

**Consumers and the Brain Drain:  
Product and Process Design and the Gains from Emigration**

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**Abstract:**

We consider the welfare effects of skilled worker emigration in a context where skilled labor plays a role in product or process design. We show such emigration can benefit the residents left behind, even when consumers' tastes exhibit a form of home bias. This is because emigration improves the design of goods designed by skilled emigrants but consumed in the sending country. In contrast to existing models of beneficial brain drain, 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 skilled emigrants to design better products or production processes abroad than at home.

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## 1. Introduction.

Will a “brain drain” from a small or low-wage economy hurt or help residents remaining behind? The earliest economics literature on this question (e.g. Berry and Soligo 1969, Bhagwati and Hamada 1974) showed that remaining residents may be harmed by diminished opportunities to trade with differently-endowed agents. More recent contributions have argued that 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), could counteract these factors, giving rise to beneficial brain drain (BBD).

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 goods. More specifically, we distinguish between two aspects of production—design and replication—and argue that skilled labor plays an important role in the former. Because improved design increases the value of every unit of a product distributed to consumers, or reduces the cost of producing each unit, its benefits accrue to all of the good’s consumers, regardless of where they live.

Obvious examples of the effect we model might be scientists sent to a U.S. laboratory, actors sent to Hollywood, and programmers sent to Silicon Valley. Slightly less obvious, but probably more important examples include contributions made by foreign-born managers and engineers to the quality of any good or service, or the efficiency of a production process, that is designed in the U.S. and consumed abroad.<sup>1</sup> Of course, the level of marginal replication costs, 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 design higher-quality goods when employed abroad? While we can think of several—including agglomeration economies and a stronger IPR environment—, our baseline 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 the product doesn’t lose too much “in translation,” the extra incentives to raise quality created by this larger market mean the (remaining residents of) the home country are better off allowing their skilled workers to emigrate.

## 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

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<sup>1</sup> It is irrelevant to our basic argument whether the good is manufactured (i.e. replicated) in the immigrant-sending or receiving country. In fact the gains to brain drain are enhanced when emigration creates manufacturing jobs in the migrant-sending country based on superior designs created by its expatriates.

undistorted “sending” economy. Although exceptions exist<sup>2</sup>, 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. Factors that accentuate the harm from brain drain include fiscal externalities: 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 substantial long run harm by reducing a country’s growth rate (Miyagiwa 1991, Wong and Yip 1999).<sup>3</sup>

At the same time, however, the literature has identified a number of factors that may give rise to “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 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).<sup>4</sup> 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. 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.

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. 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.

### 3. The Model

As noted, our vision of the production process for any good distinguishes two aspects: design and replication. The former determines two things: (a) a product’s quality, i.e. the appeal to consumers of a single unit of the good, and (b) the technology (specifically the constant unit cost) via which copies of the prototype are produced. Replication refers to the actual process of manufacturing copies and distributing them to consumers. Brains’ involvement in the design of products and processes is a key feature of our model. To illustrate our main result most simply, our base-case model focuses on a single skilled worker

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<sup>2</sup> 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.

<sup>3</sup> 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).

<sup>4</sup> According to DeVoretz (2005), it is precisely this prospect of return migration that led China to relax its exit requirements in the early 1990s.

at risk of emigration,<sup>5</sup> whose only activity is to improve the quality of a prototype good (for example a musical recording, an insight into the laws of physics, or a malaria vaccine). Following Rosen (1981), the prototype can be replicated costlessly. In Section 5 we show how the model can be easily adapted to study brains' involvement in process innovation, where their activity is now to reduce marginal copying costs from a positive initial level. Most of the main results are unchanged.

Assume, therefore, that market willingness to pay for a single copy of the good depends on two product attributes: quality,  $\rho$ , and *relevance*,  $t$ ; we discuss each attribute below. We assume individual inverse demand for a reproduction is given by  $tp(q)$  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 good with 100% relevance and quality. Define  $\varepsilon \equiv -\frac{1}{\frac{dp(q)}{dq}} \frac{p(q)}{q}$  as the elasticity of base demand. An interior solution to the profit maximization problem requires  $\varepsilon$  to 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. Treffer 1995) have argued that consumers may inherently prefer locally produced goods.<sup>6</sup> 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 good's value that survives translation to a foreign market. Recalling terminology introduced above, let  $t^{ij}$  measure the relevance to consumers in market  $i$  of a good developed in market  $j$ ; with iceberg translation costs,  $t^{SR}=t^{RS}=\tau \in [0,1]$  while  $t^{SS}=t^{RR}=1$ . One way to interpret  $\tau\rho$  is as the net premium for imported, or *translated*, goods. We treat  $\tau$  as a parameter outside the designer's and government's control, however we acknowledge that  $\tau$  will vary with the type of good considered: for instrumental music  $\tau$  may be near unity; the  $\tau$  associated with comedy is often remarked to be close to zero.<sup>7</sup>

If emigration is allowed, the designer 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

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<sup>5</sup> The remaining residents of the designer's home country can be thought of either as unskilled workers who produce a numeraire good at constant unit cost, or as other designers who produce prototypes that do not compete with the potential migrant's prototype. Either way, the *incomes* of these remaining residents will not be affected by whether the migrant stays or leaves, which allows us to focus on the new (consumption-related) aspects of our model here.

<sup>6</sup> Empirical studies tend to find strong evidence of home bias in consumption. For example, Whalley and Xin (2006) show home bias can account for over 90% of the measured border effect in US-Canada trade.

<sup>7</sup> Importantly, the home bias in our paper refers to the designer's current location, not his/her country of birth. 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).

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 designer's maximized per capita *base* profits from market  $i$ , and  $q^i = \operatorname{argmax}_q p^i(q)q$  as her optimal *per capita* deliveries to this market.<sup>8</sup> 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 designer 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 designer's total profits from market  $i$  when residing in country  $j$  as  $N^i t^{ij} \rho \pi^i$ . Further, the designer 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 brain may hire complementary inputs (a scientist outfitting a better lab, or an industrial engineer hiring more qualified colleagues and assistants), acquire additional human capital (voice lessons for an opera singer, a post doc for a biologist or M.B.A. for a manager), or simply put in more effort (work more intensely or for longer hours). We will refer to any such actions as *investments*. Let  $c(\rho)$  measure the total cost of producing a prototype of quality  $\rho$ . To make things simple we assume  $c(\rho) = \rho^{1+\Psi/\Psi}$ ; convexity requires  $\Psi > 0$ .

The designer'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 designer 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 designer lives in country  $j$  she chooses  $\rho$  to

$$\max_{\rho} \rho M^j - c(\rho).$$

The cost function's convexity ensures the second order conditions for an interior maximum hold; rearranging the first order condition  $M^j = c'(\rho)$  yields

$$\rho(M^j) = \xi M^{j\Psi} \tag{1}$$

where  $\xi \equiv \left( \frac{\Psi}{1+\Psi} \right)^{\Psi} > 0$ . Differentiating gives  $d\rho/dM^j = \Psi\rho/M^j > 0$ , indicating quality is increasing in market size. This is as one would expect: when the designer can collect a quality price premium from more consumers, she invests in creating a higher quality product. We interpret increases in  $\rho$  as *quality creation*; any action by the designer or a government that increases the size of the designer's effective market will in turn have a quality creation effect. Not surprisingly, the elasticity of product quality with respect to market size depends on the curvature of the design cost function:  $\frac{d\rho}{dM^j} \frac{M^j}{\rho} = \Psi$ , so the less convex design costs are, the more elastic quality is to market size.

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<sup>8</sup> Because  $\varepsilon$  is decreasing in  $q$ , base profits  $p^i(q)q$  are locally concave at  $q^i$  and  $q^i$  is unique.

### 3.2 Stage One: Emigration

We assume zero relocation costs. Since the designer 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 designer stays home when indifferent, we obtain the following lemma.

**Lemma 1.** If translation costs are non-zero (i.e.  $\tau < 1$ ), the designer 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 designer optimally locates herself in the country with the largest population for any non-zero level of translation costs. Of course, the designer might optimally choose a country with smaller population if its consumers were sufficiently richer than the other country.

The designer relocates only if Recipient's market is larger than Source's. Once immersed in the Recipient market, the designer responds to the increased returns on her investment, producing a higher quality prototype.

**Proposition 1:** *Voluntary emigration induces quality creation.*

**Proof:**

By Lemma 1 the designer emigrates voluntarily if and only if  $\tau < 1$  and  $X^R > X^S$ , thus  $M^R > M^S$ . Since  $dp/dM > 0$  then  $\rho(M^R) > \rho(M^S)$  and so emigration leads to higher quality 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 designer will emigrate if allowed, i.e. in which  $X^R > X^S$ .

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

**Lemma 2:** *Consumers in country  $i$  are better off when the designer voluntarily emigrates if and only if*

$$t^{iS} \rho(M^S) < t^{iR} \rho(M^R). \quad (2)$$

**Proof:** Let  $CS^{ij} = N^i t^{ij} \rho$  measure consumer surplus in country  $i$  when the designer resides in country  $j$ , where

$$\Phi^i \equiv \int_0^{q^i} p(q) dq - p(q^i) q^i$$

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  $\Phi^i$  are independent of  $\rho$ ,  $CS^{iS} < CS^{iR}$  if and only if (2). ■

**Proposition 2:** *Recipient consumers gain from voluntary migration.*

Proof: For  $i=R$ ,  $\rho(M^R) > \tau\rho(M^S)$  is guaranteed by  $\tau < 1$  and Proposition 1. ■

Proposition 2 confirms that the designer’s emigration unambiguously benefits consumers in the Recipient country. Firstly, they benefit from the quality creation stemming from the designer accessing a larger market. Secondly, migration induces *quality diversion*: the designer’s work now caters more to the tastes of Recipient consumers and less to Source’s consumers.

Quality creation benefits Source’s consumers while quality diversion hurts them. Evaluating (2) for Source’s consumers puts this tradeoff in mathematical terms: Source’s consumers are better off whenever the rate of quality creation,  $[\rho(M^R) - \rho(M^S)]/\rho(M^R)$ , dominates the rate of quality diversion,  $1 - \tau$ .

**Proposition 3:** *There exists  $\bar{\tau} \in (0,1)$  such that the designer’s emigration benefits Source’s consumers for  $\tau \in (\bar{\tau}, 1)$  if and only if the Source market is sufficiently small compared to Recipient’s and design costs are sufficiently elastic, i.e.*

$$\frac{X^R - X^S}{X^R + X^S} > \frac{1}{\Psi}; \quad (3)$$

if instead (3) is violated then Brain Drain is harmful to Source’s consumers for any  $\tau < 1$ .

**Proof:**

Define  $\bar{\tau}$  as the value of  $\tau \in (0,1)$  at which the difference between the rates of quality creation and diversion,

$$\frac{\rho(M^R) - \rho(M^S)}{\rho(M^R)} - [1 - \tau] \quad (4)$$

is zero. Since (4) equals zero at  $\tau=1$  and is negative at  $\tau=0$ , such a  $\bar{\tau}$  exists if and only if  $\frac{d}{d\tau} \left[ \frac{\rho(M^R) - \rho(M^S)}{\rho(M^R)} - [1 - \tau] \right]$  is negative when evaluated at  $\tau=1$ . Using

$$\rho(M^i) = \xi M^i^\Psi \text{ and defining } \alpha \equiv X^S/X^R < 1 \text{ allows us to write (4) as } \tau - \left[ \frac{\tau + \alpha}{1 + \tau\alpha} \right]^\Psi.$$

Differentiating with respect to  $\tau$  and evaluating at  $\tau=1$  gives

$$\frac{d}{d\tau} \left[ \frac{\rho(M^R) - \rho(M^S)}{\rho(M^R)} - [1 - \tau] \right]_{\tau=1} = 1 - \Psi \left[ \frac{1 - \alpha}{1 + \alpha} \right], \text{ which is negative only when (3)}$$

holds. ■

**Corollary:** *If (3) holds then there exists a non-empty interval of translation rates,  $\tau$ , under which voluntary emigration raises the welfare of the migrant as well as consumers in both countries.*<sup>9</sup>

Figure 1 depicts the creation-diversion tradeoff from the perspective of Source consumers. At the extremes, when translation losses are complete (i.e.  $\tau=0$ ), quality creation is irrelevant to Source's consumers since none of it survives translation. At the other extreme, if  $\tau$  is instead unity, any additional quality creation would 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 designer's product will rise for Source's consumers, rendering brain drain beneficial.<sup>10</sup>

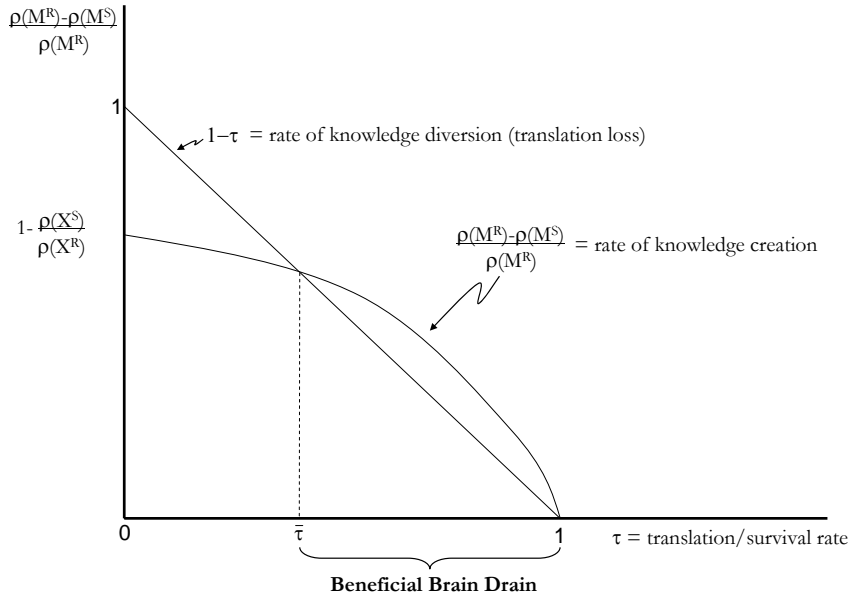


Figure 1: knowledge creation versus knowledge diversion

<sup>9</sup> Our model implicitly assumes the migrant has monopoly power. In a more general setting migrants' residency and investment choices would impact competing suppliers, as in, for example, a differentiated goods framework. The impact of quality creation and diversion on competing suppliers in the Recipient market would be straightforward: increased competition from immigrants would hurt them. Competitors remaining behind in Source may also be hurt. If  $\tau\rho^R > \rho^S$  then, even though the Source market is supplied by fewer residents, emigration would nevertheless raise *effective* supply to the Source market, hurting (non-migrating) Source producers as well.

<sup>10</sup> We characterize  $q$  as a final good and the beneficiaries of knowledge creation as consumers. However reframing  $q$  as an intermediate input, one which unskilled migrants employ to raise their own productivity, would be straightforward. Aside from accounting for feedback effects on unskilled wages (accompanying the increase in effective labor supply) our results generalize easily, suggesting skilled worker migration will benefit non-skilled migrants if intermediate goods improve in quality enough to compensate for the loss in relevance.

Whether (3) holds depends on a number of factors. Firstly, since  $\frac{X^R - X^S}{X^R + X^S} < 1, \Psi > 1$  is a necessary condition for BBD. Recalling (2),  $\Psi > 1$  equates to requiring quality be elastic with respect to market size: since quality creation is the only channel through which brain drain helps Source consumers in our model, quality creation must be sufficiently responsive to rewards in order for brain drain to be beneficial.

Secondly, because  $\rho$  is increasing in  $M$ , the larger the difference between  $M^R$  and  $M^S$  the greater the quality 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 4.** *The interval of survival rates  $(\bar{\tau}, 1)$  over which Brain Drain is beneficial to Source's consumers is larger when Source's effective market size  $X^S$  is small relative to*

*Recipient's,  $X^R$ . Specifically,  $\frac{d\bar{\tau}}{d\alpha} > 0$  where  $\alpha \equiv \frac{X^S}{X^R}$ .*

**Proof:** Holding  $\tau$  constant, raising  $\alpha$  lowers the rate of quality creation:

$$\frac{d}{d\alpha} \left[ \frac{\rho(M^R) - \rho(M^S)}{\rho(M^R)} \right] = -\Psi \left[ \frac{\alpha + \tau}{1 + \alpha\tau} \right]^{\Psi-1} \frac{1 - \tau^2}{(1 + \alpha\tau)^2} < 0.$$
 Thus an increase in  $\alpha$  shifts the quality creation curve down, raising  $\bar{\tau}$ . ■

In short, relative size matters. The smaller the Source country is relative to the recipient economy, the larger the range of translation costs at which brain drain is mutually beneficial. This suggests that brain drain is more likely to benefit consumers in small countries than those in medium sized countries: if a country's native market is large enough to induce some investment—but not large enough to drown out the siren call of large consumer markets like the U.S.—brain drain is more likely to harm consumers left behind.

## 5. Extensions

### 5.1 Process Innovation

What if, rather than improving the quality of a prototype (e.g., inventing a better mousetrap, or doing a star performance in a movie), the designer's main role is to reduce the unit costs of manufacturing copies of a prototype of given quality? To show that our results are robust to changes in the nature of the brains' activity, suppose now that quality,  $\rho$ , is exogenous, while marginal reproduction costs,  $b$ , are positive and endogenous. Assume quality and relevance amplify quantity demanded (instead of marginal willingness to pay); specifically, let  $\bar{p}^i$  measure price per unit and  $\rho^i \bar{q}^i(\bar{p}^i)$  be per capita demand in country  $i$ . For simplicity we assume the base demand functions are identical across countries:

$\bar{q}^S(\cdot) = \bar{q}^R(\cdot)$ . With reproduction costs, the designer's optimal price in market  $i$

is  $\bar{p}^i \equiv \arg \max_{\bar{p}^i} [\bar{p}^i - b] \rho^i \bar{q}^i(\bar{p}^i)$  with corresponding maximized per capita profits  $\rho^i \bar{\pi}^i$ , in

which  $\bar{\pi}^i \equiv \max_{\bar{p}^i} [\bar{p}^i - b] \bar{q}^i(\bar{p}^i)$ , and per capita consumer surplus is  $t^i \rho \bar{\Phi}^i$ , in which  $\bar{\Phi}^i \equiv \int_{\bar{p}^i}^{\infty} \bar{q}^i(\bar{p}^i) d\bar{p}^i$  is independent of quality and relevance. Effective market size is thus  $\bar{X}^i = N^i \bar{\pi}^i$ . Let  $d(b)$  denote investment costs necessary to achieve marginal reproduction cost  $b$ ; assume  $d$  is positive, decreasing, and convex. Denote the brain's total profits when residing in country  $j$  by  $\Pi^j(b) \equiv \rho t^{Sj} N^S \bar{\pi}(b) + \rho t^{Rj} N^R \bar{\pi}(b) - d(b)$ .

We assume the second order conditions for an interior maximum hold; the brain's optimal choice of input costs,  $b^j$ , solves  $\frac{d\Pi^j}{db} = \rho A^j \bar{\pi}'(b^j) - d'(b^j) = 0$  where  $A^j \equiv t^{Sj} N^S + t^{Rj} N^R$  is the size of the relevance-adjusted population when the brain resides in country  $j$ . Since  $\bar{\pi}$  and  $d$  are each independent of population size and residency, by the envelope theorem

$$\text{sgn} \left[ \frac{db^j}{dA^j} \right] = \text{sgn} \left[ \frac{\partial}{\partial A} \frac{d\Pi^j}{db} \right] = \text{sgn} [\rho \bar{\pi}'(b)].$$

As  $\bar{\pi}'(b) = -\bar{q}^i < 0$ ,  $db^j/dA^j$  is negative and so an increase in effective population,  $A$ , induces the brain to invest in lowering reproduction costs. Since the Brain emigrates only if  $A^R > A^S$ ,<sup>11</sup> brain drain thus has a cost-reducing effect. Moreover, because some of this cost reduction will be passed along to consumers, emigration indirectly lowers prices and raises base consumer surplus. Whether Source consumers are better off is ambiguous. Although base consumer surplus rises, brain drain still diverts quality away from Source consumers. Which dominates—lower costs versus less relevant products—depends on how elastic the function  $d$  is, how much larger Recipient is compared to Source, and how much relevance survives translation.

## 5.2 Effects of IPR Policy

Market size is critical in our model: differences in effective market size drive brains to migrate and are ultimately responsible for quality 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—are outside the control of policymakers, at least in the short run. However, since the goods in question can be reproduced at zero or low cost (see below), then  $\pi^S$  also depends on *de jure* and *de facto* rules governing intellectual property rights (IPRs). In Kuhn and McAusland (2006) we show that, when IPRs are modeled as probabilistic enforcement of a producer's monopoly rights, the effects of an increase in Source IPRs on optimal emigration policy (i.e. on  $\tilde{\tau}$ ) are identical in direction to the effects of an increase in source country population,  $N^S$ , or for that matter to an exogenous increase in source-country base profits ( $\pi^S$ ) (caused for example by an increase in source country income).

It follows that an exogenous rise in IPR protection in Source (Recipient) makes BBD less (more) likely. The intuition behind these results is fairly straightforward. First, note that

<sup>11</sup> Since we have assumed  $\bar{\pi}^R = \bar{\pi}^S$ , voluntary migration requires  $N^R > N^S$ .

for *any* fixed Source IPR policy (and therefore a fixed base price for the knowledge good), the only effect of brain drain on Source consumers is via its effects on the quality and appropriateness of the knowledge good. The larger the differential between the Recipient and Source country in IPR protection, the larger the increment to quality when Source's brains move abroad, making beneficial brain drain more likely. In sum, if Source has low IPR protection for reasons that lie outside our model (for example, its legal system and enforcement technology may simply not be capable of a high level of enforcement), Source's interests are more likely to involve sending its knowledge workers abroad and consuming better (if culturally less appropriate) entertainment, science and technology as a result. If Recipient (again for reasons outside our model, such as a politically powerful knowledge industry) has strong IPR protections, again it may behoove Source to "let its knowledge workers go". Put a different way, relatively weak IPRs and free emigration of knowledge workers may be complementary policies for small, poor countries under the conditions in which our model applies.

## 6. Discussion

This paper has presented a simple model in which brain drain can benefit the remaining residents of a country by improving the quality of the goods they consume, or the cost (and therefore price) of replicating a unit of the goods they consume. Some noteworthy features of this 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) 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 brains' intellectual property rights in a national treatment framework. Second, while we acknowledge that agglomeration economies (e.g. Rivera-Batiz and Romer 1991) may be important in explaining why brains may be more productive in some countries than others, such external economies are absent from our model. Instead, beneficial emigration here results simply from differences in domestic market size and home bias in tastes. Third, the level of home bias in consumers' tastes has interesting effects in our model. In particular, BBD is only possible for values of  $\tau$  (the fraction of a good's value that survives export to another country) that are strictly between zero and one: brain drain *cannot* help Source's consumers when innovations produced abroad are completely irrelevant to them, and the location of brains is immaterial to *any* consumers when brains can serve the world equally well from any location.

Finally, our results have new implications for policies affecting "brain drain" in small or poor countries. In particular, skilled-emigrant-sending countries may want to distinguish between skilled emigrants who primarily produce private goods (such as a physician who spends all of her time treating patients) and those who invent products and processes that can be replicated at low marginal cost (such as a physician primarily engaged in research on new treatments and medicines). Our model of beneficial brain drain applies to the latter type of skilled worker only.

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