BRAIN DRAIN
WITH PARTICULAR REFERENCE TO THE OUTFLOW OF GREEK SCIENTIFIC LABOUR TO THE UNITED STATES

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ABSTRACT

In the present paper, we have attempted to consider the most important factors underlying the outflow of scientific labour from Greece to the United States. More specifically, after giving an account of the situation prevailing in Greece, as regards the brain-drain phenomenon, and a description of the present tendencies concerning movements of scientists and engineers from Greece to the United States, we present the problem of brain-drain in its theoretical formulation. We then proceed to some empirical consideration by choosing to investigate the extent to which income differentials between countries may affect the decision of a scientist to emigrate. Again here, reference is made to the Greece-U.S.A. movement. The results of this effort are summarized in the last part of the paper.

The United States have long been regarded as a strong pole of attraction for a considerable percentage of educated people from the developing countries. It is well known that Greece, for example, loses about 21% of her first-degree engineers to the U.S.A. annually.[1] There are, of course, many more scientists and engineers who, having completed their post-graduate studies in the U.S.A., return to Greece and remain there to work. But these people constitute a wider category. What we are concerned with in the present paper is this 21% which decides to stay abroad for ever. These people represent what is commonly known as the "brain-drain" flow from Greece to the U.S.A. It is their behaviour which we'll try to analyse and explain.

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1. GRUBEL & SCOTT: "International Flow of Human Capital", *American Economic Review*, May 1966.

The problem of brain-drain has caused a great deal of disagreement among experts. In particular, many American economists[2] have been defending the States against the accusations made by many distinguished people, as regards the American exploitation of the poor countries. Due mainly to the importance of brain-drain, as regards the degree of development of many countries, there has always been a difference in opinions, as to what extent this scientific labour movement is beneficial or harmful for a nation. I have recently come across two articles by Professors Grubel and Scott,[3] who think that brain-drain can only be detrimental for a country, when the latter is considered to be a "nation state, whose national objective is to maximise its military and economic power". But, according to them, this view is considered as outmoded in our age, when emphasis is placed on the individuals' collective welfare. From that point of view, they think that brain-drain flows, not only don't decrease a country's welfare, but they sometimes increase it.

Strongly opposed to these ideas, is an article by J. Amuzegar.[4] The author tends to regard the outflow of scientific manpower as highly ironic, when viewed in parallel with foreign aid programs from already developed nations. In fact this movement can be viewed as a "curious backflow of aid from the poor to the rich nations".

I suspect that the source of the disagreement is the different point of view from which the two articles look at the problem. When one regards it from the point of view of the developed and rich nation, one can easily talk about general welfare maximization and long-run benefits. But we must admit that the welfare function of the developed nation is quite different compared to that of the underdeveloped. History has proven that a small nation cannot rely exclusively on foreign aid in order to attain a significant degree of development. The Turkish economy offers a good example in this case. On the contrary, the main burden during the effort towards the country's economic, political and military improvement is allocated to the domestic factors of production. Greece belongs to that category of nations that are in need of all their scientific labour force which will assist in attaining a significant level of development and —above all— stability and security. Having attained such a niveau, might permit us to start considering further problems, associated with growth, rather than development.

The purpose of this paper, however, is not to go deep into a sort of cost-benefit analysis in order to prove the usefulness or otherwise of brain-drain for Greece. Af-

2. GRUBEL & SCOTT: "International Flow of Human Capital", *American Economic Review*, May 1966.

W. ADAMS (ED.): "The Brain Drain", *MacMillan*, 1968.

3. GRUBEL & SCOTT: "International Flow of Human Capital", *American Economic Review*, May 1966.

GRUBEL & SCOTT: "The Immigration of Scientists and Engineers to the United States — 1949-1961". *Journal of Political Economy*, August 1966.

4. J. AMUZEGAR: "Brain Drain and the Irony of Foreign Aid Policy", *Economia Internationale*, 1968, p. 697.

ter all, such an evaluation is bound to include a strong political element, apart from the strictly economic aspect of the problem. Thus, our main effort will concentrate on analysing how certain factors affect the outflow of Greek scientists to the U.S. and if so, then to what extent. More specifically, we shall focus on examining whether income differences and fluctuations between countries and within each country, influence the migration of scientific labour.

In an attempt to define the brain-drain phenomenon, we may consider it as the continuous outflow of educated people — at least above high school level — who decide to stay for ever and work in a foreign country, usually more developed than their own.[5]

There are many categories in which the brain-drain movement can be classified, depending on its direction or nature, the intentions of those who migrate etc[6]. As regards the direction of the migratory movement, we are able to distinguish between the following four trends:

a) From underdeveloped to developed countries, which is the usual and most common case.

b) From developed to underdeveloped countries. Here, the motives are clearly not income differentials, although experts assigned to poor countries are paid higher wages compared to those of their native colleagues. In fact this wage discrimination takes place despite the low standard of living in the host country.

In addition to the high income earned, one should also consider the increased psychological income and fringe benefits of the foreign experts.

The reasons behind such a brain-drain flow are usually either Research and Development (R&D) Programs, or student exchange through international organisations. It is important to remember, however, that it is not very probable that an emigrant belonging to this category will apply for permanent residence in the host country. Moreover, this category of brain-drain movement is not so commonly met and therefore cannot be exactly considered as appearing in the form of a flow phenomenon.

c) From developed to developed countries, due to scientific research programs jointly undertaken by the two parts (e.g. space program cooperation). In some rare cases, however, brain-drain between two developed countries comes up as a result of differences in income. (In the U.S. during the early 70's, the crisis of Ph. D. degrees in the country was a strong motive for American Ph. D. holders to emigrate to Germany).

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5. G.A. KOURVETARIS: "Brain Drain and International Migration of Scientists", *Review of Social Research*, EKKE, Athens, 1973.

6. For example, Kourvetaris distinguishes between "actual", "potential" and "disguised" brain-drain flows (see G.A. KOURVETARIS, op. cit.).

d) Finally, it is quite rare that a scientist[7] moves from one underdeveloped country to another. This ususally happens when scientists are sent to such countries by the U.N. under certain aid programs. Also, if the receiving country presents a particular interest in a certain field (e.g. Archaeology, Biology, etc.) it is likely to become a pole of attraction for scientists, regardless of the degree of development of the country they come from.[8] It must be borne in mind, however, that migration between two underdeveloped countries involves an intermediate stage, during which the emigrant-scientist is first sent to a developed country, where he undergoes the necessary training and education, before he is chosen to be assigned to an underdeveloped country.

Having now seen the various forms under which the brain-drain phenomenon appears, we shall concentrate on examining the seriousnes and importance of this scientific outflow for Greece. To do so, it is enough to consider Table I in the Appendix. It is also estimated that the annual outflow of Greek University graduates is about 1000, while the stock on the average is about 8000 students abroad (i.e. 15% of the total enrolment in Greek Universities).[9]

A further look at Tables II and III in the Appendix, shows that a total of 1066 scientists, engineers, physicians and surgeons were admitted to the U.S. from Greece, between 1962 and 1969. Moreover, for the last decade, a total of 4517 Greek emigrants in different types of professional, technical and kindered occupations have been admitted to the States under different immigration laws.

In addition to the above figures, the UNESCO annual reports indicate that the number of Greek students going to the U.S. has been increasing from 1635 to 4500 between the years 1968 and 1973. These figures constitute a considerable percentage of the total students abroad, as indicated in Table IV of the Appendix.

Finally, Table V indicates the – strictly speaking– brain-drain for Greece, i.e. those people enjoying permanent residence status in the U.S.

The question now posed, after considering the above figures, is what factors lie behind this outflow of educated human capital from Greece. The fact is that the American embassy in Athens issues about 1000 F_1 and J_1 visas yearly.[10] This number is not at all negligible for a country of 9 million people. In the case of students only, the primary cause for this outflow is said to be the lack of organised and systematic graduate studies in Greece.

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7. The term scientist will be considered in the context as including engineers, managers, administrative staff etc.

8. An excellent analysis on this is presented by E. OTEIZA: "A Differential Approach" in W. ADAMS (ED.): "The Brain Drain", *MacMillan,* 1968, p.p. 123 et seq.

9. W ADAMS (ED.), op.cit. page 170.

10. The F_1 visas are student visas and the J_1 are given to people who go to the States for research.

But this is not likely to be the case with scientists and engineers emigrating from Greece on a permanent basis. Thus, in an attempt to find an explanation to the preference and tastes of the average emigrant-scientist, we shall proceed to put the problem in technical terms.

We shall first concentrate on analysing the behaviour of the individual emigrant-scientist.

A scientist isn't insensitive to the pecuniary motives. But certainly, he is less sensitive to money income changes than an ordinary labourer, at least in the context of the Greek labour market. The scientist tends to place emphasis on the working conditions, the prospects and the psychological income which he tries to maximise. Moreover, he has a higher degree of mobility than an ordinary worker: He usually doesn't face financial problems and in most cases he speaks at least one foreign language. Also, he may be willing to give up quite a few advantages, in order to gain something less tangible but more valuable to him.

All these characteristics will be included in a "black box" describing the structure of the phenomenon under consideration. The "black box" in other words, will include the analysis of the behaviour of the individual scientist and of the elements included in his utility function. Also, it will be concerned with the indifference curves of the individual scientist.

It is important to remember that the problem here is an "all or no one offer". The person will either emigrate or not, without considering intermediate situations.[11] But such an assumption implies that only in case we have significant differences in the parameters of the welfare function, will there occur a migratory movement. In plain words this is translated to the question: "Is it worth emigrating?".

Putting the problem in technical terms, we shall first consider the personal utility function

$$U = f(x_1, x_2, x_3, \dots\dots\dots, x_n) \qquad (1)$$

where the main factors influencing U are:

x_1 = personal income

x_2 = personal working conditions

x_3 = social conditions affecting the standard of living.

In addition to these, however, there will be a certain constraint function within the boundaries of which the above utility function is maximised. To be more specific, we shall assume that we only have two independent variables, x_1 and x_2 affecting the personal utility function U. The variables of the constraint function R, will be vectors of various incomes, working conditions etc. in selected countries. Then our constraint function R will assume the shape given in Figure I, within a two-dimensional context.

11. In fact there are always intermediate solutions, which are chosen very rarely and which we omit for the sake of simplicity.

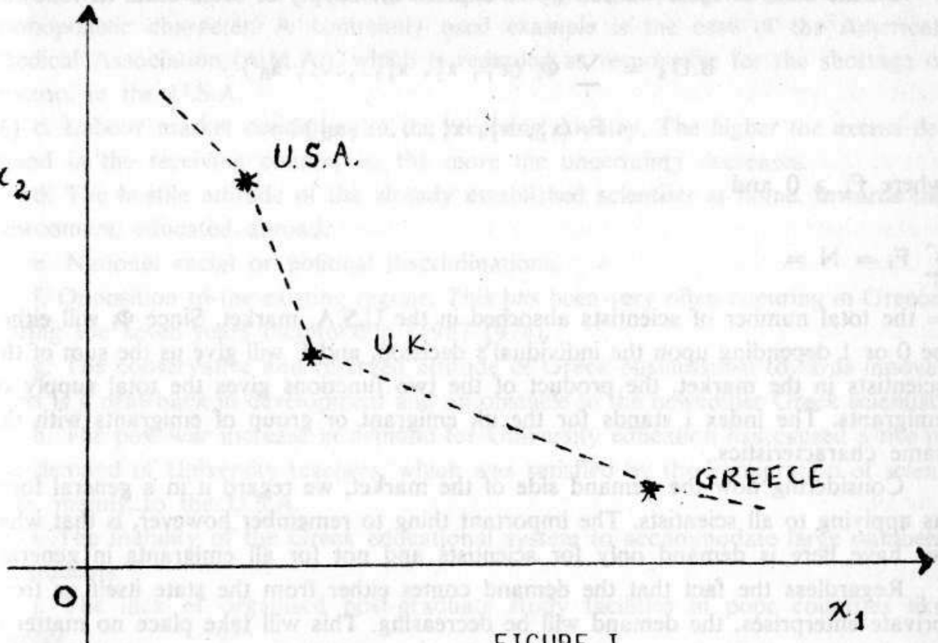

FIGURE I

Notice that the points do not necessarily lie on a straight line-something which would only represent a special case. Moreover, the more countries we include in the figure, the smoother the shape of the curve tends to be. On the contrary, while adding more countries in the constraint function will increase information regarding its shape, adding more independent variables to the utility function will lead us to an $(n+1)$ – dimensional graph, including n independent variables and one dependent. But such a formulation would certainly add to the complication of the problem.

Thus, sticking to the two-dimensional context, we shall have to proceed with dealing with the choice of the various independent variables which will be introduced in the utility function. But before doing so, we shall tackle the question of an aggregate welfare function for all emigrant-scientists.

To this end, we shall have to combine function (1) with its corresponding constraint function R, ending up with a third collective function of the form

$$\Phi_i \ (x_1^i,\ x_2^i,\ x_3^i,\ \ldots\ldots,\ x_n^i) \qquad (2)$$

We suppose that this value will be $\Phi_i = 0$ if no emigration occurs and that $\Phi_i = 1$ if emigration takes place. As one can see, we consider only the two extreme solutions.

On the basis of these we can try to express the supply of brain-drain as follows:

$$B.D_s = \sum_i \Phi_i (x_1^i, x_2^i, x_3^i, \ldots\ldots, x_n^i) \cdot$$
$$\cdot\ F_i (x_1^i, x_2^i, x_3^i, \ldots\ldots, x_n^i) \qquad (3)$$

where $F_i \geqslant 0$ and

$$\sum_i F_i = N =$$

= the total number of scientists absorbed in the U.S.A. market. Since Φ_i will either be 0 or 1 depending upon the individual's decision, and F will give us the sum of the scientists in the market, the product of the two functions gives the total supply of emigrants. The index i stands for the ith emigrant or group of emigrants with the same characteristics.

Considering now the demand side of the market, we regard it in a general form as applying to all scientists. The important thing to remember however, is that what we have here is demand only for scientists and not for all emigrants in general.

Regardless the fact that the demand comes either from the state itself or from private enterprises, the demand will be decreasing. This will take place no matter if the aim pursued is sales or profits maximisation etc. For the purposes of the present paper, one doesn't really need to go deep in analysing the factors determining this demand. The only important thing is that the demand will be declining (based on the law of marginal productivity).

It must also be borne in mind that in any analysis of actual facts, one should assume the existence of a certain ceiling in the number of immigrants accepted in a certain country per year. Such measures have been taken in many highly developed countries, in order to avoid massive immigration of scientists, which might be contrary to the interests of the native scientific personnel.

Finally, let's take a look at the market structure (i.e. interaction of supply and demand). Basically, we are going to have a migratory movement, only in case we have an excess demand for scientists. In case there is an excess supply, migration will depend ,upon which group of scientists is given priority in employment by the government. Specificaly in the U.S.A. and according to the Employment Act of 1946, priority is given to the American scientist, in filling the gap for attaining full-employment.

The factors which influence the market structure, or the "black box", are the following:

a. Available information about the opportunities abroad, reduces uncertainty in the scientific market and facilitates migration.

b. The existence of well-organized scientific groups gives the market a monopolistic character. A commonly used example is the case of the American Medical Association (A.M.A.), which is regarded as responsible for the shortage of doctors in the U.S.A.

c. Labour market conditions in the receiving country. The higher the excess demand in the receiving country is, the more the uncertainty decreases.

d. The hostile attitude of the already established scientists at home, towards the newcomers, educated abroad.

e. National racial or political discriminations.

f. Opposition to the existing regime. This has been very often occuring in Greece, during the seven-years dictatorship (1967-1974).

g. The conservative and reserved attitude of Greek businessmen towards innovations is a drawback in development and an obstacle to the newcomer Greek scientist.

h. The post-war increase in demand for University education has caused a rise in the demand of University teachers, which was satisfied by the immigration of scientists, mainly to the U.S.A.

i. The inability of the Greek educational system to accommodate large numbers of students.[12]

j. The lack of organised post-graduate study facilities in poor countries like Greece.

The last three factors can be thought of as being responsible for the increase in N (number of scientists absorbed in the market).

Bearing in mind now, what we have said so far, we can conclude that the total brain-drain can be considered as the following function:

$$B.D = f\,[x_1, x_2, x_3, D_E, S_M] \qquad (4)$$

where:

x_1 = income differential of the two countries under consideration (sending and receiving)

x_2 = working conditions in these countries

x_3 = standard of living

D_E = excess demand for scientists in receiving country

S_M = market structure

Having thus outlined the theoretical aspect of the problem, we shall proceed to consider its empirical aspect, and more specifically, the variables which will be used as determinants of the brain-drain flow.

So far we have seen that there is a variety of factors affecting the brain-drain. The lack of data and the difficulties encountered in measuring most of these

12. Every year, about 60,000 students take the University entrance examinations. The Universities can accommodate only 1/5 of this number. The rest, having "failed" the exams, decide to go abroad.

variables – due mainly to the personal element involved – do not permit an econometric analysis which considers a large number of independent variables or observations. Therefore we'll be obliged to concentrate on a limited number of variables. The data on these variables can be found in the Appendix.

It has been proved quite a difficult task to measure the actual brain-drain. The reason is that one has to know: a. The stock of Greek scientists in the U.S.A., b. the annual outflow, and c. how many scientists will remain abroad permanently. Information on the above wasn't available. So I thought that a good approximation to brain-drain might be those who ask for a permanent residence status in the U.S.A. per year (Appendix, Table I).

Income differential between U.S.A. and Greece will be our first independent variable. Fluctuations in this differential will come up as a result of variations in the income of the individual country itself, as indicated in Figure II. It is important to note, that we have selected income differentials and not per capita income differen-

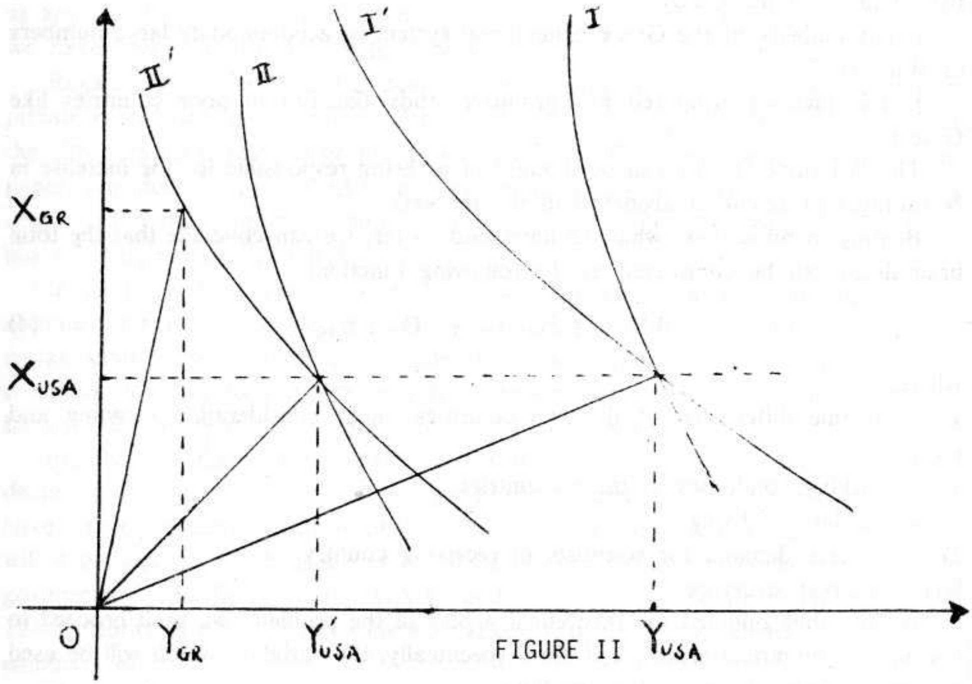

FIGURE II

tials. The reason is that by dividing by the population size, we lose the opportunity to take into account the vast difference in size between the two countries, which implies a wider choice of work for people going to the United States.

Considering the problem in terms of indifference loci, we can see that a reduction of the American income ($Y_{USA} - Y'_{USA}$), causes a reduction in the income differential ($Y_{USA} - Y_{GR}$). This difference in turn, will affect the decision of the individual to migrate. This decision will depend upon the income differential we've just mentioned, as well as on the rest of the variables in function (4), which, for the moment, we collectively call U:

$$B.D = f[(Y_{USA} - Y_{GR}), U] \tag{5}$$

On the other hand, the question which might arise would regard the possibility that it is not the income differential ($\Delta = Y_{USA} - Y_{GR}$) which influences the brain-drain movement, but the ratio ($\Lambda = Y_{USA} / Y_{GR}$). The objection might be valid and what one has to find out is the way in which the individual will maximise its prosperity. Also, much attention must be given to the way a person conceives of the idea of differences between incomes of two countries. I don't think that one might be in a position to say many things, a priori, on the subject. But if the two magnitudes we must choose between, (i.e. income ratio and income differential) both change towards the same direction, it doesnt matter so much if we choose the one or the other. The entire problem is summarised in the idea of finding an $\overline{R}^2$ which is as high as possible.

In case now that the two variables (Δ and Λ) move to opposite directions, (i.e. one increases and another decreases), then it is of vital importance to know if the ratio or the differential is the factor to be chosen.

The ratio Λ and the differential Δ can be said to move towards opposite directions if:

$$\frac{dY_{USA}}{Y_{USA}} < \frac{dY_{GR}}{Y_{GR}} \tag{6}$$

as it happens with the actual data given in the Appendix, provided that

$$\frac{dY_{USA}}{Y_{USA}}, \ \frac{dY_{GR}}{Y_{GR}} > 0 \tag{7}$$

The two magnitudes Δ and Λ are related in the following way:

$$\frac{Y_{USA} - Y_{GR}}{Y_{GR}} = \frac{Y_{USA} - Y_{GR}}{Y_{GR}} \Rightarrow \frac{Y_{USA}}{Y_{GR}} - 1 = \frac{Y_{USA} - Y_{GR}}{Y_{GR}} \Rightarrow \Lambda - 1 = \frac{\Delta}{Y_{GR}} \Rightarrow$$

$$\Rightarrow \ \Lambda = \frac{\Delta}{Y_{GR}} + 1 \tag{8}$$

From equation (8) we get:

$$d\Lambda = \frac{Y_{GR} \cdot d\Delta - \Delta \cdot dY_{GR}}{Y_{GR}^2} \Rightarrow d\Lambda = \frac{d\Delta}{Y_{GR}} - \frac{\Delta}{Y_{GR}} \cdot \frac{dY_{GR}}{Y_{GR}} < 0 \qquad (9)$$

since in our data the ratio is decreasing.

From equation (9) we get:

$$d\Delta - \Delta \cdot \frac{dY_{GR}}{Y_{GR}} < 0 \Rightarrow d\Delta < \Delta \frac{dY_{GR}}{Y_{GR}} \Rightarrow$$

$$\Rightarrow d\,(Y_{USA} - Y_{GR}) < Y_{USA} \cdot \frac{dY_{GR}}{Y_{GR}} - Y_{GR} \cdot \frac{dY_{GR}}{Y_{GR}} \Rightarrow$$

$$\Rightarrow dY_{USA} - dY_{GR} < Y_{USA} \cdot \frac{dY_{GR}}{Y_{GR}} - Y_{GR} \frac{dY_{GR}}{Y_{GR}} \Rightarrow$$

$$\Rightarrow \frac{dY_{USA}}{Y_{USA}} < \frac{dY_{GR}}{Y_{GR}} \qquad \text{(proof of equation (6))}$$

hence, it is possible to suppose that while Δ increases, Λ decreases, having as necessary and sufficient conditions (6) and (7).

We must bear in mind that the relation under consideration is not reversable, which means that we cannot use it to cover all possible variations between Λ and Δ. Having before us a function covering periods when Λ decreases and Δ increases, we cannot use it for periods when, for example, both Λ and Δ increase or decrease simultaneously. This means that the residuals left during the calculations will be augmented, because our data refer to a period during which the differential increases and the ratio decreases. But we don't consider all other possible combinations (i.e. both variables increasing or decreasing and ratio increasing contrary to differential).

Going back to equation (8) we see that we have four possible alternatives in forming a function for brain-drain:

$$B.D = g_1\,(\Lambda, x_2, x_3) \qquad B.D = g_2\,(Y_{GR}, \Delta, x_2, x_3)$$
$$B.D = f_1\,(\Delta, x_2, x_3) \qquad B.D = f_2\,(\Lambda, Y_{USA}, x_2, x_3)$$

where x_2 and x_3 refer to working conditions and standard of living.

Functions g_2 and f_2 will have a meaning only if we consider their logarithmic form which will separate the two terms of the product:

$$\log\Delta = \log\,[Y_{GR}\,(\Lambda - 1)] = \log Y_{GR} + \log\,(\Lambda - 1)$$

Also:

$$\Delta = Y_{USA} - Y_{GR} \Rightarrow \Delta = Y_{USA}\,(1 - \frac{1}{\Lambda}) \Rightarrow \log\Delta = \Rightarrow \log Y_{USA} + \log\,(1 \frac{1}{\Lambda})$$

which can justify the use of Y_{USA} instead of Y_{GR} in function f_2.

After all four regressions have been run, we choose the one that gives the highest $\bar{R}^2$. So we can finally see if the ratio Λ or the differential Δ determines better the brain-drain. But it must be borne in mind that the choice will be made under the constraint of data covering a period when Λ decreases and Δ increases. Other combinations of changes in Λ and Δ aren't included. We must also be careful not to estimate linear regressions of f_2 and g_2, since Λ and Δ can't be linearly analysed, one as a function of the other. But generaly speaking, f_2 and g_2 are considered as more complete functions. This is attributed to the fact that a decision on migration can be influenced not only by Λ and Δ, but also by the simple income level Y_{GR} or Y_{USA}. Thus it is expected that the $\bar{R}^2$ given by f_2 nad g_2 will be higher.

To sum up, if the level of income per se doesn't affect the decision of the emigrant, then f_1 and g_1 are preferable, even if they give a lower $\bar{R}^2$. This is because they include less variables, thus allowing for more degrees of freedom. But if we have reasons to believe that Y_{USA} or Y_{GR} also influence the final decision, then g_2 and f_2 are preferable.

It must be borne in mind however, that in case we decide to use the income differential instead of the income ratio, as an explanatory variable in the analysis, we shall have to assume that our function is homogenious of degree $n \neq 0$. This assumption becomes necessary, since, in case we introduce the income ratio and then multiply both the nominator and the denominator by a constant k, this constant will be eventually cancelled, and we shall end up again with a homogenious function of degree zero.

On the other hand, choosing the income differential instead of the income ratio may be interpreted that the scientist is attracted by the vast difference in incomes, not taking into account the purchasing power of the income in each country. Moreover, this difference in income between the two countries may be regarded as reflecting a favourable climate for the emigrant to the States from the point of view of fringe benefits and scale economies. On the contrary, the ratio of the two incomes may be considered as giving emphasis to a proportionate way of comparison between the two incomes.

The second independent variable will be the Research and Development expenditure in the U.S.A. Such funds are considered to be a pole of attraction for people coming from countries where research is limited or even, non-existing. Table VI in the Appendix indicates the vast difference which exists between U.S.A. and Greece in this respect.

The phenomenon of unemployment might also play an important role in the analysis, viewed both from the point of view of the U.S.A. and of Greece. Table VI in the Appendix gives the number of unemployed scientists, engineers etc., divided by the total of scientists and engineers in both countries.

One expects that almost all of the independent variables, except American unemployment, will affect the brain-drain in a positive way. To be specific, we expect that

$$\frac{\partial B.D}{\partial INCDIF} > 0$$

since the more the income differential increases, the more scientists will seek higher income in the States. We also expect that in the case of Research and Development expenditure in the States, we'll have

$$\frac{\partial B.D}{\partial [RANDD]_{USA}} > 0$$

As regards unemployment, the index of unemployed Greek scientists over the total of scientists in Greece, must give a positive first derivative,

$$\frac{\partial B.D}{\partial [UNEMPL]^{R}_{GR}} > 0$$

Finally, in the case of the U.S.A. only, the derivative is expected to be negative, since the existence of unemployment between scientists there, will make many foreigners refrain from immigrating:

$$\frac{\partial B.D}{\partial [UNEMPL]^{R}_{USA}} < 0$$

We selected only four variables among those which affect the brain-drain. The choice was based: a. On the relevance of the data to the dependent variable and b. on the availability of data. Also, the shortage of observations was the main reason why only four independent variables were used. More variables would limit even more the number of degrees of freedom we have. Anyway, I am sure that if a time trend were introduced in the equation, it would be quite significant. Moreover, for the period 1967-1974, a dummy variable could have been included, to account for the adverse attitude towards the regime, of most of the emigrating scientists

Finally, to make sure that we'll get a close approximation in determining our equation, we will try both a simple and a logarithmic form.

From the econometric point of view we expect to find a quite significant $\bar{R}^2$, which will prove the existence of a high correlation between the dependent and the independent variables. The output also gives, for each partial regression coefficient, its standard error S, which represents the degree to which the actual values are spread around the theoretical value in the regression equation. In addition, we are given the t-Student ratios. The critical values for it are 2.228 at a 5% level and 3.169 at a 1% level (for $n = 11$). Results for the F-test are also given.

One might also want to consider several other criteria not given in the MR4 output like the Durbin-Watson test, coefficients of partial correlation or partial elasticity. Anyway, the last two aren't important at this stage of analysis.

In addition to the discussion held about the ratio and the income differential, it might be useful to regress both ratio and differential of incomes on brain-drain. Then we can compare the results of these two separate bivariate regressions. (Detailed tables of the results of these and the next regressions will be found in the Appendix).

Regressing first the income differential on brain-drain, we derive a significant t-ratio for the variable, but an insignificant one for the constant term. The constant is insignificant at both 0.05 and 0.01 levels. Also the standard error shows coefficient for the income differential which is quite different from zero. The signs of the two coefficients are positive, as expected. An $\overline{R}^2$ of 43.6% indicates that the income differential can explain a significant part of variations in brain-drain flows. Finally, according to the F-test, we accept that at a level of 0.05, the estimated regression equation exists in the parent population. In short the equation we get is:

$$\begin{aligned} B.D = {} & \underset{(315.33)}{111.61} + \underset{(0.00048)}{0.00142}\ [INCDIF] \end{aligned} \tag{10}$$

Another regression using the above variables in their logarithmic form does not alter the situation very much:

$$(B.D)' = -\underset{(4.21)}{4.17} + \underset{(0.315)}{0.828}\ [INCDIF]' \qquad (11)^{13}$$

Here too, income has a significant t-ratio. But the paradox is that the negative constant means that once the influence of income ceases to exist, we'll have a negative brain-drain. Anyway, the considerably large numbers for the logarithms of income differential will outweigh the negative sign of the constant. Moreover the constant is not significantly different from zero. On the other hand the coefficient of the independent variable is significant, but the $\overline{R}^2$ has now dropped to 37.1%. Finally, the F-test at a 5% level suggests that in the parent population we can find the estimated regression equation.

The corresponding regressions for the ratio of incomes in its simple and logarithmic form yield the following equations:

$$B.D = \underset{(713.14)}{2830.65} - \underset{(6.20)}{15.80}\ [INCRAT] \tag{12}$$

13. $(B.D)' = \log B.D$ and $[INCDIF]' = \log [INCDIF]$.

$$(B.D)' = \underset{(3.32)}{15.092} - \underset{(0.70)}{1.731} \ [INCRAT]' \quad (13)$$

where $(B.D)' = \log B.D$ and $[INCRAT]' = \log [INCRAT]$.

The negative sign in equations (12) and (13) is acceptable since the ratio Y_{USA} / Y_{GR} is decreasing because Y_{GR} grows as a faster rate than Y_{USA}. On the other hand, we have an increasing brain-drain time series.

The question remains, then, what factors lie behind the brain-drain flow from Greece to the States, since the growth rate of the Greek national income appears to be more attractive. Thus, one may be inclined to think that the pecuniary motive is not so strong in affecting the decision of the Greek scientists to move, at least towards the U.S. Perhaps one should look for other factors which may explain this tendency towards emigration. In such a case, however, it is quite probable that additional difficulties might arise, mainly due to the nature and availability of the data required.

To go back to the results obtained, the $\overline{R}^2$ derived are even lower this time, i.e. $\overline{R}^2 = 35.4\%$ for the simple version and $\overline{R}^2 = 33.6\%$ for the logarithmic one. Anyway, the t-ratios in both regressions are significant at a 0.05 level, and the F-tests – though giving a little lower values this time – are still satisfactory.

All these trials indicate that it would be more convenient to use the income differential as an explanatory variable. Proceeding now to the multiple regression we derive the following equation:

$$\begin{aligned} B.D = \underset{(2054)}{1755.4} + \underset{(0.0038)}{0.00146} \ [INCDIF] + \underset{(0.114)}{0.054} \ [RANDD]^{USA} + \\ + \underset{(66497.1)}{4009.7} \ [UNEMPL]^{R}_{GR} + \underset{(2979.7)}{4696} \ [UNEMPL]^{R}_{USA} \end{aligned} \quad (14)$$

The $\overline{R}^2$ in the case of equation (10) was 43.6%, and the income differential was the only variable. Now, the introduction of three additional variables brings about a minor increase of $\overline{R}^2$ to 44.5%. A probable explanation is that the income differential had incorporated the effect of the rest of these independent variables. Therefore the addition of the extra variables in equation (14) didn't bring about a significant increase of the $\overline{R}^2$. One can see the logic of this explanation considering for example that a country could never spend so much money on research and development if it couldn't spare it, i.e. if it didn't have a very high income. So it can be very possible to have the independent variables interrelated and an $\overline{R}^2$ increased very little due to multi-collinearity between the regressors. Another weak point is that the MR4 program doesn't provide for a Durbin-Watson statistic, in order to investigate the degree of autocorrelation in our series.

In general, I think that the conclusion to which we are led, (that the influence of all these variables is insignificant) can be misleading. It is true that all t-tests give insignificant results, and so do the standard errors. This can be true for the last three independent variables. But at least the income differential, surely plays an important role in determining the brain-drain, judging from what we have said so far and considering also equation (10).

A final thing to say is that the sings of the coefficients of the variables are as expected, with the exception of the coefficient of the unemployment ratio in the States, which should be negative. A possible solution to this difficulty would be to reverse the cause and effect of the phenomenon. Due to excessive brain-drain the result is unemployment in the States. Anyway one could test the validity of this outcome by using a time lag to test the influence of previous years.

If we try to change the variables into a logarithmic form, the results are not very much different. Thus, setting $X' = \log X$ for every independent variable X and also $(B.D)' = \log B.D.$, we get:

$$\begin{aligned}(B.D)' = &- \underset{(21.47)}{1.65} - \underset{(3.40)}{0.49}\,[INCDIF]' + \underset{(2.43)}{1.41}\,[RANDD]'^{USA} - \\ &- \underset{(0.67)}{0.47}\,[UNEMPL]'^{R}_{GR} + \underset{(0.40)}{0.53}\,[UNEMPL]^{R}_{USA}\end{aligned} \qquad (15)$$

Here too, all coefficients are not significantly different from zero, while the t-ratios are insignificant as well. The $\bar{R}^2$ has dropped now to 38.3%. What is more, the coefficients of income differential and Greek unemployment are negative, contrary to our expectations. Finally the positive coefficient of the American unemployment still hasn't changed. In general, the logarithmic version proves to be the least satisfactory.

The results of the analysis performed so far may be summarised as follows:

Equations (14) and (15) do not give a satisfactory explanation of the brain-drain flow form Greece. On the other hand, the results are much better for equations (10) to (13) with the possible exception of the low values of the $\bar{R}^2$. However, we should not necessarily concentrate too much on these values as a measure of success in our estimation. As we shall be discussing later on, the shortage of observations is probably the most serious problem in getting significant coefficients in (14) and (15). In addition, the same detrimental effect upon (14) and (15) is due to the strong correlation of income with the rest of the variables used in these equations.

In choosing among equations (10) to (13), which give more satisfactory results, we should rather decide for using the income differential instead of the income ratio as an explanatory variable. The reasoning behind this is that the individual scientist is not concerned so much with a comparison between the American and the Greek national income, (which is slowly getting more favourable for Greece in the course of time) as with realising the vast gap which is constantly increasing (even though at a decreasing rate) between the incomes of the U.S. and Greece. It should be noted here, as well, that choosing between functions of linear or non-linear forms in the context of the brain-drain theory can only be based on suggestions with no sound theoretical background indicating the choice of a specific form of equation.

However, in parallel with considering and evaluating the results of the preceding analysis, one should bear in mind the following important points:

a. The real relation between the brain-drain and the explanatory variables is not as simple as we described it. A more complete explanation of the phenomenon might be given, if one took into consideration the variances and covariances of the independent variables among them.

It is not enough to know $\bar{x}_1$, $\bar{x}_2$, and $\bar{x}_3$ as given in a simple regression. What we also need to consider is the variances and covariances of the independent variables, in order to take into account their interdependence. This means that our original supply function should take the following form:

$$B.D_S = G\ [\bar{x}_1,\ \bar{x}_2,\ \bar{x}_3,\ var(\bar{x}_1),\ var(\bar{x}_2),\ var(\bar{x}_3),\ cov(\bar{x}_1\,\bar{x}_2),\ cov(\bar{x}_1\,\bar{x}_3),\ cov(\bar{x}_2\,\bar{x}_3)\ ] \qquad (16)$$

The exclusion of the variances and covariances from the model can be one cause for the low value of our $\bar{R}^2$ coefficient.[14]

Anyway, despite the high degree of uncertainty in the results, the essential point remains unaltered: Since we have a kind of "all or no one" offer, the differences in the variables must be very significant between countries, in order to start a migratory movement.

b. A second reason for the inadequate results obtained may be the fact that we have used proxy variables instead of the ones actually needed. For example, in order to describe the conditions and quality of work in a particular country, we resort to Research and Development expenditure. But R and D does not fully describe the working conditions for scientists in one country. It is also important to remember that we have used the persons adjusted to permanent residence in the States as a proxy for our dependent variable.

c. Another weakness is that we haven't disaggregated the scientists, according to their fields of study. What we have done in the model can be misleading. One should distinguish between categories of scientists and see if the supply and demand of each category is related or, perhaps, overlapping with that of another. Also, it is vital to remember that the excess scientific demand does not necessarily represent demand

14. The idea for such an aggregation method was derived from FRIEDMAN'S "Theory of Consumption Function', p.p. 18-19.

for immigrant scientists. Anyway, it facilitates the migratory movement. The reason is that state intervention may raise the emoluments of the native scientists, instead of "importing" scientific personnel from other countries. Generally, one can conclude that in the long-run, the "production" of more scientists is a solution much preferred to immigration. The latter can fill the vacancies of scientific personnel only in the short-run.[15]

d. A final difficulty, which we have already mentioned, is the lack of sufficient data. The data provided are usually incomplete and in many cases, they cannot be compared. Moreover, the 11 years of observations do not permit the introduction of more independent variables in the system.

So, I think that if one takes into account all the above, one will not find the $\bar{R}^2 = 44.5\%$ so surprising or unexpected. What is more the majority of this influence should be attributed to the income differential alone, with the other variables playing a minor role in the analysis, due to their apparent correlation with income.

A final point which is worth mentioning is the following:

In the theoretical part of the present paper we considered for a start, the individual's welfare function. But we haven't said anything so far about a factor that surely enters into one's welfare function, i.e. the well-being of his family. The family environment exerts a considerable influence on the degree of mobility of a scientist and on his final decision to emigrate. So, one should be wondering to what extent might we include in a personal welfare function, the factor "family". The reason why we haven't tried to consider this factor as well in the context of the Greek environment is twofold: First, considering the Greek family institutions,the final decision is usually taken by the "pater familias". And, second, the majority of the emigrating scientists under normal circumstances are rather young and unmarried.

15. This view regards the welfare of the States and the native scientists and is contrary to the interests of the immigrants who try to obtain a permanent residence status.

TABLE I

GREECE: EMIGRATION OF SCIENTISTS AND OTHER PROFESSIONALS IN RELATION TO TOTAL FIRST-DEGREE GRADUATES 1961-1965

	Stock according to 1961 Census	Total new Graduates 1961-1965	Permanent Emigrants 1961-1965	% Of Emigration to Graduates	Temporary Emigration 1961-1965	% Of Temporary Emigr. to Graduates
I. TOTAL PROFESSIONALS-SCIENTISTS	77600	22566	3232	14.3	1981	8.8
1. Engineers-Architects etc. first-degree graduates	5000	1876	650	34.6	191	10.2
2. Scientists	5700	2200	600	27.3	233	10.6
3. Physicians-Dentists and related fields	15500	3151	793	25.2	409	13.0
4. Teaching personnel	40000	11994	954	8.0	1072	8.9
5. Lawyers	11400	3345	235	7.0	76	2.3
II. MANAGERIAL AND HIGH ADMINISTRATIVE PERSONNEL	28500	5804	470	8.1	125	2.2
TOTAL OF GROUPS I AND II	106100	28370	3702	13.0	2106	7.4

SOURCE: ADAMS: "Brain Drain" (G. COUTSOUMARIS: "Brain Drain in Greece"), Page 170.

TABLE II

GREEK SCIENTISTS, ENGINEERS, PHYSICIANS AND SURGEONS ADMITTED TO THE UNITED STATES 1962-1969

FISCAL YEAR	SCIENTISTS	ENGINEERS	PHYSICIANS-SURGEONS
1962	17	52	—
1963	39	64	—
1964	26	53	—
1965	20	37	32
1966	51	57	48
1967	59	111	59
1968	29	108	34
1969	30	104	36
TOTAL	271	586	209

SOURCE: G.A. KOURVETARIS: "Brain Drain and International Migration of Scientists-Greece", Review of Social Research E.K.K.E., ATHENS, 1973, Page 7.

TABLE III

GREEK IMMIGRANTS IN PROFESSIONAL, TECHNICAL AND KINDERED OCCUPATIONS 1962-1971

FISCAL YEAR	TOTAL GREEKS ADMITTED	GREEK % OF TOTAL ADMISS.	GREEK PROFESS. ADMIT.	GREEK % OF TOTAL
1962	4702	1.7%	261	5.6%
1963	4825	1.6%	364	7.5%
1964	3909	1.3%	268	6.9%
1965	3002	1.0%	212	7.1%
1966	8265	2.6%	374	4.5%
1967	14905	4.1%	589	4.0%
1968	13045	2.9%	512	3.9%
1969	17724	4.9%	586	3.3%
1970	16464	4.4%	697	4.2%
1971	15939	4.3%	654	4.1%
TOTAL	102782	3.0%	4517	4.4%

SOURCE: G.A. KOURVETARIS: "Brain Drain and International Migration of Scientists-Greece", Review of Social Research.

TABLE IV

GREEK STUDENTS ABROAD WITH SPECIAL REFERENCE TO THE U.S.A. (1968-1973)

YEAR	GREEK STUDENTS IN U.S.A.	TOTAL GREEK STUDENTS ABROAD
1968	1635	9745
1969	1811	12512
1970	1968	14147
1973	4500	31170

SOURCE: Unesco Annual Reports.

TABLE V

GREEKS ADJUSTED TO PERMANENT RESIDENCE STATUS IN THE U.S.A.

YEAR	TOTAL GREEKS ADJUSTED	TOTAL GREEK STUDENTS ADJ.
1960	732	—
1961	731	—
1962	1023	—
1963	1168	—
1964	860	—
1965	662	—
1966	815	227
1967	1305	320
1968	1241	252
1969	1133	211
1970	1587	250
1971	1538	225
TOTAL	7619	1485

SOURCE: G.A. KOURVETARIS: "Brain Drain", In Review of Social Research. Also: U.S.A. Department of Justice, Immigration and Naturalization Service.

TABLE VI

YEAR	Y_{USA} (millions $)*	Y_{GR} (millions $)*	$Y_{USA} - Y_{GR}$*	Y_{USA} / Y_{GR}*	$ PER CAPITA $(RANDD)_{USA}$**	$ PER CAPITA $(RANDD)_{GR}$**	$(UNEMPL)^{R}_{USA}$**	$(UNEMPL)^{R}_{GR}$***	BRAIN DRAIN+
1960	464597	3396	461201	136.81	74.7	0.6375	0.2071	0.0125	732
1961	476077	3852	475225	124.37	80.8	0.6931	0.2532	0.0107	731
1962	513065	4053	509012	126.59	85.4	0.7391	0.2066	0.0122	1023
1963	540523	4480	536043	120.65	93.6	0.8184	0.2067	0.0132	1168
1964	581153	5004	576149	116.14	102.1	0.8965	0.1643	0.0114	860
1965	633153	5646	627507	112.14	107.3	0.9562	0.1155	0.0119	662
1966	689416	6235	683181	110.57	115.0	1.0319	0.0955	0.0090	815
1967	728886	6767	722119	107.71	121.0	1.1009	0.0901	0.0073	1305
1968	782035	7358	774677	106.28	126.7	1.1513	0.0824	0.0062	1241
1969	838961	8294	830667	101.15	130.0	1.3900	0.0844	0.0057	1133
1970	879702	9131	870571	96.34	129.3	1.4051	0.1232	0.0046	1587

* SOURCE: U.N. YEARBOOK OF LABOUR STATISTICS.
** SOURCE: UNESCO ANNUAL REPORT.
*** SOURCE: UNESCO YEARBOOK, YEARBOOK OF LABOUR STATISTICS, U.N. STATISTICAL YEARBOOK O.E.C.D. STATISTICS OF OCCUPATIONAL AND EDUCATIONAL STRUCTURE OF LABOUR FORCE IN 53 COUNTRIES.
\+ SOURCE: U.S.A. DEPARTMENT OF JUSTICE, IMMIGRATION-NATURALIZATION SERVICE.

TABLE VII

Number of Equation	Equation Form	Constant	(INCDIF)	(INCRAT)	$(RANDD)_{USA}$	$(UNEMPL)^{R}_{GR}$	$(UNEMPL)^{R}_{USA}$	$\bar{R}^2$
(10)	Simple Linear	111.61 (315.33)	0.00142* (0.00048)	–	–	–	–	43.6%
(11)	Logarithmic	–4.17 (4.21)	0.828* (0.315)	–	–	–	–	37.1%
(12)	Simple Linear	2830.65* (713.14)	–	–15.80* (6.20)	–	–	–	35.4%
(13)	Logarithmic	15.09* (3.32)	–	–1.73* (0.70)	–	–	–	33.6%
(14)	Simple Linear	–1755.4 (2054.2)	0.00146 (0.0038)	–	0.054 (0.114)	4009.7 (66497.1)	4696.78 (2979.77)	44.5%
(15)	Logarithmic	–1.65 (21.47)	–0.49 (3.40)	–	1.40 (2.43)	–0.47 (0.67)	0.537 (0.406)	38.3%

* Significant at $a = 0.05$ level.

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