Trade and Minimum Wages in General Equilibrium: Theory and Evidence

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Motivation

- Impact of minimum wage on the whole economy. Open and policy relevant question.
  - Widely used policy around the world.
  - U.S.: cities setting own minimum wage: D.C. \$12.50 *v.s.* Federal $\simeq$ \$8.00.
  - Canada: multiple provinces have (planned) large increase in minimum wages during 2017-2019, esp. in Ontario (C\$ 11.60 in 2017 to C\$ 15.00 in 2019)
- Most work is on wage/employment effects.
  - Mixed results, possible reason: U.S. setting (low federal min. wage) and fast foods chains (limited substitution between factors).
- First paper to connect the effects of minimum wage in GE setting to production and export data in China
  - more natural setting: cities set own minimum wages which can be binding across a whole range of industries
- Key insight: Tightening minimum wage laws has strong impact on selection of firms and productivity, both at firm and industry level in addition to factor intensities and production

What we do

- Build a GE model with two sectors, two factors, firm heterogeniety and rural urban migration to study the impact of rise in minimum wage
- Derive theoretical predictions on selection into production and exporting, productivity, input mix, price and output for different sectors with different capital/ skill intensity in response to a change in minimum wage
- Test our theoretical conclusions using comprehensive customs data matched with firm level survey data using city level variation in minimum wage across China

Preview of Results

We find in the data, consistent with our model predictions:

- **Selection of Firms**: Exit of existing firms rises in labor intensive sectors with a binding minimum wage.
- **TFP Distribution**: Cities with high minimum wages have a higher average productivity than that of low minimum wage cities. Similar selection mechanism within-firm also raises firm productivity.
- **Factor Intensity**: A higher minimum wage raises capital intensity, lowers labor usage.
- **Production and Export Pattern**: The output/exports of labor intensive goods falls and price rises with a binding minimum wage.

All effects are more pronounced in more labor intensive sectors and/or where minimum wage is more relevant.

Literature Review

- Labor literature: mostly partial equilibrium and reduced form.
  - Surveys: Neumark and Wascher (2008), Neumark, Salas, and Wascher (2013), Cahuc and Zylberberg (2004).
  - Some GE ideas in search settings: Flinn (2006), Engbom and Moser (2017) .
- Trade literature: HO setting without firm heterogeniety and empirical component
  - Brecher (1974)
  - Davis (1998): Trade between an economy with binding minimum wages and one without will raise wages in the latter and increase unemployment in the former.
- Insights from Chinese Data
  - Wang and Gunderson (2012), Fang and Lin (2013)
  - Huang, Lougani and Wang (2014) find firm employment falls, especially for low wage firms. Hau, Huang and Wang (2016): Minimum wages change input mix in low wage firms, reduce employment growth, management differences?
  - Gan, Hernandez and Ma (2016) study impact on firms' export behavior in China using survey data.

Model Setting

- Perfect competition.
- Three aggregate goods, X and Y, A.
- Consumers have a (homothetic) utility function

$$U = U(X, Y, A) = S(X, Y)^{1-\alpha} A^{\alpha}.$$

- $S(X, Y)$ is a CES aggregator of X, Y with elasicity σ. Services made by X and Y.
- X and Y are CES aggregators of varieties of x and y with elasicity σ_x, σ_y.
- x is labor intensive, y is capital intensive.

Model Setting

- $j \in J$ cities, each with its agricultural hinterland, and endowment $\left[K^j, L^j\right]$.
- Each city makes A in hinterland, and one variety of x or y.
- Labor of efficiency γ gets $\gamma \backsim G(\gamma)$ in agriculture and w in manufacturing.
  - high γ workers stay in agriculture.
  - low γ workers migrate to the city to work in manufacturing.
- Heterogeneous firms and free entry:
  - Fixed entry costs, $f_e c^e(w, r)$.
  - Firms do not know their costs ex-ante, but discover them ex-post to be $c(w, r)\theta$, with $\theta \backsim F(\theta)$.
  - Capacity constraints: each firm can make one unit.

Firm Interpretation

Demand

The demand for variety $j \in J$ of good x is a derived demand and comes from all cities $k = 1...J$

$$D^{jx}(.) = \sum_{k=1,..J} T^{jk} \left(\frac{p^{jx} T^{jk}}{P_k^X}\right)^{-\sigma_x} \left(\frac{P_k^X}{P_k}\right)^{-\sigma} \frac{(1-\alpha) I_k}{P_k}$$

In city k.

- p^{jx} is the factory price of the variety made in city j.
- T^{jk} is the iceberg transport cost of shipping variety j to city k.
- σ_x (σ_y) is the substitution between varieties of x (y).
- σ is the substitution between X and Y.
- P_k^X (P_k^Y) is the aggregate price index of X (Y) in city k;
- P_k is the price index of the overall aggregate good S.
- $\frac{(1-\alpha) I_k}{P_k}$ is the demand for S.

With price indices fixed, demand depends only on own price.

Supply

- Only those suppliers with cost below p produce

$$\theta \leq \tilde{\theta}(.) = \frac{p}{c(w,r)}.$$

- Supply is

$$\begin{aligned} s(p,N,c(w,r)) &= N \int_0^{\tilde{\theta}(p,w,rP^{kX})} f(\theta)d\theta \\ &= N\left[F\left(\tilde{\theta}\right)\right]. \end{aligned}$$

- N (mass of firms) and $\tilde{\theta}$ (cost cutoff) are endogenously determined.

Solving the model: selection and factor prices

- Given (w, r), free entry conditions give cutoffs $(\tilde{\theta}^x, \tilde{\theta}^y)$

$$\left[\int_0^{\tilde{\theta}^x} F^x(\theta)d\theta\right] = \frac{c^{e,x}(w,r)f_e^x}{c^x(w,r)}$$

$$\left[\int_0^{\tilde{\theta}^y} F^y(\theta)d\theta\right] = \frac{c^{e,y}(w,r)f_e^y}{c^y(w,r)}$$

- Marginal firms just cover their operating costs

$$\begin{aligned} p^x &= \tilde{\theta}^x(w,r)c^x(w,r) \\ p^y &= \tilde{\theta}^y(w,r)c^y(w,r) \\ 1 &= w^e = p^A \end{aligned}$$

Solving the model: Outputs and Factors

- Migration and Income: Given prices, we have factor prices, and so income:

$$\begin{aligned} I &= \bar{\gamma}(w)L + wG(w)L + rK \\ &= \bar{\gamma}(w)L + p^x x + p^y y \end{aligned}$$

where $\bar{\gamma}(w) = \int_w \gamma g(\gamma) d\gamma$ and is increasing in w.

- Factor market clearing (FMC) gives:

$$\begin{aligned} N^x A_{Lx}(w,r) + N^y A_{Ly}(w,r) &= G(w)L \\ N^x A_{Kx}(w,r) + N^y A_{Ky}(w,r) &= K \end{aligned}$$

where $A_{Lx}(w,r) = c_w^x(.)\bar{\theta}^x(.) + f_e c_w^{ex}(.)$ etc and $\bar{\theta}^x(\tilde{\theta}^x) = \int_0^{\tilde{\theta}} \theta f(\theta) d\theta$.

Solving the model: product prices

- Prices come from setting supply equal to demand.
- In general:

$$\begin{aligned} N^x(\overset{+}{p^x}, \overset{-}{p^y}; \overset{+}{L}, \overset{-}{K}) F^x(\tilde{\theta}^x(\overset{-}{p^x}, \overset{+}{p^y})) &= D^x(.) \\ N^y(\overset{-}{p^x}, \overset{+}{p^y}; \overset{-}{L}, \overset{+}{K}) F^y(\tilde{\theta}^y(\overset{+}{p^x}, \overset{-}{p^y})) &= D^y(.). \end{aligned}$$

and with limited selection $S^x(\overset{+}{p^x}, \overset{-}{p^y}; \overset{+}{L}, \overset{-}{K}), S^y(\overset{-}{p^x}, \overset{+}{p^y}; \overset{-}{L}, \overset{+}{K})$, where demand is as before.

Notes on Trade

- Trade is implicit in the model.
  - The difference in demand from domestic locations and supply from a domestic location is exports of that city's variety while demand for foreign varieties is met by imports.
- In equilibrium, trade will make selection stricter in the comparative advantage sector as its price rises and weaker in the comparative disadvantage sector whose price falls.
- More churning in the comparative advantage sector.
  - Existing firms will exit the comparative advantage sector.
  - Price increase will also raise the mass of firms so that entry will rise.
- Less churning in the comparative disadvantage sector.

Equilibrium with Minimum Wages

- With minimum wage, labor markets need not clear.
- The supply of labor can exceed the demand giving unemployment.
- Capital markets clear.
- Firms face $\bar{w}$, the minimum wage.
- In terms of solution we solve for equilibrium unemplyment instead of equilibrium wage.
- $\hat{w}(\bar{w})$ is the expected wage that drives migration. Migration can rise or fall with the minimum wage.

Equilibrium with Minimum Wages

- If $\bar{w}$ is binding, labor markets will not clear.
- In Factor Market

$$\begin{aligned} N^x A_{Lx}(\bar{w}, r) + N^y A_{Ly}(\bar{w}, r) &= L^D \leq G(\hat{w}(\bar{w}))L = L^s \\ N^x A_{Kx}(\bar{w}, r) + N^y A_{Ky}(\bar{w}, r) &= K \end{aligned}$$

- Where

$$\hat{w}(\bar{w}) = \left(\frac{L^D}{G(\hat{w}(\bar{w}))L} \right) \bar{w}.$$

  is the expected wage which drives migration. $\hat{w}(\bar{w})G(\hat{w}(\bar{w})$ is increasing in $\hat{w}(\bar{w})$.
- If labor demand is elastic, $\bar{w}L^D$ falls as minimum wage rises, and so must $G(\hat{w}(\bar{w}))L\hat{w}(\bar{w})$, and hence $\hat{w}(\bar{w})$ and migration.

- There is unemployment, but capital is fully utilized.

Implications of Minimum Wages

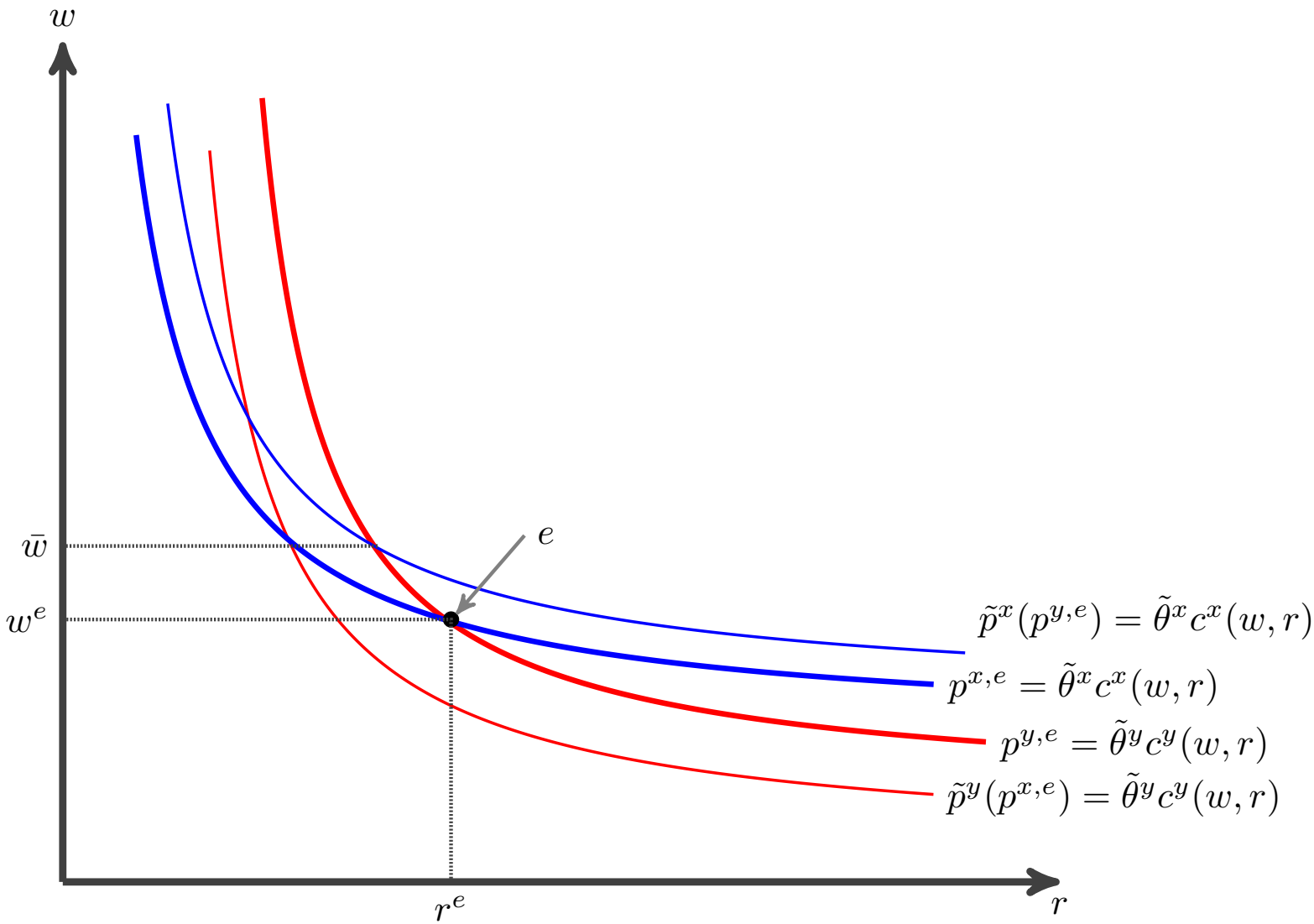
- **Selection of Firms**: Exit of existing firms should rise in labor intensive sectors with a binding minimum wage.
  - More so in more labor intensive sectors.
  - In the capital intensive sector, selection becomes weaker.

- **TFP Distribution**: Cities with high minimum wages should have a distribution of productivity that has a higher mean than that of low minimum wage cities. Similar mechanism operates within firm.
  - More pronounced effects in more labor intensive sectors.

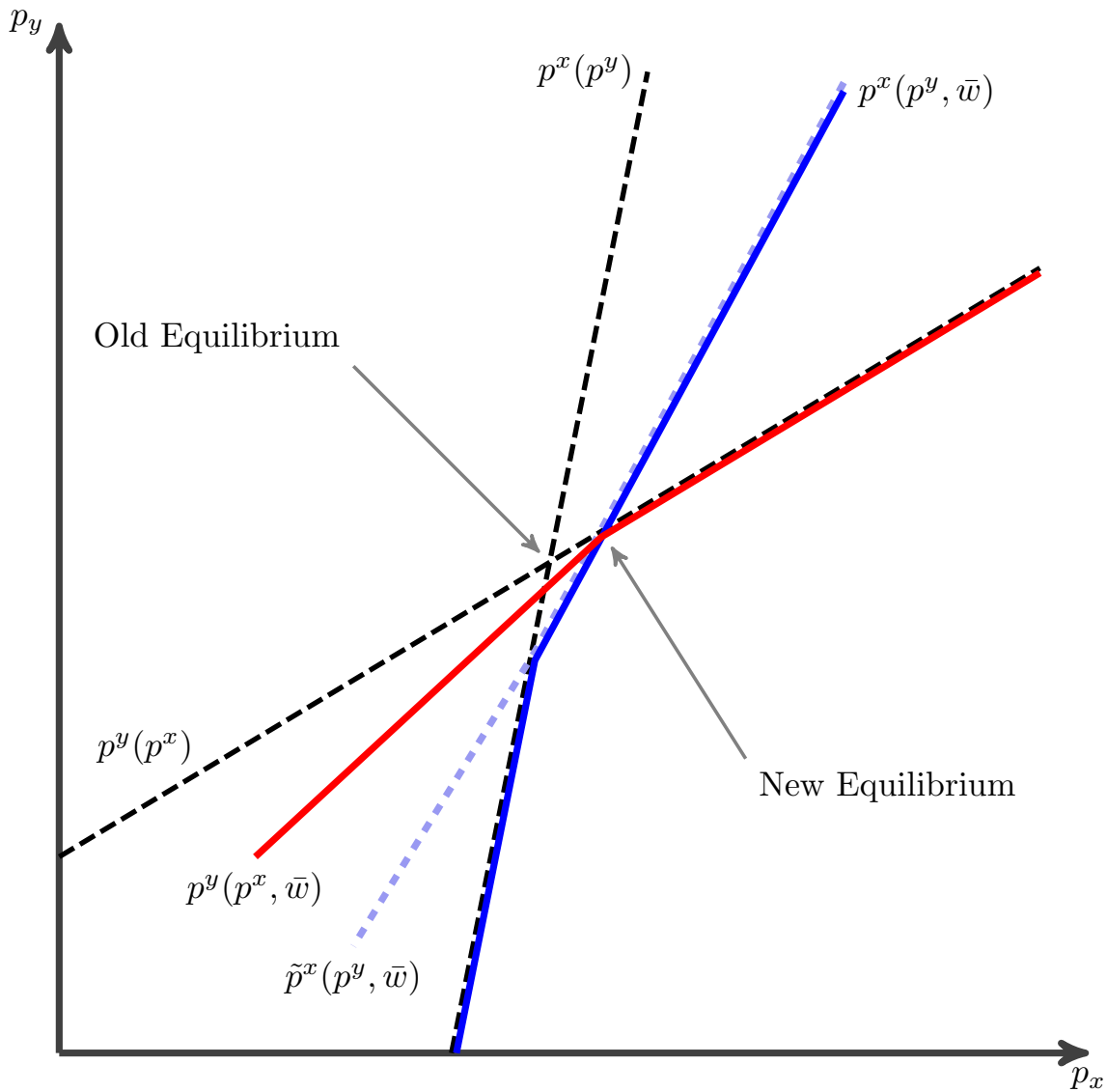
Implications of Minimum Wages

- **Factor Intensity**: A higher minimum wage should raise capital intensity and decrease labor usage.
  - More pronounced for more labor intensive sectors and for higher minimum wages.
- **Production and Export Pattern**: The output of labor intensive goods should fall and price rise with a binding minimum wage.
  - More pronounced for more labor intensive sectors and for higher minimum wages.
  - Similar implication for export.
  - Whether the *value* rise or fall depends on elasticity.

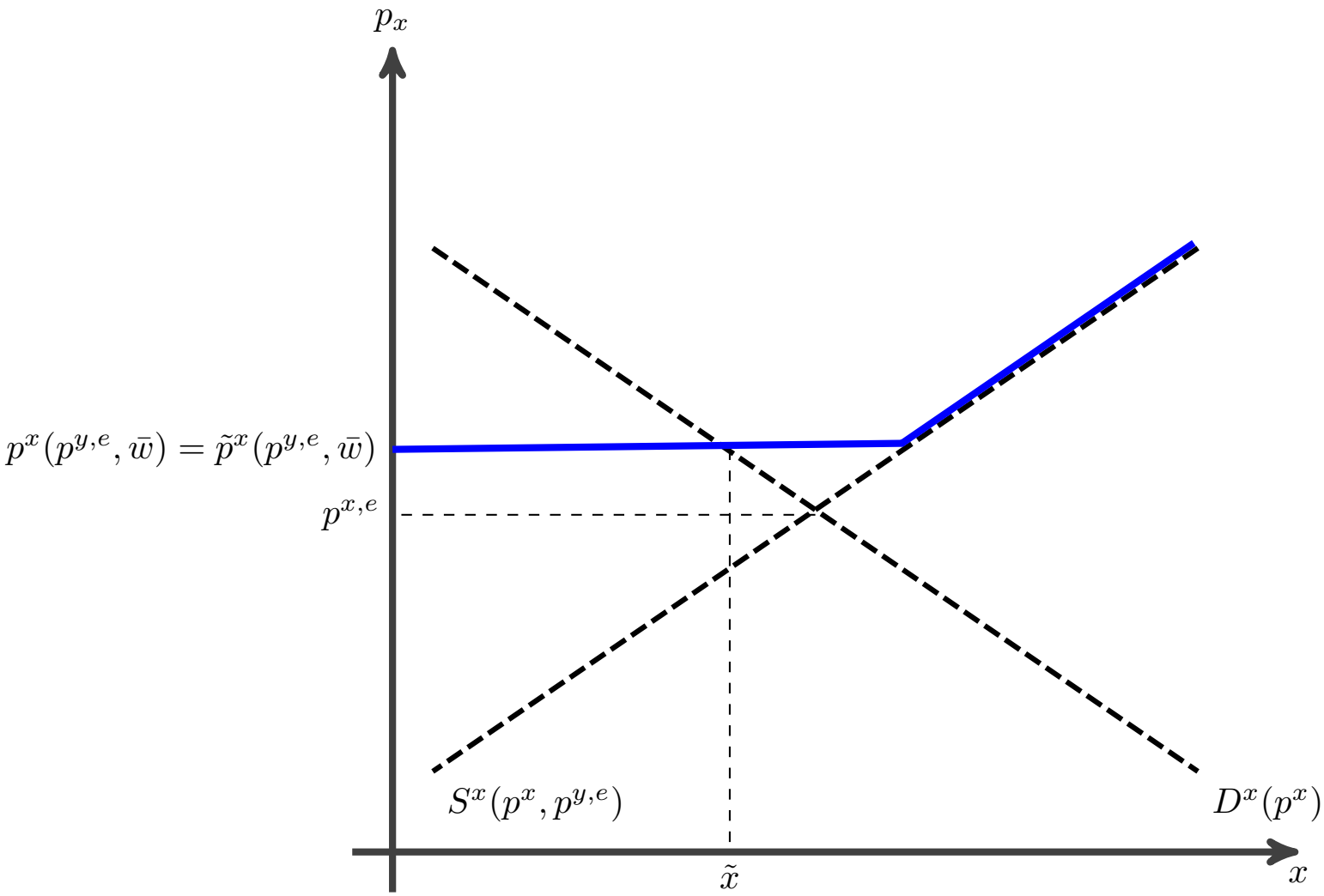
Graphical Illustration: Product Prices and Factor Prices with a Minimum Wage



Graphical Illustration: Equilibrium Prices with and without a Minimum Wage



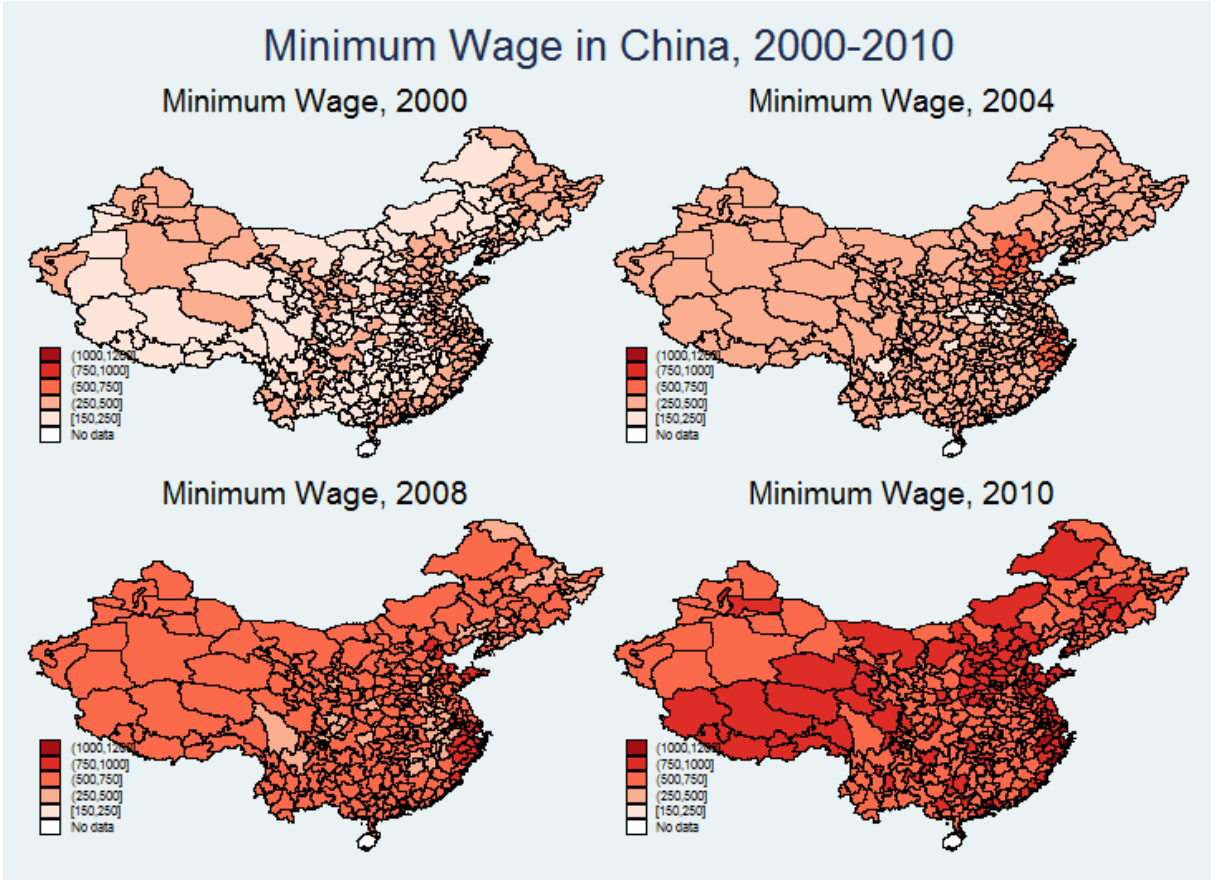
Graphical Illustration: Supply, Demand and Minimum Wages in Good X



Data

- Monthly minimum wage data is manually collected from local government websites and statistical bulletins.
  - Covers all 31 mainland provinces and provincial municipalities, 345 prefectures (similar to US county).
  - Minimum wage set at prefecture level using two methods:
    - The proportion method - minimum income necessary to cover the standard living costs
    - Engel Coefficient method - minimum food expenditure divided by the Engel coefficient in a minimum living cost.

Spatial Distribution of Minimum Wage in China



Data

- Survey data:
  - Firm-level data - ASIP - from 1998 through 2007, National Bureau of Statistics and Census of manufacturing for 2004 - information on skilled and unskilled labor employed and wage bill.
  - Includes all SOEs and non-SOEs with sales over 5 million Chinese Yuan.
  - Firms' industry of production, ownership type, age, employment, capital stocks, revenues, export values.
- Customs data
  - Transaction-level data. Collected and made available by the Chinese Customs Office.
  - Universe of transactions by Chinese firms over the 2000-2006.
  - Includes basic firm information, the value of each transaction (in US dollars) by product and trade partner for 243 destination/origin countries and $7,526$ different products at the 8-digit Harmonized System.
- Merge of the survey data and customs data matched on firm name, region code, address, legal person, and so on

Pluses and Minuses

- Survey data:
  - information on wages paid as well as estimated TFP.
  - lacks complete coverage - minimum size.
  - no information on destination of export or unit values or quantities. Only value data reported.
- Customs data:
  - unless matched with the survey data, many firm level variables are not available.
  - census so there is no lack of coverage.
  - product level information is very detailed as is destination and source of exports.
  - both quantity and value are reported, we can get unit value (price) information as well.
- Merged data strengths of both, but limited by coverage and ability to match.

Empirical Strategy

- Endogeneity of minimum wage, especially for average city-level TFP
- Possible instruments.
  - Average minimum wage of other prefectures that are "similar" to the city in terms of size or income per capita. Details
  - Initial minimum wage. Synchronization of across-prefecture minimum wage seems to be a clear policy initiative. However because this instrument is not time varying, using it would require changing our baseline empirical specification to a first-difference setup.
- We present next OLS and IV results for the first instrument.[1]

[1] Results from the second instrument can be found in the paper.

Empirical Specification

- For plant level outcomes (exit, productivity and factor intensity) the baseline regression is.

$$ln(V_{ict}) = \alpha_1 \cdot ln(mw_{ct}) + \beta_1 \cdot ln(mw)_{ct} \cdot (S/L)_h +$$

$$\beta_2 \cdot ln(mw)_{ct} \cdot ln(K/L)_h + \mu_1 X_{ct} + \lambda_i + \lambda_t + \varepsilon_{ict}$$

- For plant-product-destination level outcomes (export quantity and price) we follow a similar specification with appropriate FEs and destination level controls
- Control for city size and and GDP per capita as more productive, richer city may have lower exit, higher productivity, lower costs and prices.
- In extended specification, we also interact city minimum wage with dummies for different percentiles of average wage as proxies for different degrees of bindingness of minimum wage law
- We also test our results at the aggregate (industry-city) level

Selection

- We expect an increase in minimum wage will increase firms' probability of exiting from the export market but less so in more skill- or capital-intensive industries
- Also, we expect the exit probabilities to be higher for more low average wage firms for whom the laws are more binding
- Results are confirmed in Table 1.
  - Magnitude similar to Luca and Luca (2018) for the low average wage firms.

Table 1: Minimum Wage and Exit From Export

VARIABLES	(OLS) Firm exit	(OLS) Firm exit	(IV) Firm exit	(IV) Firm exit
ln(min wage)	0.143***	0.107***	0.163***	0.103**
	[0.017]	[0.013]	[0.044]	[0.041]
ln(min wage) × Industry-City (S/L)	-0.001	-0.000	0.001	0.002
	[0.003]	[0.003]	[0.002]	[0.002]
ln(min wage) × Industry-City ln(K/L)	-0.001***	-0.001***	-0.001***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]
ln(min wage) × low wage		0.048***		0.051***
		[0.008]		[0.007]
ln(min wage) × medium wage		0.039***		0.045***
		[0.006]		[0.005]
ln(min wage) × high wage		0.018***		0.022***
		[0.004]		[0.004]
Observations	803,147	803,147	781,994	781,994
R-squared	0.259	0.260	0.016	0.016

Note: Robust standard errors in parentheses, clustered on city-industry pair.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Productivity

- We expect an increase in minimum wage, given tougher selection, will increase firms' as well as city-industry productivity, but less so in more skill- or capital-intensive industries
- Also, we expect the probability rise to be higher for more low average wage firms for whom the laws are more binding
- Results are presented in Table 2.

Table 2: Minimum Wage and Productivity Distribution

VARIABLES	(OLS) Firm TFP	(OLS) Firm TFP	(IV) Firm TFP	(IV) Firm TFP
ln(min wage)	0.045*	-0.020	0.539***	0.450***
	[0.027]	[0.028]	[0.117]	[0.109]
ln(min wage) × Industry-City (S/L)	-0.009	-0.008	-0.008	-0.008
	[0.007]	[0.007]	[0.006]	[0.006]
ln(min wage) × Industry-City ln(K/L)	-0.000	-0.000	-0.000	-0.000
	[0.001]	[0.001]	[0.001]	[0.001]
ln(min wage) × low wage		0.109***		0.103***
		[0.025]		[0.025]
ln(min wage) × medium wage		0.046**		0.036**
		[0.018]		[0.018]
ln(min wage) × high wage		-0.001		-0.022*
		[0.010]		[0.012]
Observations	790,808	790,808	770,415	770,415
R-squared	0.993	0.993	0.112	0.116

Note: Robust standard errors in parentheses, clustered on industry-city pair.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Selection results at the aggregate level

VARIABLES	(OLS) Avg Exit	(IV) Avg Exit	(OLS) Avg TFP	(IV) Avg TFP
ln(min wage)	0.480***	0.989***	0.230***	0.901***
	[0.038]	[0.159]	[0.023]	[0.073]
ln(min wage) × Industry-City (S/L)	-0.174**	-0.207**	0.044	0.043
	[0.074]	[0.092]	[0.038]	[0.043]
ln(min wage) × Industry-City ln(K/L)	-0.008	-0.012	-0.033***	-0.040***
	[0.009]	[0.010]	[0.005]	[0.006]
Observations	40,853	38,574	123,256	122,979
R-squared	0.564	0.018	0.984	0.063

Note: Robust standard errors in parentheses, clustered on industry-city pair.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Factor Intensity

- We expect: an increase in minimum wage will (i) increase firms' capital intensity and (ii) decrease firms' labor share in costs (with labor costs evaluated at a base wage);
- We see:
  - K/L rises, less so for capital intensive industries - minimum wage is less relevant (more so for skill intensive industries –possibly due to capital skilled labor complementarities)
  - Labor cost share (at fixed wages) falls with the rise in minimum wage, less so for higher K/L, more so for skill intensive firms.

Table 3: Minimum Wage and Factor Intensity

VARIABLES	(1) ln(K/L)	(2) ln(K/L)	(3) Labor share	(4) Labor share
ln(min wage)	0.905***	0.610***	-0.028***	-0.013***
	[0.156]	[0.070]	[0.004]	[0.004]
ln(min wage) × Industry-City (S/L)	0.013	0.015*	-0.000	-0.000
	[0.011]	[0.008]	[0.000]	[0.000]
ln(min wage) × Industry-City ln(K/L)	-0.004***	-0.004***	0.000***	0.000***
	[0.001]	[0.001]	[0.000]	[0.000]
ln(min wage) × low wage		0.277***		-0.018***
		[0.013]		[0.001]
ln(min wage) × medium wage		0.174***		-0.005***
		[0.013]		[0.000]
ln(min wage) × high wage		0.126***		-0.002***
		[0.012]		[0.000]
Observations	781,994	781,994	781,994	781,994
R-squared	0.048	0.051	0.062	0.069

Note: Robust standard errors in parentheses, clustered on industry-city pair.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Export Pattern: Price, Quantity and Value

- We expect: as the minimum wage rises, export quantity falls, and price rises, but less so for skill or capital intensive goods. If export demand is elastic, value acts in line with quantity of exports.
- We confirm this in Table 4.
- About 73 percent of city-industry pairs in our sample have a positive marginal effect (i.e., $\frac{\partial ln(V_{ihcdt})}{\partial ln(mw)_{ct}} > 0$) while the remaining 27 percent of city-industry pairs have a negative response.

Table 4: Minimum Wage & Export Value, Quantity, and Price

VARIABLES	(OLS) lnv	(OLS) lnp	(OLS) lnq	(IV) lnv	(IV) lnp	(IV) lnq
ln(min wage)	-0.324*	0.241***	-0.549***	0.062	0.187**	-0.109
	[0.173]	[0.065]	[0.168]	[0.230]	[0.087]	[0.231]
ln(min wage) × Industry-City (S/L)	1.753***	-0.449***	2.163***	2.291***	-0.535***	2.778***
	[0.391]	[0.162]	[0.410]	[0.275]	[0.115]	[0.287]
ln(min wage) × Industry-City ln(K/L)	0.067	-0.037**	0.100**	0.064**	-0.043***	0.103***
	[0.046]	[0.018]	[0.045]	[0.032]	[0.012]	[0.031]
Observations	5,329,330	5,318,969	5,318,969	2,501,388	2,495,421	2,495,421
R-squared	0.912	0.982	0.935	0.018	0.017	0.007

Note: Robust standard errors in parentheses, clustered on city-product.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Supporting evidence

- Share to OECD rises with minimum wage and less so for skill/capital intensive goods. Suggests upgrading?
- Processing share falls with higher minimum wages and this is less so for skill or capital intensive goods. Upgrading?

VARIABLES	(1) share to OECD	(2) processing share	(3) share to OECD	(4) processing share
ln(min wage)	0.0901***	-0.0229***	0.0840***	-0.0200***
	[0.0168]	[0.00666]	[0.0156]	[0.00676]
ln(min wage)× Industry-City (S/L)	-0.254***	0.0138	-0.236***	0.0163
	[0.0258]	[0.00983]	[0.0255]	[0.0101]
ln(min wage)× Industry-City ln(K/L)	-0.0170***	0.00738***	-0.0173***	0.00701***
	[0.00465]	[0.00175]	[0.00433]	[0.00178]
lag ln(firm total export value)			0.00163***	0.00235***
			[0.000312]	[0.000135]
city ln(GDP/population)	-0.0197***	0.0155***	-0.0241***	0.0124***
	[0.00613]	[0.00233]	[0.00575]	[0.00221]
city ln(population)	0.118***	0.0158***	0.0628***	0.0108***
	[0.0138]	[0.00270]	[0.0101]	[0.00266]
Observations	10,191,176	10,191,176	8,191,565	8,191,565
R-squared	0.868	0.935	0.873	0.937

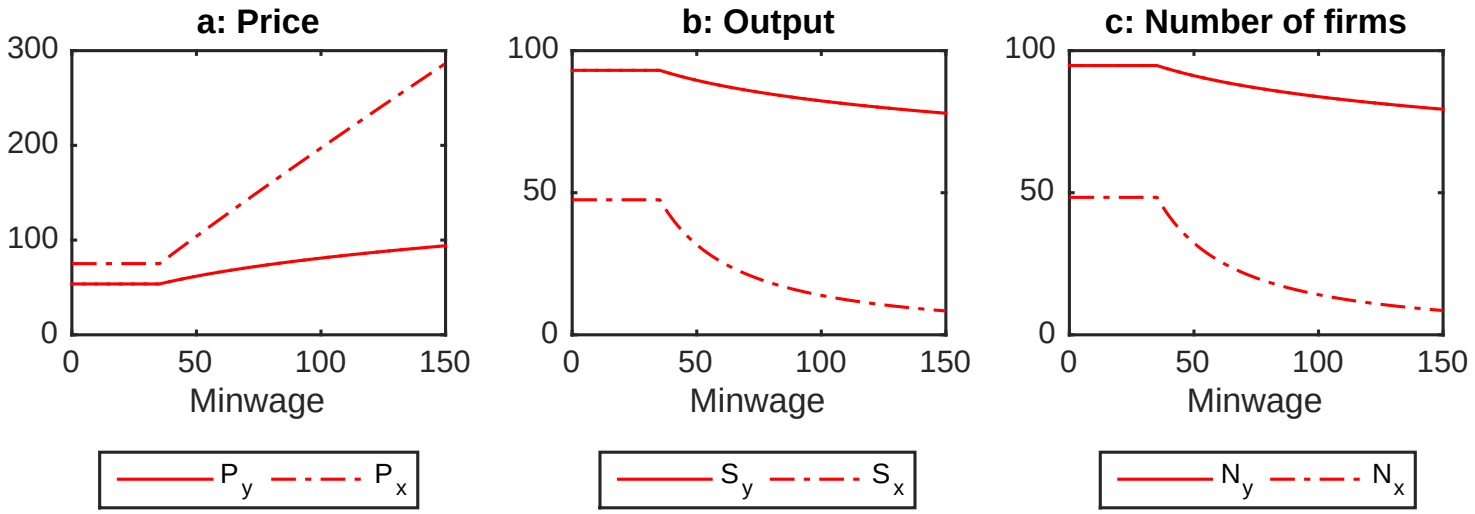
Note: Robust standard errors in parentheses, clustered on prefecture-product.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

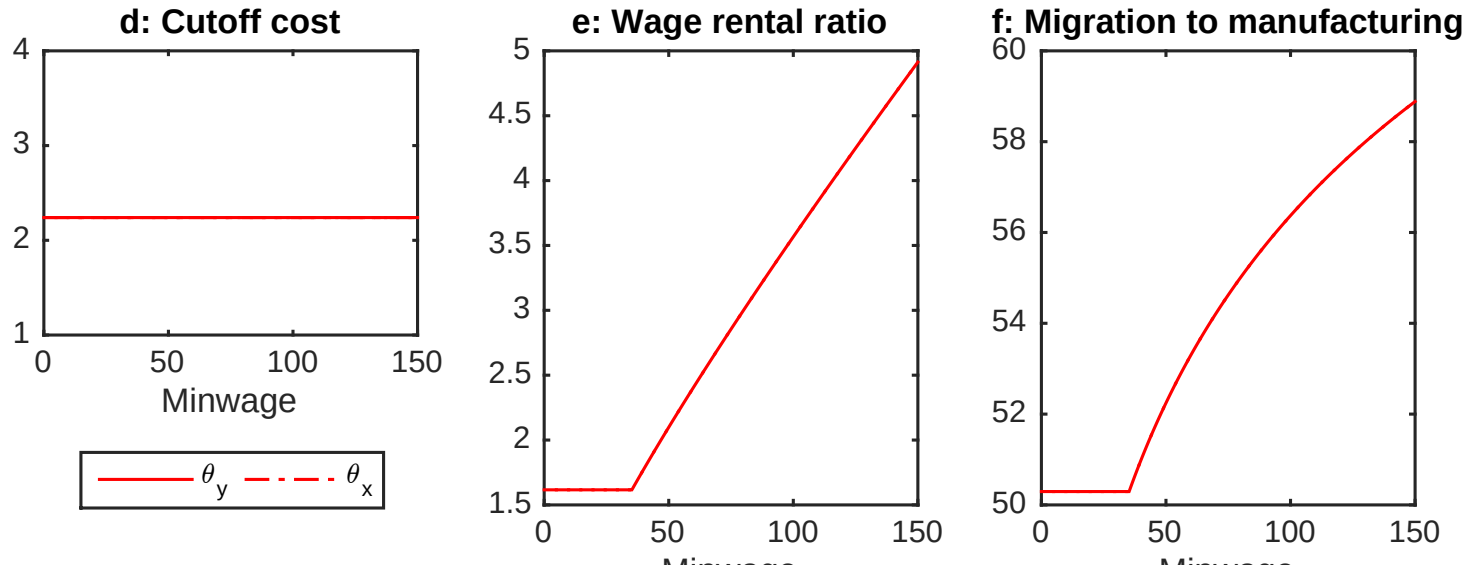
Conclusion

- Minimum wages do seem to have significant effects in a general equilibrium setting on firms' production and export pattern, choice of inputs and survival
- This selection mechanism in turn affects firm and aggregate productivity
- Future work: extensions to structural model (new urban economics) incorporating bilateral migration decision

Simulations: No Selection

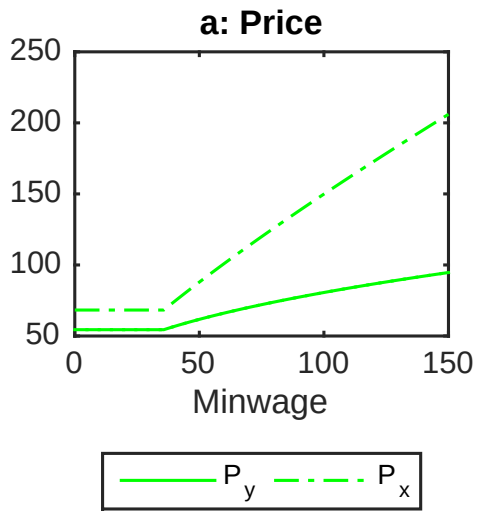
Back to Prediction

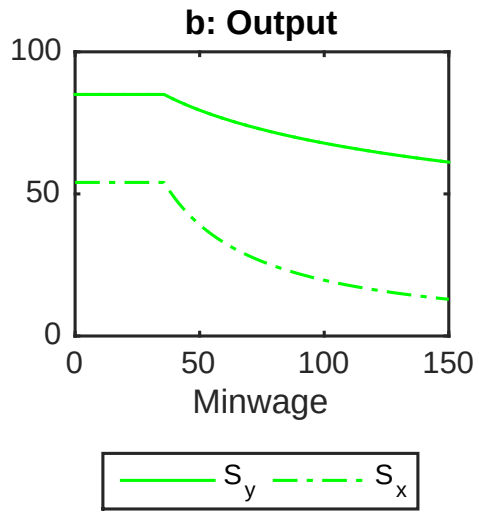


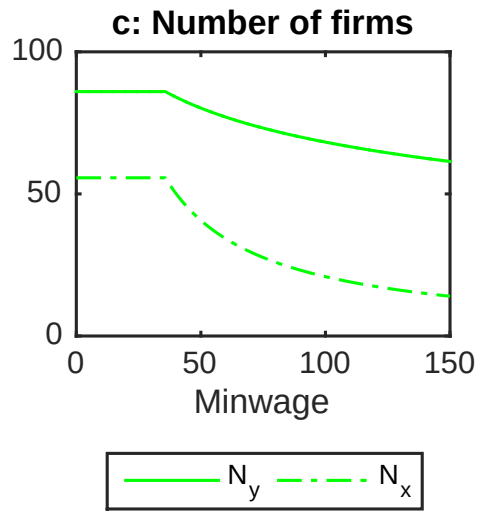


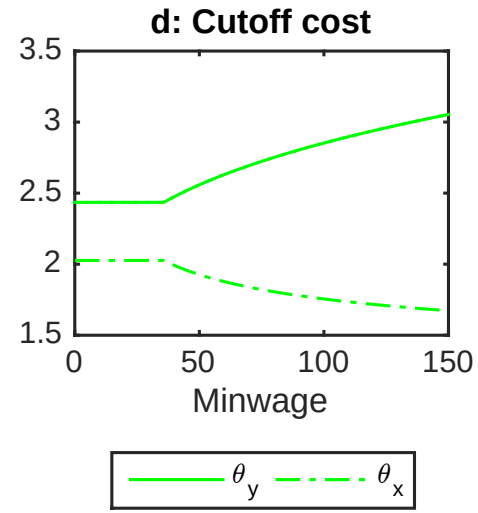
Simulations: With Selection

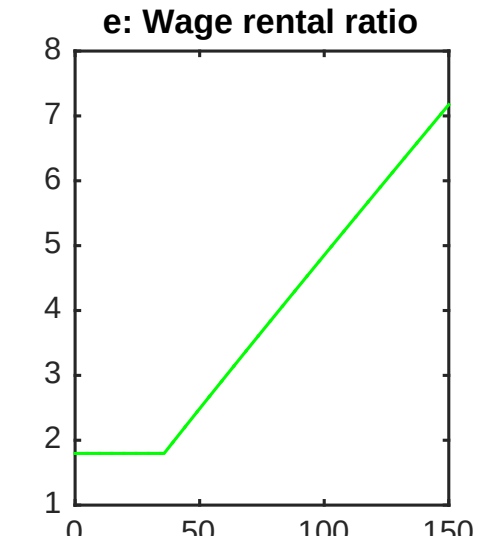
Back to Prediction

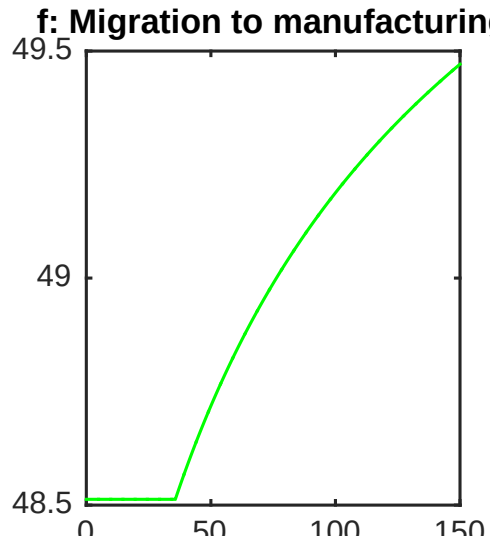












Proof of Lemma 1

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Integrating by parts over area in which the firm chooses to produce gives:

$$\begin{aligned}
\int_0^{\frac{p}{c(w.r)}} (p-\theta c(.))\, f(\theta)d\theta &= (p-\theta c(w,r))\, F(\theta)\big|_0^{\tilde{\theta}} + \int_0^{\tilde{\theta}} c(w,r)F(\theta)d\theta \\
&= \left[c(w,r)\int_0^{\tilde{\theta}} F(\theta)d\theta\right] \\
&= c^e(w,r)f_e
\end{aligned}$$

- In Figure 1, area OAB $= \frac{c^e(w,r)f_e}{c(w,r)}$.

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Market to Firm Level

- All predictions are at the city level.
- What about firm level predictions? Think of a firm as arising out of randomness as in Armenter and Koren (2014).
- A bin is a firm. Balls (draws of a unit capacity at a particular cost) are randomy assigned to bins.
- The balls in a bin define the firm's supply function and aggregating over all firms gives industry supply.
- Some firms have lots of good cost draws so they are large low cost firms,...
- The cutoff, $\tilde{\theta}$, determines which of its capacity the firm uses.
- With this interpretation, predictions carry over to the firm level.

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Details on Instrument

For each year, construct instrument for each city $c's$ minimum wage as follows.

- Group all cities by their GDP per capita into 20 groups.
- Take the average minimum wage of all other cities (mw_{-c}) in the group.

Statistics of the instrument:

- Half of the variation in minimum wage between prefectures in each year is within each GDP per capita group, with the rest being between groups.
- Cities within each GDP per capita group are not clustered geographically or specialized in similar economic activities.
  - on average, each group contains cities from 5 out of 6 regions (e.g. north, northeast, east, south central, southwest and northwest China)
  - within group distribution of city level HHI is very similar to that of the country

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