A THEORETICAL MODEL FOR THE OPTIMAL ALLOCATION OF HEALTH RESOURCES IN GREECE

N. DRITSAKIS
Associate Professor
Department of Applied Informatics
University of Macedonia

Summary

This paper presents a theoretical model which enables us to rate the efficiency of health resources in different regions. The model presented, is based on the theory of production and refers to two specific regions. At first we examine the hypotheses that determine the relationship between health care resources and their indicators, and further on, we determine the necessary conditions for the optimal regional allocation of these resources.

1. Introduction


A balanced regional development of the health care services has not been achieved yet by some advanced health care systems, like in the case of Great Britain, Culyer and Cooper (1970), Maynard (1977), Hollingsworth and Parkin (1995), Soderlund and al (1997),
Maniadakis and Thanassoulis (1998, 2000), where the regionalization of health resources had been predetermined as an essential goal since 1948. In the case of Greece, decentralization and balanced regional allocation of health care resources are considered to be essential goals of the National Health Care System. To achieve these goals some regional health care departments were created, in order to deal with the determination and evaluation of the regional health care needs. Nevertheless, the regional programming of the resources should be based on a rational and well coordinated regional and national planning. (Yfantopoulos 1979).

2. The Hypotheses of the Model

The model we are testing refers to two specific regions: Regions A and B, on which we make the following assumptions:

- We assume that the quality of the health care services offered are equivalent for both regions.
- Using the same health care metrics we can calculate the level of health care provided in both regions.
- Every region has a specific number of hospital beds, doctors, medical staff, administrative staff and medical auxiliaries. The overall number of hospital beds, doctors, medical staff distributed in both regions, can be mathematically expressed as:

\[ B_A + B_B = B \]
\[ D_A + D_B = D \]
\[ N_A + N_B = N \]

where: \( B_A, D_A, N_A \) represent the hospital beds, doctors and medical staff for region A and \( B_B, D_B, N_B \) the respective for region B.

- The health care level of each region is affected by the existent health care infrastructure. The relationship between the health care level and the health care infrastructure for both regions is presented by the following production functions:

\[ X_A = f(B_A, D_A, N_A) \quad \text{for region A} \]
\[ X_B = f(B_B, D_B, N_B) \quad \text{for region B} \]

- Every improvement of the health care infrastructure increases the level of health care in the region. This relationship is mathematically expressed by the first partial derivative of the above mentioned production functions. The first partial derivative presents the marginal products of every production coefficient and shows at what extent the total output increases, when we increase a production coefficient, i.e. at which point the health care level of the region will increase, if the health care infrastructure of that specific region increases.

We assume that the first partial derivatives are positive.

\[ \frac{\partial X_A}{\partial B_A} > 0 \quad \frac{\partial X_A}{\partial D_A} > 0 \quad \frac{\partial X_A}{\partial N_A} > 0 \quad \text{for region A} \]
\[ \frac{\partial X_B}{\partial B_B} > 0 \quad \frac{\partial X_B}{\partial D_B} > 0 \quad \frac{\partial X_B}{\partial N_B} > 0 \quad \text{for region B} \]

Suppose that the second partial derivatives are negative.

\[ \frac{\partial^2 X_A}{\partial B^2_A} < 0 \quad \frac{\partial^2 X_A}{\partial D^2_A} < 0 \quad \frac{\partial^2 X_A}{\partial N^2_A} < 0 \quad \text{for region A} \]

\[ \frac{\partial^2 X_B}{\partial B^2_B} < 0 \quad \frac{\partial^2 X_B}{\partial D^2_B} < 0 \quad \frac{\partial^2 X_B}{\partial N^2_B} < 0 \quad \text{for region B} \]

- We assume that the quality of health care services provided is identical for both regions.

3. Inter-regional Optimization

This section examines the necessary conditions so that we can achieve the maximum possible level of health care from the most effective use of health care resources. The optimal combination of health care resources for each region is determined by the production capacity curve (Diagram 1), taking under consideration the health care infrastructure of each region and the existing technology.
Every combination of resources - inflows resulting from this curve means that the health care resources are not properly allocated. Consequently, if services are better organized, a higher level of health care can be achieved. Any combination outside points $\Gamma$ and $\Delta$, is unachievable (Diagram #1). Any combination on the curve provides us with the maximum possible attainable result by the allocation of health care resources.

A balance of the health care sector is considered the point at which the ratio of the marginal products of every production coefficient (every inflow) is equal for all
coefficients. Which means that the state has allocated the health care resources in
different regions in a way that the maximum and most effective possible use of all
resources is achieved. Each region has the intention of optimizing the use of its resources.
This optimization derives from a production process that combines properly inflows –
resources and thus attains the optimal health care level. In each region a balance –
optimization is achieved where the ratio of marginal products is equal to the marginal
ratio of technical reconstruction.

\[- \frac{dB_A}{dD_A} = \frac{\partial X_A}{\partial D_A} = \frac{MP_{DA_A}}{MP_{BA_A}} \quad \text{and} \quad - \frac{dN_A}{dX_A} = \frac{\partial N_A}{\partial X_A} = \frac{MP_{NA_A}}{MP_{BA_A}} \quad \text{for region A}\]

\[- \frac{dB_B}{dD_B} = \frac{\partial X_B}{\partial D_B} = \frac{MP_{DB_B}}{MP_{BB_B}} \quad \text{and} \quad - \frac{dN_B}{dX_B} = \frac{\partial N_B}{\partial X_B} = \frac{MP_{NB_B}}{MP_{BB_B}} \quad \text{for region B}\]

After certain replacements we can define the overall balance in the health care sector.
This balance is defined as the point where the slope of the production capacity curve is
equal to the ratio of marginal products of various inflows.

\[- \frac{dX_B}{dX_A} = \frac{MP_{BA_B}}{MP_{BA_A}} = \frac{MP_{DA_B}}{MP_{DA_A}} = \frac{MP_{NA_B}}{MP_{NA_A}} = \frac{MP_{IA_B}}{MP_{IA_A}} = \frac{MP_{IA_B}}{MP_{IA_A}} \]

The above relationship also defines the criterion for attaining a balance in the health care
sector.
4. Technological Diversifications

The health care level of a specific region depends on various factors, some of which are controllable and some aren’t. The geographical structure, the social and cultural composition of every region, as well as the environment and way of life are different for each region. Therefore, since health care constitutes a multidimensional social phenomenon, affected by these factors, some differences in the health care level are to be expected. Consequently, there will be technological differences during the production process of each region. In this case we can distinguish two basic technological diversifications.

The first one is presented through a displacement upwards or downwards (Diagram #2), known as the Hicks neutral technological advance.

The second form of technological advance refers to the existing technological diversification of the partial production coefficients, such as the fact that the medical staff of a specific region may be at a higher educational level from the staff of a different region. Thus, technological diversification is incorporated in the specific production coefficient.

To present mathematically these two forms of technological advance or technological diversifications existing between two regions, we will examine the following two production functions Cobb – Douglas which refer to these specific regions.

\[ X_A = f_A (B_A, D_A, N_A .................) \quad \text{for region A} \]

\[ X_B = f_B (B_B, D_B, N_B .................) \quad \text{for region B} \]
where \( t = \) technology

The technological diversifications can be presented as follows:

- The Hicks neutral technological advance.
- Technological advance in production coefficients

Diagram 2 The Hicks neutral technological advance in the health care sector
4.1 The Hicks neutral technological diversification

The Hicks neutral technological diversification refers to the entire production function, and assuming that the production process is homogeneous in all regions, it examines the possible upwards or downwards displacements of the production functions (Diagram #2). The upward displacements of the production functions mean that with the same resources, due to a better organization of the entire production process we can achieve a higher level of health care. A gradual displacement of the production capacity curve in the health care factor is the consequence of upward displacements. The Hicks neutral technological advance can be presented as follows:

\[ X_A = (A_A e^{m_A s_A}) B_A D_A N_A \]  
for region A

\[ X_B = (A_B e^{m_B s_B}) B_B D_B N_B \]  
for region B

where \( e^{m_A s_A} \) and \( e^{m_B s_B} \) shows the technological diversification in the production function for regions A and B.

4.2 Technological advance in the production coefficients

The diversification incorporated in the production coefficients refers to the qualitative differences (e.g. training) of a specific production coefficient. Thus, in a region were there are higher education institutions, the majority of the staff consists of university doctors. Therefore, the production function in this region could present some qualitative diversifications from the production function of a different region, where there aren’t any higher education institutions. These diversifications could be presented as following:
The parameter of technological advance \( t \) does not refer in this case to the productivity parameter like in the Hicks case, but to all production coefficients, in order to show the potential qualitative diversifications presented in each region.

In Diagram 3 the influence of the qualitative diversification in the production capacity curve of the health care sector is presented.

**Diagram 3 Technological advance in the production coefficients**

\[
X_A = (A_0 e^{\mu s t_A}) B_A^{d_A} e^{\beta t_A} D_A^{d_A} e^{\gamma t_A} N_A^{d_A} e^{\delta t_A} \quad \text{for region A}
\]

\[
X_B = (A_0 e^{\mu s t_B}) B_B^{d_B} e^{\beta t_B} D_B^{d_B} e^{\gamma t_B} N_B^{d_B} e^{\delta t_B} \quad \text{for region B}
\]
5. Conclusions

This paper presents a theoretical example for the inter-regional assessment of health care resources productivity. The theoretical analysis was based on the theory of production and supports that an optimization of the health care factor is achieved when the marginal ratio of substitution between health care levels is equal to the ratio of marginal products of production coefficients. Using this ratio as a criterion for the socially optimal and financially acceptable allocation of health care resources, we have examined at which extend the existing health resources allocation is effectively applied and what is the potential for a re-distribution of resources between regions.

Bibliography


