Discussion of the paper "From Secular Stagnation to Robocalypse? Implications of Demographic and Technological Changes", by H. Basso and J. Jimeno

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Background

Very ambitious project that merges elements of different macro trends

- **Demographic changes**: old age dependency rates projected to increase from 20.6% in 1990 to more than 50% in 2050
- **New wave of automation, robotics and artificial intelligence**: since 2012, the industrial use of robots have increased by 11% per year
- **Labour market trends**: declining labour income share, reduction of low and middle income workers' employment and wages, polarization, inequality
- **TFP and GDP growth are slowing down**: average TFP growth down from more than 2% to around 0.8%. A new secular stagnation? Are ideas harder to find?

Background

What are the effects of demography on innovation and growth?

- **Aksoy, Basso, Smith and Grasl (2018)**: population ageing and low fertility are projected to reduce output growth, investment and real interest rates

- **Acemoglu and Restrepo (2017, 2018)**: ageing boosts automation, which could boost growth offsetting the direct effects of lower labour force participation and productivity
  - Acemoglu and Restrepo (2018): Cross-country evidence of a *positive* effect of ageing on gdp per capita for 169 countries between 1990-2015

THIS PAPER

New, rich, tractable **general equilibrium model** with 2 main elements

- Demographic structure á la Gertler (1999)
- Two types of R&D activities:
  - Innovation (creation of new tasks/varieties)
  - Automation (substitute labour with robots)

Main question: *How does demographics affect technological change, automation and growth?*

Demographic structure and labor

- Tractable OLG structure based on Gertler (1999). Two types of agents - workers and retirees - who are born, retire and die with fixed probabilities
- Marginal propensity to consume is age-dependent and affected by mortality and fertility
- All workers are employed - a fixed share Sw_{RD} in the research sector and the remaining $(1 - Sw_{RD})$ in production
- Workers in the research sector are employed either in automation or in innovation

OBS: In the baseline model, workers do not respond to differences in wages

Production

$$y_t = \left[\int_0^{Z_t} y_{it}^{\frac{\psi-1}{\psi}} di \right]^{\frac{\psi}{\psi-1}}$$

Specialized varieties can be produced with labor or robots:

$$\begin{aligned} y_{it} &= \left\{ K_{it}^{\alpha} \left(\theta_t M_{it} \right)^{1-\alpha} \right\}^{1-\gamma} \Upsilon_{it}^{\gamma} \text{ for } i \in A_t \\ y_{it} &= \left\{ K_{it}^{\alpha} \left(L_{it} \right)^{1-\alpha} \right\}^{1-\gamma} \Upsilon_{it}^{\gamma} \text{ for } i \in Z_t \backslash A_t \end{aligned}$$

Robots are produced with production function

$$M_t = \varrho \Omega_t^{\eta}$$

OBS: Different from Acemoglu and Restrepo (2017, 2018) and Aghion, Jones and Jones (2017)

- Distinction between robots and capital; complementarity capital and labour
- Robots are not a durable factor...

R&D activities

- **Innovation**: creation of new tasks/varieties sustain long run growth:

$$\frac{Z_{t+1}}{Z_t} = \chi \left(\frac{S_t}{V_t A_t} \right)^{\rho} \left(\frac{L_{It}}{N_t} \right)^{\kappa_L} + \phi$$

- **Automation**: over time more tasks are automated

$$\frac{A_{t+1}}{A_t} = \lambda \left(\Xi_t, \frac{L_{A,t}}{N_t} \right) \phi \frac{(Z_t - A_t)}{A_t} + \phi$$

OBS:

- *Automation is seen as a subsidiary activity of innovation*: long run growth depends on Z_t
- Direct link between population and innovation through $\frac{L_{It}}{N_t}$
- No impact of investment in automation, robotics, A.I. on innovation (assumption relaxed in an extension)

R&D activities: mechanism

- Value of innovation J_t depends on profits of labour intensive firms and are negatively affected by labour costs and demographic changes

$$\frac{N_t^w}{N_t} \downarrow \Longrightarrow J_t \downarrow \Longrightarrow S_t, L_{It} \downarrow \Longrightarrow Z_t \downarrow$$

- Value of automation depends on the difference between the value of an automated and a labour intensive good, $V_t - J_t$

$$\frac{N_t^w}{N_t} \downarrow \Longrightarrow (V_t - J_t) \uparrow \Longrightarrow \Xi_t, L_{At} \uparrow \Longrightarrow A_t \uparrow$$

- **Key trade-off**: automation increases and can generate short-run growth, but resources are diverted from innovation and the production of new ideas is compromised

Main results:

(1) Ageing boosts automation and lowers wages and labour share

(2) Despite the productivity gains brought by automation, per capita output growth invariably declines

(3) Results are robust to:

- No labour in innovation
- Endogenous movements of workers to R&D sector
- Increases in retirement age
- Different assumptions on productivity of robots
- Robots in R&D sectors

Comments 1: Robots and the Baumol's cost disease

- **Baumol cost disease**: sectors with rapid productivity growth (e.g. agriculture, manufacturing) see their share to GDP decline
  - The relative price of automated goods is declining faster (Aghion, Jones and Jones 2017)).
- In the long run equilibrium, the **relative price of robots** q_t is increasing over time

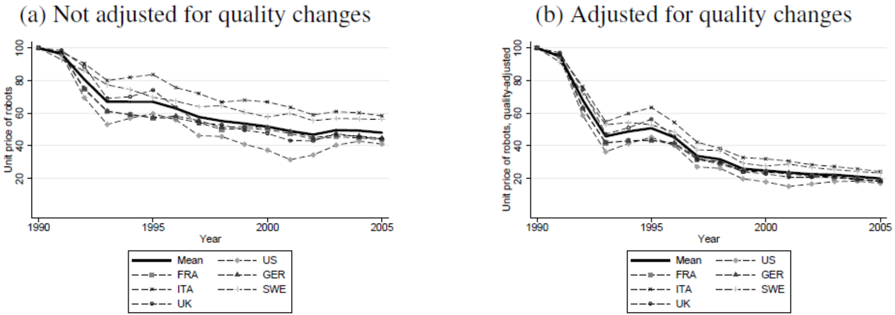
  $$g_q = g^{1-\eta}$$

  Is this consistent with empirical evidence?
- Possible solution: assume that over time robots become cheaper to produce

$$\begin{aligned} \color{red}{\varrho_t} &= \varrho A_t^{\mu} \text{ in } M_t = \color{red}{\varrho_t}\Omega_t^{\eta} \\ \Longrightarrow & \quad g_q = \frac{(g)^{1-\eta}}{g_{\varrho}} = (g)^{1-\eta-\mu} \end{aligned}$$

Problem: Implications for the medium run and long run equilibrium?

Figure 1: The Price of Robots in Six Countries 1990-2005



Graez and Michaels (2018)

Comments 2: Spillovers between innovation and automation

- In the *baseline* version of the model there is **no link between automation and innovation**
- Many authors suggest that A.I. and robotics will greatly increase R&D productivity (see e.g. Mokyr 2014, Aghion et al. 2017)
- This issue is discussed - very briefly and with a given calibration - in an extension, where R&D innovation investment is a CES of labour and robots
- *Why don't you consider the possibility of spillovers directly in the baseline model?*

$$\frac{Z_{t+1}}{Z_t} = \chi \left(\frac{S_t}{V_t A_t} \right)^{\rho} \left(\frac{L_{It}}{N_t} \right)^{\kappa_L} \left(\frac{M_{It}}{N_t} \right)^{\kappa_R} + \phi$$

Comments 3: Labour markets

- In the *baseline* version of the model, there is basically **no labour choice**: labour supply is inelastic, and the R&D share is fixed
- This is a strong assumption: following automation workers are likely to respond to wage differentials and go towards the R&D sector.
- If this mechanism is strong enough, it could actually sustain growth even after population ageing
- In an extension, the paper allows for labour choice, but only for new entrants (which are a small portion of population)

What would happen if labour moves freely across sectors?

Other Comments

Quantitative exercise:

- How sensitive are the results to the specific calibration? Steady state and sensitivity analysis?
  - For example, to achieve balance growth you need $\eta = 0.15$ in $M_t = \varrho_t \Omega_t^{\eta}$.
- How well does the model fit "in sample"? How well does it match evolution between 1990-2007?

How do you reconcile your findings with Acemoglu and Restrepo (2017, 2018)?

Conclusion

- Very nice paper on a very important question
- Well written and quite powerful explanation of the effect of demography on innovation, automation and growth
- A lot of interesting policy implications and directions for future research!
    - Implications for the pension system, social security, health system, fertility choices and policies, immigration policy, etc....