Exposure to Digital Automation and Jobs in Global Value Chains

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Outline

Motivation

- **GVC reconfiguration**: The "polycrisis" (COVID-19, geopolitical tensions, climate shocks) has exposed fragilities of hyper-globalised production (Gereffi, 2020), triggering reshoring, nearshoring and friend-shoring (Baldwin, 2022)
  - Debate on consequences for employment, especially in countries that may *lose* foreign demand
- **Digital automation shock**: Simultaneously, a wave of heterogeneous digital technologies (AI, IoT, 3D printing, e-commerce, smart mobility . . .) is reshaping how goods and services are produced *and traded*
  - $\Rightarrow$ ICT reduces coordination costs $\Rightarrow$ may *lengthen* GVCs
  - $\Rightarrow$ Automation may substitute routine labour $\Rightarrow$ may *shorten* GVCs via reshoring
  - $\Rightarrow$ Uneven diffusion $\Rightarrow$ heterogeneous impacts across sectors and countries

Central question: How does exposure to different digital automation technologies reshape employment through GVC channels? Does digitisation help or hurt workers in globally integrated economies?

Literature

- **GVC participation and employment**
  - GVC integration as driver of job creation, especially in developing countries (Timmer et al., 2014; World Development Report, 2020; Pahl et al., 2022)
  - GVC linkages amplify both demand and tehc. shocks across borders
- **Digital automation and labour markets**
  - Technology displaces routine tasks but creates new tasks; net effect is ambiguous (Acemoglu and Restrepo, 2019)
  - Literature focused on AI or robots (Stapleton and Webb, 2025; Domini et al., 2022); evidence on *heterogeneous* digital technologies is scarce
- **Digital automation and GVC reconfiguration**
  - Automation may trigger reshoring (Pahl et al., 2022; Backer et al., 2016); or increase GVC participation by reducing trade costs (logistics, fintech)
  - Skill complementarity may increase co-location (Juhász et al., 2024)
  - Giunta et al. (2025): digitalisation increase regionalisation of European GVCs
  - Bontadini et al. (2024): technology, GVCs and functional specialisation
- **Gap**: Decomposes the GVC digital-employment nexus across technologies

This paper

We decompose the digital automation–employment relationship in GVCs to study how *different* technologies influence *different* employment drivers

- We distinguish **two types of employment**:
  1. Total employment (domestic + foreign demand)
  2. GVC jobs – employment activated by *foreign* final demand (Pahl et al., 2022)
- We decompose employment growth into **three structural drivers** (Pahl et al., 2022):
  1. *Productivity*: Δ labour required per unit of output
  2. *GVC linkages*: Δ country-industry participation as GVC supplier
  3. *Final demand*: Δ scale of global consumption of final products
- We project these drivers onto exposure to **40 digital automation technologies** grouped in 9 families (Prytkova et al., 2025)

Main results overview

1. **Aggregate effects are null, masking strong structural compensation.** Productivity gains (labour-saving) and demand expansion (scale effects) frequently offset each other.
2. **Technology heterogeneity**
   - *Market-expanding* technologies (Smart Mobility, Food Services, E-Commerce in services) ↑ employment via GVC linkages and final demand
   - *Efficiency-enhancing* technologies (3D Printing, E-Commerce in manufacturing, Computer Vision in manufacturing) ↓ employment via productivity gains
3. **Manufacturing/services heterogeneity.** *Same technology can have opposite signs across sectors*
   - Manufacturing: digital exposure ⇒ labour-saving (productivity channel)
   - Services: digital exposure ⇒ GVC reorganisation and market expansion
4. **GVC linkages matter mainly in services,** where digitalisation reshapes cross-border provision of tasks

Outline

Data sources

- **OECD Inter-Country Input–Output Tables (ICIO) and Trade in Employment (TiM) 2024 release**:
  - Employment, value added, GVC jobs, final demand flows
  - Gross fixed capital formation (GFCF) in computing equipment (C26) – proxy for digital adoption capacity
  - Complement with ILO modelled estimates to maximise country coverage
- **TechXposure database** (Prytkova et al., 2025): Industries' exposure to 40 technologies grouped in 9 families. Based on patent text similarity to NACE industry descriptions (sentence transformers; 2012–19)
- **Coverage:** 74 countries $\times$ 45 industries; focus on 30 manufacturing and professional service industries for regressions

GVC jobs matrix

$$\text{Total Employment} = E' \, VBF'$$

- E' = diagonalised vector: employment per unit of value added (inverse labour productivity)
- V = diagonal matrix of VA per unit of output
- $B = (I - A)^{-1}$ = Leontief inverse (inter-country/inter-industry linkages)
- F' = diagonalised vector of final demand

$\Rightarrow$ Final demand (F') activates gross output through linkages (B); that output requires value added (V); producing value added uses labour at intensity E'

GVC jobs isolate employment activated by *foreign* final demand:

$$\text{GVC jobs} = E' \, V\hat{B}F'$$

where $\hat{B}$ sets all within-country blocks of B to zero – keeping only cross-border demand propagation (Pahl et al., 2022)

From total jobs to GVC jobs

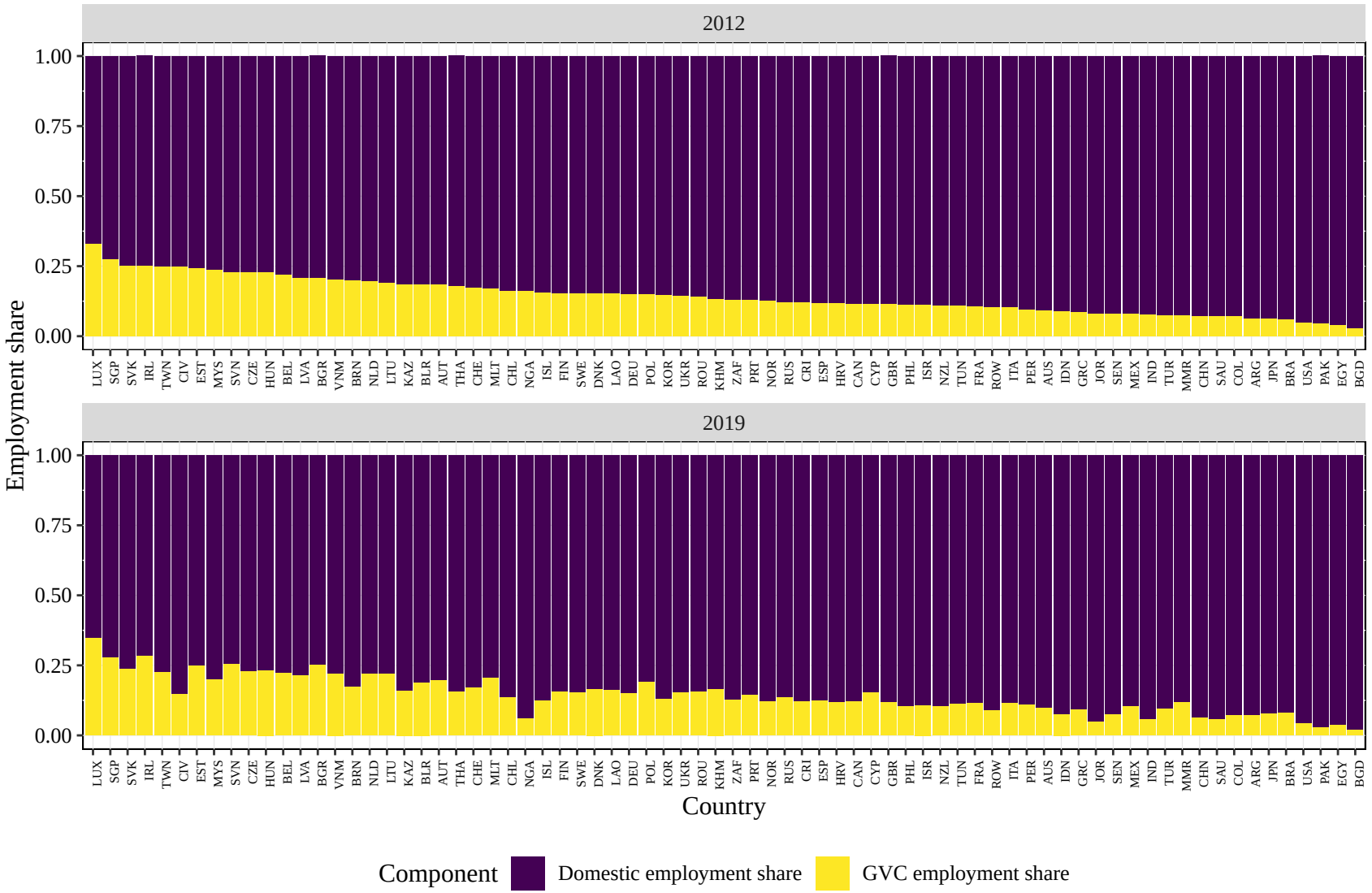
Toy example

$$E' V \hat{B} F' = \begin{bmatrix} 0 & e_a vb_{ab} f_b & e_a vb_{ac} f_c \\ e_b vb_{ba} f_a & 0 & e_b vb_{bc} f_c \\ e_c vb_{ca} f_a & e_c vb_{cb} f_b & 0 \end{bmatrix}$$

- **Rows**: where the jobs are located (country supplying labour)
- **Columns**: whose final demand is pulling jobs
- **Off-diagonals**: foreign-demand generated jobs = GVC jobs

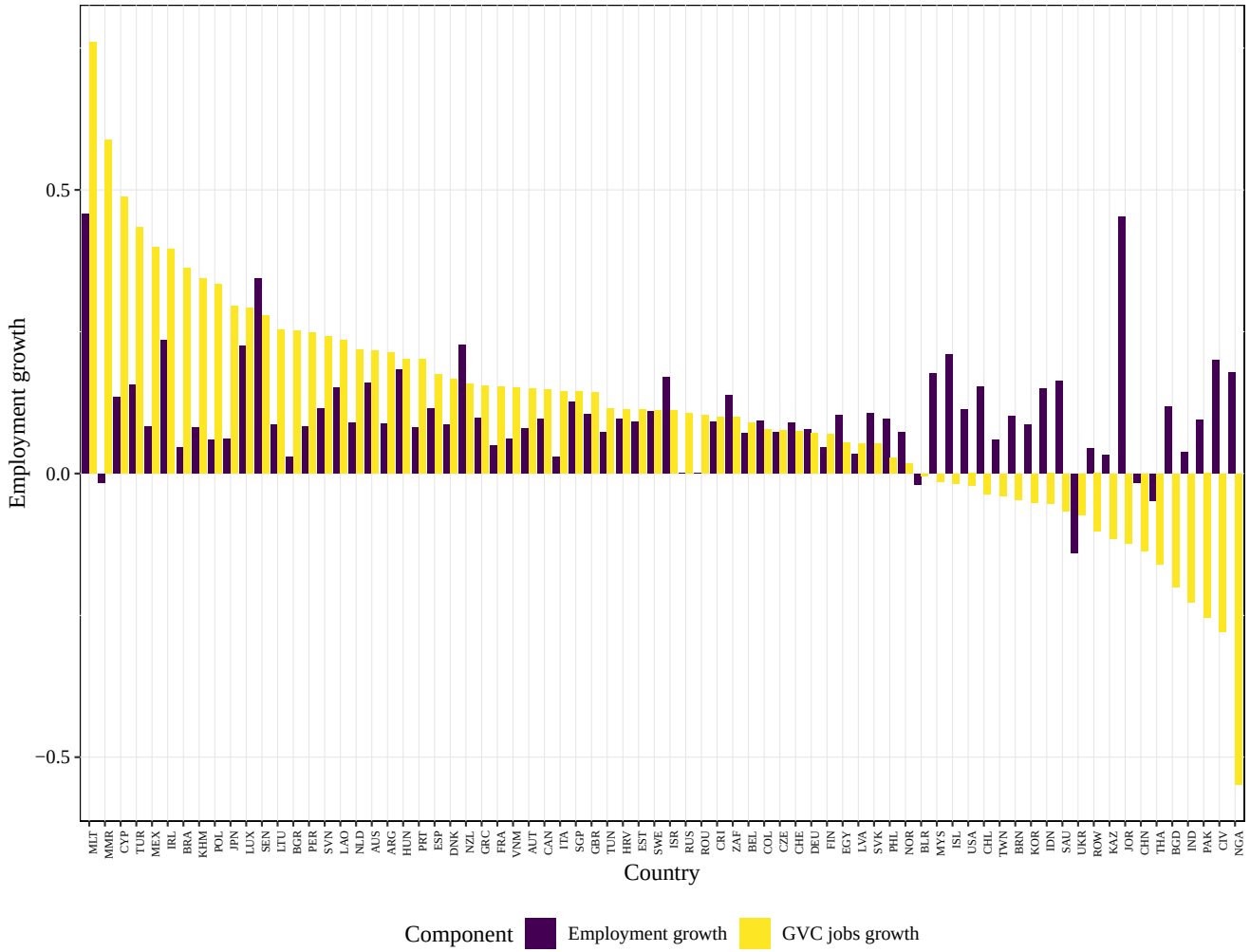
- GVC jobs are large in small, open economies (Belgium, Ireland, Estonia, Vietnam, Malaysia...)
- In large economies (US, China), domestic demand dominates (GVC jobs still a significant share)

Employment and GVC jobs: country composition



Countries sorted by GVC employment share in 2012. Small open economies dominate at the left; large economies (US, China, India) at the right.

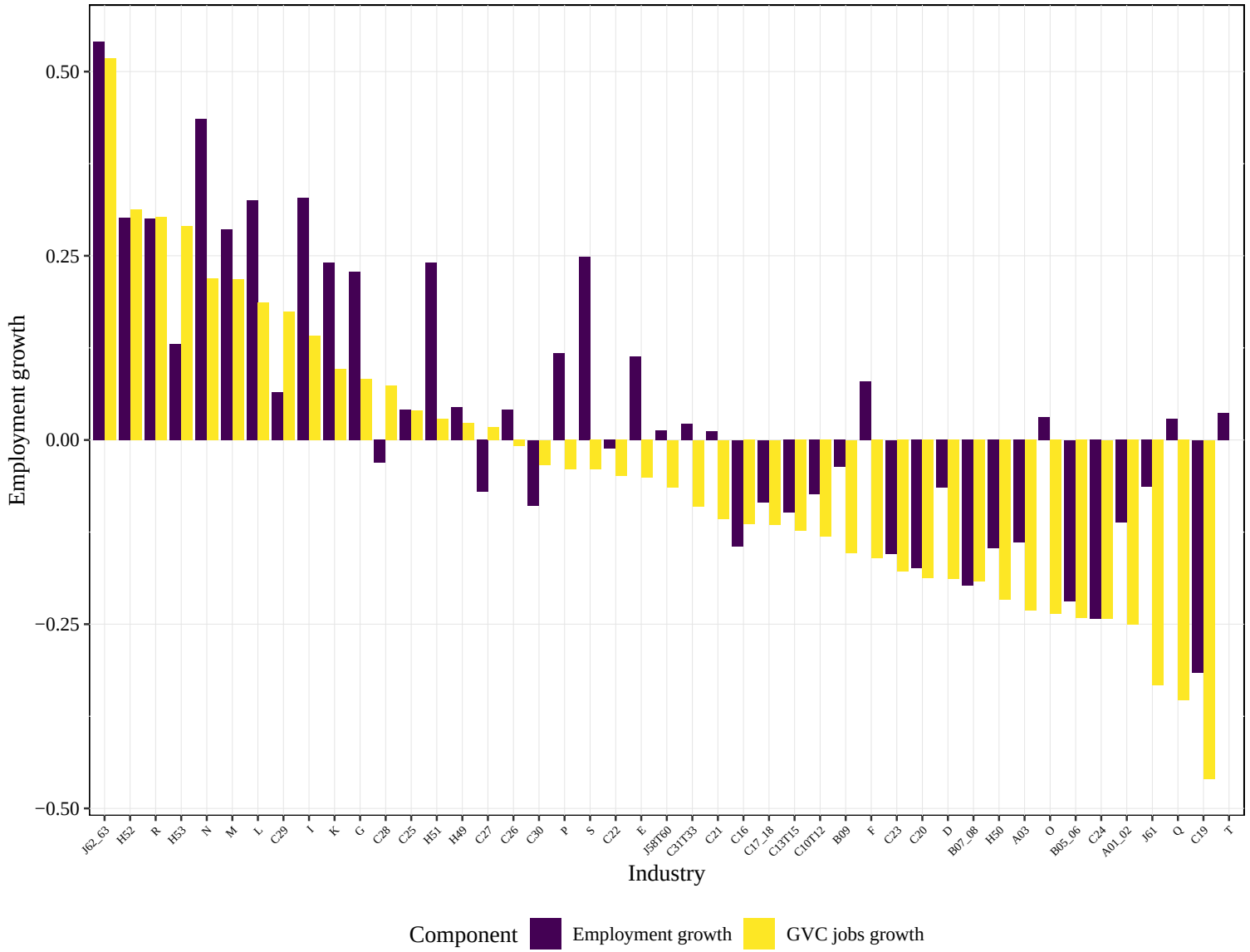
Employment and GVC jobs: growth (2012–19)



Countries sorted by GVC employment growth. GVC jobs track total employment but with more variance, especially in emerging economies.

Structural change: services GVC jobs growing fastest

Especially ICT (J62–63), Transport (H), Administrative (N) & Professional services (M)



Decomposition framework

We perform an average of two polar decompositions approach (Dietzenbacher and Los, 1998; Miller and Blair, 2022) of $\Delta E' VBF'$:

1. **Productivity** ($\Delta E'$): labour per unit of value added
2. **GVC linkages** (ΔVB): country-industry integration as GVC supplier
3. **Final demand** ($\Delta F'$): scale of global consumption

$$\Delta E' VBF' = E' VBF'_{t_1} - E' VBF'_{t_0} = \Delta E' + \Delta(VB) + \Delta F' \tag{1}$$

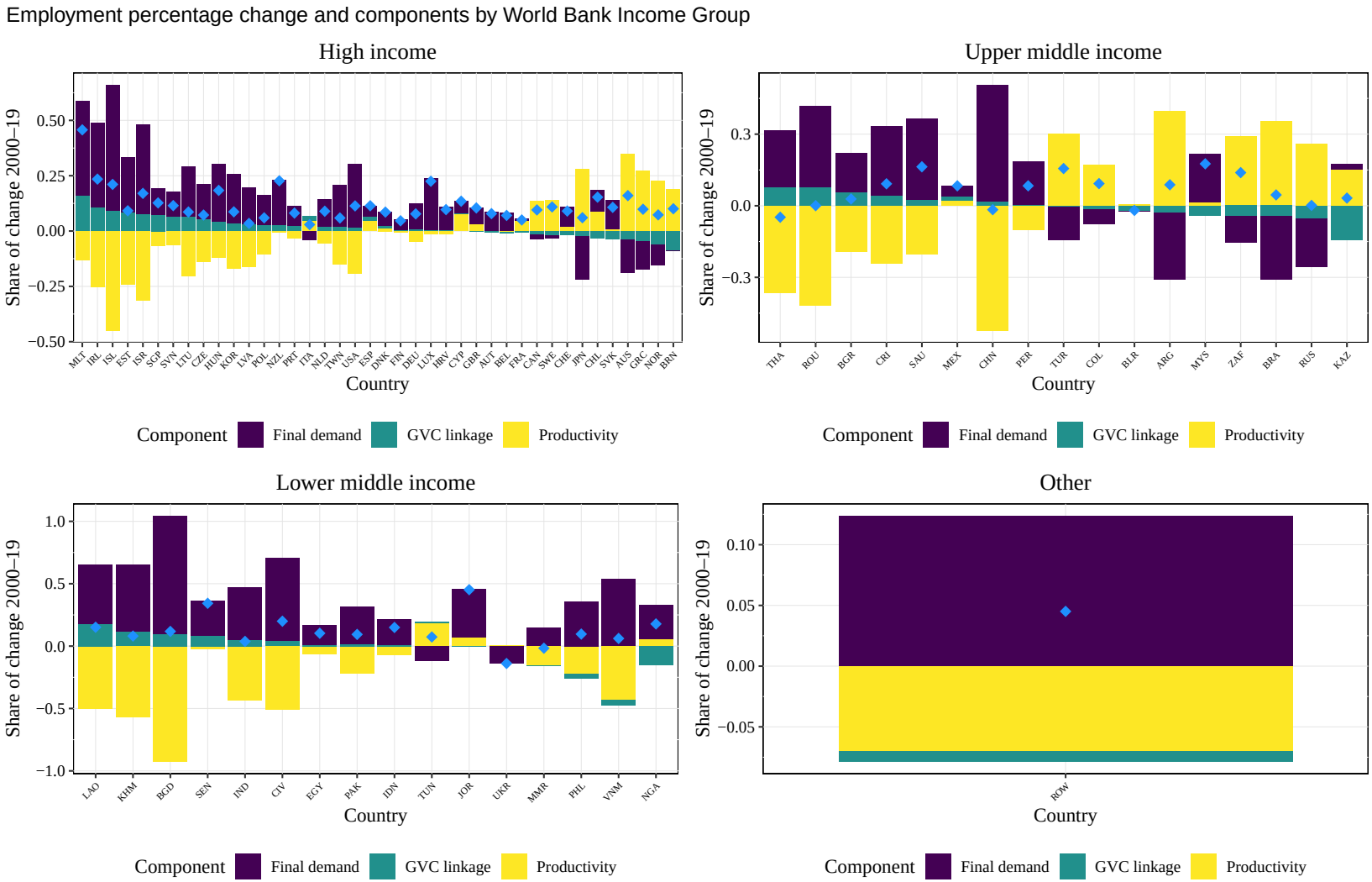
$$= \underbrace{\frac{(E'_{t_1} - E'_{t_0})\, VB_{t_0} F'_{t_0} + (E'_{t_1} - E'_{t_0})\, VB_{t_1} F'_{t_1}}{2}}_{\text{Productivity}} \tag{2}$$

$$+ \underbrace{\frac{E'_{t_0}(VB_{t_1} - VB_{t_0})F'_{t_1} + E'_{t_1}(VB_{t_1} - VB_{t_0})F'_{t_0}}{2}}_{\text{GVC linkages}} \tag{3}$$

$$+ \underbrace{\frac{E'_{t_0} VB_{t_0}(F'_{t_1} - F'_{t_0}) + E'_{t_1} VB_{t_1}(F'_{t_1} - F'_{t_0})}{2}}_{\text{Final demand}}. \tag{4}$$

The same decomposition applies to $\Delta E' V \hat{B} F'$ (GVC jobs) replacing B with $\hat{B}$

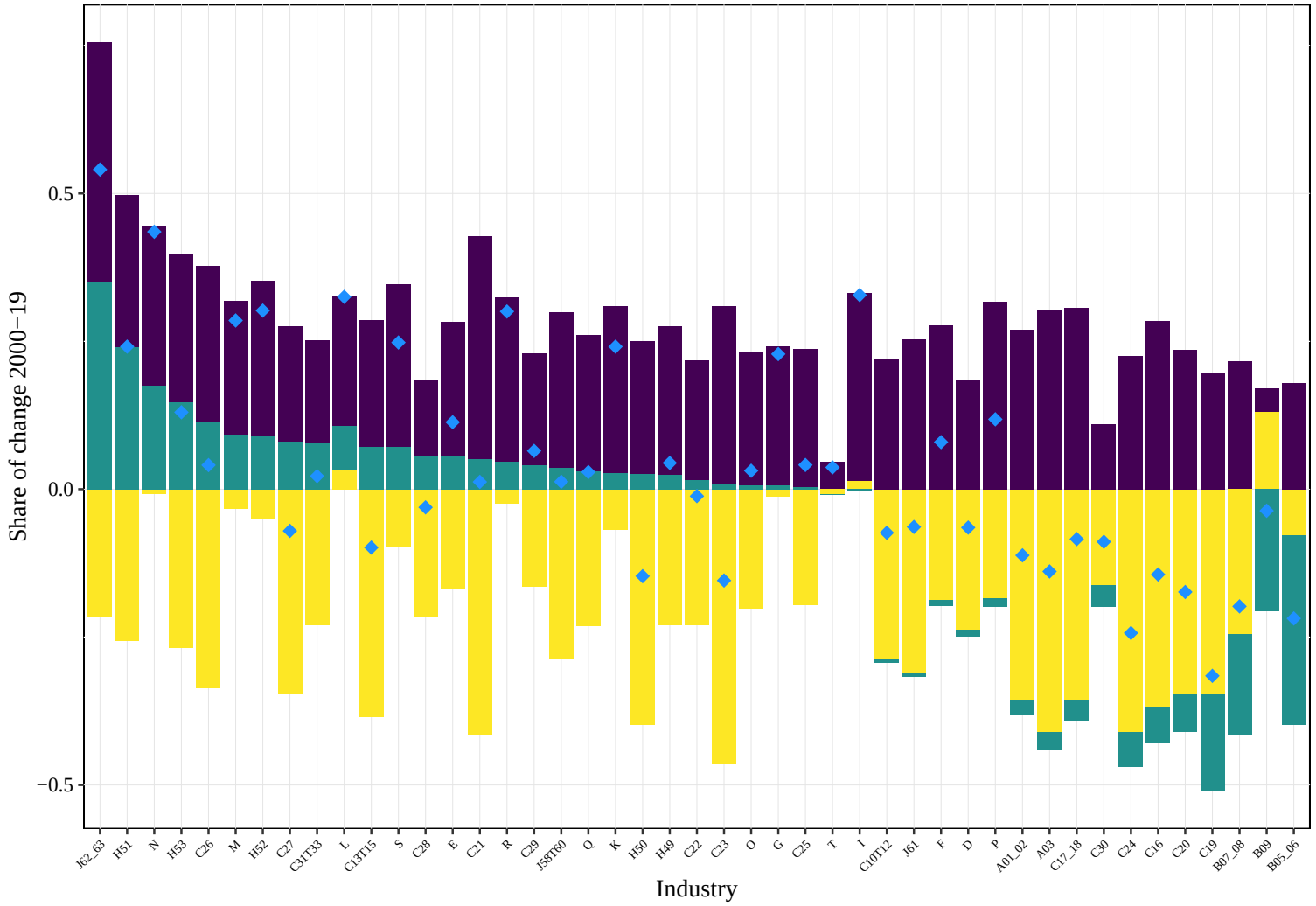
Employment decomposition by income group (2000–2019)



Final demand and productivity are the dominant drivers and typically offset each other. GVC linkages contribute more in HICs and UMICs (services) small countries.

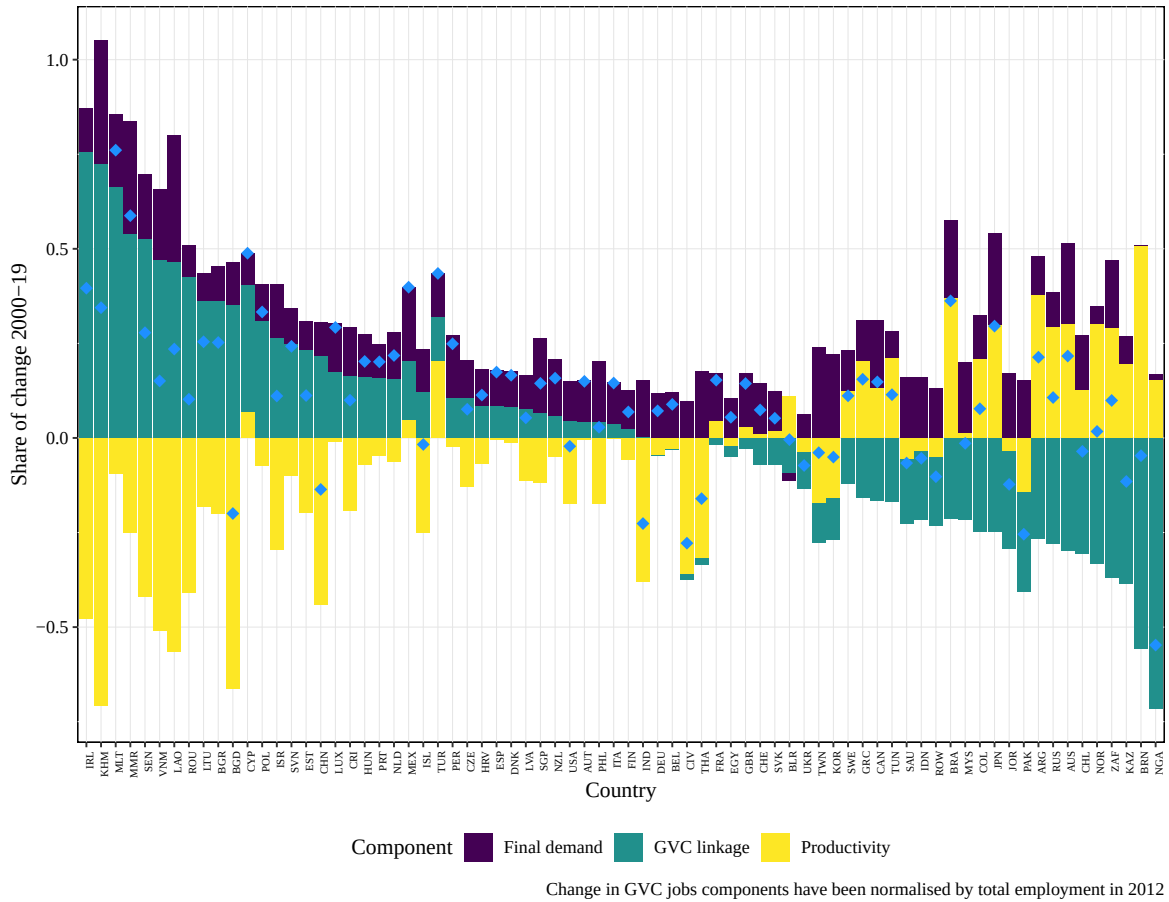
Employment decomposition by industry (2000–2019)

Structural change towards service sectors; GVC linkages significant in ICT, transport and business services



GVC jobs decomposition by industry (2012–2019)

- GVC linkages are a *larger* contributor to GVC jobs than to total employment growth
- GVC linkages drive employment gains in transport (H), internet services (J62–63), business services (N, M)
- Productivity offsets are larger for GVC-integrated manufacturing (C26, C27)
- Final D always positive



The role of digital technologies: measure

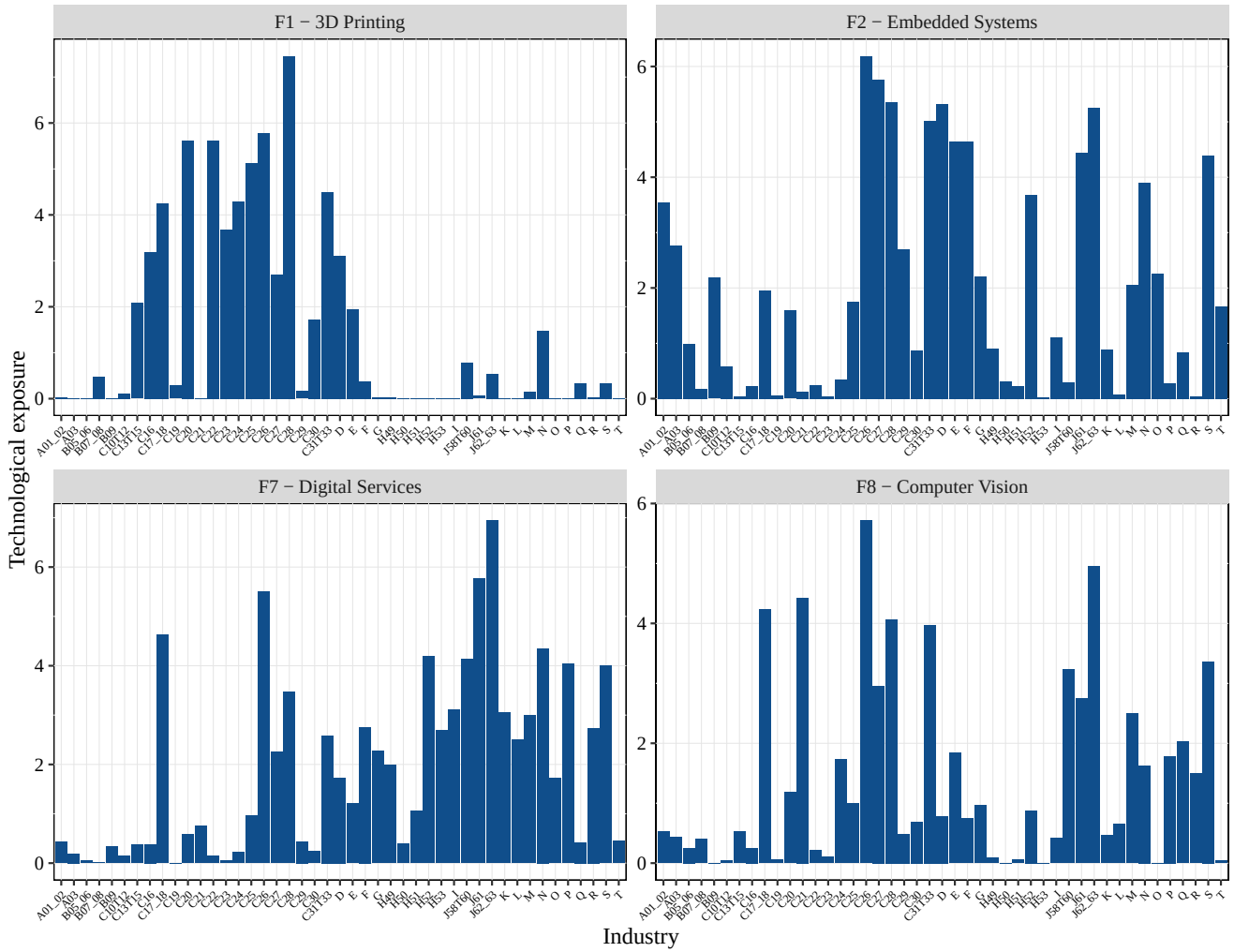
- **Industry-level exposure** to digital automation technology *tech* via *TechXposure* (Prytkova et al., 2025): 40 technologies; 9 families
  - Patent text ↔ NACE activity description similarity (sentence transformers, 2012–19 patenting)
  - Captures the *relevance* of frontier technological advances to the activities performed in each industry
- **Country-level adoption capacity** (pre-sample, 2007–11):
  - Average GFCF in computer, electronic and optical equipment (C26) per worker: infrastructure underpinning deployment of digital technologies

Combined **adoption potential** measure for country i, industry j, technology family *tech*:

$$\text{Digit}_{ij}^{tech} = \text{TechXposure}_{j}^{tech} \times \overline{cpte}_{i,\,07\text{-}11} \tag{5}$$

- $\text{TechXposure}_{j}^{tech}$: exposure of industry j to technology family *tech*
- $\overline{cpte}_{i,\,07\text{-}11}$: country i pre-sample average C26 investment per worker
- Bartik instrument logic: global technology frontier (shift) × local adoption capacity (share)

Technological exposure across industries



Exposure to four selected technology families by industry. Manufacturing sectors (C-codes) dominate 3D Printing and Embedded Systems; service sectors (J, M, N) dominate Digital Services and Computer Vision.

Econometric approach

We test the conditional correlation between technology adoption potential and employment growth in an OLS framework:

$$\Delta E_{ij} = \alpha + \sum_{tech} \beta_{tech} \, \text{Digit}_{ij}^{tech} + \kappa_i + \delta_j + \varepsilon_{ij} \tag{6}$$

- **8 outcome variables** ΔE_{ij}: [Total / GVC jobs] $\times$ [Aggregate / Final demand driver / GVC linkage driver / Productivity driver]
- κ_i: country fixed effects (absorb macro shocks, exchange rates)
- δ_j: industry fixed effects (absorb global sectoral trends)
- Period: 2012–2019; all nine technology families included jointly
- Restrict to manufacturing and professional service industries (30 sectors)
- Standard errors clustered at country-industry level

Outlier winsorisation at 1.5$\times$ IQR, conditional on industry-country having $>$10th percentile employment share in 2012

Outline

Baseline results: all sectors

When manufacturing and services are pooled, no statistically significant net employment effect. Plots

But this masks structural compensation:

- **3D Printing**: productivity saves labour (-0.0016pp), offset by final demand ($+0.01$pp)
- **E-Commerce**: labour-saving via productivity (-0.02pp); weak positive GVC linkage partially offsets
- **Computer Vision**: negative final demand coefficient (-0.04pp) may reflect consumption shifting away from labour-intensive activities
- **Health Technologies**: positive employment via final demand ($+0.03$pp, 10% sig.), consistent with Baumol cost disease in healthcare
- **Food Services platforms**: positive GVC linkage ($+0.01$pp): digital platforms deepen supply chain integration

Manufacturing vs. services

The same technology can have opposite signs across sectors

Manufacturing Plots

- Digital tech is mainly **labour-saving via productivity (total employment)**
- E-Commerce: −0.02pp productivity
- Computer Vision: −0.09pp productivity (partially offset by +0.06pp GVC linkages)
- Digital Services: offsetting effects (+0.10pp productivity, −0.07pp GVC linkages, −0.03pp demand) ⇒ net null
- Food Services: +0.03pp total employment via GVC linkages

Services Plots

- Digital tech mainly **reshapes GVC organisation and expands markets**
- Smart Mobility: +0.14pp GVC employment (GVC linkages +0.11pp, final demand +0.01pp)
- 3D Printing: +0.11pp GVC employment (GVC linkages +0.13pp)
- E-Commerce: +0.05pp GVC employment via linkages
- Computer Vision: +0.26pp GVC employment
- Embedded Systems: −0.10pp GVC employment via linkages

Manufacturing vs. services divide

- **Manufacturing**: digital technologies *automate of production tasks*
  - 3D printing, e-commerce, computer vision $\Rightarrow$ reduce labour per unit of output
  - Small impact on GVC integration
  - Consistent with standard automation-driven substitution
- **Services**: digital technologies enable *market and GVC organisation*
  - Smart mobility (logistics, transport coordination): reduces spatial friction
  - E-commerce: reallocates service GVC employment toward internationally linked activities
  - Computer vision (AI applications): expands internationally fragmented service activities
  - 3D printing: enables related services (design, testing, certification) to be traded across borders
- **Implication**: digital automation reorganises *which* services are traded and *where* they are produced, reconfiguring GVC workers tasks

Outline

Conclusions: Main findings

- We decompose the digital automation–employment nexus in GVCs into three structural drivers (productivity, GVC linkages, final demand) for total and GVC-activated employment

1. **Drivers compensation:** No significant net employment effect (pooled sectors), due to offsetting mechanisms across the three drivers
2. **Technology heterogeneity:** "Market-expanding" technologies (food services platforms, smart mobility) generate employment via GVC linkages and final demand. "Efficiency-enhancing" technologies (3D printing, e-commerce, computer vision in manufacturing) reduce employment via productivity gains.
3. **Sector heterogeneity:** manufacturing mainly labour-saving (standard automation); in services, the same technologies expand GVC-activated employment by reorganising cross-border production.
4. **GVC linkages matter mainly in services:** Digitalisation affects GVC jobs in services mainly through reorganisation of international supply.

Policy implications

REVISE

- **Consider heterogeneity:** Job creation/destruction over GVCs are driver-, technology-, and sector-specific.
- **Manufacturing policy:** Productivity-enhancing digital adoption frees resources but risks employment losses unless accompanied by **increased demand** or **functional upgrading** within GVCs.
- **Services and trade policy:** Facilitating digital services trade (interoperability, data governance, regulations) may have employment benefits.
- **Caution on "turning inward":** reshoring risks forgoing the GVC-activated employment gains form digital technologies in services sectors.
- **Re-skilling:** The reorganisation of service GVCs by digital technologies creates new tasks that require workers with complementary skills.

Thank you for your attention

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Comments and questions very welcome

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Outline

Toy example

Assumptions

- **Two countries:** A and B (one industry each).
- **Technical coefficients** (inputs per unit output in the *column* country):

$$A = \begin{bmatrix} 0.40 & 0.10 \\ 0.20 & 0.30 \end{bmatrix}$$

- **Employment per unit VA:** $e_A = 8,\ e_B = 4 \Rightarrow E' = \mathrm{diag}(8,\ 4)$
- **Final demand (by destination, \$):** $F' = \begin{bmatrix} 100 \\ 100 \end{bmatrix}$
- **Value-added shares:** (1 - inputs)

  $v_A = 1 - (0.40 + 0.20) = 0.40, \quad v_B = 1 - (0.10 + 0.30) = 0.60$

  $\Rightarrow V = \mathrm{diag}(0.40,\ 0.60)$

Linkages and total jobs

Leontief inverse:

$$B = (I - A)^{-1} = \begin{bmatrix} 1.75 & 0.25 \\ 0.50 & 1.50 \end{bmatrix}$$

Off-diagonals capture cross-border links: $b_{AB} = 0.25$, $b_{BA} = 0.50$.

Total employment pulled by final demand:

$$\text{Jobs}_{\text{total}} = E' \, V \, B \, F'$$

$$E' \, V \, B = \begin{bmatrix} 5.6 & 0.8 \\ 1.2 & 3.6 \end{bmatrix} \quad \Rightarrow \quad \begin{bmatrix} 5.6 \cdot 100 + 0.8 \cdot 100 \\ 1.2 \cdot 100 + 3.6 \cdot 100 \end{bmatrix} \quad \Rightarrow \quad \text{Jobs}_{\text{total}} = \begin{bmatrix} 640 \\ 480 \end{bmatrix}$$

Interpretation: each column is "jobs per \$1 of final demand" in that destination; each row is where the jobs are located: 640 jobs located in A; 480 jobs located in B.

Who pulls whose jobs? GVC Jobs

Back

Jobs matrix (rows = where jobs are located; cols = whose demand):

$$J = E'VB\,\mathrm{diag}(F') = \begin{bmatrix} 560 & 80 \\ 120 & 360 \end{bmatrix}$$

- Diagonals (560, 360): domestic-demand generated jobs.
- Off-diagonals (80, 120): foreign-demand generated jobs (the GVC jobs).

GVC jobs removing domestic links:

$$\hat{B} = \begin{bmatrix} 0 & 0.25 \\ 0.50 & 0 \end{bmatrix}, \quad \text{GVC jobs} = E'V\hat{B}F' = \begin{bmatrix} 80 \\ 120 \end{bmatrix}$$

Shares: A = 80/640 = 12.5%; B = 120/480 = 25%.

9 Technology Families: 40 Emerging Technologies

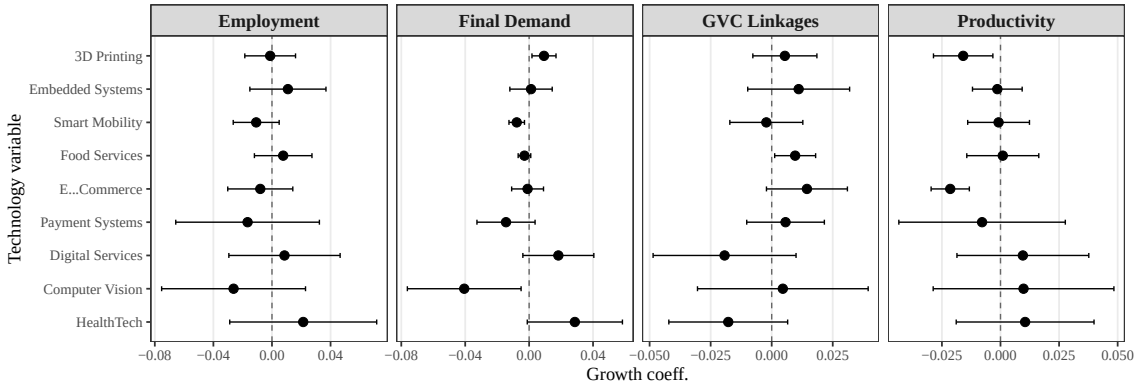
Back

	Family		Emerging Digital Technology
F1	**3D Printing**	01	3D Printer Hardware
		02	3D Printing
		03	Additive Manufacturing
F2	**Embedded Systems**	04	Smart Agriculture & Water Management
		05	Internet of Things (IoT)
		06	Predictive Energy Management and Distribution
		07	Industrial Automation & Robot Control
		08	Remote Monitoring & Control Systems
		09	Smart Home & Intelligent Household Control
F3	**Smart Mobility**	10	Intelligent Logistics
		11	Autonomous Vehicles & UAVs
		12	Parking and Vehicle Space Management
		13	Vehicle Telematics & Electric Vehicle Management
		14	Passenger Transportation
F4	**Food Services**	15	Food Ordering & Vending Systems
F5	**E-Commerce**	16	Digital Advertising
		17	Electronic Trading and Auctions
		18	Online Shopping Platforms
		19	E-Coupons & Promotion Management
F6	**Payment Systems**	20	Electronic Payments & Financial Transactions
		21	Mobile Payments
		22	Gaming & Wagering Systems
F7	**Digital Services**	23	Digital Authentication
		24	E-Learning
		25	Location-Based Services & Tracking
		26	Voice Communication
		27	Electronic Messaging
		28	Workflow Management
		29	Cloud Storage & Data Security
		30	Information Processing
		31	Cloud Computing
		32	Recommender Systems
		33	Social Networking & Media Platforms
		34	Digital Media Content
F8	**Computer Vision**	35	Augmented and Virtual Reality (AR/VR)
		36	Machine Learning & Neural Networks
		37	Medical Imaging & Image Processing
F9	**HealthTech**	38	Health Monitoring
		39	Medical Information
		40	E-Healthcare

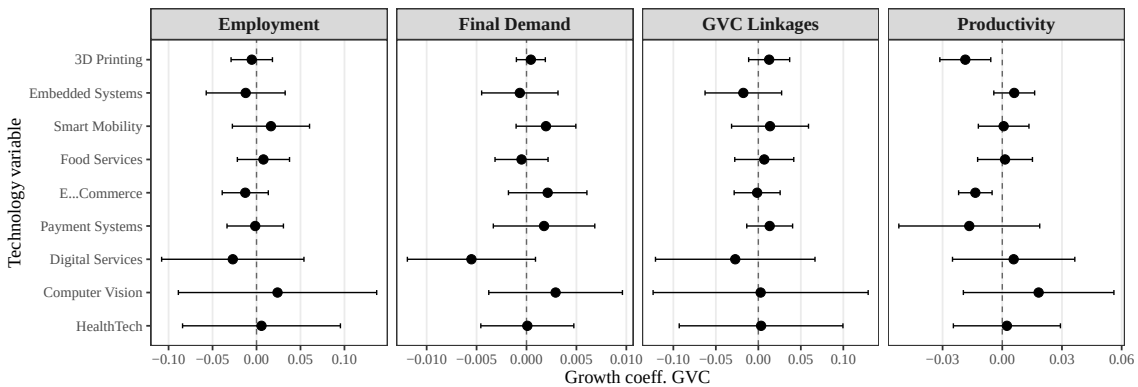
Source: Prytkova et al. (2025)

Baseline results: coefficient plots (all sectors)

Back



(a) Total employment

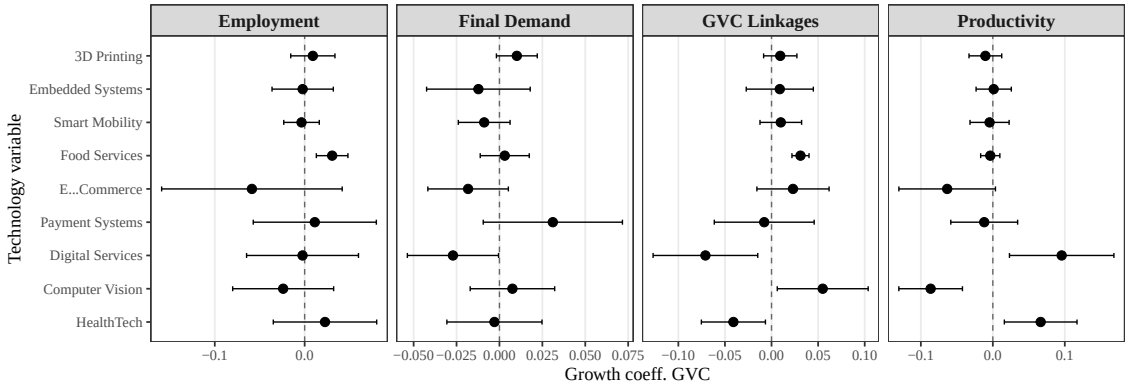


(b) GVC employment

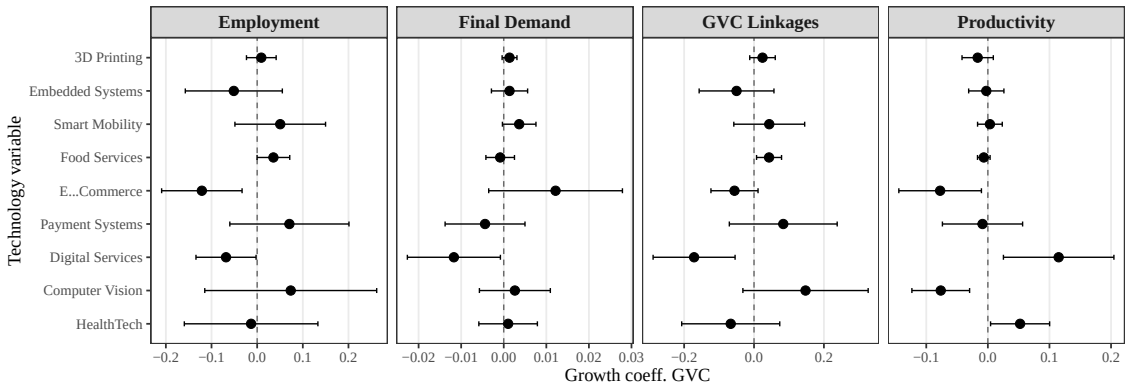
OLS coefficients for nine technology families across four outcomes (aggregate, final demand, GVC linkages, productivity). 95% CI on robust standard errors.

Manufacturing results: coefficient plots

Back



(a) Total employment – Manufacturing

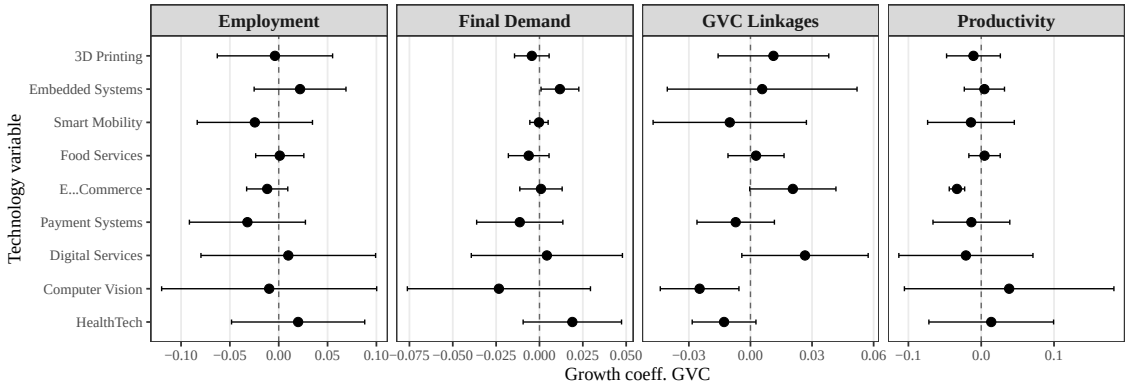


(b) GVC employment – Manufacturing

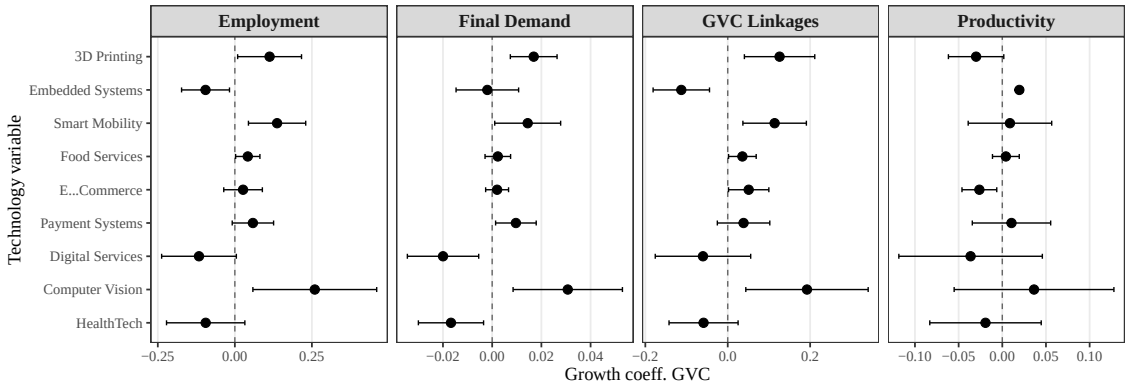
In manufacturing, statistically significant relations are predominantly through the productivity driver. Labour savings are more pronounced for GVC jobs than for total employment.

Services results: coefficient plots

Back



(a) Total employment – Services



(b) GVC employment – Services

In services, effects on total employment are muted and mainly through the GVC demand driver. GVC employment shows stronger and more systematic responses operating via GVC linkages and final demand.

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