circulation of human capital is a beneficial process, since it reflects the free choices of the individuals who choose to migrate, and the presumption that any argument to the contrary needs very careful scrutiny and documentation before it can be accepted. This is especially so because feelings of national identity among potential migrants themselves create fairly strong artificial barriers to migration—artificial in the sense that had the individual been born and grown up in another country he would have been culturally conditioned into comparable attachments to that country—so that less migration from low income to high income regions occurs than would be economically optimal, and what migration does occur probably involves substantial gains in world efficiency.

CULTURAL AND ECONOMIC DETERMINANTS OF MIGRATION CIRCUITS

It would be as well at the outset to warn against two sources of optical illusion in the evaluation of the magnitude of international flows of human capital. In both cases, the danger of optical illusion is fostered by the deficiencies of the available statistics on such flows, and by anachronistic concepts of the training and functioning of skilled people. The first is that the education of a professional person in modern times—just like the education of a scholar in medieval times—frequently entails prolonged study abroad, either formally in graduate school or informally in on-the-job training, after which the individual returns to his native country. Such training is not permanent emigration, but is frequently treated as such both statistically and in political discussion. The second is that the trained professional man now-a-days typically travels, and is prepared to travel, a great deal in the exercise of his profession; examples are the economist who takes short-term contracts to teach, do research, or advise governments in foreign countries, and the engineer or business executive employed by a large international corporation who works for successive periods of time in different countries. Thus nationality or country of domicile of such individuals is not a reliable indicator of where they do their work. In particular, people who have emigrated may nevertheless perform their professional services to a significant extent in their countries of origin; moreover, the hiring of their services (or those of other non-nationals) when needed may be more efficient for those countries than the attempt to maintain a national stock of all the skills that might be needed from time to time.

Turning to what may be termed "permanent" flows of migration of human capital, one would expect to find, as one does find, certain fairly well demarcated patterns of flow. One such is the flow from ex-colonial territories to their ex-imperial centres, most marked in the case of France and the United Kingdom. The colonial-imperial link means that the cultural barriers to such migration are lower than to other types of migration—the emigrant moves into what he assumes

(sometimes wrongly) will be a familiar culture—while the imperial tradition tends to implant the belief that in migrating to the mother country the ex-colonial is moving to a superior and more exciting culture. In addition, the colonial tradition in education policy frequently provides the successful student with an education more useful in the mother country than in his own.

Another pattern is that of general movement through intermediate stages from lower-income to higher-income countries, of which the outstanding features are the position of the United Kingdom as a country of large-scale immigration from the Commonwealth and emigration to the United States and the richer Commonwealth countries, and of Canada as a country of large-scale immigration from Europe and emigration to the United States. This process of migration by stages reflects limitations of the capacity for cultural and economic integration with a higher-level society on the part of the migrant, and also of discrimination in favour of skilled as against unskilled labour on the part of the countries of immigration. It implies that, underlying the particular bilateral flows between pairs of countries or regions, there is a more fundamental mechanism of flow which may be thought of as the attraction of professionally trained people towards higher income-earning opportunities. This mechanism operates in an imperfectly integrated market through a chain of substitutions between groups of people of different "qualities" in terms of educational qualifications and cultural mobility.

It would be over-simple, however, to regard this process as operating in more or less the same way for all types of professional people in all countries, or to conceive of migration of skilled people as being entirely motivated by economic considerations; and this point has an important bearing on the question of whether and in what precise sense the international migration of professional people may be regarded as a problem, even from the nationalistic point of view.

First, much of such emigration from some countries is prompted by aversion to the prevailing political instability, or by the fear of personal victimization by the governing regime. This is particularly the case with certain poor European countries, underdeveloped countries, and recently established new nations. It is fatuous in the extreme for sympathizers with the poor nations to assume that these countries necessarily have the political stability and legal protection of individual rights characteristics of the advanced Western nations, and to lament as a "brain drain" harmful to their economic development the exodus of political refugees who happen to have the educational qualifications necessary to escape.

Second, for various reasons the higher educational systems of certain countries produce a supply of certain kinds of educated people larger than the

economic systems of those countries can absorb; in such cases emigration provides a natural safety-valve rather than constituting a "brain drain"[1]. The production of educated people for export in certain countries may or may not involve inefficiency from a cosmopolitan point of view: a country may have a comparative advantage in the production of skills, because it has either specially suitable human raw material, or a superior educational technology (*i.e.*, superior schools), or a low alternative opportunity cost of human time spent in teaching and learning; alternatively, irrationality in educational policy may lead a country to waste resources in subsidizing certain types of education or education in general. From a nationalistic point of view the emigration may be considered a loss, though certain forms of nationalism would prefer emigration to the alternative of restricting the country's educational facilities to the rate of output the country itself could absorb.

Third, the dominating factors in the international migration of different types of professional talent may well be different. In the case of the international migration of medical doctors—traditionally very much a private enterprise profession—important factors have been the success of the monopolistic practices of the American Medical Association in restricting the supply of American-trained doctors and raising doctors' fees, thereby attracting immigrants; and the efforts of the British government to hold down the salaries of the National Health Service doctors in order to keep down the cost of the Service, thereby strengthening the incentives to emigrate. In certain "big" sciences the cost of research equipment is so great that only a few countries can afford to invest the required resources; people in other countries interested in these kinds of research have to migrate, at least temporarily. In other scientific subjects, the superiority of one or a few research teams at particular locations ("centres of excellence") may have the same migration-inducing effect. In the first case the migration of human capital is a consequence of economies of scale, in the second case of specialization and division of labour. Similar factors, operating through the economies of scale and of specialization and division of labour made possible by corporate enterprise operating in a large national or international market, influence the international migration of engineers and other scientists who work for private enterprise.

It is important to recognize the influence of scale and specialization, and more generally, of complementarities between knowledge and skill embodied in human capital and other inputs into research or production, on incentives to migrate. Otherwise it is too easy to assume, wrongly, that the migrant would have

[1] It is significant in this connection that a foundation-supported enterprise aimed at bringing Indian professional people back to India by undertaking to find them suitable employment had to be closed down due to its inability to find places for its clients.

made the same, or a comparable, contribution to research or to national income in the country from which he emigrates as he makes to the country to which he migrates[2]; or to go further and assume that all of these complementary inputs are available in the country of emigration, and that only the wilful departure of the emigrant prevents them from being used effectively.

Two other factors in the international migration of professional people deserve mention, on the grounds that they are in a sense special to this historical period and may prove to be transitory in the longer run. The first is the influence of the massive support of research and development expenditure by the federal government in the United States, and in particular, the "space race", in attracting an inflow of scientists and engineers. This factor raises some fundamental philosophical questions about how far, if at all, expenditures on armaments can be regarded as a contribution to world output and economic welfare. One might well feel that the resources expended—including the use of the talents of the immigrants attracted to such work—could be better used to promote world welfare. However, there is no possibility that the United States would be deterred from pursuing its military and space programmes by cutting off its supplies of immigrant scientists and engineers, and a strong possibility that the scientists and engineers in question would be employed on very similar projects elsewhere if such an embargo were attempted, so that this factor has no obvious implications for the evaluation of the brain drain as a possible problem.

The second factor is the vast and rapid postwar expansion of demand for university education, at both the undergraduate and the graduate level, which has created a corresponding increase in demand for educated people to serve as university teachers, an increased demand which has been satisfied to a significant extent by international migration of qualified people via the intermediary-stages process mentioned earlier. This demand is likely to be abated as current trainees find their way into the market for talented labour.

SOME ECONOMIC ASPECTS OF "BRAIN DRAIN"

From the cosmopolitan liberal point of view adopted here, the international migration of educated people is presumed to be a beneficial process, since it results from the free choices of the individuals concerned, unless for some reason or other the private benefits from migration are obtained at a social cost.

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[2] It is also only too easy to overlook the return flow of benefits that may accrue to the country of emigration from the migration of human capital, in the form of research results available to all countries, improved products obtainable through international trade, *etc.* For lengthier discussions of these benefits, *see* my earlier paper [3].

Normally such migrations—like any profit-motivated international movement of factors of production—may be expected to raise total world output, and therefore, in a sense to be elaborated below, to be economically beneficial to the world as a whole[3]. Exceptions may arise when the migrant's private calculation of gain from migration excludes certain social costs that his migration entails. It is important at this stage to notice two points about the exceptional cases. First, such social costs may arise either in the country of emigration, or in the country of immigration, or in both; and in which country they are likely to be incurred is not likely to be closely correlated with whether the migrant is educated or not, though it is conventionally assumed that the migration of poor and unskilled people imposes a social cost on the country of immigration and yields a social benefit to the country of emigration, and that the reverse is true of the migration of skilled and educated people[4]. Second, to demonstrate a net social cost it is not sufficient to demonstrate a loss to those remaining in the country of emigration; such losses, if they occur, must exceed the private gain to the migrant plus any gains or minus any losses to the other residents of his country of immigration.

If this requirement is not satisfied—and there is a general presumption that it will not be, since the evaluation starts from the fact of a positive personal gain to the migrant himself, and most of the valid arguments for the possibility of divergence of social from private cost or gain apply in reverse to the two countries of emigration and immigration—migration may be said to increase potential world welfare, in the technical sense that the gainers from such migration, normally assumed to be the migrant himself and the public of the country of immigration, could compensate the losers, normally assumed to be the public of the country of emigration, and still have something left over. One cannot, however, maintain that the world is actually better off as a result of such migration unless either there are no (or, pragmatically, negligible) losses to be compensated, or some machinery exists for compensating the losers. While

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[3] The argument will be confined to voluntary migration prompted by the expectation of private gain. The international movement of persons seeking political asylum, such as the recent Cuban exodus to the United States and the earlier west-ward flight of Hungarians after the 1956 uprising, may impose a heavy net burden on public or private charity in the country of immigration.

[4] As contrary examples, the immigration even of highly educated professional people may impose a burden on the health, education, and housing services of the country of immigration (which must be greater than could be financed by the increase in the gross incomes of those people resulting from migration if there is to be a net world loss), while the emigration even of unskilled labour would impose a social cost on the country of emigration if such people had paid taxes in their country of origin greater than the value of the public services they consumed (for this to amount to a net world loss, the excess taxes paid must exceed the difference between the gross wages of the emigrants in their country of emigration and their wages net of the cost of the public services they consume in their country of immigration).

elements of such compensatory mechanisms exist in the world as it is[5], there is no articulated machinery for compensation; hence it becomes important to determine what, if any, elements of loss there may be, and what sort of compensation might be necessary[6].

There are thus two questions to be discussed concerning the international migration of educated people: whether and in what circumstances such migration is at all likely to entail an economic loss to the world as a whole, and whether and in what circumstances it is likely to impose an uncompensated loss on the remaining residents of the countries of emigration. In both circumstances it is useful to distinguish between developed and underdeveloped countries, and to pay special attention to the latter, though the main lines of the argument are the same for both.

With respect to the question of possible economic loss to the world as a whole, the realization of such a loss requires that the migrant move from a location where his total contribution to social output would be higher to one where it will be lower. If potential migrants are motivated by purely economic considerations, they will migrate in response to differences in the private incomes available to them, where "private income" means the sum of net income after taxation and the value to them of the government services they receive in exchange for their taxes. Hence there can be a world loss from the emigration of educated people only if the relationship between the private incomes available in the countries of emigration and immigration is inverse to the relationship between the alternative contributions to social output in the two locations. This can be possible only in two major types of situations. The first is when, either because the system of public finance—including both the total taxation system and the overall pattern of government expenditure, and allowing for the possibilities of tax avoidance given to the higher-income groups (which educated people may be assumed to be)—is relatively more progressive in the country of emigration than in the country of immigration, or because government policy holds down the incomes of educated people as an extra-budgetary means of redistributing income towards poorer citizens, the ratio of social contribution to private

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5 Direct elements of compensation exist in the form of private financial remittances by emigrants to their countries of origin, which include both individuals, remittances to their families and collective remittances through charitable institutions; such remittances are frequently quantitatively important, in some cases perhaps large enough to yield a net gain to the country of emigration. Indirect elements of compensation may be found in the provision of education at the expense of countries of immigration to citizens of countries of emigration who eventually return home, and the provision to the less developed of those countries of the trained experts of the developed countries as part of their foreign aid programmes.

6 An alternative to compensation, which nationalists especially find appealing, is to take steps to prevent the emigration from occurring, which might be accomplished by policy action in either the immigration or the emigration country. These alternatives are discussed below.

income is relatively higher in the country of emigration than in the country of immigration. The second is when the activity of the educated person involves what technical economic theory terms an "externality"—that is, it contributes something to the welfare or productivity of others in the country of his residence over and above what the individual is paid for doing and for which he would not be paid in a competitive market for his services, and moreover something which is peculiar to him personally and not in his professional capacity[7]—and that externality is greater in his country of birth than in his country of immigration. Such externalities may include leadership capacity, originality of thought, inventive ability, *etc.*; but is necessary to note that many such apparent "externalities" are in fact rewarded through the market, general inspirational qualities and the capacity for making basic scientific discoveries being the main examples of externalities that cannot be "internalized" by market processes.

Externalities also include the effects of the migration of the individual on the proportions in which the various cooperating factors of production are available in the countries of immigration and emigration, insofar as such changes affect the earnings of the other factors of production, and its effects on the scales of production in these two economies, insofar as the productivity of an economy varies with its scale.

In both situations, there is a possibility of world loss; but the actuality requires the inversion of the relationships between private income and social contribution in the two alternative locations. This seems a very unlikely possibility in practice, at least for the migration of educated people among the more developed countries of the Western world. While, for example, it is true that English-trained doctors have a distorted incentive to emigrate because they are deliberately underpaid as a national policy, it is not plausible to believe that the true value of their services to the English public would have been greater than the value of their services to the Canadian, Australian, or American public. Again, the professions in the various European countries are well developed and numerous enough, and the systems of financial reward sufficiently sophisticated in compensating individuals for most of the obvious apparent "externalities" they may confer on their fellow citizens, to make it implausible to assume that the net trend of professional migration towards the United States involves sufficient net loss of externalities (if any) to entail a reduction in world social product. Further, in respect of the externalities specifically associated with basic research, it should be remarked that such externalities are generally available

7 As Grubel and Scott have pointed out, if the externality attaches to the profession rather than to the individual, the emigration of the individual will deprive the country of emigration of the externality only until he is replaced by another member of his profession. *See* [2, pp.268-274].

to the whole of the world's population, at least insofar as the various countries have enough scientists to remain in communication with the world scientific community, and that for the various reasons given in the previous section (economies of scale, and specialization and division of labour), scientific emigrants to the United States are likely to generate more externalities of this type than they would do if they remained in their countries of origin. Finally, given the sizes of the economies of the advanced countries and the degree of development of their professions, it is extremely implausible that net emigration of educated people from Europe to North America entails any significant loss due to diseconomies of smaller scale or changed factor proportions for the European countries.

The foregoing analysis rests on the assumption that educated migrants are motivated by strictly economic considerations of private income gain; but people are not strictly economic in making choices of this kind, and their departures from economic rationality tend to weaken still further the probability of world economic loss from the international migration of skilled people. First, as mentioned in the introduction, potential migrants generally have a preference for their country of birth which constitutes an artificial barrier to the efficient allocation of their talents among countries, and implies substantial marginal gains from the migration that does occur: typically migrants move only in response to substantial gains in their private incomes. Second, people frequently tend to regard the public finance systems of their country of origin as socially just, and to accept any fiscal redistribution of their incomes towards poorer people that the system may entail, whereas they are not generally either familiar with the government services provided in other countries or convinced of the justice of their tax systems; hence they are likely in effect to compare their gross incomes in their countries of origin with their disposable incomes after taxes in their countries of immigration, which again implies that what migration occurs is likely to produce substantial increases in social output. Third, the educated person is generally aware of the externalities he engenders for others, and a professional education is usually devoted in part to teaching the student to derive satisfaction from the externalities he renders as well as the income he receives for his normal services; thus what may appear to the theorist to be externalities may in fact be internalized in individual satisfaction. Further, the nationalism characteristic of the cultures of most political states is such that the educated person is likely to exaggerate and overvalue the externalities he renders in his country of origin, and to disregard or undervalue the externalities he might render in his country of immigration. The former consideration weakens the likelihood that real externalities exist that might cause international migration to lead to world losses; the latter suggests that positive net externalities are likely to result

from migration of educated people, resulting in additional gains of social output above the private gains.

This analysis suggests that international migration of educated professional people, at least among the advanced countries, is extremely unlikely to produce world losses, and is on the contrary likely to produce substantial increases in potential world economic welfare. Does the same analysis apply without qualification to the emigration of educated people from the less developed countries or is there a substantially strong possibility of world loss in that case?

In one important respect, the argument for a probable world gain from this flow of migration of human capital is much stronger, owing to the much greater size of the income differential between developed and less developed countries than among the developed countries, for people with professional qualifications. This differential is large enough to make it virtually impossible for such migration to result in a world loss as a result of the inversion of relative social and private contributions in the alternative locations by relatively more progressive fiscal systems in the less developed countries, or by the exercise in those countries of more stringent policies of holding down professional incomes for the benefit of the poorer classes of society. (In fact, it is likely on the average that the more progressive fiscal structures and income policies are to be found in the developed countries, with the result that the gain in world social product from this type of migration will exceed rather than fall short of the gain in private income.)

Any possibility of world loss must therefore hinge on a loss of externalities to the country of emigration, unmatched by an offsetting gain of externalities to the country of immigration, and quantitatively large enough to outweigh the private income gains to the migrants. Four theoretical possibilities of such loss of externalities may be discovered[8].

First, individuals who might have made scientific discoveries, or introduced improved methods of production or management that would have substantially increased the productivity of resources in the less developed countries, may be diverted to higher-paid activities of a more routine nature lacking such externally beneficial effects, for example, employment in private industrial research and development. The likelihood that this is a typical and important case must be qualified, however, by recognition that the migrant individual may have taken the probability of his making an important discovery into account in making his decision to emigrate, that the country of emigration may have lacked the resources or failed to provide the social and economic climate necessary to success-

[8] These cases were suggested by a reading of [5], though not identical with those presented in that source.

ful innovation, and that in some cases at least the individual migrates because only in a large developed country can he obtain the resources required to solve his research problem or the freedom to experiment with new production and management ideas. In short, emigration may be the only effective means available for the individual to contribute an "externality" to his country of emigration.

Second, the members of a particular profession, or the professional classes in general, may generate externalities in a less developed country that they do not generate in a developed country, by providing informal education through instruction and example to their fellow citizens in the requirement of increased efficiency. If their emigration reduces the stock of educated people performing this function below what it would otherwise be, and if the value of this externality outweighs the increase in the market value of their contribution to world output, there will be a world loss. The likelihood of a world loss on this account is questionable, first, because it is debatable how far educated people in the less developed countries perform this sort of educative function, second, because the quantitative magnitude of the resulting contribution to world output has not been investigated, and third, because it is not obvious that emigration of professional people reduces the quantity of professional people left in residence, as contrasted with increasing the total number of people who undertake professional careers.

Third, the emigration of professional people may involve a significant proportional reduction in their numbers in the less developed countries of emigration, thereby perhaps lowering the incomes (marginal products) of cooperating factors of production, without significantly altering the ratios in which factors of production are available in the developed countries of immigration (this last being a reasonable assumption). This possible source of world loss is also debatable, first, because it requires that emigration reduces the number of educated people available, instead of increasing the number prepared to undertake professional education, second, because it requires that a change in the relative quantities of factors reduce the marginal products of the cooperating factors, and third, because it requires that this reduction in the marginal products of the other factors be great enough to offset the income gain to the emigrating factor.

Fourth, the emigration of professional people, by reducing their absolute numbers to a quantitatively significant extent, may reduce the aggregate of resources available in the country of emigration and thus impose on it diseconomies of scale of production, while either not being quantitatively significant enough in the country of immigration to call into play offsetting economies of scale, or not calling such economies of scale into play because they have already been exhausted by the size already achieved by the developed economies. This

possibility also depends on the assumption that emigration reduces the stock of trained people, rather than increasing the number prepared to undertake professional training, as well as the assumption that economies of scale are quantitatively important enough to outweigh the income gain to the emigrating factor of production.

In summary, all of these possibilities raise both the qualitative question of whether the externalities posited correspond to the facts of the situation, and the quantitative question of whether their effects are important enough to countervail against the presumption of a world gain from the migration of educated people from less developed to developed countries. In the absence of any very persuasive evidence to the contrary, it would seem reasonable to conclude that there is no significant probability of world loss from the international migration of educated people.

The second question is whether such migration may nevertheless entail uncompensated losses to the countries of emigration. Most of the relevant possibilities are implicit in the argument already presented. To begin with, however, it should be noted that the country of emigration generally obtains some gains from the emigration of educated people, which may provide indirect compensation for any losses incurred. Aside from emigrant remittances, the country will obtain the benefit of basic scientific discoveries made by emigrants; it may also benefit by the availability of better-quality or lower-cost products, produced with the help of the services of the emigrants; and even where it has to pay royalties and licence fees to use the product of their research, it may be better off than if it had had to finance the research itself.

The residents of the country of emigration obviously lose from emigration, to the extent that the emigration of educated people deprives them of tax revenue in excess of the cost of governmental services that would have had to be provided to the emigrants had they remained at home. There are two major cases here. The first concerns the redistribution of personal income by governmental taxation and expenditure policies, it being assumed that the emigrant is typically in a higher income-tax bracket than the average of the population; in this case, the emigrant deprives those who remain behind of their tax-mediated share in his income. The second concerns intergenerational transfers of income through the governmental budget: to the extent that the currently working generation pays the costs of education of the young through its taxes, and in return expects to be supported in its old age by pensions financed by taxes on the incomes of the presently young after they have graduated into the currently working category, emigration of the young after completion of education deprives their elders *pro tanto* of their expected retirement benefits. Precisely the same two cases

arise when, instead of the incomes of the educated being taxed especially heavily, the incomes they can earn are reduced by deliberate government policy.

The transfer of taxable capacity from the country of emigration to the country of immigration when the emigrant changes countries has been described in the literature as a gift from one country to the other. The notion of a "gift", however, is ambiguous, in the sense that a voluntary gift entails no real loss to the giver, being recompensed by the satisfaction of having given something of value to a cherished recipient, whereas a gift given in the expectation of a recompense that is not in fact received constitutes a real loss. Thus it makes an important difference to the policy implications of international migration of educated people whether such people are provided with publicly financed education in the expectation that they will remain at home and compensate (or overcompensate) those who have financed their education by paying taxes on the incomes they will subsequently earn, or whether the education is provided as a genuine gift intended to give them a better start in life, regardless of where they subsequently choose to live. Thus it is important to the question of ascertaining whether or not there is a loss from the emigration of educated people to the country of emigration, to determine what the assumptions of its policy of public education are[9].

There is also an obvious loss to the country of emigration if the emigration of educated people deprives it of externalities that it would otherwise have enjoyed. The question then is one of determining which, if any, theoretically possible externalities are quantitatively significant. Of the four listed above pertaining to the less developed countries, the possible loss of new knowledge or improved methods of production and management is a matter on which *a priori* reasoning can throw no light; the same applies to the question of whether or not professional people perform an unpaid educational function in the less developed countries, though theory does raise the question whether the emigration of educated people reduces the locally available supply as distinct from increasing the world supply provided from local sources. The same question arises with respect to the possibility that the emigration of educated people deprives the less developed countries of economies of scale. In addition, theory would suggest that, even if the emigration of educated people does reduce the remaining stock,

[9] It is relevant also to note the technical point that the value of the gift will be substantially smaller from the point of view of the less developed country than from that of the developed country. The reason is that most of the cost of education is the cost of labour, in the form of tuition, construction of buildings, and foregone student earnings; and the cost of labour is far less in the underdeveloped countries than in the advanced ones. One important consequence is that, when students from less developed countries are trained in and at the expense of a developed country and some of them remain in that country, both countries may enjoy a net increment in their stocks of human capital when the value of human capital is reckoned at the alternative opportunity cost of creating it appropriate to the country in which it finally resides.

if and when these countries become fully developed, they will need and be able to employ much larger numbers of educated people; but this does not imply that in their present circumstances additional educated people would necessarily contribute significantly to their development. Development is an integrated process both of accumulating capital in the broad sense—material, human, and intellectual—and of evolving a culture that promotes the efficient use of such capital and the habit of constantly seeking to improve the efficiency of use. It is not likely to be promoted by concentrating attention and economic policy on the accumulation of one type of capital on the assumption that all else will follow. This has been shown by the unsatisfactory results of past development efforts, which have concentrated on the accumulation of material capital. It would be unfortunate if development theory and policy were to resurrect the myth that there is a simple and quick road to development by substituting human capital for material capital as the crucial element in the process.

IMPLICATIONS FOR MIGRATION POLICY

As argued in the preceding section, it is extremely unlikely that the migration of educated people among the advanced countries leads to a loss of world economic welfare, while the possibility of world loss from the migration of educated people from less developed to developed countries is highly questionable. The problem for policy, then, is how to compensate the countries that may lose from international flows of human capital for the losses they may incur; the establishment of institutional arrangements for such compensation would automatically prevent the occurrence of flows that entails a loss of world economic welfare, since the gainers would not be able to compensate the losers in this case without ending up worse off as a result.

Of the cases of loss to the country of emigration previously discussed, that associated with the "gift" element in the international transfer of taxable capacity is the most easily disposed of in principle. All that is required is a binding contractual arrangement by which either the individual whose education is publicly financed on the assumption that he will remain in the country of his origin, or his employer or the government in his country of immigration, is legally obliged to repay the cost of his education to the country that educated him, or perhaps to repay that cost plus an estimate of the amount of his income projected in the future in his own country of origin, which he would have been obliged to redistribute via excess taxation to his fellow citizens.

Such an obligation might be imposed on students by their government in the countries of emigration; in that case a more efficient and acceptable solution might be to finance student education, at least at the university level, by loans rather than grants, allowing interest on the loans as a deduction from income

for tax purposes; if the educated individual is regarded as owing the society a tax contribution over and above interest on the cost of his education, including in the interest charge a surcharge designed to fulfil this obligation. An alternative solution, which has already been applied to some extent in certain countries, is to oblige the recipient of a publicly financed education to remain in or return to the country for a specified number of years. This is a less efficient alternative, since it deprives the educated individual of the freedom to decide whether personal service or cash repayment is a preferable alternative, and also fails to recognize the foregone-earnings element in the cost of education, which is bound to differ among individuals.

The other possibility would be for the employer or the government in the country of immigration to pay a bounty to the country of emigration per immigrant received. This also would be an inefficient solution, owing to the difficulty of fixing a bounty that would correspond either to the loss of the country of emigration or the gain to the country of immigration; but it might be less open to evasion and breach of contract than an obligation imposed on the migrant by his own government.

The remaining possibilities of loss to the country of emigration are much more difficult to prescribe for, owing to the difficulty of quantitative estimate of the magnitude of potential losses. In view of the uncertainty attaching to these possible losses, it might be wisest to ignore them, and to concentrate policy measures on recouping for the country of emigration the costs incurred in training the migrants, on one of the alternative lines discussed above.

Where there are clear cases of loss from the various cases cited, there would seem to be a *prima facie* case for the countries of emigration to develop policies of subsidizing the presence of their educated personnel; there would seem to be no reason why the countries of immigration should pay a subsidy to the countries of emigration in return for the privilege of offering the educated citizens of the latter an opportunity to escape from a situation in which their incomes fall short of their true social value.

This last proposition, however, ignores one important element in the structure of the world economy as presently constituted—the discrimination against the international migration of unskilled labour embodied in present immigration laws. If educated people can migrate but uneducated people cannot, the justice of advising countries with predominantly unskilled labour to pay the price of keeping their skilled labour at home is open to serious question. On the other hand, given the present lack of effective population control practices in the less develoed countries, it is extremely doubtful whether the effect of

relaxation of prevailing barriers to the immigration of unskilled labour into the developed countries would do anything in the long run to improve the lot of unskilled labour in the less developed countries. It, therefore, appears that existing barriers to the immigration of unskilled labour into the developed countries have some justification and that the recommendation to the less developed countries to subsidize their resources of educated people is indirectly a recommendation to them to do something about solving their population problem. This is an endeavour to which the developed countries might well be asked to contribute, on the grounds that the welcome they accord to educated immigrants helps to perpetuate the population problems of the less developed countries by providing a safety-valve means of escape for people who might otherwise insist on the need for effective population control.

The alternative to the recommendation of compensation to the less developed countries for losses entailed in the emigration of educated labour is an embargo on the international migration of such labour. This would seem to be very much an inferior alternative, both because it would deprive the educated citizens of the less developed countries of their present opportunities of bettering their economic lot by emigration, and because the deprivation of freedom might induce these people to refuse to render to their countries of origin the externalities that constitute the main argument for depriving them of their freedom to migrate. In addition, it would be extremely difficult to devise a system of embargo that would prevent emigration or immigration while preserving the benefits of foreign study and work experience.

SOME BROADER DYNAMIC CONSIDERATIONS

The preceding sections have been concerned with the economic aspects of international flows of educated people, from a rather narrowly technical theoretical point of view. In the broader historical perspective of world economic evolution, the phenomena underlying current worries about "brain drain" are simply one aspect of a far more pervasive trend, the trend towards closer integration of the world economy, which has been proceeding rapidly since World War II. Other aspects of it are the reduction of barriers to international trade, the increasing integration of the national capital markets of the advanced countries into a world capital market, the growth of direct foreign investment by the large international corporations, the rapid spread of modern technology from country to country, and the modernization of traditional class—and status-oriented societies into less personal, more mobile, and flexible modes of interpersonal relationship conducive to economic efficiency. Many of the manifestations of this trend towards world economic integration are bound to be distasteful to traditionalists and to nationalists, especially as these manifestations can be

readily associated with American influences; fears and hatreds are aroused not only by "brain drain" but by "American control of our economy" and "Americanization of our way of life" ("American cultural penetration", in the Freudian phrase used to describe it in Canada). Nevertheless, the trend towards closer world economic integration is a powerful force operating to raise world living standards, by disseminating techniques, practices, and products that increase human productivity and satisfaction throughout the world.

One important consequence of increasing world economic integration is that the market for educated professional people, like the market for commodities, is becoming increasingly an international rather than a national market, with corresponding economic pressures towards the equalization of prices for professional work throughout the international economy, manifest in the phenomena of "brain drain". These pressures, reinforced by the increase in demand for educated people as professionals and as university teachers associated with the advance of technology and the increase in demand for education as living standards rise, imply a sharp increase in the scarcity value of educated people in most countries, sharper the lower the average level of income in the particular country. This in turn implies serious economic and social disturbance, because not only are the national economic, educational, health, and other productive systems built on traditional assumptions about the relative value and cost of educated labour as compared with ordinary labour and capital, but the social fabric is built on the assumption that economic power and social status derive ultimately from the ownership of property, rather than the possession of educated talent.

Rather than resist these pressures by attempting to eliminate one of their symptoms, "brain drain" policy in the countries affected should aim at adjusting the use of educated people to the new prevailing situation of increased relative scarcity, by recognizing the higher value of such people in contemporary circumstances, paying them accordingly, and seeking at the same time to economize on their use. In particular, industrial and governmental employers of educated people should abandon the notion of a "just price", conformable to past social relationships based on the dominance of property owners, for the services of such people, and revise methods of combining the services of the educated with other factors of production based on the assumption that the cost of these services is that "just price". The effect of the competitive pressures referred to will in any case inevitably be to force such adjustments; the question is only whether policy will be dictated by foresight or by hindsight.

In general, as already suggested, the effects of these competitive pressures in the market for educated labour should be to promote economic growth.

They should also, in the longer run, promote a more desirable society, by undermining the dominance of property ownership as a source of wealth and social status. These effects should prove beneficial in the developed and less developed countries alike, in the long run. In the near term, however, they may conceivably aggravate the problem of promoting economic development in the less developed countries. But in the broad perspective of world economic development, "brain drain" is a trivial factor in the problem of developing the underdeveloped regions of the world; and doing something about "brain drain" is far less important than increasing the flow of development assistance and the efficiency with which it is applied in development programmes, and expanding the opportunities for the less developed countries to participate in world economic growth through international trade. It would also be worth considering whether the developed countries could not contribute more to the relief of poverty in the underdeveloped countries by lowering their barriers to the immigration of unskilled labour, thereby allowing poor people more direct and immediate access to the high living standards of the developed countries than is afforded by present policies of supporting development programmes in their own countries, designed to bring them in the very long run to the standard of living that the poor in the developed countries already enjoy.

REFERENCES

1. Adams, Walter (*ed.*), *The Brain Drain.* To be published by Macmillan Company in 1968.

2. Grubel, H. G., and A. D. Scott, "The International Flow of Human Capital", *American Economic Review* (Papers and Proceedings), Vol. 56, No. 3, May 1966.

3. Johnson, Harry G., "The Economics of the 'Brain Drain': the Canadian Case", *Minerva*, Spring 1965.

4. Johnson, Harry G., "The Possibility of Income Losses from Increased Efficiency or Factor Accumulation in the Presence of Tariffs", *Economic Journal*, Vol. LXXVII, No.305, March 1967.

5. Thomas, Brinley, "The International Circulation of Human Capital", *Minerva*, Vol. V, No. 4, Summer 1967.

Appendix

NOTES ON THE EFFECTS OF EMIGRATION OF PROFESSIONAL PEOPLE ON THE WELFARE OF THOSE REMAINING BEHIND

We pose the problem in terms of a community in which there are two factors of production, capital and labour, owned by citizens in different ratios; without loss of generality we can divide the economy into two groups, migrants and non-migrants, owning capital and labour in different ratios. To make the formulation correspond to the problem of migration of professional people, we can assume that capital gets invested in such people up to the point where they earn the wage of unskilled labour plus a normal rate of return on the capital invested in them.

Analytically, it is necessary to distinguish between the short run, in which any capital the emigrants take with them can be regarded as a reduction in the total stock of capital available to the community, and the long run, in which, regardless of the emigration of professional people, the capital stock of the community is determined by the savings behaviour of the community. The following analysis is concerned only with the short run, since the long run analysis requires a much more elaborate set of analytical apparatus for proper handling.

Case I: The Aggregate Production Function: Constant Returns to Scale[1]

In this case we assume that the economy's output can be regarded as a single aggregate commodity, produced in a constant-returns-to-scale production function. For diagrammatic simplicity, we assume initially that the two population groups are equal in number. The pre-emigration equilibrium of the economy is represented in Figure 1, where ON is the number of people in each group, OR_A is the ratio of capital to labour possessed by the richer group, OR_B the capital-to-labour ratio possessed by the poorer group, and OR the average capital-to-labour ratio for the economy as a whole; and where $X_1,\ldots,X_5$ represent isoquants of the aggregate production function. In equilibrium, average output per head is X_3/N, the income per head of the richer group is X_5/N, and the income per head of the poorer group is X_2/N. Each group receives a higher income per head

[1] The analysis of this case derives from a forthcoming paper by Charles Berry and Ronald J. Soligo which I have not read but whose approach has been described to me by referees of the *Journal of Political Economy*. Credit for the approach is due to these authors, though I may have succeeded in putting their main points more succinctly.

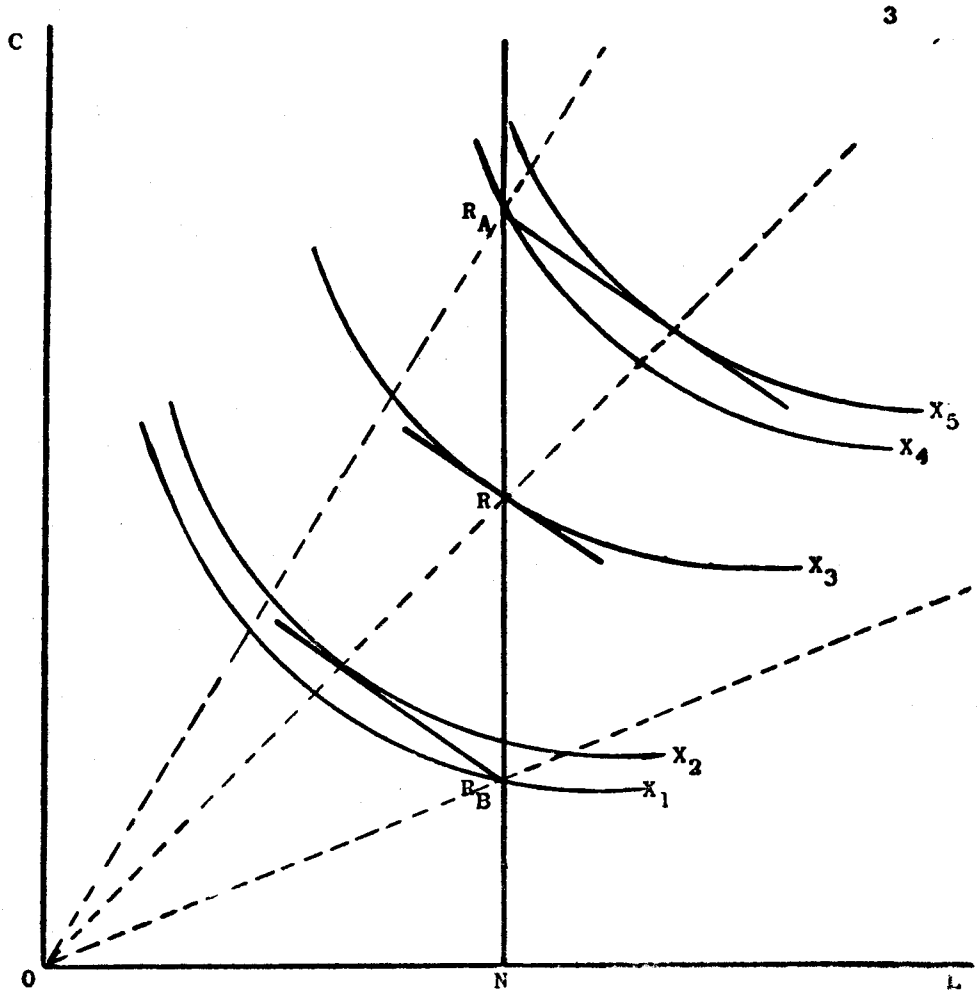

Figure 1

than it could produce with its own endowment of factors, because it can rent the services of the factor with which it is relatively poorly endowed from the other group and so produce with the average endowment ratio for the economy.

It follows immediately that if either group migrates and takes its endowment of capital with it, the other group must be made worse off than before, except in the trivial limiting case where both groups are initially endowed with the same capital-to-labour ratio. Income per head of the remaining population, however, may either fall from X_3 to X_1, or rise from X_3 to X_4, depending on whether it is the poorer or the richer group that emigrates; this point implies that the effect of migration on income per head of the remaining population is an unreliable test of its welfare effects.

The capital invested in skilled people necessarily migrates with them. Hence, if this capital is all that these people possess, those remaining behind must be made worse off by their emigration, unless their capital per head is exactly equal to the average for the economy as a whole. The damage done to those remaining, however, will depend on the elasticity of substitution between the factors in the production function, and the extent to which the emigration of professional people alters the overall capital-to-labour ratio in the economy. On *a priori* grounds, it might be argued that this damage is likely to be small, to the point of negligibility, on the grounds that: *a*) the aggregate production function should have a high elasticity of substitution, because that elasticity combines substitution not only between labour and capital in the production of particular goods but between more and less labour-intensive or capital-intensive goods in the bundle of individual goods that makes up the aggregate; *b*) professional people make up only a small proportion of the total working population, and the capital embodied in them is small relative to both total material and other human capital; *c*) migration is likely to be only a fraction of the total stock in actually relevant cases[2].

The foregoing proof of the necessity normally of some loss to the non-migrant population rests, however, on the assumption that the emigrant population takes all its capital with it; and while this is necessarily true of the human capital they own, it is not necessarily true of any material capital they own in addition. Some of such capital the emigrants are likely to leave invested in their country of origin, drawing the income on it to their new place of residence; and the presence of this capital will influence the welfare of those remaining behind. Specifically, as is evident from Figure 1, if the (relatively richer) A group emigrates, the remaining group B will be made exactly no worse off and no better off

[2] On this point, see Mathematical Appendix 1.

if the A group leaves behind it sufficient capital to maintain the overall ratio of A and B capital in the country to B labour in the country at the pre-emigration ratio OR[3]; and if group A leaves more capital behind it than this, group B will be made better off by the emigration of the A group. On the contrary, if the (relatively poorer) group B emigrates, the remaining group A will be made relatively worse off, the more of its capital group B leaves behind it.

This analysis, of course, has taken no account of the possibility that the emigrants might remit some of the income they earn in their country of immigration to those remaining behind. Such remittances might well be large enough to compensate the latter for any losses of earned income imposed on them by emigration.

Case II: **Disaggregated Production with Constant Returns to Scale and International Trade**

The aggregate production function model of the preceding case is not really satisfactory for an analysis of international migration, skilled or otherwise, because it assumes that the economy produces and consumes a single commodity and cannot compensate for changes in its overall factor ratio by trading factors, indirectly with other countries through international trade in products employing the factors in different ratios. It is well known from the theory of international trade that, if the international terms of trade are given, as they may be assumed approximately to be for many of the countries concerned about the emigration of scientists, engineers, and other professional people, changes in factor endowments occurring as a result of economic growth, migration, foreign investment in the country, and other causes can be absorbed by changes in the proportions in which commodities of different factor-intensities are produced (and correspondingly in the amounts of them traded internationally), without requiring any change in the prices of the factors of production. It follows that, so long as the emigration of professional people and their capital does not proceed so far as to move the overall ratio of capital to labour in the economy outside the range consistent with the maintenance of the initial factor-price ratio, that emigration does no harm to those who remain behind.

The argument is illustrated in Figure 2, where XX and YY are unit-isoquants respectively of the most capital-intensive and most labour-intensive commodities the country is capable of producing at world market prices in the pre-emigration situation[4], quantities being chosen for simplicity to equalize unit costs of production on the budget line FF′, the slope of which represents the

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[3] That is, if it leaves behind it the excess of its capital per head over the national average.

[4] The argument would be complicated somewhat, but not changed in essence, by recognition of the presence of tariffs, which might narrow the range of possible production patterns by preventing the export of goods initially produced under protection.

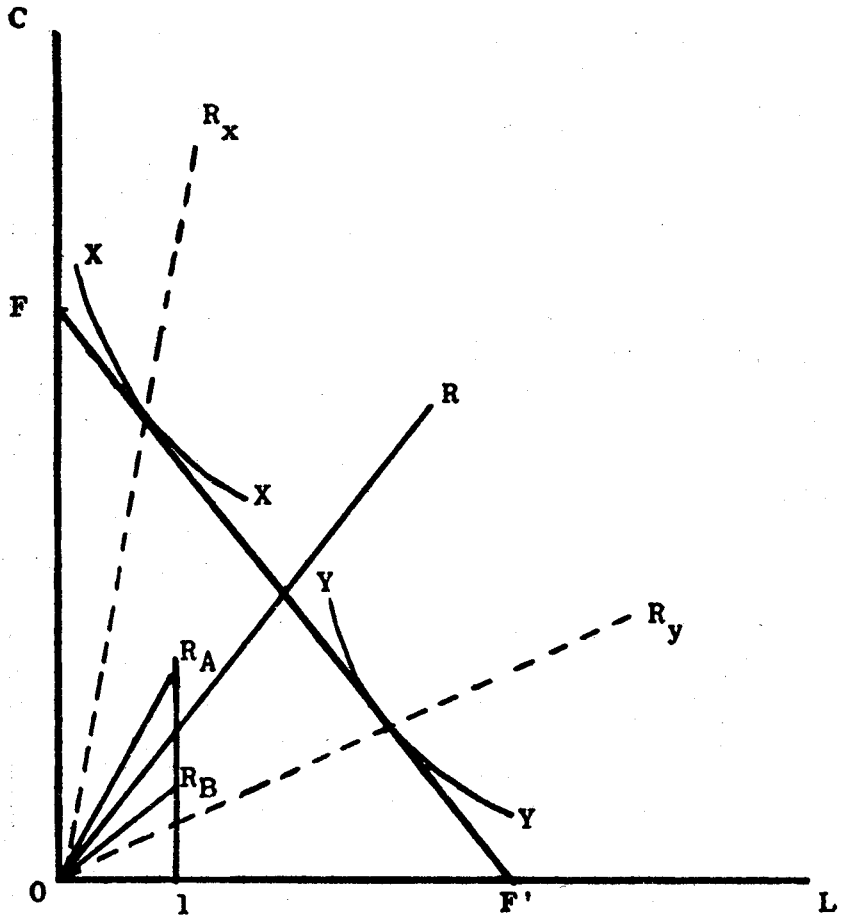

Figure 2

initial factor-price ratio. As before, OR is the overall ratio of capital to labour in the economy; OR is the average of OR_A and OR_B, the capital-to-labour ratios of the two equal groups into which the population of the economy is divided, the groups being represented in this diagram on a per capita basis. The economy initially produces X and Y in proportions such that $R_x l_x + R_y (1-l_x) = R$, where l_x is the proportion of labour assigned to the X industry. Any change in the endowment ratio of capital to labour R can be accommodated without any change in factor prices by a reallocation of factors from the X industry to the Y industry or vice versa as required, so long as the overall ratio of capital to labour within the country remains within the limits R_x to R_y. In terms of the previous case, if the richer A group emigrated, the income of the B group would be unaffected so long as its capital-to-labour ratio R_b exceeded R_y or the richer group left enough capital behind to make the overall ratio exceed R_y (in this case, enough capital might be left behind to make the overall ratio exceed R_x, in which case the country would specialize in X and the B group be better off than before). If the poorer B group emigrated, the A group would be no worse off unless either its capital-to-labour ratio exceeded R_x or the B group left enough capital behind to secure this result.

The foregoing analysis rests crucially on the assumption that the the country's terms of trade are fixed by world market forces. But the effect of allowing for variable terms of trade is inconclusive, because while the effect of changing the overall ratio of labour to capital must be to reduce the relative quantity produced of one of the goods and increase the relative quantity of the other produced, whether the good whose relative production increases will be the export good (tending to turn the terms of trade against the country) or the import good (tending to turn the terms of trade in its favour) can only be determined from a knowledge of the demand conditions. For example, if the country initially exports the capital-intensive good X, emigration of the A group with its capital would, by reducing production of X, tend to turn the terms of trade in the country's favour, and conversely if it initially exported the labour-intensive good Y.

Case III: **Partial Equilibrium Analysis: Professional Services**[5]

The two cases just analysed involved the application of general equilibrium analysis, on the assumption that the professional emigrants previously provided inputs for the production of commodities. For the case of doctors, in particular, and possibly some other professions, it is more appropriate to conceive of them as providing services directly to the consumer. In this case, it can defi-

[5] The analysis of this section grew out of correspondence with J. D. Pole, of the University College of Wales, Cardiff, and is indebted to him for its approach, which derives from a forthcoming paper of his.

nitely be established that their emigration entails a loss to the population remaining behind, if the effect of emigration is to reduce the number of professional people providing services.

Figure 3 illustrates the argument, it being assumed for simplicity that the professionals do not consume their own services, so that their emigration leaves total demand for those services unchanged. In the figure, DD is the demand curve of the rest of the population for professional services, and N_O is the number of services provided (for simplicity measured by the number of professionals). The price of services is determined by the demand for them, and is initially P_O. Reduction of the number of professionals to N_1 raises the price of services to P_1. The consumers suffer a loss of consumers surplus QP_oP_1R, and the remaining professionals enjoy an increase in income P_oP_1RS, which may be regarded as cancelling out within the total remaining population, leaving a net loss for the remaining population of QRS.

The magnitude of this loss can be measured as approximately equal to $\frac{1}{2}\frac{1}{\eta} vm^2$, where η is the elasticity of demand for the professional services, v is the initial share of expenditure on these services in total expenditure by the remaining population, and m is the proportion of the profession that emigrates. Thus, for example, if the elasticity of demand is as low as 0.5, expenditure on the service constitutes 10 per cent of national income, and one-tenth of the profession emigrates, the welfare loss will be one-tenth of 1 per cent of income per head for those remaining behind. If one-fifth of the profession emigrated, on these assumptions the welfare loss will be two-fifths of 1 per cent of income per head for those remaining behind.

The analysis presented above, however, assumes that the size of the profession is permanently reduced by emigration. But the effect of emigration is to raise the price of the services provided, and, therefore, to raise the rate of return on the capital embodied in people pursuing that profession above the rate of return on capital, human or material, employed elsewhere in the economy. Consistently with the short-run assumption that the total stock of capital in the economy is reduced *pro tanto* by the emigration of professionals, one might argue that competition would lead to a reallocation of capital towards investment in the embodiment of more capital in professionals in the emigrants' profession, and an increase in the supply of such people until returns were equalized between this and other uses of the community's stock of capital. In that case, the relevant analysis would be that of the preceding two sections; Case II in particular suggests that there need be no net loss to the remaining population as a result of the emigration of the professional people providing the services in question.

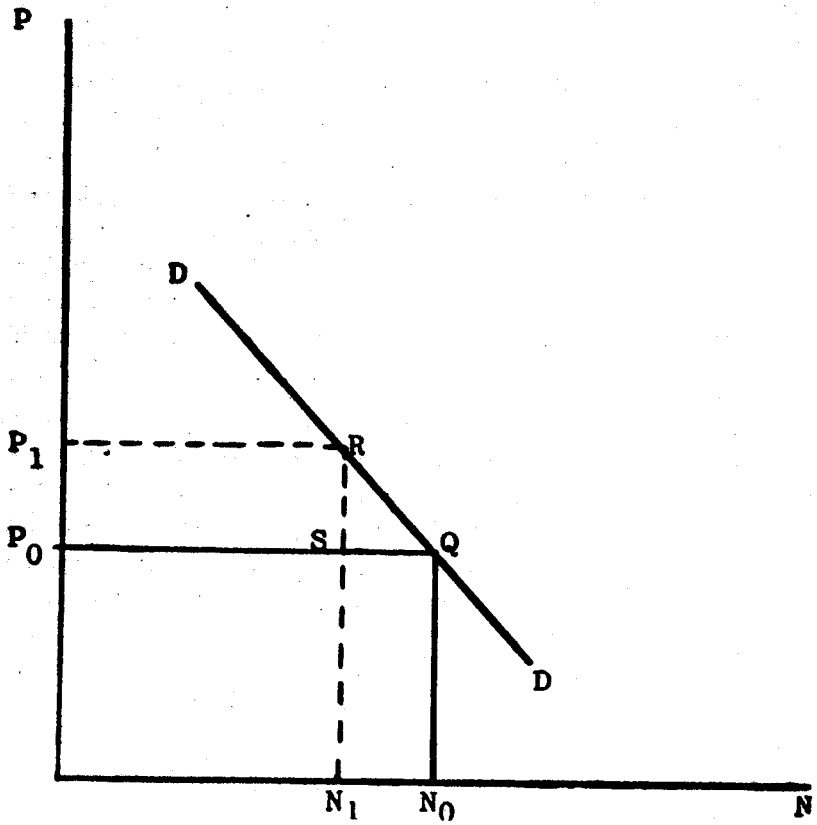

Figure 3

The process of reallocation of capital towards embodiment in professional people to replace the emigrants may, of course, be prevented by limitation of facilities for training such replacements. In that case, the loss would be attributable to the limitation of the facilities, not to the emigration of the trained people *per se*.

Case IV: **The Aggregate Production Function: Non-Constant Returns to Scale**

In the preceding sections, it has been assumed that production, either in the aggregate or in particular production activities (including the production of services) was subject to constant returns to scale. If aggregate production were subject to non-constant returns to scale, those remaining behind would suffer an additional loss from the reduction of the scale of the economy resulting from emigration, if the economy were subject to increasing returns to scale, or conversely would enjoy a gain to be offset against any other losses if the economy were subject to decreasing returns to scale.

Contrary to what is sometimes assumed in economic writing on "the brain drain", both decreasing and increasing returns to scale are possible. The reasons for assuming increasing returns to scale are well known—specialization and division of labour within a large market, and economies of scale in individual production processes. The arguments for assuming decreasing returns to scale are two. The first involves the classical problem of pressure of population on the land which may be conceived of as introducing a third factor, fixed, in overall quantity, into a constant-returns-to-scale production function. The second, which may be regarded by some as rather fanciful, is that as countries grow larger, either they may decide to waste more of their productive resources on the protection of domestic production of products they could import more cheaply, or this result may be the automatic consequence of the growth of factor supplies under a policy of protection[6].

Whether returns to scale are increasing or decreasing, the cost or benefit of emigration of professional people to those remaining behind depends on the effect of emigration on the overall scale of the economy. Such scale effects are likely to be small enough, however, to be safely neglected for the following reasons. Empirically, such people are a small part of the total population, and the capital emobied in them is a small part of the total capital stock of the community. Emigrants may be assumed to be only a small fraction of the total stock of professional people. And it is likely that scale economies are limited in scope in the sense that the extra-proportional increase in output that ensues on an increase in output is likely to be a small fraction of the initial output[7].

[6] On this point, *see* [4, pp.151-154].

[7] On this point, *see* Mathematical Appendix 2.

Mathematical Appendix 1

THE MAGNITUDE OF THE LOSS TO THOSE REMAINING—CASE I

For ease of mathematical working, and also because this particular production function can claim traditional authority and empirical support, we employ the Cobb-Douglas production function $X = L^{\alpha} K^{1-\alpha}$, where X is output, L and K are respectivelylabour and capital, and α is a parameter corresponding to labour's share in national income. The Cobb-Douglas production function implies a unitary elasticity of substitution between capital and labour in production; this may be too low, overstating the loss from emigration to those remaining, for reasons given in the text.

To introduce the concept of human capital, let n and N be the numbers of unskilled and skilled workers respectively, and let k_1 be the ratio of material capital to unskilled labour and k_2 be the ratio of human capital to the raw labour embodied in skilled labour. On the assumption that raw labour initially earns the same return whether it works with material capital or is combined with human capital, and that capital earns the same return whether invested in material or human capital form, the production function may be rewritten as

$$X = (n+N)^{\alpha} (k_1 n + k_2 N)^{1-\alpha}$$

For the analysis of the effects of emigration, it is convenient to consider the effect of an increase in the number of skilled people on the total income of those initially present, rather than the effect of a decrease in the number of skilled people on the total income of those remaining. The two situations (pre- and post-immigration) are denoted by the subscripts 0 and 1. The marginal products of the two factors, labour and capital, are $\frac{\partial X}{\partial L} = \alpha \frac{X}{L}$ and $\frac{\partial X}{\partial K} = (1-\alpha)\frac{X}{K}$; consequently in the initial situation the total income (output) of the available skilled and unskilled labour and the corresponding material and human capital is

$$Y_0 = (n_0 + N_0)\,\alpha \frac{X_0}{L_0} + (k_1 n_0 + k_2 N_0)(1-\alpha)\frac{X_0}{K_0} = X_0.$$

The total income of the same collection of factors, after the immigration of some skilled workers and the human capital they embody, is

$$Y_1 = (n_0 + N_0)\,\alpha \frac{X_1}{L_1} + (k_1 n_0 + k_2 N_0)(1-\alpha)\frac{X_1}{K_1} = L_0\,\alpha \frac{X_1}{L_1} + K_0 (1-\alpha)\frac{X_1}{K_1}.$$

Assume that the number of skilled workers increases by the fraction m; then the labour force increases by the fraction $m.\frac{N_0}{n_0+N_0} = a$, and the capital stock increases by the fraction $m.\frac{k_2N_0}{k_1n_0+k_2N_0} = b$. Note that these two fractions of increase will be equal only if $k_1=k_2$.

The total output in the new situation will be

$X_1 = X_0\,(1+a)^{\alpha}\,(1+b)^{1-\alpha}$, and

$$\frac{X_1}{L_1} = \frac{X_0}{L_0}\left(\frac{1+b}{1+a}\right)^{1-\alpha}$$

$$\frac{X_1}{K_1} = \frac{X_0}{K_\theta}\left(\frac{1+a}{1+b}\right)^{\alpha}$$

Hence the total income of the factors initially present, in the post-immigration situation, is

$$Y_1 = X_0\left[\alpha\left(\frac{1+b}{1+a}\right)^{1-\alpha} + (1-\alpha)\left(\frac{1+a}{1+b}\right)^{\alpha}\right]$$

$$= Y_0\left[\alpha\left(1+\frac{b-a}{1+a}\right)^{1-\alpha} + (1-\alpha)\left(1+\frac{a-b}{1+b}\right)^{\alpha}\right]$$

Approximating each of the expressions within the brackets by the first two terms of the Taylor expansion, this becomes

$$Y_1 = Y_0\left[1+\alpha\,(1-\alpha)\,\frac{(b-a)^2}{(1+a)\,(1+b)}\right]$$

Thus income of the factors initially present, in the post-immigration situation, must have risen unless $b=a$, which, as mentioned above, requires $k_1=k_2$, that is, that the human-capital-intensity of skilled labour be the same as the material-capital-intensity of unskilled labour.

The proportional gain in income of the factors initially present, expressed in terms of the proportional increase in the number of skilled workers and the other parameter, is

$$g = \frac{\alpha\,(1-\alpha)\,m^2\left(\frac{k_2N_0}{k_1n_0+k_2N_0} - \frac{N_0}{n_0+N_0}\right)^2}{\left(1+m.\frac{N_0}{n_0+N_0}\right)\left(1+m.\frac{k_2N_0}{k_1n_0+k_2N_0}\right)}$$

Since $\alpha\,(1-\alpha)$ has a maximum value of $\frac{1}{4}$, and by defining $r_0 = N_0/n_0+N_0$, $k_0 = k_2/k_1$, this may be rewritten as

$$g \leqslant \tfrac{1}{4}\,m^2.\frac{r_0\,(1-r_0)^2\,(k_0-1)^2/(1-r_0+k_0r_0)^2}{(1+mr_0)\left(1+m.\frac{k_0r_0}{1-r_0+k_0r_0}\right)}$$

$$\leqslant \frac{m^2}{4}\cdot\frac{r_0\,(1-r_0)^2\;\;(k_0-1)^2}{(1+mr_0)\;\;(1-r_0+(1+m)\,k_0r_0)\,(1-r_0+k_0r_0)}.$$

By its nature, this expression is likely to be a very small fraction in all but exceptional circumstances, since both terms are likely to be small fractions (in the right hand term, $r_0 (1-r_0)$ has a maximum value of 1/4).

As an example, suppose that immigration is 10 per cent of the skilled labour force($m=0.1$), skilled labour is 20 per cent of the total labour force ($r_0=0.2$), and the human-capital-to-skilled-labour ratio is twice the material-capital-to-unskilled-labour ratio. Then the maximum loss of income to the initial population, which will accrue when labour and capital contribute equally to the national output, will be 0.0217 per cent of the national income. If immigration were 20 per cent of the skilled labour force, all else unchanged, the maximum loss would be 0.0826 per cent of national income. With the 20 percentage rate of immigration but with skilled labour only 10 per cent of the total labour force, the maximum loss would be 0.0633 per cent of national income; with the first set of assumptions but with $k_0=1/2$ instead of 2, the maximum loss would be 0.0091 per cent of national income.

Mathematical Appendix 2

ON SCALE EFFECTS

Following the mathematical development of Appendix 1, rewrite the production function as $X = L^{\alpha} K^{\beta}$, removing the constant-returns-to-scale restriction that $\alpha+\beta=1$. Non-constant returns to scale imply that marginal productivity payments to the factors would either over- or under-exhaust the product; we adopt the convention that the total reward to each factor is adjusted proportionately so that the product is exactly exhausted, *i.e.*, the shares of the factors are respectively $\frac{\alpha}{\alpha+\beta}$ and $\frac{\beta}{\alpha+\beta}$. Then

$$Y_1 = L_0 \frac{\alpha}{\alpha+\beta} \frac{X_1}{L_1} + K_0 \frac{\beta}{\alpha+\beta} \frac{X_1}{K_1}$$

$$X_1 = X_0 (1+a)^{\alpha} (1+b)^{\beta}$$

$$\frac{X_1}{L_1} = \frac{X_0}{L_0} \frac{(1+b)^{\beta}}{(1+a)^{1-\alpha}}$$

$$\frac{X_1}{K_1} = \frac{X_0}{K_0} \frac{(1+a)^{\alpha}}{(1+b)^{1-\beta}}$$

$$Y_1 = Y_0 \left[\frac{\alpha}{\alpha+\beta} \cdot \frac{(1+b)^{\beta}}{(1+a)^{1-\alpha}} + \frac{\beta}{\alpha+\beta} \cdot \frac{(1+a)^{\alpha}}{(1+b)^{1-\beta}}\right]$$

$$= Y_0 \left[\frac{\alpha(1+b) + \beta(1+a)}{\alpha+\beta} (1+a)^{\alpha-1}(1+b)^{\beta-1}\right]$$

If it so happened that the human-capital-intensity of skilled labour were exactly equal to the material-capital-intensity of unskilled labour ($k_1 = k_2$) so that $a=b$, this would reduce to $Y_1 = Y_0 (1+a)^{\alpha+\beta-1}$; using the first two terms of the Taylor expansion to approximate the exponential term, the proportional change in the total income of pre-immigration residents is $a(\alpha+\beta-1)$, which may be rewritten as $mr_0 i$, where i represents the proportional rate of increasing returns (the proportion by which output increases more than proportionately to an equi-proportional increase in factor inputs—negative in the case of decreasing returns). This is likely by its nature to be a very small fraction of a percentage of initial income. For example, if (as in the previous appen-

dix) immigration is 10 per cent of the skilled labour force ($m=0.1$), skilled labour is 20 per cent of the total labour force ($r_0=0.2$), and the rate of increasing returns is 10 per cent ($i=0.1$), the proportional gain of income for the initial population will be 0.2 per cent (and conversely the proportional loss with a rate of decreasing returns of 10 per cent will be 0.2 per cent of initial income). These figures apply equally to a 20 per cent immigration with skilled labour 10 per cent of the labour force.

If the ratio of capital to labour embodied in skilled labour differs from the ratio of material capital to unskilled labour, immigration will, as shown in Appendix 1, tend to increase the total income of the initial residents under constant returns to scale; this increase will be reinforced by increasing returns to scale, and offset to a greater or lesser extent by decreasing returns to scale. Unfortunately the algebra for $a \neq b$ is too complex to be worth exploring in detail; but the results of this and the previous Appendix strongly suggest that, for empirically plausible values of the parameters, the proportional change in income is likely to be of a negligible magnitude.