We consider the welfare effects of the emigration of workers who produce a public good (knowledge). We distinguish between the knowledge diversion and knowledge creation effects of such emigration, and show that the remaining residents of a country can gain from emigration, even when tastes for knowledge goods exhibit a kind of ‘home bias’. In contrast to existing models of beneficial brain drain (BBD), our results do not require agglomeration economies, education-related externalities, remittances, return migration, or an emigration “lottery”. Instead, they are driven purely by differences in market size that induce greater knowledge creation by emigrants abroad than at home. BBD is even more likely in the presence of endogenous sending-country intellectual property rights (IPRs).

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1. Introduction.

Will a “brain drain” from a small, or low-wage economy hurt or help the remaining residents of that economy? The earliest economics literature on this question (e.g. Berry and Soligo 1969, Bhagwati and Hamada 1974) showed that remaining residents may be harmed because of diminished opportunities to trade with differently-endowed agents. More recent contributions have identified a number of factors that could give rise to beneficial brain drain (BBD). These include increased incentives to acquire education in the sending country (Mountford 1997), remittances (e.g. Ozden and Schiff 2006), and added discipline on the sending country’s tax authorities (Bucovetsky 2003).

In this paper we study another possible source of beneficial brain drain: the direct benefit to sending-country consumers that occurs when its brains move to an environment where they produce higher-quality knowledge goods. More specifically, we model brains as “knowledge workers”, whose efforts improve the quality of a good that is reproducible at zero marginal cost (Rosen 1981). Improvements in the quality of such goods benefit source-country consumers whether their brains live at home or abroad. Thus, for example, scientists sent to a U.S. laboratory, actors sent to Hollywood, and programmers sent to Silicon Valley may produce products of greater value to their origin-country consumers than the products they would have produced at home. Of course, both the amount of home bias in tastes, and the strength of intellectual property rights (IPRs) in the sending and receiving countries will affect the magnitude of these gains in consumer welfare. We study these effects as well.

What factors might induce a sending country’s brains to produce higher-quality knowledge goods when employed abroad? While we can think of several—including agglomeration economies and a stronger IPR environment—in order to illustrate the distinct nature of the causal mechanisms studied here, our most basic model assumes identical production costs and full IPRs in both the sending and receiving countries. The welfare gains from brain drain come instead from market size and home-bias effects: If the foreign market is sufficiently larger than the sending country’s, and if knowledge produced abroad is not too irrelevant to consumers in the sending country, the extra incentives to produce knowledge created by this larger market mean the (remaining residents of) the home country are better off allowing their knowledge workers to emigrate. Later in the paper we show that, if source country IPRs are chosen endogenously, BBD becomes even more likely than in the base case. This result stems from the host country’s ability to “free ride” on its own brains after they leave.

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1 The term “knowledge worker” was coined by Peter Drucker (1959); since then it has become a truism that the production of new knowledge is an essential and growing component of a developed economy. It is therefore surprising that a defining characteristic of knowledge—its publicness—has not, to our knowledge, yet been incorporated into formal models of international skilled worker migration.
2. Existing Literature

As noted, the earliest economics literature on the “brain drain” (e.g. Berry and Soligo 1969), and indeed on international factor mobility in general (e.g. Jones, Coelho and Easton 1986), focused on induced changes in domestic factor prices and producer surplus in an undistorted “sending” economy. Although exceptions exist (for example the two-good, two-factor small open economy model in which factor rewards are independent of factor endowments, and the case of large countries whose terms of trade are advantageously affected by a factor outflow), in most of these models the reduction in opportunities to trade with differently-endowed agents makes remaining residents worse off after an outflow of skilled labor.²

Since then, economists have identified a number of factors that accentuate the harm associated with a “brain drain”. One such factor is a fiscal externality: in the presence of publicly-subsidized education and progressive taxation, the exodus of highly educated workers imposes a net fiscal loss on the sending country’s remaining residents (Bhagwati and Hamada 1974). Also, in an endogenous growth context, some authors have argued that an outflow of educated workers can inflict a very high level of harm in the long run by reducing a country’s growth rate (Miyagiwa 1991, Wong and Yip 1999).³

Over the same time period, however, the literature has identified a number of factors working in the opposite direction, generating what is sometimes referred to as “beneficial brain drain” (BBD). Probably the oldest such argument is the notion that emigration provides a social “safety valve” for unemployed skilled workers in less developed countries (see for example the discussion in Bhagwati and Rodriguez 1975). Two additional factors—by no means confined to skilled workers—are emigrants’ cash remittances to the home country (e.g. Ozden and Schiff 2006), and the return migration of “brains” who have acquired new skills abroad (possibly at foreign taxpayers’ expense).⁴ Less obviously, Stark, Helmenstein and Prskawetz (1997, 1998) have argued that the possibility of emigrating and earning a higher wage can raise incentives to acquire education in less-developed sending countries. If this effect is strong enough relative to the actual outflow of educated workers, the “sending” country’s stock of skilled workers can of course rise. Extending this “emigration lottery” reasoning to an endogenous growth framework, Mountford (1997) has shown that the temporary possibility of skilled-worker emigration can “jump-start” an economy out of a poverty trap.

² Despite its age, the argument still figures prominently in contemporary policy discussions about international labor mobility (e.g. Borjas 1995). Of course, nothing in the argument is specific to skilled labor: it pertains to any non-infinitesimal factor outflow that does not mirror the nation’s factor endowment mix exactly.

³ Introducing a skilled worker outflow into more traditional growth models (where growth occurs purely via either human or physical capital accumulation) has less dramatic negative long run effects (see, e.g. Rodriguez 1975).

⁴ According to DeVoretz (2005), it is precisely this prospect of return migration that led China to relax its exit requirements in the early 1990s.
Most recently, Bucovetsky (2003) and Haupt and Janeba (2004) have considered the discipline that skilled emigration could impose on tax authorities in skilled-worker “sending” countries: human capital, once acquired, is sunk and therefore vulnerable to over-taxation by governments with limited commitment power. By constraining governments’ abilities to tax human capital, the possibility of brain drain can induce those governments to act in their country’s own long run interests, thus raising the long term level of human capital investment and per-capita income.

In addition to the literatures on brain drain and international factor mobility, the current paper also relates to recent work on intellectual property rights, including Grossman and Lai (2004). These authors examine countries with different market sizes, and show that equalizing IPRs across countries may hurt a human-capital poor country; further, such equalization is not necessary to provide optimal aggregate incentives for innovation. Helpman (1993) examines IPRs in a model of endogenous, ongoing innovation, and shows that weakening IPRs in a single country can benefit both that country and its trade partner; the welfare gain arises when weakening IPRs in high-wage North shifts production to low-wage South. Neither of these papers, however, examines the effects of international labor migration.

3. The Model

We focus on a single knowledge worker, or “artist”. The artist produces a prototype knowledge good; the prototype can be replicated costlessly. The prototype might be, for example, a musical recording, an insight into the laws of physics, or a malaria vaccine.

Market willingness to pay for reproductions depends on both the quality, $\rho$, and relevance, $t$, of the knowledge good, each to be discussed below. We assume individual inverse demand for a reproduction is given by $t \rho p(q)$ where $p(q)$ is a decreasing function of quantity consumed per capita, $q$. We can interpret $p(q)$ as base inverse demand, i.e. as marginal willingness to pay for a unit of a knowledge good with 100% relevance and quality 1. Define $\varepsilon \equiv -\frac{1}{d\rho(p(q)/dq)/q}$ as the elasticity of base demand. An interior solution to the profit maximization problem requires $\varepsilon$ be decreasing in $q$, which we assume throughout the remainder of the paper.

The variable $\rho$ captures the intrinsic quality of a good; for example, if the good is a treatment for influenza, $\rho$ may index the speed with which the treatment reduces flu symptoms. We draw a distinction between quality and applicability, or relevance: ever since Armington (1969), several economists (e.g. Trefler 1995) have argued that consumers may prefer locally produced goods to otherwise-identical imports. In the current paper we operationalize home bias via an iceberg “translation” cost $1-\tau$; we can think of $\tau$ as the fraction of a knowledge good’s value that survives translation to a

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5 Empirical studies tend to find strong evidence of home bias in consumption. For example, Whalley and Xin (2006) find home bias can account for over 90% of the measured border effect in US-Canada trade.
foreign market. Recalling terminology introduced above, let $t_{ij}$ measure the relevance to consumers in market \( i \) of a knowledge good developed in market \( j \); then with iceberg translation costs $t_{ij} = 1$ for \( i=j \) and $t_{ij} = \tau \in [0,1]$ for \( i \neq j \); accordingly, we can think of $\tau p$ as the net premium for imported, or translated, goods. We treat $\tau$ as a parameter outside the artist’s and government’s control, however we acknowledge that $\tau$ will vary with the type of knowledge good considered: for instrumental music $\tau$ may be near unity; the $\tau$ associated with comedy is often remarked to be close to zero.\(^6\)

If emigration is legal, the artist faces a two-stage problem. First she must decide where to live and work, and second she must decide what quality prototype to produce and how to price it to each market. As usual, we begin with the second stage.

### 3.1 Stage Two: Profit Maximization

We simplify the world into two countries: Source (\( S \)) and Recipient (\( R \)). Let \( N_i \) be the number of consumers in country \( i \in \{S,R\} \). Define $\pi_i = \max_q p_i(q)q$ as the artist’s maximized per capita base profits from market \( i \), and $q_i = \arg\max_q p_i(q)q$ as her optimal per capita deliveries to this market.\(^7\) Note that our inverse demand functions are indexed by country (\( i \)); this allows per-capita income differences to enter our model with higher income assumed to shift the inverse demand curve upwards. In this section we assume that both Source and Recipient provide full legal protection of intellectual property rights (IPRs). Thus the artist is an uncontested monopolist in both markets, and will choose $q_i$ such that $\varepsilon = 1$ in each market. Using these definitions, we can rewrite the artist’s total profits from market \( i \) when residing in country \( j \) as $N_{ij} \rho \pi_i$. Further, the artist can treat $\pi_S$ and $\pi_R$ as parameters when solving her investment and location problems.

Improving the quality of the prototype comes at a price. The knowledge worker may hire complementary inputs (a scientist outfitting a better lab), acquire additional human capital (voice lessons for an opera singer, a post doc for a biologist), or simply put in more effort (work longer hours). We will refer to any such actions as investments. Let $c(\rho)$ measure the total cost of producing a prototype of quality $\rho$. We assume the marginal cost of improving prototype quality is positive and increasing, i.e. $c'(\rho)$ and $c''(\rho)$ are both positive.

The artist’s optimal investment depends on the effective size of her global market. Define $X_i = N_i \pi_i$ as effective market size in country \( i \). When the artist remains in Recipient her effective global market size is $M_R = X_R + \tau X_S$; when she resides in Source it is $M_S = \tau X_R + X_S$. Thus when the artist lives in country \( j \) she chooses $\rho$ to

$$\max_{\rho} \rho M_j - c(\rho).$$

\(^6\) Importantly, the home bias in our paper refers to the artist’s current location, not his/her country of birth; thus we assume that, for example, Indian consumers treat goods produced by Indian expatriates in the United States similarly to goods produced by other Americans. In part, this is based on a prevalent notion in the business literature that close contact (in our case living in the same country and culture) with consumers is essential to producing innovations that customers like (see for example Ulwick 2002).

\(^7\) Because $\varepsilon$ is decreasing in $q$, base profits $p'(q_i)q_i$ are locally concave at $q_i'$ and $q_i'$ is unique.
A convex cost function (i.e. $d^2 c/dp^2 > 0$) ensures the second order conditions for an interior maximum, while the first order condition

$$M' = c'(\rho)$$

(1)

implicitly defines $\rho(M')$ as the price premium corresponding to the artist’s optimal investment when residing in country $j$. Because higher values of $\rho$ reflect higher quality knowledge goods, we can interpret an increase in $\rho$ as knowledge creation; differentiating the first order condition we see $dp(M)/dM = 1/c'' > 0$. Hence, if an action by the artist or a government increases the size of the artist’s effective market, that action will in turn have a knowledge creation effect. For future reference define

$$\Psi = \frac{c'}{c'' \rho}.$$

Given (1), $\Psi$ also measures the elasticity of the artist’s product quality $\rho$ with respect to market size. In general $\Psi$ is a function of $\rho$ and hence of $M$, although on occasion we will adopt the following assumption:

A1: $c$ is iso-elastic, i.e. $\Psi$ is a constant.

3.2 Stage One: Emigration

We assume zero relocation costs. Since the artist earns more when $M$ is larger, she will move to wherever her residency confers the largest global base market. For $\tau<1$, whether $M_S < M_R$ depends only on relative populations and base profits. Assuming the artist stays home when indifferent, we obtain the following lemma and proposition.

Lemma 1. If translation costs are non-zero (i.e. $\tau<1$), the artist emigrates if and only if $X_S < X_R$.

If both countries have the same individual inverse demand curves (for example because their per capita income levels and tastes are the same), Lemma 1 implies that the artist optimally locates herself in the country with the largest population for any non-zero level of translation costs. Of course, the artist might optimally choose a country with smaller population if its consumers were sufficiently richer than the other country.

The artist relocates only if Recipient’s market is larger than Source’s. Once immersed in the Recipient market, the artist responds to the increased returns on her investment, producing a higher quality prototype. Thus we have the following:

Proposition 1: Voluntary emigration induces knowledge creation.
Proof:
By Lemma 1 the artist emigrates voluntarily if and only \( \tau < 1 \) and \( X^R > X^S \), thus \( M^R > M^S \). Since \( d\rho/dM > 0 \) then \( \rho(M^R) > \rho(M^S) \) and so emigration leads to higher quality knowledge goods. ■

4. Beneficial Brain Drain

We now turn our attention to conditions under which brain drain is beneficial to the parties involved. In order to minimize the number of cases that must be described, we restrict our attention in the remainder of the paper to cases in which the artist will emigrate if allowed, i.e. in which \( X^R > X^S \).

A simple revealed preference argument confirms that the artist benefits from voluntary migration. Whether consumers gain depends on the rate of knowledge creation versus translation costs.

Lemma 2: Consumers in country \( i \) are better off when the artist voluntary emigrates if and only if

\[
\tau^S \rho(M^S) < \tau^R \rho(M^R). \tag{2}
\]

Proof: Let \( CS^i = N^i \frac{1}{\rho} \int \Phi^i \) measure consumer surplus in country \( i \) when the artist resides in country \( j \), where

\[
\Phi^i = \int_0^{q^i} p(q)dq - p(q^i)q^i
\]

is “base” consumer surplus per capita, i.e. consumer surplus associated with quality-unadjusted goods, when \( q^i \) units are sold per capita in country \( i \). As \( N^i \) and \( \Phi^j \) are independent of \( \rho \), \( CS^S < CS^R \) if and only if (2). ■

Proposition 2:
(a) Recipient consumers gain from voluntary migration.
(b) Define \( \Lambda \equiv \frac{X^R - X^S}{X^R + X^S} \) as the relative difference in market sizes.

\[
\Lambda \Psi(\rho(X^R + X^S)) > 1 \tag{3}
\]

is a sufficient condition for Source consumers to gain from the artist’s voluntary migration for some positive translation costs.

(c) If A1 and (3) each hold there exists a \( \bar{\tau} \) that divides the unit interval as follows: brain drain is neutral for Source’s consumers if \( \tau \) equals unity or \( \bar{\tau} \), is beneficial if \( \tau \in (\bar{\tau}, 1) \), and harmful if \( \tau < \bar{\tau} \).

(d) If A1 holds and (3) is violated then Brain Drain is harmful to Source’s consumers for any \( \tau \in [0, 1) \).
**Proof:** See Appendix

**Corollary 1:** If (3) holds then there exists a non-empty interval of translation rates \(\tau\) under which voluntary emigration is Pareto welfare improving.

Part (a) of Proposition 2 confirms that Recipient consumers gain from the Artist’s immigration on two counts. First, they benefit from the additional knowledge creation stemming from their large native market. Secondly, migration induces *knowledge diversion*. The Artist’s work now caters more to the tastes of Recipient consumers and less to Source’s consumers.

Source consumers also benefit from knowledge creation, but they are hurt by the knowledge diversion. If quality is highly responsive to market size, improved quality will dominate the cost from mismatched product characteristics and Source consumers gain. As laid out in Part (b) of Proposition 2, so long as translation costs are positive but small, knowledge creation will dominate. Parts (c)-(d) of Proposition 2 provide necessary and sufficient conditions for BBD when A1 holds as depicted in Figure 1. Figure 1 shows the rates of knowledge diversion (the straight line, \(1-\tau\)), and knowledge creation, \([\rho(M^R)-\rho(M^S)]/\rho(M^R)\). Clearly, the possibility of BBD depends on the curvature of the cost function and the size of the translation cost. Because \(\Lambda\) can be no larger than unity, a necessary condition for BBD is that quality be elastic in market size, i.e. \(\Psi > 1\). This is not inconsistent with investment costs being convex in quality: if \(c\) is iso-elastic, for example, convexity requires only that \(\Psi\) be positive. Rather, the constraint that \(\Psi > 1\) simply requires that investment costs not rise too quickly with quality.

\[
\tau = \text{translation/survival rate}
\]

\[
\rho(M^R) - \rho(M^S) = \text{rate of knowledge diversion (translation loss)}
\]

\[
\rho(M^R) - \rho(M^S) = \frac{\rho(M^R)}{\rho(M^S)} = \text{rate of knowledge creation}
\]

**Figure 1:** knowledge creation versus knowledge diversion
The parameter \( \tau \) also plays a critical role in our analysis. If \( \tau = 0 \) then translation losses are complete and knowledge creation is irrelevant to Source’s consumers since they won’t be able to understand, or make use of, any of it. Conversely, if \( \tau = 1 \) then any additional knowledge created will be perfectly useful to Source’s consumers; however, because \( M^S \) and \( M^R \) would be identical, emigration would leave \( \rho \) unchanged. But, if \( \tau \) has an intermediate value, then voluntary emigration prompts additional investment and some of that quality improvement survives translation. If \( \tau \) is not too small, the net value of the artist’s product will rise for Source’s consumers, rendering brain drain beneficial. Figure 1 nicely illustrates how differences in both effective market size and home bias (i.e. “translation costs”) are required for BBD: if there is no home bias, knowledge workers can serve the entire world equally well from wherever they live; thus there is no efficiency gain from sending them into a large consumer market such as the U.S.

Source’s relative size is the final determinant of whether (3) holds. Because \( \rho \) is increasing in \( M \), the larger the difference between \( M^S \) and \( M^R \) the greater the knowledge creation effect accompanying emigration. Accordingly, the larger the gap between \( X^R \) and \( X^S \) for a given \( \tau \), the more likely Source is to gain from brain drain. The following proposition formalizes this result.

**Proposition 3.** Under A1, the interval of survival rates \( (\tau, 1) \) over which Brain Drain is beneficial to Source’s consumers is larger the smaller is Source’s effective market size \( X^S \) relative to Recipients, \( X^R \). Specifically, \( \frac{d \tau}{d \alpha} > 0 \) where \( \alpha = \frac{X^S}{X^R} \).

**Proof:** See Appendix.

5. Brain Drain and Intellectual Property Rights

Market size is critical in our model: differences in effective market size drive knowledge workers to migrate and are ultimately responsible for knowledge creation. Some of the factors determining effective market size, e.g. the size and income level of the native population—the latter being a determinant of base demand \( p(q) \)—are outside the control of policymakers, at least in the short run. However, since the goods in question are knowledge goods, goods that can be reproduced at essentially zero cost, then \( \pi^S \) also depends on *de jure* and *de facto* rules governing intellectual property rights (IPRs). In this section, we develop a stylized model of endogenous IPRs in the Source country. The goal behind this exercise is to examine how our main results generalize to the case where countries optimally adapt their IPR policies to their emigration policy regime. We do so in full recognition that not all important factors affecting optimal IPR policy are included in our model (for a fuller treatment of IPRs without reference to emigration, see Grossman and Lai, 2004).\(^8\)

\(^8\) For simplicity, this section continues to characterize Source’s emigration policy as a dichotomous choice between “closing its exits”, i.e. prohibiting emigration, or not (rather than, for example, an emigration tax). Given our earlier restriction \( X^S < X^R \), brain drain is inevitable unless Source’s exit-doors are closed; thus open-exit policy is synonymous with “Brain Drain” in our discussion.
The strength of a country’s IPRs can be measured along two dimensions: the breadth of its fair use rules, and the zeal with which it enforces its rules. We consider only the case in which fair use rules are very tight, and so the consumer must purchase one copy of the artist’s prototype for each application (e.g. one copy of an operating system for the user’s desktop, another copy for his laptop), but where enforcement is imperfect. In particular, a competitive fringe sells pirated reproductions of the artist’s prototype at marginal cost; we assume all demand goes to the artist if legal and pirated goods are offered at the same price. Assume constant returns to scale in producing pirated goods, and denote their marginal cost by \( d \). Assuming pirates have access to the same reproduction techniques as the artist, the materials portion of \( d \) is zero. Thus \( d \) reflects only the expected costs of getting caught distributing copyrighted materials. In particular, we assume \( d \) equals the probability of detection multiplied by the (non-monetary) penalty for piracy. For parsimony, we assume the penalty is proportional to the price premium, \( \rho t \), for the translated good. This means the marginal cost in country \( i \) of pirated copies of a prototype produced in country \( j \) can be written

\[
d_{ij} = \beta_i t_{ij} \rho
\]

where \( \beta \) is increasing in the strength of i’s IPR enforcement. This \( \beta \) proxies the strength of de facto IPRs and equals the base price of pirated goods.

Based on (4), base profits and base consumer surplus in a market with IPR parameter \( \beta \) are as follows:

\[
\pi(\beta) \equiv \begin{cases} p^{-1}(\beta\ast)\beta \ast & \text{for } \beta \geq \beta \ast \\
p^{-1}(\beta')\beta' & \text{for } \beta < \beta \ast \end{cases}
\]

and

\[
\Phi(\beta) = \int_{0}^{p^{-1}(\beta)} p(q) dq - \beta p^{-1}(\beta)
\]

where \( \beta \ast \) is the base price the artist would set absent any competition and \( p^{-1}(\cdot) \) is the inverse of function \( p(\cdot) \). As indicated by (5), the artist is a contested monopolist when pirates are at play. Notably, \( \pi(\beta) \) and \( \Phi(\beta) \) are independent of \( \rho \) just as in the previous section. Moreover, \( \pi(\beta) \) is increasing in \( \beta \) for \( \beta < \beta \ast \), while \( d\Phi/d(\beta) = - p^{-1}(\beta) < 0 \): as usual, stricter IPRs benefit producers and hurt consumers holding product quality fixed.

Before we embark on our analysis of Source’s optimal IPRs as a function of emigration policy, we adapt the previous section’s notation to the endogenous-IPR case. Define \( X_i(\beta) = N_i \pi(\beta) \) as the effective size of market \( i \) when IPRs in \( i \) are \( \beta \). Because \( \pi \) is now endogenous via \( \beta \), we refine our restriction on Source’s relative size as follows:

\[ d\pi(\beta)/d\beta = p^{-1}(\beta)[1 - \varepsilon]. \]

Since \( \varepsilon \) is decreasing in \( q \) and \( \varepsilon \) is unity at the uncontested monopoly output \( p^{-1}(\beta \ast) \), then, for any \( \beta < \beta \ast \), \( \varepsilon < 1 \) and thus \( d\pi(\beta)/d\beta > 0 \).
Given Lemma 1, Assumption A2 ensures that Source is too small to be attractive to the artist even if Source fully protects intellectual property. In the interest of brevity we also assume A1 holds in all that follows.

Source consumer surplus is

\[
CS^S(\beta) = N^S t^S \rho \Phi^S(\beta^S).
\]  \hspace{1cm} (7)

Differentiating with respect to \(\beta\) (while appropriately allowing for the endogeneity of product quality, \(\rho\)) yields

\[
\frac{dCS^S(\beta)}{d\beta} = p^{-1}(\beta) N^S t^S \rho \left[ \frac{N^S t^S [1 - \varepsilon(\beta)] \Phi(\beta) \Psi}{M^j} - 1 \right], \hspace{1cm} (8)
\]

or, if \(\beta > 0\), equivalently

\[
\frac{dCS^S(\beta)}{d\beta} = \frac{CS^S(\beta)}{\beta} \left[ \frac{\lambda^S [1 - \varepsilon(\beta)] - \pi(\beta)}{\psi^j} \right]_{\equiv \Delta(\beta, j)} \hspace{1cm} (9)
\]

where \(\lambda^i t^i, \pi^i / M^j\) is country \(i\)'s share of the artist’s effective global market when the artist lives in country \(j\).

**Lemma 3.** Under A1, \(CS^S\) is strictly (locally) concave in \(\beta\) at any extremum.

**Proof:** See Appendix.

Referring to (9), whether strict IPRs raise or lower Source’s consumer surplus when \(\rho\) is endogenous depends on the sign of \(\Delta(\beta, j)\):

\[
\Psi \lambda^S [1 - \varepsilon(\beta)] - \frac{\pi(\beta)}{\Phi(\beta)}.
\]

The first term in \(\Delta\) reflects the investment effects of raising \(\beta\): stronger Source IPRs translate to higher base profits for the artist, prompting greater investment; the second term in \(\Delta\) measures the loss in base consumer surplus arising from consumers having to pay higher prices per (base) unit. We can think of these as the *investment* and *consumption* effects of strong IPRs. Define \(\beta^O\) and \(\beta^C\) as Source’s optimal choice of \(\beta\) when its doors are open and closed, respectively.

**Proposition 4:** Under A1 and A2,

(a) If Source offers any IPR protection at all, it offers weaker policy when its exits are open than closed. Specifically, \(\beta^O < \beta^C\) if and only if
\[
\frac{\Psi N^S [1 - \varepsilon(0)] \Phi(0)}{\tau N^R \pi^R} > 1;
\]

(10)

If (10) fails then \( \beta^O = \beta^C = 0 \).

(b) Source never offers full IPR protection: \( \beta^O \leq \beta^C < \beta^* \).

**Proof:** See Appendix.

Intuitively, Source’s optimal IPR policy balances the investment and consumption effects described above. Since the investment effects are dissipated as \( \beta \) approaches \( \beta^* \), Source will always offer less than full IPRs when the artist’s residency is given. Moreover, when the Artist lives abroad rather than in Source, the investment incentives associated with high \( \pi^S \) are diluted by translation losses. Thus the investment effect of high \( \beta \) is weaker when Source’s exits are open, rendering strong IPRs less attractive to Source.

We now revisit our earlier claims concerning when/whether Brain Drain might benefit the Source country. In particular, Proposition 2 provided a sufficient condition for BBD under the condition that Source IPR policy was full. However, as Proposition 4 highlights, Source has an incentive to set weaker IPR policy when suffering from Brain Drain. The following extends Proposition 2 to allow for endogenous IPRs.

**Proposition 5:** Suppose Source’s IPRs are set optimally given exit policy, i.e. \( \beta = \beta^O \) when Source’s exits are open and \( \beta = \beta^C \) when Source’s exits are closed. Define \( \tilde{\tau}(\beta) \) as the non-unity value of \( \tau \) at which

\[
\tau = \frac{\rho(X^S(\beta) + \tau X^R)}{\rho(X^S(\beta) + X^R)}.
\]

Under A1,

\[
(a) \quad \Psi \left[ \frac{X^R - X^S(\beta^C)}{X^R + X^S(\beta^C)} \right] > 1
\]

(11)

is a sufficient condition for Source to prefer an open-exit policy in lieu of closed-exits for some non-empty range \( (\tau^l, 1) \) of translation costs;

(b) if condition (10) holds then \( \tau^l < \tilde{\tau}(\beta^C) \).

**Proof:** See Appendix.

Part (a) of Proposition 5 offers a sufficient condition for brain drain to benefit Source even when Source adjusts its IPRs to complement its emigration policy. The underlying logic is the same as for Proposition 2: emigration transfers the local component of knowledge goods away from Source’s consumers—what we have coined *knowledge diversion*; in exchange, the large market that attracts mobile knowledge workers in the first place prompts them to produce higher quality goods, inducing *knowledge creation*. This basic principle is unchanged by endogenous IPRs. However,
as Part (b) of Proposition 5 indicates, the range of translation costs for which brain drain is beneficial is larger when IPRs are endogenous rather than fixed. This is because endogenous IPRs open up a second channel through which Source can benefit from the artist’s emigration to a large overseas market. Simply, Source can manipulate domestic IPRs to raise consumers’ share of the benefits from knowledge creation: by lowering $\beta$, i.e. by weakening domestic IPRs, Source can raise $\Phi$, allowing Source’s consumers to reap a greater share of the benefits from any increase in $\rho$. This option is not as appealing when the artist resides in Source because reductions in $X^S$ would have a larger negative impact on $\rho$.

5. Discussion

In the late twentieth century, the worldwide pattern of information goods production and IPR protection had three distinct features. First, knowledge goods production was highly concentrated in a single country with a large domestic market (in most cases the United States). Second, a significant share of these goods was produced by immigrants to that country. Third, intellectual property rights protection was strongest in the producing country and weaker in other countries, including the source countries from which migrating knowledge workers were drawn. While the exodus of talented “brains” to larger, richer economies is sometimes bemoaned in sending countries, this paper shows that, under quite general conditions, all the above features could be in the interests of both the migrating knowledge workers and the remaining residents of the nations that send them. These remaining residents benefit because “their” brains produce “better” knowledge (such as more effective medicines, more entertaining movies, or more powerful software) abroad than if they had remained at home.

Some noteworthy features of our model include the following. First, beneficial brain drain “BBD” is possible even when (a) the sending country places no welfare weight on the utility of its expatriates, (b) knowledge/cultural goods are less culturally relevant to the source market when produced abroad, that is, when demands exhibit home bias, or “translation loss”, and (c) both sending and receiving countries fully protect knowledge workers’ intellectual property rights in a national treatment framework.

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10 A case in point might be Canadian intellectual property rights, under which “borrowing a musical tape from a friend to copy onto a blank tape for private use” (Canadian Intellectual Property Office 2005, p.6) is not considered copyright infringement. Such rules shrink the size of Canada’s effective market for new CD sales (although not quite in the way we have modeled) and accentuate the gains to Canadian consumers from allowing Canadian musical talent to emigrate to the U.S.

11 Using purchasing power parity measures of R&D activity, Dougherty et al (2003) find that expenditures in the US exceeded the combined expenditures of the next four leading research nations, Germany, Japan, France and UK. In 2000, 34.3% of Triadic Patent Families (defined by the OECD as “patents taken out at the European Patent Office (EPO), the Japanese Patent Office (JPO) and the US Patent & Trademark Office (USPTO) that share one or more priorities”) were taken out by American residents. The comparable proportions for residents of Japan and the EU are 26.9 and 31.4 (Source: OECD, Patent Database, September 2004.) The international predominance of the United States as a source of commercial popular culture is well known.

12 In addition to entertainers, this of course includes scientists and engineers working in U.S. firms and universities. Nearly one in five scientists and engineers in the United States is an immigrant; 51 percent of US doctorates in engineering are currently awarded to foreigners (Zakaria 2005).
Second, while we acknowledge that agglomeration economies may be important in explaining the location of many industries (e.g. Rivera-Batiz and Romer 1991) such external economies are absent from our model. Instead, international specialization --via the migration of producers to a single country-- can result simply from differences in domestic market size and home bias in tastes. In future work, we plan to examine the effects of agglomeration economies on BBD in a dynamic context; importantly however such dynamics are not essential to the basic argument introduced in this paper.

Third, source countries’ gains from brain drain depend on intellectual property rights in both the sending and receiving countries. The likelihood that brain drain benefits the source country increases when we expand its menu of policy tools to include an optimal choice of IPRs. Thus it may be in the interests of a small, or poor country to simultaneously specialize out of knowledge goods production (even actively sending its talented knowledge workers abroad) and keep the price of knowledge goods low by setting weak IPRs.

Fourth, the level of home bias in consumers’ tastes has interesting effects in our model. If we think of our parameter $\tau$ (the fraction of a knowledge good’s value that survives export to another country) as rising over time due to declines in international transportation and communications costs, then our model predicts that source countries’ benefits from brain drain will be minimal when international communication is poor, and will then rise as the ability of knowledge workers in one country to serve consumers in another rises. It is only in the limiting case of zero ‘home bias’ ($\tau = 1$)—where knowledge workers can serve the world’s consumers equally well from any location—where better international communication eliminates the gains to consumers in a small or poor country from sending their brains abroad.

Finally, our results have implications for policies affecting “brain drain” in small or poor countries that have not, to our knowledge, been noted before. For example, skilled-emigrant-sending countries may want to refine their policies (or at least their discussion of brain drain) by distinguishing emigrants according to the “publicness” of the goods they produce. Thus, for example, the emigration of a physician who spends all of her time treating patients (a private good) may be more likely to hurt the remaining residents of her country than the emigration of a physician primarily engaged in research on new treatments and medicines (the sort of knowledge good modeled in this paper).

In sum, this paper shows that brain drain may benefit the remaining residents of a country by improving the quality of the goods they consume. To the best of our knowledge, this effect has not yet been noted in the economics literature. Instead, existing models of international factor mobility tend to treat the quality of traded goods as exogenous; partly in consequence, consumer welfare is typically not modelled explicitly. We hope the present paper encourages others to explore additional feedback effects of international migration on consumers in both the sending and receiving countries.
References

Armington, Paul S. "A Theory of Demand for Products Distinguished by Place of Production." International Monetary Fund Staff Papers March 1969, 16(1): 159-78.


Appendix

Proof of Proposition 2:

(a) For $i=R, \rho(M^R) > \tau \rho(M^S)$ is guaranteed by $\tau \leq 1$ and Proposition 1.
(b) By Lemma 2, Source consumers are better off with emigration if and only if $\tau \rho(M^R) - \rho(M^S) > 0$. As $\tau \rho(M^R) = \rho(M^S)$ when $\tau = 1$, proving brain drain is beneficial for some positive translation costs merely requires proving the derivative of $\tau \rho(M^R) - \rho(M^S)$ is negative at $\tau = 1$.

Differentiating, evaluating at $\tau = 1$ and factoring out terms gives

$$\frac{d}{d\tau} \left[ \tau \rho(M^R) - \rho(M^S) \right] \bigg|_{\tau = 1} = \rho(M^R) \left[ 1 - \Psi(M^R) \Lambda \right].$$

(c) Define $\Gamma(\tau) \equiv \frac{\rho(M^S)}{\rho(M^R)}$. Given A1, we can write $\Gamma \equiv \left( \frac{M^S}{M^R} \right)^\psi$. Define $\alpha$ such that $X^S = \alpha X^R$ where $\alpha < 1$. This allows us to write $\Gamma = \left( \frac{\alpha + \tau}{\alpha \tau + 1} \right)^\psi$. Twice differentiating $\Gamma$ with respect to $\tau$ when $\Psi$ is constant gives

$$\frac{d^2 \Gamma}{d\tau^2} = \Gamma \Psi \left( \frac{1 - \alpha^2}{(\tau \alpha + 1)^2 (\alpha + \tau)^2} \right) \left[ \Psi \left[ 1 - \alpha^2 \right] - \alpha^2 - 2 \alpha \tau - 1 \right]$$

which is positive for all $\tau \in [0,1]$ if and only if (3) holds. Hence (3) ensures $\Gamma$ is globally convex in $\tau$ and thus there exists $\bar{\tau} \in (0,1)$ such that $\Gamma(\bar{\tau}) = \Gamma$ and $\bar{\tau}$ divides the unit interval into regions where brain drain is and is not beneficial to Source’s consumers.

(d) Differentiating $\Gamma$ with respect to $\tau$ gives

$$\frac{d\Gamma}{d\tau} = \Psi \Gamma \left[ \frac{1 - \alpha^2}{(\tau \alpha + 1)(\alpha + \tau)} \right].$$

If (3) holds then $d\Gamma/d\tau$ is less than unity whenever $\tau$ is such that $\Gamma = \tau$. Hence the 1-$\Gamma$ curve cannot cross the 1-$\tau$ line in Figure 1 from above. Moreover, since $\Gamma = 1$ when $\tau = 1$ and $\frac{d\Gamma}{d\tau} \bigg|_{\tau = 1} < 1$ then $\Gamma \leq \tau$ is ruled out whenever (3) holds and $\tau < 1$. Finally, suppose $\Lambda \Psi = 1$; then $\Gamma$ is strictly convex in $\tau$ for $\tau < 1$. Moreover, since $\Gamma > 0$ for $\alpha > 0$ when $\tau = 0$, while $\Gamma$ and $d\Gamma/d\tau$ are both unity when $\tau = 1$, then $\Gamma \leq \tau$ is ruled out whenever $\Lambda \Psi = 1$. ■

Proof of Proposition 3:

When (3) is satisfied, $\frac{d\Gamma}{d\alpha} = \Gamma \Lambda \left[ \frac{1}{\alpha + \tau} - \frac{\tau}{\alpha \tau + 1} \right] > 0$ for $\tau < 1$, which implies $d\bar{\tau}/d\alpha > 0$; thus the smaller is $\alpha$, the larger the interval $(\bar{\tau},1)$. ■
Proof of Lemma 3:

Differentiating the right hand term in (8) with respect to $\beta$ and evaluating at any extremum gives

$$\frac{d^2 CS^j(\beta)}{d\beta^2} = p^{-1}(\beta)N^j\rho N^j\Psi^j \left[ - \Phi(\beta) \frac{d\varepsilon(\beta)}{d\beta} + \frac{1-\varepsilon}{M^j} \Phi(\beta) \frac{dM^j}{d\beta} \right]$$

Because $\varepsilon$ is decreasing in $q$, $\varepsilon$ is non-decreasing in $\beta$; since higher prices translate to lower consumer surplus, $d\Phi/d\beta<0$; since profits are increasing in $\beta$, $dM^j/d\beta>0$. Hence $d^2 CS^j(\beta)/d\beta^2 < 0$ at any extremum of $CS^j$.

Proof of Proposition 4:

We prove Part (b) first. Since the artist’s marginal costs of reproduction are zero, if her monopoly power is uncontested then she sets prices such that $\varepsilon=1$. From equation (8), $dCS^j(\beta)/d\beta<0$ whenever $\varepsilon=1$, thus Source never offers full intellectual property protection if the artist’s residency is fixed. Finally, when $A2$ holds, Source’s exit-policy fully determines the artist’s residency; thus Source can treat the artist’s residency as invariant to $\beta$ within a given exit-policy regime.

Part (a). When (10) fails then, from equation (8), $dCS^j(\beta)/d\beta \leq 0$ for $j \in \{S,R\}$ and so Source sets $\beta^k=0$ for $k \in \{O, C\}$. If instead (10) holds then $\beta^C>0$; by part (b), $\beta^C<\beta^*$. Hence $\beta^C$ takes an interior value; from equation (9), $\beta^C$ solves $\Delta(\beta^C,S)=\frac{\lambda^{SR}[1-\varepsilon]}{\psi^S} - \frac{\pi(\beta^C)}{\Phi(\beta^C)}=0$. By Lemma 3, $A1$ implies $CS$ is locally concave in $\beta$. Using (9), evaluating $dCS^{SR}(\beta)/d\beta$ at $\beta^C$ and factoring out like terms gives

$$\frac{dCS^{SR}(\beta)}{d\beta} \bigg|_{\beta=\beta^C} = \frac{CS^{SR}[1-\varepsilon(\beta^C)]}{\beta^C \psi^S} \left[ \lambda^{SR} - \lambda^{SS} \right].$$

Since $\lambda^{SR}<\lambda^{SS}$ under $A2$, then $A1$ implies $dCS(\beta;M^R)/d\beta \bigg|_{\beta=\beta^C} < 0$, hence $\beta^O<\beta^C$.

Proof of Proposition 5:

Part (a): Define $CS'(\beta)$ as Source’s consumer surplus when Source’s IPR policy is $\beta$ and exit-door policy is $k \in \{\text{open, closed}\}$. By Proposition 2, equation (11) is a sufficient condition for $CS^{open}(\beta^C) > CS^{closed}(\beta^C)$ whenever $\tau \in (\tau(\beta^C),1)$. Revealed preference ensures $CS^{open}(\beta^O) \geq CS^{open}(\beta^C)$.

Part (b): When condition (10) holds then, by Proposition 4, $\beta^C>\beta^O$. Since Source’s consumer surplus is strictly locally concave in $\beta$ by Lemma 3, then $CS^O(\beta^O) > CS^O(\beta^C) = CS^C(\beta^C)$ when $\tau=\tau(\beta^C)$. Since $CS^O(\beta^O) > CS^C(\beta^C)$ at $\tau=\tau(\beta^C)$, then $\tau<\tau(\beta^C)$.