Quality upgrading and position in global value chains

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INRAE
science for people, life & earth

BATModel
better agri-food trade modelling for policy analysis

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Motivation

- **Product quality** plays an important role in explaining **international trade patterns**:
  - Higher income countries and more productive firms export higher quality goods (Schott, 2004; Hummels and Klenow, 2005; Baldwin and Harrigan, 2011; Fajgelbaum et al., 2011)
  - Quality upgrading permits firms to increase their export performance (Crozet et al. 2012)
- **GVCs** have transformed international trade
  - Production processes are highly fragmented across country borders
  - An increasing number of firms organize production on a global scale
  - A higher content of imported inputs in exports and of services in manufacturing

    $\approx$ 45% of global trade in agricultural and food products goes to intermediate consumption
  - A reorganization (reshoring, regionalization, digitalization) of GVCs after Covid-19?
- How firms **position in GVCs**?
  - Upper and lower ends of the value chain provide higher value added and profit margins (the *smile curve*: Rungi and del Prete, 2018; Mahy et al., 2021)
  - More productive firms internalize a larger span of production stages (Chor et al., 2021)

    $\Rightarrow$ Chinese firms have increased their participation in GVCs by integrating more upstream stages.
- How **quality** affects firms' participation and **position in GVCs**?

Question: How firms that differ in terms of product quality position in GVCs?

Approach: Extend the CMY framework to include firms' decision on product quality.

Chor, Manova and Yu (2021):

Heterogeneous firms maximize profits by choosing the processing level and quantity of goods they produce and of inputs they buy.

+ Consumers are willing to pay higher prices for higher-quality goods.
+ Producing higher-quality goods is harder and costlier.
+ Firms choose the quality level of produced goods.

Empirics: Data on French agri-food firms, 2000-2018.

Result: Quality upgrading determines firms to internalize more production stages.

H1: Participation to GVCs = firm's joint involvement in import and export activities (Baldwin and Yan, 2014; Antras, 2020)

⇒ We focus on firms in GVCs, i.e. that both import and export in a given year.

H2: Firms' **imports** and **exports** reflect their **purchases** and **outputs** in terms of product composition

⇒ Imports (from all sources) ∼ firm's input purchases
⇒ Exports (to all destinations) ∼ firm's sales of produced output

H3: Position in the chain = the level of transformation (processing) of goods used and produced by the firm.

(Fally, 2012; Antras et al., 2012; Alfaro et al., 2019)

⇒ A highly disaggregated I-O table to identify the level of transformation of each industry
Apply the same level to all products within an industry.

H4: More upstream products are traded at **lower prices**

Model

- Consumers value quality (λ) and maximize a CES utility function over available varieties Ω_υ:

$$\Upsilon = \left(\int_{\Omega_\upsilon} [\lambda(\upsilon) q(\upsilon)]^{\frac{\varepsilon - 1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon - 1}}$$

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- Production of each variety υ requires the completion of a continuum of tasks u, indexed by their remoteness from final demand (upstreamness), using a CES aggregator:

$$q = \theta \left(\int_{U^X}^{U^M} x(u)^{\frac{\sigma-1}{\sigma}} du + q_M^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\rho\sigma}{\sigma-1}}$$

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Producing higher-quality goods is harder ($0 \leq \gamma < 1$) and incurs fixed costs λ^{α}.

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Producing higher-quality goods is harder ($0 \leq \gamma < 1$) and incurs fixed costs λ^α.

- Firms choose the quantity (q_M, $x(u)$) and processing level (U^M, U^X) of inputs they purchase and produce in-house, and the quality of output (λ) that maximize their profits:

$$\pi = pq - \left(p_M q_M + \int_{U^X}^{U^M} [c(u) x(u) + F(u)] \, du + \lambda^\alpha \right)$$

Under reasonable assumptions:

- mild decreasing returns to scale $\left(\rho > \frac{\sigma - 1}{\sigma}\right)$
- relatively small variable & fixed costs of in-house produced inputs $\left(\frac{c(u)x(u)}{p_M q_M}, \frac{F_M}{p_M q_M}\right)$

Quality upgrading $(\lambda > 0)$ leads to:

1. the purchase of more upstream inputs $\left(\frac{dU^M}{d\lambda} > 0\right)$
   the production of more downstream goods $\left(\frac{dU^X}{d\lambda} < 0\right)$
   $\Rightarrow$ larger span of production stages performed by the firm $\left(\frac{d\left(U^M - U^X\right)}{d\lambda} > 0\right)$
2. an increase in variable & fixed costs, input purchases, and value added;
   a negligible effect on profits.

Data on French agri-food firms: 2000–2018

AMADEUS	turnover, size (# employees), ... , economic activity (NACE)
French customs	product-level bilateral imports and exports
Sample	3,562 importing firms 4,714 exporting firms 2,582 firms in GVCs (import & export)

US input-output table (BEA)

+ US/French industry correspondences

+ for multiple correspondences, assume equal weights for all industry pairs

⇒ an input-output table at the level of French industries

405 US industries (42 agrifood) ⟶ 604 NACE industries (88 agrifood)

NACE I-O table

- Compute the upstreamness of each industry r as a weighted average of the number of production stages from final demand for which it provides inputs (Fally, 2012; Antràs et al., 2012; Antràs and Chor, 2013):

$$U_r = 1 \cdot \frac{F_r}{Y_r} + 2 \cdot \frac{\sum_s b_{rs} F_s}{Y_r} + 3 \cdot \frac{\sum_s \sum_k b_{rk} b_{ks} F_s}{Y_r} + 4 \cdot \frac{\sum_s \sum_k \sum_l b_{rl} b_{lk} b_{ks} F_s}{Y_r} + \ldots$$

(weights = shares of provided inputs in industry's output)

	Frequency	Min	Max	Mean	Std. dev.
Upstreamness - all industries	604	1.00	4.51	1.88	0.75
Upstreamness - agrifood	88	1.08	3.61	1.85	0.72

Industry upstreamness

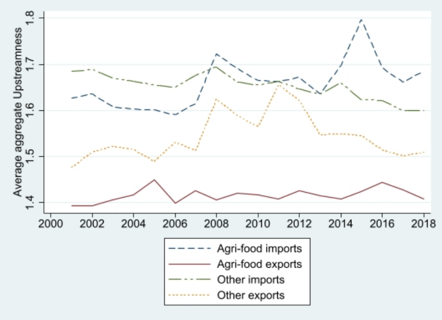
NACE industry	Upstreamness
Retail sale of fruit and vegetables in specialised stores	1.01
Retail sale of meat and meat products in specialised stores	1.01
Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised stores	1.01
Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes	1.08
Manufacture of bread; manufacture of fresh pastry goods and cakes	1.10
Manufacture of prepared meals and dishes	1.20
Manufacture of wine from grape	1.23
Growing of vegetables and melons, roots and tubers	1.28
Manufacture of cocoa, chocolate and sugar confectionery	1.39
Processing and preserving of meat	1.44
Growing of pome fruits and stone fruits	1.46
Processing of tea and coffee	1.47
Manufacture of fruit and vegetable juice	1.47
Processing and preserving of fish, crustaceans and molluscs	1.60
Marine fishing	1.66
Raising of swine/pigs	2.10
Manufacture of starches and starch products	2.16
Manufacture of oils and fats	2.72
Raising of dairy cattle	2.98
Growing of cereals (except rice), leguminous crops and oil seeds	3.45
Seed processing for propagation	3.61

- Use the product composition of trade to compute the upstreamness for each firm f:

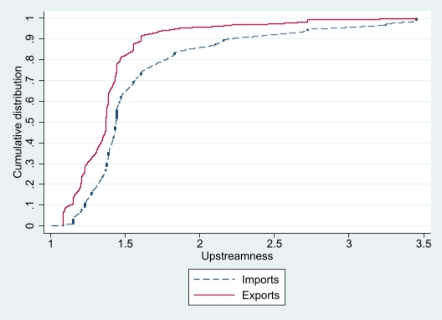
Upstreamness of exports: $U_f^X = \sum_r \frac{X_{fr}}{X_f} U_r$

Upstreamness of imports: $U_f^M = \sum_r \frac{M_{fr}}{M_f} U_r$

Involvement in GVCs: $GVC_f = U_f^M - U_f^X$ (span of in-house production stages)



(a) Average import and export upstreamness



(b) Cumulative distribution of French firms

- Use the product composition of trade to compute the upstreamness for each firm f:

Upstreamness of exports: $U_f^X = \sum_r \frac{X_{fr}}{X_f} U_r$

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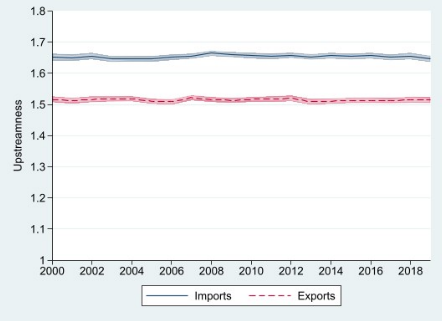
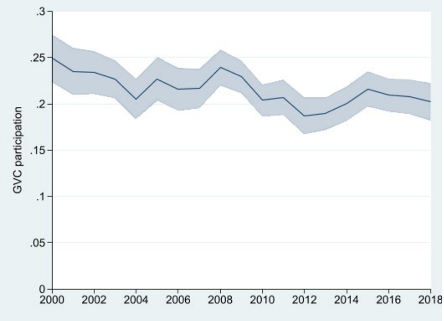


(a) Import and export upstreamness (U^M and U^X)



(b) Involvement in GVC ($U^M - U^X$)

Decomposition of sector-level *upstreamness*

$$\Delta U_t^M = \sum_{f\in\Xi_t^M} \frac{M_{ft}}{M_t}\cdot U_{ft}^M - \sum_{f\in\Psi_t^M} \frac{M_{f,t-1}}{M_{t-1}}\cdot U_{f,t-1}^M + \sum_{f\in\Gamma_t^M} \frac{M_{f,t-1}}{M_{t-1}}\cdot \Delta U_{ft}^M + \sum_{f\in\Gamma_t^M} \Delta\frac{M_{ft}}{M_t}\cdot U_{ft}^M$$

$$\Delta U_t^X = \underbrace{\underbrace{\sum_{f\in\Xi_t^X} \frac{X_{ft}}{X_t}\cdot U_{ft}^X}_{\text{starting firms}} - \underbrace{\sum_{f\in\Psi_t^X} \frac{X_{f,t-1}}{X_{t-1}}\cdot U_{f,t-1}^X}_{\text{stopping firms}}}_{\text{extensive margin}} + \underbrace{\underbrace{\sum_{f\in\Gamma_t^X} \frac{X_{f,t-1}}{X_{t-1}}\cdot \Delta U_{ft}^X}_{\Delta\text{upstreamness}} + \underbrace{\sum_{f\in\Gamma_t^X} \Delta\frac{X_{ft}}{X_t}\cdot U_{ft}^X}_{\Delta\text{mkt share}}}_{\text{intensive margin}}$$

	Extensive margin			Intensive margin (incumbent)			Overall
	Starting firms	Stopping firms	Net effect	change in firm's upstreamness	change in firm's mkt share	Net effect	
ΔU_t^M	0.1329	-0.0336	0.0993	0.0064	0.0559	0.0623	0.1616
ΔU_t^X	0.1846	-0.1074	0.0772	-0.0032	0.1029	0.0998	0.1770
$\Delta U_t^M - \Delta U_t^X$	-0.0517	0.0738	0.0221	0.0096	-0.0470	-0.0374	-0.0154

$\Rightarrow$ Annual changes in sector-level upstreamness explained mainly by the extensive margin (firms that start/stop exporting/importing) and changes in firms' market shares.

$\Rightarrow$ Small changes in firms' upstreamness.

Product and firm-level quality

- Compute quality at firm-product-market level as the residual extra quantity for a given price (Khandelwal et al., 2013):

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = \text{Controls (FE)} + e_{fjkt}$$

and price elasticities ε_k estimated by Fontagné et al. (2022) at the HS 4-digit level.

$\Rightarrow$ relative **quality** of the firm in a specific **product-destination** market: $\ln \widehat{\lambda}_{fjkt} = \frac{\widehat{e}_{fjkt}}{\varepsilon_k - 1}$

- Retrieve **firm**-specific **quality**:

– Estimate price-adjusted quantities with firm-year FE and country-product FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{ft} + FE_{jkt} + e_{fjkt}$$

– Standardize estimated firm FE: $\widehat{\mathbf{Q}}_{ft} = \frac{\widehat{FE}_{ft} - \overline{\widehat{FE}_{ft}}}{\text{SE}\left[\widehat{FE}_{ft}\right]}$

+ 3 alternative ways to obtain firm quality

quality

- Compute quality at firm-product-market level as the residual extra quantity for a given price (Khandelwal et al., 2013):

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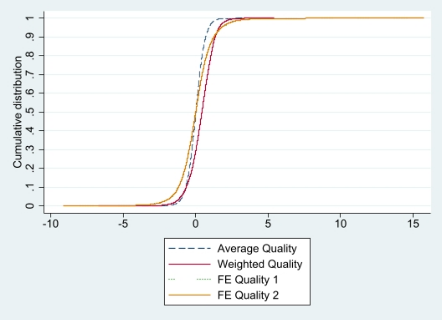
$\Rightarrow$ relative **quality** of the firm in a specific **product-destination** market: $\ln \widehat{\lambda}_{fjkt} = \frac{\widehat{e}_{fjkt}}{\varepsilon_k - 1}$

- Four measures of **firm quality**:

$$\begin{pmatrix} & \widehat{\mathbf{Q}}_{ft} & \widehat{\mathbf{Q1}}_{ft} & \widehat{\mathbf{Q2}}_{ft} & \widehat{\mathbf{Q3}}_{ft} \\ \widehat{\mathbf{Q}}_{ft} & 1 & & & \\ \widehat{\mathbf{Q1}}_{ft} & 0.8543 & 1 & & \\ \widehat{\mathbf{Q2}}_{ft} & 0.6383 & 0.7829 & 1 & \\ \widehat{\mathbf{Q3}}_{ft} & 0.9695 & 0.8397 & 0.6267 & 1 \end{pmatrix}$$



Test the model predictions

	Imports upstreamness (U_{ft}^M)	Exports upstreamness (U_{ft}^X)	Involvement in GVCs (GVC_{ft})	Imports upstreamness (U_{ft}^M)	Exports upstreamness (U_{ft}^X)	Involvement in GVCs (GVC_{ft})
Quality				0.0171**	-0.0098*	0.0270***
				(0.0067)	(0.0052)	(0.0085)
ln Productivity	-0.0022	0.0031	-0.0053	-0.0031	0.0112	-0.0143
	(0.0159)	(0.0101)	(0.0185)	(0.0194)	(0.0119)	(0.0219)
Firm size						
small	reference	reference	reference	reference	reference	reference
medium	0.0353	0.0053	0.0300	0.0502	0.0138	0.0364
	(0.0274)	(0.0166)	(0.0326)	(0.0339)	(0.0174)	(0.0378)
large	0.0395	0.0276	0.0120	0.0691	0.0318	0.0374
	(0.0526)	(0.0221)	(0.0561)	(0.0636)	(0.0252)	(0.0687)
Fixed effects	firm, industry-year			firm, industry-year		
Observations	6,383	6,383	6,383	5,069	5,069	5,069
R^2	0.829	0.831	0.764	0.842	0.858	0.793

⇒ Non significant effect of productivity on firms' upstreamness and involvement in GVCs.

⇒ Higher-quality firms import more upstream inputs and export more downstream products. perform a larger span of in-house production stages.

⇒ Similar results with the four quality measures and additional controls.

Reverse causality between quality and GVCs position

⇒ IV estimates: instrument quality by the change in foreign demand for firms' products.

	First stage	Second stage		
	Quality	U^M_{ft}	U^X_{ft}	GVC_{ft}
Instrument	0.0309***			
	(0.0092)			
Quality		0.2038*	-0.1761**	0.3799***
		(0.1120)	(0.0731)	(0.1293)
ln Productivity	0.0360	-0.0088	0.0203	-0.0291
	(0.0422)	(0.0215)	(0.0144)	(0.0248)
Firm size				
small	reference	reference	reference	reference
medium	-0.0196	0.0468	0.0141	0.0327
	(0.0705)	(0.0332)	(0.0185)	(0.0370)
large	-0.1779	0.0956	0.0024	0.0932
	(0.1364)	(0.0673)	(0.0269)	(0.0714)
Fixed effects	firm, industry-year	firm, industry-year		
Observations	4,845	4,845	4,845	4,845
R^2	0.721	0.847	0.862	0.799
F-stat	11.3938			
Endogeneity test		2.901*	5.519**	7.673**
p-value		(0.0885)	(0.0188)	(0.0056)

- Firm quality and productivity
  - Firm's quality is weakly correlated to productivity (< 0.10).
  - Productivity positively affects quality

	Quality $\widehat{\mathbf{Q}}_{ft}$	Average quality	Weighted quality	FE quality
ln Productivity	0.0775**	0.0433**	0.0590***	0.0681**
	(0.0304)	(0.0192)	(0.0221)	(0.0299)
Firm size:				
small	reference	reference	reference	reference
middle	0.0451	0.0265	0.0993**	0.0334
	(0.0554)	(0.0323)	(0.0431)	(0.0558)
large	-0.0487	0.0136	0.1520*	-0.0950
	(0.1194)	(0.0662)	(0.0874)	(0.1096)
Fixed effects	firm, industry-year			
Observations	8,737	8,785	11,039	8,737
R^2	0.727	0.697	0.700	0.746

- Test the model prediction on firms' costs, value added, profits

	Raw Input Costs	Wagebill	Total Assets	Pofits	Value Added
Involvement in GVC	0.0108	-0.0112	-0.0054	0.0224	-0.0176
	(0.0182)	(0.0142)	(0.0160)	(0.0448)	(0.0195)
Fixed effects	firm, industry-year				
Observations	9,629	9,646	9,782	7,669	9,274
R^2	0.961	0.975	0.977	0.851	0.961

$\Rightarrow$ Similar results with additional controls.

- Test the model prediction on firms' costs, value added, profits

	Raw Input Costs	Wagebill	Total Assets	Pofits	Value Added
Import upstreamenss	0.0178	-0.0047	-0.0078	0.0401	-0.0046
	(0.0237)	(0.0187)	(0.0194)	(0.0554)	(0.0262)
Export upstreamenss	0.0059	0.0269	-0.0005	0.0167	0.0484*
	(0.0415)	(0.0285)	(0.0323)	(0.0742)	(0.0260)
Fixed effects	firm, industry-year				
Observations	9,629	9,646	9,782	7,669	9,274
R^2	0.961	0.975	0.977	0.851	0.961

⇒ Similar results with additional controls.

Conclusion

Question: How product **quality** affects **firms' position in GVCs**?

Approach and results:

- Extend Chor, Manova and Yu (2021) to include firms' decision on product quality:
  - ⋆ Quality upgrading ⇒ a larger span of in-house production stages and
    ⇒ an increase in firms' costs and value-added
- Prediction on GVC position confirmed by data on French agri-food firms
- Similar results with different quality measures
- Controlling for reverse causality yields a stronger effect
- No effect of GVC position on firms' costs, value added, and profits

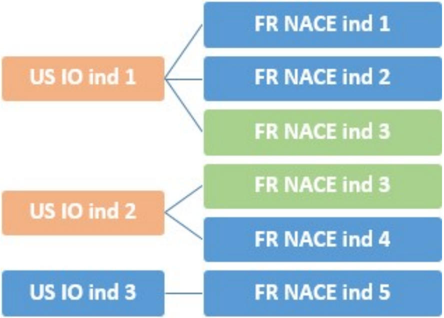
To do list:

- Control for reverse causality between productivity and position in GVCs
- Alternative ways to measure firm productivity
- Explain the absence of an effect of GVC position on firms' costs and value added
- Check model predictions with a Cobb-Douglass production function

Build a detailed input-output table for France

		Used inputs and value added			Final use	Total use
		US IO ind 1	US IO ind 2	US IO ind 3		
Supply of inter-mediate inputs	US IO ind 1	a_{11}	a_{12}	a_{13}	F_1	Y_1
	US IO ind 2	a_{21}	a_{22}	a_{13}	F_2	Y_2
	US IO ind 3	a_{31}	a_{21}	a_{33}	F_3	Y_3
Value added		VA_1	VA_2	VA_3		
Total output		Y_1	Y_2	Y_3		

(a) US input-output table



(b) Multiple industry correspondences

Figure: US input-output table structure and correspondences with NACE Rev.2

Build a detailed input-output table for France

		US IO ind 1			US IO ind 2		US IO ind 3
		FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
US IO ind 1	FR NACE ind 1	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
	FR NACE ind 2	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
	FR NACE ind 3	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{9} a_{11}$	$\frac{1}{6} a_{12}$	$\frac{1}{6} a_{12}$	$\frac{1}{3} a_{13}$
US IO ind 2	FR NACE ind 3	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{4} a_{22}$	$\frac{1}{4} a_{22}$	$\frac{1}{2} a_{13}$
	FR NACE ind 4	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{6} a_{21}$	$\frac{1}{4} a_{22}$	$\frac{1}{4} a_{22}$	$\frac{1}{2} a_{13}$
US IO ind 3	FR NACE ind 5	$\frac{1}{3} a_{31}$	$\frac{1}{3} a_{31}$	$\frac{1}{3} a_{31}$	$\frac{1}{2} a_{21}$	$\frac{1}{2} a_{21}$	a_{33}

Figure: Equal weights for all correspondences within each pair of industry codes

Build a detailed input-output table for France

	FR NACE ind 1	FR NACE ind 2	FR NACE ind 3	FR NACE ind 4	FR NACE ind 5
FR NACE ind 1	$b_{11} = \frac{1}{9} a_{11}$	$b_{12} = \frac{1}{9} a_{11}$	$b_{13} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{14} = \frac{1}{6} a_{12}$	$b_{15} = \frac{1}{3} a_{13}$
FR NACE ind 2	$b_{21} = \frac{1}{9} a_{11}$	$b_{22} = \frac{1}{9} a_{11}$	$b_{23} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{24} = \frac{1}{6} a_{12}$	$b_{25} = \frac{1}{3} a_{13}$
FR NACE ind 3	$b_{31} = \frac{1}{9} a_{11} + \frac{1}{6} a_{21}$	$b_{32} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12}$	$b_{33} = \frac{1}{9} a_{11} + \frac{1}{6} a_{12} + \frac{1}{6} a_{21} + \frac{1}{4} a_{22}$	$b_{34} = \frac{1}{6} a_{12} + \frac{1}{4} a_{22}$	$b_{35} = \frac{1}{3} a_{13} + \frac{1}{2} a_{13}$
FR NACE ind 4	$b_{41} = \frac{1}{6} a_{21}$	$b_{42} = \frac{1}{6} a_{21}$	$b_{43} = \frac{1}{6} a_{21} + \frac{1}{4} a_{22}$	$b_{44} = \frac{1}{4} a_{22}$	$b_{45} = \frac{1}{2} a_{13}$
FR NACE ind 5	$b_{51} = \frac{1}{3} a_{31}$	$b_{52} = \frac{1}{3} a_{31}$	$b_{53} = \frac{1}{3} a_{31} + \frac{1}{2} a_{21}$	$b_{54} = \frac{1}{2} a_{21}$	$b_{55} = a_{33}$

Figure: Group weights across NACE industries

back

- **Average quality**: Estimate price-adjusted quantities with country-product-year FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{jkt} + e_{fjkt}$$

Standardize $\ln \widehat{\lambda}_{fjkt} = \widehat{e}_{fjkt} / (\varepsilon_k - 1)$: $\Xi_{fjkt} = \frac{\ln \widehat{\lambda}_{fjkt} - \overline{\ln \widehat{\lambda}_{fjkt}}}{SE[\ln \widehat{\lambda}_{fjkt}]}$

Regress results on firm FE: $\Xi_{fjkt} = \widehat{\mathbf{Q1}}_{ft} + \omega_{fjlt}$

- **Exports-weighted average quality**: $\widehat{\mathbf{Q2}}_{ft} = \sum_{j,k} \frac{X_{fjkt}}{X_{ft}} \cdot \Xi_{fjkt}$

- **Firm FE quality**: Estimate price-adjusted quantities with firm-year FE and country-product FE:

$$\ln q_{fjkt} + \varepsilon_k \ln p_{fjkt} = FE_{ft} + FE_{jk} + e_{fjkt}$$

Standardize firm FE: $\widehat{\mathbf{Q3}}_{ft} = \frac{FE_{ft} - \overline{FE}_{ft}}{SE[FE_{ft}]}$

back