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ABSTRACT

Benefits and Costs of Brain and Ability Drain*

Ability drain's (*AD*) impact on host countries is significant: 30 percent of US Nobel laureates since 1906 are immigrants, and they or their children founded 40 percent of Fortune 500 companies. However, 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 $s = s(a, h)$, for home country residents and migrants under the 'vetting' immigration system, which accounts for *s* (e.g., US H-1B program). Findings are: i) Education increases with ability; ii) Migration reduces (raises) residents' (migrants') average ability, with an ambiguous (positive) impact on the average level of h and *s*; iii) These effects increase with ability's inequality or variance; iv) The model and empirical studies suggest that $AD \geq BD$ for educated US immigrants and that their real income is about twice their home country income; v) A net drain in average *s* holds for any *BD* and for an *AD* that is a fraction of our estimate; vi) This article also provides a detailed description of the multiple home country benefits generated by the brain and ability drains. And policy implications are presented.

JEL Classification: F22, J24, J61, O15

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

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1. Introduction

A large literature exists on the costs and benefits of skilled migration or brain drain, where skills are typically thought of as human capital (education or education and experience). This literature has exhibited a profound change over time, from a negative view of the brain drain for migrants' home country to a more positive outlook associated with i) the brain drain's impact on the incentive to acquire more education – or brain gain, and ii) the impact of migration, particularly skilled migration, on a number of social, economic and other variables in the country of origin, and its impact on the relationship between migrants' home and host countries.

One aspect of migration that has mostly been ignored is the fact that migrants are typically endowed with greater entrepreneurial ability than non-migrants.[1] The importance of ability cannot be underestimated. First, as shown in Section 4, individuals' education level is positively related to their ability level. Second, the inequality in ability's distribution plays a crucial role in the brain and ability drains. Third, it is important to recognize that the social, economic and other benefits of skilled migration for migrants' home country are (at least partly) attributable to their ability.

The model in this paper – which was developed to examine i) the relationship between individual ability and education, and ii) the brain drain, brain gain, ability drain, and their relative size – is a simplified version of the model in Schiff (2017). That model was developed to allow a comparison between what I refer to as the "vetting" system (see end of Section 2), the points system – an immigration policy formerly used in Australia, Canada and the UK, and which accounts for

[1] Thus, observably identical twin brothers in observably identical conditions are not identical in the case where one remains in the home country while the other emigrates to improve his economic situation.

education but not for ability – and a hybrid of the vetting and points systems. This required adjusting the equations to ensure that the same average migration probability prevailed under the three immigration systems, though the main results under the vetting system are not affected.

The paper is organized as follows. Section 2 presents a selected literature on the ability and brain drains, and on the various home country benefits from skilled migration. Section 3 sets forth the model and the closed economy case. Section 4 examines the "vetting system" – such as the US H-1B visa program. Section 5 presents a comparison of the size of the ability drain and the brain drain, and of the home and host countries' income. Section 6 assesses the sign of migration's impact on *productive* human capital, which is a function of ability and human capital. Section 7 presents policy implications and Section 8 concludes.

2. Selected Literature

2.1. Brain drain and brain gain

Studies conducted in the late 1960s and 1970s considered the brain drain to be a loss for migrants' home countries. The studies include Berry and Soligo (1969), Bhagwati and Dellalfar (1973), Bhagwati and Hamada (1974), Bhagwati and Rodriguez (1975), Grubel (1975), McCulloch and Yellen (1975), Bhagwati (1976), and many more. They considered inter alia a tax, known as the Bhagwati tax, which was designed to compensate migrants' home countries for the loss of human capital and the cost of educating the skilled migrants. This proposal led to a literature that dealt with the design of the tax, its administration, and the administrator – the host country, the home country or the United Nations – and whether the collection of such a tax is legally feasible (Devoretz and Maki 1975, Oldman and Pomp 1975, Wilson 2007).

Starting in the 1990s, a literature developed which found that the brain drain has positive effects. For instance, Mountford (1997), Vidal (1998), and Beine et al. (2001, 2008) find a positive impact of brain drain on brain gain and growth.[2] Other studies have examined migration's positive impact on the transfer of information between host and home countries, resulting in a reduction in information costs inherent in the international transfer of tangible (e.g., goods, services, investment) and intangible flows (e.g., norms and knowledge). Some examples are given below.

2.2. Impact on Trade and Investment

Migration can affect bilateral trade and investment by reducing their transaction costs because migrants have a greater knowledge of their home and host countries' cultures (including their languages and customs), their business practices and their laws. Unsurprisingly, the impact is greater in the case of high-skilled migration.

Studies that have examined the impact of migration on trade typically find a positive impact that is larger for skilled migration and for host and home countries that are more different. Felbermayr and Toubal (2012) obtain a positive trade impact that is largest for high-skilled migrants. Fogiolo and Mastrorillo (2014) find that trade is positively affected by migration and by the host country's centrality in the complex network of international migration corridors. Mayda et al. (2017) find that an increase in the share of refugees in a US state (relative to the state's population) increases exports to their country of origin, i.e., this impact does not only hold for economic migrants but for refugees as well. Genç (2014) reviews the literature related to OECD trade and reports on studies that find elasticities of trade to high-skilled immigration that are close to 2.5 times those

[2] Two excellent surveys of brain drain and induced brain gain issues are Commander et al. (2004) and Docquier and Rapoport (2012). An analysis of the extent of the brain gain is Schiff (2006).

for low-skilled immigration. And Parsons (2011) finds that North-North and South-North immigration only affects exports to the South, a result explained by the fact that the North exports more differentiated and complex products and that information barriers between North and South are the greatest. An excellent survey on migration's impact on trade is Parsons and Winters (2014).

As for investment, Javorcik et al. (2011) find that migrants and especially high-skilled migrants have a positive impact on bilateral investment from migrants' host country to their home country. Similar results are obtained by Kugler and Rapoport (2007). And Kugler et al. (2018) find that migration has a positive impact on financial flows from migrants' host country to their home country, and that the impact is strongest for high-skilled migrants, for countries between which informational barriers are largest, and for more complex asset types.

2.3. Intangible Effects

Beine et al. (2013) show that migrants transfer fertility norms from the host to the home country, irrespective of whether fertility in the former is higher or lower than in the latter. Thus, South-North migration has led to a decline in fertility, while the impact of South-South migration depends on the host and home countries' relative fertility rates. For instance, migration from Egypt to Gulf countries has led to an increase in Egypt's fertility.

Rapoport et al. (2021) find that migration is a source of cultural convergence between migrants' home and host countries. They further show that migration tends to promote the diffusion of host countries' culture towards migrants' home countries, rather than from home to host countries, as the main driver of convergence. Docquier et al. (2016) find that home countries' emigration and

human capital level both increase democracy and economic freedom. Though this implies that unskilled (skilled) emigration has a positive (ambiguous) impact on institutional quality, simulations show that skilled emigration generally has a positive impact – once incentive effects of emigration on human capital formation are accounted for. And Bahar et al. (2020) show how migrant inventors transfer knowledge from their home to their host countries, and that it results in greater patenting in the host countries.

Return migrants have also contributed to their home country development. For instance, much has been written about Taiwan's success in reversing the brain drain between the 1950s and the 1970s and attracting back highly skilled and business Taiwanese, and about their contribution to the economic and social development of the country (e.g., Tzeng 2006). Batista and Vicente (2010) examined whether international migration from Cape Verde promotes better institutions at home. They used a household survey to examine the determinants of demand for political accountability and find a positive effect that is mainly due to return migrants who emigrated to countries with better governance.

Spilimbergo (2009) finds that return migrants who obtained their education in democratic countries have a positive impact on democracy back home, while those who studied in non-democratic countries do not. And Wahba (2014) reviews the economics literature on return migration. She focuses on returnees' contribution to the economic development of their home country, reducing credit constraints, allowing for brain circulation and gain, and transmitting norms back home.

2.4. Ability

Migrants have performed both below and above the host country average, and some have turned out to be great scientists or 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).

However, the studies in Section 2.1 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. 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, all of which affect individuals' migration and education decisions. With developed countries' higher return to ability, migrants are positively selected for it (Schiff 2006).

Due in part to the difficulty of measuring ability, its economic significance has not been ascertained to date. This paper shows that individuals' ability positively impacts their education and that the 'ability drain' associated with skilled migration is important. And the fact that a brain drain generates a brain gain while an ability drain does not also raise the latter's relative importance. Note that a significant part of the home country benefits generated by the brain drain – i.e., skilled or highly educated migration – is due to the ability drain (see Section 4).

The model shows, among others, that both the ability drain and the brain drain increase with ability's heterogeneity. 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 (BD), with $AD = 1.074BD$. The reason is provided in Section 3. This result, together with an empirical study of the brain drain's impact on the average level of education, suggests that the home country's average *productive* human capital – a combination of ability and education – falls with skilled migration, a result that even holds for an ability drain that is much smaller than the one obtained.

No statistical confidence levels or significance tests are available at this stage. However, this does not diminish the potential importance of the results obtained. As mentioned above, the conclusion that the brain drain's average impact on *productive* human capital is negative at all brain drain levels is robust in the sense that it holds even if the ability drain, AD, is less than one tenth of the AD value obtained. 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.

Few studies have examined the impact of ability theoretically. The importance of heterogeneous ability for the brain drain has been incorporated in Haque and Kim (1995), Haque (2007) and Schiff (2017). Regarding empirical estimation, I have only found three studies that use a direct measure of ability, or some element of it, to examine the relationship between ability and brain drain.

Miguel and Hamory (2009) find a higher rural-urban migration rate in Kenya for individuals with higher cognitive skills, i.e., for those who scored higher on a primary school test. 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 emigrate is incorporated in the model in Section 3.[3]

Given the potential importance of the relationship between migration and ability, the paucity of empirical studies on this issue is unfortunate. Except for Clemens, Montenegro and Pritchett (CMP, 2009), which focuses on low-skilled migrants, and for the three studies mentioned above, I have found no studies that have examined the ability drain or its impact.

This paper contributes to this fledgling literature by i) developing a model to examine migration' impact on average ability and education for both source countries' residents and migrants; ii) combining the model and data in order to obtain a measure of the relative importance of the ability drain and the brain drain, and skilled migration's impact on *productive* human capital, which is a function of both ability and education; and iii) showing the ability's contribution to the positive impact of migration by establishing a link between ability and education.

[3] A study that infers some aspect of ability's relationship with migration is Mattoo et al. (2008). They examine the degree of success of highly educated immigrants to the US. They find that migration's distance raises educated immigrants' level of success. As migration's cost rises with distance, its expected return must increase to make migration worthwhile, i.e., migrants' ability must increase with migration distance.

Immigration policies vary across countries and time. Given that the available data – together with the model – that are used to derive the ability drain deal with migration to the US, the type of immigration policy examined is the US H1-B visa program. Under the 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 for their level of education and ability since they benefit from good hiring decisions and pay the cost of bad ones. [4]

3. Model

Assume individuals' productive human capital can be observed and valued properly by employers in both countries. This makes sense as they are likely to thoroughly vet prospective employees in order to assess their qualifications before making a hiring decision.

Denote individual i's ability by a_i, human capital by h_i, the home country or country of origin by "0", the host or destination by "d", source country residents' (migrants') income by y_{0i} ($y_{\mathrm{d}i}$), and the immigration probability by $p_i \in [0,1]$. *Productive* human capital, s_i, is a function of a_i and h_i, and expected income y_i is a function of y_{0i} and $y_{\mathrm{d}i}$, i.e.:

$$s_i = a_i + h_i,\ y_{0i} = \alpha_0 s_i,\ y_{\mathrm{d}i} = \alpha_{\mathrm{d}} s_i;\ \alpha_{\mathrm{d}} > \alpha_0 > 0,$$

[4] With points systems – where one of the criteria for prospective migrants is education (in addition to other factors) but not intrinsic ability – leading to unsatisfactory employment outcomes, a number of countries, including Canada, Australia and New Zealand, moved to a system that gives more weight to the labor market demand side, i.e., a system that accounts for employers' preferences and is a hybrid of the vetting and points systems.

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

where parameters α_0 and α_d reflect the respective countries' levels of technology, institutional development, and more.

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

$$u_i = c_i = y_i - \frac{h_i^2}{2} = [\alpha_0 + (\alpha_d - \alpha_0)p_i]s_i - \frac{h_i^2}{2} \geq 0.^{6} \quad (2)$$

Individuals maximize expected utility by selecting h_i subject to their innate ability a_i and their migration probability p_i.[7] Average migration probability is $P = \int_0^{\bar{a}} p_i f(a_i) da_i$, where $f(a_i)$ denotes a_i's probability density function and $\bar{a}$ is the maximum ability. 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 account for the fact that the migration probability depends on both education and ability under the vetting system, i.e., $p_i = p_i(a_i, h_i)$. Given that source countries have both migrant and non-migrants, interior solutions are assumed throughout.

[5] 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 increases with a_i (see Sections 3). Specifying s_i as $s_i = a_i h_i$ would complicate the model without affecting the qualitative results – though it would lead to a greater impact of migration on the average ability and education of home country residents and migrants.

[6] 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, i.e., the second derivative of c_i with respect to education is negative (and equal to -1).

[7] For simplicity, individuals are assumed to be risk neutral.

3.1. Closed Economy

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

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

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

$$h_{ic} = H_c = \alpha_0, A_c = A^G, s_{ic} = a_i + \alpha_0, S_c = A^G + \alpha_0, V(s_{ic}) = V(a_i). \quad (4)$$

4. Vetting System

Under the US H1-B visa, prospective migrants must obtain a job offer and have at least a Bachelor's degree or equivalent in order to be able to immigrate. As mentioned earlier, I refer to this type of policy as the "vetting" system, as employers are likely to thoroughly vet potential employees before making a hiring decision Thus, both ability and education are accounted for under a vetting immigration policy.

Probability p_i and, from equation (2), consumption c_i, are:

$$p_i = \pi(a_i + h_i) = \pi s_i, \ \pi > 0,$$

$$c_i = y_i - \frac{h_i^2}{2} = [\alpha_0 + \pi s_i(\alpha_d - \alpha_0)]s_i - \frac{h_i^2}{2} = \alpha_0 s_i + \pi(\alpha_d - \alpha_0)s_i^2 - \frac{h_i^2}{2} \geq 0. \quad (5)$$

We maximize c_i with respect to h_i. Defining $\phi \equiv 1 - 2\pi(\alpha_d - \alpha_0)$ and $\lambda \equiv \frac{\pi(\alpha_d - \alpha_0)}{\phi}$, and noting that $1 + 2\lambda = \frac{1}{\phi}$, the solutions for h_i, s_i, p_i, $h_i - h_{ic}$, and $s_i - s_{ic}$, are:

$$h_i = \frac{\alpha_0 + 2\pi(\alpha_d - \alpha_0)a_i}{1 - 2\pi(\alpha_d - \alpha_0)} = \frac{\alpha_0}{\phi} + 2\lambda a_i,\ s_i = a_i + h_i = \frac{\alpha_0 + a_i}{\phi} = \frac{s_{ic}}{\phi},\ p_i = \pi s_i,\ h_i - h_{ic} = h_i - \alpha_0 = 2\lambda(\alpha_0 + a_i) = 2\lambda s_{ic},\ s_i - s_{ic} = \frac{s_{ic}}{\phi} - s_{ic} = 2\lambda s_{ic}. \quad (6)$$

So, $h_i - h_{ic} = s_i - s_{ic} = 2\lambda s_{ic} > 0$, and $s_i = a_i + h_i = \frac{\alpha_0}{\phi} + (1 + 2\lambda)a_i = \frac{a_i + \alpha_0}{\phi}$. [8]

From (6), home country residents' individual human capital h_i and *productive* human capital s_i are greater than in the closed economy case. However, though this implies that $H^G > H_c$ and $S^G > S_c$, it does not necessarily imply that the *net* average values H and S – i.e., *net* of the brain and ability drains – are larger than those under the closed economy. Furthermore, from (6), we have $\frac{\partial h_i}{\partial a_i} = 2\lambda > 0$. Thus, human capital increases with ability, even though they enter additively in the income and probability functions.

Solutions for *gross* average H^G and S^G, and for average probability P are:

$$H^G = \frac{\alpha_0}{\phi} + 2\lambda A^G, S^G = \frac{1}{\phi}(\alpha_0 + A^G) = \frac{S_c}{\phi}, P = \frac{\pi}{\phi}(\alpha_0 + A^G) = \frac{\pi S_c}{\phi}, \quad (7)$$

where H^G denotes the average gross level of education or the level before migration takes place, i.e., excluding the brain drain. The same holds for $S^G = A^G + H^G$.

From (7), the brain gain, BG, and productive human capital gain, SG, are identical:

[8] Note that the second order condition for a maximum for c_i implies $\phi > 0$.

$$BG = H^G - H_c = S^G - S_c = 2\lambda(\alpha_0 + A^G) = 2\lambda S_c, \quad (8)$$

i.e., brain gain BG and *productive* human capital gain SG are both equal to $2\lambda S_c > 0$.

The ability drain AD and brain drain BD increase with the degree of inequality in the ability distribution, as measured by a_i's variance $V(a_i)$. An example may help explain why. Assume two groups, Group 1 and Group 2, with the same number of individuals. Their abilities are $a_1 = A^G + \varepsilon$, and $a_2 = A^G - \varepsilon$ $(\varepsilon > 0)$, and the variance of $a_i = \{A^G + \varepsilon, A^G - \varepsilon\}$ is $V(a_i) = \varepsilon^2$. Assume first $\varepsilon = 0$. Then, all individuals are identical and $AD = BD = 0$. With $\varepsilon > 0$, the higher ability in Group 1 implies a higher migration probability than in Group 2 ($p_1 > p_2$). Thus, the share of high-ability individuals who migrate is larger than that of low-ability individuals. This reduces the home country's average ability ($A < A^G$). Moreover, this effect is exacerbated as ε increases and $V(a_i) = \varepsilon^2$ increases. Given the positive relationship between ability and education, the same result holds for the latter, i.e., $H < H^G$, and the gap $BD = H^G - H$ increases with $V(a_i)$.

Solutions that incorporate the ability drain AD and the brain drain BD are presented in (9) below. Solutions for the average net value of ability A, education H and productive human capital S, for home country residents, migrants and natives – i.e., for X, X^M, and X_N $(X = A, H, S)$ – are:

$$A = A^G - \frac{\pi}{\phi(1-P)}V(a_i), \quad A^M = A^G + \frac{\pi}{\phi P}V(a_i), A_N = A^G;$$

$$H = H^G - \frac{2\pi\lambda}{\phi(1-P)}V(a_i), \quad H^M = H^G + \frac{2\pi\lambda}{\phi P}V(a_i), H_N = H^G;$$

$$S = S^G - \frac{\pi}{\phi^2(1-P)}V(a_i), \quad S^M = S^G + \frac{\pi}{\phi^2 P}V(a_i), S_N = S^G, \quad (9)$$

where X_N, the home country population's average, is $X_N = (1-P)X^G + PX^M, X = A, H, S$.

Table 1. Non-migrants' Ability, Brain and Productive Human Capital: Net Gain or Net Drain? [a]

	Ability (1)	Education (2)	Productive human capital (1 + 2)	Ratio (1) / (2)
Gain (ii)	--	$2\lambda(A^G + \alpha_0)$.	$2\lambda(A^G + \alpha_0)$.	--
Drain (i)	$-\frac{\pi}{\phi(1-P)}V(a_i)$.	$-\frac{2\pi\lambda}{\phi(1-P)}V(a_i)$.	$-\frac{\pi}{\phi^2(1-P)}V(a_i)$.	$1/2\lambda \geq 1$
Net Gain (i) + (ii)	$-\frac{\pi}{\phi(1-P)}V(a_i)$.	$2\lambda(A^G + \alpha_0) - \frac{2\pi\lambda}{\phi(1-P)}V(a_i) \gtrless 0$.	$2\lambda(A^G + \alpha_0) - \frac{\pi}{\phi^2(1-P)}V(a_i) \gtrless 0$.	--

a: Results are relative to the closed economy case.

The results in (9) and the brain gain for home country residents are presented in Table 1 below. From (9), ability drain $AD = \frac{\pi}{\phi(1-P)}V(a_i)$ and brain drain $BD = \frac{2\pi\lambda}{\phi(1-P)}V(a_i)$. Thus, $AD/BD = 1/2\lambda$ and, with $\lambda \leq \frac{1}{2}$ for $a_i \geq 0$,[9] i.e., $\frac{AD}{BD} \geq 1$ for $a_i \geq 0$. Note that though AD and BD increase with $V(a_i)$, the ratio AD/BD is independent of $V(a_i)$. The net brain gain $NBG = BG - BD = 2\lambda(\alpha_0 + A^G) - \frac{2\pi\lambda}{\phi(1-P)}V(a_i) \gtrless 0$. Thus, while migration reduces average ability, the impact on

[9] The proof is presented in fn. 10 in Schiff (2017).

the average level of education is ambiguous, and so is the impact on the average level of productive human capital, i.e., $NSG = 2\lambda(\alpha_0 + A^G) - \frac{\pi}{\phi^2(1-P)} V(a_i) \gtrless 0$.

5. Comparing Ability and Brain Drain, and Home and Host Country Incomes

This section examines the relationship between the ability drain, AD, and the brain drain, BD, as well as migrants' income in the host and home countries. Educated immigrants who enter the US under the H1-B visa program must obtain a job offer and must have a Bachelor's Degree or more in order to qualify. [10] As discussed in the Introduction and in Section 3, 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. Moreover, the empirical results used here are based on the US H-1B vetting system. Thus, the latter is used in the analysis. The analysis is based on the model and empirical results in CMP (2009). Derivations in this section are found in in Schiff's (2017) Appendix. CMP use a database on PPP-adjusted wages and other characteristics for two million individuals in the US and in 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 correct observations of migrants' US income for selection on education and ability in order to obtain estimates of the impact of migration on migrants' income.

Thus, denote migrants' US income by $Y_d = \alpha_d(A^M + H^M)$ and home country income by $Y_0 = \alpha_0(A + H)$, and the relative income $y \equiv Y_d/Y_0$. The objective is to replace A^M and H^M by A and

[10] This is the level of education for which the relationship between ability drain and brain drain is derived.

H. After correcting for selection on education, we have $y' = \alpha_d(A^M + H)/\alpha_0(A + H)$, and after correcting for selection on ability, we have $y'' = \alpha_d(A + H)/\alpha_0(A + H) = \alpha_d/\alpha_0$.

CMP find that correcting for selection on education – i.e., for the difference between migrants' and home country residents' education level – reduces migrants' average income, relative to their income in the country of origin from $y \equiv Y_d/Y_0 = 7.99$ by 2.88, i.e., to $y' = 5.11$ or by 36 percent. They then correct for selection on migrants' ability, which reduces y' to $y'' = \alpha_d/\alpha_0$, the relative income free of selection on observable and unobservable traits.

The adjustment made by CMP is for migrants with nine years of education. As they mention, selection on 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 used here adjusts y'' to reflect this difference. Using a grid analysis, the ratio of ability drain to brain drain, AD/BD, is obtained for the full range of parameter values and for the overall average.

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 the 42 source countries and US data, are presented in Section 6.2.

5.1. 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 about 100 percent ($y'' = 2.02$).

iii) Education is endogenous and determined by ability, and the home country benefits from skilled migration are (at least partly) attributable to the ability drain. Also, irrespective of AD and BD's 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 (9) or Table 1).

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 1). Note also that the average correction level for selection on ability is $y' - y'' = 3.09$, which is close to the correction for selection on education.

5.2. Country groupings

As shown in (1), individual income in the home country is $y_{0i} = \alpha_0 s_i$, where parameter α_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 $\lambda \equiv \frac{\pi(\alpha_d - \alpha_0)}{\phi}$.

Thus, $\frac{\partial\lambda}{\partial\alpha_0} = -\frac{\pi}{\phi^2} < 0$ and $\frac{\partial(AD/BD)}{\partial\alpha_0} = \frac{\partial(AD/BD)}{\partial\lambda}.\frac{\partial\lambda}{\partial\alpha_0} = \frac{\pi}{2\lambda^2\phi^2} > 0$, i.e., AD/BD increases as α_0 – and source countries' income – increases, one reason being that BD declines as α_0 increases.

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 42 countries. The data show that

countries and regions with the largest *BD* impact 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 .625. 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 also suggest that the brain drain declines with source countries and regions' income.

6. Productive Human Capital: Net Gain or Net 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, $NBG = BG - BD$. The third-order polynomial reduced-form relationship between the brain gain (i.e., the change in the proportion of college graduates) and the brain drain is $NBG = 0.0788BD - 0.4587BD^2 + 0.02746BD^3$, with $NBG > (<)\ 0$ for $BD < (>)\ 0.18$, or 18 percent. 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, $NSG = NBG - AD = NBG - 1.0742BD = -.9954BD - 0.4587BD^2 + 0.02746BD^3$. Assuming Beine et al.'s result also holds for the 42 source countries as a whole, it follows that for any $BD \in (0,1]$, $NSG < 0$. In other words, migration results in a net loss in the average level of *productive* human capital. Thus, while Beine et al. (2003, 2008) found a positive net brain gain for $BD < 0.18$, once ability drain is accounted for – and assuming their result holds for the 42 source-country sample – the change in the average skill level is negative for any positive BD, and is negative for $AD > .08BD$or some 13 times smaller than the AD results obtained.

7. 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 drain in productive human capital, with a net 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, generates a larger ability drain and a larger net brain drain (or a smaller net brain gain) than the points system where the immigration probability depends on human capital but is independent of ability. The fact that several immigration countries, including Australia, New Zealand and Canada, reformed their immigration

policy from the old points system to a new one that includes elements of the vetting system, raises the importance for source countries of devising market-friendly policies in order to minimize the drain in productive human capital and of collaborating with host countries in order to raise both countries' migration benefits (see below).

As described in Section 2, skilled migration results in tangible and intangible flows between migrants' host and home countries (e.g., trade, investment, financial flows, institutional progress, behavioral convergence with host countries, etc.). Host countries concerned with home countries' development could further increase source countries' gains from skilled migration by providing 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. One possibility is for source country universities to allow joint appointments with host country ones.[11]

Similarly, foreign students from developing countries often receive financial support from some public or private agency in their home or host country (e.g., government agency, private employer, 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 their home country

[11] 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.

(which is the case for foreign students who enter the US on 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.[12]

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

[12] 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 of the GATT), they would benefit both home and host countries – with the former countries supplying labor services in, say, construction, cleaning and hospitality, and the latter supplying services in, say, banking, insurance, and ICT. Such arrangements would reduce some of the concerns related to the brain and ability drain associated with permanent migration. So far, though, both sets of countries – and especially the developed host ones – have limited the access to this mode of trading services.

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.[13] As described in Section 2.1, Taiwan undertook successful policies that led to a significant reversal of the brain drain.

8. Conclusion

A large number of studies have examined the determinants of migration and its impact on the home country nationals' education in source and host countries but have not done so in the case of ability. This paper is an attempt to begin 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. Thus, the ability drain is slightly higher than the education drain for the 42 developing source countries, and the change in productive human capital 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 average productive human capital in migrants' home country, including when the ability drain is a small fraction of the level obtained in this paper.

iii) Skilled migration results in an increase in the average ability and education levels of source countries' migrants.

[13] 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.

iv) Source countries' ability drain, brain drain and productive human capital drain increase with ability's inequality, as measured by its variance.

v) Migration is also likely to result in higher average ability and education levels for migrants because of its impact on the incentive to acquire more education and because migrants comprise larger shares of high than of low-ability individuals. And this impact also increases with the variance of ability. Thus, a host country' benefit increases with inequality in source countries' ability.

vi) The various home country benefits from skilled migration or brain drain through tangible and intangible flows between migrants' host and home countries are also attributable to the ability drain.

The paper's findings suggest that the ability drain is likely to be important. Thus, migration policy research and policymaking should focus on both education and ability – recognizing that migration is likely to result in an ability drain and in a decline in productive human capital, and thus in a productivity loss – in order to obtain a correct estimate of the impact of skilled migration on income and growth. This issue has essentially been ignored in the literature and in the policy debate.

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