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Efficiency and Productivity of Cancer Care in Europe

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SUMMARY

This study demonstrates how a frontier analysis can be used to measure relative efficiency and productivity in European cancer care. The country comparisons show that countries can be separated as efficient and inefficient in a systematic way. Results show a declining marginal rate of return and a decline in productivity over time, i.e. the increase in resource use yields a smaller than proportional improvement in outcome. Performance of cancer care over time and between countries needs to be better understood to increase policy precision.

METHOD

The frontier analysis is based on distance functions, Shephard, 1953 [2] and generates efficiency scores for each country by comparing how countries produce **outputs** (e.g. survival and quality of life) from different combinations of **inputs** (e.g. number of oncologists, hospital days, and radiation units). The distance function is capable of measuring many inputs producing many outputs; it is independent of unit of measurement allowing variables to be measured in their original units, no prices are needed which in the absent of market prices is an essential characteristic. The distance function can mimic complex production processes and be solved by a straight forward linear programming algorithm; no assumption on functional form is needed.

The frontier analysis is illustrated in *Figure 1*. The best practice frontier (I-Í) is constructed from data on inputs (resources) producing outputs (outcomes). Countries **a** and **b** are technically efficient since they are on the frontier with an **efficiency score** of one. They use the fewest possible inputs to produce the same level of output y. They do this with a different mix of inputs (x_1 and x_2) but no other country does this more efficiently. Country **c** on the other hand produces the same output as countries **a** and **b**, but with more inputs, that is, country **c** is inefficient and the degree of inefficiency is measured by the distance function.

In addition to the static technical efficiency in *Figure 1*; an inter-temporal (Malmquist) productivity index approach over the 2005/2010 and 2010/2015 periods are conducted. The index result in country specific measures of *efficiency change* and *technical change* (shift in the frontier) over time and is illustrated in *Figure 2* for two time periods (t and t+1).

Figure 1. The input set and the measurement of technical efficiency

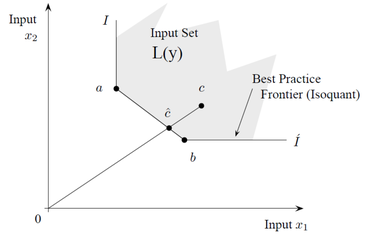
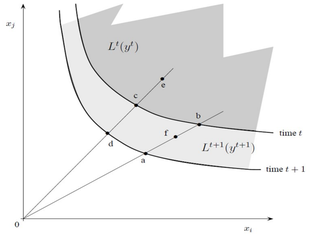


Figure 2. Improved efficiency over time and the Malmquist input-based productivity index



BACKGROUND

An estimated 2.6 million new cases of cancer were diagnosed in EU27 in 2012 and in the same year 1.3 million deaths were estimated [1]. Breast and lung cancer inflict a significant burden on patients as well as on limited European health care budgets. To make the most of available resources it is essential that the production of cancer care is carried out as efficiently as possible. Efficient use of resources reduces waste and frees up resources for use elsewhere in the production of cancer care.

DATA

The inputs and outputs of the 2015 efficiency analysis are presented in *Table 1* (breast cancer) and in *Table 2* (lung cancer). In breast cancer the efficiency analyses were completed with the inputs: *breast cancer screening, oncologists, radiation units, cancer drug expenditure, Defined Daily Dose (DDD)* and *breast surgery*, to produce the outputs: *five-year relative survival (RS)* and *life expectancy adjusted by disability-adjusted life years (DALYcv)*. In lung cancer the efficiency was calculated with the input variables: *oncologists, radiation units, cancer drug expenditure, Defined Daily Dose (DDD)* and *pulmectomy* to produce the same outputs as in breast cancer. Note the radically lower *five-year relative survival* in lung cancer.

In the Malmquist productivity measurement, data on the same variables as the 2015 efficiency analysis were used to calculate the productivity change, efficiency change, and technical change going from 2005 to 2010, and from 2010 to 2015.

Table 1. Breast cancer: Descriptive statistics on input and output variables, 2015

	Min	Max	Mean	SD	Source
Input variables					
Screening %	0.1	90.4	60.7	21.5	Eurostat [3]
Oncologists per 100 000 inhab	1.3	7.3	3.4	1.2	Eurostat [4]
Radiation units per 100 000 inhab	0.4	1.3	0.8	0.3	Eurostat [4]
Cancer drugs (drug exp/cap)	6.1	60.5	30.3	16.8	Jönsson et al [5]
Inpatient days BC per 100 000 inhab	424.9	4,468.9	1,420.2	951.0	Eurostat [4]
DDD/case BC	170.0	405.0	310.7	77.2	Jönsson et al [6]
Breast surgery per 100 000 inhab	42.5	155.0	106.1	33.5	Eurostat [4]
Output variables					
DALYcv BC**	71.1	75.5	73.3	1.3	WHO/Eurostat [7,8]
RSSy BC***	66.7	86.1	79.5	5.8	Sant et al. [9]

Table 2. Lung cancer: Descriptive statistics on input and output variables, 2015

	Min	Max	Mean	SD	Source
Input variables					
Oncologists per 100 000 inhab	1.3	7.3	3.4	1.2	Eurostat [4]
Radiation units per 100 000 inhab	0.5	1.3	0.8	0.3	Eurostat [4]
Cancer drugs (drug exp/cap)	6.1	60.5	30.3	16.8	Jönsson et al [5]
DDD/case LC	3.0	56.0	25.4	12.9	Jönsson et al [6]
Inpatient days LC per 100 000 inhab	574	2,319	1,121	501.9	Eurostat [4]
Pulmectomy per 100 000 inhab	0.7	38.2	14.9	7.3	Eurostat [4]
Output variables					
DALYcv LC**	57.4	72.8	67.9	3.2	WHO/Eurostat [7,8]
RS5 LC***	9.0	16.7	12.6	2.2	Francisci et al. [10]

References:

[1] Ferlay, J. et al, Cancer incidence and mortality patterns in Europe: estimates for 40 countries in 2012, Eur J Cancer, 2013 49(6) **[2]** Shepard, R.W. Cost and production functions. 1953: Princeton University Press **[3]** Eurostat, Cancer statistics — specific cancers. 2017 **[4]** Eurostat, Cancer statistics, 2017 **[5]** Jönsson, B et al, The cost and burden of cancer in the European Union 1995-2014. Eur J Cancer, 2016 **[6]** Jönsson, B et al Comparator report on patient access to cancer medicines in Europe revisited, IHE report 2016:4 **[7]** WHO. DALY estimates 2000-2015. 2017 **[8]** Eurostat, Mortality and life expectancy statistics. 2017 **[9]** Sant , M et al, Survival of women with cancers of breast and genital organs in Europe 1999-2007. Results from EUROCARE-5 study, Eur J Cancer, 2015.51(15) **[10]** Francisci, S et al, Survival patterns in lung and pleural cancer in Europe 1999-2007. Results from EUROCARE-5 study, Eur J Cancer, 2015.51(15)

OBJECTIVE

The objective is to measure the efficiency and productivity of breast and lung cancer care in Europe during the 2005 to 2015 period. The goal is to identify best practice to inform future policy decisions.

RESULT

The data displays differences in both inputs and outputs between countries and over time, and this is reflected in the performance measures. The frontier analysis provides efficiency scores that separate countries in groups of efficient and inefficient countries. The 2015 efficiency analysis in **breast cancer** identified six efficient countries out of the 17 included with a mean inefficiency of 0.88 and a minimum of 0.65, i.e. the same outcome could have been produced with 65 % of the inputs used. In **lung cancer** five countries were found to be efficient with a mean inefficiency of 0.81 and a minimum of 0.54. The result shows a diminishing marginal rate of return, which indicates that the first euros spent on health care yield higher returns than the last. For some resource intensive countries this is reflected in lower efficiency scores.

On average the productivity analysis demonstrates decreasing productivity, increasing efficiency, and decreasing technical change over the 2005/2010 and 2010/2015 periods. Again, the explanation is that the significant increase in resource use over time does not lead to a proportional improvement in outcome (output), see *Figure 3* and *4*.

A limitation of this study is its dependency on limited official EU-level data. More detailed data on resource use and health outcomes would improve the precision of the analysis and increase the value to inform future policy decisions related to efficiency and productivity. This macro analysis should be complemented by more granular analysis of processes of care, which is outside the scope of this study.

Figure 3. Breast cancer - Using more input does not proportionally increase output—Declining marginal rate of return both between countries and over time

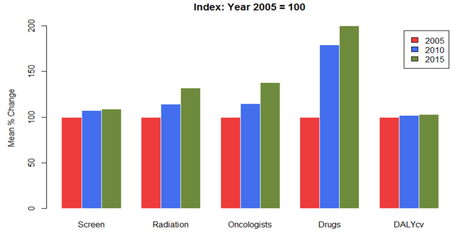
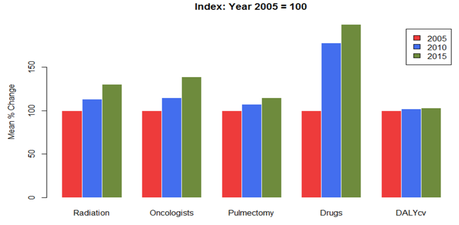


Figure 4. Lung cancer - Using more input does not proportionally increase output—Declining marginal rate of return both between countries and over time



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