The Puzzling Convergence of Intangible Investments

Angelos A. Antzoulatos1 · Dimitris Karanastasis1 · Thomas Syrmos1

Accepted: 22 November 2022/Published online: 5 December 2022
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Abstract  Motivated by the rising prominence of intangibles, this paper explores whether there are common forces that drive intangible investments in the U.S. and the Euro area, in tandem with firm-specific characteristics. If such forces exist, there should be groups of firms (convergent clubs) for which the time-varying cross-sectional variance of intangible investments (scaled by total assets) declines over time. The empirical results indicate that there is a big convergent club in both economic areas, the sectoral composition of which is similar to that of the entire sample, an indication that the common forces are economy-wide and not sector-specific. Moreover, the country composition of the big club in the Euro area is also similar to that of the entire sample, an indication that they are not country-specific either. More puzzling, the evidence of common forces is stronger for the Euro area countries, despite their differing overall economic and financial-market conditions, and that their bank-based financial systems are less likely to finance intangible assets than the U.S. market-based one. The paper also used probit analysis to identify the common forces; but this analysis did not yield any firm results. Nevertheless, the main finding of the paper, itself a novel contribution to the rapidly growing literature on intangibles, suggests another angle to re-examine the existing empirical literature and identifies potential misspecification problems of related microeconomic studies. As such, it should be of interest to researchers, market participants, and to standard-setters and policymakers who base their decisions on empirical studies.

Keywords  Intangible investments · Convergence · Phillips and Sul algorithm

JEL  E20 · G30 · G32 · C33

* Angelos A. Antzoulatos
antzoul@unipi.gr

1 Department of Banking & Financial Management, University of Piraeus, 80 Karaoli & Dimitriou Street, 18534 Piraeus, Greece
Introduction

In today’s economy, most sectors (industrial ones notwithstanding) rely heavily on services and technologies, a development that highlights the importance of intangible assets, such as human capital, innovative products, brands, patents, software, customer and supplier relationships, database collection and processing, and distribution systems. Indicatively, Corrado and Hulten (2010) estimated that, during the period 1995–2007, intangible assets accounted for 34% of total corporate capital in the U.S. nonfarm business sector. Using a sample of U.S. firms involved in more than 1,500 acquisition events, Ewens et al. (2019), estimated that intangible assets increased from 37% of total assets in 1975 to 60% in 2016. Across sectors, this proportion in 2016 ranged from 40% in manufacturing to more than 80% in healthcare. At the macro level, Gu and Lev (2017) reported that investments in intangible assets in the U.S. increased from 9% of gross value-added in 1977 to 14% in 2014, while investments in tangible assets declined from 15% of gross value-added to 9% over the same period. As corroborating casual evidence, the combined stock-market capitalization of the six biggest tech companies, Facebook, Amazon, Apple, Netflix, Alphabet-Google and Microsoft (FAANGM), was $9.29 trillion in October 2021, more than 20% of the entire stock market capitalization.

Motivated by the rising prominence of intangibles, this paper uses the Phillips and Sul (2007) convergence algorithm to explore whether there are any common forces that drive intangible investments. This algorithm tests for convergence for a group of cross-sectional units (firms) either as a whole or in subgroups of one or more convergent clubs. Lack of convergent clubs would indicate that firm-specific characteristics dominate the relevant decisions of firms, here intangible investments (scaled by total capital). At the other end, convergence in levels would indicate that some, common to all club members, force(s) drive(s) intangible investments to the same value. In between, convergence in rates would indicate that both firm-specific and common forces work in tandem, the former sustaining the distance between the firms as time goes by, while the latter causes intangible investments to move in parallel. The common force(s) may be related to specific sectors or to the overall economic and financial-market conditions in a country.

The results, from a sample of 843 United States (U.S.) firms for which relevant data exist for the period 1990–2020, indicate that there is convergence in rates. Specifically, there are four convergent clubs, the biggest of which comprises 65% of the sample firms, while the share of the remaining three clubs ranges from 6 to 15%. For a sample of 251 European firms from eight Euro area countries over the same period, convergence is seemingly stronger. There are only two clubs with convergence in rates, the biggest of which comprises 87% of the sample firms. In both samples, the sectoral composition of the big convergent club is similar to that of the whole sample, an indication that sector-specific forces are not behind convergence. Additionally, in the Euro area sample, the country composition of the big club is similar to that of the whole sample, an indication that convergence is not driven by country-specific forces, but by forces operating across the Euro area.
The existence of the two big convergent clubs is puzzling, but even more so is the stronger convergence in the Euro area. For one thing, the economic and financial market conditions, such as financial development, competition in the banking sector, contract enforcement, bankruptcy rules and access to credit information (Demmou et al., 2019) differ across the Euro area countries. Thus, the forces that might lead to a big convergent club are likely to be weaker than in the U.S. In addition, the U.S. market-based financial system is more likely to finance intangible investments than Europe’s bank-based financial systems (Demmou et al., 2019). Hence, given convergence, one would reasonably expect it to be stronger in the U.S.

To shed some light on this puzzle, probit analysis was used to explore the measurable characteristics of the firms in the big clubs. The underlying expectation was that these characteristics might help identify the forces behind convergence. Unfortunately, no firm insights emerged from that analysis.

**Literature Review**

To the best of our knowledge, this is the first paper that identifies this puzzle. As such, the paper contributes to the rapidly growing literature on intangibles which, so far, has explored issues related to the rising importance of intangibles, productivity, measurement, information asymmetry, financing, and asset pricing.

The importance of intangible capital as a driver of productivity growth has been widely recognized both at the macroeconomic and microeconomic/firm levels. At the macroeconomic level, the positive effects of intangible capital are viewed as externalities that lead to regional concentration of economic activity (Corrado et al., 2009, 2012; Goodridge et al., 2017). In turn, this promotes economies of scale, workforce specialization and lower transaction costs, all of which improve efficiency at the firm and local-economy level (Duranton & Puga, 2004; Krugman, 1991, 1998). At the firm level, intangible capital has been recognized as an important determinant of innovation and growth (Ilmakunnas & Piekkola, 2014; Marrocu et al., 2012; Riley & Robinson, 2011). Related to this, Li et al. (2021), found evidence that the adoption by U.S. state governments of addback statutes, in order to constrain the use of intangible assets in tax-motivated state income shifting, impeded corporate innovation.

It has also been recognized that the measurement of intangible assets is difficult (Riley & Robinson, 2011) and further complicated by the lack of an accurate definition (Marrocu et al., 2012; Webster & Jensen, 2006). Intuitively, intangible assets are more firm-specific and, thus, less comparable across firms than tangible assets (e.g., fixed assets, real estate, factories, and equipment). Compounding the difficulty, the existing accounting and reporting rules have not kept pace with the rise of intangible investments (Dugar & Pozharny, 2021), potentially leading to significant mismeasurement of important firm characteristics, such as productivity (Bhandari & McGrattan, 2021; Corrado et al., 2009; Haskel & Westlake, 2017), book equity and earnings (Lev, 2019; Srivastava, 2014).

The preceding suggests that the increase in intangible assets may have been associated with an increase in information asymmetry. Consistent with this, Gu and Wang (2005)
found that analysts’ earnings forecast errors were larger for more intangible-intensive firms, the hypothesis being that intangible assets are associated with information complexity. In addition, Palmon and Yezegel (2012) found that analysts’ recommendation revisions were more valuable for firms with high research & development (R&D) intensity, the hypothesis being that R&D intensity increases information asymmetry. Furthermore, Dugar and Pozharny (2021) found that the value relevance of book equity and earnings declined only in firms with high intangibles.

Turning to financing, Segol et al. (2021) showed that quantity rationing is a primary determinant of borrowers’ propensity to invest in intangible assets. Related to this, Montresor and Vezzani (2016) found that the lack of tangible collateral is one of the obstacles frequently identified by investing firms. In addition, Demmou et al. (2019) concluded that market-based systems are more likely to finance intangible assets, as equity investors are more willing to finance risky investments without collateral, a conclusion that neatly encompasses the findings and intuition of the papers mentioned previously.

Lastly, Gulen et al. (2022) showed that incorporating intangibles into the empirical factor models of Fama and French (1993, 2015) and Hou et al. (2015) significantly improved these models, especially over recent decades during which intangible investments became increasingly important. In addition, Peters and Taylor (2017) argued that there is a role for intangible capital in neoclassical investment theory. According to this theory, tangible capital plays a prominent role. They also proposed a new Tobin’s Q measure that incorporates intangible capital, with excellent empirical results.

Empirical Issues

Convergence Algorithm

The methodology to test for convergence was developed by Phillips and Sul (2007), hereafter referred to as PS. In essence, this methodology tests whether the dispersion of the variable of interest across cross-sectional units declines over time. Let \( X_{it} \) denote the variable of interest, with \( i = 1, 2, \ldots, N \) and \( t = 1, 2, \ldots, T \) denoting, respectively, the cross-sectional units and time periods. \( X_{it} \) is deconstructed into a common, \( g_{it} \), and an idiosyncratic, \( a_{it} \), component. Convergence occurs when the idiosyncratic components across the cross-sectional units converge over time.

\[
X_{it} = g_{it} + a_{it}
\]

PS transform Eq. (1) such that \( X_{it} \) is decomposed into two time-varying components, one common, \( \mu_t \), and one idiosyncratic, \( \delta_{it} \),

\[
X_{it} = \left( \frac{g_{it} + a_{it}}{\mu_t} \right) \mu_t = \delta_{it} \mu_t, \text{ for all } i, t
\]

In this way, testing for convergence is equivalent to testing whether the idiosyncratic components \( \delta_{it} \) converge. To this end, PS define the relative transition parameter,
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where \( h_{it} \) measures the idiosyncratic component \( \delta_{it} \) in relation to the panel average, \( \frac{1}{N} \sum_{i=1}^{N} X_{it} \). Note that its mean is equal to 1 for all \( t \), and the time-varying cross-sectional variance, \( H_t \), is

\[
H_t = \frac{1}{N} \sum_{i=1}^{N} (h_{it} - 1)^2.
\]

Under convergence, \( H_t \) declines over time.

PS developed a formal econometric procedure to test for convergence. Briefly, the null hypothesis of convergence is rejected if the t-statistic of the estimated \( \hat{b} \) coefficient in Eq. (2) is below the critical value of -1.65.

\[
\log \frac{H_1}{H_t} - 2\log(t) = c + b \log(t) + u_t,
\]

(2)

In the case of convergence, the absolute value of \( \hat{b} \) determines whether convergence is in rates or in levels. \( |\hat{b}| < 2 \) implies convergence in rates and \( |\hat{b}| \geq 2 \) implies convergence in levels. The standard errors are heteroskedasticity and autocorrelation consistent (HAC). The data for this regression start at \( T_0 = [rT] \), where \( [rT] \) is the integer part of \( rT \) and \( r = 1/3 \), as suggested by PS.

Furthermore, PS extend their algorithm to test for convergent clubs in case there is no convergence for the full sample. The cross-sectional units not belonging to any club are characterized as divergent.

### Application to Intangible Investments

Regarding the variable of interest, the idiosyncratic component, \( \delta_{it} \), corresponds to firm-specific forces that affect the relevant decisions of firms, while the common component, \( \mu_t \), corresponds to sector-specific and/or economy-wide forces. The latter pertain to both economic and financial-market conditions. If, as previously mentioned, the firm-specific forces are significant, there cannot be convergence in levels, only in rates. In this case, if economy-wide forces are driving convergence, there will be a big convergent club whose sectoral composition will be similar to that of the whole sample. By the same logic, if the sector-specific forces are driving convergence, the composition of each convergent club will be dominated by firms in one or more sectors. ‘Dominated’ means that these clubs will have a higher proportion of firms from these sectors relative to the whole sample.

In the Euro area, country-specific forces may also drive convergence. In this case, the convergent clubs will be dominated by firms in one or more countries. However, if the common forces operate across the Euro area, there will be one big convergent club. Moreover, as stated in the introduction, when a big convergent club exists, one would expect stronger evidence of convergence in the U.S.
Data

The variable of interest, intangible investment, was calculated as in Peters and Taylor (2017):

\[ \text{Research} \& \text{Development (R\&D)} + 0.3x(\text{Sales, General} \& \text{Administrative (SG\&A) expense}), \]

scaled by total capital. Total capital was also calculated as in Peters and Taylor (2017).

The sample includes all Refinitiv/Eikon listed firms except financials (TRBC Business Classification) (Refinitiv, 2022a), economic sector 55), utilities (59), real estate (60), institutions, associations & organizations (61), government activity (62) and academic & educational services (63). The sample period is 1990–2020. Firms with missing values were excluded, as the PS algorithm works with balanced panels.

Results

Main Results

Table 1 summarizes the results of the Phillips and Sul (2007) convergence tests. Column (1) shows the sample and number of firms. Columns (2) and (3) show the results of the tests for full-sample convergence, and column (4) displays the conclusion: when the \( t \)-statistic, \( t_b \), is less than the critical value of -1.65, there is no convergence. Column (5) shows the number of the convergent clubs. The next three columns present the results of the convergence tests for the big convergent club; when the estimated coefficient \( \hat{b} \) is less than 2 in absolute value, it is convergent in rates. The next column shows the percentage and the number (in parentheses) of firms in the big convergent club. The last column displays the percentage and the number of firms in the remaining convergent clubs.

As Table 1 indicates, there is no convergence for the full sample for either the U.S. or the Euro area samples. In both cases, \( t_b \) is less than the critical value of -1.65. However, there are convergent clubs, with convergence in rates: 4 in the U.S. and 2 in the Euro area. For all convergent clubs, for both samples, \( t_b \) is greater than -1.65 and \( \hat{b} \) is between 0 and 2 in absolute value. In addition, there are no divergent firms.

Two things stand out in these results. First, the existence of a big club. For the U.S. sample, the biggest club comprises 65.2% of the sample firms. For the Euro area, this proportion rises to 87.2%. Notably, convergence is not likely driven by sector-specific forces for, as Table 2 documents, the sectoral composition of the whole sample and the big club are essentially the same. Table 2, column (1) displays the sector according to the TRBC Business Classification (Refinitiv, 2022a) system. Columns (2) and (3) show the sectoral composition: the number of firms and percentage of the whole sample. Columns (4) and (5) display the same information for the big convergent club for the U.S. sample. The remaining four columns show the same information for the Euro area sample. Furthermore, convergence in the Euro area sample is not likely driven by country-specific forces (Table 3). The country composition of the whole sample and of the big club are essentially the same.
### Table 1: Convergence tests results for 1990–2020

| Sample               | Full sample | # of clubs | Big club | % of firms in other clubs |
|----------------------|-------------|------------|----------|--------------------------|
|                      | $\hat{b}$  | $t_b$      | Convergence | $\hat{b}$  | $t_b$      | Convergence | % of firms |
| U.S (843 firms)      | -3.31       | -18.31     | No        | 4                       | -0.14       | -1.24      | In rates   | 65.2% (550)   | 5.8%–15.4% (49–131) |
| Euro area (251 firms)| -1.65       | -4.47      | No        | 2                       | -0.80       | -1.61      | In rates   | 87.2% (219)   | 12.7% (32)      |

Data Source: Worldscope (Refinitiv, 2022b)
| Sector                  | U.S. sample |                           | Euro area sample |                           |
|-------------------------|-------------|-----------------------------|-----------------|-----------------------------|
|                         |             | Whole sample | Big club | Whole sample | Big club | Whole sample | Big club | Whole sample | Big club | Whole sample | Big club |
|                         | # of firms | % of total sample | # of firms | % of total sample | # of firms | % of total sample | # of firms | % of total sample | # of firms | % of total sample |
| Basic Materials         | 34         | 4.0%          | 26       | 4.7%          | 30         | 11.9%          | 28         | 12.8%          |
| Consumer Cyclicals      | 157        | 18.6%         | 121      | 22.0%         | 73         | 29.1%         | 59         | 26.9%         |
| Consumer Non-Cyclicals  | 45         | 5.3%          | 33       | 6.0%          | 24         | 9.6%          | 19         | 8.7%          |
| Energy                  | 56         | 6.6%          | 36       | 6.6%          | 7          | 2.8%          | 7          | 3.2%          |
| Healthcare              | 187        | 22.2%         | 108      | 19.6%         | 22         | 8.8%          | 19         | 8.7%          |
| Industrials             | 137        | 16.3%         | 90       | 16.4%         | 47         | 18.7%         | 46         | 21.0%         |
| Technology              | 227        | 26.9%         | 136      | 24.7%         | 48         | 19.1%         | 41         | 18.7%         |

Data Source: Worldscope (Refinitiv, 2022b)
Second, contrary to expectations, the evidence of convergence is stronger for the Euro area sample. Specifically, there are two convergent clubs, versus four for the U.S. sample, and the biggest club comprises a much bigger fraction of the sample firms, 87.2% vs. 65.2%.

Characteristics of the Firms in the Big Convergence Club

To shed some light on these results, probit analysis was used to explore the measurable characteristics of the firms in the big clubs. Probit was chosen because the dependent variable is dichotomous. It takes the value of one for the firms in the big club and zero otherwise. The underlying expectation was that the statistically significant explanatory variables might help identify the forces behind convergence.

The potential explanatory variables and their expected signs are from the literature review. Briefly, a positive coefficient of the ratio market value to book value, a proxy of growth prospects, would provide evidence that the common forces are related to the stock market. It would also be consistent with the assessment by Demmou et al. (2019) that a market-based system is more likely to finance intangible investments. Likewise for earnings before income taxes (EBIT), a proxy of profitability, the logic being that shareholders benefit more from the upside potential of firms than debt-holders.

Moreover, a positive coefficient of (log) total assets would be consistent with the expectation that lenders are more willing to finance big firms because these firms are, all else equal, less likely to default (Montresor & Vezzani, 2016; Segol et al., 2021), hence the common forces could be related to the banking sector and the debt markets. Likewise, a positive coefficient of total debt to total assets would be an indication that, due to the common forces, firms had the opportunity to borrow to finance intangible investments. Lastly, a positive coefficient of sales to total assets would be consistent with the need of firms to invest more in distribution channels, customer relationships and databases, all of which are part of intangible capital.

The values of these variables are from 2020, at the end of the sample period. As a robustness check, and to account for the dynamic nature of convergence, probit was

| Table 3 | Country composition of the Euro area big club for 1990–2020 |
|---------|----------------------------------------------------------|
|         | Whole sample                                           | Big club                   |
|         | # of firms | % of the total sample | # of firms | % of the total sample |
| Austria | 10         | 4.0%                   | 10         | 4.6%                   |
| Belgium | 7          | 2.8%                   | 7          | 3.2%                   |
| Finland | 13         | 5.2%                   | 12         | 5.5%                   |
| France  | 35         | 13.9%                  | 32         | 14.6%                  |
| Germany | 87         | 34.7%                  | 75         | 34.3%                  |
| Greece  | 27         | 10.8%                  | 21         | 9.6%                   |
| Italy   | 60         | 23.9%                  | 51         | 23.3%                  |
| Netherlands | 12 | 4.8%                   | 11         | 5.0%                   |

Data Source: Worldscope (Refinitiv, 2022b)
also run using the average 2016–2020 values of the potential explanatory variables. In further robustness checks, the two probit models were run with country (for the Euro area sample) and sector dummies. Note, however, that the results of the Euro area sample should be viewed with caution, due to the very high percentage of the firms in the big club (more than 85%).

Again, the sample includes all Refinitiv/Eikon listed firms except financials, utilities, real estate, institutions, associations & organizations, government activity and academic & educational services. Firms with a missing or non-positive book value of assets or sales and firms with less than $5 million in physical capital were excluded, as is standard in the literature. Also, all variables were winsorized at the 0.5% level to remove outliers.

The results, similar in all specifications, do not provide any firm insights about the forces behind convergence. Briefly, for the U.S. sample, sales to total assets and (log) assets, both with positive signs, are significant at the 5% or higher level. However, the economic significance is low, as indicated by the less than 3% (pseudo) R². For the Euro area sample, (log) assets, with a positive sign, is significant at the 5% or higher level, while the (pseudo) R² is around 10%.

Further Research

Despite that the probit analysis did not provide any concrete evidence about the forces behind convergence, the main finding of the paper, the existence of a big convergent club, suggests several research questions that are worthy of further investigation. To begin with, it provides a new angle to re-examine existing empirical evidence, an angle that should be of interest to both researchers and market participants. Consider, for example, the studies that explored analyst forecasts and intangibles (Dugar & Pozharny, 2021; Gu & Wang, 2005; Palmon & Yezegel, 2012). Another way to split the sample, other than high vs. low intangibles as in the existing literature, is convergent club firms vs. all others. The researchers may not know what the common forces are, but the analysts, who examine a vast array of quantitative and qualitative information, may take these forces into consideration. Similarly for the papers that explore intangible assets and firm financing.

Moreover, the finding that there are common forces driving intangible investments, which operate at the economy-wide level, raises the possibility of potential misspecification problems in microeconomic studies of the determinants of intangible investments. These problems potentially apply to every variable for which there exist big convergent clubs, something researchers and policymakers who estimate and use empirical models must take into account.

Briefly, let $X_{i,t}$ denote the variable of interest in the panel estimation $X_{i,t} = a_i + bZ_{i,t} + dY_t + eC_t + u_{i,t}$; $Z_{i,t}$ is a vector of firm-specific characteristics, $Y_t$ a vector of variables related to the common forces driving convergence, $C_t$ a vector of country-specific variables, $b$, $d$ and $e$ are the respective coefficient vectors, $a_i$ the cross-sectional intercepts and $u_{i,t}$ the usual stochastic term. Not including $Y_t$ in the equation would result in biased estimates of the firm-specific and the country-specific variables that are correlated with the omitted $Y_t$. Additionally, and related to the current paper, estimating this equation would result in lower significance of the
variable(s) in $Y_t$ because they affect only the firms in the big convergent club. Even worse, some significant variable(s) might become insignificant. Hence, the estimated equation would not provide reliable indications of what the common forces might be.

Returning to the seemingly stronger convergence in the Euro area relative to the U.S., a possible explanation might be the strong intervention of the European Central Bank (ECB), starting with the European debt crisis in the early 2010s, to avert the then perceived as existential threat for the euro, and continuing with the unconventional monetary-policy measures in the middle of the decade, in an effort to combat the then looming deflation, and in 2020, to ameliorate the economic fallout from the Covid-19 pandemic. This prolonged intervention may have weakened the effect on intangible-investment decisions of the diverging economic and financial-market conditions across the Euro area countries and strengthened the effect of the common across the Euro area forces.

Looking forward, another interesting question is whether the forces behind convergence will continue operating in the future. Consider the case where these forces were related to the rise of global supply chains in the 1990s. These chains allowed U.S. and European firms to subcontract a bigger part of production to other firms all over the world, thus reducing their own need for investments in tangible assets. Could the unravelling of the global supply chains, in the wake of the Covid-19 crisis and the rising geopolitical risks, lead to higher tangible investments by firms and, thus, strengthen the firm-specific determinants of intangible investments and weaken convergence? In such a case, while intangible assets will continue to be crucial for competitiveness (Marrocu et al., 2012), tangible investments could become a necessary condition in the emerging new economic environment. As a result, the implied hollowing out of the productive capacity of U.S. and European firms, a side effect of the presumed subcontracting, may in the future be associated with higher stock-price volatility of firms with high intangibles.

Acknowledgements This research was co-financed by Greece and the European Union (European Social Fund - ESF) through the Operational Programme “Human Resources Development, Education and Lifelong Learning 2014-2020” in the context of the project “Intangible capital, finance and banking institutions” (MIS 5050635). We thank an anonymous referee and Nicholas Apergis whose comments and suggests helped improve the paper substantially.

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