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Άυλα περιουσιακά στοιχεία, παγκόσμιες αλυσίδες αξίας και καινοτομία στην Ευρωπαϊκή μεταποίηση

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The scope of this study

- This study aims to empirically investigate the contribution of **intangible inputs** and **global value chain (GVC) participation** to the development of **manufacturing (technological) innovation**
- *Why is this important*? – **Two** basic reasons
  - **Innovation in GVCs** is accelerating (Ambos et al. 2021; Buciuni and Pisano 2021) → **but empirical evidence is still rather scarce**
  - The role of **intangibles in GVCs** → knowledge/IP assets whose accumulation and control is linked with significant **benefits** in terms of **innovation**, growth, specialization, and -more recently- competitiveness in GVCs (Corrado et al. 2022; Tsakanikas et al. 2022; Cadestin et al. 2021; Durand and Milberg 2020; Jona-Lasinio et al. 2019)
- *How do we aim to address this*?
  - Focus on the sector level, in a sample comprising EU and UK manufacturing sectors
  - Develop a GVC-adjusted version of the knowledge production function (KPF) (Crépon et al. 1998; Pakes and Griliches 1984)
  - Adopt a new approach on the measurement of intangibles as **production inputs** → use the GLOBALINTO Input-Output Intangibles Database (GIOID) (Dimas et al., 2022, 2023; Tsakanikas et al., 2020)

GVCs and innovation development

- The relationship between **GVC participation** and **innovation** has been a **much-debated** subject – yet studies that have investigated their direct link are rather **scant** (Ambos et al. 2021; Lema et al. 2021; Morrison et al., 2008)
- Participation in GVCs entails a **learning-by-interacting** process
  - **A linkage-induced innovation paradigm** where horizontal and vertical production linkages induce innovation either on lead firms (MNEs) or their suppliers and clients (sometimes both) (Ambos et al., 2021; De Marchi et al. 2018; Lema et al. 2019)
- From a different view, GVC transactions entail **learning-by-importing** and **learning-by-exporting** effects
  - Innovation can be enhanced through a **variety of channels**, e.g., knowledge dissemination, spillovers, technology transfer, competition effects in international markets (Castellani and Fassio 2019; Montalbano et al. 2018; De Loecker 2013)
  - Especially for **manufacturing** sectors → **prone to the GVC trade** of intermediates and the innovation-propelling effects from:
    - access to foreign inputs not available in the domestic market (Colantone and Crinó 2014; Goldberg et al. 2010)
    - access to product-embodied knowledge acquired through imported intermediates from competent and knowledge-intensive suppliers (Castellani and Fassio 2019; Ciriaci et al. 2015)

Producer-user interactions and a first set of HPs

- Production linkages between manufacturing sectors and their suppliers and clients correspond to **bi-directional producer-user interactions**
  - Learning-by-interacting knowledge diffusion mechanism of Innovation Systems (Binz and Truffer 2017; Lundvall 1992, 1988)
  - Co-evolution of GVCs and Innovation Systems and joint contribution to innovation capacity (Lema et al. 2019; 2021)
  - Sector specific characteristics are important → technological performance and innovation depend on sectoral patterns of innovation (Malerba 2002; Breschi et al. 2000; Castellacci, 2008) – GVC participation is also related with sector specificities (Timmer et al., 2015)
- GVC participation can enhance innovation *per se* (Tajoli and Felice 2018) but also act as an *enabler for upgrading* into higher value-added activities (Brancati et al., 2017; Ito et al., 2023)

HP1: *Participation in GVCs can stimulate sectoral innovation performance*

- GVC participation for manufacturing sectors is bi-directional → they act both as suppliers to downstream clients (forward – learning-by-exporting) and users of upstream products (backward – learning-by-importing)

HP1a: *Forward participation in GVCs can contribute to sectoral innovation performance*

HP1b: *Backward participation in GVCs can contribute to sectoral innovation performance*

Intangibles and innovation

- **Intangible assets** (knowledge-based or intellectual) are non-physical and non-financial assets that derive from a specific range of innovative activities (OECD/Eurostat 2018)
  - The most famous intangible asset: R&D
- Common characteristic among them → they are significant **sources of value** (Corrado et al. 2022; Haskel and Westlake 2018; Lev 2001) and essential building blocks of a firm's **comparative advantage** (Teece 2015)
- Intangibles are naturally interrelated with innovation → predominant focus on the effects of R&D investments on innovative outcomes
  - R&D is conceptualized as technological innovation input leading to an inventive outcome → the famous KPF approach (Crepon et al., 1998; Pakes and Grilliches, 1984; Verba, 2022)
  - Abundance of R&D statistics (Cohen 2010) **but lack of data for other intangibles**
- However, **innovation** is an outcome of **a bundle of knowledge inputs** (Antonelli and Colombelli 2015)
  - Recent studies have integrated additional intangibles as innovation determinants in firm level applications (Montresor and Vezzani 2016, 2022)
  - Empirical research is still confined → significant challenges that relate to the identification and measurement of intangibles due to their immaterial and ambiguous nature (Lampel et al. 2020)

Measuring intangibles at higher aggregation levels – the GIOID approach

- Corrado et al. (2009, 2005) proposed a framework to identify intangible assets and derive to intangible investment measures at the sector and country level → three umbrella categories:
  - Computerized information: software and databases
  - Innovative property: R&D, design, mineral's exploitation, artistic originals, and other IP assets
  - Economic competencies: advertising and market research, organizational capital, and training
- Building on this, Dimas et al. (2022; 2023) proposed an input-output framework to measure intangible flows in GVCs
  - Focuses only on **external (purchased) intangibles** and treats them as intermediate inputs → producer's services
  - Identifies a set of intangibles-producing knowledge-intensive business service (KIBS) sectors → supply different types of intangibles to other sectors → **knowledge production linkages**
  - Knowledge production linkages can be both domestic and international → classification of **intangibles** based on **production origin** (domestic vs. imported) → enables the **mapping of knowledge dissemination in GVCs**
  - The framework was applied in the development of the GIOID → sector and country level data for intangibles (and other competitiveness and innovation metrics) for 56 NACE Rev.2 sectors in the EU and the UK in the period 2000-2014

Intangible inputs, innovation, and a second set of HPs

- The use of intangible inputs from manufacturing sectors links to their relationship with KIBS sectors
  - KIBS to manufacturing production-based knowledge (both tacit and codified) transmission (Ciriaci et al., 2015; Landry et al., 2012)
  - The role of KIBS as system "*innovation propellers*" and "*knowledge carriers*" (Castellacci 2008; Tether 2005; Müller and Zenker 2001)
  - Producer (KIBS) – user (manufacturing) interactions that enhance manufacturing innovation based on sector-specific characteristics (Breschi et al., 2000; Malerba, 2002)

***HP2**: Intangible inputs can enhance sectoral innovation performance*

- **Origin matters** : the use of **domestic intangible inputs** from **manufacturing sectors** relates to:
  - ➢MNE's "home bias" in key knowledge intensive activities (Belderbos et al. 2016; Castellani and Pieri 2013)
  - ➢Coordination, compatibility, and technological proximity gains (Timmer et al. 2019; Del Prete and Rungi 2017)
  - ➢Complementarity of activities (Meliciani and Savona, 2015), cognitive proximity, and KIBS-driven technology transfer that hase a postive impact on manufacturing innovation (Ciriaci et al., 2015)

➢At the same time, **imported intangible inputs** are also important:

- ➢International KIBS-manufacturing production linkages provide the same innovation-inducing effects with domestic
- ➢Imported intangibles entail knowledge transimmision from specialized foreign knowledge suppliers (Castellani and Fassio 2019)→ provision of knowledge complentary to- or not available from the local market (Scalera et al. 2018; Cano-Kollmann et al. 2016)

***HP2a**: Both domestic and imported intangible inputs can enhance sectoral innovation performance*

Innovation-inducing effects from different types of intangibles

- Foreign knowledge has been proxied mainly by R&D and patent statistics (Danguy, 2017)
  → little to no interest on non-R&D intangibles
- Intangibles are **non-rivalrous**, with significant **complementarities** and **synergies** (Corrado et al., 2022; Haskel and Westlake, 2018)
- Both R&D and (mostly) non-R&D (domestic) KIBS inputs contribute to manufacturing technological innovation (Ciriaci et al., 2015)

***HP2b**: Both R&D and non-R&D (domestic and imported) intangible inputs can enhance sectoral innovation performance*

Summary of HPs

- ***HP1: Participation in GVCs can stimulate sectoral innovation performance***
  - ***HP1a:*** *Backward participation in GVCs can contribute to sectoral innovation performance*
  - ***HP1b:*** *Forward participation in GVCs can contribute to sectoral innovation performance*

- ***HP2: Intangible inputs can enhance sectoral innovation performance***
  - ***HP2a****: Both domestic and imported intangible inputs can enhance sectoral innovation performance*
  - ***HP2b****: Both R&D and non-R&D (domestic and imported) intangible inputs can enhance sectoral innovation performance*

Methodology

- The empirical analysis includes 18 NACE Rev.2 manufacturing sectors from 24 countries of the EU-27* and the UK and refers to the period 2000-2013
- Data sources: GIOID and WIOD (Timmer et al., 2015) (2016 release and corresponding SEA for sector-level labour data)
- The log-linearized, **GVC-adjusted** version of the **KPF**:

$$\ln(\text{inno})_{i,t} = \alpha + b_1 \ln(\text{gvc})_{i,t-1} + b_2 \ln(\text{intan})_{i,t-1} + b_3 \ln(\text{kb})_{i,t-1} + \lambda_t + \lambda_i + \varepsilon_{i,t}$$

- GVC participation (**gvc**), intangible inputs (**intan**) and each sector's existing knowledge base (**kb**) are considered as **innovation inputs** to its inventive process
- All variables are divided by labor (no. of employees) and lagged by one period
- Country-sector (i) and time (t) fixed effects are included
- To proxy (technological) innovation in the model, we use patent applications to the EPO per employee at the sector level (**pat_app**) → **innovation output**
  - Patent apps at the sector level are included in GIOID (EPO data only)
  - Despite their known caveats, patents are a reliable proxy for technological innovation in manufacturing sectors (Ciriaci et al., 2015; Danguy, 2017)
  - Patents signal different technological regimes among sectors and highlight their role in their respective sectoral systems of innovation (Breschi et al., 2000; Malerba, 2002)

*We exclude Cyprus, Luxembourg, and Malta from the analysis due to the service-based nature of their economies and their limited patenting activities

Intangible inputs

- We retrieve intangible inputs data for the EU and the UK at the sector level from GIOID (period 2000-2013)
- In contrast to the readily available data*, we use **three specific intangible inputs** with established links with innovation performance:
  - Computer and information service activities (J62-J63)
  - Scientific R&D (M72)
  - Advertising and market research (M73)
- **Accounting for origin,** we develop three indicators →total (**intan_t**), domestic (**intan_d**), and imported (**intan_m**) intangibles inputs per employee in different models (lagged by one period)
- **Accounting for type**, we include R&D (**RD_t**) and non-R&D (**nonRD_t**) inputs per employee in different models and with respect to their origin (total, domestic, imported – again lagged by one period)

*GIOID treats sector N as an intangibles-producing sector (administrative support services) as well

GVC participation and sector knowledge base

- **GVC participation variables** are calculated using WIOD data and the Wang et al. (2022) factor decomposition framework → production-based approach that focuses on **final demand** and not **gross exports**
  - Backward participation (**gvc_b**) refers to foreign VA imported via intermediates and consumed domestically (i.e., embodied in the importing sector's final demand)
  - Forward participation (**gvc_f**) refers to domestic VA exported in intermediates and consumed abroad (directly and/or re-exported)
  - Both variables are per no. of employees and lagged by one period
- To account for **sector knowledge base**, we utilize its cumulative patent applications per employee (**pat_base**) (lagged by one period)
  - Robust proxy for each sector's inventive capacity (based on the track record of previous technological inventions)
  - Signals sectoral technological regime and trajectories (Corrocher et al. 2021; Breschi et al. 2000; Malerba and Orsenigo 1996)

Variables and sources

Variables	Data source
Patent applications (no.)	GIOID/EPO
Intangible inputs per type and origin (in mil. $, current prices)	GIOID
GVC participation per type (in mil. $, current prices)	WIOD
Labor (no. of employees, in thousands)	WIOD SEA

Descriptive statistics: Domestic vs. imported intangible inputs use

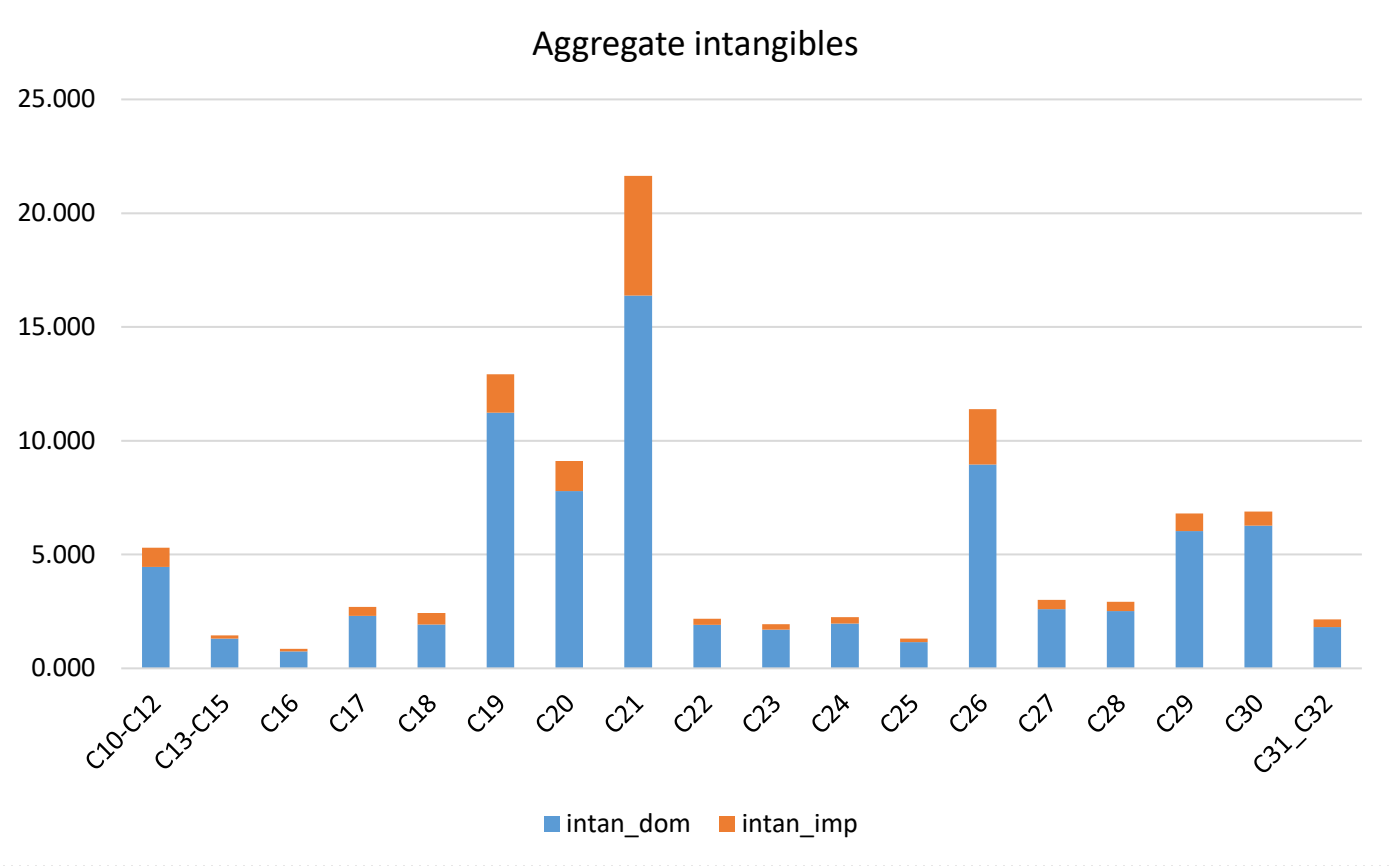

Fig. 1: Aggregate intangible inputs ($) per employee for the EU-27 and the UK manufacturing sectors, 2000-13 (series average). Note: the imported dimension relates to intangible inputs purchased from outside each sector's domestic national borders.

- Some general patterns:
  - Domestic intangible inputs are preferable for EU manufacturing sectors
  - All intangible-intensive sectors exhibit high imported shares → demand for diversified foreign knowledge that (probably) complements the domestic
  - Imported intangible inputs come from the EU (Tsakanikas et al, 2022) → strong intra-EU trade-in-knowledge
- High-tech sectors [pharmaceuticals (C21) and computer, electronic and optical parts (C26)] are the most intangible intensive sectors in the EU
  - Both for domestic and imported intangible inputs use
- But some low- and medium-low- tech sectors [petrochemicals (C19), food beverage tobacco (C10-C12)] are also intangible intensive
  - Low-tech sectors are "carriers" of knowledge and innovation from upstream sectors (in our case KIBS) (Heidenreich 2009)
  - Diversified knowledge base beyond R&D – are they really low-tech? (Hirsch-Kreinsen 2008)

Descriptive statistics (2): R&D vs. non-R&D intangible inputs use (per origin)

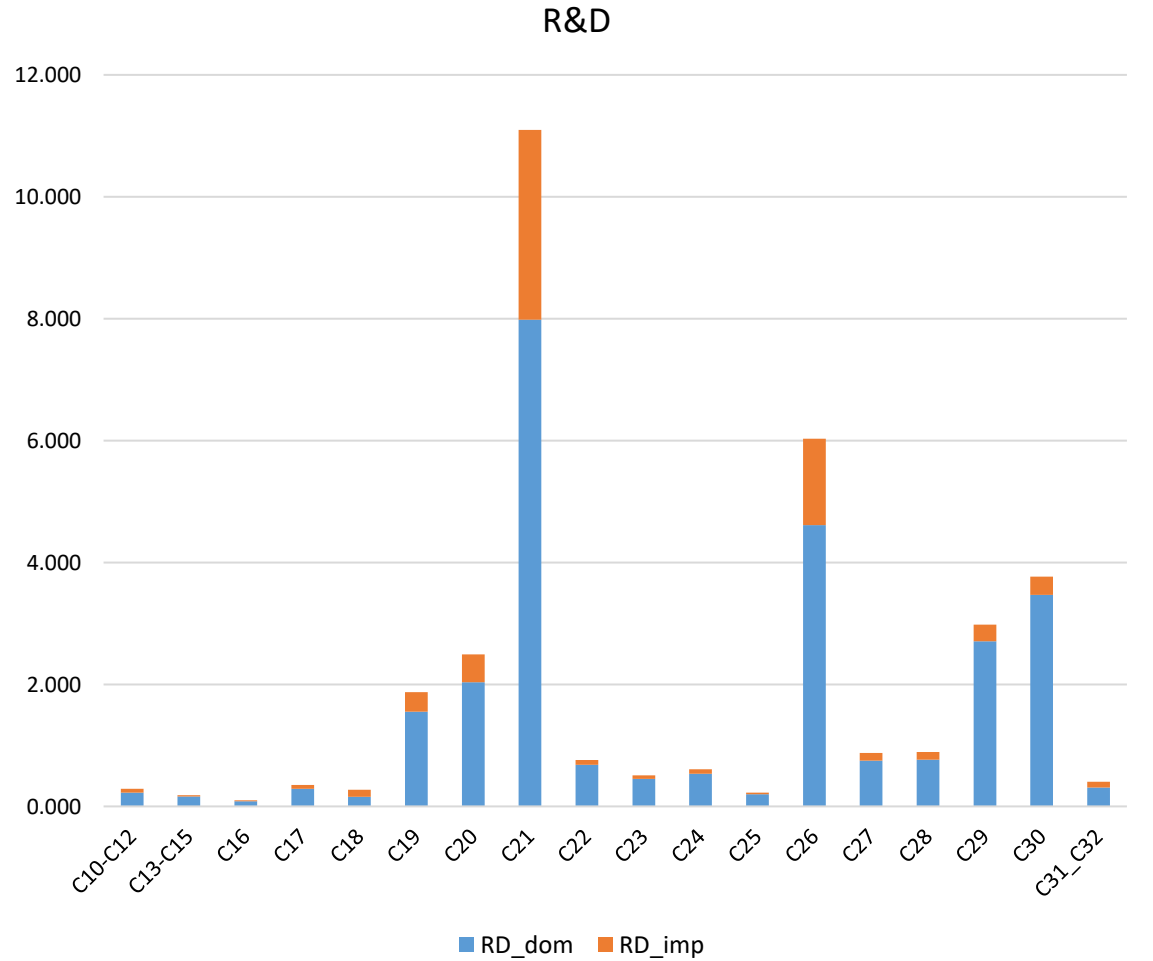

Fig. 2: R&D (M72) inputs ($) per employee for the EU-27 and the UK manufacturing sectors, 2000-13 (series average).

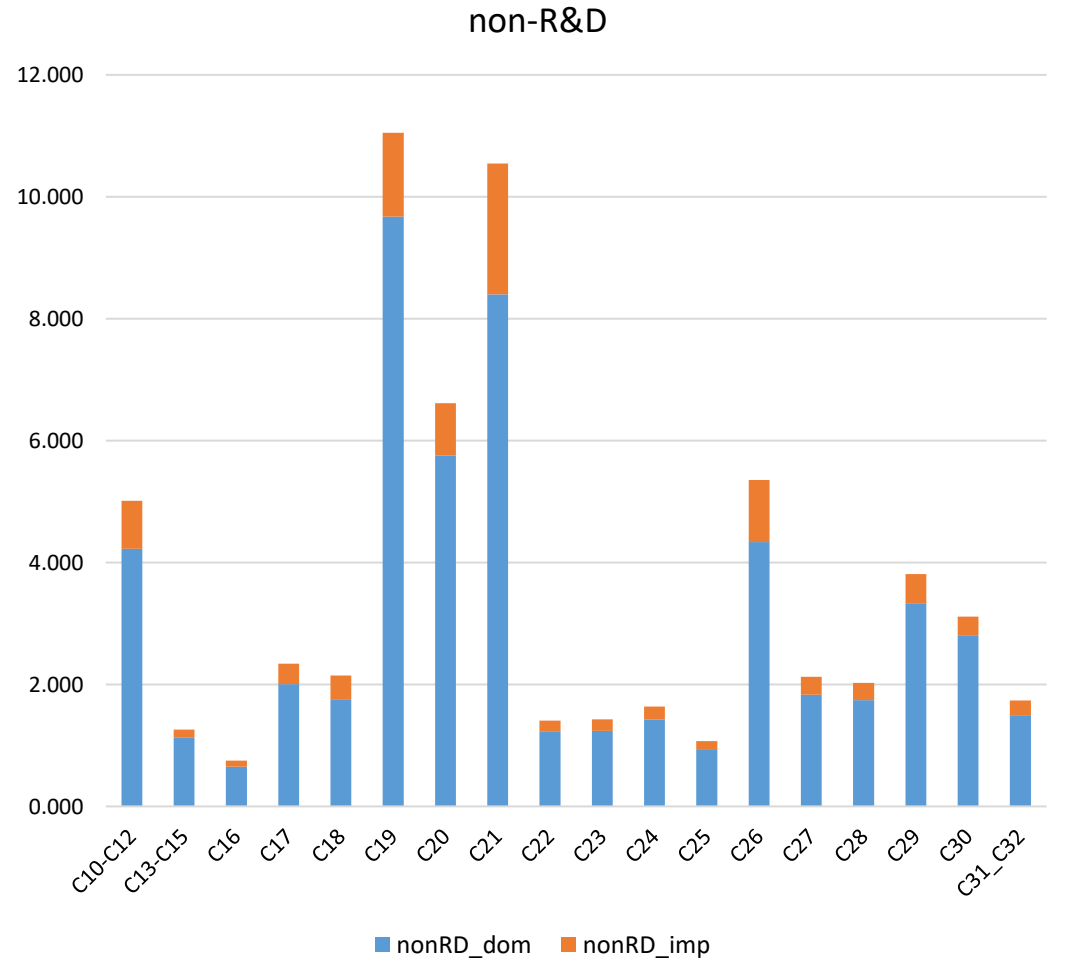

Fig. 3: Non-R&D (J62-63 and M73) inputs ($) per employee for the EU-27 and the UK manufacturing sectors, 2000-13 (series average).

Descriptive remarks for different tech groups

- Different type-related preferences emerge for different sector tech groups
- High-tech sectors appear to jointly utilize high shares of both R&D and non-R&D inputs
  - Complementarity between them and intangibles-producing KIBS (Meliciani and Savona, 2015)
  - Enhancement of their knowledge base with specialized external knowledge beyond their internal R&D efforts
- Medium-high sectors present similar patterns but mostly rely on non-R&D, domestic intangible inputs
- Not surprisingly, non-R&D inputs are predominant in medium-low- and low-tech sectors
  - Petrochemicals (C19) is in fact the most intangible-intensive sector in terms of non-R&D knowledge
  - FBT (C10-C12) presents higher non-R&D intensity than most medium high-tech sectors
  - Non-R&D nature of their knowledge base (Robertson et al., 2009)

Empirical results: Basic model (origin)

	Total sample		
pat_app	(1)	(2)	(3)
intan_t	0.135***		
	(0.041)		
intan_d		0.108***	
		(0.040)	
intan_m			0.120***
			(0.036)
gvc_b	-0.018	-0.009	-0.011
	(0.047)	(0.044)	(0.043)
gvc_f	0.165***	0.175**	0.195***
	(0.07)	(0.069)	(0.066)
pat_base	0.089***	0.090***	0.092***
	(0.027)	(0.027)	(0.028)
constant	-1.871***	-1.892***	-1.719***
	(0.216)	(0.218)	(0.231)
Country-sector FE	yes	yes	yes
Year FE	yes	yes	yes
Observations	4555	4555	4555
R^2	0.574	0.57	0.587
No. of groups	426	426	426

Notes: Robust (bootstrapped) standard errors reported in parentheses. *, **, ***, indicate p<0.1, p<0.05, and p<0.01

- **HP1** is only **partially supported** → only forward participation in GVCs enhances manufacturing innovation (**HP1a** is **supported**)
  - Benefits from forward linkages that entail learning-by-exporting channels for innovation performance
  - Backward linkages (learning-by-importing channels) are a non-significant antecedent for innovation → **HP2b** is **rejected**
  - Results consistent with Ito et al. (2023) and align with the "linkage-induced innovation" paradigm of Ambos et al. (2021) adding a sectoral and a linkage-direction perspective
  - Note: the direction could (probably is) sample specific → backward linkages with advanced economies can enhance innovation in developing economies (Tajoli and Felice 2018) – this is not our case
- **HP2** is **supported** → intangible inputs enhance manufacturing innovation
  - Innovation-inducing effects of KIBS (intangible) inputs and their system "innovation propelling" effects (Castellacci, 2008; Ciriaci et al., 2015)
- Both domestic and imported intangibles enhance innovation → **HP2a** is **supported**
  - Producer-user interactions and high cognitive proximity with domestic and foreign KIBS (Ciriaci et al., 2015) → hints towards complementarity (domestic and imported)
  - **The nature of imported intermediates is critical** → only imported intangible inputs enhance manufacturing innovation

Empirical results (2): Extended model (origin + type)

	Total sample					
pat_app	(1)	(2)	(3)	(4)	(5)	(6)
RD_t	0.050***					
	(0.016)					
RD_d		0.028**				
		(0.012)				
RD_m			0.088***			
			(0.018)			
nonRD_t				0.151***		
				(0.052)		
nonRD_d					0.121**	
					(0.050)	
nonRD_m						0.055
						(0.040)
gvc_b	0.011	0.02	-0.007	-0.023	-0.013	0.01
	(0.043)	(0.042)	(0.041)	(0.048)	(0.046)	(0.045)
gvc_f	0.198***	0.214***	0.166**	0.164***	0.171**	0.220***
	(0.068)	(0.066)	(0.065)	(0.073)	(0.071)	(0.064)
pat_base	0.093***	0.094***	0.087***	0.086***	0.089***	0.094***
	(0.027)	(0.029)	(0.027)	(0.028)	(0.027)	(0.028)
constant	-1.907***	-1.997***	-1.576***	-1.801***	-1.837***	-1.930***
	(0.217)	(0.211)	(0.212)	(0.239)	(0.233)	(0.243)
Country-sector FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Observations	4555	4555	4555	4555	4555	4555
R^2	0.559	0.552	0.563	0.568	0.567	0.574
No. of groups	426	426	426	426	426	426

- In the case of **R&D**, the contribution of **imported inputs** is ~ **3x higher** than that of the **domestic ones**
  - Importance of **access to foreign R&D** → consistent with the offshoring and internationalization of R&D literature (Ambos et al., 2021; Papanastassiou et al. 2020)
  - Tapping **foreign knowledge pockets** is more beneficial than "home bias" → home-augmenting strategy with complementary foreign knowledge (Ambos et al., 2021; Kuemmerle, 1997)
  - *Note: foreign linkages are difficult to find and usually (much) more expensive to maintain (Scalera et el. 2018)*
- For **non-R&D inputs** there is a **reverse pattern** → only **domestic inputs** enhance **innovation**
  - Cognitive and technological **proximity effects** of home market KIBS (Ciriaci et al., 2015)
  - The positive effect of imported intangible inputs can be attributed only to foreign R&D
  - Note: **HP2b** is **supported** but some specificities arise
- **Knowledge base** effects on innovation are positive and statistically significant across all models
  - Path-dependance in patenting activities
  - Sector-specific knowledge base and cumulativeness effects (Castellacci 2008; Malerba, 2002)

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Summary and conclusions

- In this study we empirically investigated the effects of GVC participation and intangible inputs to manufacturing technological innovation in the EU and the UK
- We used a GVC-adjusted version of the KPF
- Our findings are summarized in the following remarks
- GVC participation enhances manufacturing innovation but conditional to its direction
  - Only forward participation provides innovation-inducing effects
  - Becoming a key supplier in upstream production stages can induce a virtuous circle of high innovation performance that leads to high VA gains and retains specialization in these stages
- Intangible inputs enhance manufacturing innovation, irrespective of their origin and type
  - Consistent with both their nature as products (knowledge-intensive services) and the role of the KIBS intangibles-producing sectors as manufacturing "innovation propellers"
  - The nature of imported intermediates matters! → imported intangibles have a higher contribution on innovation performance and due to R&D inputs – in contrast general backward participation is non-significant)
  - The effects of domestic intangible inputs mostly reflect the contribution of non-R&D inputs

Thank you for your attention

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