Journal of Business Research 69 (2016) 5507–5511

Contents lists available at ScienceDirect

Journal of Business Research

# Management and performance features of cancer centers in Europe: A fuzzy-set analysis☆

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ARTICLE INFO

*Article history:*
Received 1 January 2016
Received in revised form 1 March 2016
Accepted 1 April 2016
Available online 24 May 2016

*Keywords:*
Comparative qualitative analysis
Cancer centers
Financial performance

ABSTRACT

The specific aim of this study is to identify the performance features of cancer centers in the European Union by using a fuzzy-set qualitative comparative analysis (fsQCA). The fsQCA method represents cases (cancer centers) as a combination of explanatory and outcome conditions. This study uses data on seven centers from a European benchmarking project: BENCH-CAN. The fsQCA uses the net income and productivity as the outcome conditions and five explanatory conditions: the level of dedication to R&D, annual budget level, size, type, and whether the center is a comprehensive cancer center. Despite the modest number of cases, the study successfully applies the fsQCA. The findings show that public, comprehensive cancer centers with at least two of the three other explanatory conditions (dedication to R&D, annual budget, or size) have an association with high net income and high productivity.



## 1. Introduction

With a mortality rate in Europe of 1.75 million in 2012, cancer became the second leading cause of death (Ferlay et al., 2013). Therefore, this disease has an important effect on the healthcare system. The research by Aggarwal and Sullivan (2014) shows that in high-income countries the cost of delivering high quality, equitable care is outstripping the present social budgets. Cancer centers are essential actors in the delivery of care in various countries. They are important for scientific discovery and for advancing excellence in cancer care (Simone, 2002). But, society forces cancer centers to provide a high productivity level at lower costs to cope with increasing demand. Across all disciplines, healthcare is becoming more complex, leading to quality and performance challenges (Plsek & Greenhalgh, 2001). Further, society calls for transparency on the relative performance between and within healthcare organizations (Leape et al., 2009). A variety of features both internal and external to a center, such as available resources, level of professional training, and size (Merkow, Chung, Paruch, Bentrem, & Bilimoria, 2014), are possible explanatory conditions for high performance.

Benchmarking is a common and effective method for measuring and analyzing performance in order to identify areas of improvement. Van Lent, de Beer, and van Harten (2010) define benchmarking as "the search for and implementation of best practices" (pp. 253). Their research shows that benchmarking can produce relevant input to improve the operational management of specialty hospitals such as cancer centers.

One method to identify the importance of quantitative performance features and how they relate to outcomes is the fuzzy-set qualitative comparative analysis (fsQCA). This method provides a systematic, transparent, and exhaustive analytical approach in the realm of comparative research (Ragin, 2000). The method essentially uses a qualitative comparative analysis (QCA) for the identification of patterns that hold across the sample of cases (Fiss, 2007; Rihoux & Ragin, 2009) and is becoming increasingly common in organization and management science (Wagemann, Buche, & Siewert, 2016). In contrast to other quantitative methods, such as a regression analysis, fsQCA can use small sample sizes (5–50 cases) (Fiss, 2012). Several examples of studies with ten or fewer cases exist in which fsQCA provides valuable insights (Stokke, 2007; Magnier-Watanabe & Senoo, 2008) and in which statistical tests would be unreliable. Few examples exist of the application of fsQCA within health research (Warren, Wistow, & Bambra, 2013).

☆ This article received funding from FEDER through Programa Operacional Factores de Competitividade — COMPETE and the National Funds through FCT — Fundação para a Ciência e a Tecnologia within CINTESIS (UID/IC/4255/2013), the R&D Unit and ADVANCE (Project UID/SOC/04521/2013), and the CHAFEA (Consumers, Health, Agriculture and Food Executive Agency) through the BENCH-CAN project (2012 12 11 – BENCH-CAN).

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http://dx.doi.org/10.1016/j.jbusres.2016.04.162
0148-2963/

This study explores the use of the fsCQA to investigate the association between preselected explanatory conditions and financial performance outcomes (net income, the profit per discharge; and productivity, the total number of patient visits divided by the number of inpatient beds) that use data from the BENCH-CAN project (2016). BENCH-CAN is an international project that aims to benchmark comprehensive cancer care and yield examples of good practices in a way that contributes to improving the quality of interdisciplinary patient treatment. Following Merkow et al. (2014) and Delgado (2008), this study hypothesizes that a large budget, substantial size, and a significant involvement in research and development (R&D) are important conditions for highly productive and financially sound and profitable centers. Thus, this study tests the following proposition: a highly productive center has large profits if the center has a high budget, is large, and focuses primarily on R&D. Following this introduction, Section 2 contains the theoretical framework. Section 3 describes the data used and analyses performed. Section 4 presents the findings. Section 5 offers discussions with limitations and Section 6 the conclusion.

## 2. Performance measurement

### 2.1. Healthcare management and benchmarking

Since 1934 when the University of Chicago first offered its seminal program in hospital administration, both the private and public healthcare sectors have established themselves as a specific field of applied management. In fact, this field combines a multidisciplinary approach by demanding skills in leadership, policy, management, finance, and social service delivery that manifest themselves through several distinctive factors: strong information asymmetry; lack of integration; high uncertainty regarding outcomes; highly complex organizations; and specificity in measuring production through financing rules, leadership sources, types of outcomes, and stakeholders' conflicting expectations (Costa, 2008). Some phenomena are at the heart of healthcare managers' concerns today, such as “how to measure and control costs,” “how to innovate” or “how to best deliver innovation,” “how to finance,” or “how to sustain profitability” (Requart, 2015; Devine, O'Clock, & Lyons, 2000). Different studies show that specialty hospitals such as cancer centers might have a financial advantage over general hospitals because they can recap the benefits of profitable services without having to cross-subsidize unprofitable services (Schneider et al., 2007; Choudhry, Choudhry, & Brennan, 2005). However, this financial advantage is only true when all cancer services are profitable, which is not always the case. The innovative financing of cancer care, for example, through comprehensive cancer centers, can drive efforts toward universal health coverage (Gospodarowicz, Trypuc, D'Cruz, Khader, & Knaul, 2015).

A well-known management saying claims that “what is not measured cannot be managed or improved” (Kaplan & Porter, 2011). Thus, benchmarking is a useful technique for establishing patterns, measuring performance, and performing a comparative analysis (Gonzalez-Padron, Akdeniz, & Calantone, 2014). Although many studies examine the healthcare industry, Nogueira, Lira, Albuquerque, and Linhares (2015) show that these studies are insufficient to evaluate a hospital's financial performance, hence the need for more research. The settings of healthcare organizations cause the insufficient nature of these studies. These organizations often involve developing teaching and research while providing complex health services that require humane and integral care in an imposing technological, financial, legal, and ethical environment.

### 2.2. The fuzzy-set qualitative comparative analysis

Since Ragin (1987), the QCA has evolved into a robust and valuable alternative method to rather traditional statistical approaches (Ragin, 2008; Woodside, 2013). The QCA uses set theory and Boolean algebra where the variables define the conditions, a condition or a combination of conditions defines a set, and cases are members of the sets if they have any of the conditions. To compare sets, the QCA uses a minimization algorithm and the causality between explanatory and outcome conditions in terms of necessity and sufficiency.

In the early stages, the research used the crisp-set theory to build a QCA. In a crisp set, cases can be either members or non-members (1 or 0). More recently, the research has developed the fsQCA as an alternative to the crisp set. In this approach, cases have membership degrees (a value between 0 and 1), that is, cases can be partially in a set. This new approach represents a qualitative enhancement of the method by allowing better adjustment to the real data, an issue that would otherwise arise when dichotomizing variables that are continuous in nature (Ragin, 2000).

A study by the Agency for Healthcare Research and Quality (Thygeson, Peikes, & Zutshi, 2013) that evaluates the patient-centered medical home (PCMH) model shows that the fsQCA is a powerful approach for studying PCMHs and other health services (Thygeson et al., 2012; Kahwati et al., 2011). The fsQCA assumes that many pathways can lead to the same outcome, equifinality (Ragin, 2008; Fiss, 2011). Second, the fsQCA assumes that each pathway can contain different combinations of explanatory characteristics (Thygeson et al., 2013). Third, if the analysis can link the presence of a combination of conditions to the presence of an outcome, then the absence of the combination does not necessarily lead to the absence of the outcome, the so-called asymmetric causality (Fiss, 2011). In sum, rather than quantifying the effect of a variable in the outcome, this method detects which combinations of conditions have a positive association with the outcome and which have a negative effect (Woodside, 2013).

## 3. Material and methods

### 3.1. Data

The study uses data from seven cancer centers in Europe regarding seven variables (Prod — level of productivity; Income — net income; RD — level of dedication to R&D; Budget — annual budget; Size — size of center based on the number of beds; CCC — comprehensive cancer center; and Public — public center. The data comes from a European benchmarking project (BENCH-CAN). The centers within this project were selected through convenience sampling of three geographical regions within the European Union (North-Western, Southern, East-Central). Centers are represented by capital letters to ensure that they remain anonymous.

### 3.2. Outcome conditions

The outcome conditions considered to assess the financial performance of centers are: Income — net income measured as the profit per discharge (inpatients and daycare patients), and Prod — productivity measured as the total number of patient (inpatients, daycare, and outpatients) visits divided by the number of inpatient beds.

### 3.3. Explanatory conditions

The study uses five explanatory conditions (R&D, Budget, Size, Public, CCC) regarding the center's (i) level of dedication to R&D (percentage of new patients in clinical trials per annum); (ii) annual budget; (iii) size as measured by the number of inpatient beds; (iv) whether the center is public, non-profit, or private; and (v) whether the center is a CCC. A CCC is a cancer center that has a well-established combination of fundamental and translational cancer research and that has a sufficient portfolio of cancer care services that extend along the total care pathway. The CCCs in this study receive their accreditation from the Organisation of European Cancer Institutes (OECI) Accreditation and Designation program, (Saghatchian et al., 2014).

### 3.4. Analysis

The fsQCA tests whether the empirical data supports a relation between the explanatory and the outcome conditions. Given that the set theory is the basis for the QCA, the analysis compares subsets and super sets. A set is a combination of conditions (conditional pattern), and cases (cancer centers) are members of a set if they present that conditional pattern. When a condition is dichotomous (e.g., CCC and Public), this condition defines its membership or non-membership. However, the study uses the fuzzy-set calibration to set membership when the conditions are continuous variables. The fsQCA allows partial membership of cases in a set based on three anchor values (percentiles 0.95, 0.5, and 0.05): full membership equal to 0.95 or higher, a crossover point of maximum ambiguity equal to 0.5, and full non-membership equal to 0.05 or lower. Cases on different sides of the crossover point are qualitatively different, while cases with differing memberships on the same side of the crossover point differ in degree (Ragin, 2008). Table 1 depicts the sample after the calibration. In the data, a high score in Budget indicates a high degree of membership in the set defined by a high annual budget. The symbol "~" prior to the condition's name indicates the negation of a condition. In this case the absence of a high annual budget means the presence of a low annual budget.

This study uses consistency and coverage metrics to assess the necessity and sufficiency analyses (Ragin, 2000). Under the fsQCA approach, condition A is necessary to outcome Y if in each case the degree of membership in Y is consistently less than or equal to the degree of membership in A ($Y \leq A$). Condition A is sufficient to Y if across all cases the degree of membership in condition A is consistently less than or equal to the degree of membership in Y (Legewie, 2013).

The sufficiency analysis constructs a truth table that lists all possible conditional patterns and the respective number of empirical cases (in our case $2^5 = 32$ patterns are possible). The conditional patterns in the truth table are then subject to a minimization algorithm that simplifies the patterns into sufficient solutions. These analyses identify both the presence and the absence of outcomes (Income, ~Income, Prod, ~Prod) in order to address asymmetric causality.

The simplification process yields different solutions depending on the logical remainders (conditional patterns that do not have empirical cases). When limited variability exists in the sample and when many of the conditional configurations (rows in a truth table) are logical remainders, then the research recommends a counter-factual analysis based on theoretic knowledge about the relation between the conditions and the outcome (Ragin, 2008). This study implements the counter-factual analysis by following Fiss (2011). His approach provides a way to identify core and peripheral conditions using the parsimonious and intermediate solutions of the minimization algorithm. Fiss (2011) states that "core elements are those causal conditions for which the evidence indicates a strong causal relationship with the outcome of interest and peripheral elements are those for which the evidence for causal relationship with the outcome is weaker." For better transparency and reproducibility of the results, the current study can supply, on request, the truth table and sufficiency analysis output table. All analyses use the fsQCA 2.5 software (Ragin & Davey, 2009).

## 4. Findings

Tables 2 and 3 show that of the five explanatory conditions, being CCC and Public are necessary conditions for both outcomes (high net income and high productivity). These conditions are necessary because they meet the recommended thresholds of consistency (≥0.9) and coverage (≥0.5) (Ragin, 2008; Legewie, 2013).

Table 4 shows the results from the sufficiency analysis for high net income and low net income, and Table 5 shows the results for high productivity and low productivity. For each solution, the study presents the centers with a given causal pattern. The study also presents the individual and overall consistency and coverage metrics. According to Ragin (2008), overall consistency scores of at least 0.8 are acceptable.

The results show that three alternative causal patterns exist for centers with a high net income and high productivity. These patterns indicate that Public and CCC with a high level of at least two of the explanatory conditions, dedication to R&D, annual budget, or size, tend to have high net income (Income) and high productivity (Prod) (Tables 4 and 5 show the configurations for high performance). However, the conditional pattern that combines a high level of dedication to R&D with a high annual budget (solution 3 in Table 5) covers more empirical cases (raw coverage 0.50). Centers A, F, and G most consistently show this conditional pattern. These two models have an overall consistency above 0.8, which is acceptable.

Analysis on the negation of outcomes shows three alternative conditional patterns that associate centers with low net income and two alternative causal patterns that lead to low productivity. Either low dedication to R&D or a low budget is a core condition for low performance. Each solution covers only one empirical case. The overall consistency of the negation models shows a consistency that is close to the acceptable threshold.

## 5. Discussion

This exploratory study successfully applies the fsQCA (which was so far limitedly applied in healthcare research) to study the association between five explanatory conditions and two financial performance outcomes in a healthcare context. Of the five necessary conditions, this study finds that being a CCC and a public center are necessary for both high income and high productivity when in combination with at least two of the three other possible explanatory conditions (dedication to R&D, annual budget, or size).

However, because almost all of the empirical cases in this study are public and comprehensive cancer centers, a possible argument might be whether this relation will hold true when including more private centers that are not CCCs. The literature suggests that CCCs are usually able to focus efforts and organize resources for the efficient and interactive accomplishment of the goals in patient care and research (Simone,

**Table 1**
Summary table of membership scores (after implementation of calibration).

| Center | Outcome measures | Causal conditions | | | | | |
|---|---|---|---|---|---|---|---|
| | Prod | Income | RD | Budget | Size | CCC | Public |
| A | 0.51[a] | 0.51[a] | 0.98 | 0.75 | 0.1 | 1 | 1 |
| B | 0.81 | 0.64 | 0.43 | 0.98 | 0.51[a] | 1 | 1 |
| C | 0.04 | 0.03 | 0.07 | 0.06 | 0.64 | 1 | 0 |
| D | 0.96 | 0.78 | 0.51[a] | 0.04 | 0.63 | 1 | 1 |
| E | 0.08 | 0.11 | 0.04 | 0.19 | 0.98 | 0 | 1 |
| F | 0.36 | 0.98 | 0.73 | 0.51 | 0.05 | 1 | 1 |
| G | 0.94 | 0.26 | 0.72 | 0.51[a] | 0.05 | 1 | 1 |

[a] The table uses a score of 0.51 instead of 0.5 in order to avoid scores of maximum ambiguity that reduce the number of cases that define conditional patterns.

**Table 2**
Analysis of necessary conditions for the outcomes for high net income and low net income.

| Outcome measure | Income | | ~Income | |
|---|---|---|---|---|
| | Consistency | Coverage | Consistency | Coverage |
| CCC | 0.97 | 0.53 | 0.76 | 0.47 |
| ~CCC | 0.03 | 0.11 | 0.24 | 0.89 |
| Public | 0.99 | 0.55 | 0.74 | 0.45 |
| ~Public | 0.01 | 0.03 | 0.26 | 0.97 |
| RD | 0.76 | 0.72 | 0.52 | 0.55 |
| ~RD | 0.53 | 0.50 | 0.74 | 0.77 |
| Budget | 0.63 | 0.69 | 0.45 | 0.55 |
| ~Budget | 0.59 | 0.49 | 0.75 | 0.69 |
| Size | 0.45 | 0.50 | 0.62 | 0.77 |
| ~Size | 0.79 | 0.65 | 0.60 | 0.55 |

**Table 3**
Analysis of necessary conditions for the outcomes for high productivity and low productivity.

| Outcome measure | Prod | | ~Prod | |
|---|---|---|---|---|
| | Consistency | Coverage | Consistency | Coverage |
| CCC | 0.98 | 0.60 | 0.72 | 0.40 |
| ~CCC | 0.02 | 0.08 | 0.28 | 0.92 |
| Public | 0.99 | 0.61 | 0.71 | 0.39 |
| ~Public | 0.01 | 0.04 | 0.29 | 0.96 |
| RD | 0.71 | 0.75 | 0.46 | 0.44 |
| ~RD | 0.47 | 0.50 | 0.74 | 0.69 |
| Budget | 0.64 | 0.77 | 0.47 | 0.51 |
| ~Budget | 0.59 | 0.56 | 0.79 | 0.66 |
| Size | 0.39 | 0.49 | 0.60 | 0.67 |
| ~Size | 0.74 | 0.68 | 0.55 | 0.45 |

2002). According to Simone (2002), cancer centers enable and catalyze a high level of cancer-focused achievement that would not happen without such a formal organization of staff and programs. Merkow et al. (2014) show that NCI (National Cancer Institute) accredited cancer centers provide more efficient care and that accredited centers offer more structural resources. Further, the NCI accreditation program is the basis for the OECI accreditation and designation program by which CCCs become accredited (van Harten, 2014).

Further examination of the results shows that three alternate causal patterns exist that associate centers with high performance. These patterns indicate that Public and CCC in combination with a high level of at least two explanatory conditions, dedication to R&D, annual budget, or size, tend to have high net income and high productivity. Providing cancer care is expensive. With the fast increase in the costs of medical technologies and cancer drugs (Aggarwal, Ginsburg, & Fojo, 2014), achieving a high net income and high productivity become far more relevant aims. The research by Delgado (2008) supports the finding that size could be an explanatory condition by showing that larger cancer centers have better financial performance than smaller centers. However, research by Litvak and Bisognano (2011) shows that having more beds does not necessarily make a hospital more efficient. The results indicate that having fewer beds has no association with low performance. However, a lack of dedication to R&D and a low budget do dictate low performance.

**Table 4**
Configurations of causal conditions for high and low net income including the individual and overall consistency.

| | Configurations for high net income (Income) | Configurations for low net income (~Income) | | | | |
|---|---|---|---|---|---|---|
| Configuration | 1 | 2 | 3 | 1 | 2 | 3 |
| Centers | B | D | A, F, G | E | C | B |
| Causal conditions | | | | | | |
| RD | | + | + | −− | −− | −− |
| Budget | + | | + | − | − | |
| Size | + | + | | | | |
| CCC | ++ | ++ | ++ | | + | + |
| Public | ++ | ++ | ++ | + | | + |
| Consistency | 1.00 | 1.00 | 0.78 | 0.72 | 0.74 | 0.55 |
| Raw coverage | 0.23 | 0.34 | 0.53 | 0.37 | 0.40 | 0.24 |
| Unique coverage | 0.02 | 0.14 | 0.33 | 0.22 | 0.25 | 0.09 |
| Overall solution consistency: | 0.82 | | | 0.78 | | |
| Overall solution coverage: | 0.69 | | | 0.72 | | |

Note: Columns display a conditional pattern for the intermediate result (solution). For each pattern, the table depicts the core conditions with large-size symbols and the peripheral conditions with small-size symbols. A plus symbol (+) indicates that the solution includes the presence of the explanatory condition, while a minus symbol (−) indicates that the solution includes the negation of the explanatory condition. Double + or − represent core conditions, and single + and − indicate peripheral conditions. Blank cells indicate that the explanatory condition is not in the conditional pattern of a solution, that is, its presence or absence is irrelevant for the outcome when associated with that solution.

**Table 5**
Configurations of causal conditions for high and low productivity.

| | Configurations for high productivity (Prod) | Configurations for low productivity (~Prod) | | | |
|---|---|---|---|---|---|
| Configuration | 1 | 2 | 3 | 1 | 2 |
| Centers | B | D | A, F, G | E | C |
| Causal conditions | | | | | |
| RD | | + | + | −− | −− |
| Budget | + | | + | −− | −− |
| Size | + | + | | | |
| CCC | ++ | ++ | ++ | − | + |
| Public | ++ | ++ | ++ | + | − |
| Consistency | 1.00 | 1.00 | 0.83 | 1.00 | 1.00 |
| Raw coverage | 0.20 | 0.31 | 0.50 | 0.25 | 0.28 |
| Unique coverage | 0.02 | 0.13 | 0.32 | 0.25 | 0.28 |
| Overall solution consistency: | 0.86 | | 1.00 | | |
| Overall solution coverage: | 0.65 | | 0.53 | | |

Note: Columns display a conditional pattern for the intermediate result (solution). For each pattern, the table depicts the core conditions with large-size symbols and the peripheral conditions with small-size symbols. A plus symbol (+) indicates that the solution includes the presence of the explanatory condition, while a minus symbol (−) indicates that the solution includes the negation of the explanatory condition. Double + or − represent core conditions, and single + and − indicate peripheral conditions. Blank cells indicate that the explanatory condition is not in the conditional pattern of a solution, that is, its presence or absence is irrelevant for the outcome when associated with that solution.

The causal pattern that combines the presence of a high level of dedication to R&D and a high annual budget is a more common solution within the analysis. The fact that centers A, F, and G most consistently have this conditional pattern is interesting because these three centers are in three different geographic regions (Western Europe, Northern Europe and Southern Europe). Although the correct terminology for fsQCA is to speak about causal patterns, some cases such as the patterns with a high level of involvement in R&D might better reflect a relational pattern. If a center receives a lot of money from, for example, the government to perform R&D activities, then a relational pattern exists. If a positive relation exists between R&D and the desired outcomes, then that relation is an extension of the relation between internal innovation and external innovation (Hidalgo & D'Alvano, 2014). Organizations that pursue R&D in healthcare can in fact have a positive effect on the care that organization provides to patients. The results of this study support that the presence of these conditions relates to the presence of high (financial) performance, while their absence relates to low (financial) performance. Therefore, these conditions appear to be critical factors for (financial) performance.

This study has several limitations. First, the small sample of centers leads to a lack of variability in some causal conditions. Most of the cancer centers are public with comprehensive care. Although the fsQCA is conducive to small samples like this one, the lack of variability affects the association of the presence of these conditions with the conditional pattern for both the presence and absence of the two outcome conditions (high net income and high productivity). Second, the study uses a limited number of medical conditions that is arbitrary (however based on logical thinking that might convey a possible bias). Including more conditions and more cases could lead to a better understanding of what actually makes these cancer centers (financially) perform so highly. The research by Delgado (2008) shows that significant evidence exists that points to high productivity as a causal condition for high financial performance, which this study does not address. Future research should take this evidence into account. Despite the limitations, this study shows that the fsQCA is a promising method to measure the performance in healthcare and more specifically in health service research. Due to its young age, the fsQCA is still under development and improvement, but the launch of new software packages and innovative forms of graphical representation constantly improves the possibilities for its application.

## 6. Conclusion

This study shows that the fsQCA is a powerful approach for health service research despite the method's limited use. The study provides a new avenue of research in healthcare services management through the use of this novel technique. From a managerial and healthcare organizational point of view, this study shows that centers that are public and that offer comprehensive cancer care have both a high income and a high productivity. Second, these centers show a high level of dedication to R&D and have a high annual budget. Some of these variables are likely to be actionable from the point of view of the hospital's management or from the perspective of the healthcare system — so the possible choices that exist for these variables could enable better performance for healthcare providers.

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