Intangible Capital and Modern Economies
Online Appendix

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Introduction

This appendix provides an overview of the EU KLEMS & INTANProd database and summarizes the methods used to develop the estimates of intangible investment and capital used in the paper.

EU KLEMS & INTANProd is a new productivity database, produced at LUISS Lab of European Economies (LUISS 2022) and funded by the Directorate General for Economic and Financial Affairs (DG-ECFIN) of the European Commission.[1] The new database updates previous editions of the EU KLEMS database and extends them with productivity estimates that incorporate measures of intangible investment from INTAN Invest.[2] The creation of EU KLEMS & INTANProd represents a significant advancement for productivity analysis and policymaking in this respect, as it is the first cross-country productivity database including all Corrado, Hulten and Sichel intangible assets in a framework coherent with national accounts.

The database provides data for 27 EU Member States, the United Kingdom, United States and Japan across 40 industries and 23 industry aggregates for the period 1995-2020. Industry detail and coverage varies over time and across countries. The Japanese module is kindly supplied by RIETI institute and Hitotsubashi University.[3]

The estimates of intangible investment developed for the intangibles-extended productivity calculations in EU KLEMS & INTANProd for European countries and the United States incorporate significant improvements relative to previous editions of INTANInvest including:

- The harmonized estimates for intangible assets are now available for 38 NACE industries versus 19 industries of past editions.
- Manufacturing is now disaggregated to cover 12 industries. Selected service sectors (wholesale and retail trade, transport, professional services, and health) also are expanded to provide more industry detail.
- Nominal intangible investment by asset type covers purchased and own-account activity and estimates of all components are based industry-level total expenditure.
- Real intangible investment incorporates price deflators based on closely aligned services output; a deflator for investment in brand and marketing research was developed from input price

[1] Funding occurred under procurement procedure ECFIN/2020/OP/0001 – Provision of Industry level growth and productivity data with special focus on intangible assets – 2020/S 114-275561. For information about past releases of EU KLEMS see www.euklems.net; van Ark, O'Mahony and Timmer (2008); and Timmer, Inklaar, O'Mahony and van Ark (2010).

[2] INTAN Invest was initiated as an unfunded research collaboration by the authors of this paper in 2012. For more information about INTAN Invest see www.intaninvest.net and Corrado, Haskel, Jona-Lasinio, and Iommi (2012).

[3] Data and documentation about Japanese estimates of intangibles are available at: https://www.rieti.go.jp/en/database/JIP2021/index.html

indexes for content development and production costs, internet advertising sales, and traditional media advertising sales.

EU KLEMS & INTANProd consists of two modules. The **statistical** module is a repository of all the key variables for industry-level productivity analysis provided directly by the national accounts of individual countries.

The **analytical** module complements these data with information on investment and capital stocks for intangible assets that are not included as investment in national account calculation of GDP. This module is the repository of ongoing improvements on estimates of intangibles and growth accounting with intangibles. Among the most recent developments include the following:

1. The analytical module includes harmonized capital stocks for all tangible and intangible assets based on geometric depreciation.
2. The analytical growth accounting incorporates also bottom-up aggregations for market sector excluding agriculture and for total industries for productivity analysis.

The database and complete methods documentation are downloadable at https://euklems-intanprod-llee.luiss.it/.

The remainder of this appendix details the methods and summarizes the data sources used to measure nominal investment flows for the expanded components of intangible investment, i.e., for the assets not classified as investment in national accounts. A summary of price deflators and estimation of net stocks follows, again with specific attention to assets not classified as investment in national accounts.

Measuring Nominal Intangible Investment: Methods and sources

Procedures used to estimate nominal intangible investment flows for assets not currently classified as investment in national accounts follow the general approach adopted for software by official statistics. The approach involves the estimation of two components, o*wn-account* and *purchased* investment.

The approach is summarized as follows:

- Purchases of noncapitalized intangibles usually are found among the detailed product categories in supply-use tables, which are consistent with national accounts and reflect a reconciliation of comprehensive data from economic censuses and annual surveys, administrative sources, and international transactions.
- Estimates of most own-account components of intangible investment included in EU KLEMS & INTANProd are developed using a *sum-of-costs* approach.

The methods used for the European economies and the United States are similar, but there are some departures and differences in data availability.

Table 1A summarizes the data sources used to measure intangible assets currently not classified as investment in national accounts, distinguishing between purchased and own account components. The main source for the purchased components is the Supply and Use Tables (SUTs) from national accounts. Own-account components are developed from survey data on employment and compensation by occupation and industry.

Table A1. Data Sources for Expanded Components of Intangible Investment

Intangible Asset	Purchased	Own-account (O-A)	Total
1. Attributed designs	Supply-use tables	Employment and wages by occupation & industry	Purchased + O-A
2. New financial products	n.a.	Employment and wages by occupation & industry	O-A
3. Market research and brand	Supply-use tables	Employment and wages by occupation & industry	Purchased + O-A
4. Operating models	Supply-use tables	Employment and wages by occupation & industry	Purchased + O-A
5. Firm-specific human capital	Supply-use tables (US only)	Employment and wages by occupation & industry (US only)	Survey data (EU) Purchased + O-A + employer opportunity cost (US)

The methods and sources used to estimate both purchased and own-account intangible investment in assets listed on lines 1 to 4 are described in more detail below and an example for each (i.e., purchased and own-account) are set out in Box 1 and Box 2.

The estimation procedures for investment in firm-specific human capital for European countries the United States, which as may be seen on line 5 of the table differ, are reviewed in a separate section.

Purchased components

Measures for the purchased components of market research and brand, attributed design and operating models for *Europe* are obtained directly at the industry level (NACE Rev.2/CPA 2008) using data on intermediate costs gathered from the Use Tables (UT) for the following products: advertising and market research services (CPA M73), architectural and engineering services, technical testing and analysis services (CPA M71) and legal and accounting services, services of head offices and management consulting services (CPA M69 and M70). The products classified as advertising and market research services (CPA M73) and architectural and engineering services, technical testing, and analysis services (CPA M71) are considered good proxies of expenditures in the corresponding assets, thus not needing to be integrated with additional information from other sources.

As for legal and accounting services, services of head offices and management consulting services the CPA M69 -M70 is a broad category including expenditures beyond consulting services. Therefore, to get a better proxy of management consulting services, the expenditure corresponding to CPA M69_M70 is adjusted with the share of turnover of NACE M702 (consulting services) in total turnover of NACE M69_M70. The share is kept constant across industries in each country.

Finally, a capitalization factor (CF) is applied to total expenditure by market producers to obtain the value of total expenditure to be capitalized. The capitalization factors are asset specific and are as follows: Operating models (0.8), Brand (0.6) and Attributed Design (0.5). The capitalization factors do not vary across industries, except for the industry producing the corresponding asset, where capitalization factors are reduced to reflect estimates of industry own use, i.e., subcontracting activity within the industry.

Box A1

Example: Calculating purchased investment in market research and brand

As previously indicated, the main source for measuring purchased investment in market research and brand in is the USE table from National Accounts reporting expenditures on advertising and market research services by industry. Official national accounts record these expenditures as intermediate consumption.

The approach for capitalizing this expenditure is as follows.

Denote I_i^{Bp} the purchased component of brand investment for industry i, γ_i^b the corresponding capitalization factor and IC_i^{M73} the intermediate consumption expenditure for Advertising and Market Research Services (CPA M73). Thus, investment in brand (purchased component) is measured as:

$$I_i^{Bp} = IC_i^{M73} * \gamma_i^b$$

The same calculation can be applied to any country with due consideration for the specific-country classification product codes, e.g., for the United States the intermediate consumption expenditure is measured as

$$I_i^{Bp} = \lambda_i^b * IC_i^{BEA5412OP} * \gamma_i^b$$

where λ_i^b is a time-varying factor that represents the portion of relevant purchases in BEA's annual intermediate use series 5412OP that includes brand investment. The time-varying factor is developed from benchmark-year values for intermediate purchases of advertising, public relations, and related services (BEA/NAICS 5418) and marketing research and public opinion polling services (NAICS 54191). Because benchmark year values for intermediate purchases of NAICS 54191 not available (they are included in "all other professional, scientific, and technical services, BEA industry code 5419AO), information on industry revenues of NAICS 54191 relative to the other industries included in 5419AO (NAICS 54193 and 54199) is also used to the develop the annual factor λ_i^b applied to $IC_i^{BEA5412OP}$.

Estimates for the United States follow a similar approach, though the U.S. industry data follow the North American Industry Classification System (NAICS). The main source for the purchased components of expanded investment is BEA's Annual UT and Input-Output Accounts (IO), which are available for 71 commodities defined according to NAICS from 1997 on; these data are linked to earlier formats (with slightly fewer industries) from 1977 to 1997. Management and technical consulting services (NAICS 5416), advertising and market research (NAICS 5418 and 54191), and architectural and engineering design services (5413) are not separate commodity codes in BEA's annual system; they are included along with

selected other services in "Miscellaneous professional, scientific and technical services (BEA 5412OP).[4] Detailed annual gross output statistics and information from benchmark SU/IO tables available at five-year intervals from 1987 to 2012 (covering 405 industry groups for 2007 and 2012, with slightly fewer in earlier years) are used to determine individual times series for the relevant components of this aggregate.

Another complication is that, in the underlying NAICS data, strategic consulting services are not limited to the management consulting industry; rather strategic IT consulting expenditures are part of intermediate purchases from the computer design industry (NAICS 541512) and headquarter provision of strategic services to separately located establishments are included in purchases from management of companies (NAICS 55). Fractions that represent the relevant long-lived service flows are estimated using a combination of benchmark SUTs and detailed product-level revenue data from the US Census Bureau; the resulting time series are included in the purchased component of investment in organization structure.

As with the estimates for Europe, noting that the sum-of-costs approach to estimating co-production requires separating firms that produce the intangible asset as a line of business from those with hypothetical factories that produce for own use, e.g., workers at firms that sell software products or training services would not be included as workers producing software or training services on own account. For the United States, the benchmark SUTs provide the information needed to estimate this exclusion. The capitalization factors for design, management consulting and advertising are the same as those used for European economies.

Own-account components.

Estimates for the own-account component of market research and brand, attributed design, operating models, and new financial products are obtained using a *sum-of-cost* approach, consistent with the national accounts method for estimating own account software and databases.

The approach develops estimates using data on employment and compensation by type of occupation and by industry. For European countries the main sources are: 1) the Structural of Earning Survey (SES), which provides information on the annual earnings and number of employees by occupation (at the three-digit level of the 2008 International Standard Classification of Occupations, ISCO) and 2) the Labor Force Survey (LFS). For the United States, the main sources are 1) employment and earnings data by occupation from the Current Population Survey (CPS) and 2) industry-level compensation and employment data from national industry accounts. Information from Occupation and Earnings Survey (OES) of the Bureau of Labor Statistics (BLS), which provides wages and employment by occupation by detailed NAICS industries, is used to provide starting values for time series estimates developed via bi-proportional balancing of (1) and (2).

The main steps for generating own account intangible investment measures consistent with national accounts are summarized below in Box A2.

[4] The grouping also covers NAICS 5412 (Accounting, tax preparation, bookkeeping and payroll services), NAICS 5414 (Specialized design services), NAICS 5417 (Scientific research and development services) and NAICS 54192, 3, 4 and 9 (Photographic, veterinary, and other miscellaneous professional, scientific, and technical services).

Box A2

Example: Estimating own-account investment in market research and brand for a European country

The application of the general approach to the generation of estimates of own-account investment in market research and brand for industry i in a country proceeds according to the following steps:

Step1. Identify the relevant occupations: Sales, marketing and development managers (ISCO 122) and Sales, marketing and public relations professionals (ISCO 243).

Step 2. Assume that sales, marketing and development managers spend 15 percent of their time producing long-lived services to be used internally by the (same) firm and that sales, marketing and public relations professionals spend 50 percent of their time. Thus, indicating with τ_j the time share spent by each type of occupation (j) in producing the asset, the time assumptions for ISCO 122 and ISCO 243 occupations are as follows:

$$\tau_{122} = 0.15$$
$$\tau_{243} = 0.50$$

Step 3. The total wage cost of employees corresponding to the production of market research and brand asset, $W_{i,j}^{Br}$,for own-account use generated in each industry (i) by each type of occupation (j) is then computed as:

$$W_{i,j=122}^{Br} = W_{i,j=122} * \tau_{122}$$
$$W_{i,j=243}^{Br} = W_{i,j=243} * \tau_{243}$$

where $W_{i,j=122}$ and $W_{i,J=243}$ are the wages earned by j=ISCO_122 and ISCO_243 occupations in each industry (i) gathered from the SES survey.

Step 4. Once $W_{i,j}^{Br}$ is computed it is necessary to make it consistent with national accounts' estimates of labor costs. To do so, first it is necessary to calculate the share of the wage cost for market research and brand assets production in each industry (i):

$$W_i^{Br} = (W_{i,j=122}^{Br} + W_{i,j=243}^{Br})/W_i$$

where W_i is the total wage in industry (i), also from the SES survey.

Step 5. Then, for each industry (i), labor costs related to the production of own-account market research and brand assets consistent with national accounts are calculated multiplying the wage shares from step 4 by compensation of employees by industry from national accounts C_i:

$$C_i^{Br} = W_i^{Br} * C_i$$

Step 6. Finally, the output of market research and brand produced for own use, $I_i^{Br\_OA}$, is obtained as:

$$I_i^{Br\_OA} = C_i^{Br} * bp^{Br}$$

where bp^{Br} is a factor that coverts compensation to gross output; for brand and marketing, this factor is 1.8.

The ISCO occupations and time use assumptions used for estimating own-account investment components for European countries are included in forthcoming EU KLEMS & INTANProd documentation (available at https://euklems-intanprod-llee.luiss.it/documentation/ before December 2022). The example provided in Box 2 illustrates assumptions to estimate own-account investment in market research and brand for a European country. For the United States, the identification of relevant occupation codes used for the own account component of brand are found in Corrado and Hao (2014, page 85), for new financial products in Corrado et al. (2012, pages 29-31), and for organizational capital Corrado (2021, Box 2).

Measuring Firm-Specific Human Capital

Availability of information for measuring firm specific human capital differ noticeably between Europe and the United States but the conceptual basis of the EU KLEMS & INTANProd estimates for European economies and the United States, like the INTANInvest estimates that preceded them, is the same.

Note first there is no ongoing, official source of data covering private sector spending on employer-provided training for the United States. The US intangible investment estimates are benchmarked to a one-time BLS survey of employer-provided training (SEPT) conducted in 1995 that has been extended using information from multiple sources: Industry Reports issued annually in *Training* magazine (e.g., Training 2021); intermediate purchases other education services (NAICS 6114-7) from annual USE tables; and estimates of the annual payroll of workers assigned to the training function within private organizations developed from CPS data.

This approach to measuring U.S. investment in firm-specific capital follows the conceptual framework of the SEPT, in which the cost of *formal* employer-provided training is captured by the sum of (a) purchases of training services, (b) the in-house cost of providing training services (wages of training personnel and materials used), and (c) the opportunity cost in terms of hourly wages paid for employee time spent in training functions. The industry distribution of (a) and (b) is implicit in the source data used for the extrapolators for these components (Use tables and CPS survey data). The industry distribution for the opportunity cost component is benchmarked to the SEPT, extended by information on hours and spending by industry (broad groups only) in the annual industry report in *Training.*

For European countries investment in firm specific human capital (training) is obtained as the sum of investment in vocational training and apprenticeships. Estimates are based on data from the EU Continuing Vocational Training Survey (CVTS) integrated with data from the EU Labour Cost Survey (LCS) to generate investment by industry. The CVTS collects information on enterprises' investment in the continuing vocational training of their staff and is available for the years 2005, 2010, and 2015. Continuing vocational training (CVT) refers to education or training courses that are financed in total or at least partly by the enterprise (directly or indirectly).

Estimates of training costs based on the CVTS include both the purchased and the own account component. Both internal and external CVT courses are identified, and courses' costs include the labour costs of internal trainers. In addition, CVTS costs also cover the opportunity cost for employees attending courses, as they include the labour cost of participants for vocational training courses that take place during paid working time.

The country coverage of the CVTS is almost complete, but the industry detail is very coarse, so the information gathered from the CVTs is complemented with data on investment in training from LCS. The approach used for Europe can be described as follows. Define E_i^{CVT} the cost of CVT courses and compute the share over total labor cost W_i as:

$$T_i^{CVT} = E_i^{CVT} / W_i \quad .$$

As CVT is available only for a limited number of years, a time series for T_i^{CVT} is generated via linear interpolation. To guarantee consistency with national accounts, the share of CVT expenditure is multiplied by compensation of employees C_i as:

$$C_i^{CVT} = T_i^{CVT} * C_i \quad .$$

The apprenticeships component is calculated using the same approach as vocational training: the share of apprentice costs in total labor cost from the LCS is multiplied by compensation of employees from national accounts.

Estimates of training are based on the assumption all expenditures increase the value of the stock and therefore should be considered as investment (i.e. the capitalisation factor is equal to one).

Measuring Real Intangible Investment: Method and sources

Real investment for each asset listed in table A1 is obtained by dividing its nominal investment flow by an appropriate price index. Specific investment deflators for Table A1 assets are not available from official statistics, thus EUKLEMS & INTANProd uses closely aligned services output deflators from national accounts. The data sources used as listed in table A2. The services output price indexes listed as sources for assets listed on lines 1, 2, 4 and 5 are directly used as price indexes for the corresponding assets.

Table A2. Sources for Price Deflators for Expanded Components of Intangible Investment

Intangible Asset		United States		European Countries	
		Indicator	Data sources	Indicator	Data sources
1.	Attributed designs	Gross output price deflator NAICS 5413	BEA	Gross output price deflator NACE M71	OECD STAN, EUROSTAT Service producer prices, EUROSTAT National accounts
2.	New financial products	R&D investment deflator in the financial, insurance, and real estate services	BEA	R&D investment deflator in the financial and insurance activities industry (NACE K)	EUROSTAT National accounts
3.	Market research and brand (see text for further explanation)	Gross output price deflator NAICS 5418, input price indexes for internet and traditional paid media costs	BEA, BLS	Gross output price deflator NACE M73	OECD STAN, EUROSTAT Service producer prices, EUROSTAT National accounts
4.	Operating models	Gross output price deflator NAICS 541512, NAICS 54161	BEA	Gross output price deflator NACE M69_70	OECD STAN, EUROSTAT Service producer prices, EUROSTAT National accounts
5.	Firm-specific human capital	Gross output price deflator NAICS 6114-7	BEA	Gross output price deflator NACE M	OECD STAN, EUROSTAT Service producer prices, EUROSTAT National accounts

A price index for investments in market research and brand has been specifically constructed for the intangibles module in EU KLEMS & INTANProd. The price index is calculated as a weighted average of production/content development costs and media dissemination costs. The former is proxied by a related gross output price deflator—the deflator for the advertising and related services industry (NAICS 5418) in the United States and the advertising and market research industry in European countries (M73). Media costs for the United States are constructed from BLS producer *input* price indexes for internet and traditional media (newspapers, periodicals, television, and radio). BLS estimates that the cost of internet advertising declined more than 5 percent per year from 2010 to 2020.[5] Comparable internet media cost price indexes are not available for European countries, however, and changes in the US input price index are used to develop the prices indexes for investments in market research and brand used for European countries.

Aggregated (by industry and asset) real investment is obtained using annual chain-linked measures (i.e., quantity indexes are based on the linking (chaining) of indexes for consecutive periods to form time series). Annual chain-linked measures are recommended by the *2008 System of National Accounts* and used to compile official national accounts both in the US and in European countries. However, in the US annual changes in the quantities are calculated using a Fisher index formula (which incorporates weights from 2 adjacent years) to construct the chain-type indexes, while European countries use Laspeyres quantity indexes (which incorporate weights derived from the previous year). To maintain consistency with national accounts, in EUKLEMS & INTANProd we use Fisher for the US intangibles and Laspeyres for European countries.

Measuring Real Intangible Capital Stocks

Capital stock estimates in real terms are derived using the perpetual inventory method (PIM), which involves aggregating real investment over time but allowing for declines in efficiency and value until assets reach the end of their service lives and are retired. Intangibles are not subject to wear and tear like most fixed assets, such as machinery and buildings, but their value declines over time because they are subject to obsolescence.

In particular, we use the so-called geometric model, which defines the real stock of intangible asset j in industry i at the end of year t ($Kq_{i,t}^{j}$) as:

$$Kq_{i,t}^{j} = Kq_{i,t-1}^{j} * (1-\delta^{j}) + Iq_{i,t}^{j}$$

where $Kq_{i,t-1}^{j}$ is the real stock of intangible asset j in industry i at the end of year t-1, δ^{j} is the annual depreciation rate for asset j and $Iq_{i,t}^{j}$ is real investment for asset j in industry i during year t. Note that depreciation rates are asset-specific and are assumed to not vary across industries and over time.
Our calculation of intangible capital stocks is based on specific assumptions on depreciation rates. Annual depreciation rates equal to 0.4 for operating models and firm-specific human capital, 0.2 for attributed design and new financial products, and 0.55 for market research and brand are used to develop stocks for market sector industries.

[5] Annualized percent change in BLS PPI Commodity Code WPU365 (U.S. BLS 2022).

Note: R&D stocks computed for the analysis in the main paper are based on applying the same rate of depreciation (.15) to all industries, consistent with earlier editions of INTANInvest. The 2022 version of the analytical module for INTANProd (available by December 2022) and INTANInvest going forward, applies industry-specific depreciation rates based on available studies, e.g., Li and Hall (2018) among others.

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