality (Falkinger and Zweimüller, 1996, 1997)

Aim of the paper

Model these three aspects of structural change and their interactions

- exogenous parameters define the structure of an economy and the way in which this unfolds through time

Reconciling Keynesian and Schumpeterian ideas

- Modelling the interactions at the micro level: emerging properties

S–1 **Organisation of production** [number of tiers of executives (labour structure and firm size)]

S–2 **Technology of production** [speed of change in capital innovation]

S–3 **Composition of production** [initial variance in the good's quality]

D–2 **Consumption patterns** [change in consumer preferences]

D–1 **Income distribution** [earning disparities & profit shares]

Outline of the presentation

1. Introduction: motivations, aims, and background
2. The Model: structure and main micro behaviours
3. Simulation results
4. Summing up and final considerations

Micro economic interactions of structural change

For a given rate of investment, the larger is the increase in the productivity of capital vintages, the higher is the growth of firm productivity

An increase in firm productivity leads to an increase in the relative demand for its good (via a price reduction)

The increase in firm sales is followed by organisational changes toward larger production units and a higher number of management levels, and higher investment

The increase in the number of organisational layers induces the formation of new consumption classes with different preferences for the goods' quality and price

For large earnings disparities this also leads to a higher purchasing power of the new classes and higher inequality.

Our approach

Micro to macro simulation model

We analyse the parameters that control the three aspects of structural change using numerical simulations

The remaining parameters are initialised with reference to empirical evidence

Main assumptions

Different consumption classes:

- earn a different wage
- move towards different expenditure shares

Income growth

- increases labour force **level**, and modify **organisations**

$\Rightarrow$ increases the level of demand ad its heterogeneity

$\Rightarrow$ Income growth modifies both the class composition and their consumption patters

Class composition of demand affects firm's

- product innovation
- competitiveness
- organisation

Main findings

Identify a number of stylised facts that characterise (and explain) patterns of growth at different stages of the development cycle

Output growth is lessened by a high initial variety of products and demand;

A larger increase in firm size and number of organisational layers coupled with faster technological change in capital goods leads to higher productivity and output growth despite being conducive of earning disparities and higher income inequality;

Large earning disparities, coupled with intermediate levels of organisational complexity, lead to large income inequality and to lower output growth.

Basic model structure

Final good firms:

- Process technology: L for production and K to build capacity and determine productivity
- Hierarchical labour organisation

Capital suppliers

- Process technology: L for production
- Product technology: R&D $\Longrightarrow$ process innovation / capital vintages
- Hierarchical labour organisation

Workers/Consumers

- Use income generated by production (wages)
- Preferences on product technology

Wage setting: min wage (macro), labour hierarchies, bonuses

Firm's output

Each firm $f \in 1, ..., F$ produces one good, satisfying one consumer need $n \in \{1, 2, ..., N\}$ (= sector), with price (i_p) and quality (i_q).

Output constrained by **labour** and **capital**:

$$Q_t = \min \left\{ Q_t^d; A_{t-1} L_{t-1}^1; DK_{t-1} \right\}$$

A_{t-1} is the labour productivity embedded in K vintages

Price is determined as a fixed mark–up on variable costs

- Firm organisations/size (**S-1**)
- Labour productivity (**S-2**)

Factors of production: Labour

S–1 Organisation of production

Demand for **first tier workers** L_t^1 function of output and productivity.

$$L_t^1 = \epsilon_L L_{t-1}^1 + (1-\epsilon_L)\left[\left(1+u^l\right)\frac{1}{A_{t-1}} min\{Q_t^d; DK_{t-1}\}\right]$$

Pyramidal firms: **Higher tiers** workers co-ordinate a batch of ν subordinates

$$L_t^2 = L_t^1 \nu^{-1}$$
$$\vdots$$
$$L_t^\Lambda = L_t^1 \nu^{1-\Lambda}$$

where Λ is the total number of firms' layers

Factors of production: Capital Stock

S–2 Technology of production

Investment decision of new capital units is unconstrained, and prior use of firm profits Investment may increases the efficiency of production

$$A_t = \sum_{\tau=0}^{t} \frac{k_\tau (1-\delta)^{t-\tau}}{K_t} a_\tau$$

δ: depreciation; a_τ: vintage productivity

Capital good firms innovate improving the productivity of the supplied vintages proportionally to sales/profits: **stochastic R&D**:
$a_{g,\tau} = a_{g,\tau-1}\left(1 + max\{\varepsilon_g(t); 0\}\right)$ where $\varepsilon_g(t) \sim N(0; \sigma^a)$.

Selection of capital goods firms: capital supply constraint

Wage structure

D–1 Income distribution

A **minimum wage** w^m is negotiated at the macro level

Exponential wage structure along the organisational pyramid

$$\begin{aligned} w_t^1 &= \omega w_{t-1}^m \\ w_t^2 &= b w_t^1 \\ &\vdots \\ w_t^\Lambda &= b^\Lambda w_t^1 . \end{aligned}$$

ω: firm bargain; b: executive multiplier

Executives receive **bonuses** ψ^l from **residual** profit shares

Income classes

D–2 Consumption patterns

Each class z is populated by the workers of a corporation's tier with the respective wage and bonus

Consumption level differ by **labour/income** class

Consumers in the same class share the same **preferences**

Consumer behaviour

For each need, given the **perceived** characteristics of a good $i^*_{f_n,m} = N\left(i_{f_n,m}, \sigma^i i_{f_n,m}\right)$ (quality and price), a consumer selects all the firms that offer a good with **equivalent** values

$$i^*_{f_n,m} \equiv i^*_{B_n,m} \Leftrightarrow |i^*_{f_n,m} - i^*_{B,m}| < (1 - \upsilon_{z,m}) \cdot i^*_{B,m}$$

$\upsilon_{z,m}$: tolerance level

The tolerance with respect to *less–then–optimal* quality on each characteristic defines consumer class preferences.

Moving along income classes the tolerance towards *good's quality* reduces, and *price* becomes relatively indifferent

Total purchases close the model: firms sales.

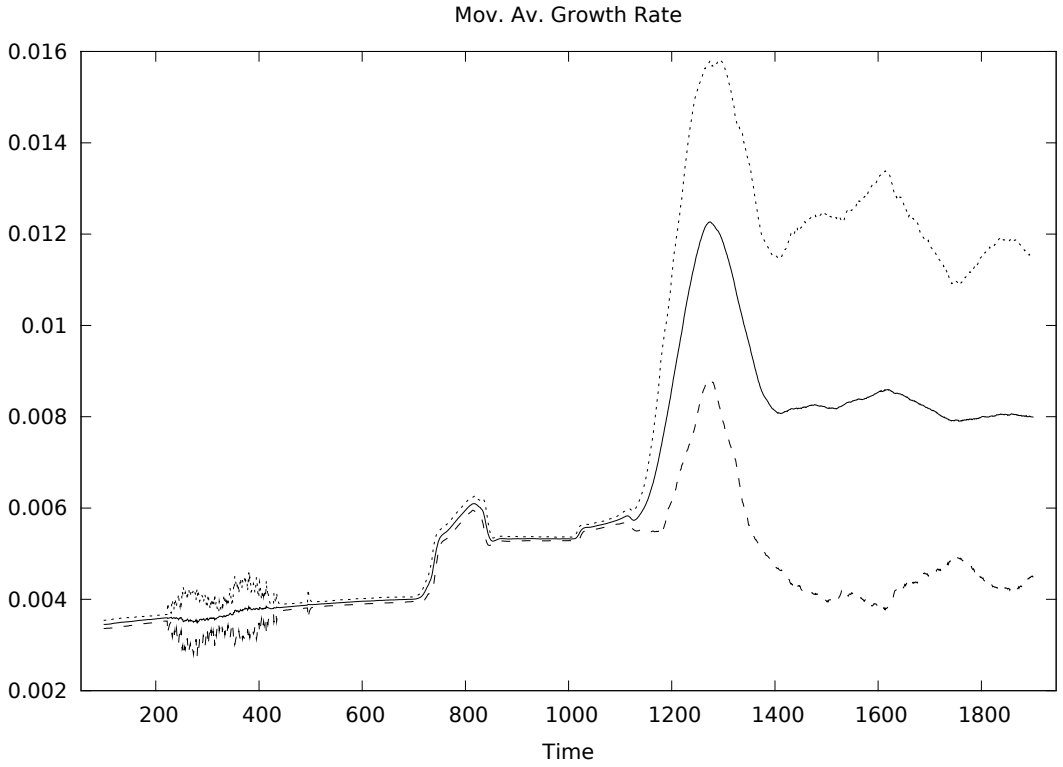
Initial conditions

1. 50 manufacturing firms initially differ only with respect to good's quality
2. 15 capital good firms
3. 2 Income classes
4. Firms hierarchical structure (number of tiers and wage differences across tiers) reflects empirical observation
5. Averages over multiple runs controls for random effects

Main results outline

1. Empirical validation and model dynamics (VAR of model's fundamentals)
2. Relation between change in capital vintages (σ^a) and in the firm organisational structure (ν)
3. Relation between the firm organisational structure (ν) and the distribution of wages and premia (b)
4. Composition of production and demand: variance of the distribution of a product's quality and price (standard deviation (sd) of $i_{2,f}$) and variance in the preferences of different earning classes ($|\upsilon^{max} - \upsilon^{min}|$)

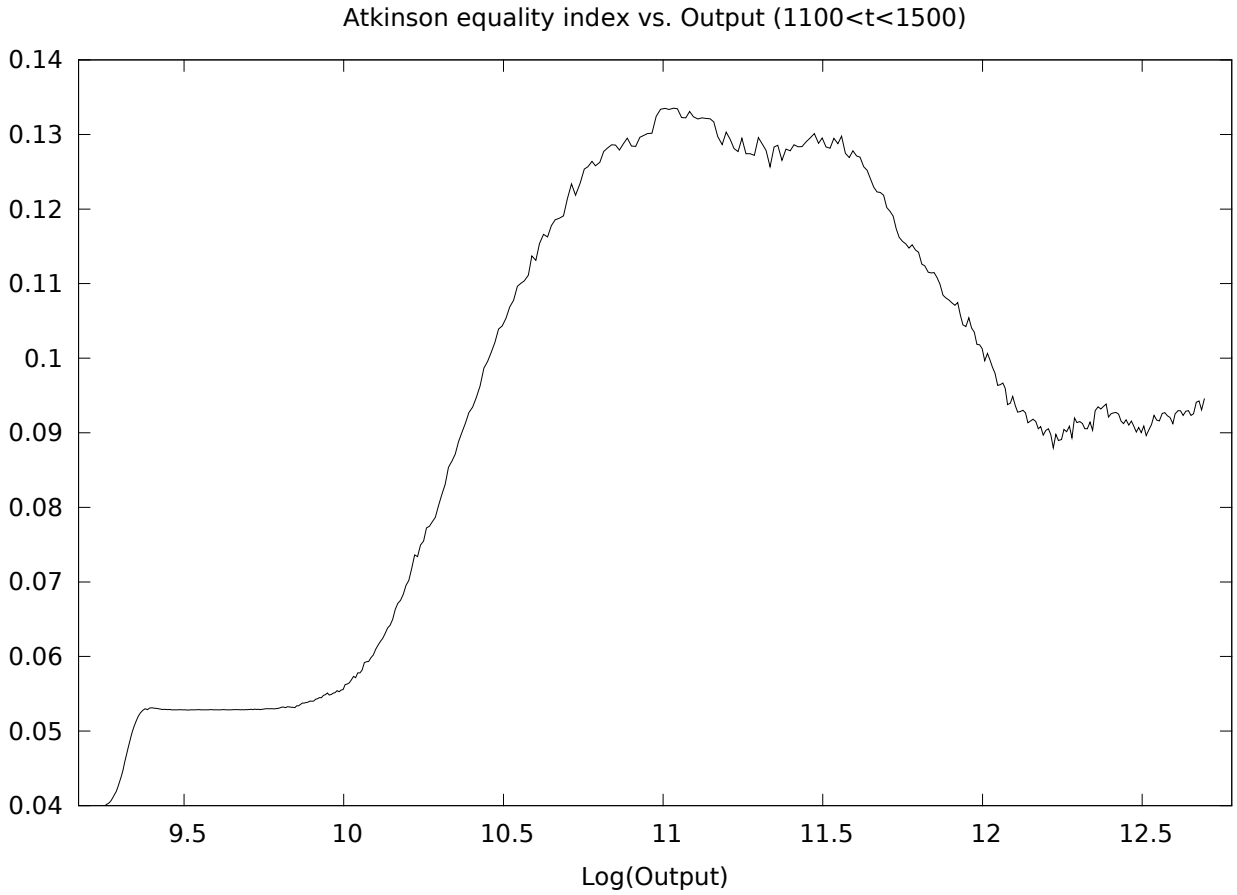
Growth rates for the economy output across time steps



Pre- and post-Malthusian growth

(1) *demand*-led regime: Stagnant Output, low (increasing) mkt concentration, increasing Productivity
(2) *Kaldorian* regime: Cumulative causation: ↑ Prod, ↓ Price, ↑ D, ↑ Investment, ↑ Firm size, ↑ Population & Consumer heterogeneity.

Kuznets curve



Atkinson inequality index vs. output (log)

Sample of data in $t \in [1100 : 1500]$ (around take-off)

Kaldor stylised facts

Table : Kaldor-Verdoorn Law *Overall Estimations*

		$\Delta Y(2000)/Y(1)$	R^2	R^2_{corr}	Obs.
(OLS)	$\Delta A(2000)/A(1)$	0.117***	0.44	0.434	100
		(0.013)			
(LAD)	$\Delta A(2000)/A(1)$	0.125***			100
		(0.030)			

Standard errors (computed with 500 bootstraps) in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table : Capital deepening and growth. *LAD estimates of the growth of K/L ratio over the 2000 periods.*

	$\Delta Y(2000)/Y(1)$	Const.	$PseudoR^2$	Obs.
$\frac{\Delta K/L(2000)}{K/L(1)}$	10.67***	2.981***	0.299	100
	(0.505)	(0.529)		

Standard errors (computed with 400 bootstraps) in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Dynamic correlation between selected macro-level indicators

Variables	(1) $\Delta Y/Y(t)$	(2) $\Delta A/A(t)$	(3) $\Delta P/P(t)$	(4) $\Delta IHI/IHI(t)$	(5) $\Delta AT/AT(t$
$\Delta Y/Y(t-1)$	1.23***	0.03	0.05	0.31	0.38***
	(0.07)	(0.02)	(0.03)	(0.20)	(0.12)
$\Delta A/A(t-1)$	0.00	1.04***	-0.02**	1.18***	-0.44**
	(0.01)	(0.04)	(0.01)	(0.31)	(0.19)
$\Delta P/P(t-1)$	-0.56***	-0.03**	1.01***	-0.02	-0.02
	(0.03)	(0.01)	(0.07)	(0.05)	(0.04)
$\Delta IHI/IHI(t-1)$	0.03***	0.01***	-0.01***	0.53***	-0.24***
	(0.00)	(0.00)	(0.00)	(0.06)	(0.03)
$\Delta AT/AT(t-1)$	0.01***	-0.01***	-0.00	0.02	0.77***
	(0.00)	(0.00)	(0.00)	(0.03)	(0.04)
$\Delta Y/Y(t-2)$	-0.11	-0.01	-0.08	-0.42**	-0.34***
	(0.09)	(0.03)	(0.06)	(0.20)	(0.12)
$\Delta A/A(t-2)$	-0.04**	0.25***	-0.01	0.54	-0.26*
	(0.02)	(0.05)	(0.01)	(0.33)	(0.15)
$\Delta P/P(t-2)$	0.84***	0.03	0.04	0.33**	0.27**
	(0.06)	(0.02)	(0.06)	(0.16)	(0.12)
$\Delta IHI/IHI(t-2)$	-0.03***	-0.01***	0.00	0.31***	0.09**
	(0.01)	(0.00)	(0.00)	(0.04)	(0.04)

Dynamic correlation between selected macro-level indicators

Momentum in growth rates: output, productivity and prices exhibit a significant cumulative causation process, at the core of the endogenous growth

Auto correlations

- cyclical output;
- productivity is autocatalytic;
- concentration is strongly persistent over time;
- price only short term variations

Macro dynamics

- market concentration increases prices and income inequality;
- price growth induces output growth with one lag
- inequality has only a marginal effect on output, changing over the different phases of growth

Organisation and production technology

- Flat Vs. pyramidal organisation: $\downarrow \nu$
- Increased technology capacity: $\uparrow \sigma^a$
- Supply:
  - $\downarrow \nu$: increase cost (workers) and dynamic heterogeneity
  - $\uparrow \sigma^a$: decrease cost (workers) and increase dynamic heterogeneity
- Demand:
  - $\downarrow \nu$: increase consumers and their heterogeneity
  - $\uparrow \sigma^a$: reduce consumers and the cost of goods

Organisation and production technology: output

σ^{α}	ν 5	6	7	10	15
0.01	**17.05**	9.64	6.50	4.77	4.66
0.02	18.13	9.67	6.53	4.79	4.67
0.03	20.52	9.85	6.58	4.80	4.69
0.04	22.94	11.27	6.67	4.85	4.71
0.05	23.53	12.99	6.84	4.90	4.74
0.06	28.13	14.50	6.81	4.94	4.77
0.08	35.01	19.83	7.43	5.21	4.93
0.1	49.53	26.12	9.58	5.64	5.29
0.13	49.90	38.17	11.69	6.09	5.32
0.16	70.45	50.10	17.45	9.62	8.11
0.2	90.28	71.69	56.11	14.98	14.33

Benchmark case in **Bold**

p<0.01, p<0.05, p<0.1:

Faster change in technology and organisational complexity

(i) $\uparrow$ GDP via effective demand: $\downarrow \nu \rightarrow \uparrow$ D $\rightarrow \uparrow$ I $\rightarrow \uparrow$ Agg. prod;
$\uparrow \sigma^{a} \rightarrow \uparrow$ Firm Prod $\rightarrow \uparrow$ D $\rightarrow \uparrow$ I $\rightarrow \uparrow$ Aggr Prod

Organisation and production technology: inequality

σ^{α}	ν 5	6	7	10	15
0.01	**0.058**	0.022	0.017	0.017	0.023
0.02	0.064	0.022	0.017	0.017	0.023
0.03	0.079	0.022	0.017	0.017	0.023
0.04	0.092	0.028	0.017	0.017	0.022
0.05	0.095	0.035	0.017	0.018	0.022
0.06	0.113	0.042	0.017	0.018	0.022
0.08	0.142	0.067	0.018	0.018	0.023
0.1	0.182	0.092	0.027	0.019	0.024
0.13	0.173	0.134	0.035	0.021	0.024
0.16	0.192	0.156	0.061	0.034	0.036
0.2	0.195	0.175	0.138	0.058	0.069

Benchmark case in **Bold**
p<0.01, p<0.05, p<0.1:
Standard errors of the joint difference of each cell with respect to the benchmark computed with a quantile regression (400 bootstraps)

Faster change in technology and organisational complexity

Increase inequality, in a non linear way (↑ output ↑ workers ↓ agg prod ↓ profit distribution).

Organisation and wage structure

- Flat Vs. pyramidal organisation: $\downarrow \nu$
- Uniform Vs. skewed compensation: $\uparrow b$
- Supply: increase cost (workers) and dynamic heterogeneity
- Demand:
  - $\downarrow \nu$: increase demand and its heterogeneity
  - $\uparrow b$: increase income classes disparities (demand of higher classes)

Organisation and wage structure: output

b	ν 5	6	7	10	15	20	25	50
1	17.69	10.78	6.83	5.17	4.99	4.96	4.94	4.92
1.25	17.44	9.86	6.73	4.81	4.63	4.61	4.60	4.59
1.5	17.53	9.82	6.78	4.72	4.55	4.53	4.52	4.51
1.75	17.15	9.82	6.84	4.80	4.60	4.55	4.54	4.52
2	**17.18**	9.85	6.91	4.92	4.65	4.59	4.57	4.54
2.25	17.25	9.90	6.97	5.04	4.73	4.63	4.60	4.56
2.5	17.09	9.94	7.02	5.16	4.81	4.66	4.62	4.58

Benchmark case in **Bold**
p<0.01, p<0.05, p<0.1:
Standard errors of the joint difference of each cell with respect to the benchmark computed with a quantile regression (400 bootstraps)

Increase in organisational complexity and wage disparities

(i) number of layers: always ↑ growth and reflects on ↑ inequality (non linear) $\Longrightarrow$ demand has a stronger effect.
(ii) wage disparities: ↓ growth and ↑ inequality: difference between prices and minimum wage

Organisation and wage structure: inequality

b	ν 5	6	7	10	15	20	25	50
1	0.008	0.002	0.000	0.001	0.007	0.014	0.019	0.038
1.25	0.016	0.002	0.002	0.003	0.008	0.013	0.017	0.031
1.5	0.028	0.007	0.005	0.005	0.007	0.010	0.013	0.023
1.75	0.039	0.013	0.010	0.009	0.010	0.013	0.016	0.025
2	**0.056**	0.021	0.017	0.014	0.012	0.013	0.015	0.022
2.25	0.075	0.029	0.024	0.019	0.015	0.016	0.017	0.021
2.5	0.093	0.038	0.031	0.025	0.019	0.019	0.019	0.022

Benchmark case in **Bold**
p<0.01, p<0.05, p<0.1:
Standard errors of the joint difference of each cell with respect to the benchmark computed with a quantile regression (400 bootstraps)

Product and preferences heterogeneity

- Homogeneous vs Heterogeneous product quality: $\uparrow$ **s.d.** i_q
- Homogeneous vs Heterogeneous consumer preferences across income classes: $\uparrow \max(v) - \min(v)$
- Supply:
  - $\uparrow$ **s.d.** i_q: Increase heterogeneity
  - $\uparrow \max(v) - \min(v)$: Increase mkt concentration, with higher consumer classes
- Demand: when both conditions hold, increase selection of higher consumer classes

Composition of production and demand: output

	$\upsilon^{max} - \upsilon^{min}$									
s.d. i_2	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1.15	13.43	13.44	13.44	13.44	13.44	13.45	13.46	14.00	**15.06**	16.24
3.15	6.34	6.30	6.32	6.33	6.31	6.34	6.30	6.38	6.83	9.80
5.15	4.75	4.75	4.75	4.75	4.75	4.75	4.74	4.75	4.85	5.83
7.16	4.71	4.71	4.70	4.71	4.71	4.71	4.72	4.72	4.75	5.05
9.16	4.69	4.69	4.68	4.69	4.69	4.70	4.69	4.69	4.71	4.84
11.17	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.67	4.69	4.77
13.17	4.66	4.66	4.66	4.66	4.66	4.66	4.66	4.67	4.67	4.72
15.17	4.63	4.64	4.64	4.64	4.64	4.64	4.64	4.65	4.66	4.70
17.18	4.61	4.62	4.62	4.62	4.63	4.64	4.63	4.63	4.66	4.69
19.18	4.63	4.60	4.61	4.63	4.62	4.63	4.63	4.64	4.67	4.71

Benchmark case in **Bold**

p<0.01,	p<0.05,	p<0.1

Standard errors of the joint difference of each cell with respect to the benchmark computed with a quantile regression (400 bootstraps)

The curse of initial large variety

(i) low GDP: ↑ s.d. i_q → ↑ concentration ↓ vacancies (no ↑ I) → ↓ D → ↓ I ⟹ ↓ Prod & L

(ii) Higher demand selection increase GDP *cp*

(iii) Stagnant unequal ec. (π distribution) VS Growing exp, mildly unequal ec

Composition of production and demand: inequality

	$v^{max} - v^{min}$									
s.d. i_2	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1.15	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.07	**0.08**	0.09
3.15	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.05
5.15	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
7.16	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03
9.16	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04
11.17	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05
13.17	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06
15.17	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.06	0.06
17.18	0.09	0.09	0.09	0.09	0.08	0.08	0.08	0.07	0.07	0.06
19.18	0.10	0.10	0.10	0.10	0.09	0.08	0.08	0.08	0.07	0.07

Benchmark case in **Bold**

p<0.01,	p<0.05,	p<0.1

Standard errors of the joint difference of each cell with respect to the benchmark computed with a quantile regression (400 bootstraps)

Non linear effect

Stagnant unequal ec. (π distribution) VS Growing exp, mildly unequal ec

Summary of results

Organisation and production technology

- Large number of organisational tiers, and large productivity gains, lead to higher output, despite higher income inequality, which after the take-off has a negative effect on growth
- Organisational tiers has a non linear effect on inequality, $\uparrow$ for very flat organisations. Initial condition of stagnating economy where profits are distributed as bonuses and not invested.

Organisation and wage structure

- Organisational and earning structures affect economic growth both via the level of aggregate demand and inequality. Large hierarchies sustain aggregate demand in the long run, inducing demand-led cumulative causation growth.
- The increase in earning disparities and inequality limits growth, due to the high cost of (managerial) labour reducing the purchasing power of the large bulk of the consumers, lower investments and slow productivity.

Summary of results

Product and preferences heterogeneity

- Product variety plays a relevant role in the economic growth of an economy only when it is generated through time and when it is accompanied by heterogeneity in consumer preferences.
- If variety is broad during the initial stages of stagnant growth, strong firm selection before the expansion of demand level and variety hinders the cumulative feedbacks.
- Economic quasi-stagnation is also accompanied by a large inequality
- In a long-run growth perspective, an economy gains from diversifying once it has built an industrial base sufficient to induce a high internal demand and investment. An initial big push toward industrial diversification is not conducive to high growth.

Main transmission mechanisms

Productivity growth, firm size and market concentration, and the distribution of income across income classes dominate the causal relations and affect most aspects of the model dynamics

1. Firm selection generates an oligopolistic competition, ↑ in capital investments by the growing firms;
2. Concentration of D and I induces ↑ high R&D investments in the capital sector, ↑ *production technology*;
3. Firm selection and market concentration result from the variety in the *composition of production*, and from the heterogeneity of *consumption patterns* emerging across consumer classes;
4. *Organisation of production* – number of managerial tiers – ↑ cost differences and price dispersion across firms, and different wage classes;
5. *Earning structure* amplifies these differences;
6. Capital I ↑ heterogeneity in the model, ↑ selection and market concentration, sustaining this cumulative causation dynamics.

Conclusions

Evidence suggesting mutual effects on the relations between structural changes in different aspects of the economy and economic growth

Structure of production, firm organisation, and structure of demand, are the main candidates to explain the growth differences.

Model that accounts for these three different dimensions of structural change, generating different patterns of growth and income distribution

Micro relations between the different aspects of structural change on the supply and the demand side

Model replicates a number of stylised facts

Analyse the main causal relations among the different aspects of structural change, growth and inequality: take-off and *Kaldorian* growth.

Analyse the conditions under which these parameters generate the take-off

Some empirical evidence of long run growth: industrial revolution in England

1. Slow increase in productivity and output
2. Stagnant living standards, slow increase in wages
3. Higher minimum wages
4. Increasing pop: mass of unskilled workers (demand) and increasing household productivity in agriculture
5. Increase in market size: shift to high income elasticity goods/sectors
   - Slow change in sectoral composition
6. Irrelevance of human capital
7. Increase in firm size and organisation of labour

Source: Voth (2003); Voigtländer and Voth (2006); Desmet and Parente (2009); Berg (2002); Mokyr (1992)

Empirical evidence of long run growth ctd.

8. Structural change
9. Innovation: small innovators turning ideas into prototypes:
   - no IPR and monetary incentives: entrepreneurs
   - cumulative process
10. Not only process innovation to increase productivity
   - New product demand driven: changing tastes, not prices

Source: Voth (2003); Voigtländer and Voth (2006); Desmet and Parente (2009); Berg (2002); Mokyr (1992)

Caveats

- Observation of economic relations: deepest causes? Abramovitz (1986)
- How are these dynamics related and why in the UK?
- One particular case

Theoretical Background - Growth

1. Development and growth as changes in the **structure** of the economy Pasinetti (1981); Sirquin (1988); Cornwall and Cornwall (1994)
2. Growth follows an **evolutionary** process:
   - Supply side selection Nelson and Winter (1982); Silverberg and Verspagen (2005); Metcalfe et al. (2006)
   - Demand and selection Dosi et al. (1994); Verspagen (2002)
   - Capital accumulation and vintages Amendola and Gaffard (1998)
   - Str. Ch. & of product variety Saviotti and Pyka (2008)
   - **Evolutionary Keynes** Dosi et al. (2010)
3. **Unified growth theory** Galor (2010); Desmet and Parente (2009)
4. **Unbalanced growth** models Murphy et al. (1989)
   - With demand changes Aoki and Yoshikawa (2002); Matsuyama (2002); Bertola et al. (2006); Patriarca and Vona (2009)

Theoretical Background ctd.

5. Patterns of **consumption** change with income *needs*: satiation Pasinetti (1981); Witt (2008, 2001)
   - Bounded rational consumer Gigerenzer (1997); Gigerenzer and Selten (2001); Valente (1999)
   - Lexicographic preferences
6. Changes in production structure affect the **distribution of income** Atkinson (1997); Aghion et al. (1999); Galbraith (1999)
   - Firms' organisation and wage tiers on income distributionSimon (1957); Lydall (1959); Rosen (1982)
7. **Methodology**: micro behaviour and generative processes Akerlof and Shiller (2009); Frydman and Goldberg (2007)
   - Computational empirically based macro Colander et al. (2008); Deissenberg et al. (2008); Howitt (2006)

Caveats (and future agenda)

- Much of the results are related to firms growth (K investment, increase workers more then proportionally, etc)
  - No population constraints
  - Need for division of labour and (structural) changes in organisation
- Very rough accounting of competition (rigid markets)
- Consumption does not increase with variety of markets, or quality

Basic model structure and short term dynamics

- **Manufacturing firms**: product technology, process technology, organisation, product innovation
- **Capital suppliers**: R&D $\Longrightarrow$ capital vintage, organisation
- **Consumers**: preferences, consumer classes, expenditure shares
- **Wages setting**: min wage (macro), labour hierarchies, bonuses

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