The March of the Techies: Technology, Trade, and Job Polarization in France, 1994–2007

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Wage inequality and job polarization

- Job polarization one form of structural change in labor mkts.
  - Decline of employment shares in middle-wage jobs, growth in both high and low wage jobs.
  - Mechanically increases wage inequality.
- Evidence:
  - Solidly documented in UK, US in the 1990s–2000s, accompanied by growing wage inequality (Goos-Manning 2007, Autor *et al.* 2008).
  - In continental Europe (Goos *et al.* 2014—challenged by Oesch 2013).
  - A different pattern compared to 1980s.
- If this is a long run process, it is troubling.
  - Can lead to bifurcated society.
  - In US, this process seems to have slowed down, but employment growth at low wage jobs still important (Acemoglu-Autor 2011).

Leading hypothesis: technological change, routinization

- Better/cheaper ICT lowers the cost/increases the efficiency of obtaining, organizing, retrieving, transferring information.
  - People whose jobs are predominantly about these "routine cognitive tasks" can be substituted for cheaper inputs (hardware, software).
  - People whose jobs are predominantly about analyzing, manipulating information ("non-routine cognitive tasks") become more efficient in doing so—their demand increases.
  - Decline of real relative price of ICT implies relative demand shifts.
- Evolution of ICT over time may imply different patterns of relative demand shifts in different periods.
- Need to remember: firms adopt and implement ICT to gain productivity, so either way, there can be (large) aggregate gains.

Leading hypothesis: technological change, routinization

- 1980s, early 1990s: skill-biased technological change (SBTC).
  - Relative demand for skilled (educated) workers who are able to work with computers, in predominantly "non-routine cognitive task"-intensive occupations, increases (Reshef 2013).
  - As supply responds, we have occupational/skill upgrading: in the long run "everyone" is better off.
- 1990s–2000s: job polarization.
  - ICT evolves, and in addition directly substitutes workers in middle of wage distribution, in "routine cognitive task"-intensive occupations.
  - Middle-wage workers downgrade, residual demand at bottom of wage distribution absorbs ever more workers, while employment polarizes.
  - This gives rise to social and political concerns.
- The times they are a changin'. In other words, technological change is itself a changin'—not a linear, monotone process.
  - Unifying theories may be hard to identify, or test.

What about France?

Job polarization in France, 1994–2007

- An interesting period.
- Important changes in technology, globalization, policy.
  - ICT diffusion, China WTO 2001, Euro 1999, EU integration.
- Relative macroeconomic stability.
- Relatively stable wage distribution.
  - Declining 90/10 (Charnoz *et al.* 2013, Verdugo 2014)—unusual among rich countries.
  - Modest increases of top fractile income shares (Landais 2008, Godechot 2012, Piketty data)—much less than other rich countries.

Administrative data

- DADS Poste: French private sector (75% of total hours).
  - **Firms**: industry, trade, employment.
  - **Hours paid**, wage (age, gender, tenure at firm).
  - Classified into one of 22 **occupations** (PCS).
    - Autor (2013): "task index approach" can be problematic.
    - We prefer examining occupations directly, more transparent.
- French customs
  - **Trade** (imports and exports) matched to firms.

PCS occupation codes

14 biggest occupations (each at least 5% of hours worked)

37	Top managers and professionals
38	Technical managers and engineers
46	Mid-level professionals
47	Technicians
48	Foremen, Supervisors
54	Office workers
55	Retail workers
56	Personal service workers
62	Skilled industrial workers
63	Skilled manual laborers
64	Drivers
65	Skilled transport workers
67	Low skill industrial workers
68	Low skill manual laborers

Routinization/drop in price of ICT expected to cause

- more demand for 37 (nonroutine cognitive), 38+47 (techies).
- less demand for 46, 48, 54 (routine cognitive).
- Residual: 55, 56, 62, 63, 64, 65 (nonroutine manual, interpersonal).

Techies develop, install, maintain ICT & other technology

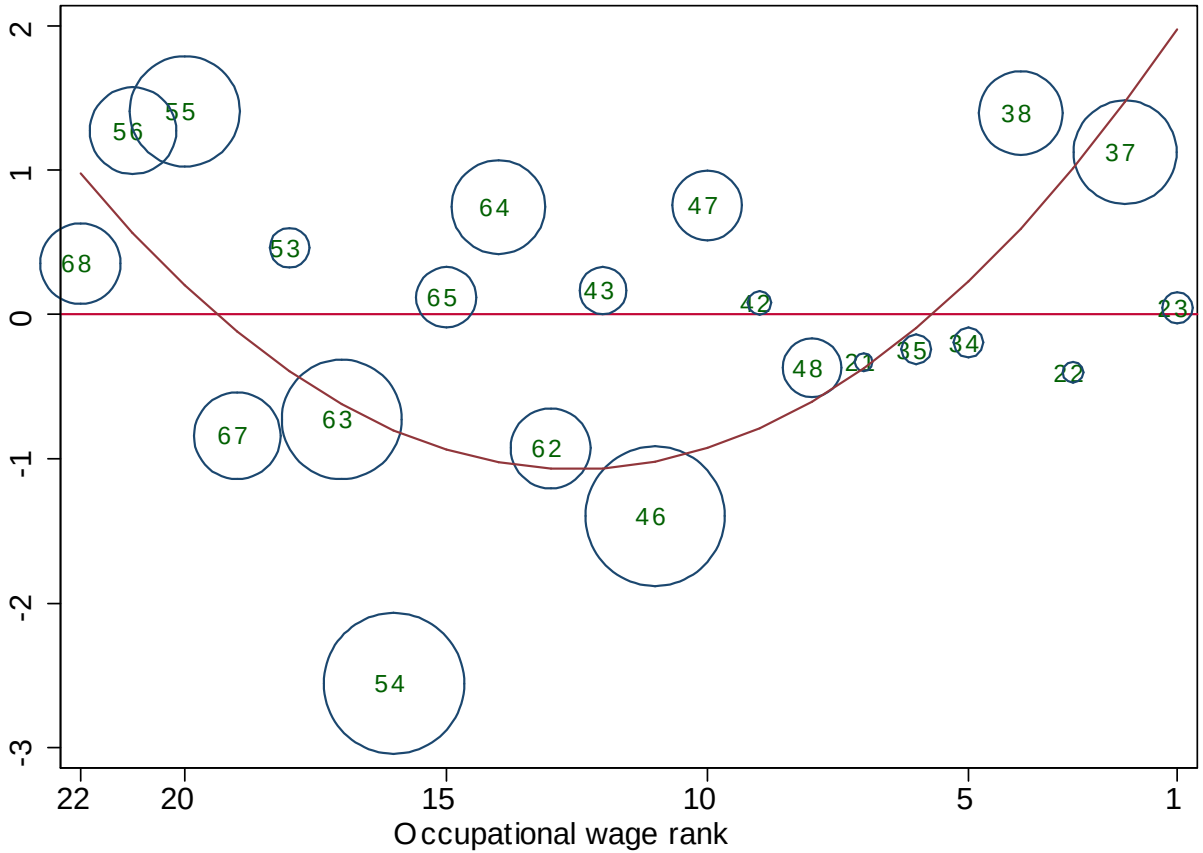
38 Technical managers and engineers

Technical managers for large companies
Engineers and R&D managers
Electrical, mechanical, materials and chemical engineers
Purchasing, planning, quality control, and production managers
Information technology R&D engineers and managers
Information technology support engineers, product managers, and managers
Telecommunications engineers and specialists

47 Technicians

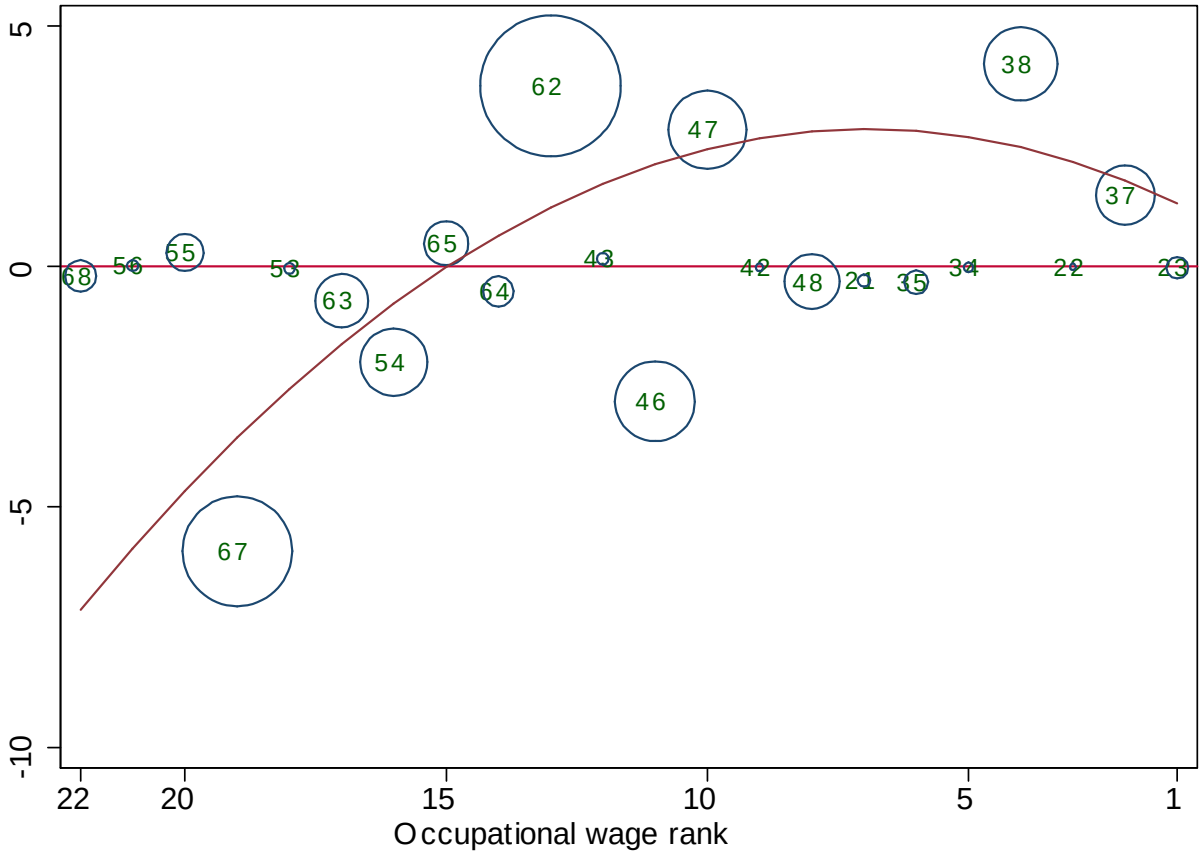
Designers of electrical, electronic, and mechanical equipment
R&D technicians, general and IT
Installation and maintenance of non-IT equipment
Installation and maintenance of IT equipment
Telecommunications and computer network technicians
Computer production, operation, installation and maintenance technicians

Polarization within Non-manufacturing, 1994–2007



- Large reductions in middle, consistent with routinization, in particular office workers (54) and mid-level professionals (46).
- Much heterogeneity; drivers (64) not replaceable by computers (yet).

Skill upgrading within manufacturing, 1994–2007



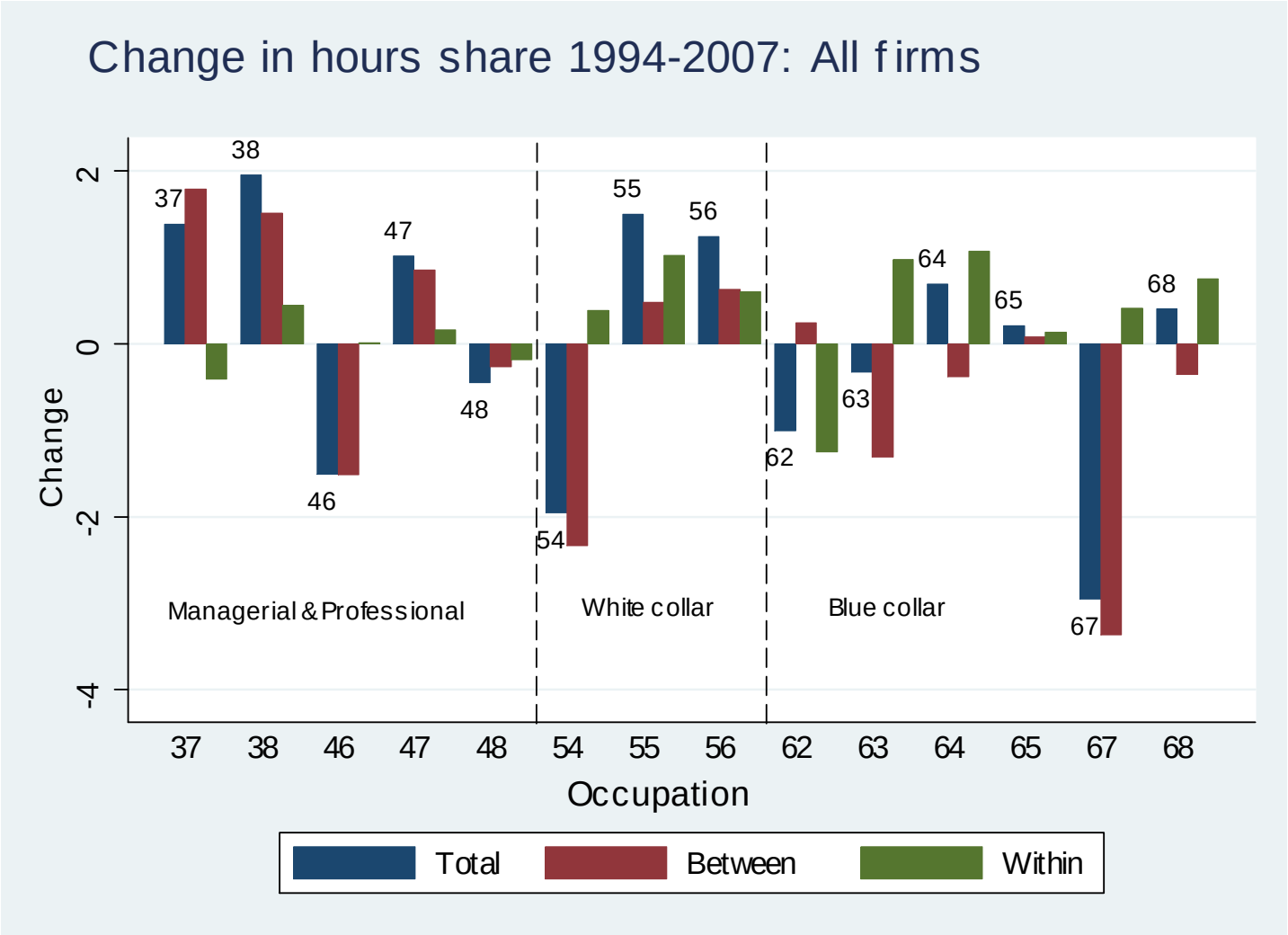
- Increased importance of techies (47+38), managers (37); drops in mid-level professionals (46), office workers (54).
- Within blue collar skill upgrading (62 vs. 67).

Decomposition of aggregate occupational change

- $S_{ot} = \sum_f \lambda_{ft} s_{fot}$ share of occupation o hours in total hours worked.
  - λ_{ft} = employment share of firm f in time t.
  - s_{fot} = employment share of occupation o within firm f in time t.
- Decompose changes in S_{ot}

$$\Delta S_o = \underbrace{\sum_f \Delta \lambda_f \bar{s}_{fo}}_{\text{BETWEEN}} + \underbrace{\sum_f \bar{\lambda}_f \Delta s_{fo}}_{\text{WITHIN}}$$

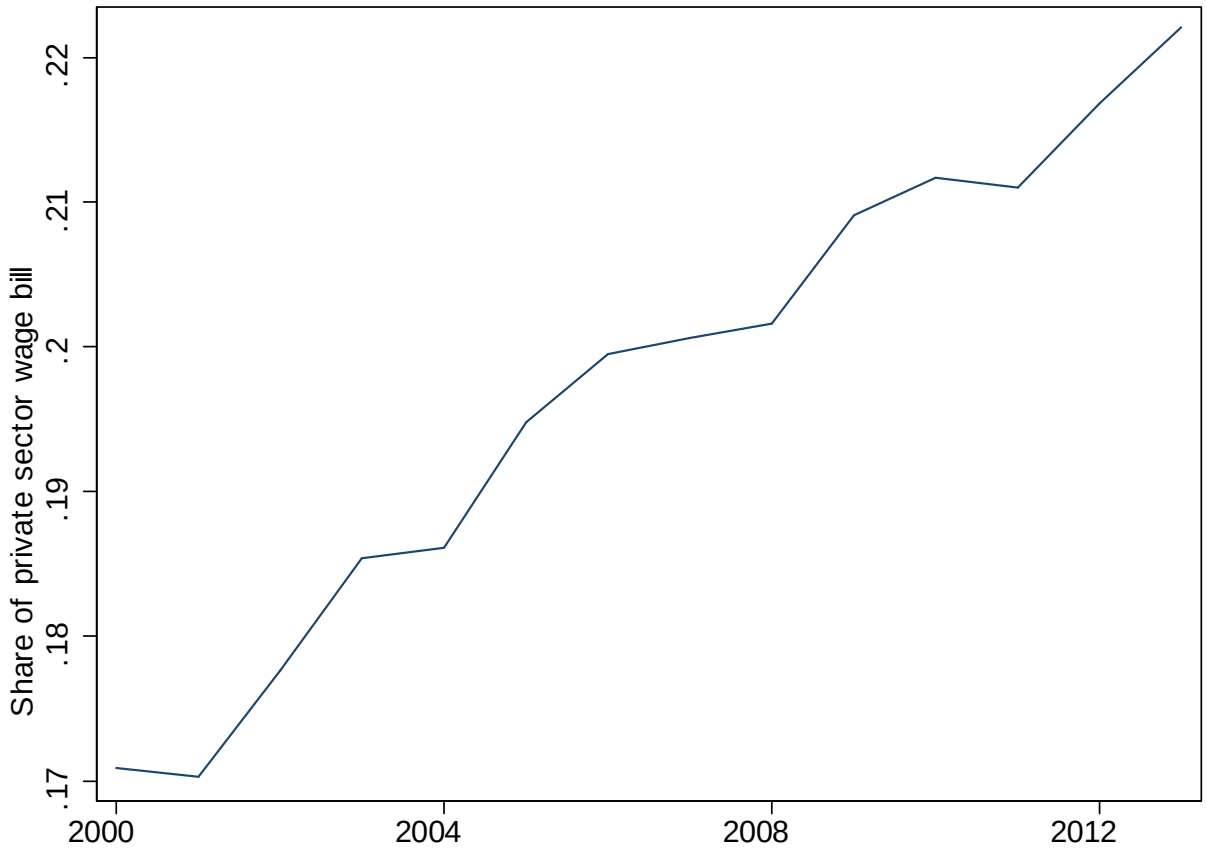
  - BETWEEN: changes in firm composition, holding constant within-firm occupational shares.
  - WITHIN: changes in within-firm occupational shares, holding constant firm composition.
- Focus on 14 largest PCS.



- Substitution within broad categories fits routinization hypothesis.
- Changes in firm composition dominate for many important PCS, but not all $\Rightarrow$ **not a simple substitution story** (62 vs. 67; 54).

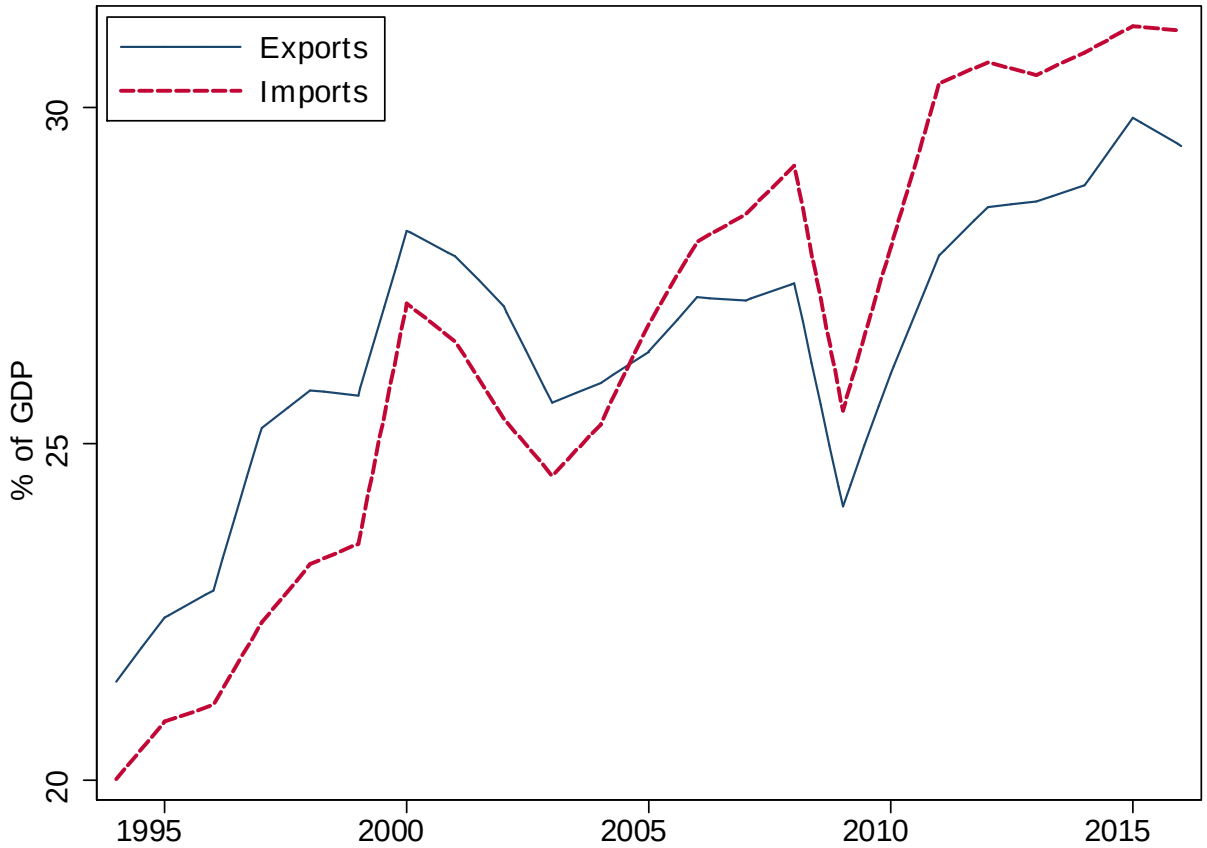
Hypotheses

The march of the techies



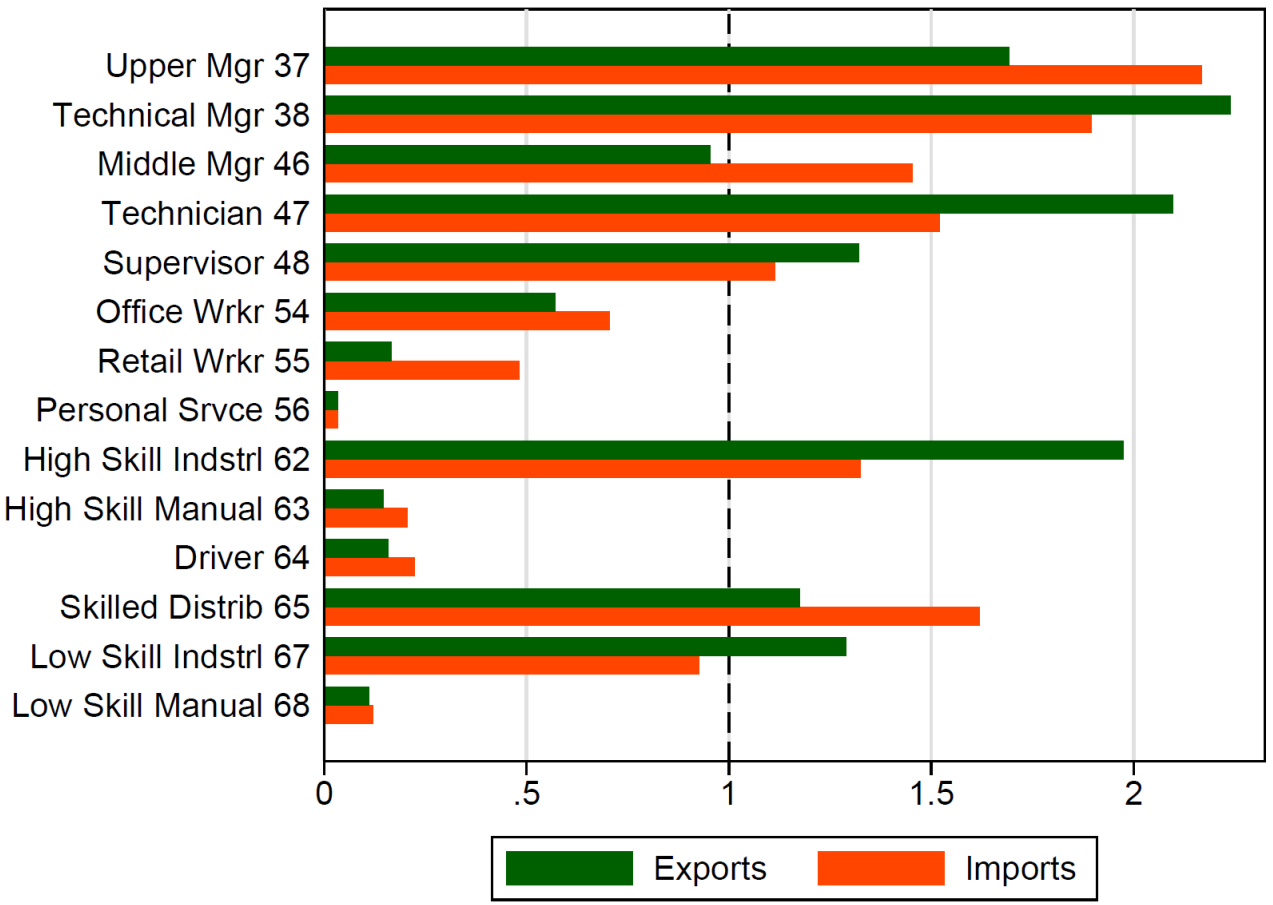
- France has become more techie abundant.
- An indicator/manifestation of technological change.

Trade globalization



- France has become more open to trade.
- Imports overtake exports.

Occupational exposure to trade



- Direct exposure, using information on firms where employed.
- Variation in intensities: 37–48 (skilled), 62, 65, 67 (industry) vs. rest.
- Variation in relative import and export: 46 vs. 62, 67.

Estimation

Estimation of firm employment growth

$$
\begin{aligned}
growth_{ft} \quad = \quad & \beta_i + \beta_{tech}\, techies_{ft-1} + \beta_{techp}\mathbf{1}\left(techies_{ft-1} > 0\right) \\
& + \beta_{exp}\, exports_{ft-1} + \beta_{expp}\mathbf{1}\left(exports_{ft-1} > 0\right) \\
& + \beta_{imp}\, imports_{ft-1} + \beta_{impp}\mathbf{1}\left(imports_{ft-1} > 0\right) + u^{o}_{it}
\end{aligned}
$$

- Separately for manufacturing, non-manufacturing.
- Using instruments to gain causal interpretation (lagged values).

Estimated employment growth effects

Table: Effects of techies (A) and trade (B) on employment growth rates

	overall		no trade		imports & exports	
	extensive	intensive	extensive	intensive	extensive	intensive
Panel A	(1)	(2)	(3)	(4)	(5)	(6)
Nonmanufacturing	0.344	0.011	0.311	0.153	0.244	-0.148
	0.189	*0.043*	*0.179*	*0.059*	*0.305*	*0.088*
Manufacturing	0.939	0.219	1.140	0.134	0.392	0.264
	0.211	*0.067*	*0.211*	*0.146*	*0.291*	*0.080*

	imports				exports			
	overall		techies		overall		techies	
	extensive	intensive	extensive	intensive	extensive	intensive	extensive	intensive
Panel B	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nonmanufacturing	-0.126	0.002	-0.090	0.008	-0.339	-0.005	-0.279	-0.010
	0.218	*0.009*	*0.372*	*0.014*	*0.218*	*0.005*	*0.373*	*0.003*
Manufacturing	-0.148	0.036	-0.207	0.043	0.077	-0.038	0.025	0.003
	0.268	*0.039*	*0.339*	*0.044*	*0.212*	*0.051*	*0.280*	*0.050*

- Techies cause faster growth.
- No effects of trade on growth

Table: Effects of techies, exports and different classes of imports (manufacturing)

	extensive (1)	intensive (2)	extensive (3)	intensive (4)	extensive (5)	intensive (6)
techies	0.939	0.219	0.929	0.221	0.815	0.229
	0.211	*0.067*	*0.209*	*0.067*	*0.210*	*0.069*
exports	0.077	-0.038	0.055	-0.031	0.182	-0.020
	0.212	*0.051*	*0.213*	*0.051*	*0.200*	*0.050*
imports	-0.148	0.036	0.698	0.066		
	0.268	*0.039*	*0.518*	*0.057*		
imports of intermediate inputs			-0.815	-0.032		
			0.375	*0.046*		
imports from China					-0.085	0.006
					0.188	*0.005*
imports from high income countries					-0.010	0.098
					0.227	*0.049*
imports from other countries					-0.431	-0.025
					0.211	*0.011*

Standard errors italicized.

- For manufacturing firms,
  - Techies cause much faster growth, mainly extensive margin.
  - Imports of intermediate goods (offshoring) reduce growth.
  - Imports from developing countries (but not China) reduce growth.

Estimation of within-firm occupational changes

$$\begin{aligned}\Delta s_{fot} &= \beta^o_i + \beta^o_{tech} techies_{ft-1} + \beta^o_{techp} \mathbf{1}\left(techies_{ft-1} > 0\right) \\ &+ \beta^o_{exp} exports_{ft-1} + \beta^o_{expp} \mathbf{1}\left(exports_{ft-1} > 0\right) \\ &+ \beta^o_{imp} imports_{ft-1} + \beta^o_{impp} \mathbf{1}\left(imports_{ft-1} > 0\right) + u^o_{it}\end{aligned}$$

- For each occupation o, separately for manufacturing, non-manuf.
- Using instruments to gain causal interpretation (lagged values).

Results (large effects):

- Techies cause skill upgrading within firms.
- Imports cause blue-collar skill upgrading in manufacturing.
  - Consistent with offshoring of least skill-intensive tasks.
- Exports cause faster growth in managers in manufacturing.
- No direct effects of trade in nonmanufacturing (non-surprising).

Conclusions: The March of the Techies

- Structure of French labor market changed in 1994–2007.
  - Evidence for job polarization, but not a smooth U-shape.
  - Patterns consistent with routinization.
  - Changes in firm composition more important than within-firm changes: not a simple substitution story.
  - Technology-related occupations ("techies") grew fast.

- Big techie effects everywhere, big trade effects in manufacturing.
  - On employment growth.
  - On firm occupational composition.

- More recent data, post 2008 crisis period: skill upgrading.
  - Top managers and professionals, techies keep on rising.
  - Rest fall, with industrial construction workers and mid-level professionals falling the most.

Detailed Regression Estimates

Impact of technology and trade on polarization

$$extensive\_techies_o = \frac{\widehat{\beta}^o_{techp} + \widehat{\beta}^o_{tech} \times p50\left(techies^o\right)}{p75\left(s_o\right) - p25\left(s_o\right)}$$

and

$$intensive\_techies_o = \frac{\widehat{\beta}^o_{tech} \times \left[p75\left(techies^o\right) - p25\left(techies^o\right)\right]}{p75\left(s_o\right) - p25\left(s_o\right)}$$

where $pN(x)$ is the N^{th} percentile of variable x; for explanatory variables we use percentiles of the distribution of strictly positive values.

- Analogous expressions for imports and exports.
- More complex expressions for interaction effects.
- 90% confidence intervals, using appropriate standard errors.

Table: Effects of techies in nonmanufacturing

		overall		no trade		imports & exports	
		extensive	intensive	extensive	intensive	extensive	intensive
		(1)	(2)	(3)	(4)	(5)	(6)
37	Top managers and professionals	0.340	0.215	0.516	0.051	0.179	0.295
46	Mid-level professionals	-0.106	0.048	-0.128	0.019	0.276	0.096
54	Office workers	0.006	-0.055	-0.003	-0.028	-0.399	-0.094
55	Retail workers	0.120	-0.153	0.066	0.002	-0.030	-0.251
56	Personal service workers	-0.616	0.130	-0.319	0.161	-3.570	0.014
62	Skilled industrial workers	1.458	-0.261	1.430	0.275	0.787	-0.401
63	Skilled manual laborers	0.214	-0.062	0.181	0.025	0.263	-0.095
64	Drivers	-0.080	-0.132	-0.108	-0.288	0.254	-0.061
67	Low skill industrial workers	0.220	0.154	0.525	0.100	-1.060	0.218
68	Low skill manual laborers	-0.673	-0.199	-0.712	-0.156	0.095	-0.230

- Skill upgrading.

Table: Effects of techies in manufacturing

		overall		no trade		imports & exports	
		extensive	intensive	extensive	intensive	extensive	intensive
		(1)	(2)	(3)	(4)	(5)	(6)
37	Top managers and professionals	0.211	0.073	0.832	-0.206	-0.123	0.204
46	Mid-level professionals	0.563	0.324	0.539	0.259	0.636	0.301
48	Foremen, Supervisors	-0.465	-0.134	-0.899	0.180	-0.011	-0.170
54	Office workers	-0.511	-0.163	-0.528	0.399	-0.874	-0.175
62	Skilled industrial workers	-0.822	-0.163	-1.270	0.256	0.015	-0.216
63	Skilled manual laborers	0.601	-0.030	2.560	-2.670	-2.910	0.099
67	Low skill industrial workers	1.133	0.035	1.540	-0.623	0.086	0.126
68	Low skill manual laborers	1.962	0.444	2.900	1.310	0.582	0.388

- Polarization.

Table: Effects of imports in manufacturing

		imports			
		overall		techies	
		extensive	intensive	extensive	intensive
		(1)	(2)	(3)	(4)
37	Top managers and professionals	0.112	0.000	0.031	0.036
46	Mid-level professionals	0.187	-0.012	0.028	0.000
48	Foremen, Supervisors	0.485	0.021	0.650	0.030
54	Office workers	-0.162	0.062	-0.231	0.025
62	Skilled industrial workers	1.250	-0.016	1.530	-0.002
63	Skilled manual laborers	6.196	0.064	4.460	0.132
67	Low skill industrial workers	-3.255	-0.015	-3.620	-0.048
68	Low skill manual laborers	0.071	0.046	-0.210	0.027

- Blue-collar skill uprading.
- Consistent with offshoring of least skill-intensive tasks.

Table: Effects of exports in manufacturing

		exports			
		overall		techies	
		extensive	intensive	extensive	intensive
		(1)	(2)	(3)	(4)
37	Top managers and professionals	0.413	-0.002	0.333	-0.035
46	Mid-level professionals	-0.068	-0.002	0.085	-0.040
48	Foremen, Supervisors	-0.053	-0.010	-0.117	-0.008
54	Office workers	0.103	-0.039	0.180	-0.008
62	Skilled industrial workers	-1.013	0.139	-1.158	0.153
63	Skilled manual laborers	-3.435	0.208	-2.687	0.273
67	Low skill industrial workers	2.106	-0.178	2.451	-0.230
68	Low skill manual laborers	-0.558	-0.119	-0.804	-0.037

- Exports cause faster growth in managers
  - Consistent with higher nonproduction/production ratio.
- Exports cause blue-collar skill *downgrading*
  - Within-production worker effects not previously estimated in literature.

PCS Codes

PCS 37 & 46

37 Top managers and professionals

Managers of large businesses
Finance, accounting, sales, and advertising managers
Other administrative managers

46 Mid-level professionals

Mid-level professionals, various industries
Supervisors in financial, legal, and other services
Store, hotel, and food service managers
Sales and PR representatives

PCS Codes

PCS 48

48 Foremen, Supervisors

Foremen: construction and other
Supervisors: various manufacturing sectors
Supervisors: maintenance and installation of machinery
Warehouse and shipping managers
Food service supervisors

PCS Codes

PCS 54

54 Office workers

Receptionists, secretaries

Administrative/clerical workers, various sectors

Computer operators

Bus/train conductors, etc

PCS Codes

PCS 55 & 56

55 Retail workers

Retail employees, various establishments
Cashiers
Service station attendants

56 Personal service workers

Restaurant servers, food prep workers
Hotel employees: front desk, cleaning, other
Barbers, hair stylists, and beauty shop employees
Child care providers, home health aids
Residential building janitors, caretakers

PCS Codes

PCS 62 & 63

62 Skilled industrial workers

Skilled construction workers
Skilled metalworkers, pipefitters, welders
Skilled heavy and electrical machinery operators
Skilled operators of electrical and electronic equipment
Skilled workers in various industries

63 Skilled manual laborers

Gardeners
Master electricians, bricklayers, stonemasons, wodworkers, and carpenters
Skilled electrical and electronice service technicians and repair workers
Skilled autobody and autorepair workers
Master cooks, bakers, butchers
Skilled artisans (jewelers, potters, etc)

PCS Codes

PCS 64 & 65

64 Drivers

Truck, taxi, and delivery drivers

65 Skilled transport workers

Heavy crane and vehicle operators

Warehouse truck and forklift drivers

Other skilled warehouse workers

PCS Codes

PCS 67 & 68

67 Low skill industrial workers

Low skill construction workers
Low skill electrical, metalworking, and mechanical workers
Low skill shipping, moving, and warehouse workers
Other low skill transport industry workers
Low skill production workers in various industries

68 Low skill manual laborers

Low skill mechanics, locksmiths, etc
Apprentice bakers, butchers
Building cleaners, street cleaners, sanitation workers
Various low skill manual laborers

PCS Codes

Additional Tables and Figures

Table: Shea first stage partial R^2

Nonmanufacturing						
PCS	37	46	48	54	55	56
techies02	0.669	0.657	0.699	0.657	0.640	0.744
techpos02	0.245	0.262	0.245	0.275	0.306	0.305
Simport02	0.603	0.600	0.631	0.601	0.633	0.694
imppos02	0.204	0.210	0.199	0.211	0.228	0.171
Sexport02	0.550	0.560	0.572	0.556	0.573	0.587
exppos02	0.210	0.214	0.216	0.214	0.239	0.197
PCS	62	63	64	65	67	68
techies02	0.708	0.665	0.681	0.675	0.697	0.664
techpos02	0.242	0.295	0.280	0.243	0.268	0.290
Simport02	0.630	0.626	0.642	0.623	0.622	0.642
imppos02	0.189	0.217	0.211	0.221	0.209	0.209
Sexport02	0.590	0.538	0.566	0.556	0.578	0.543
exppos02	0.202	0.219	0.207	0.231	0.221	0.217
Manufacturing						
PCS	37	46	48	54	55	56
techies02	0.561	0.550	0.563	0.551	0.560	0.661
techpos02	0.142	0.167	0.147	0.171	0.167	0.117
Simport02	0.571	0.571	0.573	0.562	0.669	0.688
imppos02	0.131	0.136	0.126	0.140	0.112	0.071
Sexport02	0.681	0.679	0.681	0.677	0.735	0.784
exppos02	0.183	0.183	0.172	0.186	0.177	0.149
PCS	62	63	64	65	67	68
techies02	0.542	0.556	0.550	0.568	0.551	0.569
techpos02	0.168	0.171	0.180	0.142	0.169	0.174
Simport02	0.564	0.598	0.581	0.569	0.567	0.561
imppos02	0.138	0.113	0.135	0.110	0.137	0.115
Sexport02	0.674	0.701	0.720	0.689	0.675	0.697
exppos02	0.185	0.165	0.204	0.164	0.184	0.157

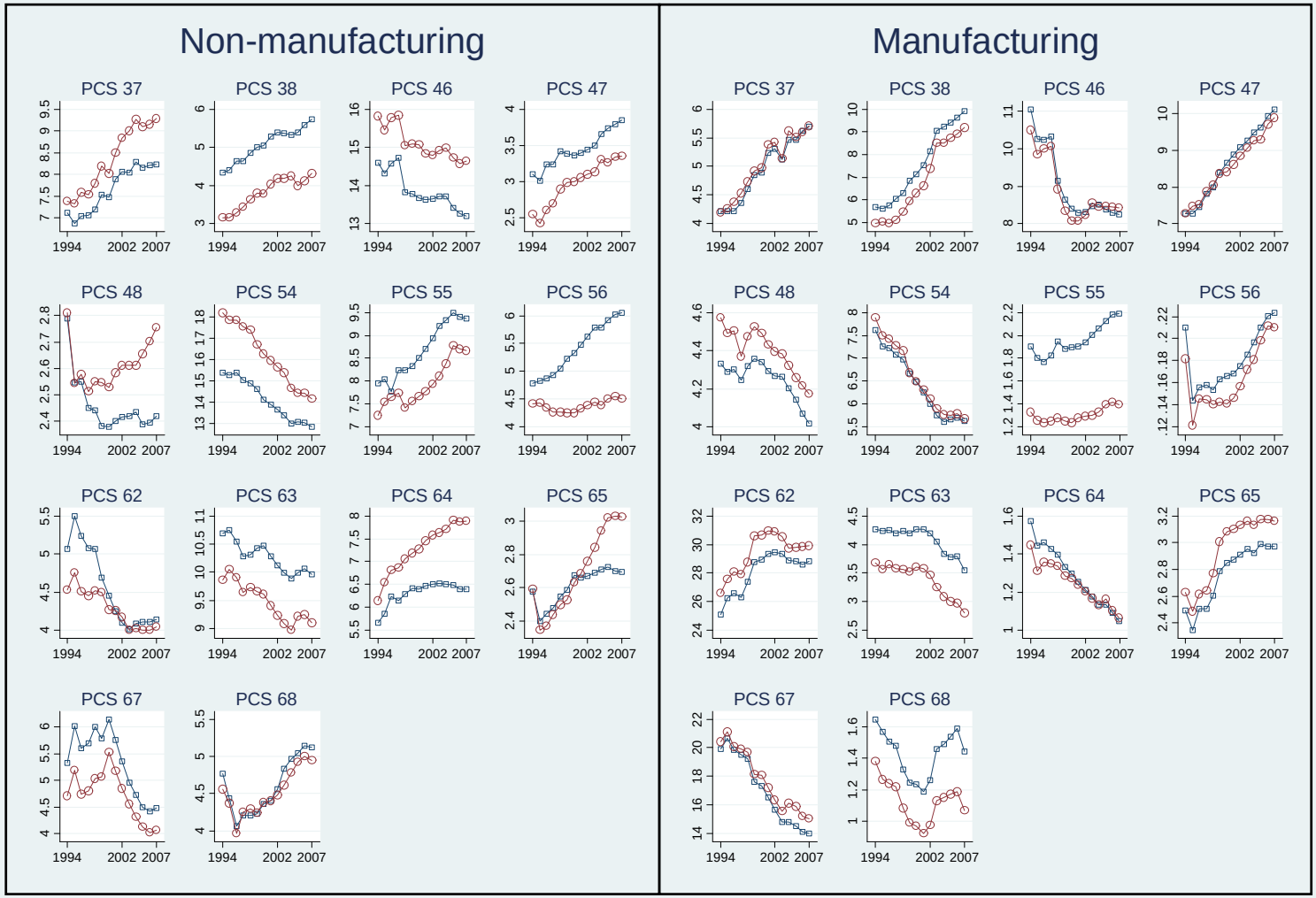
Valid IVs?

Table: Second stage goodness of fit and test statistics

Nonmanufacturing						
PCS	37	46	48	54	55	56
Goodness of fit						
Weighted R^2	0.052	0.017	0.022	0.034	0.017	0.020
Explained within	-2.827	-0.714	0.066	2.410	0.346	-0.664
p-values						
Joint significance, $\chi^2(6)$	0.000	0.029	0.161	0.000	0.040	0.044
Endogeneity, $\chi^2(6)$	0.000	0.000	0.000	0.000	0.000	0.000
Overid, $\chi^2(24)$	0.000	0.000	0.000	0.000	0.000	0.000
PCS	62	63	64	65	67	68
Goodness of fit						
Weighted R^2	0.035	0.003	0.017	0.033	0.050	0.033
Explained within	8.162	0.669	-0.136	0.560	1.834	0.158
p-values						
Joint significance, $\chi^2(6)$	0.244	0.005	0.111	0.000	0.061	0.015
Endogeneity, $\chi^2(6)$	0.000	0.000	0.000	0.000	0.000	0.000
Overid, $\chi^2(24)$	0.000	0.000	0.000	0.000	0.000	0.000

Table: Second stage goodness of fit and test statistics

Manufacturing						
PCS	37	46	48	54	55	56
Goodness of fit						
Weighted R^2	0.067	0.035	0.015	0.030	0.020	0.015
Explained within	-17.185	0.249	0.100	-0.798	0.646	0.287
p-values						
Joint significance, $\chi^2(6)$	0.000	0.000	0.017	0.000	0.012	0.021
Endogeneity, $\chi^2(6)$	0.000	0.000	0.000	0.000	0.000	0.715
Overid, $\chi^2(24)$	0.000	0.000	0.038	0.000	0.025	0.808
PCS	62	63	64	65	67	68
Goodness of fit						
Weighted R^2	0.176	0.064	0.013	0.121	0.376	0.011
Explained within	-0.096	1.277	-24.195	-0.618	0.788	2.862
p-values						
Joint significance, $\chi^2(6)$	0.000	0.000	0.000	0.086	0.000	0.000
Endogeneity, $\chi^2(6)$	0.000	0.000	0.001	0.000	0.000	0.139
Overid, $\chi^2(24)$	0.000	0.000	0.990	0.000	0.000	0.057



blue box = all firms, red circle = permanent firms

Permanent sample hits most occupation share trends, if not in levels.