First publ. in: Economics Letters 91 (2006), 2, pp. 287-292

Minimum wage increases can lead to wage reductions by imperfectly competitive firms

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Abstract

In a model with imperfect competition and multiple equilibria we show how an increase in the minimum wage can lead firms to reduce wages (and employment). We find some empirical support for this in the Card–Krueger minimum wage data.

Keywords: Minimum wages; Oligopoly; Oligopsony

JEL classification: D43; E24; J48

1. Introduction

In a competitive labour market, a minimum wage increase raises wages to the new minimum wage level if they were initially below that level, with no change otherwise; the effect on employment can only be a reduction. Although monopsony can reverse the employment effect (e.g. Manning, 2003), the wage predictions are unchanged. Recently, Bhaskar and To (2003) have shown how oligopsony may also change the wage prediction, with firms who originally set wages above the new minimum wage further

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increasing their wage. We expand on these possibilities by showing that in a model of oligopsony where the firms are also oligopolists, minimum wage increases can induce a *reduction* of wages (along with a reduction of employment). We present some evidence of this phenomenon in the Card and Krueger (1995) data on the New Jersey fast-food sector.

2. The model

We combine features of Dixon (1992) and Kaas and Madden (2004) in a 2-stage game, with wages and employment determined at stage I and prices and output at stage II. There are two firms, duopsonists in the labour market at stage I and duopolists in the stage II output market.[1] The production function of firm i is $y_i = l_i$ where y_i is output and l_i is labour employed. At wage w the upward sloping labour supply is $S(w)$, and the downward sloping inverse output demand is $p = P(Y)$ where p is output price and Y aggregate quantity. The revenue function $R(Y) = P(Y)Y$ is increasing (so demand is elastic) and concave. The unique Walrasian equilibrium wage w^{WE} is defined by $w(=p) = P(S(w))$.

Strategic interaction between firms under laissez-faire is as follows.

2.1. Stage I

Firms choose wages $w_i \geq 0$ and labour demands J_i. If $w_1 = w_2 = w$ we assume that initially half of the supply $S(w)$ offer to work at each firm, any unsuccessful offers being diverted to the other firm, implying for $i = 1, 2$ and $j \neq i$;[2]

$$l_i = \min\left[J_i, \max\left(\frac{1}{2}S(w), S(w) - J_j\right)\right]. \quad (1)$$

If $w_1 > w_2$ then workers $S(w_1)$ offer themselves to firm 1 and those with the lowest reservation wage are hired first,[3] leaving a residual of $\max[S(w_2) - \min(J_1, S(w_1)), 0]$ for firm 2, giving

$$l_1 = \min(J_1, S(w_1)), \; l_2 = \min[J_2, \max(S(w_2) - l_1, 0)]. \quad (2)$$

2.2. Stage II

Firms choose prices p_1, p_2 for the sale of up to the output levels $y_i = l_i$. Since demand is elastic, this stage II ("Bertrand–Edgeworth") subgame always has a unique Nash equilibrium, with market-clearing prices $p_1 = p_2 = P(l_1 + l_2)$ — see Madden (1998).

Thus subgame perfect equilibria of the two-stage game reduce to the Nash equilibria of the simultaneous move game where firm i chooses (w_i, J_i) and, with l_i defined by Eqs. (1) and (2), payoffs

[1] For instance, a town in New Jersey has 2 fast food outlets that are the sole employers of the town's teenage labour supply (duopsony) and the only suppliers of fast food to the town (duopoly). Generalizing the results to the oligopoly case is straightforward but tedious.

[2] Alternatively phrased, we are assuming here uniform rationing at symmetric wages.

[3] This assumption (innocuous here) is the efficient rationing rule of the Bertrand Edgeworth literature.

are:

$$\pi_i(w_1, J_1, w_2, J_2) = [P(l_1 + l_2) \quad w_i]l_i. \tag{3}$$

$w_1 = w_2 = w^{WE}$ with $J_1, J_2 \geq S(w^{WE})$ and $\pi_1 = \pi_2 = 0$ is an equilibrium of this game; if firm 1 undercuts the Walrasian wage, firm 2 takes the whole market (because of $J_2 \geq S(w^{WE})$ and Eq. (2)), leaving firm 1 with zero profits, and if firm 1 raises the wage, aggregate output can only increase (again because of $J_2 \geq S(w^{WE})$ and Eq. (2)) and its price falls, ensuring a loss for firm 1. The Appendix shows that this equilibrium isunique;

Theorem 1. *Under laissez-faire the unique equilibrium wage, employment and profit levels are Walrasian* $\left(w_1 = w_2 = w^{WE}, l_1 = l_2 = \frac{1}{2}S(w^{WE}), \pi_1 = \pi_2 = 0\right)$, *supported by any labour demands* J_1, $J_2 \geq S(w^{WE})$.

The excess demands for labour ($J_i > l_i$) neutralise the output market power of firms. For instance a deviation from equilibrium in only J_1 has no effect on aggregate output (even if $J_1 = 0$ this remains at $S(w^{WE})$) and so has no effect on output price (which is always $P(S(w^{WE}))$).

With a legally binding minimum wage $w^{MIN} > 0$, the game is the same except for the stage I restriction to $w_i \geq w^{MIN}$. If $w^{MIN} = w^{WE}$ the equilibrium of Theorem 1 remains, but there is another equilibrium. Suppose $w_1 = w_2 = w^{MIN}$ and firms set labour demands which produce unemployment ($J_1 + J_2 < S(w)$); profits are $\pi_i = [P(J_1 + J_2) \quad w^{MIN}]$, which is concave in J_i. Maximizing with respect to J_i produces candidate new equilibrium labour demands $J_1 = J_2 = J$ where $Y = 2J$ and,

$$w^{MIN} = \psi(Y) = P'(Y)Y/2 + P(Y) \tag{4}$$

The marginal revenue curve $\psi(Y)$ slopes down as in Fig. 1. In fact Y is the Cournot–Nash aggregate output level when firms face constant marginal costs $w = \psi\ ^{1}$. The candidate generates the assumed unemployment whenever $w > w$ shown in Fig. 1, and firms earn positive profits $(= (P(Y) \quad w^{MIN})Y/2 = \quad P'(Y)Y^2/4 > 0$.

It turns out that setting the minimum wage and hiring $Y/2$ workers is indeed equilibrium behaviour provided that the minimum wage exceeds a certain threshold level. Without the minimum wage, firms

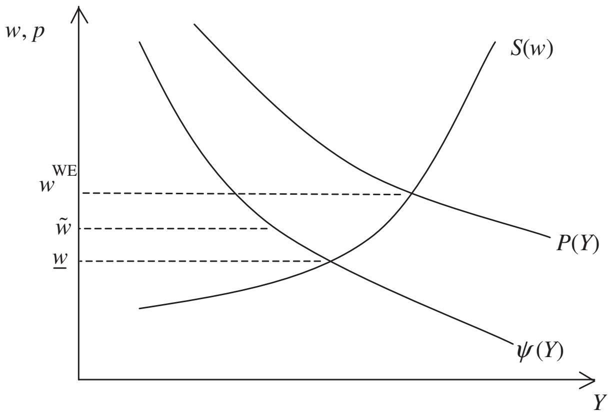

Fig. 1. Equilibrium wages and output.

Table 1
Starting wages: descriptive statistics

	New Jersey		Pennsylvania	
	Before	After	Before	After
At minimum	95 (31%)	268 (89%)	22 (32%)	20 (29%)
Mean Wage ($)	4.62	5.08	4.65	4.62
(standard dev.)	(0.3452)	(0.1066)	(0.3559)	(0.3597)
Above $5.05	23 (8%)	33 (11%)	4 (6%)	2 (3%)
Reduce wage	19 (6%)		27 (40%)	
Above $5.05 and reduced to $5.05	18 (6%)			
Sample size	302		68	

would undercut while hiring the same number of workers. The minimum wage removes this option to undercut, thus sustaining the new equilibrium. In the Appendix we prove

Theorem 2. *There exists a wage* $\tilde{w} \in (w, w^{WE})$ *such that*

(a) *For* $w^{MIN} < \tilde{w}$*, the unique equilibrium is that of* Theorem 1.
(b) *For* $\tilde{w} \leq w^{MIN} \leq w^{WE}$ *there are two equilibria, the equilibrium of Theorem 1 and a minimum wage, positive profits, unemployment equilibrium with* $w_1 = w_2 = w^{MIN}$ *and* $J_1 = J_2 = \frac{1}{2}Y$ where $\psi(Y) = w^{MIN}$.
(c) *For* $w^{MIN} > w^{WE}$ *the unique equilibrium is the minimum wage, positive profits, unemployment equilibrium of (b) above.*

One can argue for the positive profits at the new equilibrium as a selection mechanism — the new minimum wage equilibrium Pareto dominates the original. The announcement of the new minimum wage may also make the new equilibrium focal. Thus a minimum wage increase may lead to lower wages and employment at firms that were originally paying wages above the minimum wage.

3. Empirical evidence

We analysed Card and Krueger's (1995) "natural experiment" data on fast food restaurants in Pennsylvania and New Jersey in 1992. In April 1992 the New Jersey minimum wage rose from $4.25 to $5.05 while the minimum wage in Pennsylvania remained at $4.25. Card and Krueger examined the employment impact of the wage hike, however they also collected data on the starting wage for restaurant employees.

Table 2
Full time equivalent employment

	New Jersey		Pennsylvania	
	Before	After	Before	After
All Restaurants	20.67	21.88	23.70	21.20
Wage Reducers	27.39	22.06		

Table 1 shows that a relatively small proportion of New Jersey restaurants offered starting wages above the new minimum of \$5.05 before the hike. Of the 23 firms in New Jersey that were paying in excess of \$5.05, 18 reduced their starting wage to the new minimum when it came into effect. This is prima facie evidence in favour of the theoretical result. Further analysis of the firms that reduced starting wages to \$5.05 suggests that this was not a trivial reduction in the majority of cases. The mean reduction was 27 cents while the modal reduction was 45 cents.

There is evidence that firms that lowered wages also reduced employment. Table 2 shows the change in full-time equivalent employment for all restaurants in New Jersey and Pennsylvania as well as for those 18 restaurants in New Jersey that reduced their wage to the new minimum. The second row, where we consider only the wage reducers in New Jersey, shows a substantial and statistically significant reduction of around five employees (two-tailed p-value$=0.028$).

Acknowledgement

We are grateful to an anonymous referee for helpful comments on a previous version of this paper. Leo Kaas thanks the Austrian Science Fund (FWF) for financial support. The data we use are available on the World Wide Web. See Chapter 1 of Card and Krueger (1995) for access details.

Appendix A. Proof of Theorem 1

To show uniqueness, consider symmetric wages $w_1=w_2=w$. (a) There is no equilibrium with $J_1+J_2<S(w)$. If firm 1 reduces w_1 a little it will still be able to hire the same J_1, so aggregate output and price are unchanged and profits higher. (b) There is no equilibrium with $J_1+J_2\geq S(w)$, $w>w^{\mathrm{WE}}$. Aggregate output would be $S(w)$, its price $P(S(w))<P(S(w^{\mathrm{WE}}))=w^{\mathrm{WE}}$ so at least one firm (i say) makes a loss, which $J_i=0$ improves on. (c) There is no equilibrium with $J_1+J_2\geq S(w)$, $w<w^{\mathrm{WE}}$. Here $\pi_1+\pi_2=[P(S(w))\quad w]S(w)$. By raising w_i and taking the whole market either firm can attain profits close to $\pi_1+\pi_2$, which must be an improvement for at least one of them. (d) There is no equilibrium with $J_1+J_2\geq S(w)$, $w=w^{\mathrm{WE}}$ and $J_i<S(w)$ and $J_i<S(w)$ some i. Note $\pi_1=\pi_2=0$ in any such equilibrium. Suppose $J_2<S(w)$. If 1 deviates to $\hat{J}_1\in(0,S(w)\quad J_2)$ then it makes strictly positive profits since $P(\hat{J}_1+J_2)>P(S(w))>w$. The proof of non-existence of asymmetric wage equilibria is available upon request. □

Appendix B. Proof of Theorem 2

Let $\pi(w)=[P(Y)\quad w]Y/2$ where $w=\psi(Y)$, and let $\hat{\pi}(w)=[P(S(w))\quad w]\,S(w)$ denote "whole market" profits. Suppose $\psi(Y)=w^{\mathrm{MIN}}\geq$ w, so $w_1=w_2=w^{\mathrm{MIN}}$, $J_1=J_2=Y/2$ is the candidate new equilibrium with $\pi_1=\pi_2=\pi(w^{\mathrm{MIN}})>0$.

Given $w_i=w^{\mathrm{MIN}}$, $J_1=Y/2$ is a best response to $J_2=Y/2$-concavity of $[P(J_1+J_2)\quad w^{\mathrm{MIN}}]J_1$ ensures that deviations to $J_1\hat{I}[0,S(w^{\mathrm{MIN}})\quad Y/2]$ are unprofitable and deviations to $J_1\geq S(w^{\mathrm{MIN}})\quad Y/2$ leave l_1 unchanged at $S(w^{\mathrm{MIN}})\quad Y/2$ (from Eq. (1)). Suppose firm 1 raises its wage from the candidate level. We show that this is beneficial only if there is some wage $w_1=w^{\mathrm{MIN}}$ which, with $J_1=S(w_1)$ is also beneficial. First suppose $w_1 > w^{MIN}$ is coupled with $J_1 \in [0, S(w^{MIN}) \quad Y/2]$. This cannot be beneficial since the resulting employment J_1 can also be attained choosing w^{MIN} and the same J_1 with the same aggregate output and price, and higher profit. Second, if $w_1 > w^{MIN}$ is coupled with $J_1 \in [S(w^{MIN}) \quad Y/2, S(w^{MIN})]$ then $\pi_1 = [P(S(w^{MIN})) \quad w_1]J_1$. This cannot be beneficial if $w^{MIN} \geq w^{WE}$ (non-positive π_1); if $w^{MIN} < w^{WE}$ then $J_1 = S(w^{MIN})$ is the best for 1 in this J_1 range, allowing profits arbitrarily close to $\hat{\pi}(w^{MIN})$, by choosing a small enough wage increase. Third $w_1 > w^{MIN}$ and $J_1 \in S(w^{MIN}), S(w_1))$ is dominated for 1 by the same J_1 and $\hat{w}_1 = s^{\quad 1}(J_1) \in (w^{MIN}, w_1)$, $\hat{\pi}_1(\hat{w}_1)$. Finally, $w_1 > w^{MIN}$ and $J_1 \geq S(w_1)$ implies $\pi_1 = \hat{\pi}_1(w_1)$. Thus the best that firm 1 can achieve with $w_1 > w^{MIN}$ is $\hat{\pi}(w_1)$. Hence the candidate is an equilibrium iff $\pi(w^{MIN}) \geq \hat{\pi}(w_1)$ for all $w \geq w^{MIN}$.

Now $\hat{\pi}(\mathrm{w}) = 2 \quad \pi(w) > 0$, so $\hat{\pi}(w) > \pi(w)$; also $\hat{\pi}(w^{WE}) = 0 < \pi(w^{WE})$and $\hat{\pi}(w) \leq 0$ for $w \geq w^{WE}$. In the interval $[w, w^{WE}]$ we have the following with $Y = \psi^{1(\quad 1)}(w)$; $\hat{\pi}'(w) = A \quad s(w)$, $\pi'(w) = B \quad Y/2$ where

$$A \qquad s'(w)[P'(s(w))\, s(w) + P(s(w)) \quad P(Y) \quad P'(Y)Y/2]$$
$$B \qquad P'(Y)Y[\psi'(Y)]^{\quad 1}/4$$

Since $P(Y)$ is downward sloping and $R(Y)$ is increasing and concave, $A < 0$, and since $\psi(Y)$ is downward sloping $B > 0$. Since $S(w) > Y(2)$ it follows that $\hat{\pi}'(w) < \hat{\pi}'(w)$ on $[w, w^{WE}]$. Hence there is an unique $\tilde{w} \in (w, w^{WE})$ where $\hat{\pi}(\tilde{w}) = \hat{\pi}(\tilde{w})$ and $\pi(w^{MIN}) \geq \hat{\pi}(w)$, for all $w \geq w^{MIN} \geq \tilde{w}$. Thus the candidate is an equilibrium if and only if $w^{MIN} \geq \tilde{w}$. The uniqueness arguments in Theorem 1 ensure that this is the only new candidate, completing Theorem 2. □

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