LOCAL IMPACTS OF GLOBAL MARKETS

Tasks, Occupations, and Wage Inequality
in an Open Economy

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Tasks, Wage Inequality, and Trade

- Wage inequality within plant-occupations dominates overall inequality
- Tasks characterize plant-occupations and differ across plants
- Large plants assign less multitasking and show more wage inequality within plant-occupations
- Trade expansion in Germany in the 2000s reduced multitasking and raised wage inequality within plant-occupations at large plants

Division of Labor, Plant Size and Prosperity

"[M]aking a pin is . . . **divided** into about **eighteen distinct operations**. . . . [T]en persons . . . could make among them upwards of forty-eight thousand pins in a day. But if they had all wrought separately and independently . . . they certainly could not each of them have made twenty, perhaps not one pin in a day."

"It is the great multiplication of the productions of all the different arts, in consequence of the **division of labour**, which **occasions**, in a well-governed society, that universal **opulence which extends itself to the lowest ranks** of the people."

Adam Smith, *The Wealth Of Nations*, Book I, Chapter I

Related Literature

- **Tasks**. Polarization (Autor, Katz, Kearney 06), offshoring (Levy, Murnane 04)
- **Tasks and trade**. Heckscher-Ohlin (Grossman, Rossi-Hansberg 08), Ricardian (Rodriguez-Clare 10; Acemoglu, Autor 11); Krugman (Chaney, Ossa 12).
- **Trade and inequality**. Stolper-Samuelson (Costinot, Vogel 10), offshoring (Feenstra, Hanson 99), between firms (Helpman, Istkhoki, Redding 10)
- **Human resource practices**. Management quality (Bloom, van Reenen 11) or hierarchies (Caliendo, Monte, Rossi-Hansberg 12) and effort incentives (Cunat, Guadalupe 09)
- **Between-firm matching**. Trade-induced changes in match quality (Amiti, Pissaridis 05; Davidson, Heyman, Matusz, Sjöholm, Zhu 14)
- **Within-firm matching**. Lazear, Shaw 09: Wage structure more dependent on employer-internal sorting to occupations than on sorting to employers.
  Bombardini, Orefice, Tito (15): Permanent wage component in firm-worker sorting model based on Eeckhout, Kircher (11)

Plant-Worker Data: Residual Log Wage Inequality

Contribution of component (%)		Subsamples			
		high w	age $\geq$45	skilled	manager
within industry*	88	97	88	88	88
within occupation	84	87	82	86	92
within plant	71	88	68	79	77
within plant-layer	65	71	60	72	73
within plant-occupation	54	60	46	61	63

Source: LIAB 1996-2014.
Notes: Economy-wide variance decomposed into within- and between-group component (groups g):

$$(1/L)\sum_{i=1}^{L}\left(\ln w_i - \overline{\ln w}\right)^2 = (1/L)\sum_{g\in\mathbb{G}}\sum_{i=1}^{L_g}\left(\ln w_i - \overline{\ln w_g}\right)^2 + \sum_{g\in\mathbb{G}}(L_g/L)\left(\overline{\ln w_g} - \overline{\ln w}\right)^2.$$

Residual log daily wage from Mincer regressions on demographics, education and tenure as well as time, industry and region effects ($R^2 = 53\%$; *Mincer regression excluding industry effects $R^2 = 42\%$). 357 occupations at 3-digit KldB-88 level. Layers of hierarchy based on mapping of Caliendo, Monte, Rossi-Hansberg (15) hierarchies to KldB-88 using ISCO-88.

Agenda

- Data
- Two+ Facts
- Model
- A Test
- Go Structural

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Workplace Operations

- Acemoglu, Autor (11): *A task is a unit of work activity that produces output (goods or services).*

- BIBB-BAuA: 15 tasks (workplace operations) time consistent since 1979. 20,000 or more worker interviews every 6-7 years

  Examples: 1. Manufacture, Produce Goods; 6. Gather Information, Develop, Research, Design; 14. Organize, Plan, Prepare Others' Work; 15. Control Machinery and Technical Processes.

Task Imputation to Plant-Worker Data

- Combine BIBB-BAuA task information with LIAB plant-worker data
- Preserve within-occupation and time variation
- In BIBB-BAuA data, regress indicator for task on
  worker, occupation and plant attributes also observed in LIAB
- Impute with out-of-sample prediction into LIAB data at worker level
  Also: Reverse imputation into BIBB-BAuA data for robustness

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Two+ Facts and a Hypothesis

1. Larger plants and exporters adopt more occupations.

2. Workers at larger plants perform *fewer* tasks *within* occupations.

3. Wages are more dispersed in plant-occupations with fewer tasks.

- `Hypothesis`: Workers at larger plants are more specialized in fewer tasks. Their abilities are better matched to tasks on average. But surplus is more responsive to bad matches at more specialized plants, so a higher wage dispersion within plant-occupations results.

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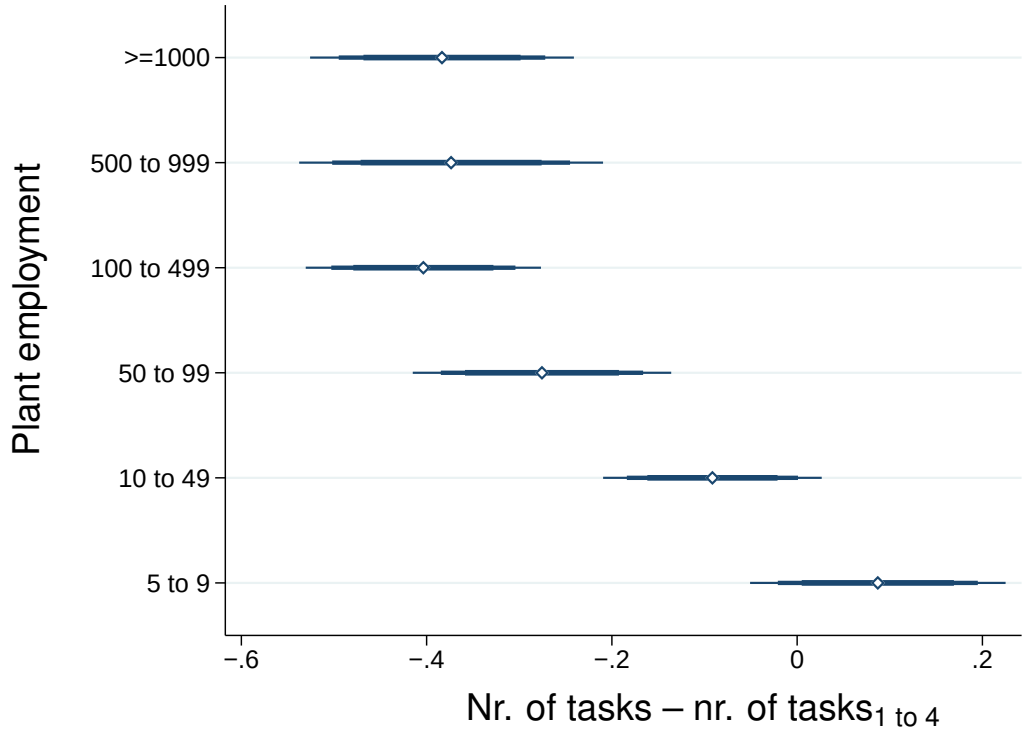
Fact 2: *Number of Tasks per Occupation by Plant Employment*



Source: BIBB-BAuA 1999, 2006 and 2012. Prediction of number of tasks b within plant-occupation by plant employment category, controlling for sector, region, occupation and worker characteristics. Results are differences to smallest plant-size category (1 to 4 workers). Thick, medium, and thin lines represent the 99, 95, and 90 percent confidence intervals.

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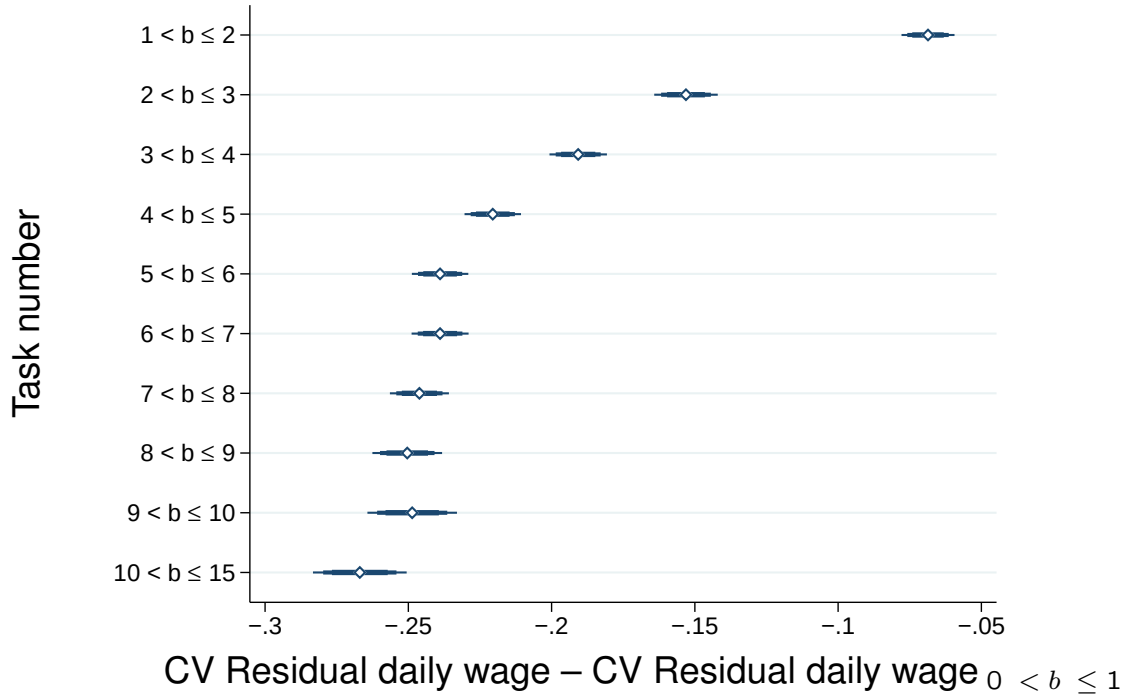
Fact 3: *Within-occupation Wage Inequality by Number of Tasks*



Source: LIAB 1996-2014, with imputed task information per plant-occupation from BIBB-BAuA 1999, 2006 and 2012. Prediction of coefficient of variation of daily wage residual (exponentiated Mincer residual) CV within plant-occupation by task number, controlling for sector, region, occupation and worker characteristics. Results are differences to smallest task-number category (0 to 1 tasks). Thick, medium, and thin lines represent the 99, 95, and 90 percent confidence intervals.

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Model

- Tasks and workers around segment of circle
- Employer splits task range into occupations
- More occupations mean narrower task range per occupation,
  so workers more specialized in fewer tasks
- Workers have core ability, most efficient at specific task in full range
  Workers monotonically less efficient at tasks away from core ability

Tasks in Production

- Production: Workers perform tasks in occupations

- Plant ω has elemental productivity $\tilde{\varphi}$ and chooses:
  - count of occupations $n(\omega) + 1$, with $[n(\omega) + 1] = 1, 2, \ldots,$ implying occupation-invariant range of tasks $b(\omega)$ per occupation,
  - wage schedule $w(i, b)$ for worker with *core ability* i,
  - employment $\ell_j(\omega)$ per occupation j.

Task Assignment to Occupations

- Plants must select tasks from (different) subinterval with length $\tilde{z} < 1$
- Plants bundle adjacent tasks into occupations: range $b < \tilde{z}$
- If division of task space mutually exclusive: $b = \frac{\tilde{z}}{n+1}$
- If tasks overlap between occupations: $b = \frac{\tilde{z}}{\nu n + 1}$ with $\nu \in (0, 1]$

  (In limit $\nu = 0$, each occupation exhausts whole task range, regardless of n.)

Ability-Occupation Mismatch and Worker Efficiency

- Worker allocates same amount of time to tasks in occupation.
  Worker efficiency falls linearly in distance to core ability i.
  Mistakes worse in narrower task ranges, magnifying mismatch

- Mismatch: $m(i,b) = \frac{1}{b}\left[\int_0^i (i-t)\,\mathrm{d}t + \int_i^b (t-i)\,\mathrm{d}t\right]$

- Worker efficiency:

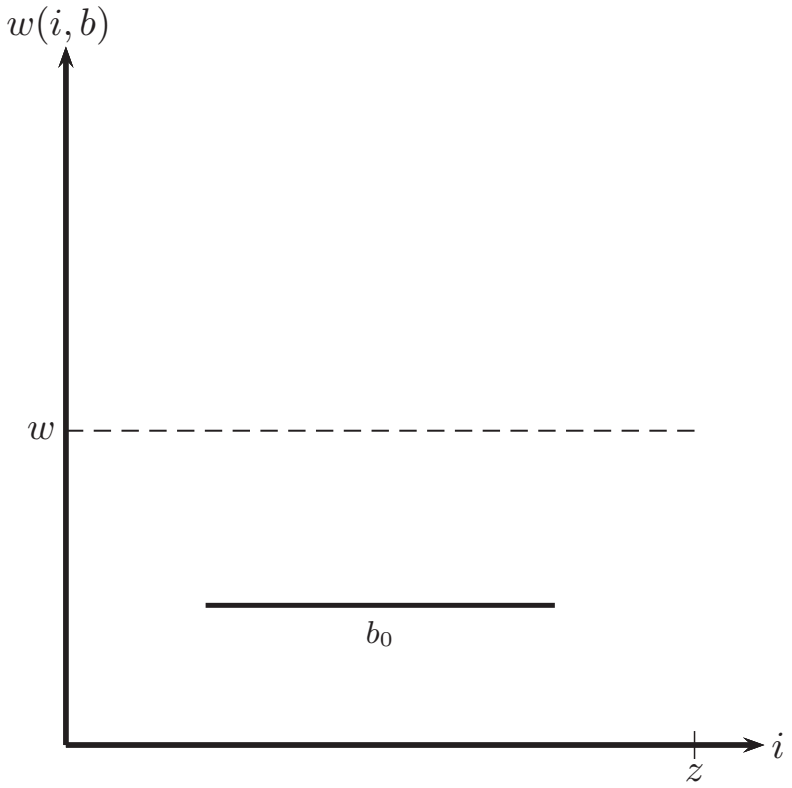
$$\lambda(i,b) \equiv \frac{\tilde{\eta}}{\tilde{z}} + \frac{1}{m(i,b)}$$

  with **sensitivity of performance** $\tilde{\eta} > -2$.

Summary of Remaining Model

- Cobb-Douglas production: combine occupation outputs into product
- Stole-Zwiebel wage bargaining over surplus: $w(i,b)/w = \lambda(i,b)/\lambda$
- Plants can raise output by creating additional occupations.
  Match quality raises occupation-level efficiency in addition
- Span-of-control fixed cost dampen occupation creation in Melitz model
- Larger plants more unequal iff sensitivity of performance positive

Within-occupation Wage Schedule by Plant Type



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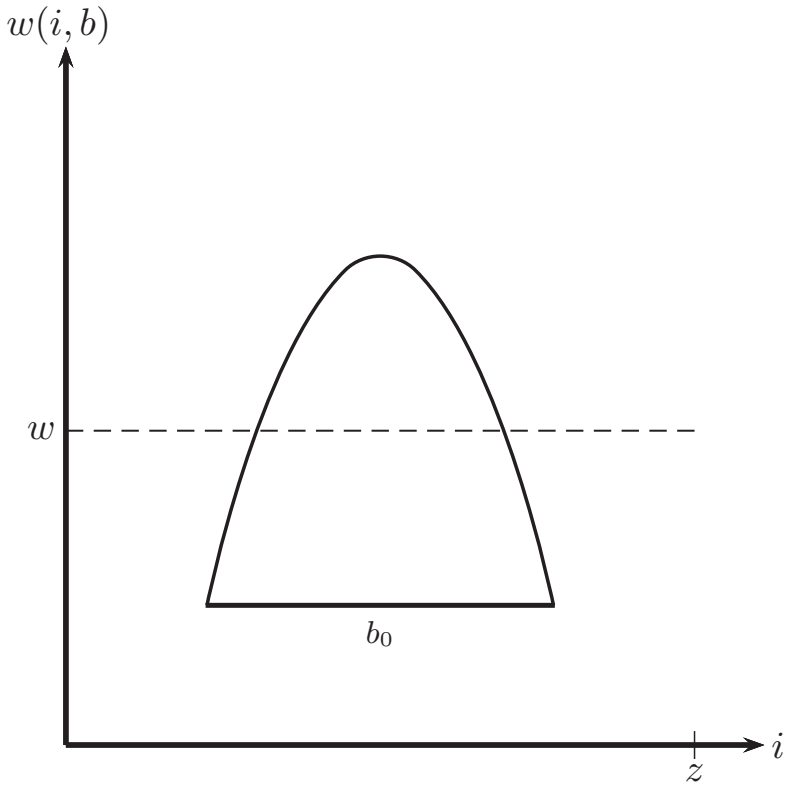

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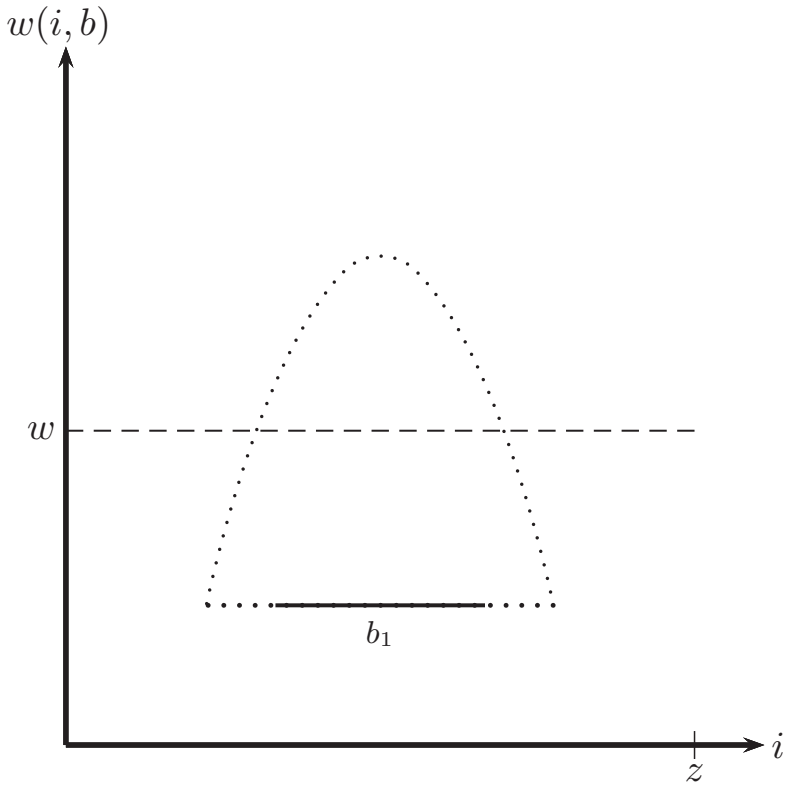

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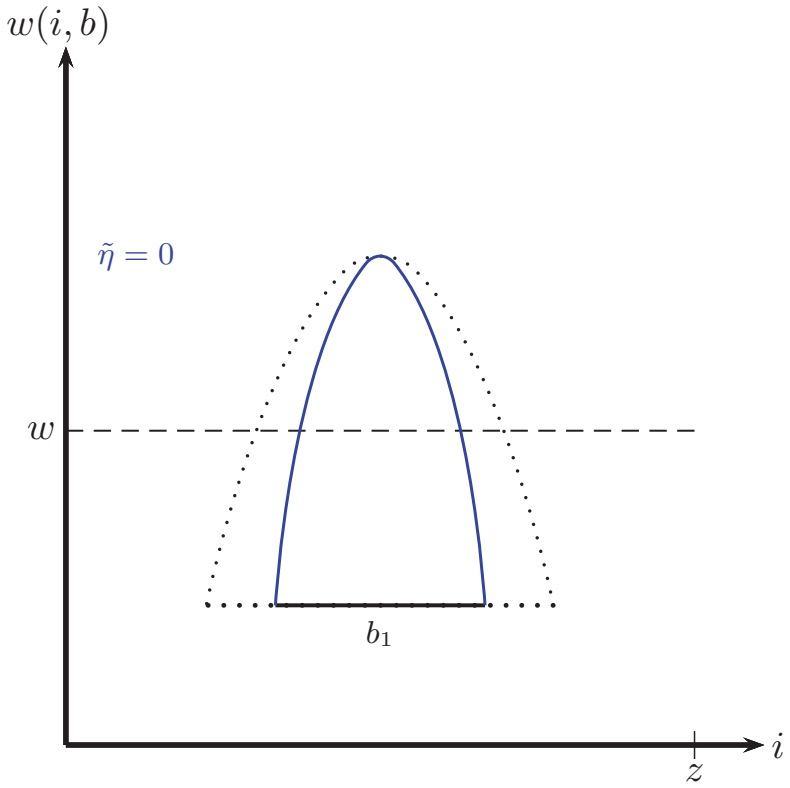

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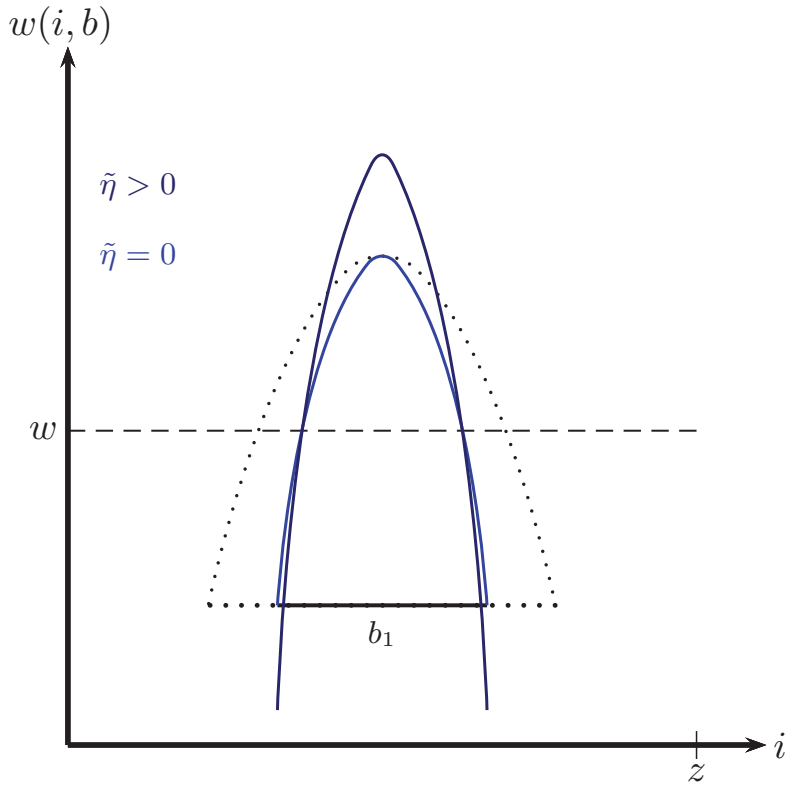

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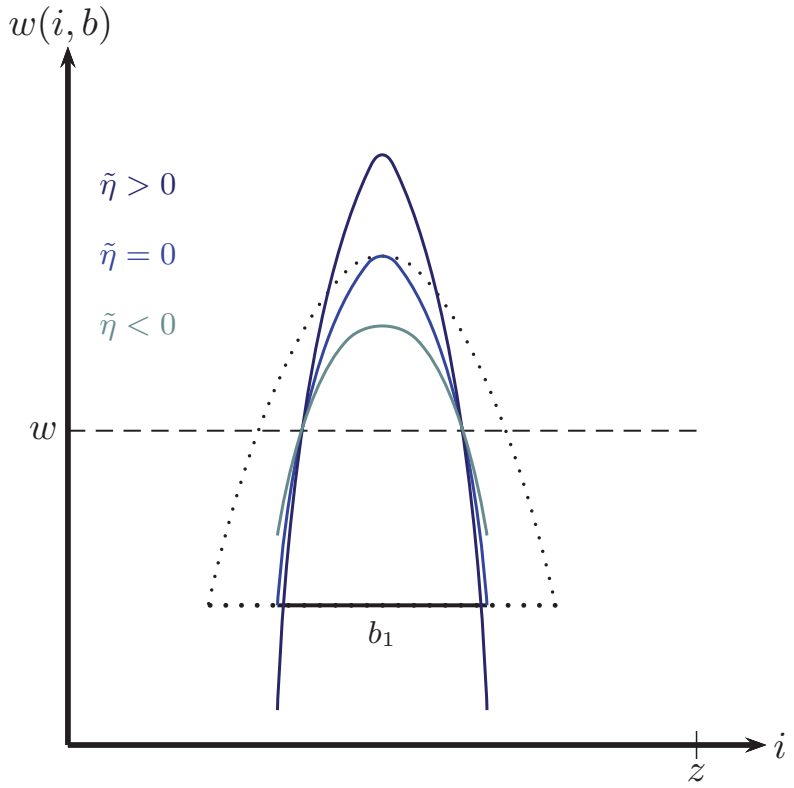

Open-economy Equilibrium

- Trade opening leads productive plants into exporting, raising welfare
- Exporters adopt less multitasking, non-exporters more multitasking
- Within plant-occupation variance of wages increases at exporters, declines at non-exporters iff sensitivity of performance positive
- Economy-wide wage inequality higher in open economies iff sensitivity of performance positive

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Sensitivity of Performance and Financial Losses from Mistakes

Dependent variable: $\tilde{\eta}$ proxy	for Wages		for Residual wages	
Financial losses from small mistakes				
seldom or occasionally	.134 (.034)***	.008 (.021)	.144 (.032)***	.021 (.015)
frequently	.318 (.044)***	.117 (.034)***	.302 (.038)***	.104 (.025)***
Occupation area (1-dgt) FE	yes		yes	
Occupation class (4-dgt) FE		yes		yes
Adj. R^2	.604	.806	.688	.865
Observations	44,610	32,895	44,610	32,895

Sources: BIBB-BAuA 1999, 2006, 2012; LIAB 1996-2014. Plants with more than 2 full-time workers.

Notes: Sensitivity of performance: $\tilde{\eta}(\omega)/\tilde{\zeta}(\omega) = \left[\sqrt{4-\pi(\pi-2)}/CV_w(\omega) - \pi\right] \Big/ [b(\omega)/z(\omega)]$.

Financial losses from small mistakes in three categories, omitted: never or almost never. 34 industry effects, 7 plant size categories, 6 occupation areas (KldB-88 1-dgt), 1,144 occupation classes (KldB-88 4-dgt). Standard errors clustered at industry level. Significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Other Tests

- Use Autor, Dorn, Hanson (13) style IVs for Germany (Dauth, Findeisen, Suedekum 14)
- Instrumented revenues and occupation counts predict **stricter task specialization** within plant-occupations
- Instrumented revenues and occupation counts predict **higher wage dispersion** within plant-occupations

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From Theory to Estimation

- Plant-level Endogenous Switching Model with Censoring

$$\begin{aligned}
\ln r(\omega)_t &= \alpha_{0,t} + \alpha_{1,t}\mathbf{1}_{\mathbf{x}}(\omega)_t + \xi_t \ln \tilde{\varphi}(\omega)_t, \\
\ln CV_w(\omega)_t b(\omega)_t / z(\omega)_t &= \beta_{0,t} - (1/\gamma_t) \ln r(\omega)_t + \ln \tilde{\zeta}(\omega)_t, \\
\mathbf{1}_{\mathbf{x}}(\omega)_t = 1 &\Leftrightarrow \delta_{0,t} \geq \ln \tilde{f}_x(\omega)_t - \xi_t \ln \tilde{\varphi}(\omega)_t, \\
\text{missing} &\Leftrightarrow \xi_t \ln \tilde{\varphi}(\omega)_t < a_t.
\end{aligned}$$

- `Variables:` $r(\omega), \mathbf{1}_{\mathbf{x}}(\omega), CV_w(\omega), b(\omega)/z(\omega)$
  `Stochastic fundamentals:` $\tilde{\varphi}^{\xi}, \tilde{\zeta}, \tilde{f}_x; \tilde{\eta}$
  `Parameters:` $a; \gamma; \alpha_0, \beta_0, \alpha_1, \delta_0$ (functions of fundamentals)
  variances, covariances of stochastic fundamentals

Implementation of Structural Estimation

- Endogenous switching and joint normality restrict higher moments

  Proposition. If variance of outcome among exporters exceeds that among non-exporters, then exporter share must surpass one-half, unless there is censoring.

- Censoring on unobserved plant characteristic (productivity) not Tobit

- Estimation with fixed higher moments and time-varying parameters

- Keep stochastic fundamentals of plant population, shock parameters

Data and Simulation Results

	Data		Simulation	
	1999	2012	1999	2012
Exporter share	.133	.152	.157	.169
Export share in revenues at exporters	.228	.240	.228[a]	.252
Changes in				
mean Number of tasks per occupation				-17.1%
mean CV of wages within plant-occupations				43.3%

[a]Calibriation of the elasticity of substitution to $\sigma = 3.50$ matches the observed export share in revenues at exporters in 1999.

Sources: LIAB and BIBB-BAuA, 1999 and 2012. Plants with more than 2 full-time workers, weighted by sampling frequencies.
Notes: Simulation for population of 20,000 plants with constant stochastic characteristics but exposed to time-varying parameter changes.

Concluding Remarks

- Large and globalized plants adopt less multitasking per occupation and exhibit more wage dispersion within plant-occupation
- Model of internal labor-market responses to trade predicts labor efficiency and welfare gains but more inequality
- Structural estimation and simulations speak to economic importance
- Globalization may be associated with increase of wage dispersion within plant-occupations and in the aggregate in all economies