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# Ability Drain: Size, Impact, and Comparison with Brain Drain under Alternative Immigration Policies\*

Maurice Schiff<sup>a</sup>

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## Abstract

Ability drain's (*AD*) impact seems economically significant, with 30% of US Nobel laureates since 1906 being immigrants, and immigrants or their children founding 40% of Fortune 500 companies. Nonetheless, while brain drain (*BD*) and gain (*BG*) have been studied extensively, *AD* has not. I examine migration's impact on ability (*a*), education (*h*), and *productive* human capital or 'skill'  $s = s(a, h)$ , for source country residents and migrants under a) the points system (*PS*) which accounts for *h*, and b) the 'vetting' system (*VS*) which accounts for *s* (e.g., US H-1B program). Findings are: i) Migration reduces (raises) residents' (migrants') average ability, with an ambiguous (positive) impact on average education and skill, and net skill drain, *SD*, likelier than net *BD*; ii) these effects increase with ability's inequality or variance, are greater under *VS* than *PS*, and hurt source countries; iii) the model and two empirical studies suggest that, for educated US immigrants, average  $AD \geq BD$ , with real income about twice home country income; iv) *SD* holds for any *BD*, and also for a very small *AD* (7.4% of our estimate). Policy implications are provided.

Keywords: Migration, points system, vetting system, ability drain, brain drain, brain gain

JEL Code: F22, J24, J61, O15

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## 1. Introduction

While the brain drain literature in the 1970s saw it as hurting migrants' source countries (e.g., Bhagwati and Hamada 1974, Bhagwati 1976),<sup>1</sup> studies in the last two decades have found that it has a number of positive effects, including on brain gain and growth (e.g., Mountford 1997; Vidal 1998; Beine et al. 2001, 2008), fertility (Beine et al. 2013), institutions (Docquier et al. 2016), and many more. Two excellent surveys of brain drain issues are Commander et al. (2004) and Docquier and Rapoport (2012).

This paper focuses on the migration of educated individuals. The studies above that looked at the brain drain's impact on source countries' average level of education by comparing it with the brain gain implicitly assumed that educated migrants are identical and ignored an important source of heterogeneity, namely innate ability.<sup>2</sup> The latter includes the ability to learn, adapt, communicate, motivate, work in groups, and attributes such as entrepreneurship, creativity, responsibility, ambition, intelligence, leadership, work ethic, and more, and which affect individuals' migration and education decisions (see Sections 3-5). With developed countries' higher return to ability, migrants are positively selected for it (Schiff 2006).

Some migrants' performance may be (below) average, while others may become great scientists or great entrepreneurs. For instance, 30 percent of all US Nobel laureates since 1906 (and a greater percentage since 1950) were foreign-born. And over 40 percent of US Fortune 500 companies were founded by immigrants or their children (Partnership for a New American Economy, 2011). Given the difficulty in measuring ability, its economic significance has not been ascertained to date, though these examples suggest that the "ability drain" may be important. Moreover, that a brain drain generates a brain gain while an ability drain does not, raises the latter's relative importance.

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<sup>1</sup> Bhagwati and Rodriguez (1975) provide an overview of a collection of studies dealing with pre-1970s and 1970s' brain drain theory, evidence and policy.

<sup>2</sup> Some innate ability might be further developed later in life, though at a cost (which may well be prohibitive for those poorly endowed with it or with complementary ones). I abstract from this possibility to provide a sharp contrast between this study and previous ones which have typically excluded heterogeneous ability.

The model developed here examines the impact of the points system, “vetting” system and “new” points system. The points system – e.g., Canada’s pre-2015 immigration policy – accounts for prospective migrants’ education (and some other factors, such as age and fluency in the host country’s language), while the “vetting” system – e.g., the US H1-B visa program (when properly run; see Section 7) – also accounts for their ability. The “new points system” – such as those in Australia, Canada and New Zealand – consist of a hybrid of the points and vetting systems.

The model shows, among others, that ability and brain drains are larger under the vetting than under the points system, and that both increase with ability’s heterogeneity, with a greater increase under the former than the latter.<sup>3</sup> Combining the model with a study of the gains for US immigrants from 42 developing countries suggests that the magnitude of the average ability drain,  $AD$ , for those with a college degree or more is about the same as that of the brain drain ( $AD = 1.074BD$ ). This result, together with an empirical study of the brain drain’s impact on average education, suggests that average *productive* human capital or ‘skill’ – a combination of ability and education – falls with migration, a result that even holds for an ability drain that is only 7.4 percent of the levels obtained.

No statistical confidence levels or significance tests are available at this stage. However, note that this does not diminish the potential importance of the results obtained, for two reasons. First, as mentioned above, the conclusion that the brain drain’s average impact on *productive* human capital or skill is negative at all brain drain levels is robust in the sense that it holds even if the ability drain,  $AD$ , is only  $0.079BD$  or 7.4 percent of the average  $AD$  value obtained. Second, this is as far as I know the first study that has attempted to put some numbers on the level of the ability drain. Given the paucity or lack of data on migrants’ and non-migrants’ average ability, this attempt should be viewed as an initial effort that will hopefully lead to further work on this issue.

Though the ability drain and its impact may matter for both source and host countries, I have only found three studies that use a direct measure of ability, or of some element of it, to examine its relationship with migration. Miguel and Hamory (2009) find a higher rural-

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<sup>3</sup> The importance of heterogeneous ability and schooling quality for the brain drain has been emphasized in Haque and Kim (1995) and Haque (2007).

urban migration rate in Kenya for individuals with higher cognitive skills, i.e., for those who scored higher on a primary school test.<sup>4</sup> Kleven et al. (2010) show that the migration response to changes in European countries' taxation rates is greater for the more successful football players, i.e., they are more responsive to changes in incentives. As for attitudes toward risk, Akgüç et al. (2015) and Dustmann et al. (2015) find for rural China that those who are least averse to taking risks and better able to do so are the most likely to migrate. These studies' findings that more able individuals are more likely to migrate is incorporated in the model in Section 2.

Other studies that infer some aspect of ability's relationship with migration include Özden (2006) and Mattoo et al. (2008). These studies examine highly educated US immigrants' success, i.e., whether their occupation is commensurate with their education level or whether they are overeducated. One finding is that migration distance has a positive impact on migrants' degree of success. As the cost of the migration project rises with distance, its expected return must increase to make migration worthwhile, i.e., migrants' ability must increase with distance.

Given the potential importance of the relationship between migration and ability, the paucity of studies on this issue is unfortunate. Except for Clemens, Montenegro and Pritchett (CMP, 2009), which focuses on low-skilled migrants, none of the studies examined ability drain or its impact. This paper contributes to this fledgling literature i) by developing a model to examine migration' impact on average ability and education for both source countries' residents and migrants; and ii) by combining the model, empirics and data in order to obtain a measure of the relative importance of the ability and brain drain, and educated migrants' impact on *productive* human capital or 'skill', a function of both ability and education.

Immigration policies vary across countries and time. Three of them are examined here. Under the points system, a policy that prevailed in Australia, Canada and New Zealand, prospective migrants obtain points according to their level of education (and other criteria,

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<sup>4</sup> Hanushek and Woessmann (2008, 2009) find that cognitive skills strongly impact individual income, its distribution and growth, and Heckman and Rubinstein (2001) and Heckman and Kautz (2012) find that non-cognitive skill are important as well. None of these studies deal with migration.

e.g., age and fluency in the host country’s language). Under the US H1-B visa program, prospective migrants must obtain a job offer and have at least a Bachelor’s degree or equivalent in order to be able to immigrate. I refer to this type of policy as the “vetting” system, given that employers are likely to thoroughly vet potential employees since they benefit from good hiring decisions and pay the cost of bad ones. With points systems leading to unsatisfactory employment outcomes, a number of countries, including Canada, Australia and New Zealand moved to a ‘new’ points system, a hybrid of the (old) points system and the vetting system, thus giving more weight to the labor market demand side.

The paper is organized as follows. Section 2 presents the model and closed economy case. Sections 3 and 4 examine (and compare) the points and vetting systems. Section 5 briefly looks at the new points system, while Section 6 provides a comparison of the size of the ability and brain drains. Section 7 assesses the sign of migration’s impact on productive human capital or ‘skill’. Section 8 presents policy implications and Section 9 concludes.

## 2. Model

Assume individuals’ productive human capital or skill can be observed and valued properly by employers in both countries. This makes sense since, as mentioned earlier, employers benefit from good hiring decisions and pay the cost of bad ones, and are thus likely to thoroughly vet prospective employees in order to assess their skill level.

Denote individual  $i$ ’s ability by  $a_i$ , the source country or country of origin (destination) by “0” (“d”), source country residents’ (migrants’) income by  $y_{0i}$  ( $y_{di}$ ), and the immigration probability by  $p_i \in [0, 1]$ . Skill  $s_i$ , income in both countries, and expected income  $y_i$ , are:

$$s_i = a_i + h_i, y_{0i} = \alpha_0 s_i, y_{di} = \alpha_d s_i, \alpha_0 \in (0, \alpha_d),$$

$$y_i = (1 - p_i)y_{0i} + p_i y_{di} = y_{0i} + p_i(y_{di} - y_{0i}) = [\alpha_0 + p_i(\alpha_d - \alpha_0)]s_i.^5 \quad (1)$$

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<sup>5</sup> I selected as simple a model as possible in order to obtain results that are clear and make intuitive sense. For instance, with  $s_i = a_i + h_i$ , there are no interaction effects between ability and education. Nevertheless, the optimal value of  $h_i$  rises with  $a_i$ , with the exact relationship depending on the host country’s immigration policy (see Sections 3 to 5). One could also specify  $s_i$  as  $s_i = a_i h_i$ . This would complicate the model without affecting the qualitative results – though it would lead to a greater negative (positive) impact on home country residents’ (migrants’) average ability and education.

The cost of education  $h_i$  is  $h_i^2/2$ . Thus, (expected) utility or consumption is:

$$u_i = c_i = y_i - \frac{h_i^2}{2} = [\alpha_0 + (\alpha_d - \alpha_0)p_i]s_i - \frac{h_i^2}{2} \geq 0. \quad (2)$$

Individuals maximize expected utility by selecting  $h_i$ , subject to their innate ability and the host country's immigration policy. For comparison purposes,  $p_i$  is such that the source country's expected migration rate  $P$  is identical under the three policies examined, i.e.,  $P_p = P_v = P_n = P$ , where  $P = \int_0^{\bar{a}} p_i f(a_i) da_i$ ,  $f(a_i)$  denotes  $a_i$ 's probability density function, and  $p(v)(n)$  denote the points (vetting) (new vetting) system. Gross average ability,  $A^G = \int_0^{\bar{a}} a_i f(a_i) da_i$ , is the source country's average ability before migration takes place. Individuals take into account the fact that the migration probability depends on education under the points system, i.e.,  $p_i = p_i(h_i)$ , and depends on both education and ability under the vetting system, i.e.,  $p_i = p_i(a_i, h_i)$ .<sup>8</sup> Given that source countries have both migrant and non-migrants, interior solutions are assumed throughout.

### 2.1. Closed Economy

Before turning to the points and vetting systems, results are provided for the 'closed economy' immigration policy. In that case, the migration probability  $p_i = 0$ . Denoting the variables in this case with subscript "c", equation (2) becomes:

$$c_{ic} = y_{ic} - \frac{h_{ic}^2}{2} = \alpha_0 s_{ic} - \frac{h_{ic}^2}{2} = \alpha_0 (a_i + h_{ic}) - \frac{h_{ic}^2}{2} \geq 0. \quad (3)$$

<sup>6</sup> A large number of empirical studies show that investment in education exhibits diminishing returns. Given that income is a linear function of education in (1), assuming a quadratic education cost function results in diminishing returns to education (with a negative second derivative of  $c_i$  with respect to education).

<sup>7</sup> Of the 42 sample countries in the empirical analysis (provided in Section 6 and the Appendix), 55 percent are either low-income or lower-middle-income countries (defined by the World Bank for 2017 as countries with a per capita income below US \$4,036 in 2015) and about two thirds of the sample countries had a per capita income of US \$5,000 or less in 2015. A quadratic education cost seems reasonable for those countries as a constraint is likely to prevail on the number and qualifications of individuals teaching students who are completing a bachelor's degree or more – which is the level of education for which the relationship between ability drain and brain drain is derived (as shown in the Appendix).

<sup>8</sup> Thus, average education and skill levels are higher for migrants than for residents, i.e., migrants are positively selected for both ability  $a_i$  and education  $h_i$ . As Docquier and Marfouk (2006) show for education, the share of the highly educated in South-North migrants is three times that among the South's residents, and the ratio is larger for poor, landlocked and island countries (e.g., 15 for Sub-Saharan Africa).

Maximizing  $c_{ic}$  with respect to  $h_{ic}$ , the values for  $h_{ic}$ , its average  $H_c$ , average ability  $A_c$ , skill  $s_{ic}$ , average skill  $S_c$  and its variance  $V(s_{ic})$ , consumption  $c_{ic}$  and its average  $C_c$ , are:

$$\begin{aligned} h_{ic} = H_c = \alpha_0, A_c = A^G, s_{ic} = a_i + \alpha_0, V(s_{ic}) = V(a_i), S_c = A^G + \alpha_0, \\ c_{ic} = \alpha_0 \left( \frac{\alpha_0}{2} + a_i \right), C_c = \alpha_0 \left( \frac{\alpha_0}{2} + A^G \right). \end{aligned} \quad (4)$$

### 3. Points System

Under the points system (e.g., Canada's pre-2015 policy), applicants receive points for education but not for ability. The immigration probability  $p_{ip}$  is  $\pi h_{ip}$ , to which a constant,  $\pi A^G$ , is added to ensure the average immigration probability or average migration rate is identical under the points and vetting systems, i.e.,  $P_p = P_v = P$ , which is assumed for comparison purposes (as shown later).

The immigration probability and consumption in this case are:

$$p_{ip} = \pi(A^G + h_{ip}), c_{ip} = [\alpha_0 + \pi(\alpha_d - \alpha_0)(A^G + h_{ip})](a_i + h_{ip}) - \frac{h_{ip}^2}{2} \geq 0, \pi > 0. \quad (5)$$

Defining  $\phi \equiv 1 - 2\pi(\alpha_d - \alpha_0)$  and  $\lambda \equiv \frac{\pi(\alpha_d - \alpha_0)}{\phi}$ ,  $h_{ip}$ ,  $H_p^G$ ,  $s_{ip}$ ,  $S_p^G$ ,  $p_{ip}$  and  $P_p$  are: given by:

$$\begin{aligned} h_{ip} = \frac{\alpha_0}{\phi} + \lambda(a_i + A^G), H_p^G = H_v^G = H^G = \frac{\alpha_0}{\phi} + 2\lambda A^G, s_{ip} = \frac{\alpha_0 + a_i}{\phi} - \lambda(a_i - A^G), \\ S_p^G = S_v^G = S^G = A^G + H^G = \frac{1}{\phi}(\alpha_0 + A^G), \\ p_{ip} = \pi \left[ \frac{\alpha_0 + A^G}{\phi} + \lambda(a_i - A^G) \right], P_p = \frac{\pi}{\phi}(\alpha_0 + A^G) = P, \end{aligned} \quad (6)$$

where  $\phi > 0$  is the second-order condition,  $S_p^G = S^G = A^G + H^G$ , where  $H^G$  denotes the average 'gross' level of education, i.e., the level that includes the brain gain (i.e.,  $H^G - H_0 = H^G - \alpha_0$ ) generated by the points system, but before migration takes place, i.e., excluding the brain drain.

As shown in (6),  $P_v = P_p = P$  implies  $S_v^G = S_p^G = S^G$ , as the former are a multiple (by  $\pi$ ) of the latter. This implies in turn that  $H_v^G = H_p^G = H^G$  (compare (6) and (13) in Section 5)



and  $S^G = A^G + H^G$ . Also, the brain gain is given by  $H_p^G - H_0 = 2\lambda(A^G + \alpha_0)$ . Since  $\frac{1}{\phi} = \frac{\phi + 2\pi(\alpha_d - \alpha_0)}{\phi} = 1 + 2\lambda$ , we have  $V(s_{ip}) = V\left[\frac{\alpha_0 + a_i}{\phi} + \lambda(A^G - a_i)\right] = V\left[\left(\frac{1}{\phi} - \lambda\right)a_i\right] = V[(1 + \lambda)a_i] = (1 + \lambda)^2V(a_i) = (1 + \lambda)^2V(s_{i0}) > V(s_{i0})$ . Thus, the points system raises the variance of individual skills or skill inequality, relative to the closed economy case. This is also apparent from the derivatives  $\frac{\partial s_{i0}}{\partial a_i} = 1$  and  $\frac{\partial s_{ip}}{\partial a_i} = 1 + \lambda$ .

The host country's policy change from a closed economy to a points system raises the expected return on education, with an impact on residents' education and skill  $h_{ip} - h_{i0} = s_{ip} - s_{i0} = \lambda(a_i + A^G + 2\alpha_0) > 0$ . However, residents' *average* skill need not increase because education increases with ability, which raises the migration probability. Thus, the migration rate is higher (lower) at higher (lower) ability and education levels, which reduces both average ability and average education.

Denote a variable  $x_{ip}$ 's population-weighted average value by  $X_p \equiv \frac{1}{1-P} \int_0^{a_M} x_{ip}(1 - p_{ip})f(a_i)da_i$  for source-country residents, by  $X_p^M \equiv \frac{1}{P} \int_0^{a_M} x_{ip}p_{ip}f(a_i)da_i$  for migrants, by  $X_{pN} \equiv (1 - P)X_p + PX_p^M$  for all natives, and by  $S_p^G$  ( $S_p^G = A^G + H_p^G$ ) for the gross (pre-migration) average skill. Solutions for  $X_p$ ,  $X_p^M$  and  $X_{pN}$  ( $X = A, H, S$ ) are:

$$\begin{aligned} A_p &= A^G - \frac{\pi\lambda}{1-P}V(a_i), A_p^M = A^G + \frac{\pi\lambda}{P}V(a_i), A_{pN} = A^G, \\ H_p &= H^G - \frac{\pi\lambda^2}{1-P}V(a_i), H_p^M = H^G + \frac{\pi\lambda^2}{P}V(a_i), H_{pN} = H^G, \\ S_p &= S^G - \frac{\pi(\lambda + \lambda^2)}{1-P}V(a_i), S_p^M = S^G + \frac{\pi(\lambda + \lambda^2)}{P}V(a_i), S_{pN} = S^G. \end{aligned} \quad (7)$$

As shown in (7), the brain drain is  $\lambda$  times the ability drain, i.e.,  $BD = \lambda AD$ , the reason being that  $a_i$  enters into  $h_i$  with coefficient  $\lambda$  (see (6)). Since  $\lambda < 1$  (footnote 8), the ability drain is larger than the brain drain. And from (6),  $V(h_{ip}) = \lambda^2V(a_i)$ , i.e., the variance of  $a_i$  is greater than that of  $h_{ip}$ . Results are also shown in Table 1 below.

Another result from (7) is that residents' (migrants') population-weighted average ability, education and skill levels fall (rise) with inequality in the source country's ability

distribution, as measured by the variance of  $a_i$ . Thus, the host country benefits from greater inequality in ability as it raises the average skill level of its immigrants. And, as shown above, the policy itself also raises inequality in migrants' source country. Finally, the variance of  $a_i$  does not affect natives' average ability, education or skill as its impact on residents' and migrants' values cancel each other out. Table 1 presents the impact of the points system on the ability, brain and skill drain and on the brain and skill gain, relative to the closed economy case.

What is the policy's impact on ability, education and skill, relative to a closed economy policy ( $\pi = 0$ ), i.e.,  $\Delta X_p \equiv X_p - X_0$  ( $X = A, H, S$ )? Since there is no ability gain, average ability declines. Moreover, given that  $H_0 = \alpha_0$ ,  $S_0 = A^G + \alpha_0$ ,  $H^G = \frac{\alpha_0}{\phi} + 2\lambda A^G$ , and  $S_p = A^G + H_p^G - \frac{\pi(\lambda+\lambda^2)}{1-p} V(a_i)$ , we have:

**Table 1: Points System– Source Country's Ability, Education and Skill: Net Gain or Net Drain? <sup>a</sup>**

	<u>Ability</u> (1)	<u>Education</u> (2)	<u>Skill</u> (1 + 2)	<u>Ratio</u> (2)/(1)
Drain (i)	$-\frac{\pi\lambda}{1-p} V(a_i)$	$-\frac{\pi\lambda^2}{1-p} V(a_i)$	$-\frac{\pi(\lambda+\lambda^2)}{1-p} V(a_i)$	$\lambda$
Gain (ii)	--	$2\lambda(A^G + \alpha_0)$	$2\lambda(A^G + \alpha_0)$	--
Net Gain (i) + (ii)	$-\frac{\pi\lambda}{1-p} V(a_i)$	$2\lambda(A^G + \alpha_0) - \frac{\pi\lambda^2}{1-p} V(a_i) \gtrless 0$	$2\lambda(A^G + \alpha_0) - \frac{\pi(\lambda+\lambda^2)}{1-p} V(a_i) \gtrless 0$	--
Variance	$V(a_i)$	$\lambda^2 V(a_i)$	$(1 + \lambda)^2 V(a_i)$	$\lambda^2$

<sup>a</sup>: Results are relative to the closed economy case.

$$\Delta A_p \equiv A_p - A^G = -\frac{\pi\lambda}{1-p}V(a_i) < 0, \Delta H_p \equiv H_p - H_0 = 2\lambda(\alpha_0 + A^G) - \frac{\pi\lambda^2}{1-p}V(a_i) \geq 0, \\ \Delta S_p \equiv S_p - S_0 = 2\lambda(\alpha_0 + A^G) - \frac{\pi(\lambda+\lambda^2)}{1-p}V(a_i) \geq 0, \Delta S_p < \Delta H_p. \quad (8)$$

Thus, the policy's impact on ability (education and skill) is negative (ambiguous). Since  $\Delta S_p = \Delta H_p + \Delta A_p = \Delta H_p - \frac{\pi\lambda}{1-p}V(a_i) < \Delta H_p$ , the policy's impact on skill is more likely to be negative than its impact on education. Some studies (e.g., Beine et al. 2008) find that a net brain gain is more likely in larger source countries ( $\Delta H_p > 0$ ), in which case  $\Delta S_p < 0 < \Delta H_p$  is a distinct possibility. They also find that most countries exhibit a net brain drain ( $\Delta H_p < 0$ ), implying a larger net skill drain, i.e.,  $\Delta S_p < \Delta H_p < 0$ . On the other hand, the points system raises migrants' ability, education and skill, with:

$$\Delta A_p^M \equiv A_p^M - A^G = \frac{\pi\lambda}{p}V(a_i) > 0, \Delta H_p^M \equiv H_p^M - H_0 = 2\lambda(\alpha_0 + A^G) + \frac{\pi\lambda^2}{p}V(a_i) > 0, \\ \Delta S_p^M \equiv S_p^M - S_0 = 2\lambda(\alpha_0 + A^G) + \frac{\pi(\lambda+\lambda^2)}{p}V(a_i) > 0. \quad (9)$$

Results for source country's natives as a whole (denoted by subscript  $N$ ) is:

$$H_{pN} - H_0 = S_{pN} - S_0 = 2\lambda(\alpha_0 + A^G) > 0, A_{pN} - A_0 = 0. \quad (10)$$

In other words, natives' average education and skill levels are higher under the points system than under a closed economy, while their average ability is unchanged.

Finally, note from (7) that both the brain and ability drain vanish ( $BD = AD = 0$ ) under homogenous ability, i.e., for  $V(a_i) = 0$ .

#### 4. Vetting System

I refer to an immigration policy that takes both ability and education into account as a "vetting system," with variables designated by subscript 'v'. One such system is the US H1-B visa program, where employers' hiring decisions determine whether or not immigration takes place.<sup>9</sup> Probability  $p_{iv}$  and consumption under this policy  $c_{iv}$  are:

<sup>9</sup> This assumes a well-functioning visa program, which is not necessarily the case. See Section 8 for more on this issue.

$$\begin{aligned}
p_{iv} &= \pi(a_i + h_{iv}) = \pi s_{iv}, \quad c_{iv} = y_{iv} - \frac{h_{iv}^2}{2} = [\alpha_0 + \pi s_{iv}(\alpha_d - \alpha_0)]s_{iv} - \frac{h_{iv}^2}{2} \\
&= \alpha_0 s_{iv} + \pi(\alpha_d - \alpha_0)s_{iv}^2 - \frac{h_{iv}^2}{2} \geq 0, \quad \pi > 0.
\end{aligned} \tag{11}$$

Maximizing  $c_{iv}$  with respect to  $h_{iv}$ , the solutions for  $h_{iv}$ ,  $s_{iv}$ ,  $p_{iv}$ , and  $h_{iv} - h_{ip}$  are:

$$\begin{aligned}
h_{iv} &= \frac{\alpha_0}{\phi} + 2\lambda a_i, \quad s_{iv} = \frac{1}{\phi}(a_i + \alpha_0) = \frac{s_{i0}}{\phi}, \quad p_{iv} = \frac{\pi}{\phi}(a_i + \alpha_0) = \frac{\pi s_{i0}}{\phi}, \\
p_{iv} - p_{ip} &= \pi(1 + \lambda)(a_i - A^G) \geq 0 \Leftrightarrow a_i \geq A^G, \\
h_{iv} - h_{ip} &= s_{iv} - s_{ip} = \lambda(a_i - A^G) \geq 0 \Leftrightarrow a_i \geq A^G.
\end{aligned} \tag{12}$$

Thus, high- (low-) ability individuals attain a higher (lower) education level and have a higher immigration probability under the vetting than under the points system, resulting in greater education and skill inequality (or variance) under the former, as shown next.

From (12),  $s_{iv} = \frac{s_{i0}}{\phi} = (1 + 2\lambda)s_{i0} > s_{i0}$ , i.e., the vetting system results in greater residents' individual skill relative to the no-migration case. From (10), we have:  $V(s_{iv}) = \frac{V(s_{i0})}{\phi^2} = (1 + 2\lambda)^2 V(s_{i0}) > V(s_{i0}) = V(a_i)$ . Since  $V(s_{ip}) = (1 + \lambda)^2 V(s_{i0})$ , it follows that  $V(s_{iv}) = \frac{(1+2\lambda)^2}{(1+\lambda)^2} V(s_{ip}) > V(s_{ip})$ , with  $\frac{V(s_{iv})}{V(s_{ip})} \in (1, \frac{16}{9}]$  for  $\lambda \in (0, .5]$ . Moreover,  $V(h_{iv}) = 4\lambda^2 = 4V(h_{ip})$ . Thus, inequality of residents' skill is greater under the vetting system. The solution for  $H_v^G$  and  $P_v$  is:

$$H_v^G = \frac{\alpha_0}{\phi} + 2\lambda A^G = H_p^G = H^G, \quad S_v^G = S_p^G = S^G, \quad P_v = \frac{\pi}{\phi}(\alpha_0 + A^G) = \frac{\pi S_0}{\phi} = P_p = P. \tag{13}$$

Solutions for residents, migrants and natives' average ability, education and skill, are:

$$\begin{aligned}
A_v &= A^G - \frac{\pi}{\phi(1-P)} V(a_i), \quad A_v^M = A^G + \frac{\pi}{\phi P} V(a_i), \quad A_{vN} = A^G; \\
H_v &= H^G - \frac{2\pi\lambda}{\phi(1-P)} V(a_i), \quad H_v^M = H^G + \frac{2\pi\lambda}{\phi P} V(a_i), \quad H_{vN} = H^G; \\
S_v &= S^G - \frac{\pi}{\phi^2(1-P)} V(a_i), \quad S_v^M = S^G + \frac{\pi}{\phi^2 P} V(a_i), \quad S_{vN} = S^G,
\end{aligned}$$

$$A_v^M - A_v = \frac{\pi}{\phi^P(1-P)} V(a_i), H_v^M - H_v = \frac{2\pi\lambda}{\phi^P(1-P)} V(a_i), S_v^M - S_v = \frac{\pi}{\phi^{2P}(1-P)} V(a_i), \quad (14)$$

As  $AD = \frac{\pi}{\phi(1-P)} V(a_i)$  and  $BD = \frac{2\pi\lambda}{\phi(1-P)} V(a_i)$ , it follows that  $AD/BD = 1/2\lambda$  and, with  $\lambda \leq \frac{1}{2}$ , one would expect  $AD/BD \geq 1$ .<sup>10</sup> The results are summarized in Table 2.

Residents (migrants') average education, ability and skill levels decline (increase) with inequality in the ability distribution under both the points and vetting systems, though migration's quantitative impact is greater under the latter. Denote ability drain by  $AD_v$  ( $AD_p$ ) under the vetting (points) system. From (14),  $AD_v = \frac{\pi}{\phi(1-P)} V(a_i) = \frac{\pi(1+2\lambda)}{(1-P)} V(a_i) > AD_p = \frac{\pi\lambda}{1-P} V(a_i)$ , and  $BD_v = \frac{2\pi\lambda}{\phi(1-P)} V(a_i) > BD_p = \frac{\pi\lambda^2}{1-P}$ . Hence,  $SD_v = AD_v + BD_v = \frac{\pi(1+2\lambda)}{\phi(1-P)} V(a_i) = \frac{\pi(1+2\lambda)^2}{1-P} V(a_i) > SD_p = \frac{\pi(\lambda+\lambda^2)}{1-P} V(a_i)$ . Similarly, migrants' education, ability and skill gains are greater under the vetting than under the points system.

Note also that, though  $V(a_i)$  affects both  $AD$  and  $BD$ , it has no impact on  $AD/BD$  under either the points or vetting systems (see Table 2). Comparing average levels of education, ability and skill, for residents, migrants and all natives, under the two systems, we have:

$$\begin{aligned} H_v &= H_p - \frac{\pi(2\lambda + 3\lambda^2)}{1-P} V(a_i), H_v^M = H_p^M + \frac{\pi(2\lambda + 3\lambda^2)}{P} V(a_i), H_{vN} = H_{pN} \\ A_v &= A_p - \frac{\pi(1 + \lambda)}{1-P} V(a_i), A_v^M = A_p^M + \frac{\pi(1 + \lambda)}{P} V(a_i), A_{vN} = A_{pN}, \\ S_v &= S_p - \frac{\pi(1 + 3\lambda + 3\lambda^2)}{1-P} V(a_i), S_v^M = S_p^M + \frac{\pi(1 + 3\lambda + 3\lambda^2)}{P} V(a_i), S_{vN} = S_{pN}. \end{aligned} \quad (15)$$

From (14), and from  $H_0 = \alpha_0$  and  $S_0 = \alpha_0 + A^G$  (as shown in (4)), it follows that whether the vetting system results in a net brain and skill gain or drain is ambiguous, though net

<sup>10</sup> Proof that  $\lambda \leq \frac{1}{2}$ : Residents' actual (as opposed to expected) consumption under the vetting system is  $c_{iv}^A = \alpha_0 S_{iv} - \frac{h_{iv}^2}{2} = \alpha_0 \left( \frac{\alpha_0}{2} + a_i \right) - 2\lambda^2 (\alpha_0 + a_i)^2 \geq 0$ , and thus  $\lambda^2 \leq \psi = \frac{\alpha_0^2 + 2a_i\alpha_0}{4(a_i + \alpha_0)^2} = \frac{1}{4} - \frac{a_i^2}{4(a_i + \alpha_0)^2}$ , which reaches a maximum,  $\psi_M = \frac{1}{4}$  at  $a_i = 0$ , so that  $\psi \leq \frac{1}{4}$  and  $\lambda^2 \leq \psi \leq \frac{1}{4}$ , i.e.,  $\lambda \leq \frac{1}{2}$ . QED.

brain drain and skill drains are more likely under the vetting than under the points system, and the ability drain is greater under the former. Since  $P_p = P_v = P$  by construction, it follows that natives as a whole have the same average ability, education and skill levels under the points and vetting systems.

The host country benefits from greater inequality in the source country's ability as it raises migrants' average skill level, and more so under the vetting than under the points system. Moreover, the policies themselves raise inequality, and more so under the vetting system.

**Table 2: Vetting System – Non-migrants' Ability, Brain and Skill: Net Gain or Net Drain? <sup>a</sup>**

	<u>Ability</u> (1)	<u>Education</u> (2)	<u>Skill</u> (1 + 2)	<u>Ratio</u> (2)/(1)
Drain (i)	$-\frac{\pi}{\phi(1-P)}V(a_i).$	$-\frac{2\pi\lambda}{\phi(1-P)}V(a_i).$	$-\frac{\pi}{\phi^2(1-P)}V(a_i).$	$2\lambda \leq 1$
Gain (ii)	--	$2\lambda(A^G + \alpha_0).$	$2\lambda(A^G + \alpha_0).$	--
Net Gain (i) + (ii)	$-\frac{\pi}{\phi(1-P)}V(a_i).$	$2\lambda(A^G + \alpha_0) - \frac{2\pi\lambda}{\phi(1-P)}V(a_i) \geq 0.$	$2\lambda(A^G + \alpha_0) - \frac{\pi}{\phi^2(1-P)}V(a_i) \geq 0.$	--
Variance	$V(a_i)$	$4\lambda^2V(a_i)$	$(1 + 2\lambda)^2V(a_i)$	$4\lambda^2 \leq 1$

<sup>a</sup>: Results are relative to the closed economy case.

## 5. New Points System

In order to attract immigrants with skills that better reflect labor market needs, various host countries, including Australia, New Zealand and Canada, moved to a new points system (denoted by subscript  $n$ ), consisting of a combination of the (old) supply-driven points system and the demand-driven vetting system. Denoting the weights of the old points system and vetting system in the new points system by  $\omega$  and  $1 - \omega$ , respectively, with  $c_{in} = \omega c_{ip} + (1 - \omega)c_{iv}$ , it can be shown that the solutions are equal to the weighted

average of the solutions under the points and vetting systems, except for the variance. The weighted average of the variance of  $h_{ip}$  (for the points system) and  $h_{iv}$  (for the vetting system) is greater than the variance of  $h_{in}$  (for the new points system), and the same holds for the skill variance.

## 6. Comparing Ability and Brain Drain

This section examines the relationship between the ability drain,  $AD$ , and the brain drain,  $BD$ . Educated immigrants typically enter the US under the H1-B visa program, i.e., they must obtain a job offer and must have a Bachelor's Degree or more in order to qualify. As discussed in the Introduction and in Section 4, they are likely to be thoroughly vetted with regard to both their education and their ability, as employers obtain the benefits of judicious hiring decisions and bear the cost of hiring mistakes. Thus, a vetting system policy is assumed in the analysis.

The analysis is based on the model and on empirical results in CMP (2009) who use a database on PPP-adjusted wages and other characteristics for two million individuals in the US and 42 developing source countries, based on the US Census in 2000 and household surveys in the 42 source countries for 2000 or close to it, in order to obtain estimates of the impact of migration on migrants' income.

CMP find that correcting for selection on observables – i.e., for the difference between migrants' and non-migrants' education level – reduces migrants' average income, relative to their income in the country of origin, from  $y_d = 7.99$  to  $y'_d = 5.11 = 0.64y_d$ , or by  $0.36y_d$  (see Appendix). They then use several approaches, based on microeconomic and macroeconomic evidence, to obtain an estimate of parameter  $\eta$  in order to capture the impact of selection on unobservable ability on the “place premium,” i.e., on the ratio of migrants' income in the US to their income back home,  $y''_d$ , where  $y''_d = y'_d/\eta$ .

The value of  $\eta$  obtained by CMP is for migrants with nine years of education. As CMP mention, selection on unobservable traits – i.e., ability – is unlikely to be strong for immigrants with low or moderate education. On the other hand, immigrants who enter the US under the H1-B visa program must have at least a Bachelor's degree or sixteen years

of education, and the model is used to adjust the value of  $\eta$  in order to reflect this difference. The ratio of ability drain to brain drain,  $AD/BD$ , is derived for the range of parameter values in order to obtain an overall average for it.

The main results for the 42 source countries' average values are presented in Section 6.1. The relationship between source countries' income and the ratio  $AD/BD$  derived from the model, as well as its relationship with the brain drain derived from data on the 42 source countries and the US, are presented in Section 6.2. Derivation of the results is provided in the Appendix.

### 6.1. Average for the forty-two developing source countries

The main findings for the 42 countries as a whole are:

- i) The average value of  $AD/BD$  is 1.074.
- ii) US immigrants from developing source countries with at least a Bachelor's degree raise their income on average by slightly over 102 percent.
- iii) Education is endogenous and determined by ability (equation (12)). And, irrespective of their relative size, ability's heterogeneity is the cause of both the ability and the brain drain – as  $AD = BD = 0$  under homogeneous ability (i.e., for  $V(a_i) = 0$  (see equation (14) or Table 2).

The result that the ability drain is 1.074 times the brain drain under the vetting system is consistent with the findings of the model that the ratio  $AD/BD = 1/2\lambda$  is greater than or equal to one (see Table 2).

### 6.2. Country groupings

As shown in equation (1), the income of source country individual  $i$  is  $y_{0i} = \alpha_0 s_i$ , where parameter  $\alpha_0$  reflects the level of technology, institutional development, etc. Recall that under the vetting system,  $AD = -\frac{\pi}{\phi(1-P)}V(a_i)$  and  $BD = -\frac{2\pi\lambda}{\phi(1-P)}V(a_i)$ , with the ratio  $AD/BD = 1/2\lambda$ , and with  $\lambda$  defined as  $\lambda \equiv \frac{\pi(\alpha_d - \alpha_0)}{\phi} = \frac{\pi(\alpha_d - \alpha_0)}{1 - 2\pi(\alpha_d - \alpha_0)}$ . Thus,  $\frac{\partial \lambda}{\partial \alpha_0} = -\frac{\pi}{\phi^2}$  and  $\frac{\partial(AD/BD)}{\partial \alpha_0} = \frac{\partial(AD/BD)}{\partial \lambda} \cdot \frac{\partial \lambda}{\partial \alpha_0} = \frac{\pi}{2\lambda^2 \phi^2} > 0$ , i.e.,  $AD$  increases relative to  $BD$  as source countries' income increases.



A contributing factor would be a negative impact of source countries' income on the brain drain. Data on the correction of US immigrants' income for selection on education, i.e., for the brain drain's impact on their income, are available for each of the 41 countries. They show that countries and regions with the largest  $BD$  impact – i.e., with the highest selection on ability – tend to be poorer than those with the smallest impact. For instance, the five countries with the largest  $BD$  impact are Ethiopia (.666), India (.662), Sri Lanka (.612), Nepal (.600) and Uganda (.584), with an average impact of .612. The five countries with the smallest  $BD$  impact are Chile (.030), Jamaica (.045), Mexico (.056), Peru (.117) and Argentina (.130), with an average impact is .076. Thus, the former group's  $BD$  is eight times that of the latter.

The region with the greatest  $BD$  impact is South Asia (.556), followed by Sub-Saharan Africa (.415), South-East Asia (.400), the Middle East and North Africa (.328), the Caribbean (.276), Central America (.219) and South America (.176). The average impact for Latin America and the Caribbean – which includes the latter three regions plus Mexico – is .209. These results suggest that the brain drain declines with source countries and regions' income.

## 7. Net Skill Gain or Net Skill Drain?

Beine et al. (2003, 2008) estimate the impact of migration of college-educated individuals on the average level of education in their country of origin, i.e., they estimate the net brain gain,  $NBG$  or difference between the brain gain and the brain drain. The third-order polynomial reduced-form relationship between the net brain gain (measured as the change in the domestic proportion of college graduates) and the brain drain, depicted in Figure 1 of their paper, is  $NBG = 0.0788BD - 0.4587BD^2 + 0.02746BD^3$ , with  $NBG > (<) 0$  for  $BD < (>) 0.18$ . Thus,  $NBG$  is positive (negative) for the larger (smaller) countries. They also find that  $NBG$ 's global average is positive.

With  $AD = \delta BD$  and  $\delta = 1.0742$  for migrants with at least a Bachelor's degree, we have  $AD = 1.0742BD$ . Thus, the net skill gain,  $NSG = NBG - AD = NBG - 1.0742BD$ . Assuming Beine et al.'s result holds for the 42 source countries as well, it follows that  $NSG = -.9954BD - 0.4587BD^2 + 0.02746BD^3 < 0, \forall BD \in (0,1]$ . In other words,

migration results in an average net skill drain or a loss in the average level of *productive* human capital or skill. Thus, while Beine et al. (2003, 2008) found a positive net brain gain for  $BD < 0.18$ , once ability drain is accounted for, the change in the average skill level is negative for any positive  $BD$ .

Finally, note that a coefficient of  $BD$ ,  $0.0788 - \delta$ , equal to zero is a sufficient condition for  $NSG < 0, \forall BD \in (0, 1]$ . Thus,  $AD = 0.0788BD$  is a sufficient condition for  $NSG < 0, \forall BD \in (0, 1]$ . In other words, an ability drain that is as small as 7.5 percent of the value obtained in this paper ( $\delta = 1.0742$ ) results in a net skill drain, for any positive  $BD$ .

## **8. Policy implications**

Studies of the brain drain have found that a number of countries, particularly the larger ones, experience a net brain gain (e.g., Beine et al. 2008). As migrants are also positively selected for ability, migration results in an ability drain. Thus, countries might exhibit a net brain gain together with a net skill drain, with a net skill gain requiring on average a brain gain greater than twice the brain drain. The situation is obviously worse for countries experiencing a net brain drain – including especially small poor island countries – as they typically exhibit a high brain drain in addition to the ability drain.

The vetting system, such as the US H1-B visa program, was shown to generate a larger ability drain and a larger net brain drain (or a smaller net brain gain) than the points system, thereby further raising the likelihood of a net skill drain. The fact that several immigration countries, including Australia, New Zealand and Canada, reformed their immigration policy from the old to a new points system that includes elements of the vetting system, raises the urgency for source countries of devising market-friendly policies to minimize the skill drain and collaborating with host countries in order to raise both countries' migration benefits (see below).

The model shows that host countries benefit more from the 'vetting system' than from the new points systems (assuming that vetting systems such as the H1-B visa program are implemented as was intended; see below) and more from the new points system than from its early versions. Given the problems associated with the points system and the reforms

undertaken in a number of host countries, it is somewhat surprising that this system was considered in the US Senate's 2013 Immigration Bill.

Host countries concerned with source countries' development could provide H1-B visas or other skilled immigrant visas whose extension or conversion to permanent status would require applicants to make some contribution to their home country, such as imparting their acquired knowledge to home country individuals – whether by working there for some period of time, regular visits of shorter duration, teaching via the internet, through some business relationship, or other.<sup>11</sup> One possibility is for source country universities to allow joint appointments with host country ones. Such a policy has been successfully pursued by Israeli universities, where top scientists and other academics often hold positions in both Israel and the US or Europe.

Similarly, foreign students from developing countries often receive financial support from some public or private agency in their home country (e.g., government agency, private employer, university) or in the host country (e.g., university, foundation). Source and host countries could cooperate to ensure that foreign students who obtain their degree and apply for an immigrant visa spend some time in the source country (which is the case for foreign students who enter the US with a J-visa) or engage in some other form of interaction, such as cooperation with research institutions and scientists back home, teaching, or other, which is likely to benefit both countries. Moreover, as Spilimbergo (2009) has shown, foreign students who return after studying in advanced democracies have a positive impact on democratic institutions in their home country, an outcome that might also arise in the case of increased interaction between foreign graduates and their home country.<sup>12</sup>

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<sup>11</sup> In addition to generating a direct benefit for migrants' home country, such interaction would also likely raise bilateral trade and investment over and above the increases found in existing studies because of further reductions in information and transactions costs, thereby benefiting both countries (see Parsons and Winters' (2014) excellent survey on migration's impact on bilateral trade, and Javorcik et al. (2009) and Kugler and Rapoport (2007) on migration's impact on bilateral investment).

<sup>12</sup> As for agreements on expanded market access commitments for services, such as those delivered through the temporary cross-border movement of natural persons (a.k.a. Mode IV), would benefit both source and host countries – with the former supplying labor services in, say, construction, cleaning and hospitality, and the latter supplying, say, banking, insurance, and ICT. Such arrangements would reduce some of the

A more fundamental issue is that the market for talent is a global one and incentives provided by the international market for the most talented are likely to be too powerful for developing country governments to counter through some unilateral migration restrictions. Retaining talented individuals and encouraging those who work or study abroad to return, as well as competing in the global talent market, would require a wholesale change in policy that goes way beyond migration policy. It is likely to require improvements in governance, merit-based pay in countries where the public sector employs a large share of the labor force and the wage distribution is compressed, provision of research facilities and labs in order for professionals to maintain their skills and keep up with advances elsewhere, appointment of the most talented rather than political appointees to head these research facilities and labs as well as university and other education programs, liberalizing domestic markets and trade, and more.<sup>13</sup>

As for host countries, some would benefit from enforcing existing skilled migration policies. For instance, under the US H1-B visa program, skilled immigrants can be hired for positions for which no Americans are available. However, as has been widely reported, the policy has been ‘captured’ by a few large outsourcing firms that apply and obtain a large share of the available visas, enabling some large corporations to replace US professionals with younger and cheaper immigrants.<sup>14</sup> These immigrants are typically less experienced than the ones smaller enterprises that need someone with unique skills want to hire but are unable to do so. In other words, the quality of H1-B immigrants is most likely lower and they are likely to be closer substitutes to US natives – both of which are less beneficial – than if the visa program worked properly. Moreover, many of the US professionals who are being replaced end up in positions that pay less, another cost for the

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concerns related to the brain and ability drain associated with permanent migration. So far, though, both sets of countries have limited the access to this mode of trading services.

<sup>13</sup> Haque (2007) argues that human capital should be thought of exactly as financial capital, where the return of flight capital depends in large measure on the policies implemented by the country of origin.

<sup>14</sup> A notable example is Southern California Edison, which replaced its IT employees with younger ones brought in through the H-1B program, with the original employees forced to train their replacements and sign nondisclosure agreements and gag orders. Salaries fell from \$110,000 to \$70,000 a year on average or by 36% (based on depositions in a Senate Judiciary Committee hearing spurred by complaints of the practice).

US. Avoiding such negative effects requires stricter enforcement of the rules of the H1-B visa program.

## **9. Conclusion**

A large number of studies have examined the determinants of migration and its impact on education in source and host countries but have not done so in the case of ability. This paper is an attempt to start filling this gap.

Based on the model and two empirical studies (CMP 2009; Beine et al. 2008), I find that:

- i) The vetting system results in an average ability drain equal to 1.074 times the average brain drain for individuals with at least a college degree (and an additional year of education on average). Thus, the loss of average ability is slightly larger than the change in average education in the 42 developing source countries (CMP 2009) and can be negative even when the change in average education is positive.
- ii) In fact, Beine et al.'s (2008) results imply that skilled migration reduces the source country's average skill level, including when the ability drain is only 7.4 percent of the level obtained in this paper.
- iii) Skilled migration results in an increase in average ability, education and skill levels for source countries' migrants.
- iv) Source countries' ability, brain and skill drains increase with inequality, as measured by the variance of ability (and thus also by that of education). And the policies' positive impact on migrants' average ability, education and skill also increases with the variance in ability (and education). These effects are larger under the vetting than under the points system. Thus, a host country obtains a greater benefit from a vetting than from a points system, and from greater inequality in source countries' ability.

The paper's findings suggest that the ability drain is likely to be important. Thus, policy research and policymaking should focus on both education and ability, recognizing that migration is likely to result in an ability drain and thus in a productivity loss, a loss that must be the productivity change associated with a net brain drain or gain in order to obtain

a correct estimate of the impact of migration on income and growth. This issue has essentially been ignored in the literature and in the policy debate.

Migration is also likely to result in higher average ability and education levels for migrants because of its impact on the incentive for individuals to acquire more education and because migrants comprise higher shares of high than low-ability individuals.

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## Appendix

Clemens, Montenegro and Pritchett (2009) – referred to as CMP – use data on 41 developing source countries  $j$  and the US, and examine various income ratios (denoted here by lower-case letters), where the denominator is the average income of source country residents,  $Y_0 = \alpha_0 S = \alpha_0(A + H)$ , where  $A$  is unobservable ability and  $H$  is observable education. CMP's objective is to obtain the average income ratio,  $y_d'' = Y_d''/Y_0$ , of migrants living in the US who were educated in their home country, relative to the income of home country residents with the same  $A$  and  $H$  levels, i.e.,  $y_d'' = Y_d''/Y_0 = \alpha_d(A + H)/\alpha_0(A + H) = \alpha_d/\alpha_0$ . The problem with such comparisons is of course that migrants self-select on both ability and education, whose levels are denoted by  $A^M$  and  $H^M$ , respectively, and that their observed income is  $Y_d = \alpha_d S^M = \alpha_d(A^M + H^M)$  rather than  $Y_d''$ .

CMP find that for the 42 source countries, migrants' average income ratio  $y_d = \alpha_d S^M/\alpha_0 S = \alpha_d(A^M + H^M)/\alpha_0(A + H) = 7.99$ , i.e., migrants' average income is 7.99 times that of source country residents. They first correct  $y_d$  for migrants' self-selection with respect to observable  $H$  in order to obtain  $y_d' = \alpha_d S^{M'}/\alpha_0 S = \alpha_d(A^M + H)/\alpha_0(A + H)$  where, from equation (14),  $\Delta H \equiv H^M - H = \frac{2\pi\lambda}{\phi P(1-P)} V(a_i)$  and, from equation (1),  $y_d - y_d' = \alpha_d \Delta H/Y_0$ . They find that  $y_d' = 5.11 = .64 y_d$  for the 42 countries. Thus, correcting for selection on observables (i.e., education) reduces migrants' income by  $\frac{\alpha_d \Delta H}{Y_0} = 2.88 = 0.36 y_d$ , or a reduction in migrants' relative income of 36 percent.

US immigrants and home-country residents may also differ in terms of non-observable characteristics associated with migrants' self-selection on ability. CMP correct for



migrants' self-selection on ability, replacing  $y'_d = \alpha_d(A^M + H)/Y_0$  by  $y''_d = \alpha_d(A + H)/Y_0$ , where  $\Delta A \equiv A^M - A = \frac{\pi}{\phi P(1-P)}V(a_i)$ , and  $y'_d - y''_d = \alpha_d\Delta A/Y_0$ .

Two conditions make it possible to obtain the value of the ability drain,  $AD$ , brain drain,  $BD$ , and their relative size,  $AD/BD$ , from the relationship between  $y_d - y'_d$  and  $y'_d - y''_d$ :

i) the relationship between  $AD$  and  $BD$  is identical to that between  $\Delta A$  and  $\Delta H$ . From (14),  $\Delta A \equiv A^M - A = \frac{\pi}{\phi(1-P)}V(a_i) + \frac{\pi}{\phi P}V(a_i) = \frac{\pi}{\phi P(1-P)}V(a_i)$ , so that  $AD = \frac{\pi}{\phi(1-P)}V(a_i) = P * \Delta A$ .<sup>15</sup> Similarly,  $BD = P * \Delta H$ . Thus,  $AD/BD = \Delta A/\Delta H$ ; and

ii)  $\Delta A$  and  $\Delta H$  are multiplied by the same parameter,  $\alpha_d$ , to obtain the income changes associated with the vetting system, so that  $AD/BD$  can be obtained from the difference between relative incomes  $y'_d$  and  $y''_d$ .

CMP use various methods, based on both macroeconomic and microeconomic evidence, to obtain an estimate of the impact on migrants' average income of selection on (non-observable) ability,  $\eta$ , in  $y''_d = y'_d/\eta$ , where  $\eta \geq 1$ . They conclude that the degree of positive selection on unobserved wage determinants results in a bias,  $\eta$ , between 1.0 (no bias) and 1.45 in the case of Peru, i.e.,  $\eta \in [1.0, 1.45]$ . The average ability drain obtained over these  $\eta$ -values is  $AD = 1.0742BD$ , as shown below.

CMP obtained the range of  $\eta$  values for workers with 9 years of education and state that selection on ability for less-educated workers is likely to be attenuated by the fact that they tend to work in occupations without plausibly high returns to unobserved skill, a result confirmed by the model.

Recalling that  $h_i = 1$  represents 20 years of education, it follows that  $h_i = 0.45$  for nine years of education. From (12), we have  $h_i = \frac{\alpha_0}{\phi} + 2\lambda a_i$ , or  $a_i = \frac{1}{2\lambda\phi}(\phi h_i - \alpha_0)$ . For individuals with nine years of education, we have  $a_i = \frac{1}{2\lambda\phi}(0.45\phi - \alpha_0)$ . Migrants who enter the US via the H1-B visa program must have at least a Bachelor's degree or a

<sup>15</sup> Migrants' average ability 'gain' is  $\frac{\pi}{\phi P}V(a_i) = [(1-P)/P]*AD$  and their average education 'gain'  $\Delta H^M = (H^G - H_0) + \frac{2\pi\lambda}{\phi P}V(a_i) = 2\lambda(\alpha_0 + A^G) + [(1-P)/P]*BD$ .

minimum of 16 years of education, i.e., a level of  $h_i$  equal to 0.8 or higher, and the equation for  $a_i$  and the correction for selection on ability must take the difference in education levels into account. Rothwell and Ruiz (2013) report that 90 percent of US companies' H-1B applications are for occupations that require *high-level STEM* (i.e., high-level science, technology, engineering and math) knowledge. These typically require a graduate degree or equivalent, which takes at least one year and often two years to complete.<sup>16</sup> Thus, it seems reasonable to assume that H-1B immigrants average one to two more years of education. Assuming conservatively that they have one more year of education implies that  $h_i = 0.85$ . Then,  $a_i = \frac{1}{2\lambda\phi}(0.85\phi - \alpha_0)$ , and the correction for selection on ability,  $\eta$ , becomes  $\eta' = \eta \left( \frac{0.85\phi - \alpha_0}{0.45\phi - \alpha_0} \right)$ . Thus, for these individuals,  $y_d'' = y_d'/\eta'$  and ability drain's impact is  $y_d' - y_d'' = y_d' [(\eta' - 1)/\eta'] = 0.64y_d [(\eta' - 1)/\eta']$ .

With the correction for self-selection on education equal to  $0.36y_d$ , we have:

$$\frac{AD}{BD} = \frac{0.64}{0.36} [(\eta' - 1)/\eta'] = 1.778 [(\eta' - 1)/\eta'], \eta' = \eta \left( \frac{0.85\phi - \alpha_0}{0.45\phi - \alpha_0} \right). \quad (\text{A.1})$$

Probability  $p_i = \pi(a_i + h_i) \leq 1$ , with  $\pi \leq \frac{1}{a_i + h_i}$ ,  $\forall a_i \in [0, a_M], h_i \in [0, 1]$ , implying that  $\pi \leq \frac{1}{1+a_M}$ . Individual education is  $h_i = \frac{\alpha_0}{\phi} + 2\lambda a_i = \frac{\alpha_0 + 2\pi(\alpha_d - \alpha_0)a_i}{1 - 2\pi(\alpha_d - \alpha_0)} \leq 1$ . Define  $x \equiv \alpha_d - \alpha_0 > 0$ , so that  $h_i = \frac{\alpha_0 + 2\pi x a_i}{1 - 2\pi x} \leq 1$ , or  $\alpha_0 \leq 1 - 2\pi x(1 + a_i)$ ,  $\forall \pi \left( 0, \frac{1}{1+a_M} \right]$ , i.e.,  $\alpha_0 \leq 1 - 2x \frac{(1 + a_i)}{(1 + a_M)}$ . With  $h_i(a_M) = 1$ , we have  $\alpha_0 = 1 - 2x = 1 - 2(\alpha_d - \alpha_0)$ . Thus,  $\alpha_d = \frac{1 - \alpha_0}{2}$ .

I proceed now to 'guess' a solution for  $\alpha_d/\alpha_0$ , namely  $\alpha_d/\alpha_0 = 2$  (this is verified below). Then, from  $\alpha_d = \frac{1 - \alpha_0}{2}$ , it follows that  $\alpha_0 = .2$  and  $\alpha_d = .4$ . Thus,  $\alpha_d - \alpha_0 = .2$  and  $\phi = 1 - 2\pi(\alpha_d - \alpha_0) = 1 - .4\pi$ . From  $\lambda \leq \frac{1}{2}$  and  $h_i(a_M) = 1$ , we have  $\pi \leq .8$  or  $\pi \in (0, .8]$ .

<sup>16</sup> This is consistent with their finding that H-1B visa holders earned on average 13.5 percent more than US native-born workers with a Bachelor's degree.

I verify now whether the ‘guess’ that  $\alpha_d/\alpha_0 = 2$  is correct. The average ability drain relative to the brain drain,  $AD/BD$ , is obtained by averaging the  $AD/BD$  values obtained for  $\eta \in [1, 1.45]$  and  $\pi \in (0, .8]$ . For instance, take  $\pi = .2$  and  $\eta = 1.25$ . Then,  $\phi = 1 - .2 * .4 = 0.92$ . Substituting the values for  $\phi$  and  $\eta$  into equation (A.1), the ratio  $AD/BD = 1.0301$ , which means that the ability drain is 3 percent larger than the average brain drain.

The average value is  $AD/BD = 1.0742$ . Thus,  $AD = 1.0742BD = .3867y_d = 3.09$ , and the impact of selection on unobservable traits is to reduce  $y'_d = 5.11$  by 3.09, so that  $y''_d = 2.02$  (or 1 percent above 2). Thus, developing country natives with a Bachelor’s degree (or more) who migrate to the US would be expected to earn on average about twice the real income they earned in their country of origin.<sup>17</sup>

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<sup>17</sup> Given that prices are typically lower in the home country, US immigrants gain more than 100 percent of the income earned back home if part of their income is transferred back home – say, through remittances – and consumed by family members there.