Online Appendix

"The effect of low-skill immigration restrictions on U.S. firms and workers: Evidence from a randomized lottery"

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In this Appendix we present derivations of the model in the main text, a discussion of monopsony power in rural labor markets, summary statistics for the firm sample (with comparisons of selected traits to the firm universe), and numerous extensions of the empirical analysis, some prespecified and others not.

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A1 Derivations

While we will ultimately execute derivations for CES production function shown in (8), let us begin with the general setup underlying proposition 1. Inverting the demand function (7) as $p = D^{\frac{1}{\eta}} Q^{-\frac{1}{\eta}}$, we have that revenues, $R = Q(p)p = D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}}$. The firm's problem is to maximize profits

$$\Pi(I, N, K) = D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} - w_I I - w_N N - rK - \mathcal{F}$$

subject to $I \leq \bar{I}$ (if it faces the hiring constraint). In summary, they maximize the objective function:

$$\mathcal{L}(I, N, K) = D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} - w_I I - w_N N - rK - \mathcal{F} + \lambda(I - \bar{I})$$

where $\lambda = 0$ for an unconstrained firm. This produces the following first order conditions:

$$\frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{-\frac{1}{\eta}} \frac{\partial Q}{\partial I} = w_I + \lambda \tag{A.1}$$

$$\frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{-\frac{1}{\eta}} \frac{\partial Q}{\partial N} = w_N \tag{A.2}$$

$$\frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{-\frac{1}{\eta}} \frac{\partial Q}{\partial K} = r \tag{A.3}$$

...and $I \leq \bar{I}$ for a constrained firm. Notice that λ represents a positive wedge between a firm's marginal revenue product of immigrant labor and immigrant wages for constrained firms.

In light of this, we can compute optimal total costs as follows:

$$\begin{aligned} C^*(I, N, K, \mathcal{F}) &= w_I I + w_N N + rK + \mathcal{F} \\ &= \frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{-\frac{1}{\eta}} \left(\frac{\partial Q}{\partial I} I + \frac{\partial Q}{\partial N} N + \frac{\partial Q}{\partial K} K \right) + \mathcal{F} - \lambda I \\ &= \frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} + \mathcal{F} - \lambda I \end{aligned}$$

where the last step follows from homogeneity.[1] Optimal profits are then given by

$$\Pi^* = R^* - C^* = D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} - \left(\frac{\eta - 1}{\eta} D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} + \mathcal{F} - \lambda I \right) \tag{A.4}$$

$$= \frac{1}{\eta} D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} - \mathcal{F} + \lambda I \tag{A.5}$$

Now let us contrast constrained and unconstrained firms. Since unconstrained firms can freely choose I – and, in particular, could choose $I_w \leq \bar{I}$, it must be that unconstrained firms have profits that are at least as large as constrained firms, and therefore $\frac{1}{\eta} D^{\frac{1}{\eta}} Q_w^{\frac{\eta-1}{\eta}} \geq \frac{1}{\eta} D^{\frac{1}{\eta}} Q_\ell^{\frac{\eta-1}{\eta}} + \lambda I_\ell$ (where recall that subscript w refers to unconstrained "winning" firms and ℓ refers to constrained "losing" firms). But this implies that

[1] This abstracts from permanent labor, which is described as fixed at share γ in the main text. Accounting for this changes the math slightly – instead, $C^* = (1 - \gamma) \frac{\eta-1}{\eta} D^{\frac{1}{\eta}} Q^{\frac{\eta-1}{\eta}} + \mathcal{F} - \lambda I$, which slightly alters subsequent expressions – but it does not change any of the implications described here. We re-incorporate permanent labor below.

unconstrained revenues are weakly higher $D^{\frac{1}{\eta}} Q_w^{\frac{\eta-1}{\eta}} \geq D^{\frac{1}{\eta}} Q_\ell^{\frac{\eta-1}{\eta}}$, and therefore that unconstrained output is weakly higher $Q_w \geq Q_\ell$. Rearranging, the proportional revenue increase induced by a relaxation of the hiring constraint is larger the larger is the demand elasticity:

$$\ln(R_w/R_\ell) = \frac{\eta-1}{\eta} \ln(Q_w/Q_\ell).$$

Additional notation can help illustrate why winning the lottery must cause revenue to rise. Let I_w represent the number of immigrant hires the firm makes when unconstrained—"winning" the lottery—and $I_\ell \leq \bar{I}$ when losing. Use analogous notation for capital (K_w and K_ℓ) and low-skill U.S. worker employment (N_w and N_ℓ). The impact of winning can be linearly approximated with the Euler equation,

$$\ln \frac{R_w}{R_\ell} \approx s_I \ln \frac{I_w}{I_\ell} + s_N \ln \frac{N_w}{N_\ell} + s_K \ln \frac{K_w}{K_\ell}, \tag{A.6}$$

where R_w and R_ℓ are revenues without and with the constraint, respectively, and s_I, s_N, and s_K are immigrant labor, U.S. labor, and capital's share in revenue, respectively. The partial effect of increasing immigrant labor on revenues is thus positive. While the adjustment of other factor inputs that may substitute for I can lessen this effect, the total effect is always (weakly) positive.

As proposition 1 says, however, profit *rates* are not necessarily higher in the unconstrained firms:

$$\Pi_w/R_w - \Pi_\ell/R_\ell = \mathcal{F} D^{-\frac{1}{\eta}} \left(Q_\ell^{-\frac{\eta-1}{\eta}} - Q_w^{-\frac{\eta-1}{\eta}} \right) - \lambda I_\ell D^{-\frac{1}{\eta}} Q_\ell^{-\frac{\eta-1}{\eta}}.$$

The first term of the expression is positive, but the second one is negative, so the impact on profit rates is ambiguous. This is because while relaxing the hiring constraint allows output and profits to increase (first term), it also reduces the wedge between the marginal revenue product of immigrant labor and wages (second term), reducing revenues and profits. The more important fixed costs are, the more the first term dominates, and the likely the impact on profit rates is to be positive. The impact on profit rates is also more likely to be positive at higher demand elasticities.

A1.1 Nested CES

We proceed to the CES production function (8) in steps. Returning to the full version in the next section, let us first consider a simpler version without permanent labor ($\gamma = 0$), which implies that revenue

$$R = D^{\frac{1}{\eta}} z^{\frac{\eta-1}{\eta}} K^{\beta \frac{\eta-1}{\eta}} \left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1} \frac{\eta-1}{\eta} (1-\beta)}. \tag{A.7}$$

In this case, the first order conditions become:

$$\frac{\eta-1}{\eta} (1-\beta) D^{\frac{1}{\eta}} z^{\frac{\eta-1}{\eta}} K^{\beta \frac{\eta-1}{\eta}} \left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1} \frac{\eta-1}{\eta} (1-\beta) - 1} \alpha I^{-\frac{1}{\sigma}} = w_I (+\lambda) \tag{A.8}$$

$$\frac{\eta-1}{\eta} (1-\beta) D^{\frac{1}{\eta}} z^{\frac{\eta-1}{\eta}} K^{\beta \frac{\eta-1}{\eta}} \left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1} \frac{\eta-1}{\eta} (1-\beta) - 1} (1-\alpha) N^{-\frac{1}{\sigma}} = w_N \tag{A.9}$$

$$\beta \frac{\eta-1}{\eta} D^{\frac{1}{\eta}} z^{\frac{\eta-1}{\eta}} K^{\beta \frac{\eta-1}{\eta} - 1} \left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1} \frac{\eta-1}{\eta} (1-\beta)} = r \tag{A.10}$$

Solving for the total impact on factor demand of relaxing the immigrant hiring constraint uses the fact that these first order conditions hold in both constrained and unconstrained cases, and factor prices remain the same. For example, there is the well-known fact the Cobb-Douglass outer nest implies that capital's share is a constant:

$$\frac{rK_w}{R_w} = \frac{rK_\ell}{R_\ell} = \beta\frac{\eta-1}{\eta} = s_K \tag{A.11}$$

which implies $\ln(K_w/K_\ell) = \ln(R_w/R_\ell)$. Recall that substituting this into (A.6) also delivers :

$$\ln(R_w/R_\ell) = \ln(K_w/K_\ell) \approx \frac{s_I}{1-s_K}\ln(I_w/I_\ell) + \frac{s_N}{1-s_K}\ln(N_w/N_\ell) \tag{A.12}$$

For U.S. employment, we can use the equality of (A.9) at different factor mixes:

$$\begin{aligned}
&\frac{\eta-1}{\eta}(1-\beta)D^{\frac{1}{\eta}}z^{\frac{\eta-1}{\eta}}K_w^{\beta\frac{\eta-1}{\eta}}\left(\alpha I_w^{\frac{\sigma-1}{\sigma}} + (1-\alpha)N_w^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}(1-\alpha)N_w^{-\frac{1}{\sigma}} = w_N \\
&= \frac{\eta-1}{\eta}(1-\beta)D^{\frac{1}{\eta}}z^{\frac{\eta-1}{\eta}}K_\ell^{\beta\frac{\eta-1}{\eta}}\left(\alpha I_\ell^{\frac{\sigma-1}{\sigma}} + (1-\alpha)N_\ell^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}(1-\alpha)N_\ell^{-\frac{1}{\sigma}}
\end{aligned}$$

to get that

$$-\frac{1}{\sigma}\ln(N_w/N_\ell) = -s_K\ln(K_w/K_\ell) - \left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)}\right]\ln\left(\frac{\alpha I_w^{\frac{\sigma-1}{\sigma}} + (1-\alpha)N_w^{\frac{\sigma-1}{\sigma}}}{\alpha I_\ell^{\frac{\sigma-1}{\sigma}} + (1-\alpha)N_\ell^{\frac{\sigma-1}{\sigma}}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)} \tag{A.13}$$

where the ugly ratio of parameters that multiply the second term on right hand side are included in order to get it back into the form it was in the revenue function, (A.7). This allows us to construct the approximation:[2]

$$\ln(N_w/N_\ell) \approx \sigma s_K\ln(K_w/K_\ell) + \sigma\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)}\right][s_I\ln(I_w/I_\ell) + s_N\ln(N_w/N_\ell)] \tag{A.14}$$

After collecting the $\ln(N_w/N_\ell)$ terms, we have that

$$\ln(N_w/N_\ell) \approx \frac{\sigma s_K}{c_1}\ln(K_w/K_\ell) + \frac{\sigma s_I}{c_1}\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)}\right]\ln(I_w/I_\ell) \tag{A.15}$$

$$= \frac{\sigma s_K}{c_1}\ln(K_w/K_\ell) + \frac{s_I}{c_1}\left[\frac{\sigma(\eta-1)(1-\beta)-\eta(\sigma-1)}{(\eta-1)(1-\beta)}\right]\ln(I_w/I_\ell) \tag{A.16}$$

where

$$\begin{aligned}
c_1 &= 1-\sigma s_N\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)}\right] \\
&= \frac{(1-\beta)[(\eta-1)(1-s_N)+(\sigma-1)s_N]+\beta s_N\eta(\sigma-1)}{(\eta-1)(1-\beta)} > 0
\end{aligned}$$

[2]This comes from applying (A.6) to (A.7), taking out the (ln separable) part assigned to capital.

That c_1 is larger than zero comes from the fact that the numerator is a weighted average of positive parameters $(\eta - 1, \sigma - 1)$ and the denominator is also positive for a similar reason.

Before fully solving this, we use (A.16) to show results for intuitive the two factor case (in which we also impose $\beta = 0$ so $s_K = 0$):

$$\ln(N_w/N_\ell) \approx s_I \frac{\eta - \sigma}{\eta(1 - s_N) + \sigma s_N - 1} \ln(I_w/I_\ell)$$

...which is positive whenever $\eta > \sigma$.

To include the adjustment of capital, we substitute the expression for capital, (A.12), into (A.16) :

$$\begin{aligned}
\ln(N_w/N_\ell) &\approx \frac{\sigma s_K}{c_1}\left[\frac{s_I}{1 - s_K}\ln(I_w/I_\ell) + \frac{s_N}{1 - s_K}\ln(N_w/N_\ell)\right] + \frac{s_I}{c_1}\left[\frac{\sigma(\eta - 1)(1 - \beta) - \eta(\sigma - 1)}{(\eta - 1)(1 - \beta)}\right]\ln(I_w/I_\ell) \\
&= \left[1 - \frac{\sigma s_K}{c_1}\frac{s_N}{1 - s_K}\right]^{-1}\left[\frac{\sigma s_K}{c_1}\frac{s_I}{1 - s_K} + \frac{s_I}{c_1}\frac{\sigma(\eta - 1)(1 - \beta) - \eta(\sigma - 1)}{(\eta - 1)(1 - \beta)}\right]\ln(I_w/I_\ell) \\
&= \left[\frac{c_1(1 - s_K)}{c_1(1 - s_K) - \sigma s_K s_N}\right]\left[\frac{\sigma s_K}{c_1}\frac{s_I}{1 - s_K} + \frac{s_I}{c_1}\frac{(1 - s_K)}{(1 - s_K)}\frac{\sigma(\eta - 1)(1 - \beta) - \eta(\sigma - 1)}{(\eta - 1)(1 - \beta)}\right]\ln(I_w/I_\ell) \\
&= s_I\left[\frac{\sigma s_K(\eta - 1)(1 - \beta) + (1 - s_K)\left[\sigma(\eta - 1)(1 - \beta) - \eta(\sigma - 1)\right]}{(\eta - 1)(1 - \beta)[c_1(1 - s_K) - \sigma s_K s_N]}\right]\ln(I_w/I_\ell)
\end{aligned}$$

Some algebra, plus the fact that $s_K \times \eta = \beta(\eta - 1)$ from (A.11), simplifies the numerator of this to:

$$\sigma s_K(\eta - 1)(1 - \beta) + (1 - s_K)\left[\sigma(\eta - 1)(1 - \beta) - \eta(\sigma - 1)\right] = (\eta - 1)(1 - \beta) - (\sigma - 1) \tag{A.17}$$

We can now we can write a simpler expression for $\ln(N_w/N_\ell)$:

$$\ln(N_w/N_\ell) = s_I\left[\frac{(\eta - 1)(1 - \beta) - (\sigma - 1)}{c_2}\right]\ln(I_w/I_\ell), \tag{A.18}$$

where $c_2 \equiv (\eta - 1)(1 - \beta)[c_1(1 - s_K) - \sigma s_K s_N]$. The sign of c_2 is not obvious, but it is positive. It can be rewritten further by defining the numerator of c_1 as $c_1^{num} = c_1 \times (\eta - 1)(1 - \beta)$ which gives

$$c_2 = c_1^{num}(1 - s_K) - \sigma s_N s_K(\eta - 1)(1 - \beta). \tag{A.19}$$

A1.2 Including Permanent Labor

To carry out accurate simulations of the model, we need to account for the substantial role permanent employees appear to take in production (see summary statistics in Table A1), even if their employment is not adjusting to seasonal fluctuations in the employment of other factors. So now using the production function in (8), that is,

$$Q = zH^\gamma K^\beta\left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1 - \alpha)N^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}(1-\beta-\gamma)}, \tag{A.20}$$

we have the revenue function:

$$R = D^{\frac{1}{\eta}} z^{\frac{\eta-1}{\eta}} H^{\gamma\frac{\eta-1}{\eta}} K^{\beta\frac{\eta-1}{\eta}}\left(\alpha I^{\frac{\sigma-1}{\sigma}} + (1 - \alpha)N^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}. \tag{A.21}$$

We assume that permanent labor does not adjust to winning and losing the lottery, but rather stays at its optimal level for the *expected* mix of other inputs. (One might imagine that there is a cost of recruiting or firing permanent employees that make such adjustments not cost effective within a season.) A brief aside on this: larger changes not being considered in this model – like changes in visa quota, or permanent changes to demand conditions – could still impact on permanent employment. An expansion of the number of H2-B visas available might have a different – and likely larger – impact on revenue and U.S. worker seasonal employment at the average firm than simply "winning" a single year's lottery.

Because H is fixed, the expressions above largely hold – for example the revenue growth identity stays the same (A.6) – but the factor shares need to be adjusted in some cases. (A.12), describing the responses of revenues and capital to N and I, holds as is. (A.16), describing N's response, requires adjustment to

$$\ln(N_w/N_\ell) \approx \frac{\sigma s_K}{c_3}\ln(K_w/K_\ell) + \frac{s_I}{c_3}\left[\frac{\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)}{(\eta-1)(1-\beta-\gamma)}\right]\ln(I_w/I_\ell) \tag{A.22}$$

where

$$\begin{aligned} c_3 &= 1-\sigma s_N\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right] \\ &= \frac{(1-\beta-\gamma)[(\eta-1)(1-s_N)+(\sigma-1)s_N]+(\beta+\gamma)s_N\eta(\sigma-1)}{(\eta-1)(1-\beta-\gamma)} > 0 \end{aligned}$$

Carrying this through to the expression for (N_w/N_ℓ)

$$\ln(N_w/N_\ell) \approx \left[\frac{c_3(1-s_K)}{c_3(1-s_K)-\sigma s_K s_N}\right]\left[\frac{\sigma s_K}{c_3}\frac{s_I}{1-s_K} + \frac{s_I}{c_3}\frac{(1-s_K)}{(1-s_K)}\frac{\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)}{(\eta-1)(1-\beta-\gamma)}\right]\ln(I_w/I_\ell) \tag{A.23}$$

$$= s_I\left[\frac{\sigma s_K(\eta-1)(1-\beta-\gamma)+(1-s_K)\left[\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)\right]}{(\eta-1)(1-\beta-\gamma)[c_3(1-s_K)-\sigma s_K s_N]}\right]\ln(I_w/I_\ell) \tag{A.24}$$

$$= s_I\left[\frac{(\eta-1)(1-\beta-\gamma\sigma)-(\sigma-1)}{c_4}\right]\ln(I_w/I_\ell) \tag{A.25}$$

where $c_4 = c_3^{num}(1-s_K)-(\eta-1)(1-\beta-\gamma)\sigma s_K s_N$ and c_3^{num} is the numerator of c_3 (when written out in long form), shown above. Note that c_4 (which corresponds to Θ in the main text of the paper) (a) has a positive derivative with respect to σ (it can be written as $s_N\,(1-\beta-\gamma+(\gamma\eta+\beta)) > 0$) and (b) is greater than zero when $\sigma = 0$ (it can be written as $(1-s_K)\,[(1-\beta-\gamma)\;(\eta-1)-\eta s_N] > 0$ since $\eta\, s_N < (1-\beta-\gamma)\,(\eta-1)$ by definition of s_N), which jointly implies that $c_4 > 0$ for all $\sigma \geq 0$. The response of U.S. employment is thus positive if $(\eta-1) > \frac{(\sigma-1)}{1-\beta-\gamma\sigma}$, as was asserted in the text after Proposition 2.

For revenues, we go back to (A.12) to obtain

$$\ln(R_w/R_\ell) \approx \frac{s_I}{1-s_K}\ln(I_w/I_\ell) + \frac{s_N}{1-s_K}\ln(N_w/N_\ell) \tag{A.26}$$

$$= \frac{s_I}{1-s_K}\left(1+s_N\left[\frac{(\eta-1)(1-\beta-\gamma\sigma)-(\sigma-1)}{c_4}\right]\right)\ln(I_w/I_\ell). \tag{A.27}$$

A1.3 Incorporating Labor Supply – Simple Case

Now suppose that U.S. labor supply to the firm is upward sloping, due to "modern monopsony" labor market frictions (Manning 2021) or "classical monopsony" heterogeneity in U.S. workers' preferences over firms (Card et al. 2018), with constant elasticity e_N. The first order condition then produces the well-known result that wages are marked down from the marginal revenue product R_N:

$$w_N = \left(1 + \frac{1}{e_N}\right)^{-1} R_N, \tag{A.28}$$

where $w_N = a_N N^{\frac{1}{e_N}}$, and $a_N > 0$ is a constant. This leads to a modification of the expressions above. Ignoring capital and permanent labor for simplicity, notice that this alters (A.13) as follows:

$$\left(\frac{1}{e_N} + \frac{1}{\sigma}\right) \ln(N_w/N_\ell) = \left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta} - 1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}}\right] \ln\left(\frac{\alpha I_w^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N_w^{\frac{\sigma-1}{\sigma}}}{\alpha I_\ell^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N_\ell^{\frac{\sigma-1}{\sigma}}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)} \tag{A.29}$$

Since $\left(\frac{1}{e_N} + \frac{1}{\sigma}\right)^{-1} = \frac{e_N}{\sigma+e_N}\sigma$, and $\ln\left(\frac{\alpha I_w^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N_w^{\frac{\sigma-1}{\sigma}}}{\alpha I_\ell^{\frac{\sigma-1}{\sigma}} + (1-\alpha) N_\ell^{\frac{\sigma-1}{\sigma}}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta)} \approx s_I \ln(I_w/I_\ell) + s_N \ln(N_w/N_\ell)$, we now have that:

$$\ln(N_w/N_\ell) \approx \frac{e_N}{\sigma + e_N}\sigma \left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta} - 1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}}\right] \left[s_I \ln(I_w/I_\ell) + s_N \ln(N_w/N_\ell)\right] \tag{A.30}$$

Furthermore, as $\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta} - 1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}}\right] = \left[\frac{\eta-\sigma}{\sigma(\eta-1)}\right]$, after collecting terms this expression simplifies to:

$$\ln(N_w/N_\ell) \approx \frac{s_I \frac{e_N}{\sigma+e_N}\sigma \left[\frac{\eta-\sigma}{\sigma(\eta-1)}\right]}{1 - s_N \frac{e_N}{\sigma+e_N}\sigma \left[\frac{\eta-\sigma}{\sigma(\eta-1)}\right]} \ln(I_w/I_\ell) \tag{A.31}$$

$$= s_I \frac{e_N(\eta - \sigma)}{(\sigma + e_N)(\eta - 1) - s_N e_N (\eta - \sigma)} \ln(I_w/I_\ell) \tag{A.32}$$

$$= s_I \frac{e_N(\eta - \sigma)}{e_N[(\eta - 1)(1 - s_N) + (\sigma - 1)s_N] + \sigma(\eta - 1)} \ln(I_w/I_\ell) \tag{A.33}$$

This is a modified version of the expression from Lemma 2, and shows that the U.S. employment response to immigration is increasing in magnitude in the U.S. labor supply elasticity. The response is zero when U.S. labor supply is inelastic ($e_N = 0$), and converges to the expression in Lemma 2 as the elasticity increases.

A1.4 Incorporating Labor Supply – General Case

If we include capital and permanent labor, along with the same (empirically supported) assumptions about adjustments as before (capital adjusts, but permanent labor does not), the proportional difference in equilibrium U.S. temporary labor is given by:

$$\left(\frac{1}{e_N}+\frac{1}{\sigma}\right)\ln(N_w/N_\ell)$$

$$= s_K\ln(K_w/K_\ell)+\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]\ln\left(\frac{\alpha I_w^{\frac{\sigma-1}{\sigma}}+(1-\alpha)N_w^{\frac{\sigma-1}{\sigma}}}{\alpha I_\ell^{\frac{\sigma-1}{\sigma}}+(1-\alpha)N_\ell^{\frac{\sigma-1}{\sigma}}}\right)^{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}$$

$$\approx s_K\ln(K_w/K_\ell)+\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]\left[s_I\ln(I_w/I_\ell)+s_N\ln(N_w/N_\ell)\right]$$

This implies

$$\ln(N_w/N_\ell)\approx\frac{e_N}{\sigma+e_N}\frac{\sigma s_K}{c_3'}\ln(K_w/K_\ell)+\frac{e_N}{\sigma+e_N}\frac{\sigma s_I}{c_3'}\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]\ln(I_w/I_\ell) \tag{A.34}$$

where

$$c_3'=1-\frac{e_N}{\sigma+e_N}\sigma s_N\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]$$

Notice that this is already sufficient to see that the qualitative result is the same in this general case. As e_N goes to infinity—that is, the case where we ignored upward sloping U.S. labor supply—then $\frac{e_N}{\sigma+e_N}$ goes to one, c_3' goes to c_3 and A.34 goes to A.22. In contrast, as e_N goes to zero, there is no response of U.S. hires to immigrant hires, like in the last section.

We can also rearrange c_3' as

$$c_3'=\frac{(\eta-1)(1-\beta-\gamma)-\frac{e_N}{\sigma+e_N}s_N\left[\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)\right]}{(\eta-1)(1-\beta-\gamma)},$$

which allows us to define $c_3'^{num}$ as the numerator of this expression, which we will use below.

The last step is to solve for the expression for $\ln(N_w/N_\ell)$ in this general case. Here again we substitute in A.12 for $\ln(K_w/K_\ell)$ (into A.34), to obtain:

$$\ln(N_w/N_\ell)\approx\frac{e_N}{\sigma+e_N}\frac{\sigma s_K}{c_3'}\left[\frac{s_I}{1-s_K}\ln(I_w/I_\ell)+\frac{s_N}{1-s_K}\ln(N_w/N_\ell)\right]$$
$$+\frac{e_N}{\sigma+e_N}\frac{\sigma s_I}{c_3'}\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]\ln(I_w/I_\ell).$$

Finally, collecting terms and solving for $\ln(N_w/N_\ell)$:

$$\ln(N_w/N_\ell) \approx \frac{e_N}{\sigma + e_N}\left(1 - \frac{e_N}{\sigma + e_N}\frac{\sigma s_K}{c_3'}\frac{s_N}{1-s_K}\right)^{-1} m\left(\frac{\sigma s_K}{c_3'}\frac{s_I}{1-s_K} + \frac{\sigma s_I}{c_3'}\left[\frac{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)-1}{\frac{\sigma}{\sigma-1}\frac{\eta-1}{\eta}(1-\beta-\gamma)}\right]\right)\ln(I_w/I_\ell).$$

The rightmost term can be rewritten as $\frac{\sigma s_K}{c_3'}\frac{s_I}{1-s_K} + \frac{s_I}{c_3'}\frac{1-s_K}{1-s_K}\frac{\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)}{(\eta-1)(1-\beta-\gamma)}$ and the middle term as $\frac{c_3'(1-s_K)}{c_3'(1-s_K)-\frac{e_N}{(\sigma+e_N)}\sigma s_K s_N}$. Substituting these in and collecting terms, we have that:

$$\ln(N_w/N_\ell) \approx s_I\frac{e_N}{\sigma + e_N}\left(\frac{\sigma s_K(\eta-1)(1-\beta-\gamma) + (1-s_K)\left[\sigma(\eta-1)(1-\beta-\gamma)-\eta(\sigma-1)\right]}{c_4'}\right)\ln(I_w/I_\ell) \tag{A.35}$$

$$= s_I\frac{e_N}{\sigma + e_N}\left(\frac{(\eta-1)\left(1-\beta-\gamma\sigma\right)-(\sigma-1)}{c_4'}\right)\ln(I_w/I_\ell) \tag{A.36}$$

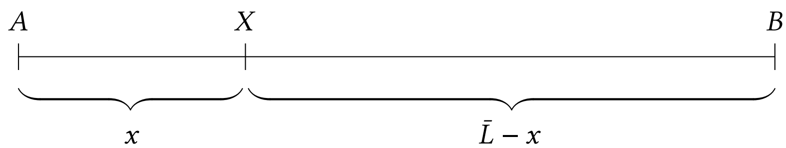
where $c_4' = (\eta-1)(1-\beta-\gamma)\left[c_3'(1-s_K) - \frac{e_N}{\sigma+e_N}\sigma s_K s_N\right] = c_3'^{num}(1-s_K) - \frac{e_N}{\sigma+e_N}(\eta-1)(1-\beta-\gamma)\sigma s_K s_N$. Notice that as long as $c_4' > 0$, the condition for a positive response remains as before, that is, $(\eta-1) > \frac{(\sigma-1)}{1-\beta-\gamma\sigma}$. Also, A.36 goes to A.25 as e_N goes to infinity, and to zero as e_N goes to zero.

A2 Imperfect competition and rural labor markets

The main text explained intuitively why the pre-analysis plan predicted less negative or more positive treatment effects of immigrant employment on U.S. employment in rural areas relative to urban areas. This is a consequence of monopsony power in rural labor markets created by frictions in the national labor market between thin rural labor markets and thick urban labor markets. A consequence of those frictions is that the best alternative wage for two workers of identical marginal product can be lower in rural relative to urban areas. This would tend to make it easier for an alternative employer *within the rural area* to recruit "exploited" workers (Pigou's term) in rural areas away from their best local alternative. That is, the elasticity of firm-level labor supply to an alternative employer within the rural area—and thus not isolated from rural residents by transportation costs or information costs—would tend to be higher than in an urban area.

This can be seen somewhat more formally in a simple Hotelling duopsony model, following Monte and Pinheiro (2021). Consider two firms producing a single tradable product in perfect competition, firm A in a small, remote rural area and firm B in a large, densely populated urban area. Workers are identical except for their location. They are distributed evenly—by travel cost or information cost—on a segment between the two firms (Figure A1). The total labor supply is $\bar{L}$ and workers choose to supply labor to firm A or firm B. To work at either firm the worker incurs a cost κ per unit distance (transportation or information).

Figure A1: A rural-urban Hotelling model of labor-market duopsony



At location X, the marginal worker is indifferent between working for firm A at wage w_A or for firm B at wage w_B: $w_A - \kappa x = w_B - \kappa\left(\bar{L} - x\right)$. The optimum size of the rural labor supply is

$$x = \frac{\kappa \bar{L} + w_A - w_B}{2\kappa}.$$

That is, a necessary and sufficient condition for rural wages to be lower than urban wages ($w_A < w_B$) is for the rural labor market to be smaller than the urban labor market $\left(x < \frac{\bar{L}}{2}\right)$. Recalling that all workers have identical marginal revenue product, this implies that wage markdowns are greater in the rural area.

Consider now two different attempts by a third employer to recruit workers currently employed by firm A in the rural area. First, suppose a firm *in the urban area* tries to recruit those workers, by offering just above the going rate in the urban area, $w_b + \varepsilon$. The marginal supply of rural labor to that urban firm barely rises, by $\frac{\varepsilon}{2\kappa}$. That supply elasticity is lower as the friction κ increases. This is the finite-elasticity labor supply that produces the wage markdown in the rural area, induced by the frictions associated with firm A's remoteness.

Second, suppose a third firm *in the rural area* tries to recruit the same workers, those employed in the rural area. It offers just above the going rate in the rural area, $w_A + \varepsilon$. The marginal supply of rural labor to that *rural* firm, in this model, is infinitely elastic. All workers in the rural area (and a few just to the right of point X) would instantly supply their labor to the third firm.

Why, then, would the urban firm B not experience similarly infinitely-elastic labor supply within the urban area? To take an extreme case, suppose that the third firm's technology is such that the marginal revenue product of labor lies between w_A and w_B. Because the profit-maximizing firm cannot pay more than the marginal revenue product, at the margin the elasticity of labor supply to that firm would be zero if it were located in the urban area; it would be infinite if it were located in the rural area. In other words, workers in urban areas surrounded by high-productivity firms have better reserve options, reducing their elasticity of labor supply to the third firm.

A less extreme case of the same tendency, extending beyond the toy model above, is simply that of "classical monopsony" power originating from the existence of a range of firms with different productivity and different amenities, and a range of workers with different preferences (Card et al. 2018). The variation of firms and workers in a large, relatively diverse urban area would generally exceed the variation in small, more homogeneous rural area. This would create a greater tendency for less-than-infinite labor supply elasticities in urban areas than in rural areas, for reasons unrelated to spatial frictions in the worker's location choice.

A3 Details on survey and data collection

The industry associations of H-2B employers sent the 2021 survey to their members seven weeks after the end of the second half of fiscal year 2021, on October 21, 2021, and followed up with email reminders to their members on November 1, 12, and 30. We received responses from October 21, 2021 through January

26, 2022. We closed the 2021 survey to further responses on February 8, 2022. We conducted the 2022 survey in a nearly identical manner, first disseminating the survey form on March 10, 2023 and closing the survey on April 25, 2023.

The title of the survey was "*Survey of U.S. businesses after the H-2B visa lottery*". It stated its purpose to respondents as, "*We are economists studying how the H-2B visa lottery in January 2021 [or 2022] affected American businesses that entered that lottery. We want to hear from you whether or not you were able to hire any H-2B workers this year.*" The survey instrument then asked nine factual questions about how many H-2B workers they petitioned for; which lottery letters they received; how many of different types of workers they employed between April and September; their revenue and investment during the same period; and a few questions about business conditions including the degree of competition they faced, recent changes in their costs, and their geographic location. The survey questionnaire is reproduced in the Appendix.[3] Respondents were told that "U.S. worker" includes both citizens and lawful permanent residents. The survey respondents were well aware of their randomization outcome. One advantage of the purely online administration of the survey is that the enumeration experience is identical for all respondents, without regard to randomization status. There was no face-to-face contact that could in principle convey enumerator expectations of different responses by lottery winners versus lottery losers.

The survey measures the degree of competition faced by each firm in two different, pre-specified ways. The first, following Nickell (1996), is simply to ask each firm to report the absolute number of direct competitors it faces in the market it serves. The second, following Tang (2006), is to ask the firm to subjectively rate, on a four-step ordered scale, "how easy it would be for one of your business's competitors to steal your clients simply by underpricing you?"

The survey measures profits indirectly, due to the well-known reluctance of firms to directly report profits on surveys (e.g. Iarossi 2006, 53). The survey asks a prespecified question about its year-on-year change in *operating costs*, which combined with information about the change in revenues, yields a proxy measure of the change in profits (specifically: Earnings Before Interest, Taxes, Depreciation, and Amortization, EBITDA).

When the 2021 survey closed we had received survey forms from 371 respondents. 54 of these (14.6%) were dropped because they were too incomplete for analysis. In most cases, this was because the respondent had answered questions about the H-2B lottery only, and had not answered any of the questions about business outcomes such as revenue. Another 15 responses (4.0%) were dropped because the firm reported petitioning for zero H-2B workers for the period April–September 2021, despite the instruction that the survey was intended only for 2021 H-2B lottery entrants. Another 13 responses (3.5%) were dropped because two different people from the same firm had sent separate responses.[4] This left a final 2021 survey sample of 289 firms that had answered most questions about 2021. The core 2021 sample used in most regressions to follow, 251 firms, comprises those that also provided full pre-lottery baseline data from 2020.

When the 2022 survey closed we had received forms from 297 respondents. Ten of these (3.4%) were dropped because they were duplicate responses; in all cases the response kept was the one that contained responses to more questions. Two responses (0.7%) were dropped because the respondent firms appeared to cease operations in 2022 with near-zero revenue. This left a final 2022 survey sample of 285 firms that

[3]Firms were then given an opportunity to identify themselves by firm name and postal code if they wished, though the survey instrument prominently indicated that this question was optional; 73% of firms chose to do so. Both DOL and DHS already make public the names of every firm that petitions for H-2B workers and the details of those petitions, so it was unsurprising that most firms felt comfortable identifying themselves in this survey.

[4]For one of these, only one of the respondents had completed a substantial portion of the survey, so the other response from that firm was dropped. For the other twelve, roughly the same amount of information was provided by both respondents from each firm, so a random number generator was used to choose which of the two responses for each firm was kept.

Appendix Table A1: Summary statistics

	mean	*sd*	*min*	*max*	*count*
Revenue ($)_curr	8.7*e*+06	5.3*e*+07	5000.000	1.0*e*+09	472
H-2B temp. workers employed	22.570	44.817	0.000	412.000	472
U.S. temp. workers employed	31.867	130.207	0.000	1821.000	472
U.S. perm. workers employed	50.227	215.423	0.000	3600.000	471
Investment ($)	4.2*e*+05	1.7*e*+06	0.000	3.0*e*+07	456
ln Revenue	14.729	1.289	8.517	20.723	472
ihs H-2B temp. workers employed	2.855	1.501	0.000	6.714	472
ihs H-2B temp. workers requested	3.556	1.053	1.444	7.281	472
ihs U.S. temp. workers employed	2.415	1.828	0.000	8.200	472
ihs U.S. perm. workers employed	3.270	1.498	0.000	8.882	471
ihs Investment	10.835	4.672	0.000	17.910	456
Change in profit rate, year-on-year	0.025	0.488	−2.357	4.321	441
Lottery win (IV)	0.314	0.464	0.000	1.000	472
Expected share of workers (IV)	0.723	0.149	0.539	0.927	472
Competitors (number)	371.470	4878.795	0.000	1.0*e*+05	447
Competition on price (subjective)	3.087	0.789	1.000	4.000	461
Rural (non-metropolitan)	0.260	0.439	0.000	1.000	461
Low-population ZIP code	0.479	0.500	0.000	1.000	472
Region: Northeast	0.206	0.405	0.000	1.000	472
Region: Midwest	0.324	0.469	0.000	1.000	472
Region: South	0.341	0.475	0.000	1.000	472
Region: West	0.108	0.311	0.000	1.000	472

Note: '*ihs*' is inverse hyperbolic sine.

had answered most questions about 2022. The core 2022 sample used in most regressions to follow, 221 firms, comprises those that also provided full pre-lottery baseline data from 2021.

A4 Survey questionnaire

Figure A2 reproduces the online survey exactly as respondents saw it, on 11 separate click-through screens. Respondents reached the survey form by clicking on a link named "http://visalotterystudy.org" in an email from an industry association of which their firm was a paying member. We estimate that it took the average respondent 15 minutes to complete.

A5 Summary statistics

Table A1 shows summary statistics across firms in the survey sample, pooled 2021 and 2022.

A6 Compare sample to universe

Table A2 compares the number of H-2B workers by industry in the sampling universe to the number employed by survey-respondent firms. Groundskeeping and landscaping is the most common industry in both the universe (39.5% of workers) and the sample (46.2% of workers). The survey sample somewhat overrepresents forestry and seafood processing workers; it somewhat underrepresents workers in hospitality, construction, restaurants, carnivals, and golf courses/country clubs.

Appendix Table A2: Compare industry breakdown of H-2B workers among survey respondents with industry breakdown in sampling universe, 2021 and 2022 pooled

Industry	Universe		Sample	
	Workers	*Frac.*	*Workers*	*Frac.*
Landscaping	187,016	0.395	5,874	0.428
Golf courses/country clubs	46,536	0.098	478	0.035
Hospitality	43,349	0.091	894	0.065
Forestry	42,146	0.089	1,978	0.144
Seafood processing	42,100	0.089	1,292	0.094
Construction	38,928	0.082	382	0.028
Restaurants	11,856	0.025	66	0.005
Carnivals	10,534	0.022	637	0.046
Other	51,532	0.109	1,123	0.082

The unit of observation is H-2B workers employed by firms that entered the January 2021 and January 2022 lotteries. The number in the universe is the number petitioned for, whether or not the petition was successful. The number in the sample is the number reported actually employed by survey-responding firms.

Appendix Table A3: Workers requested by rural/urban employer in sampling universe vs. survey sample

	Frequency		Proportion	
Employer address	*Universe*	*Sample*	*Universe*	*Sample*
Rural	148,686	3,515	0.316	0.340
Urban	322,242	6,812	0.684	0.660

Years 2021 and 2022 pooled. The unit of observation is workers requested on DOL petitions entered into the DOL lottery for H-2B visas for the second half of each fiscal year (universe) and H-2B workers employed by survey-respondent firms (sample). Includes only workers on petitions in the universe and sample for which firms reported a postal code for the employer.

Table A3 displays the corresponding comparison by rural/urban location of the employer. The geographic distribution of firms in the sample (34% rural) is close to the distribution in the universe (32% rural).

A7 First-stage regressions

Table A4 presents the first-stage regressions underlying the 2SLS estimates of Tables 2–3 in the main text. Both the 'lottery win' instrument and the 'expected share' instrument cause large and highly statistically significant increases in immigrant employment, conditional on predetermined firm traits. Losing the lottery causes firms' employment of low-skill immigrants to fall by $1 - e^{-0.618} = 46\%$.

Figure A3, corresponding to Figure 5 in the main text, shows the distribution of H-2B workers hired by lottery result, conditional on observed baseline traits.

Appendix Table A4: First stage regressions, pooled 2021 and 2022

Dep. var.:	H-2B hired (IHS)	
Lottery win	0.618 (0.112)	
Expected share		2.233 (0.374)
U.S. temporary hired, baseline (IHS)	−0.027 (0.035)	−0.025 (0.035)
Revenue, baseline (ln)	0.348 (0.066)	0.354 (0.067)
H-2B hired, baseline (IHS)	0.313 (0.039)	0.310 (0.040)
U.S. year-round hired, baseline (IHS)	0.009 (0.049)	0.004 (0.049)
Number of firms	472	472

Presents the first-stage regressions from the rightmost columns of Tables 2–3. 'Baseline' is 2020 for the 2021 lottery, and 2021 for the 2022 lottery. Includes constant term and a year dummy (for 2022). Robust standard errors in parentheses. 'IHS' is inverse hyperbolic sine.

A8 Industry-level parameter assumptions

Table A5 shows the sources and estimates of capital share for several of the leading industries for H-2B employment estimated by IBISWorld, a global research consultancy founded in 1971 in Australia, that compiles industry- and country-specific data including firms' typical costs structure. We include in the capital share: depreciation, amortization, rent, and net income (that is, operating profit minus insurance and taxes). A typical capital share in these industries is 0.3 (implying $\beta = s_K \cdot \frac{\eta}{\eta-1} \approx 0.35$ for $\eta \approx 8$), with a range of roughly 0.25 to 0.45 in plausible values ($\beta \approx 0.29$–0.51 for $\eta \approx 8$).

This leaves γ and α to be estimated for the firms in the core survey sample. The average firm's year-round U.S. employment as a fraction of total employment is 0.421 (std. err. 0.013, $N = 470$). This implies $\gamma = 0.470 \cdot (1 - s_K) \cdot \frac{\eta}{\eta-1} = 0.313$ for $\eta = 8$. The average firm's share of H-2B workers in all temporary employment is 0.572, implying a U.S. share of the inner labor nest of 0.668 (std. err. 0.012 $N = 470$).

IBISWorld rates concentration in each industry on a three-point scale. For all of the industries in Table A5 except 'amusement parks', it assesses concentration as 'low'. It describes the 'landscaping' industry in the United States with the follow passage, typical of the other low-concentration industries: "*The Landscaping Services industry has a low level of market share concentration. …The industry is characterized by a large number of small operators. According to the latest Economic Census, 94.0% of establishments employ fewer than 20 workers. Several companies have the resources to operate on a national scale and are typically integrated with landscape architecture departments, which enables them to bid for lucrative design-build-installation projects for commercial clients such as hotels and resorts. Nevertheless, the sheer volume of small-scale, low-value work conducted by nonemployers and small companies in the single-family housing market prevents these larger companies from capturing a substantial portion of revenue*" (Dmitry Diment,

Appendix Table A5: Capital share estimates from typical industry cost structures

Industry	Year	NAICS	Wages	Net inc.	Deprec.	Rent	K share	Source
Landscaping	2022	56173	32.6	8.8	3.7	1.8	0.305	(1)
Hotels	2021	72111	32.2	3.2	8.1	2.0	0.292	(2)
Golf courses	2022	71391	39.0	1.1	9.2	7.2	0.310	(3)
Amusement parks	2022	71311	41.6	9.9	8.4	5.7	0.366	(4)
Seafood preparation	2022	31171	11.8	2.1	1.1	0.6	0.244	(5)
Forest support serv.	2021	11531	29.2	13.6	3.6	6.6	0.449	(6)

Sources: 1. Dmitry Diment, IBISWorld *Industry Report 56173: Landscaping Services in the US*, June 2022; 2. Jared Ristoff, *IBISWorld Industry Report 72111: Hotels & Motels in the US*, September 2021; 3. Brigette Thomas, *IBISWorld Industry Report 71391: Golf Courses & Country Clubs in the US*, June 2022; 4. Thi Le, *IBISWorld Industry Report 71311: Amusement Parks in the US*, July 2022; 5. Dmitry Diment, *IBISWorld Industry Report 31171: Seafood Preparation in the US*, July 2022; 6. John Madigan, *IBISWorld Industry Report 11531: Forest Support Services in the US*, November 2021.

IBISWorld Industry Report 56173: Landscaping Services in the US, June 2022, p. 24).

A9 Check for nonresponse bias and/or randomization irregularities

Table A6 tests both for nonresponse bias and/or randomization irregularities by running a placebo test for spurious explanatory power of firm-level lottery results by firms' baseline (pre-lottery) traits in the survey sample. The tests reveal no economically or statistically significant explanatory power of the lottery results by baseline traits. The is inconsistent with substantial nonresponse bias that is correlated with treatment status and relevant observed baseline traits. It is also inconsistent with any randomization irregularities favoring firms with certain observed traits, such as larger firms or firms that employ more U.S. workers. These results are compatible with genuine randomization.

A10 Robustness to industry composition

Firms with NAICS two-digit industry code 56 (groundskeeping and landscaping) represent the largest share of employers in the sample and universe. It is thus of interest to know if the core results are driven by treatment effects on that specific industry. Figure A7 tests the heterogeneity of the core results according to whether or not a respondent firm's industry is groundskeeping and landscaping. The 2SLS point estimates on H-2B worker employment are higher for non-landscaping firms than for non-landscaping firms in the revenue, U.S. employment, and investment regressions. This suggests that if anything, the local average treatment effect estimated for the firm sample is lower than it would be if groundskeeping/landscaping firms were less prevalent.

A11 Robustness to influential observations

Table A13 repeats the core regression analysis with quantile regressions (p50) that are robust to influential observations. The IV quantile regressions are executed with the smoothed estimating equations method of Kaplan and Sun (2017) and Kaplan (2022). The qualitative pattern of results is similar to the results in the core regressions, which is incompatible with substantial sensitivity to a small number of influential observations.

Appendix Table A6: Placebo test for spurious explanatory power of lottery result by baseline traits in the survey sample

Dep. var.:	*Lottery win*	*Expected share*
Estimator:	OLS	OLS
Revenue, baseline (ln)	0.004	-0.002
	(0.021)	(0.007)
H-2B hired, baseline (IHS)	-0.002	0.001
	(0.013)	(0.004)
U.S. year-round hired, baseline (IHS)	-0.018	-0.002
	(0.018)	(0.006)
U.S. temporary hired, baseline (IHS)	-0.011	-0.004
	(0.012)	(0.004)
Number of firms	472	472
R^2	0.033	0.017

Robust standard errors in parentheses. *IHS* is inverse hyperbolic sine. Pooled 2021 and 2022 sample. 'Baseline' for 2022 value is reported 2021 value; 'baseline' for 2021 value is reported 2020 value. All regressions include constant term and dummy variable for 2022.

A12 Robustness to randomization inference

Young (2018) notes that some data obtained from randomized controlled trials do not meet the conditions necessary to rely on the asymptotic properties of conventional standard errors. Table A14 shows the core results of the reduced-form regressions using the 'lottery win' instrument using Fisher's randomization inference as implemented by Heß (2017). The first column is an OLS regression of H-2B employment on the instrument, controlling for the standard baseline traits. Columns 2–4 are randomization-inference versions of the reduced-form regressions in col. 2 of Table 2, col. 6 of Table 2, and col. 2 of Table 3 respectively. The qualitative pattern of inference is identical to that in the core regressions of the main text using conventional standard errors.

A12.1 Components of the elasticity of substitution

As we derive estimates of the elasticity of substitution and place them in the context of the literature, we must consider the information contained in various estimates of this parameter. In standard labor-market analysis of immigration at the aggregate level, across geographic areas or statistical cells, the estimated immigrant-U.S. worker elasticity of substitution comprises three independent effects.

First, the typically-estimated elasticity of substitution measures a process *within* firms: purely technical substitution within a firm's current or available production technology.

Second, the elasticity measures a process *between* firms: factor-price and output-price-induced shifts in demand from immigrant-intensive to native-intensive goods and services, known as Rybczynski effects. When the elasticity of substitution was invented by Hicks (1932, 120) and Robinson (1933, 256), Hicks specified that it measured some mix of these two processes, a mix that he called the "community level" elasticity that included effects of "commodity substitution" Hicks (1936, 8); Knoblach and Stöckl (2020) call this the "aggregate" elasticity.

But third, as Hicks (1936) soon clarified, the elasticity is furthermore shaped by imperfect competition in output markets or in factor markets (see e.g. Freeman and Medoff 1982). Including such features of the institutional environment yields what Knoblach and Stöckl (2020) call the "effective elasticity of substitution". For example, if immigration increased employers' monopsony power, immigration could reduce the immigrant-native "effective elasticity of substitution" for reasons unrelated to production technique or Rybczynski effects (Amior and Manning 2020). Standard estimates of the immigrant-native elasticity of substitution in the literature combine all three interpretations.

Our parameter σ is measured at the firm level. It omits Hicks's "community level" substitution of demand between firms (Rybczynski effects), but includes the influence of both purely technical substitution and institutional imperfections in factor markets faced by the firm. It is most comparable to other elasticities of substitution measured at the firm level.

This specific elasticity is highly informative and merits estimation, for three reasons. First, the literature has generally found that between-firm adjustment is limited, and that the principal channels of economic adjustment to immigration shocks occur within firms (Card and Lewis 2007; Dustmann and Glitz 2015). This lends some priority to pursuing unbiased estimates of firm-level substitution. Second, the *exclusion* of Rybczynski effects is desirable in the present setting because it allows us to exploit randomized variation in immigrant employment across firms. This is extremely rare across aggregates, resulting in estimates of aggregate elasticities that are less transparent and vary widely (Dustmann et al. 2016). Third, the *inclusion* of institutional features is also desirable since we seek the Policy-Relevant Treatment Effect—as Hicks urged. All policy occurs within an institutional setting, and our estimates include the influence of the precise institutional setting in which a marginal change in policy would occur. "Concentration upon technical substitution alone would certainly be misleading," wrote Hicks (1936, 10), for the purpose of "interpreting facts."[5]

A13 Full regression results from tests for heterogeneous treatment effects

Table A11 and Table A12 report the full regression results underlying the coefficient plots in Figure 7.

A14 Item nonresponse

The most important form of item nonresponse in the survey was firms that declined to give thir postal code, preventing us from including them in our prespecified tests for heterogeneous effects by rural location. Table A7 tests the sensitivity of the core results to restricting the sample to firms that did give a postal code. The core results in Tables 2–3 are substantially the same for the subgroups that did or did not provide a ZIP code. The coefficient is not statistically significantly different in the 'No ZIP' subgroup for any of the three outcomes.

[5] Relatively few empirical papers attempt to separate institutional determinants of the elasticity of substitution from the others, by modeling and specifying native labor supply; these include Card (2001, 26) and Amior and Manning (2020). In the model of Amior and Manning (2020), immigration itself alters the effective elasticity of substitution by reducing other immigrants' wage-bargaining power. In the setting we study, as discussed above, the immigrant wage is centrally set by the federal government at the level prevailing for similar U.S. workers in the same industry and geographic area. It is fixed before the (random, unpredictable) immigrant employment shock occurs for each firm. We thus expect the firm-level shocks we study, per se, to have negligible effects on the elasticity of substitution.

Appendix Table A7: Tests for sensitivity of the results to item nonresponse for firm postal code

Dep. var.:	Revenue (ln)	U.S. hired (IHS)	Investment (IHS)
Specification:	2SLS	2SLS	2SLS
H-2B hired (IHS)	0.209	0.165	2.093
	(0.082)	(0.151)	(0.732)
H-2B hired (IHS) × No ZIP	0.360	0.884	−0.096
	(0.453)	(1.105)	(8.192)
No ZIP	−1.031	−2.470	−1.799
	(1.485)	(3.513)	(24.699)
Full baseline controls	*Yes*	*Yes*	*Yes*
Number of firms	472	472	456

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term, full baseline controls, and a dummy for the year 2022. 'No ZIP' is an indicator variable taking the value one if the respondent left the response for their postal code blank, 0 otherwise. All regressions are 2SLS with two endogenous variables and two instruments. The endogenous variables are 'H-2B hired' and its interaction with 'No ZIP'. The instruments are the 'lottery win' instrument and its interaction with 'No ZIP'.

A15 Effect on U.S. year-round employment

The preanalysis plan specified reporting tests of the effect of employing H-2B temporary low-skill workers on an additional secondary outcome: employment of year-round, generally higher-skill U.S. workers. Table A8 reports these tests, analogous to the core outcomes of interest in the main text. Although firms with similar baseline traits but greater hiring of H-2B workers exhibit higher employment of higher skill year-round U.S. workers, this relationship could arise from unobserved confounders. In the 2SLS specifications (cols. 4 and 8) any positive *effect* of H-2B hiring on year-round U.S. employment (elasticity 0.07–0.09) is statistically indistinguishable from zero. The present research design only measures effects in the short term, that is, within the same half-year as the change in H-2B hiring occurred.

A16 Testing for a competition channel for treatment effects

Table A9 presents tests of the reduced-form effect of the lottery result on the competitive environment faced by lottery-entrant firms. These tests were not pre-registered.

The first column presents a regression of an indicator variable for high subjective competition (the firm reports that it would be "very easy" for a competitor to steal its customers) on an indicator for winning the lottery, controlling for the standard set of predetermined baseline traits. The coefficient estimate is negative and far from statistically significant. A negative coefficient estimate implies that firms that lose the lottery are less likely to report facing conditions of high subjective competition. The second column repeats the exercise using the expected share instrument as the regressor. Again the coefficient is negative, implying less subjective competition faced by firms that exogenously hire a lower share of their desired H-2B workers, but not statistically distinguishable from zero. The final two columns repeat the

Appendix Table A8: Effect of H-2B worker employment on higher-skill, year-round U.S. employment

Dep. var:	*U.S. year-round workers (IHS)*							
Estimator:	OLS		2SLS		OLS		2SLS	
Instrument:			*Lottery win*				*Expected share*	
H-2B temp. employed (IHS)			0.071	0.068			0.084	0.092
			(0.079)	(0.074)			(0.067)	(0.061)
Anderson-Rubin p-*val.*			*0.369*	*0.360*			*0.206*	*0.128*
Lottery win	0.043	0.042						
	(0.048)	(0.046)						
Expected share					0.187	0.205		
					(0.148)	(0.136)		
U.S. year-round workers, baseline (IHS)	0.938	0.876	0.919	0.876	0.938	0.876	0.915	0.876
	(0.025)	(0.042)	(0.028)	(0.041)	(0.025)	(0.042)	(0.028)	(0.041)
Full baseline controls	—	*Yes*	—	*Yes*	—	*Yes*	—	*Yes*
Number of firms	471	471	471	471	471	471	471	471

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. Robust standard errors in parentheses. The dichotomous 'Lottery win' instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. The continuous 'Expected share' instrumental variable is the share of overall workers petitioned for that the firm could expect to be certified according to the certification rates in the sampling universe for each lottery letter. IHS is inverse hyperbolic sine. *Full baseline controls* are the 2020 values of revenue, number of U.S. year-round workers, number of U.S. temporary workers, and number of H-2B temporary workers.

Appendix Table A9: Effects on Competitive Environment

Dep. var.:	High subjective competition, indicator (0,1)		Subjective competition, raw score (1–4)	
Lottery win	−0.031		−0.000	
	(0.048)		(0.080)	
Expected share		−0.140		−0.049
		(0.150)		(0.253)
Observed baseline controls	*Yes*	*Yes*	*Yes*	*Yes*
Number of firms	461	461	461	461

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. OLS regressions with robust standard errors in parentheses. "High" subjective competition means the business self-reported that it would be "very easy" (4 on a 4-point scale of ease) for competitors to steal their customers. The raw score is the number reported by each firm, where 1 means it would be very difficult for competitors to steal their customers. These questions were asked of firms a few months after the end of the hiring season, referring to *current* (not retrospective) conditions. *Observed baseline controls* are the previous-year values of revenue, number of U.S. year-round workers, number of U.S. temporary workers, and number of H-2B temporary workers.

regressions of the first two, but using as the dependent variable the raw score for subjective competition reported by the firm (on a 1–4 scale, where a higher number means that it is easier for competitors to steal customers). The coefficient of interest in these regressions is either negative or very close to zero. Collectively these regressions fail to detect evidence of a substantial effect of the lottery outcome on firms' subjective competitive environment.

A17 Partial replication in 2020

We partially replicate the 2021/2022 natural experiment in fiscal year 2020. This analysis was not prespecified because we did not anticipate that it would be possible. Although the Department of Labor conducted a very similar, independent lottery on January 1, 2020 for the second half of fiscal year 2020, our survey did not ask about firms' lottery-letter result from 2020. The 2021 survey did ask for firms' traits in 2020, such as revenue and employment, only to be used as baseline controls for analysis of the 2021 lottery.

But to our surprise, 89.3% of respondents chose voluntarily to identify their firm by name. This might have been foreseeable, given that most of the information requested on the survey is already published by the government along with detailed firm-by-firm identifiers, but we did not expect the rate of self-identification to be so high.

The firms that did self-identify could be easily matched to public records of their 2020 lottery-letter result, allowing the replication exercise for 2020. This exercise has advantages and disadvantages. One reason to expect greater statistical power in 2020 is that the lottery was a stronger determinant of access to H-2B workers in 2020 than in 2021/2022, because in 2020 no supplemental visas were issued by DHS (Figure 3). On the other hand, a reason to expect lower statistical power in 2020 is that the sample size is reduced, since only self-identifying firms can by included in the 2020 analysis. Another disadvantage is that the prior-year baseline traits used in the 2021/2022 analysis are unobserved in the 2020 analysis.

(The survey did not ask about revenue or employment in 2019.) Instead, in the 2020 analysis we control for the only observed, time-varying firm trait that is predetermined in 2019: the number of H-2B workers requested from DOL in the 2020 lottery, which was fixed by December 31, 2019. This predetermined trait is informative because it is correlated with the size of the firm, but is a more imperfect control for baseline size than (unobserved) baseline revenue.[6] For this reason the 2020 replication is partial rather than exact.

Figure A4 reports the DOL decision dates for the 2020 lottery. The pattern is highly similar to the pattern in the corresponding decision dates for 2021/2022, with the exception that no supplemental visas were issued in 2020.

Figure A5 shows the distribution of firm-level share of petitions receiving lottery result A in the 2020 lottery. The pattern is highly similar to the pattern in the 2021/2022 lotteries.

Table A10 presents the results of the 2020 replication exercise for the revenue and U.S. employment outcomes, corresponding to the 2021/2022 results in Table 2 above. The magnitudes of the coefficient estimates are broadly similar in this independent experiment.

For example, the reduced-form regression of revenue on 'lottery win' yields an estimate of 0.223 in 2020 (Table A10, col. 2), compared to an estimate of 0.135 from 2021/2022 (Table 2, col. 2). The reduced-form regression of revenue on 'expected share' yields an estimate of 0.348 in 2020 (Table A10, col. 4), compared to an estimate of 0.443 from 2021/2022 (Table 2, col. 4). The analogous comparison of the reduced-form coefficients in the U.S. temporary workers regressions shows a coefficient on 'lottery win' of 0.100 in 2020 (Table A10, col. 7) versus 0.116 in 2021/2022 (Table 2, col. 7); and a coefficient on 'expected share' of 0.371 in 2020 (Table A10, col. 9) versus 0.136 in 2021/2022 (Table 2, col. 9).

In isolation, the reduced sample of firms whose lottery result is observed in 2020 does not yield estimates with statistical precision at conventional levels. The revenue effect of H-2B worker employment in 2020 using the 'expected share' instrument, for example, yields a coefficient of 0.146 that is not statistically significant at the 10% level (Table A10, col. 5; p-val. 0.111). But the 2020 replication is more informative when considered in conjunction with the results from 2021/2022—an independently randomized natural experiment—where the corresponding coefficient estimate takes the similar magnitude of 0.198 (Table 2, col. 5; p-val. 0.004). The chance that two independent experiments would yield coefficients that are both positive and similar magnitude is much smaller than the p-values presented in the two tables separately. The same comparison for the effect of H-2B employment on U.S. worker employment (in 2020, Table A10, col. 10, coefficient 0.166 with p-val. 0.262; in 2021/2022, Table 2, col. 8, coefficient 0.188 with p-val. 0.219) again shows striking similarity.

The 2020 replication serves as a check not just on internal validity but on external validity. The U.S. labor market was very tight during 2021/2022, the period of focus in this paper. The same was not true in the second half of fiscal 2020 (Domash and Summers 2022; Duval et al. 2022). The seasonally-adjusted Job Openings rate estimated by the Bureau of Labor Statistics was similar in the second half of fiscal 2020 to what it had been in the years before the Covid-19 pandemic. It nearly doubled by mid-2021.[7] The average national unemployment rate in the second half of fiscal 2020 was 10.9%; in 2021 it was 5.5%.[8] The similar magnitude of the point estimates in Tables 2 and A10 is inconsistent with any crucial dependency of the results on the tighter labor market conditions of 2021/2022.

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[6]The regressions with investment as an outcome cannot be done in this setting because the survey does not ask about investment in 2020.

[7]Bureau of Labor Statistics *Job Openings and Labor Turnover Survey*, May 2022 release.

[8]Bureau of Labor Statistics "(Seas) Unemployment Rate, 16 and over", series LNS14000000, extracted Aug. 5, 2022.

Appendix Table A10: Robustness: The 2020 Lottery

Dep. var:	*Revenue 2020 (ln)*					*U.S. temporary workers 2020 (IHS)*				
Estimator:	OLS		2SLS	OLS	2SLS	OLS		2SLS	OLS	2SLS
Instrument:			*Lottery win*		*Expected share*			*Lottery win*		*Expected share*
H-2B employed 2020 (IHS)	0.234		0.151		0.146	0.108		0.071		0.166
	(0.045)		(0.103)		(0.091)	(0.083)		(0.170)		(0.150)
Anderson-Rubin p-*val.*	—		*0.152*		*0.111*	—		*0.680*		*0.262*
Lottery win 2020		0.223					0.100			
		(0.155)					(0.242)			
Expected share 2020				0.348					0.371	
				(0.217)					(0.330)	
Baseline control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Number of firms	191	191	191	191	191	212	212	212	212	212
R^2	0.304	0.300	0.296	0.303	0.297	0.126	0.118	0.125	0.122	0.124

The unit of observation is firms. Robust standard errors in parentheses. All regressions control for the only predetermined measure of firm scale available for 2020: the number of H-2B workers *requested* by the firm in 2020 (IHS), a number that is well correlated with revenue and was chosen by each firm in 2019. Other baseline controls for this lottery are not observed. All regressions include constant term. The dichotomous 'Lottery win' instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. The continuous 'Expected share' instrumental variable is the share of overall workers petitioned for that the firm could expect to be certified according to the certification rates in the sampling universe for each lottery letter. IHS is inverse hyperbolic sine.

A18 Treatment of zeros

In the 2021 survey, the question on investment was set up to be answered in the data type *currency*, which had the effect of defaulting to the value $0.00. In other words, item nonresponse cannot be distinguished from an affirmative answer of zero for investment in the 2021 survey. In 2022, the survey form was set up so that the response for investment was treated as freeform text, meaning that nonresponse (blank) can be distinguished from an affirmative zero. For this reason, in Table A15, we repeat the analysis of the investment outcome restricting the sample to the 2022 survey only. The results are not materially different compared to Table 3. In the restricted table, the reduced-form effect of *lottery win* on investment and the 2SLS effect instrumented by *lottery win* are larger in magnitude and remains highly statistically significant (cols. 2-3). Using the *expected share* instrument, both the reduced-form effect and the 2SLS effect increase in magnitude, though the standard errors become somewhat larger (the sample falls sharply, to 207 firms). The 2SLS effect with the *expected share* instrument is only statistically distinguishable from zero with a p-value of 0.159. There is no systematic decline in the coefficient estimates in the restricted regressions, and the increase in standard errors is what we would expect in the much smaller sample. We conclude that item nonresponse concealed as zeros in the 2021 data is not an important driver of these results.

Appendix Table A11: Heterogeneous effects by competition and size

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of competitors		Competition (subjective)		Small firm	
	High	*Low*	*High*	*Low*	*Yes*	*No*
Dep. var.: Revenue (ln)						
H-2B employed (IHS)	0.260	0.189	0.412	0.169	0.345	0.076
	(0.143)	(0.069)	(0.285)	(0.073)	(0.130)	(0.088)
And.-Rubin p-*val.*	0.074	0.006	0.117	0.024	0.006	0.408
N	272	200	169	303	226	246
Dep. var.: U.S. temporary workers employed (IHS)						
H-2B employed (IHS)	0.075	0.346	0.962	0.004	0.139	0.240
	(0.253)	(0.161)	(0.599)	(0.139)	(0.220)	(0.211)
And.-Rubin p-*val.*	0.771	0.036	0.044	0.980	0.538	0.260
N	272	200	169	303	226	246
Dep. var.: Investment (IHS)						
H-2B employed (IHS)	0.986	3.161	2.922	1.748	3.837	0.493
	(0.995)	(1.060)	(1.988)	(0.689)	(1.243)	(0.963)
And.-Rubin p-*val.*	0.309	0.000	0.108	0.005	0.000	0.609
N	262	194	160	296	217	239

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. All regressions are two-stage least squares with 'H-2B employed (IHS)' as the endogenous regressor, in a regression with full baseline controls, corresponding to the specification in col. 3 of Table 2, col. 8 of Table 2, and col. 3 of Table 3. The dichotomous instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. IHS is inverse hyperbolic sine. All regressions include the full set of predetermined baseline control variables. "High" number of competitors means greater than the median response. "High" subjective competition means the business self-reported that it would be "very easy" (4 on a 4-point scale of ease) for competitors to steal their customers by underpricing them. "Small" firms are those with less than median revenue at baseline (in 2020).

Appendix Table A12: Heterogeneous effects by location

	(7)	(8)	(9)	(10)
	Rural		Low population	
	Yes	*No*	*Yes*	*No*
Dep. var.: Revenue (ln)				
H-2B employed (IHS)	0.330	0.189	0.307	0.179
	(0.235)	(0.078)	(0.145)	(0.097)
And.-Rubin p-*val.*	0.150	0.018	0.032	0.069
N	131	341	226	246
Dep. var.: U.S. temporary workers employed (IHS)				
H-2B employed (IHS)	0.613	0.078	0.292	0.112
	(0.338)	(0.168)	(0.190)	(0.226)
And.-Rubin p-*val.*	0.053	0.646	0.131	0.623
N	131	341	226	246
Dep. var.: Investment (IHS)				
H-2B employed (IHS)	4.418	1.339	3.820	0.695
	(2.253)	(0.756)	(1.278)	(0.913)
And.-Rubin p-*val.*	0.001	0.067	0.000	0.441
N	121	335	219	237

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. All regressions are two-stage least squares with 'H-2B employed (IHS)' as the endogenous regressor, in a regression with full baseline controls, corresponding to the specification in col. 3 of Table 2, col. 8 of Table 2, and col. 3 of Table 3. The dichotomous instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. IHS is inverse hyperbolic sine. All regressions include the full set of predetermined baseline control variables. "Rural" firms are those whose ZIP code is classified by the the U.S. Dept. of Agriculture as anything other than "Metropolitan Area, Core" (RUCA code 1; ERS 2020). "Low" population means the firm's ZIP code has less than the median population among all ZIP codes (20,459 residents) in the 2010 full-count census (NBER 2017).

Appendix Table A13: Robustness: Quantile regressions (p50)

Dep. var:	Revenue (ln)		U.S. temporary workers (IHS)	
Estimator:	Quantile	IV quantile	Quantile	IV quantile
H-2B employed (IHS)	0.078	0.112	0.047	0.006
	(0.008)	(0.054)	(0.010)	(0.055)
Number of firms	472	472	472	472

Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term, baseline controls, and a dummy for the year 2022. Quantile IV estimator due to Kaplan and Sun (2017). All regressions include constant term. Standard errors in parentheses. The dichotomous 'Lottery win' instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. IHS is inverse hyperbolic sine.

Appendix Table A14: Robustness: Randomization inference

Dep. var:	H-2B temp. workers employed (IHS)	Revenue (ln)	U.S. temp. workers employed (IHS)	Investment (IHS)
Lottery win	0.6176	0.1347	0.1160	1.3251
	(0.1121)	(0.0508)	(0.0952)	(0.4155)
Rand. inference p-val.	<0.001	0.005	0.235	0.003
Full baseline controls	*Yes*	*Yes*	*Yes*	*Yes*
Number of firms	472	472	472	456

Robust standard errors in parentheses. Uses Fisher's randomization inference implemented by Heß (2017). Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022.

Appendix Table A15: EFFECT OF H-2B WORKERS ON INVESTMENT, 2022 ONLY

	(1)	(2)	(3)	(4)	(5)
Dep. var:	*Investment (IHS), 2022 only*				
Estimator:	OLS		2SLS	OLS	2SLS
Instrument:			*Win*		*Share*
H-2B employed (IHS)	−0.092		4.709		3.188
	(0.310)		(2.870)		(2.759)
Anderson-Rubin p-*val.*	—		*0.017*		*0.159*
Lottery win		1.450			
		(0.615)			
Expected share				2.799	
				(2.018)	
Full baseline controls	Yes	Yes	Yes	Yes	Yes
Number of firms	207	207	207	207	207

Data for the January 2022 lottery only. The unit of observation is firms. All regressions include constant term. Robust standard errors in parentheses. The dichotomous *Win* ('Lottery win') instrumental variable is an indicator variable for winning the lottery, that is, receiving 'A' on petitions totaling at least 50% of workers requested. The continuous *Share* ('Expected share') instrumental variable is the share of overall workers petitioned for that the firm could expect to be certified according to the certification rates in the sampling universe for each lottery letter. IHS is inverse hyperbolic sine. 'Full baseline controls' include the predetermined values of the prior year's revenue, number of U.S. year-round workers, number of U.S. temporary workers, and number of H-2B workers.

Figure A2: The 2021 firm survey questionnaire as respondents saw it on 11 screens

Survey of US businesses after the H-2B visa lottery

DARTMOUTH — Center for Global Development — IZA Institute of Labor Economics (Initiated by Deutsche Post Foundation)

Welcome!

This research project is being conducted by Dr. Michael Clemens at the Center for Global Development in Washington, DC and Professor Ethan Lewis in the Department of Economics at Dartmouth College, Hanover, NH.

We are economists studying how the H-2B visa lottery in January 2021 affected American businesses that entered that lottery.

We want to hear from you *whether or not you were able to hire any H-2B workers this year.*

Please step inside...

[Click here to enter] [Save]

1 / 11

Survey of US businesses after the H-2B visa lottery

You should know

There are 10 questions. **Please be sure to click "Save" or "Submit" when you're finished**, or we won't receive your answers.

Your participation is voluntary. Participation requires the completion of a 15-minute computer-based survey. The survey asks simple questions about your employment of various workers and other business conditions in the past year. You may choose not to answer any or all questions, and you may withdraw from the survey at any time. The information collected will be maintained confidentially and securely.

If you have any questions or concerns, please reach out! You can reach us via our colleague Cassie Zimmer by email at: [redacted] or by phone at 202-416-[redacted]

— Ethan and Michael

Please click below to begin...

[Start the survey] [Save]

2 / 11

Survey of US businesses after the H-2B visa lottery

1. In January 2021, how many H-2Bs did you petition for?

Please enter one petition per row

Number of H-2Bs requested	Lottery group received	Job title (or occupation)
	Click to choose	
	Click to choose	
	Click to choose	

[+ Add Petition]

☐ Check here if it's easier to upload a file instead.

[Back] [Next] [Save]

3 / 11

Survey of US businesses after the H-2B visa lottery

2. How many H-2B workers actually worked for your business...

...this year's season (Apr-Sep 2021)? [0] ...LAST year's season (Apr-Sep 2020)? [0]

Your best rough estimate is fine. Count all H-2Bs of any kind, including returning or supplemental.

[Back] [Next] [Save]

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Survey of US businesses after the H-2B visa lottery

Now please think of all the US workers that your business employs year-round. Include managers and owners.

3. How many year-round US workers did your business employ...

...as of last week? [0] ...as of one year ago (Oct 2020)? [0]

Seven questions to go. *If you ever get interrupted, please click 'Save' so that we receive your responses.*

[Back] [Next] [Save]

5 / 11

Survey of US businesses after the H-2B visa lottery

Now we'll ask about seasonal US workers.

4. How many seasonal US workers did your business employ...

...this year's season (Apr-Sep 2021)? [0] ...LAST year's season (Apr-Sep 2020)? [0]

Your best rough estimate is fine.

[Back] [Next] [Save]

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Survey of US businesses after the H-2B visa lottery

5. What was your business's total revenue...

...so far this year (Jan-Sep 2021)? [$0.00] ...the same period of last year (Jan-Sep 2020)? [$0.00]

Your best rough estimate of these dollar amounts is absolutely fine.

You're halfway to the end.

[Back] [Next] [Save]

7 / 11

Survey of US businesses after the H-2B visa lottery

6. Are your normal monthly operating costs...

...higher or lower this year? ...by what percent (%)?

☐ Higher than last year

☐ Lower than last year

Your best rough estimate is absolutely fine. Enter 0 for unchanged.

By 'operating costs' we mean all the expenditures it takes to keep your business running in a typical month, excluding occasional large purchases of equipment or real estate. That includes wages, recruiting, and overhead.

[Back] [Next] [Save]

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Survey of US businesses after the H-2B visa lottery

7. How much did your business spend on large, occasional investments in equipment or real estate this year ($)?

[$0.00]

Your best rough estimate is absolutely fine.

Just three questions to go. *If you ever get interrupted, please click 'Save' so that we receive your responses.*

[Back] [Next] [Save]

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Survey of US businesses after the H-2B visa lottery

8. How intense is competition?

Roughly how many other businesses compete directly with yours, in the market you serve? [Please enter a number]

Your rough estimate is absolutely fine.

How easy would it be for one of your business's competitors to steal your clients simply by underpricing you?

☐ Very easy

☐ Moderately easy

☐ Moderately hard

☐ Very hard

[Back] [Next] [Save]

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Survey of US businesses after the H-2B visa lottery

9. What kind of business do you do, and where?

Your industry [ ] **Your ZIP code** [ ]

A few examples: Landscaping, hotel/motel, country club, restaurant, amusement park, roofing contractor, street paving, forestry, seafood products, spectator sports…

10. What is your business's name?

We will never disclose your business's name. It's only for our internal checks on data quality.

Any optional comments before you click 'Submit'?

That's it!

Please be sure to click SUBMIT below so that we receive your responses:

[Back] [SUBMIT] [Save]

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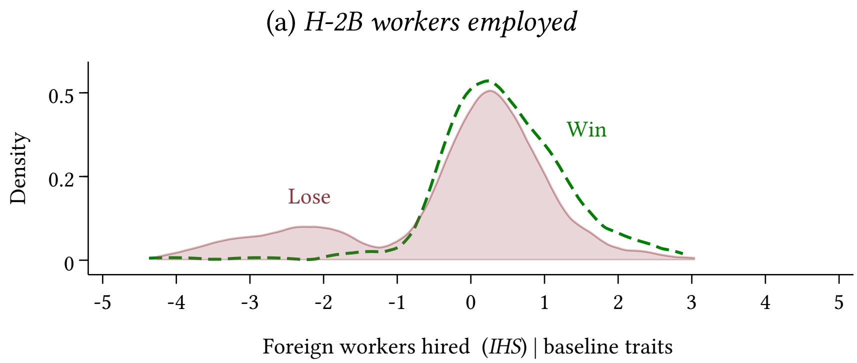
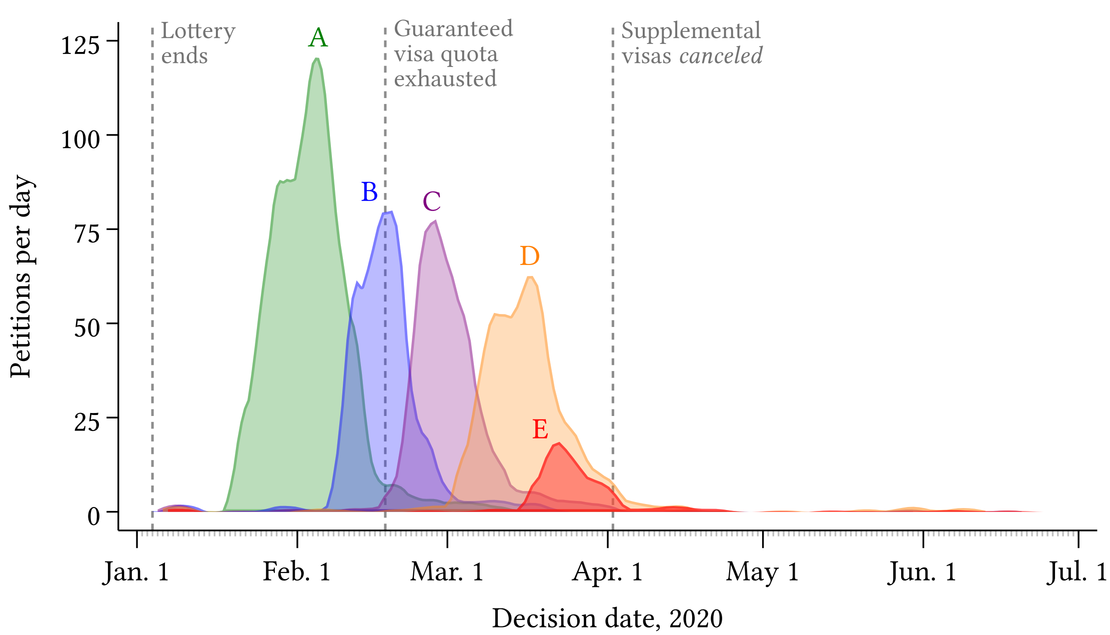
Note: The 2022 survey was essentially identical.

Figure A3: Reduced-form effect of lottery outcome on H-2B worker employment



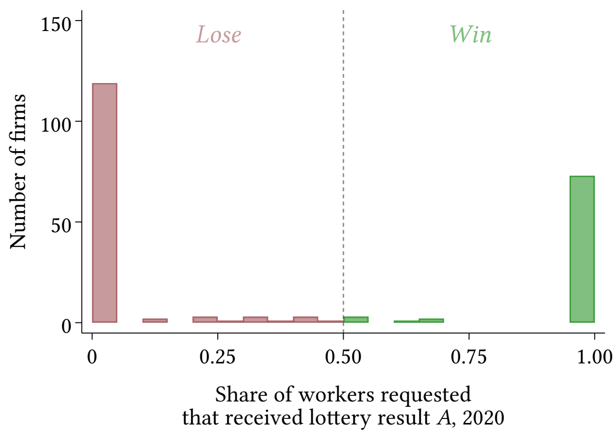
The unit of analysis is firms, pooled 2021 and 2022 samples. 'Win' is defined as a firm receiving randomized lottery letter '*A*' for petitions exceeding half of the total workers requested; all other results are defined as 'lose'. Graphs show Epanechnikov kernel density estimates with a bandwidth of 0.15 inverse hyperbolic sine (IHS) points. Residuals are estimated controlling for the full set of baseline traits, corresponding to column 4 in Table 2, measured in the year prior to the lottery.

Figure A4: H-2B worker petition decision dates by lottery result, universe of firms, second half of fiscal year 2020



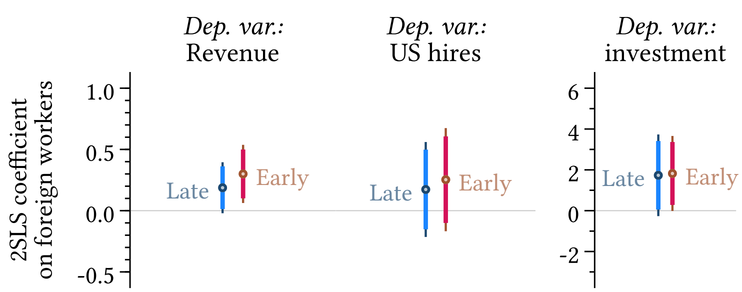
Shown is the universe of firms entering each lottery. Epanechnikov kernel densities, bandwidth 2 days. 'Decision date' is the date of the Department of Labor's decision on whether or not to certify each petition, a necessary condition of proceeding to petition USCIS for a visa. The 2020 lottery was conducted for DOL petitions received January 2–4, 2020. The statutory quota of 33,000 guaranteed visas for the second half of the fiscal year was reached on Feb. 18, 2020.

Figure A5: Defining a lottery 'win' at the firm level, 2020 lottery



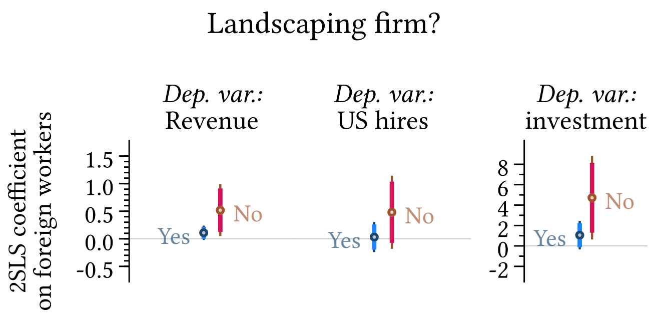
Only includes firms that voluntarily self-identified in the survey, allowing them to be matched to public records of their 2020 lottery result.

Figure A6: Test for nonresponse bias



Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. 'Late' responses are those that took more than the median time (in that year's survey) to complete the survey after the first firm completed it. For the survey on 2021 operations, the first response was received on October 21, 2021 at 9:36am Eastern time; the median response was received on October 25, 2021 at 1:14pm Eastern time. For the survey on 2022 operations, the first response was received on March 10, 2023 at 2:05pm Eastern time; the median response was received April 7, 2023 at 3:38pm Eastern time. The vertical axis in each pane shows the 2SLS coefficient on H-2B workers employed (IHS) in a regression with full baseline controls, corresponding to col. 3 of Table 2, col. 8 of Table 2, and col. 3 of Table 3. The coefficients can be interpreted as elasticities. Thin vertical line shows 95% confidence interval, thick line shows 90% confidence interval.

Figure A7: Test for bias from sampling overweight on groundskeeping/landscaping



Pooled data for the January 2021 and January 2022 lotteries. The unit of observation is firms. All regressions include constant term and a dummy for the year 2022. 'Yes' indicates the firm's industry is groundskeeping and landscaping (two-digit NAICS industry code 56); 'no' indicates any other industry. The vertical axis in each pane shows the 2SLS coefficient on H-2B workers employed (IHS) in a regression with full baseline controls, corresponding to col. 3 of Table 2, col. 8 of Table 2, and col. 3 of Table 3. The coefficients can be interpreted as elasticities. Thin vertical line shows 95% confidence interval, thick line shows 90% confidence interval.

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