Trade and Minimum Wages in General Equilibrium: Theory and Evidence

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August 27, 2019

Abstract

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1 Introduction

Countries from Afghanistan to Zambia set a minimum wage. Australia has among the highest minimum wage of about $13.00 (Australian $18.93) in 2019 compared to the federal minimum wage of $7.25 in the U.S. The rationale for a minimum wage and the level at which it is set can vary with the circumstances. In the U.S. the minimum wage has traditionally been used to enable workers to have a "living wage" though in the last few decades, the real minimum wage has fallen

equilibrium model which can guide them in terms of the entire set of predictions to test and through which they can interpret the data. As a result, their model specifications and some empirical results al. (2007)'s approach as the benchmark model is that their assumptions regarding factor intensities of entry and production costs specifically exclude selection effects that arise due to changes in factor prices which occur with minimum wages. Their model *can* be extended to allow for such effects at some cost in complexity. It would deliver similar results, as the forces that operate with minimum wages tend to do so in similar ways across a range of standard models. Minimum wages would raise costs, and more so in the labor intensive sector so that there would tend to be a loss of comparative advantage in this sector with consequent effects on prices, production and exports.

which is homothetic. In particular, we will assume that

$$U = A \ S^{1}$$

and

$$S$$

We will use these definitions when we come to the market equilibrium defined below. We will first analyze what happens in a single city and then extend our model to many cities.

Take a representative city (j) and sector (x or y) to begin with. We first show how factory prices (p) define selection of the ex-post heterogeneous firms making each good. Then we show how to solve for factor prices and outputs. Once we have this, we are able to write down supply and together with demand to solve for equilibrium prices.

If the price of the good is p, only those suppliers who draw a cost below price will produce, that is, $c(w;r)$ p, or $\tilde{}( ) = \frac{p}{c(w;r)}$ will choose to produce the good. This defines the marginal firm as having $= \tilde{}( )$. Supply of the city's variety at price p, given N, the mass of firms, and $f( )$, the density of is thus:

$$s(p;N;c(w;r)) = N \quad F \quad \frac{p}{c(w;r)} \quad : \tag{1}$$

This defines the industry supply curve in the short run (i.e., for given N). In the long run, as there is a cost of entry, and firms only discover their productivity after incurring this cost, N is endogenous.

Firms enter until their expected profits equal the fixed cost of entry. Clearly, selection depends on the specification of entry costs.

Lemma 1.

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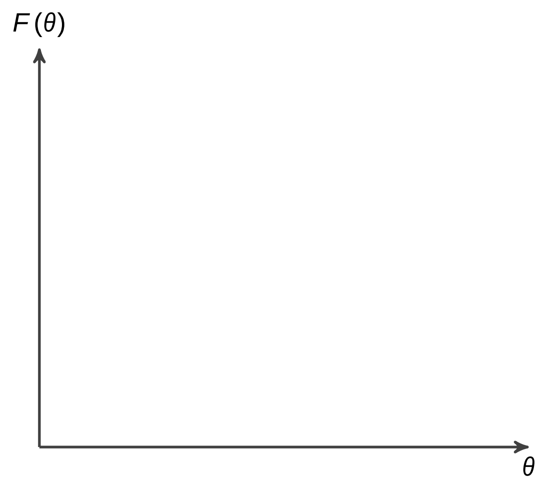
firm24426(ysof)43 arm24420(fix)15(ed)43 0(cost)4420(of)43 1(entry)65(s)]TJ/F23 11.9552 where the second line above follows from integration by parts.[9] Thus,

2 ~

6
4

Figure 1: Cutoff Productivity



both the price of x and y are endogenously determined, not just their ratio, so that we need to first solve for the price of one good given the price of the other and then solve for the equilibrium prices themselves. Third, migration makes labor supply endogenous. Consequently, product price changes bleed over into factor availability. For example, an increase in the price of the capital intensive good will raise r and reduce w, reducing capital intensity and thereby raising the supply of the capital intensive good. The fall in w also affects the labor supply available to industry due to migration. If migration falls with a fall in w, then there is a magnified supply response coming from migration via a Rybczynski like effect.

statics of the model continue to hold.

3 Solving the Model

In this section we look at the different modules that make up the model before turning to the effects of a minimum wage. Throughout we assume that there are no factor intensity reversals and that endowments pat tssectits g(sectits)iectitsyctitsrevectitsn65(0(a499(Note[(and)-31(in13(pat)awm

Figure Productreactorre

work in the same direction. So the Stolper-Samuelson theorem remains, but is *magnified* due to the selection effect.

Of course, in an analogous manner, an increase in the price of the capital intensive good raises the rental rate and reduces the wage. It also reduces the "real cost" of entry ($\frac{c^{ey}(w;r)}{c^{y}(\ )}$) in the capital intensive good, making selection tighter there, and as it raises the real cost of entry ($\frac{c^{ex}(w;r)}{c^{x}(\ )}$) in the labor intensive good, making selection looser there. A more formal proof is in the Appendix.

3.1.1 Migration and Income

Let $G(\ )$

workers not in agriculture. This makes sense: workers on the margin of switching out of agriculture are indifferent between working in agriculture or manufacturing, and so gain nothing from the switch. The income of those that remain in agriculture is unchanged, while the income of workers in industry rises with an increase in the wage. Capital income, of course, rises with the rental rate.

3.2 Outputs and Factors

Let

Figure 3: Entry and Endowments

This raises the mass of entry in the labor intensive sector and reduces it in the capital intensive one. Similarly, an increase in K raises the mass of entry in the capital intensive sector and reduces

Proof.

result is much like that in Bernard et al. (2007) though the mechanism differs. We are now finally in a position to look at the effects of a minimum wage in our model.

4 Minimum Wages and Outcomes

while capital markets clear so that:

$$N^x A_{Lx}(w; r) + N^y A_{Ly}(w; r) \;=\; L^D \quad G(\hat{w}(w))L = L^s \tag{21}$$

$$N^x A_{Kx}(w; r) + N^y A_{Ky}(w; r) \;=\; K \tag{22}$$

where the expected wage $\hat{w}(w)$ is given by:

$$\hat{w}(w) = \quad \frac{L^D}{L^S} \quad w \tag{23}$$

and income, I, in the city is

$$I = \quad (\hat{w}(w))L + \hat{w}(w)G(\hat{w}(w))L + rK: \tag{24}$$

Goods market clearing will give product prices:

$$D^x(p^x; I) = N^x(p^x; p^y; w; G(\hat{w}(w)L; K)\; F^x(\tilde{\ }^x(\ )): \tag{25}$$

$$D^y(p^y; I) = N^y((p^x; p^y; w; G(\hat{w}(w)L; K)\; F^y(\tilde{\ }^y(\ )): \tag{26}$$

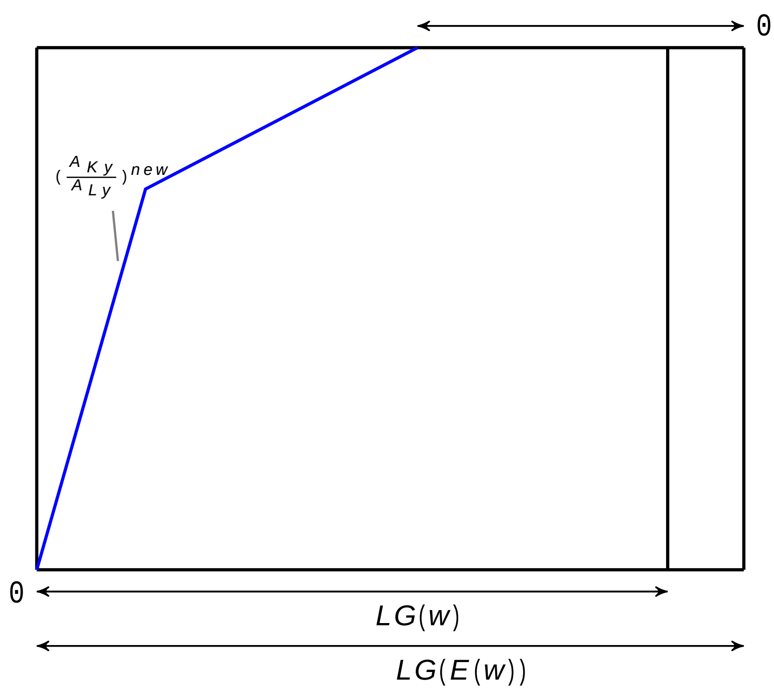
Consider the determination of factor prices at the equilibrium product prices $(p^{x;e}; p^{y;e})$ in the absence of a minimum wage in Figure 6. We depict the case where cutoffs are fixed. The curves represent $p^{x;e} = \tilde{\ }^x c^x(w; r)$ and $p^{y;e} = \tilde{\ }^y c^y$

Figure 6: Product Prices and Factor Prices with a Minimum Wage

such that x is made, given $p^x = p^{x;e}$. Recall that at $\tilde{p}^y(p^{x;e}; w)$, the two price equal to cost curves intersect at w: If p^y rises beyond $\tilde{p}^y(p^{x;e}; w)$ in Figure 5, only y is made. As a result, there is a flat part for the supply function at $\tilde{p}^y(p^{x;e}; w)$

Figure 7: Equilibrium Prices with and without a Minimum Wage

Figure 8: Factor Market Equilibrium with Minimum Wages



It is worth noting that while an increase in the wage always increases migration, an increase in the minimum wage could *raise* or *lower* migration. Note that the demand for labor is a derived demand from the final goods. As shown above migrants will equate their productivity in agriculture

4.1 Predictions of the Model

In this section we summarize the predictions regarding an increase in minimum wage for selection, in Figure 4 (but below the intersection of the two dashed lines in Figure 5) only the output of x will be constrained by demand so that production *will fall of the labor intensive good despite the*

Figure 9: Geography of Minimum Wages, 2000-2010

5.2 Firm and Transaction-Level Data

Besides city level minimum wage data, our main empirical results are drawn from transaction-level export and import data, collected by the China Customs General Administration. This dataset provides the universe of transactions by Chinese firms that participated in international trade over the 2000-2008 period. It reports for each transaction the value (in US dollars) and quantities at six-digit HS product level, the destination/origin country, and the firm's identification code, name and address. As we have value and quantity, we can calculate the unit value for each transaction.

Table 1: Summary Statistics

	Mean	Std. Dev.	5th Pctl	Median	95th Pctl	No. of Obs
ASIP Data						
Firm-Year Level						
ln (Average Wage)	2.5693	0.6312	1.6714	2.5603	3.6082	943951
Average firm wage / city minimum wage	2.5583	2.5024	1.0031	2.0555	5.5676	943951
ln (K/L)	3.5240	1.3426	1.2566	3.5984	5.5736	943951
Labor Share	0.0216	0.0323	0.0021	0.0133	0.0641	943951
Export Status	0.2983	0.4575	0	0	1	943951

The lower panel gives the summary statistics for the Customs Data. Price in the customs data is measured in US dollars. Quantity is measured in the product's recorded units of measurement. An observation is at the firm-product-destination-year level. Transactions are aggregated to obtain, for example, the quantity of exports by a firm to a particular destination for a HS6 category in a particular year.

5.3 Endogeneity of Minimum Wage

Our main predictions focus on the consequence of higher minimum wages. However, a higher

6 Empirical Results

Table 2: Minimum Wage and Export Exit

	OLS		IV	
	(1)	(2)	(3)	(4)

to separate agglomeration from selection following Combes, Duranton, Gobillon, Puga and Roux (2012). The predictions for selection are shown to be borne out in Tables 2 and 3.

In Table 2, we use $Exit_{ihct}$, a dummy variable that indicates whether firm i exports in period t 1 but exits in the next period t, as the dependent variable. Columns (1) and (2) report the OLS

Table 3: Minimum Wage and Firm Productivity

	OLS		IV	
	(1)	(2)	(3)	(4)
	Productivity	Productivity	Productivity	Productivity

Table 4: Minimum Wage and Factor Intensity

	OLS				IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ln (K/L)	ln (K/L)	Labor share	Labor share	ln (K/L)	ln (K/L)	Labor share	Labor share
ln (min. wage)	0.205***	0.051	-0.006***	0.001	0.541***	0.256*	-0.024***	-0.011***

The regression equation is specified as follows:

$$ln(E_{ihct}) \quad = \quad {}_{1} \; ln(mw)_{ct} + {}_{1} \; ln(mw)_{ct} \quad (S{=}L)_{hc} +$$

on exports where we can calculate unit value from export value and quantity. Our Customs data covers the universe of transactions of Chinese exporters during 2000-2006.[38] More specifically, we use export information at the firm (*i*) - product (*h*) - city (*c*) ‑ destinationiverse o11971 0 Td [(()]TJ/F23 11.

Table 5: Minimum Wage and Firm Exports

	OLS		IV	
	(1)	(2)	(3)	(4)
	ln (P)	ln (Q)	ln (P)	ln (Q)
ln (min. wage)	0.248***	-0.602***	0.199**	-0.128
	[0.059]	[0.152]	[0.090]	[0.234]
ln (min. wage) Industry-City (S/L)	-0.522***	2.253***	-0.586***	2.908***
	[0.147]	[0.360]	[0.103]	[0.250]
ln (min. wage) Industry-City ln (K/L)	-0.035**	0.113***	-0.042***	0.129***
	[0.017]	[0.042]	[0.011]	[0.028]
city ln(GDP per capita)	-0.035**	0.032	-0.036***	0.046*
	[0.016]	[0.042]	[0.009]	[0.024]
city ln(Population)	-0.068**	-0.213**	-0.076***	-0.160***
	[0.031]	[0.093]	[0.019]	[0.053]
destination ln(GDP per capita)	-0.116***	-0.223**	-0.116***	-0.222***
	[0.040]	[0.107]	[0.022]	[0.060]
Observations	6,252,280	6,252,280	3,003,363	3,003,363

Note: Robust standard errors in parentheses, clustered on city-product pair. * $p < 0{:}10$, ** $p < 0{:}05$, *** $p < 0{:}01$

Table 6: Minimum Wage and Firm Exports with Firm Level Controls

minimum wage leads to a 10 percent increase in the likelihood of exit for a 3.5-star restaurant

Table 8: Effects of Minimum Wage Increase on Export Price

Elasticity	ln (P)
Simple Average	-0.0496
Weighted Average	-0.0292
Predicted Ratio of Positive Elasticities (Firm Level - 2004 Census)	0.5457

Table 9: Minimum Wage and Export Entry

	OLS	IV

6.5.3 An Alternative Instrument

Is there another instrument we can use to check on the robustness of our estimates? Figure 9

Table 11: Minimum Wage and Firm Productivity: First Difference

Table 13: Minimum Wage and Firm Exports: First Difference

	(1)	(2)	(3)	(4)	(5)	(6)

equilibrium rather than focusing on a single one or a small subset of them. Third, we test these

Card, David and Alan B Krueger

Harasztosi, Péter and Attila Lindner, "Who pays for the minimum wage?," *American Economic Review*, 2019, *109* (8), 2693–2727.

Hau, Harald, Yi Huang, and Gewei Wang, "Firm response to competitive shocks: Evidence from China's minimum wage policy," *Swiss Finance Institute Research Paper*, 2018, (16-47).

Lemma 2. An increase in the price of the labor intensive good raises w and reduces r and makes selection stricter in the labor intensive good and weaker in the capital intensive one. Analogously, an increase in the price of the capital intensive good reduces w and raises r

Using the fact that " $\tilde{R}$

Since $_{Lx} > \ _{Le}$ and $_{Ly} < \ _{Le}$ and $^{0}_{L}s$ are convex combinations of $_{L}$ and $^{e}_{L}$ we know that $_{Ly} < \ _{Lx}$. This is depicted below.

$$_{Ly} < \ _{Ly} < \ _{Le} < \ _{Lx} < \ _{Lx}$$

Similarly, $_{Ky} > \ _{Kx}$

$$\hat{\sim}_x = v^x [(_{Le} \quad _{Lx}) \hat{w} + (_{Ke} \quad _{Kx}$$

Since

$$K_x \quad L_y \qquad K_y \quad L_x \quad = \quad K_x \quad K_y \left(\frac{L_y}{K_y} \quad \frac{L_x}{K_x} \right)$$

$$a_{Ly}(\,)^{\sim y} F(^{\sim y}) N^{y}$$

$$= \quad K_x \quad K_y \left(\right.$$

$$_{Lx}\hat{N}^x + \ _{Ly}\hat{N}^y + \ _{Lx}\hat{A}_{Lx}(\ ) + \ _{Ly}\hat{A}_{Ly}(\ ) = \hat{L} + \frac{wG'(w)}{G(w)}\hat{w} \qquad (47)$$

$$_{Kx}\hat{N}^x + \ _{Ky}\hat{N}^y + \ _{Kx}\hat{A}_{Kx}(\ ) + \ _{Ky}\hat{A}_{Ky}(\ ) = \hat{K} \qquad (48)$$

where $_{Lx} = \frac{N^x A_{Lx}(w;r)}{G(w)L}$; $_{Ly} = \frac{N^y A_{Ly}(w;r)}{G(w)L}$; $_{Kx} = N^x A_{Kx}(w\ )$

Recall that

$$\hat{w} = \frac{1}{Lx \quad Ky \qquad Ly \quad Kx} h$$

$$\begin{bmatrix} \hat{N}_x \\ \hat{N}_y \end{bmatrix} = \frac{1}{Det} \begin{bmatrix} K_y & L_y \\ K_x & L_x \end{bmatrix} \begin{bmatrix} B \end{bmatrix}$$

Proof. As

$$p$$

k_x

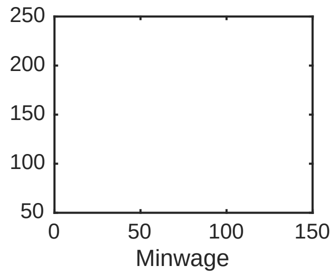
which has expected wage in manufacturing for rural migrants as an unknown. Expected wage is defined by probability of finding a job in manufacturing times the minimum wage, and this probability depends on labor demand in manufacturing which in turn depends on number of firms in operation in each sector. Expected income affects demand. Hence, now we need to solve factor market and goods market clearing conditions simultaneously. Given a set of values for N^x and N^y, we can obtain labor demand from (20) as the A's are known once we have factor prices and cutoffs. Then

$$\hat{w}(w) = \quad L^D$$

Figure 12: Comparative Statics of Minimum Wage without Selection

differ from $_{x}$ and also let $_{e;y}$ to differ from $_{y}$. In particular, in this example we set $_{e;x}$ to $.7$ and $_{e;y}$ to $.2$, and leave $_{x}$ and $_{y}$ at $.8$ and $.1$ respectively

Figure 13: Comparative Statics of Minimum Wage with Selection



8.3 First Stage Estimates

In Tables 15 to 21, we present the first stage regression results of the baseline and the first-difference IV regressions corresponding to Tables 2 to 5 and Tables 11 to 13. We do not have weak identification problems as the values for the Kleibergen-Paap rk Wald F statistics are above the critical levels.[48]

[48]We use the Kleibergen-Paap rk Wald F statistics as the standard errors are clustered.

Table 15: Minimum Wage and Exit from Export: IV Regression First Stage

	(1) ln (min. wage)	(2) ln (min. wage) Industry-City (S/L)	(3) ln (min. wage) Industry-City ln (K/L)
IV ln (min. wage)	0.236 ***	-0.098***	-3.081***
	(0.019)	(0.005)	(0.080)
IV ln (min. wage) Industry-City (S/L)	-0.004**	1.005***	-0.017*
	(0.002)	(0.001)	(0.010)
IV ln (min. wage) Industry-City ln (K/L)	0.000	0.000	1.010***
	(0.000)	(0.000)	(0.001)
low wage	-0.010***	-0.002***	-0.041***
	(0.001)	(0.000)	(0.005)
medium wage	-0.004***	-0.001***	-0.016***
	(0.001)	(0.000)	(0.005)
high wage	-0.002**	-0.000*	-0.009***
	(0.001)	(0.000)	(0.003)
city ln (GDP per capita)	-0.008	0.001	-0.001
	(0.013)	(0.002)	(0.051)
city ln (Population)	-0.097***	-0.016***	-0.374***
	(0.022)	(0.003)	(0.083)
Observations	914952	914952	914952

Table 17: Minimum Wage and Factor Intensity: IV Regression First Stage

Table 19: Minimum Wage and Firm Productivity (First Difference): IV Regression First Stage

	(1)	(2)	(3)
	ln (min. wage)	ln (min. wage)	ln (min. wage)

Table 21: Minimum Wage and Firm Exports (First Difference): IV Regression First Stage