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Metabolism of public organizations: A case study

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Abstract.
This study suggests the concept of Metabolism of organization that explains how public organizations use and/or transform inputs (mainly public funding) to produce and supply products and services. This approach is useful for analyzing costs and supporting best practices of management to increase efficiency of organizations. An application of this approach is showed on one of the largest public research organizations in Europe. Results indicate, from 1997 to 2015 period, that the cost of personnel has a very high growth rate (167.87), total cost of CNR has a high one (127.44), whereas total revenue (state subsidy) has a lower growth rate:118.72. This result suggests an imbalance of growth rates between dynamics of total revenue and vital costs within this PRO, generating economic issues and inefficiencies for this organization in the long run. R&D management implications conclude this study.
Keywords. Research organizations, R&D funding, Cost management, Cost analysis, Budget system, Metabolism.
JEL. N30, O30, O31, I23.

1. Introduction

The concept of metabolism, in a broad analogy, can be applied from biology to management to analyze processes running from inputs to outputs in organizations and explain how public organizations use economic resources provided by governments to produce/supply outputs and services in society for a cost analysis. The concept of metabolism is uncommon in the studies of management and a brief background is useful to clarify it (Coccia, 2018). In biology, metabolism indicates chemical processes that, in a living organism, transform food and drink into energy. The concept of metabolism in a context of Generalized Darwinism can explain how complex systems –e.g., organizations–function and behave (cf., Hodgson, 2002; Hodgson & Knudsen, 2006). Metabolismhas a vast use in several disciplines, such as industrial ecology, urban geography, economic geography, ecological economics, etc. (Kennedy *et al.*, 2007). Metabolism of public organizationsis a new approach for analyzing the use of inputs (e.g., public funding) to support production, operations and survival of these organizations in markets. This approachcan also detect organizational problems for designing best practices ofpublic management

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directed to control and improveallocation of public funding and other inputs for increasing the efficiency of public organizationsthemselves (Coccia, 2018). In particular, this approach considers public organizations as complex systems of economic and human resources (inputs), and production processes directed to produce/supply products and services in society. For instance, a public organization is research institution that combines economic and human resources to generate innovative outputs and new knowledge (cf., Coccia, 2001, p.454; Coccia, 2018)[1]. Next section presents a theoretical framework of this new approach for cost analysis of public organizations.

2. Theoretical framework of themetabolism of public organizations

For the sake of clarity, this section describes the approach for a specific public organization given by Public Research Organizations (PROs). Of course, the approach can be generalized for all typologies of public organizations. The concept of metabolism in public research organizations (PROs) has the goal toexplain*how* these complex systems use and transform inputs (e.g.,public funds) to manage labs, produce and supply scientific and innovative outputsin society (e.g., scientific research and knowledge, inventions and technological innovations;within national system of innovation; cf., Coccia, 2001; 2005, 2012)[2]. In particular, the concept of metabolism, applied in public management, considers PRO as a complex system with (Coccia, 2001, 2008; Coccia *et al.*, 2015; cf., Brown & Svenson, 1998):

1. *Inputs:* human resources, equipment, public funding for research, etc.
2. *Production process* transforms inputs into outputs in labs.
3. *Outputs*: publications, software, patents, innovative outputs, etc.

The system of public research organizations is represented in Figure 1 with a linear model of metabolism.

[1] Coccia, 2001, 2005, 2008, 2009, 2010, 2010a, 2010b, 2010c, 2011, 2012, 2014, 2014a, 2014b, 2014c, 2014d, 2015, 2015a, 2017, 2017a, 2018, 2018b, 2018c, 2018d, Coccia & Benati, 2018; Coccia & Bellitto, 2018; Coccia & Cadario, 2014; Coccia & Rolfo, 2009, 2010, 2013: Coccia *et al.*, 2015.

[2] cf., Coccia, 2005a, 2015b, 2016, 2017b, 2018e, 2018f

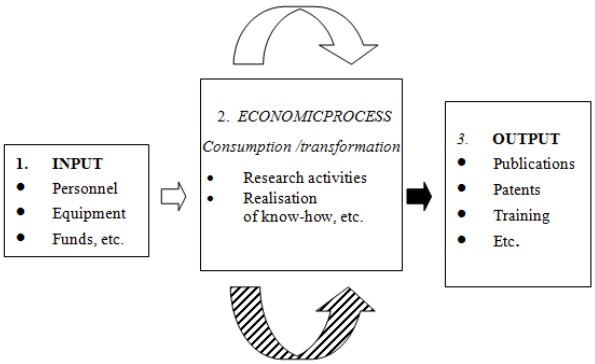

Figure1. *A linear model of the metabolism ofpublic research organizations (PROs)*

This approach can identify howpublic funding for research is used within public research organizations to analyze possible causes of organizational efficiency orinefficiency. Especially, the approach of metabolism here can support managers to analyze costs and design appropriate R&D management strategies directed to increase efficiencyand productivity of public research labs in the presence of scarce economic resources (Coccia, 2005, 2011, 2012).

- Firstly, the preliminary analysis of the metabolism of public organizations is given by descriptive statistics, trends and bar graphs that represent the arithmetic mean of variables on *y*-axis and inputs (public funding, etc.) on *x*-axis.

- Secondly, the coefficient M_{it} (Metabolism *t*) explains the dynamics of the metabolism of public organization *i* for a critical input measured in $ or € for international comparisons (or local currency for domestic comparisons) and related to a source of funding. M_{it} for a public organization *i* is given by:

$$M_{it}=\left(\frac{cost\ of\ input}{revenue}\ \%\right)_t \qquad (1)$$

For instance, considering the cost of personnel in PRO*i*

$$M_{it}=\left(\frac{cost\ of\ personnel}{State\ \ subsidy}\ \%\right)_t \qquad t=time \qquad (2)$$

In particular, Eq. [2] indicates the proportion of cost of input on total revenue, a main indicator of the consumption of public fundsin PROs over time. Similar coefficients can be calculated for other inputs divided by revenueof PROs.

- Thirdly, another coefficient of this approach is the rate of arithmetic growth of main organizational variables, such as revenue (based on state subsidy and public contracts), cost of personnel and total cost. In particular, if the level of these organizational variables at beginning is P_a and at the end of the period is P_t, and the period of time is equal to *t* ($P_a - P_t$=*t* period),

the rate of arithmetic growth r_a of organizational variables under study is given by:

$$P_t = P_0 + P_0(r_a \cdot t)$$

$$P_t - P_0 = P_0\, r_a \cdot t$$

and hence

$$r_a = \frac{P_t - P_0}{P_0 \cdot t} = \text{rate of arithmetic growth} \qquad (3)$$

3. Application of the metabolism of public organizations: a case study of a large public research body in Europe

An application of theapproach of metabolism ofpublic organizations is on the biggest public research body in Italy: The National Research Council of Italy or Consiglio Nazionale delle Ricerche (in short, CNR) that has an organizational behavior similar to other research institutions in Europe, such as CNRS in France, CSIC in Spain, etc. (Coccia, 2014; Coccia & Rolfo, 2009, 2010, 2013; Coccia & Cadario, 2014). The sources of data are the annual financial statements of the CNR (Consiglio Nazionale delle Ricerche, 2016; Coccia, 2018a). Results of this approach of metabolism, based on data from income statement of the Italian National Research Council (CNR) over 1997-2015 period, are as follows. Figure 2 shows main components of cost of the CNR; the highest level of costwithin this PRO is given by the cost of personnel, followed by service, materials and products, leased assets of third parties. In particular, the cost of personnel is mainly based on salary and social security taxes. Therefore, the analysis here, considering this preliminary information, focuses on thecritical factor of the cost of personnel to assess the processes of metabolism within this public research organization under study, and as a consequence, its organizational and managerial behavior.

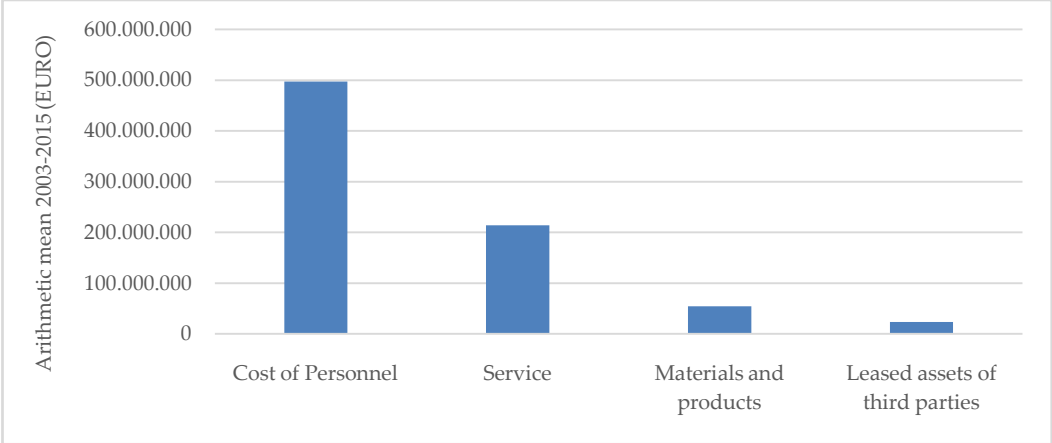

Figure 2. *Metabolism of the CNR organization: Arithmetic mean of main costs over time in €*

Figure 3 showsthat the proportion $M_t$of the cost of personnel on total revenue (eq. [2])is increasing over time; the analysis of metabolism revealsthat the cost of personnel on total revenue (state subsidy) within this PRO (i.e., CNR)is growing over time and in 2015 absorbs more than 65% of total revenue received by government.

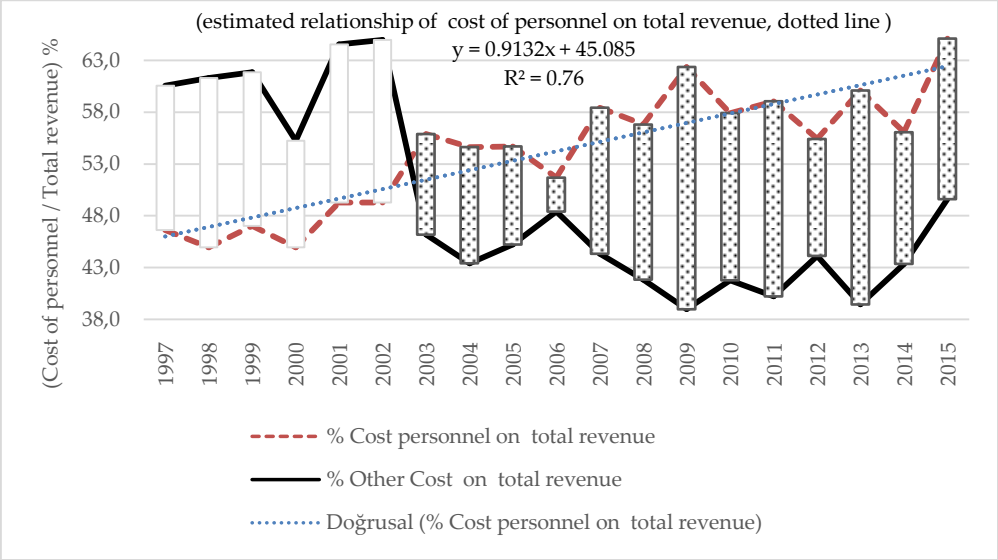

Figure 3. *Metabolism of the CNR organization: proportion of the cost of personnel (and other costs) on total revenue from 1997 to 2015*

Table 1 shows the growth rate of economicfactors of CNR based on eq. [3]. Results indicate, from 1997 to 2015 period, that the cost of personnel hasa very high growth rate (167.87), total cost of CNR hasa high one (127.44), whereas total revenue (state subsidy) has a lower growth rate:118.72. This result suggests an imbalanceof growth rates between dynamics of total revenue and vital costs within this PRO, generating economic issues for this organization in the long run.

Table 1. *Metabolism of the CNR organization: rate of arithmetic growth of some economicfactors from annual income statements (for data see Coccia, 2018a)*

Rate of arithmetic growth	Total revenue	Cost of personnel	Total cost
r_a (1997-2015)	118.72	167.87	127.44

To sum up, the analysis of this PROseems to reveal that the metabolism of this public research organization absorbs a substantial proportion of public funds (state subsidy and public contracts)to cover high cost of personnel over time. Overall, then, the approach of metabolism applied on this research institution suggests possible organizational inefficiencies, driven by high cost of personnel in the long run.

4. Conclusion and public management implications

The metabolism of public organization can reveal critical organizational and managerial issues, such as public research organization described

above absorbs a high share of the total revenue for the cost of personnel, generating economic problems and several organizational inefficiencies. This result is due to a public research system in Italy that has a rigid organization to cope with economic crises and public rules of budget balance that generate cuts of public funding from governments to research organizations (Coccia, 2018). This approach provides main information for public management of the PRO under study that has to control the growth of the cost of personnel in the presence of shrinking public research lab budgets to support efficiency and sustainability of this research body in the long run.

In general, the approach of metabolism, presented here, is critical to cost analysis and management within public organizations. In particular, this approach can support public management that, in the presence of budget cuts, can improve the allocation of resources and the efficiency of public organization by controlling specific costs, and by balancing the utilization of public funding between different costs to support the efficiency of overall public organizations. Moreover, if public organizationscannot reduce the high cost of personnel in order to increase general productivity, as well as they cannot offer substantial *extrinsic (financial) incentives* because of rigid scheme of salary and scarce public funds, then public management could increase *intrinsic rewards* to support motivation and performanceof public organizations (Belle & Cantarelli, 2015; Weibel *et al.*, 2010; cf., Ryan & Deci, 2000, 2000a; cf., Benati & Coccia, 2017, 2018). O'Reilly *et al.*, (1991) have suggested that intrinsic rewards may support job involvement and satisfaction of people in organizations. Specifically, intrinsic rewards may supportproductivity of personnelalso in the presence of budget cuts (cf., Frank & Lewis, 2004; Wright, 2007, p. 60). In this context, Crewson (1997, pp.503–4) argues that: "Intrinsic rewards are more important to public employees than to those employed in the private sector".

Hence, the approach of metabolism can be a useful managerial technique to analyze costs and design best practices of public management directed to support an efficient organizational and managerial behavior of public organizations in turbulent markets.

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