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Building a Better H-1B Program

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Abstract

The H-1B program allows highly-educated foreign-born labor to temporarily work in the United States. Quotas restrict the number of labor force entrants, however. In many years, all available work permits were allocated by random lottery. This paper argues that an alternative distribution method based upon ability would increase output, output per worker, and wages paid to less-educated workers. Baseline estimates suggest that a change in allocation policy could result in a $26.5 billion gain for the economy over a six year period. This estimate grows when H-1B demand rises.

Key Words: Skilled Workers, H-1B Work Permit, Immigration

JEL Codes: J61, F22

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1 Introduction

Academic economists agree that highly-educated workers are scarce and productive inputs in the creation of macroeconomic output. The H-1B program attempts to increase the domestic supply of highly-educated workers, and therefore output, by providing temporary work permits to foreign-born individuals in specialty occupations seeking employment in the United States. Current policy restricts the number of new H-1B permits distributed to perspective employees of for-profit firms to 65,000 per year, plus an additional 20,000 for workers who have obtained a masters degree or higher education in the US.

The distributional consequences of this program are widely debated in the academic literature. Basic supply and demand models argue that the increased supply of educated foreign labor should reduce compensation paid to similar native-born workers. Though some empirical studies support this view, alternative work argues that immigrants instead complement native-born labor and expand employment opportunities. Policy implications of these studies inform opposing views about whether access to skilled worker permits should be expanded or contracted. This paper takes no stance on that debate: We assume that the current quota is given and fixed, and we recognize that the question of whether expansion of the H-1B program would lead to greater or lesser labor market opportunities for native-born workers is a topic well-covered by other studies.[1] Instead, this paper focuses on *how* H-1B permits are allocated. We argue that a simple change to the H-1B program can raise output without increasing the number of labor market entrants.

In principal, US Citizenship and Immigration Services (USCIS) distributes H-1B work permits according to a first-come / first-served basis. However, applications for fiscal years 2008, 2009, 2014, 2015, and 2016 exceeded the number of available permits during the first week of eligibility. USCIS responded by conducting a random lottery to assign all H-1Bs in those years. This paper develops a simple theory to argue that a more productive allocation method would assign permits according to ability, as measured by the wage and marginal product of labor associated with individual applicants. Such a distribution method would increase macroeconomic production and output per worker regardless of the elasticities of substitution across education and nativity groups. Wages paid to workers with little educational attainment would also rise. Whether highly-educated native-born workers benefit or suffer from the alternative policy, in contrast,

[1] See Doran, Gelber, and Isen (2014), Ghosh, Mayda, and Ortega (2014), and Peri, Shih, and Sparber (2015a) for recent contributions.

does depend upon relative elasticities.

In some respect, the implications of this paper are obvious: If policy is designed to allow the most productive individuals to work in the economy, then productivity will increase. And yet, the US has not designed its policy in this way. This makes the paper's exercise worth conducting. While economists, policy-makers, and the general public continue to debate broad immigration issues such as the expansion or contraction of the H-1B program, disappointingly little attention has been paid to narrower immigration policy changes that could enhance productivity. All parties concerned about immigration policy should have a sense of how much output is lost – and is easily recoverable – due to the current H-1B allocation method.

This is not a question that lends itself to regression analysis, as there is no obvious counter-factual. Instead, we rely on theory and simulation analysis built upon observed data and prior work. Section 2 develops the theory. It takes a restrictive view of the benefits of immigration. Recent work has argued that highly-educated foreign-born workers are vital for the Science, Technology, Engineering, and Mathematics (STEM) workforce of the economy, which is in turn responsible for much of the country's technological and productivity growth. This paper's model instead restricts foreign inputs to the production of finished goods. Those workers might or might not complement native-born and less-educated workers in the production process, but the model does not permit them to generate technology spillovers. As noted above, the degree of complementarity does not affect the main productivity implications of the model, though it will influence wage effects.

Section 3 outlines the mathematics behind two policy proposals: The current US policy randomly allocating work permits, and an alternative that allocates permits to the highest ability workers. Section 4 simulates the model based upon observed data found in the US Census and American Community Survey (ACS),[2] USCIS information acquired from a Freedom of Information Act (FOIA), and parameter estimates produced by past studies. Simulations show that changing the allocation scheme from the current lottery method to one favoring the most productive workers can raise output (and output per worker) by 0.15% over a six-year period (the maximum length of time an individual can work on H-1B status). On the one hand, this figure appears small. On the other hand, small gains seem plausible. Moreover, a 0.15% rise in

[2] See Ruggles et al. (2015).

US income is the equivalent of about \$26.5 billion in 2014. This amounts to a level of output comparable to the entire GDP of Jamaica in purchasing power parity terms, and it exceeds the GDP of nearly 100 nations of the world.[3]

Section 5 provides an important but brief discussion of the policy proposal that considers issues such as the ease of implementation, reasons for opposing the policy change, and potential benefits unmodeled in the paper. Section 6 concludes.

2 Theoretical Model of Production

Recent studies have produced ample evidence that highly-educated foreign-born workers (and H-1B workers more specifically) generate technological gains. For example, Hunt (2011) argues that immigrants are more entrepreneurial and innovative than native-born workers. Hunt and Gauthier-Loiselle (2010) and Kerr and Lincoln (2010) cite the disproportionate innovative activity among immigrants in the form of patents. And Peri, Shih, and Sparber (2014, 2015b) note that skilled foreign workers specialize in STEM work responsible for much of the productivity gains in the US in recent decades.

Positive externalities associated with innovation, entrepreneurship, and technological progress imply that theoretical models incorporating foreign-born contributions to these phenomena are especially likely to find that immigration generates productivity and wage gains throughout the economy. The model in this paper, by contrast, adopts a more modest view with the aim of developing conservative estimates of foreign-born contributions to aggregate output, output per worker, and wages. Thus, the model underlying the analysis in this paper allows workers to enter the production function directly without causing spillovers.

2.1 Model with Homogenous Foreign Skills

Suppose aggregate output (Y) is produced by using two intermediate goods: Y_L is a good produced using low-education labor, and Y_H is produced using high-education labor. These two inputs are imperfectly substitutable according to the elasticity $\sigma \in (0, \infty)$. The relative productivity of Y_L and Y_H are captured by $\beta_Y \in (0, 1)$ and $(1 - \beta_Y)$. A constant and exogenous level of technology augments production by a factor of

[3] See CIA World Factbook.

K. These intermediate goods combine to form final output according to Equation (1).

$$Y = K \cdot \left(\beta_Y \cdot Y_L^{\frac{\sigma-1}{\sigma}} + (1-\beta_Y) \cdot Y_H^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{1}$$

Let us assume that Y_L is produced by low-education labor only, which supplies labor inelastically. This input is homogenous, implying that $Y_L = L$, the total low-education labor supply. The good produced by high-education labor is more nuanced. This process uses highly-educated native workers (N) and a composite measure of education foreign-born labor supply (Y_F). Educated native and foreign-born groups might be differentiated from each other and complementary in some way. For example, one group might have a comparative advantage leading it to specialize in STEM work, while the other might instead specialize in communication skills.[4] The model is agnostic about the exact mechanism through which complementarities occur, and is indeed agnostic about whether such complementarities exist at all. It merely allows for the possibility of complementarities that directly enter into the production function without generating technology (or other) spillovers. These inputs produce good Y_H according to Equation (2).

$$Y_H = \left(\beta_H \cdot N^{\frac{\theta-1}{\theta}} + (1-\beta_H) \cdot Y_F^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{2}$$

Similar to above, $\theta \in (0, \infty)$ measures the elasticity of substitution between highly-educated native and foreign-born workers (or more specifically, a composite of educated foreign-labor contributions governed by Y_F), whereas $\beta_H \in (0,1)$ and $(1-\beta_H)$ describe their relative productivity. Individuals are again assumed to supply labor inelastically so that N and F represent the total supply of native and foreign-born labor with high levels of education. For now, let us assume that foreign-born labor is homogenous in nature so that Y_F and F are equivalent.

If markets are competitive and workers are paid a wage (w) equal to their marginal product of labor, then the first derivative of the production function identifies equilibrium wages:

$$w_L = \beta_Y \cdot \left(\frac{Y}{L} \right)^{\frac{1}{\sigma}} \tag{3}$$

[4] See Peri and Sparber (2011) for a discussion of comparative advantage among highly-educated workers.

$$w_N = (1-\beta_Y)\cdot\beta_H\cdot\left(\frac{Y}{Y_H}\right)^{\frac{1}{\sigma}}\cdot\left(\frac{Y_H}{N}\right)^{\frac{1}{\theta}} \tag{4}$$

$$w_F = (1-\beta_Y)\cdot(1-\beta_H)\cdot\left(\frac{Y}{Y_H}\right)^{\frac{1}{\sigma}}\cdot\left(\frac{Y_H}{F}\right)^{\frac{1}{\theta}} \tag{5}$$

The production function is homogenous of degree one in the inputs L, N, and $Y_F = F$. Each factor J's share of income is easily computed as $\frac{w_J \cdot J}{Y}$, which also represents the elasticity of Y with respect to J, $\frac{d\ln(Y)}{d\ln(J)}$. Thus, the parameters $\lambda = \frac{d\ln(Y)}{d\ln(L)}$, $\eta = \frac{d\ln(Y)}{d\ln(N)}$, and $\phi = \frac{d\ln(Y)}{d\ln(Y_F)} = \frac{d\ln(Y)}{d\ln(F)}$ are the income shares paid to less-educated labor, highly-educated natives, and highly-educated foreign workers, respectively. Their values sum to one. Importantly, the last of these income shares is also an expression of educated foreign labor's effect on output, which is incorporated into other effects experienced in the economy:

$$\frac{d\ln(Y)}{d\ln(Y_F)} = \phi \tag{6}$$

All wages are positive but decreasing in the supply of own-group labor. More interesting is the effect of high-education foreign labor on low-education and native-born high-education workers. It is straightforward to show that

$$\frac{d\ln(w_L)}{d\ln(Y_F)} = \frac{1}{\sigma}\cdot\frac{d\ln(Y)}{d\ln(Y_F)} = \frac{\phi}{\sigma} \tag{7}$$

$$\begin{aligned}\frac{d\ln(w_N)}{d\ln(Y_F)} &= \frac{1}{\sigma}\cdot\left(\frac{d\ln(Y)}{d\ln(Y_F)} - \frac{d\ln(Y_H)}{d\ln(Y_F)}\right) + \frac{1}{\theta}\cdot\left(\frac{d\ln(Y_H)}{d\ln(Y_F)}\right) \\ &= \frac{1}{\sigma}\cdot\left(\phi - \frac{\phi}{1-\lambda}\right) + \frac{1}{\theta}\cdot\left(\frac{\phi}{1-\lambda}\right) \\ &= \left(\frac{\phi}{1-\lambda}\right)\cdot\left(\frac{1}{\theta} - \frac{\lambda}{\sigma}\right)\end{aligned} \tag{8}$$

It is clear from (7) that wages paid to less-educated workers are strictly increasing in the number of highly-educated foreign-born workers in the market. Effects on wages paid to highly-educated native-born workers are ambiguous. Although the relative wage paid to native versus foreign-born workers is always increasing in F since $\frac{d\ln(\frac{w_N}{W_F})}{d\ln(F)} = \frac{1}{\theta} > 0$, absolute wages of highly-educated natives rise only if $\sigma > \theta\cdot\lambda$. That is, highly-educated foreign-born workers increase wages of similar native-born workers if high and low education labor is highly substitutable (σ is high), native and foreign-born workers are highly complementary

(θ is low), or if the elasticity of output with respect to low education workers (λ) is low (implying that high education workers contribute more to aggregate output). Other implications from the model include that foreign labor flows benefit low-education workers more than high-education natives if $\sigma < \theta$. That is, if high and low education labor are less substitutable than native and foreign-born labor within education groups.

2.2 Model with Heterogenous Foreign Skills

We now relax the assumption of homogenous skills among educated foreign workers. Suppose that a highly-educated foreign worker (i) is associated with a quality adjuster $q_i \in (0, \infty)$ of mean value equal to one. This parameter captures a foreign-born worker's innate ability beyond educational attainment. Without loss of generality, suppose workers are ordered from highest to lowest ability. Then the composite input of educated foreign-born workers becomes $Y_F = \sum_{i=1}^{F} q_i$, and the high-education intermediate good is produced according to Equation (9).

$$Y_H = \left(\beta_H \cdot N^{\frac{\theta-1}{\theta}} + (1 - \beta_H) \cdot \left(\sum_{i=1}^{F} q_i \right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{9}$$

Note that $\sum_{i=1}^{F} q_i = F$ due to the assumption that q_i has a mean value of one. Furthermore, the function in (9) encompasses the case of homogenous educated foreign labor in the event that all $q_i = 1$. The principal difference with heterogenous foreign-born labor is that the wage paid to foreign worker i is scaled by the value of his or her ability q_i as in (10). Not only does this equation identify productivity consequences of hiring worker i, but it carries pragmatic significance as well: It argues that if workers are paid their marginal product of labor, higher ability workers can be identified in through their wages. In other words, the highest ability candidates in a pool of H-1B applicants will be those individuals who have received the largest wage offers.

$$w_{F_i} = q_i \cdot (1 - \beta_Y) \cdot (1 - \beta_H) \cdot \left(\frac{Y}{Y_H} \right)^{\frac{1}{\sigma}} \cdot \left(\frac{Y_H}{F} \right)^{\frac{1}{\theta}} \tag{10}$$

The heterogenous model in (9) does not alter the wage functions for low-education workers or high-education natives expressed in (3) and (4).[5] The share of income paid to heterogenous foreign labor remains

[5] Though one might want to replace the homogenous F in the high-education input with $\sum_{i=1}^{F} q_i$.

$\phi = \frac{d\ln(Y)}{d\ln(Y_F)}$, but the addition of an F^{th} worker of quality q_F implies $\frac{d\ln(Y)}{d\ln(F)} = \frac{d\ln(Y)}{d\ln(Y_F)} \cdot \frac{d\ln(Y_F)}{d\ln(F)} = \phi \cdot q_F$. This expression is incorporated into the low and high education wage effects of native born workers ($\frac{d\ln(w_L)}{d\ln(F)}$ and $\frac{d\ln(w_N)}{d\ln(F)}$). Thus, the addition of a foreign worker of quality q_i alters the output of the high-education good, the high-education native wage, and the low-education wage by a factor of q_i relative to the average effect (i.e., the effect from a one-unit increase in homogenous labor unit F). However, elasticities with respect to the composite input Y_F expressed in equations (7) and (8) are unaltered. These expressions, which remain a function of high-education foreign-labor's share of income (ϕ), are central to simulation exercises examining the wage implications of alternative H-1B allocation policies.

3 Policy Proposals

Suppose policy-makers decide to limit the number of high-education foreign workers it allows into the country to a fixed proportion, $\rho \in (0,1)$, of the total number of workers (F) who would like to do so. Let us consider two alternatives for implementing this policy. Policy A works much like the current H-1B program and distributes work permits through a random lottery. Policy B achieves the same goal of immigration reduction and admits the equivalent number of applicants by instead choosing those with the highest ability. Output of the highly-educated intermediate good is governed by one of the two following functions:[6]

$$Y_H \equiv Y_A = \left(\beta_H \cdot N^{\frac{\theta-1}{\theta}} + (1-\beta_H) \cdot \left(\rho \cdot \sum_{i=1}^{F} q_i\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{11}$$

$$Y_H \equiv Y_B = \left(\beta_H \cdot N^{\frac{\theta-1}{\theta}} + (1-\beta_H) \cdot \left(\sum_{i=1}^{\rho \cdot F} q_i\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{12}$$

Output and less-educated workers both benefit from the policy that generates higher levels of Y_H since both final output (Y) and wages paid to less-educated labor (w_L) are unambiguously increasing in Y_H. Output per worker also rises since the number of workers is equivalent in the two scenarios.

Expression (11) arising from Policy A effectively comes from the expected value of foreign-labor contri-

[6] Policy A results in a probabilistic outcome. We present ouput resulting from expected values.

butions. Each worker i has an equal probability ρ of receiving a work permit. Since no selection of $\rho \cdot F$ workers can result in a higher level of total skill supply than the selection of the best $\rho \cdot F$ workers implied by Expression (12) and Policy B, we know that $Y_B > Y_A$.

More formally, it can be shown that $Y_B > Y_A$ if $\sum_{i=1}^{\rho \cdot F} q_i > \rho \cdot \sum_{i=1}^{F} q_i$. That is, if the total ability of the best $\rho \cdot F$ workers exceeds ρ% of the ability of all possible workers. The concave nature $\sum_{i=1}^{F} q_i$ that arises due to the ordering of individuals guarantees that this result holds. Suppose that the function $f(F) = \sum_{i=1}^{F} q_i$ is strictly increasing, concave, and homogenous of degree $n \in (0, 1)$. Then the high-education output lost going from a level of $F = F_0$ to a level of output scaled by ρ is $(1 - \rho) \cdot f(F_0)$. This is the output lost under Policy B. Policy A instead scales F by a factor of ρ, resulting in lost high-education output equalling $f(F_0) - f(\rho \cdot F_0) = f(F_0) - \rho^n \cdot f(F_0) = (1 - \rho^n) \cdot f(F_0)$. Since both n and ρ are positive numbers less than one, we can see that lost output from Policy B is smaller. That is, Policy B results in more output, productivity, and wages paid to less-educated workers.

Graphical representation in Figure 1 helps to illustrate this effect. The total ability of high education foreign workers is identified by the curve Σq. In an unrestricted immigration regime in which F individuals migrate, the total ability is marked U. Policy A generates an expected skill level curve identified by $\rho\Sigma q$, with an overall expected skill, $E(Skill)$, identified by the value of this curve at F. The total number of workers admitted is equal to ρF. The expected outcome is marked A. Note, however, that Policy B would have selected the first ρF workers with the highest skill level. This corresponds to a total ability that falls along the original Σq curve marked B – a level exceeding the ability arising from Policy A. Ability-based work permit allocation leads to a higher level of skill supply than random allocation.

4 Parameterization and Simulation

Sections 2 and 3 outlined the basic theory and mathematics underlying two methods for allocating H-1B permits to highly-educated foreign-born workers. The currently-employed method of distributing permits by random lottery will result in lost output, output per worker, and wages paid to low education workers when compared to a process of allocating permits to the highest ability foreign-born workers. The magnitudes of these effects depend upon parameters underlying the model. To understand these effects better, we now turn to a simulation exercise that uses data and parameters from the US Census, ACS, USCIS (acquired from a FOIA), and past work.

Ultimately, we are interested in the changes of output (Y), low education workers' wages (w_L), and high education native-born workers' wages (w_N) caused by a change in the value of the composite input of high education foreign-born workers (Y_F). These expressions were derived in Equations (6)-(8). The right hand side of these expressions are fully governed by the income shares λ, η, and ϕ, and the elasticities of substitution between education groups (σ) and between highly-educated native and foreign-born workers (θ). Values for changes in Y_F implied by the different H-1B allocation schemes require estimates of the quality of foreign-born workers (q) and the proportion of foreign individuals seeking a work permit who successfully acquire one (ρ).

4.1 H-1B Data and the Skills of Foreign Workers

Values for ρ and q can be gleaned from USCIS information but will vary depending upon the year used to construct the parameters due to both changing H-1B demand and the evolution of the program.

Limits on the number of new H-1B issuances per year have fluctuated over time. The H-1B quota for fiscal year 2000 (October 1999 – September 2000) was 115,000. Though the cap was reached six months prior to the end of the fiscal year (in March), USCIS received applications for new H-1B permits throughout that year because Congress acted to temporarily raise the annual cap to 195,000 for fiscal years 2001-2003. When that temporary limit expired, the quota was reduced to 65,000 for fiscal year 2004. Beginning in fiscal year 2005, an additional 20,000 permits have been available to workers with an advanced degree from US universities.[7] Our analysis will begin by assuming that $\rho \cdot F = 65,000$, though later simulations will also incorporate the additional 20,000 permits for advanced US degree recipients.

Unfortunately, there is no way to know for sure how large the desired number of permits (F) is. Demand is latent since there is no reason to apply after the available permits have been distributed. However, we can gain insight by measuring H-1B demand from a year in which H-1B limits were less restrictive. The years 2000 and 2001 are viable candidates. High labor demand due to favorable macroeconomic conditions led

[7] Employees of colleges, universities, and non-profit research institutions are exempt from H-1B caps.

141,178 individuals to apply for cap-bound H-1B permits in 2000.[8] If the cap had been set at 65,000 in that year, it would have implied that $\rho = 0.46$. *A priori*, 2001 might seem like a better year for calibrating the value of ρ since the H-1B cap was high and non-binding throughout the calendar year. However, declining cyclical GDP and the events of 9/11 combined to reduce H-1B demand, leading to a hypothetical value of $\rho = 0.77$. This observation points to an important regularity: The value of ρ, which cannot be measured in the current policy environment, will be lower in years with higher latent H-1B demand.

Calculation of Y_F for policies A and B requires several steps and methodological choices. The most literal derivation from the theory would assume that all highly-educated foreign-born workers enter the US via the H-1B program. Though an extreme assumption, it is useful for illustration. Recall the relationship between q_i and wages derived above. The assumed mean of $q_i = 1$ simply reflects a normalization of individual wages such that $q_i = \frac{w_{F_i}}{\bar{w}_F}$, where $\bar{w}_F$ is the average wage paid to highly-educated foreign workers. Since $\frac{1}{F}\sum_{i=1}^{F} q_i = 1$ is the average value of q, Policy A implies that the value of $Y_F = \rho \cdot F = 65,000$ by construction.

The value of Y_F in Policy B, in contrast, depends upon the distribution of foreign ability. Again, USCIS data is informative. Figure 2 plots a histogram of the ability distribution of H-1B applicants during calendar year 2000. The values of q_i approximate a log-normal distribution, but with heavy skewness to the right. Bars shaded in maroon reflect the individuals among the top 65,000 wage earners, and would therefore be included in the Policy B construction of Y_F. The summed skills of these top 65,000 workers equals 82,252, thus implying a much greater production input than the expected value generated by the lottery.

Figure 3 provides further illustration of the policy differences. The horizontal axis records the 114,178 workers applying for an H-1B permit in 2000, ordered from highest to lowest ability. The vertical axis measures cumulative wages, normalized by the average wage. That is, it represents $Y_F = \sum_{i=1}^{F} q_i$. The blue curve represents the skill sum possible without restricting immigration. The red curve scales that value by the parameter ρ. The maximum value of this curve equals $Y_F^A = \rho \cdot \sum_{i=1}^{F} q_i$, the expected foreign-born skill supply under Policy A's lottery distribution of 65,000 permits. The skill value of the 65,000 highest ability applicants who would receive permits under Policy B, $Y_F^B = \sum_{i=1}^{\rho \cdot F} q_i$, equals 82,852 as cited above. The

[8] Individuals who are not subject to H-1B caps (such as those renewing their H-1B status) are removed from this calculation. We also retain only those individuals earning between \$15,000 and \$1,000,000 during the year so as to remove people at the extreme ends of the wage distribution (who might be subject to measurement error).

figure closely mirrors the theoretical construct presented in Figure 1, but is instead created from observed data.

If the stock of all highly-educated foreign-born workers in the economy entered via the H-1B program, then $\ln\left(\frac{82{,}852}{65{,}000}\right) = 0.235$ would be a reasonable approximation for $d\ln(Y_F)$ necessary for computing the economic implications of comparing Policies A and B. But as noted above, this is an unreasonably extreme assumption. Many highly-educated foreign-born individuals in the United States have a long-established residence in the country and would not have been subject to current H-1B policy restrictions. A more reasonable approach for calibrating the model would be to instead assume that $\rho \cdot \sum_{i=1}^{F} q_i$ and $\sum_{i=1}^{\rho \cdot F} q_i$ represent *changes* to the stock of college-educated foreign-born labor under different policy regimes. In other words, it would be appropriate to adjust the measure of Y_F by a constant factor representing foreign workers who are not (or were not) affected by the policy in question.

To accomplish this task, first define $\hat{F}$ as a measured stock of educated foreign workers in the economy. Since Policy A currently governs US migration, assume that $Y_F^A = \hat{F}$. Second, let us assume that in a single year, the change in this stock value ($\Delta\hat{F}$) grew according to Policy A such that $\Delta\hat{F}_A = \rho \cdot \sum_{i=1}^{F} q_i$. If Policy B had instead been in place, this stock would have grown by $\Delta\hat{F}_B = \sum_{i=1}^{\rho \cdot F} q_i$. Third, note that individuals can work on H-1B status for a maximum of six years. If all H-1B workers had stayed in the US for this period, then the level of foreign skills that the economy could have obtained under this alternative policy equals $\hat{F} + 6 \cdot \left(\sum_{i=1}^{\rho \cdot F} q_i - \rho \cdot \sum_{i=1}^{F} q_i\right)$. Altogether, this implies that Equation (13) provides a comparison of policy proposals over a six year period.[9] Given the data outlined above, one could substitute $\rho \cdot \sum_{i=1}^{F} q_i = 65{,}000$ and $\sum_{i=1}^{\rho \cdot F} q_i = 82{,}852$.

$$d\ln(Y_F) = \ln\left(\frac{Y_F^B}{Y_F^A}\right) = \frac{\hat{F} + 6 \cdot \left(\sum_{i=1}^{\rho \cdot F} q_i - \rho \cdot \sum_{i=1}^{F} q_i\right)}{\hat{F}} \tag{13}$$

We explore two alternative methods of computing relevant income shares and creating measures of $\hat{F}$ using US Census data, which we discuss in the next section.

[9] An alternative but equivalent interpretation would remove 6*65,000 workers from the measured stock and then simply replace them with the skills that would be accumulated (i.e., the skill sum values described above) over a six-year period as governed by the relevant policy: $\ln\left(\frac{Y_F^B}{Y_F^A}\right) = \frac{\hat{F} - 6 \cdot \left(65{,}000 - \sum_{i=1}^{\rho \cdot F} q_i\right)}{\hat{F} - 6 \cdot \left(65{,}000 - \rho \cdot \sum_{i=1}^{F} q_i\right)}$

4.2 Census Data and Income Shares

The 2000 Census provides information on employment, wages, and nativity that facilitates construction of income shares. Our first method of parameterizing the model groups all workers with some college or less education into L; native-born workers with a bachelor's degree or more education are in N; and similarly-educated foreign-born workers are in Y_F. The data implies that income shares $\{\lambda, \eta, \phi\}$ equal $\{0.56, 0.39, 0.05\}$ and that 3,537,313 highly-educated foreign-born individuals worked in the US in 2000. Using this figure as a measure of $\hat{F}$ and inserting it into Equation (13) implies a baseline value of $d \ln(Y_F) = 0.0288$. That is, an H-1B program allocating permits according to ability would increase the composite educated foreign labor input in production by 2.88% relative to the current program, according to 2000 Census and USCIS data.

The choice of including the full number of educated foreign-born workers in the construction of Y_F might be an extreme assumption since larger $\hat{F}$ values will bring the $\frac{Y_F^B}{Y_F^A}$ ratio closer to one and its log closer to zero. A second method of parameterizing the model instead measures $\hat{F}$ using just the 769,573 workers in the 2000 Census who have resided in the US six or fewer years – the maximum number of years a person can have H-1B status. This raises $d \ln(Y_F)$ to 0.1262, or an implied 12.62% increase in the foreign skill component of production. By removing established immigrants from the construction of Y_F, however, income shares will change as well. We adopt an assumption that established college-educated immigrants and similar natives are perfectly substitutable and therefore incorporate both into the construction of N. This changes the income shares $\{\lambda, \eta, \phi\}$ to {0.56, 0.43, 0.01}.

4.3 Elasticities of Substitution

The final parameters needed for simulating the effects of H-1B allocation policy are the elasticities of substitution between low and high education workers (σ) and between highly-educated native and foreign-born workers (θ). We take these values from the existing economics literature.

The former elasticity is relatively non-controversial. Table 6 of Ciccone and Peri (2005) provides a helpful summary of σ from the literature with a remarkably narrow range values spanning from 1.31 to 2.00, with higher values implying greater substitutability across education groups.[10] In the context of this

[10] Citied sources include Johnson (1970), Fallon and Layard (1975), Katz and Murphy (1992), Angrist (1995), Murphy, Riddle, and Romer (1998), Krusell et al. (2000), and Caselli and Coleman (2000).

paper's model, the effects of σ are purely distributional. Low values imply that the gains from increased highly-educated foreign-labor skills dissipate to complementary low-education labor. High values increase the likelihood of positive wage effects for educated native-born workers.

The elasticity of substitution across nativity groups, in contrast, remains subject to wide debate in the literature. Card (2009, p. 17) argues that "both the time series and cross-city evidence are consistent with a small but detectable degree of imperfect substitution between immigrants and natives." He finds a value of θ near 40 for less-educated workers and a value near 17 for among college-educated workers.

A series of papers in the February 2012 issue of the *Journal of the European Economic Association* provides great insight into challenges estimating this parameter. Manacorda, Manning, and Wadsworth (2012) produce estimates suggesting the strongest complementarities. Using short-run data from the United Kingdom, their baseline estimates find $\theta = 7.8$. When estimated using recent immigrants only, the level of complementarity grows (and the parameter shrinks) to $\theta = 4.6$. University graduates exhibit a value of $\theta = 5.7$.

Ottaviano and Peri (2012) use long-run US data and find evidence for complementarity but at much higher values of θ. Their preferred estimate centers around $\theta = 20$. However, estimates for the inverse elasticity among college graduates are never significantly different from zero and sometimes have the wrong sign. When converted into an elasticity, college-educated values of θ range from about 40 to 110. Manacorda, Manning, and Wadsworth (2012) provide helpful insight into these discrepancies by noting that natives and immigrants might be more substitutable in the long run than in the short run, and that this might contribute to their disparate findings.

Critics of existing estimates of the elasticity of substitution between groups include Borjas, Grogger, and Hanson (2012) who note that results are extremely sensitive to sample selection, weighted regression techniques, variable construction, and other methodological considerations. Their estimates of θ range from a low of 18.8 to perfect substitutability ($\theta = \infty$). Dustmann and Preston (2012) argue that estimates will be biased by discrimination and accessibility issues: If new immigrants skill-downgrade and work in jobs below their skill level, models estimating the degree of competition between natives and immigrants will face a great deal of measurement error that could bias estimates against finding perfect substitutability. If immigrants upgrade the skill-level of their occupations rapidly as they become established, the disconnect between short-run estimates and long-run estimates will grow, which could explain part of the difference between the Manacorda, Manning, and Wadsworth (2012) and Ottaviano and Peri (2012) results.

In the context of this paper's model, the consequences of θ are largely distributional. High substitutability between educated native and foreign-born workers implies that an increase in foreign ability is likely to reduce wages paid to similar native-born workers. Our approach will take a fairly limiting view of the potential complementarities across nativity groups by adopting a baseline assumption of $\theta = 30$. We will see that the model reaches asymptotic conclusions that occur rather quickly as θ grows, so the distinction between θ values of 20, 30, 40, or even larger values are relatively minor.

4.4 Simulation

4.4.1 Main Results

Table 1 displays estimated output, productivity, and wage implications of moving from the current H-1B policy – which distributes work permits via random lottery – to one in which permits are awarded to an equivalent number of the highest ability applicants. All estimates in the table assume that low and high education workers have a high degree of complementarity ($\sigma = 1.75$) but highly-educated native and foreign-born workers are highly substitutable ($\theta = 30$).

Column (1) displays the baseline estimates. It computes parameter values using data from the 2000 Census and H-1B applications. All college-educated foreign-born workers are included in the calculation of foreign-born income shares. As noted above, the model predicts that a change in the H-1B permit allocation method would increase the skills supplied by foreign-born workers by 2.88% without changing the total number of migrants. Output gains are scaled by the skilled foreign-worker income share, resulting in a 0.15% rise in GDP over a six year period. Since labor is inelastically supplied and constant, output per worker rises by an equivalent amount. Though 0.15% is a small figure, it is not trivial. Given the size of the US economy ($17.46 trillion in real 2014 terms), the implied change is equivalent to $26.5 billion, roughly the size of the entire Jamaican economy, and greater than the GDP of nearly 100 countries in the world.

The increase in high-education skills leads to a 0.09% rise in wages paid to complementary low-education workers. This translates to a low dollar amount of \$34 per worker without a four-year college degree, but these workers accounted for 71% of the US labor force in 2000 so that a large number of people benefit. Native-born workers with a bachelor's degree or more education experience a 0.10% wage decline. The loss arises due to the highly substitutable nature of highly-educated native and foreign-born workers (relative to the substitutability across education groups) and the large share of the gains paid to low education workers.

Column (2) adopts an alternative methodology that assumes that established high-education immigrants are perfectly substitutable with educated natives, thus reducing the size of skills supplied by foreign-born educated labor (Y_F) to those skills supplied only by new immigrants (people in the US for six or fewer years). This increases the disparity in skill supply offered by the two H-1B allocation methods to a sizeable 12.62%. However, it also greatly diminishes the income share paid to relevant highly-educated foreign-workers. These two effects are largely offsetting. The implied output benefit from improved policy decreases from 0.15% to 0.12%, and the wage consequences diminish proportionally.

4.4.2 Implications of H-1B Scarcity, Income Shares, and Skill Distributions

The parameter ρ effectively measures the probability that an H-1B applicant secures a permit from the random lottery. Column (3) begins to explore how changes in H-1B scarcity (variation in ρ) affect the productivity gap between H-1B allocation methods.

2000 was a year of high H-1B demand. Reduced demand in 2001 implies that if the cap had been set at 65,000, a higher proportion of individuals who wanted work permits would have been able to secure them. The implied value of ρ would have been 0.77 in that year. In low-demand states of the world, the difference between distributing permits to random workers versus highest ability workers is small. Column (3)[11] demonstrates that a change in policy at a $\rho = 0.77$ success rate reduces the skill difference between the two allocation methods to just 1.26%. This in turn reduces the output and wage consequences. Column (4) repeats this exercise but uses the alternative measurement of foreign-labor that includes only recent migrants. Results are qualitatively similar.

The H-1B cap reverted from 195,000 per year in 2003 to 65,000 in 2004, but an extra 20,000 permits were added to the program beginning in fiscal year 2005. Column (5) repeats the exercise of column (1) but

[11] Simulations also use income shares calculated from the 2001 ACS.

raises the implied value of ρ from 0.46 to a 0.60 value associated with 85,000 available permits. With a larger number of lower-ability workers included in the selection process, this again dampens the discrepancy between the policy schemes, though not as severely as the results implied by 2001 H-1B demand. Comparison between columns (1) and (5) suggests that the GDP loss associated with the lottery allocation method reduces from \$26.5 billion when 65,000 permits are available to \$23 billion when 85,000 permits are available.

Columns (3)-(5) highlight an important role of ρ in determining the lost output caused by random allocation of H-1B permits. Unfortunately, the current value of this parameter is unknowable. USCIS (2015) announced that it had received 233,000 applications for the 65,000 available general permits and 20,000 advanced degree exemption permits during the first week of application eligibility for fiscal year 2016. This suggests $\rho = 0.36$, but it ignores latent demand from individuals who might be interested in applying later in the year, as well as people interested in working in the US but unwilling to submit themselves to random selection (for example, high ability individuals with secure job offers in other countries). Moreover, it is not possible to record the skills of the applicants with the highest 36% of ability since forms not selected for processing are not recorded in USCIS data.

In trying to understand further the consequences of acute shortages implied by high H-1B demand, one method of overcoming data limitations is to assume that the distribution of skills in any year is governed by the distribution witnessed through H-1B applications received in 2000. Suppose that the number of permits is fixed at 85,000 (thus accounting for the advanced degree exemption). Column (6) indicates that this would imply a GDP loss equal to one quarter of a percent.

Column (7) modifies the estimation procedure by using the 2013 ACS – the most recent year available – to identify factor levels and income shares. These values change considerably to $\hat{F} = 6,475,667$ and $\{\lambda, \eta, \phi\} = \{0.47, 0.44, 0.09\}$. Most notably, both the share of income paid to highly-educated immigrants and the stock of skilled foreign-workers grew considerably between 2000 and 2013. These regularities have offsetting effects on the implied GDP effects of switching allocation policy. Column (7) finds a GDP loss of 0.22%, quite similar to the figure found in column (6).

Figure 4 illustrates output comparisons of Policies A and B as a function of H-1B demand using 2013 employment levels and factor shares. The key insight illustrated by this figure (consistent with Table 1) is that – given the fixed number of permits – increased H-1B demand will drive down the value of ρ. The expected skill value of H-1B recipients selected by the random lottery is unaffected: 85,000 individuals of average quality (q_i) equal to one are allowed to work regardless of the number of applicants. However, a larger number of applicants also implies a larger number of high-ability applicants. Thus, an allocation method that selects the highest ability workers will select more exceptional workers in times of high demand. This exacerbates the gap in quality, and hence output, implied by the two allocation methods. The model suggests that random lottery allocation costs the economy 0.18% of output when $\rho = 0.46$ as assumed from H-1B demand in 2000. Using $\rho = 0.77$ from 2001 H-1B data implies a GDP gap of just 0.07%. If $\rho = 0.36$ – an upper-bound estimate for fiscal year 2016 – then the output gap rises to 0.23%. Random lottery allocation of H-1B permits is particularly costly during times of high demand.[12]

Finally, column (8) of Table 1 explores whether conclusions are driven by dependence upon the 2000 skill distribution. Consider instead calendar year 2008 when all new H-1B permits were allocated by lottery. If the lottery was truly random, then the resulting sample distribution should approximate the population distribution. Thus, we can use the distribution to estimate the quality of workers that could have been achieved using a merit-based allocation system. The 2008 skill distribution, coupled with 2016 H-1B demand and the 2013 factor levels and income shares,[13] combine to estimate a GDP loss of 0.21%, or $37 billion.

The results of Table 1 and Figure 4 together illustrate that the output gap implied by moving from Policy A to Policy B is sensitive to – and grows with – H-1B demand. Other features of the model are not as important. Results are robust to using different years to construct income shares and employment levels, and are similarly unaffected by the year used to construct the H-1B skill distribution.

4.4.3 Implications of Native and Foreign-Born Substitutability

Equations (6)-(8) demonstrate that the elasticity of substitution between educated native and foreign-born workers (θ) plays no role in determining the output or low-education wage effects of H-1B allocation policy at the margin, but it does affect wages paid to educated natives. These conditions assume fixed income shares that were parameterized according to observed Census and ACS data. Let us now relax that assumption.

[12] Estimates in Figure 4 differ from selected values of Table 1 due to a combination of the use of 2013 ACS information, an assumed 85,000 H-1B permits instead of the previously-used 65,000 value, and rounding error.

[13] These are the most recent surveys available to us that are appropriate for this analysis.

Begin by calibrating the model such that the values of β_Y, β_H, foreign skills, factor supply, and income shares are consistent with $\sigma = 1.75$ and $\theta = 30$ as done above. This information can be used to simulate the value of the high-education factor input (Y_H) and output (Y) under Policies A and B. Suppose θ is then allowed to vary. This will fundamentally alter the high-education input and therefore output as well.

Figure 5 illustrates the effect of θ on output, low-education wage, and high-education native wage differences across policy. Values at $\theta = 30$ are recorded in Column (1) of Table 1 and imply that a switch in policy would cause a 0.15% increase in output, 0.09% increase in average low education wages, and a 0.10% decline in average wages paid to native-born workers with a college degree. At lower levels of θ, educated foreign-workers become more complementary to educated natives. Since foreign workers are relatively scarce, an increase in their supply of skills is particularly beneficial. At $\theta = 4.6$ – the lowest value found in the literature – the output gap between policies increases to 0.20% and the wages paid to low education workers rises to 0.12%. Even at this high level of complementarity, however, highly-educated natives still suffer a wage loss of 0.05%. The asymptotic behavior of the functions are reached at even low levels of θ. In order for the policy switch to be wage-neutral for educated natives, θ would need to be less than or equal to 3. Although the implied income shares $\{0.87, 0.34, 0.09\}$ are not terribly different from what is seen in the observed data, $\theta \leq 3$ is highly inconsistent with all empirical estimates of the elasticity of substitution between native and foreign-born workers.

5 Discussion

Moving from a system that randomly distributes H-1B permits to one that awards permits to the highest quality applicants would generate unambiguous output and productivity gains. It is somewhat surprising, therefore, that the US continues to implement a lottery allocation method. Several possible motivations are worth considering.

Winners and Losers The model in this paper implies that low-education labor would never oppose H-1B immigration on economic reasons alone, but high-education natives might. The conditions that determine the high-education native-born wage effects of an increased number of highly-educated foreign workers are the same conditions that determine the effects of an increase in foreign skill. Thus, the same individuals opposed to an increase in immigration based on economic grounds are likely to resist a move to an allocation system based upon merit. Though only a minority of workers suffer wage losses, if those workers vote in much greater proportion (or have disproportionate influence on policy decisions in general), then the lottery allocation system is likely to persist.

Non-Economic Determinants of Immigration Policy Individual preferences toward immigration are not motivated by economic concerns alone. Card, Dustmann, and Preston (2012), for example, use data from 21 countries in the 2002 European Social Survey and find that concerns about how immigration alters the composition of the population explain two to five times more of the variation in attitudes toward migration than is explained by concerns over wage and tax implications.[14] Mayda (2006) performs similar work using a cross-section of OECD countries and similarly finds greater importance of noneconomic factors in shaping immigration attitudes.

Would a change in H-1B allocation policy have ethnic composition consequences? Again, the 2000 H-1B skill distribution can be informative. Table 2 indicates that compositional consequences are minimal. Of the ten most common H-1B source countries (accounting for 80% of applications in 2000), only Japan fails to appear in the ten source countries with the highest ability applicants. A switch in policy would lead to more than a one percentage-point increase in the share of H-1B entrants only from China (1.9%), India (1.4%), and the United Kingdom (1.0%). The share from the Philippines would fall 1.5%. Ethnic fractionalization of new migrants – an index commonly-used in the diversity literature[15] to measure the probability that two people, drawn at random, will be from different ethnic groups – would fall from 66.2% with the lottery allocation method to 64.4% using the ability method. Compositional concerns should not play a substantive role in determining how H-1B permits are allocated.

Ease of Implementation Random permit allocation is exceptionally easy to implement. USCIS must first determine whether an H-1B application is subject to the quota. It then submits all cap-dependent applications to a random lottery conducted by a computer. On the surface, allocation to the highest ability

[14] Indicators of compositional concerns come from survey questions pertaining to the desirability of shared customs, traditions, religions, culture, and language, as well as questions about social tensions and violence.

[15] See Alesina et al. (2003) or Ottaviano and Peri (2005, 2006), for example.

workers might appear to be an onerous alternative. However, this is not likely to be the case. Application materials already list the H-1B beneficiary's wage. Indeed, this information – acquired from USCIS through a FOIA – was central to the simulation exercises presented above. So long as the number of applicants exceeds the number of available permits sufficiently early in the application period (as has been the case in recent years), USCIS could first sort applicants according to the wage offer and allocate permits accordingly. If USCIS wishes to maintain a random component to H-1B distribution, it could do so by subjecting applications at (or near) the cutoff threshold to a lottery, while still employing a merit-based system rewarding permits to workers of the highest ability.

This alternative distribution method does require accepting the assumption that wages proxy for ability and the marginal product of labor. University professors and non-profit research workers might object to this view, but such workers are already exempt from H-1B limits. Also, oversight would be needed to ensure that employers pay workers as advertised on application forms. Nonetheless, the administrative burden of the alternative system should be lower than the potential economic benefit.

Equity Some might contend that the current system is inherently fair in that it gives all perspective foreign employees an equal chance to work in the United States and that productivity should not be the lone determinant of who receives a work permit. These arguments are unconvincing motives for opposing a merit-based allocation method for at least three reasons.

First, US immigration policy offers a menu of methods for residing in the country. For example, permanent residency (green card) policy favors family reunification: family-sponsored preference visas are limited to 226,000 per year, while employment-based green cards are capped at just 140,000. It also offers 50,000 visas based on diversity (country of origin) criteria. The H-1B program, in comparison, was explicitly designed to attract temporary workers in specialty occupations. The Immigration Act of 1990 – which created the program – clarifies that "'specialty occupation' means an occupation that requires (A) theoretical and practical application of a body of highly specialized knowledge, and (B) attainment of a bachelor's degree or higher degree in the specific specialty (or its equivalent)."[16] It would make sense, given the desire for specialized knowledge, for the program to select the most knowledgeable workers. Not only does the current

[16] See Public Law (1990).

program fail to accomplish this, evidence from Kato and Sparber (2013) suggests that it has even reduced the quality of students interested in studying in the US. One interpretation of this finding is that the highest quality perspective students rationally seek education opportunities near labor markets capable of hiring them without restriction upon graduation. It is possible that the current allocation system deters the highest quality workers from considering US employment for similar reasons.

Second, there is great concern among critics that the H-1B program amounts to an indentured servitude scheme.[17] Once an H-1B worker ends his/her employment, he/she must exit the US unless he/she secures another job. This might limit the mobility of H-1B lottery winners. If so, firms gain market power and can underpay H-1B employees and their competing native-born workers alike. One way to assure that foreign-workers are not underpaid – and therefore ensure fair competition with native-born workers – is to develop a permit allocation system that incentivizes firms to pay the marginal product of labor. An allocation method favoring ability does precisely this. By awarding permits to the individuals earning the highest wage (a proxy for ability), it raises the incentives for sponsoring firms to accurately report their willingness to pay (at least to a level surpassing the expected cutoff for successful permit acquisition).

Third, it is reasonable to suspect that the current system favors large employers. Consider two firms, a and b. The two organizations are productive firms competing to hire a specific perspective employee in need of an H-1B permit. The firms make identical offers that would pay the worker a wage equal to his/her marginal product. The difference between firms, however, is that Firm a is a large company with an international presence, and Firm b is smaller and only has operations in New York City. The perspective employee – fully rational – is aware of a $1 - \rho$ probability of losing the H-1B lottery. In the event of a loss, he/she could be relocated to an international office of Firm a, whereas Firm b is unable to make any such arrangement. In practice, Firm b might even decline to make an offer at all if the $1 - \rho$ probability of losing the worker would cause a sizeable dent in the firm's expected staff. Random allocation gives an advantage to large firms that possess the flexibility of absorbing random shocks. Ability-based distribution treats firms of all sizes more equitably.

[17] See concerns expressed in Hira (2010), Matloff (2008, 2013), and Miano (2007), for example. Depew, Norlander, and. Sorensen (2013) and Sparber (2015) offer counter-evidence.

6 Conclusion

With some exceptions, H-1B policy limits the number of work permits for new, temporary, high-education, foreign-born employees to 65,000 per year, plus an additional 20,000 permits to workers who have obtained an advanced degree in the US. Educated workers are widely-recognized as a scarce and productive input into the production process. However, economists, policy-makers, and the popular press continue to debate the distributional effects of this program, such as H-1B implications for the employment opportunities of highly-educated native-born workers.

This paper takes no stance on the optimal number of permits that should be awarded. Instead, it evaluates the method through which available permits are allocated. Though officially awarded on a first-come / first-served basis, strong H-1B demand has led USCIS to distribute permits according to a random lottery conducted among applications received in the first week of eligibility. An alternative method resulting in the same number of foreign workers could instead award permits to the highest-ability applicants as measured by wage offers reflecting workers' marginal product of labor.

To assess the effects of this alternative, this paper builds a model upon a simple production function incorporating low-education, high-education native-born, and high-education foreign-born labor. Workers of different types may be imperfectly substitutable with each other. The theory adopts a restrictive view of the potential gains from immigration by, for example, ignoring potential technological and productivity spillovers caused by the innovative capacity of immigrants.

The effects of policy can be ascertained from simulations that incorporate plausible parameter values and observed data from USCIS, Census, and ACS data, as well as estimates from prior studies. The exercise uncovers several key insights about moving from an allocation method that distributes H-1B permits via random lottery to one that awards permits based upon ability:

- Output and output per capita would rise 0.15% over a six year period. This amount is approximately equal to $26.5 billion in 2014, a level higher than the GDP of about nearly 100 countries.

- Workers without a bachelor's degree would experience small wage gains spread over a large number of individuals.

- Native-born workers with a bachelor's degree are likely to experience small wage losses. Those workers opposed to raising the H-1B cap would also be opposed to increasing the skill level of workers who successfully acquire permits.

- As H-1B demand rises and scarcity becomes more acute, the output gap between allocation methods grows. H-1B demand for fiscal year 2016 implies that output would rise more than 0.20% by switching to a merit-based allocation system.

- The elasticity of substitution between educated native and foreign-born workers – a contested parameter estimate in the literature – plays little to no role in driving the results of the model.

The paper closed by briefly discussing important but unmodeled concerns about changing allocation methods, including the ease of implementation, non-economic policy objectives, and fairness considerations. These issues do not seem sufficient for opposing a change to the allocation system given the potential benefits of doing so.

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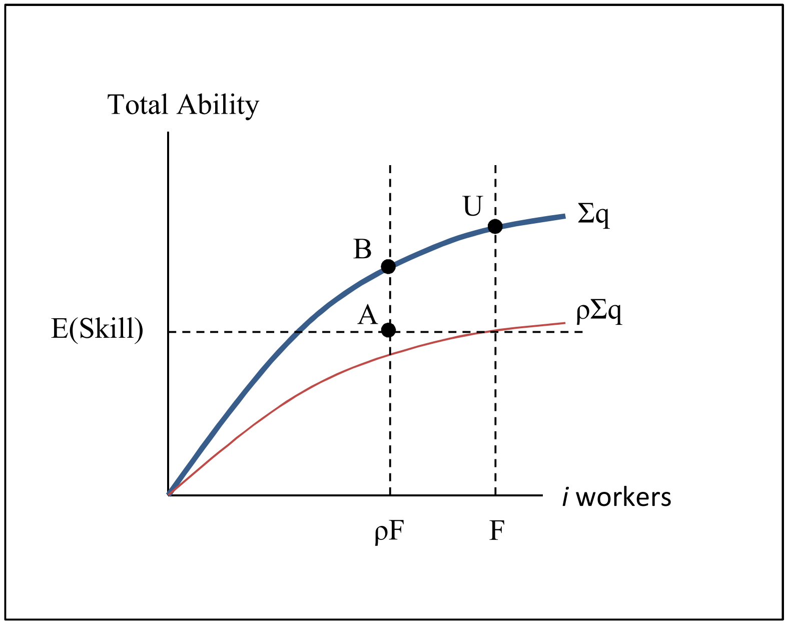
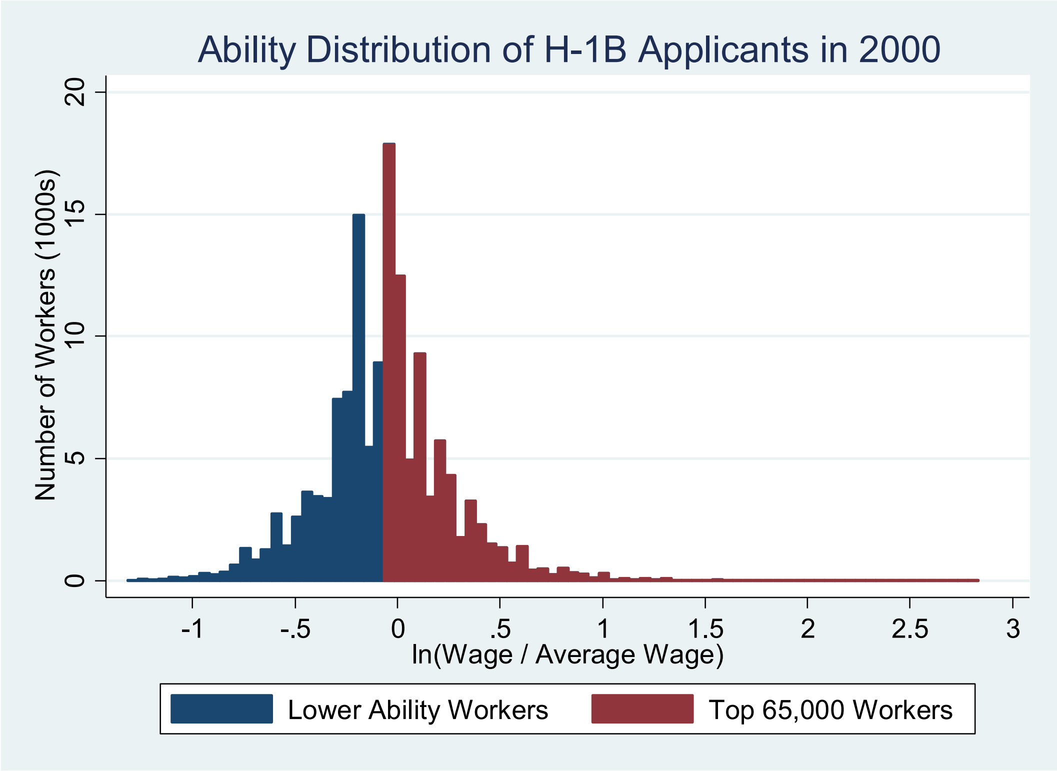
Figure 1: Theoretical Skill Comparison between Lottery (A) and Ability-Based (B) Permit Allocation



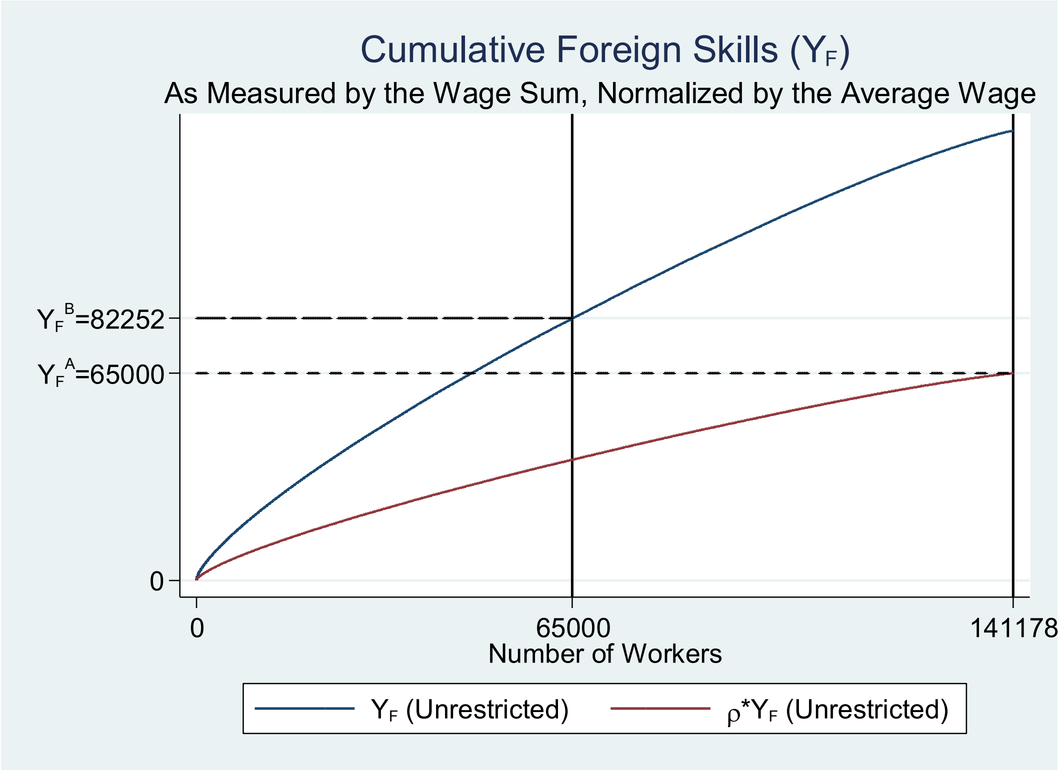
Individual workers (i) are ordered from highest to lowest ability. Σq represents the total ability of workers, which reaches a level marked by *U* at a total of *F* workers. If policy allows only a fraction (ρ) of randomly-selected workers to enter the country, the expected ability is ρΣq. The number of workers and expected ability is marked by *A*. If the workers selected for entry are instead the ρF workers of highest ability, the outcome is marked by point *B*.

Figure 2: Ability Distribution (in Natural Logs) of 2000 H-1B Applicants



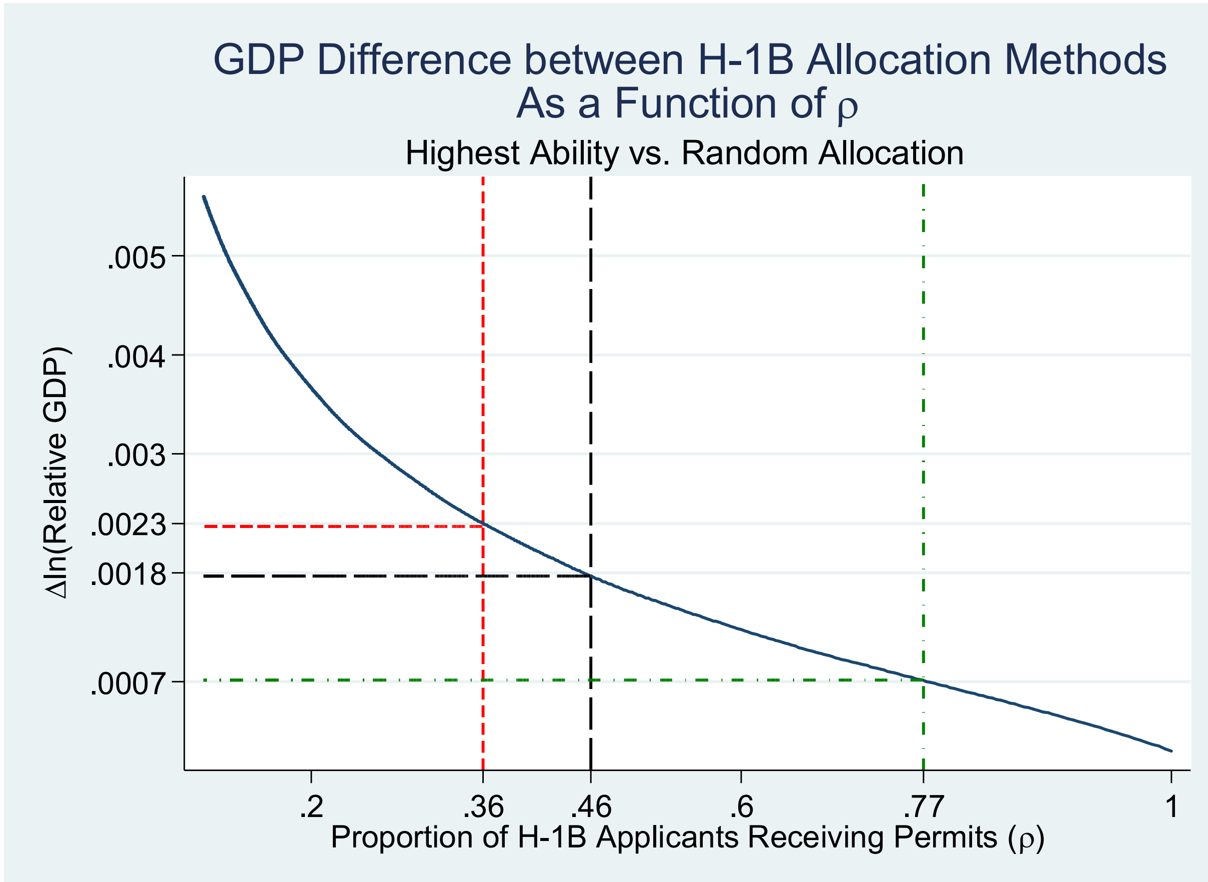
Ability (q) is measured by the wage offer paid to foreign workers, normalized by average wages. The distribution of q from H-1B applications received in the calendar year 2000 follow an approximate log-normal distribution with right skewness. If a cap of 65,000 permits had been implemented in that year with permits distributed to the highest ability workers, the log-ability distribution would have been represented by the maroon shading.

Figure 3: Empirical Skill Comparison between Lottery (A) and Ability-Based (B) Permit Allocation in 2000



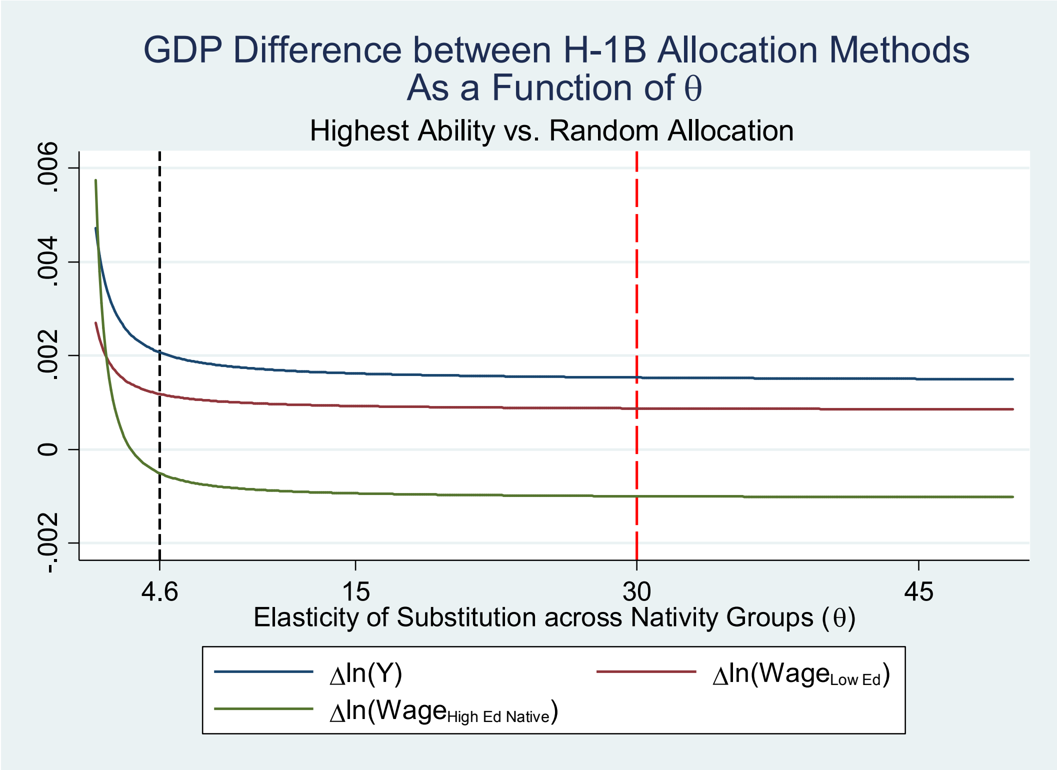
141,178 workers applied for H-1B permits in calendar year 2000. If a quota had capped the number of permits at 65,000, lottery distribution and an average skill level equal to one equivalent worker would together imply a skill contribution of Y_F^A =65,000 from educated foreign workers. If instead the permits were distributed to the 65,000 highest ability workers, the skill contribution would have been Y_F^B =82,252 equivalent workers.

Figure 4: Comparing GDP from Lottery (A) and Ability-Based (B) Permit Allocation Policies as a Function of H-1B Demand



With a fixed number of 85,000 available work permits (including 20,000 for US advanced degree holders), an increase in H-1B demand (*F*) reduces the proportion of applicants who receive permits (ρ). High demand implies a greater number of workers from across the ability spectrum, including those of highest ability. Allocation that favors the highest-ability workers over random selection leads to particularly high skill contributions if more high ability workers are available. Thus, the gap in equivalent workers, and hence GDP, implied by the two policies grows as demand increases (i.e., falls as ρ approaches one).

Figure 5: Comparing GDP from Lottery and Ability-Based Permit Allocation Policies as a Function of Native and Foreign-Born Labor Substitutability



Income shares and parameter values are calibrated to match data and an elasticity (θ) equal to 30. GDP and wage implications at θ=30 match Column (1) of Table 1.

Table 1: Simulated Effects of Moving from a Lottery to an Ability-Based H-1B Permit Allocation Method

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Census/ACS Year	**2000**	**2000**	**2001**	**2001**	**2000**	**2000**	**2013**	**2013**
Skill Distribution Year	**2000**	**2000**	**2001**	**2001**	**2000**	**2000**	**2000**	**2008**
Success Proportion Year	**2000**	**2000**	**2001**	**2001**	**2000**	**2016**	**2016**	**2016**
College-Educated Included in $\widehat{F}$	**All**	**New**	**All**	**New**	**All**	**All**	**All**	**All**
				Assumed Values				
Quota	65,000	65,000	65,000	65,000	85,000	85,000	85,000	85,000
λ	0.56	0.56	0.55	0.55	0.56	0.56	0.47	0.47
η	0.39	0.43	0.39	0.44	0.39	0.39	0.44	0.44
ϕ	0.05	0.01	0.06	0.01	0.05	0.05	0.09	0.09
ρ	0.46	0.46	0.77	0.77	0.60	0.36	0.36	0.36
				Simulated Values				
$\ln(F_B/F_A)$	2.88%	12.62%	1.26%	4.89%	2.52%	4.67%	2.62%	2.49%
$\Delta\ln(Y)$	0.15%	0.12%	0.07%	0.06%	0.13%	0.25%	0.22%	0.21%
$\Delta\ln(W_L)$	0.09%	0.07%	0.04%	0.04%	0.08%	0.14%	0.13%	0.12%
$\Delta\ln(W_N)$	-0.10%	-0.08%	-0.05%	-0.04%	-0.09%	-0.16%	-0.10%	-0.10%
GDP Gain ($Billions, 2014)	26.47	21.49	12.90	10.99	23.13	42.83	38.99	37.05

Table reports simulated effects of moving from a lottery to an ability-based H-1B permit allocation method on the supply of foreign skills (F_B/F_A), output (Y), wages paid to workers without a bachelor's degree (W_L), and native-born workers with a bachelor's degree or more education (W_N). The final row presents the implied gain in GDP given real GDP in 2014 equal to $17.46 trillion. The first rows indicate the year used to compute income shares and employment levels (Census/ACS data), the skill distribution (H-1B data), and the proportion of applicants (ρ) successfully receiving an H-1B (H-1B data). Table assumes θ=30 and σ=1.75. "New" college-educated workers are those residing in the US for six or fewer years.

Table 2: Compositional Effects of Moving from a Lottery to an Ability-Based H-1B Permit Allocation Method, Based on Year 2000 H-1B Applicants

	<u>**Overall Applicants**</u>		<u>**Highest Ability Applicants**</u>		
Source Country	*Rank*	*Share*	*Rank*	*Share*	*Difference in Share*
India	1	0.573	1	0.586	0.014
China	2	0.071	2	0.090	0.019
Philippines	3	0.035	4	0.020	-0.015
United Kingdom	4	0.025	3	0.036	0.010
South Korea	5	0.020	5	0.018	-0.003
Pakistan	6	0.020	6	0.017	-0.003
Taiwan	7	0.018	9	0.015	-0.003
Japan	8	0.017	11	0.009	-0.008
Russia	9	0.015	7	0.015	0.001
France	10	0.013	8	0.015	0.002
Colombia	11	0.011	15	0.006	-0.005
Germany	12	0.011	10	0.013	0.002

Table reports the percentage (share) of applicants from each source country in 2000 overall and from among the 65,000 applicants of highest ability (those with the highest wage offers).