Intangible Capital and Innovation: Extending the Neoclassical KLEMS Model and EU/US Productivity Growth

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Disclaimer: opinions those of authors

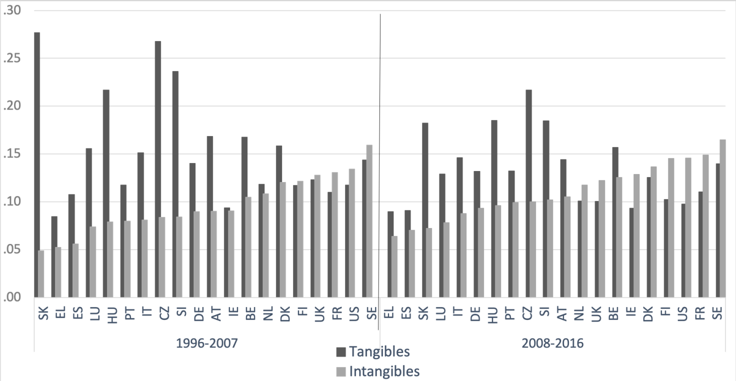
Background

- The changing nature of the global economy has placed novel attention on intangible capital as a source of economic growth.
- Our paper demonstrates the increased relevance of intangible capital using the neoclassical theoretical and empirical framework for analyzing factors affecting economic growth developed by Dale Jorgenson (and co-authors) over the years.
- Our paper
  - (a) sets out a model for thinking about the role of knowledge investments and innovation in fostering economic growth;
  - (b) uses standard growth accounting decompositions to illustrate the empirical relevance of intangible capital deepening as a source of growth, and
  - (c) considers how knowledge spillovers from investments in both R&D and nonR&D intangible assets might contribute to our understanding of the slowdown in productivity since the global financial crisis.

Measuring intangible investment: **INTAN-Invest**

- **INTAN-invest** is a research collaboration dedicated to improving the measurement and analysis of intangible assets (see `http://www.intaninvest.net`).
- Our analysis uses a recent release of the **INTAN-Invest©2018** dataset, covering the market sector of 20 European countries and the United States through 2016.
- Detailed methodological information can be found in
  - C. Corrado, J. Haskel, C. Jona-Lasinio , M. Iommi (2016). *"Intangible investment in the EU and US before and since the Great Recession and its contribution to productivity growth*," in "Investment and Investment Finance in Europe" , Chapter 2, p. 73-102, European Investment Bank Report, November 2016.

Intangible and tangible investment shares of GDP



- Intangible shares of GDP vary considerably across countries, ranging from 6 and 7 percent to 15 and 16 percent for the two lowest and two highest in the latter period;
- the gap between countries above and below the median intangible share did not narrow over the two periods, but intangible investment shares for all countries rose or stayed the same.

- The model has two sectors, an upstream, or knowledge-producing, sector and a downstream, or knowledge-using, sector.
- The upstream sector takes freely available concepts or ideas - basic knowledge - and produces "finished" ideas or commercial knowledge (e.g., blueprints), Nt.
- The upstream/downstream framework is then set out as follows:

$$N_t = F^N(L_t^N, K_t^N, R_t^N; t); \quad P_t^N N_t = \mu_t(P_t^L L_t^N + P_t^K K_t^N) \tag{1}$$

$$Y_t = F^Y(L_t^Y, K_t^Y, R_t^Y; t); \quad P_t^Y Y_t = (P_t^L L_t^Y + P_t^K K_t^Y + P_t^R R_t^Y). \tag{2}$$

- There are then two sources of knowledge spillovers in this model:
  - i.e., upstream commercial knowledge production directly reflects "free" public knowledge as inputs, and
  - downstream a^Y will reflect the diffusion of partially appropriable commercial knowledge R^Y—or directly appropriable R^N, i.e., an "excess"return to R that accrues to society.

- Without the capitalization of intangibles, GDP consists soley of downstream sector output Y, but when investments in innovation are capitalized, the growth of aggregate value added reflects current production in both sectors Q:

$$P^Q Q = P^Y Y + P^N N \equiv P^C C + P^I I + P^N N \quad . \tag{3}$$

- Log differentiating (1), (2), and using (3), we obtain the following sources-of-growth (SOG) decomposition with intangible capital

$$dq = s_Q^C dc + \underbrace{s_Q^I di + s_Q^N dn}_{\text{Expanded Investment}} \quad . \tag{4}$$

- Competitive innovation $\mu = 1$

$$da = s_Q^Y da^Y + s_Q^N da^N \tag{5}$$

- Costly innovation $\mu > 1$

$$da = s_Q^Y da^Y + \frac{s_Q^N da^N}{\mu} \tag{6}$$

- When intangibles are ignored, TFP measured as the change in the sum of value added inputs subtracted from the change in value added output (da_m), that is:

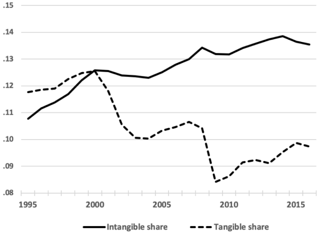
$$
\begin{aligned}
da_m = \; & \underbrace{da}_{\text{Knowledge spillovers}} \\
- \; & \underbrace{(dq - dv)}_{\text{Missing investment, } N} \\
+ \; & \underbrace{\sigma_Q^R(dr^Y - dx)}_{\text{Misstated returns to } R} \\
- \; & \underbrace{(dx' - dx)}_{\text{Overweighted } K \text{ input}} \quad .
\end{aligned}
\tag{7}
$$

- understate actual TFP growth (da) to the extent the growth in intangible investment exceeds the growth in value added output, but
- overstate actual TFP growth due to the fact that only some portion of the returns to fast-growing intangibles are captured in conventional input measures.

Productivity slowdown

- In the context of the current slowdown in measured productivity da_m, what does the intangibles-augmented SOG framework say about what might have caused it?
- Consider that productivity may be mismeasured due to uncounted intangibles, there are two important aspects to the impact of this mismeasurement:
  - There are unmeasured intangibles, and they are fast-growing, leading measured TFP growth (da_m) to understate actual TFP growth.
  - Or, unmeasured intangibles grow only slightly faster than conventional value added inputs, but they have a large share (σ^{R^Y}) and boost measured TFP growth.
- In recent work, Brynjolfsson, Rock and Syversson (2018) suggest the introduction and rise of artificial intelligence (AI) might be an example of bias to current measures of TFP.
- AI investments are both fast-growing and missing, and this is why the slowdown might be expected to be temporary—the returns to AI have yet to come.

Intangible and tangible investment shares of GDP

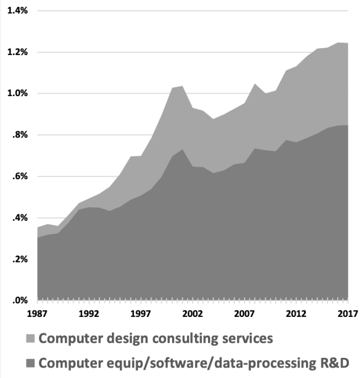


(a) Europe plus United States

(b) Europe (left) versus United States (right)

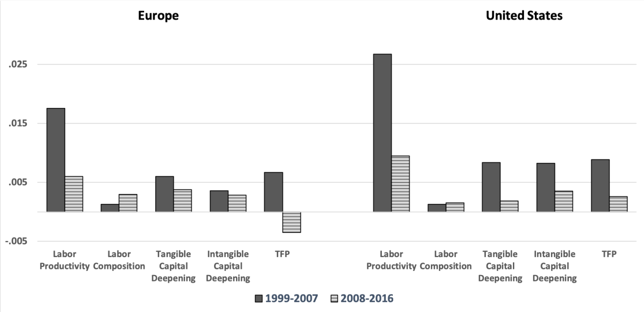
Note—See section 3.1 for industry and country coverage. Shares are of aggregate GVA including all intangibles.
Source—Authors' elaboration of data from INTAN-Invest@2018, EU KLEMS, Eurostat, and national accounts for European countries and the United States.

Indicators of AI Product Development in the United States (percent of GDP)



- While data on computer design consulting services for Europe are lacking, estimates of computer-related R&D based on industry-level estimates from EU KLEMS suggest the pace of these investments are generally stable relative to GDP in Europe.
- This differential pattern is consistent with established patterns in EU-US productivity comparisons, namely, that ICT investment rates are relatively higher and more dynamic in the United States.

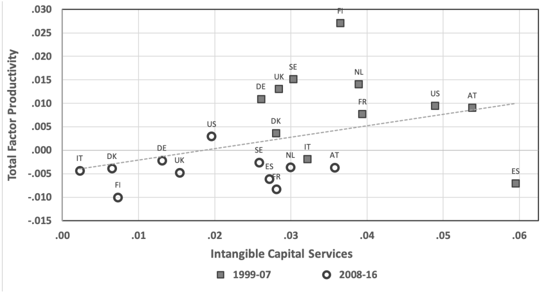
Sources of growth results



- In the pre-crisis years (1999–2007), labor productivity grew at faster pace in the United States (2.7 percent per year) compared with Europe (1.8 percent per year); both were largely driven by capital deepening that accounted for about 60 percent of the advances in labor productivity. TFP growth was a relevant driver in both geographies during this period.
- The overall picture is remarkably different in the during/post-crisis period (2008–2016), when the slowdown was driven by both a decline in capital intensity and weak/negative changes in TFP.
- Over the two periods, TFP slowdowns of 1.0 percentage point per year (Europe) and .63 percentage points per year (United States).

Spillovers to Intangible Capital Services

- CHJL (2017) found a positive correlation between TFP and intangible capital services growth rates, consistent with a spillover relationship driven by partial appropriability. Data below suggest that a relationship persists in recent years.



- Assuming the previously estimated spillover coefficient $\hat{\beta}$ is applicable to recent experience and revised data, how much of the TFP decline can be accounted for by the slowing of intangible investment?
- Applying the CHJL findings that $\hat{\beta} = .2$ to the figures for the slowdown in intangible capital services, we find that knowledge spillovers can account for *nearly all* of the slowdown in productivity in the United States and one-third of the decline in TFP growth in Europe.

- Our investigation of intangibles and the productivity slowdown found:
  - the decline in capital deepening (tangible and intangible) directly accounts for a large part of the labor productivity slowdown after the financial crisis but that intangible capital growth recovered comparatively faster than tangible capital, especially in the United States;
  - the positive cross-country relationship between TFP and intangibles continues to suggest that knowledge spillovers arise from investments in both R&D and nonR&D intangible assets, i.e., as in CHJL 2017;
  - when the estimated spillover relationship is applied to recent data, the decline intangible capital growth accounts for the decline in estimated TFP growth in the United States but explains very little of the larger TFP growth decline in Europe.