THE BEHAVIOURAL ADDITIONLITY DIMENSION IN INNOVATION POLICIES: A REVIEW

Davide Antonioli[♣] and Alberto Marzucchi[♦]

Abstract

The concept of additionality, when public interventions are considered, can be synthesised as the net effects that would not have occurred in the absence of the intervention of the public actor. The present paper reviews the body of literature dealing with the concept of additionality, devoting particular attention to its behavioural dimension (i.e. changes in beneficiaries' behaviours resulting from the policy intervention). In the first sections it is stressed that the behavioural additionality, though not yet clearly defined and still characterised by some drawbacks, complement the input and output dimensions of the concept of additionality and can be used to evaluate innovation policies according to the evolutionary and system perspectives. In the subsequent sections we present a review of the recent econometric and quantitative studies focused on the behavioural additionality in order to present a state of the art of the methods, with their limits and their strengthens, that can be used in this kind of evaluation.

Keywords: evaluation, additionality, innovation policy, behavioural additionality,

[♣] University of Ferrara
[♦] University of Trento, International Doctoral School in Local Development and Global Dynamics

"[…] less than perfect quantitative measures can be far better than none"

(Green *et al.,* 2001).

0. Introduction

Although evaluation of innovation policy is a very diverse research field that can cover a wide range of topics, impacts, purposes and employ different methodologies (Edler et al., 2010), in economic literature a large number of contributions have assessed the performances of public support schemes by making use of the concept of additionality. This concept allows the researcher to provide an objective and unbiased evaluation of the policy by focusing on the net effects that would not have occurred in absence of the public intervention. More precisely the additionality evaluation aims at providing a comparison between the actual effects on the beneficiaries with the counterfactual situation, which describes what would have occurred also in the absence of the public support.

The objective of the paper is to provide an updated review of the theoretical and empirical contributions dealing with the concept of additionality, here considered as a multidimensional notion. Following a recent strand of literature, initiated by Buisseret et al. (1995), the review is mostly focused on the behavioural additionality (i.e. changes in beneficiaries' behaviours resulting from the policy intervention), rather than on the more traditional input and output dimensions (i.e. respectively the proportion of innovative inputs that would not have been allocated without the intervention and the proportion of outputs that would not have been achieved without the policy). This type of work, which to our best knowledge has not been provided yet, tries to contribute to the existing literature in two ways. On the one hand it provides a theoretical guidance to future evaluations, by demonstrating that the concept of behavioural additionality, being consistent with the evolutionary and system perspectives, complements the input and output dimensions, which rely on neoclassical assumptions. On the other hand the paper aims at providing a picture of the state of the art of the methodologies that can be used to evaluate the behavioural additionality, presenting a review of the recent contributions that employ quantitative and econometric methodsThis is particularly relevant as until now these empirical approaches have been less extensively used to investigate the behavioural dimension than the input and the output ones (Georghiou, 2004).

The reminder of the paper is organised as follows. The first section provides a critical analysis of the input and output additionality that can be used, in a neoclassical perspective, to evaluate the ability of the policy to overcome the underinvestment in R&D and the underproduction of innovation generated by market failures. The second section begins with a brief overview of the evolutionary and system foundations of innovation policy. Then the analysis emphasises the fact

that the behavioural dimension, though sometimes vaguely and too broadly defined, can be used to evaluate innovation policies according to these heterodox perspectives. At the end of this section some criticalities and issues that might emerge in the use of the concept of behavioural additionality are presented. Particular attention is devoted to the analysis of possible synergies between the three dimensions of the additionality concept. The subsequent section is devoted to the assesmento of the empirical issues that works on behavioural additionality share with the evaluation literature. Then, the section proceed reviewinig the empirical studies and pointing out their main characteristics and results. Section four concludes.

1. Additionality in a neoclassical perspective: defining the input and output dimensions

Economic rationales of innovation policy determine not only the different objectives and means of the policy intervention but also the dimensions of the concept of additionality to be taken into consideration. In a neoclassical perspective the concern is on whether the policy has been able to overcome the underinvestment and underproduction of innovation. In this sense the focus has to be on the input and output additionality.

1.1 The market failures framework

Nelson (1959) and Arrow (1962) in their seminal works introduce the foundations for the innovation policy under a neoclassical perspective. Nelson (1959), stressing the fact that basic research activities are characterized by externalities and uncertainty, claims for a direct intervention of the government in order to overcome the private underinvestment in research. According to Arrow (1962), due to non-perfect appropriability, uncertainty, indivisibility and increasing returns, there is a systematic difference between private and public returns to innovation, here considered as information. Also in this case the result is an underinvestment in innovative activities with respect to the social optimum.

Following the neoclassical approach firms are seen as "optimising innovators" that, in order to maximise their profits, set their level of R&D investment, so that the present value of the marginal profitability of research equates the marginal cost of research (Metcalfe, 1995). However, due to market failures, this optimisation rule cannot lead to an investment in R&D equal to the social optimum. Within this perspective in order to correct the private incentive to innovate and, thus, to increase the level of investment in R&D policy can intervene in two ways: by lowering the cost of producing an increasing amount of new technological knowledge (e.g. with subsidies or tax incentives) or by increasing the revenues of this additional knowledge (e.g. with patents) (Felli,

2002).

However, it is important to stress that the neoclassical approach is not only concerned with the optimal level of investment in R&D. Due to the underlying linear relation between innovative inputs and outputs (Kline and Rosenberg, 1986) an underinvestment in R&D, caused by the presence of market failures, leads to an underproduction of innovation.

1.2 Input additionality

As emerged above a main objective of the neoclassical innovation policy is to provide incentives to overcome the underinvestment in R&D that is caused by market failures. With this respect the policy intervention is justified by the need to stimulate a certain amount of private investment in R&D in order to reach the social optimum. A first dimension of the additionality concept, the input additionality, is then identified. This is concerned with whether the resources provided to the firms are additional to those that would have allocated also in absence of the intervention; in other terms the focus is on the amount of resources and innovative inputs (i.e. R&D investment) that would not have been allocated without the policy (Georghiou, 2002; 2004; Clarysse et al. 2004). When the input additionality is the focus of the evaluation the objective of the analysis is to understand whether the policy has generated additional R&D expenditures or whether it has crowded-out the private investment in innovation; in its strict definition, input additionality emerges in cases in which the additional R&D investment activated by the policy is higher than the subsidy received[1] (Cerulli, 2010).

Despite the literature on the input additionality of R&D support schemes is mainly 'empirically-oriented' (David et al., 2000; Cerulli, 2010), at least three contributions (Usher, 1994; David et al., 2000; Hall and Maffioli, 2008) present interesting theoretical insights. Usher (1994) proposes a set of theoretical rules for policy interventions that can be considered as a test of "ideal incrementality" (Lipsey and Carlaw, 1998). Accordingly, the funded project must be the least costly way to undertake the desired level of R&D investment, social benefits must exceed the subsidy (including transaction costs, deadweight and other leakages) and discounted benefits must exceed the discounted cost of intervention. David et al. (2000) investigate the effect of the innovation policy by adopting a model in which the optimal level of private R&D investment is where the marginal rate of return (MRR) and the marginal cost of capital (MCC) are equalized. A direct R&D subsidy

[1] This perspective can face a practical limitation when the researcher does not have information about the precise amount of the subsidies received by the beneficiaries. In these cases, when only a binary treatment status is available, it is possible at most to estimate the amount of resources that would not have been allocated without the policy.

scheme, by relieving the recipients of some cost related to innovative activities, can have a positive and additional effect on the private level of R&D expenditure. However, innovation policy can also crowd-out private R&D investment, targeting technological areas that firms would anyhow found worthwhile. This results in a displacement of private funding with public ones[2]. Another theoretical analysis of the input additionality is proposed by Hall and Maffioli (2008). In their model each firm faces a downward sloping demand for R&D and a supply cost of R&D that is flat until the innovative projects are internally funded then jumps up to the cost of external funds and increases the more external funds are needed. A policy intervention[3] reduces the cost of financing and increases the internal funding availability resulting in a new optimal level of R&D investment that depends on the shape of the demand of R&D. The conclusion of the model is that crowding-out is a possibility for firms that rely on internal funds, but it is unlikely for those that are financially constrained, though in this latter case beneficiaries can always divert funds to other types (i.e. non-R&D) of investment.

Although the concept of input additionality is quite straightforward it presents strong limitations and criticalities. Bach and Matt (2005) refer to three cavalier assumptions upon which the estimation of the input additionality is based: the clear link between input and output of the innovation activities; the presence of divisibility and constant return to scale of the innovative activity; the fact that the nature of the outputs generated by public funds and private funds is the same. However, the main argument against the input additionality is related to the fact that this is simply focused on the effects of the policy on the allocation of resources, disregarding the impacts on the organisation, the behaviour of the beneficiaries and the acquisition of knowledge and capabilities, which are in fact at the core of the behavioural additionality evaluation.

1.2 Output additionality

As mentioned at the beginning of the section, due to the linear innovation model, market failures are expected to generate also an underproduction of innovation. Hence, innovation policy intervention is aimed also at increasing the amount of innovative outputs produced by private actors. In this sense a second dimension of the additionality concept emerges, the output additionality, which is focused on the proportion of outputs that would not have been achieved without the policy intervention (Georghiou, 2002; 2004; Georghiou and Clarysse, 2006). The fact that output

[2] For sake of simplicity the discussion of the model presented here is quite limited. David et al. (2000) refer to a much larger number of effects generated by policy interventions.

[3] Hall and Maffioli (2008) present two versions of the model, one for matching grants and another for tax credits.

additionality is consistent with the market failures framework is, in a sense, stated also by Lipsey and Carlaw (1998), who refer to the "narrow test of incrementality" as the test that has to be performed according to the neoclassical perspective. This is concerned with the extent to which some technology is actually developed or installed due to the intervention under consideration.

A first problem in the evaluation of output additionality is related to the definition of what outputs actually are. Innovation activities can have a number of different results[4], however it could be difficult to estimate a direct causal relation between the policy intervention and long-term or macro effects due to the difficulty to isolate these impacts from the general economic background "noise". In this sense it is better to focus on the microeconomic effects of the policy intervention (Buisseret et al. 1995). These can be the outputs of the supported projects (e.g. reports, papers, patents, prototypes, business plans) and their outcomes (e.g. improved business performances as resulting from the introduction of new products, processes, services) (Georghiou, 2002).

Apart from this issue, output additionality is afflicted at least by two main limitations. The first is that, almost by definition, this additionality dimension relies on the strict assumption that there is a clear linear link between inputs, allocated with the support of the policy funding, and outputs. This link is much more complex and unpredictable and needs to be investigated in depth, looking also at the internal behaviour of the supported organisations (Georghiou and Clarysse, 2006). In fact, as it will be shown below, this aspect is crucial in the behavioural additionality evaluation. The second limitation emerges when the evaluation of the output additionality is focused on formal outputs, as patents for example. This can be a serious problem when dealing with particular types of beneficiaries, as SMEs operating in traditional sectors, whose innovative activities rarely result in the production of formalized outputs. Particularly in these cases limiting the analysis to this kind of outputs rather than focusing on aspects more related to the upgrading and improvement of competences and strategies could lead to an incomplete evaluation of the policy.

2. Additionality in the evolutionary and system perspectives: the behavioural dimension

As the input and output dimensions of the additionality concept are consistent with the neoclassical approach, the behavioural dimension can be used to evaluate the additionality of the innovation policy under the evolutionary and system perspectives. In order to make explicit this point it is useful to introduce the evolutionary and systemic foundations to the innovation policy.

[4] For a review see Hse and Hsueh (2009)

2.1 Evolutionary and system foundations: the system failures framework

To introduce the main features of the evolutionary and system perspectives three aspects should be stressed. First, economic actors are seen as heterogeneous routine-based "behavioural innovators" that behave differently according to their specific competences and to their particular strategic, cognitive, and organizational aspects (Metcalfe, 1995). Second, the innovation process is characterized by the lack of linearity between innovative inputs and outputs; innovation is a highly uncertain process, characterized by trials and errors. The innovation process can be explained by a chain model, in which different phases, both internal and external to the firms, are complementary and interconnected also through feedbacks (Kline and Rosenberg, 1986). Third, according to the literature on the systems of innovation firms do not innovate in isolation but interacting and collaborating with other actors, both public and private. More precisely the constituents of a system of innovation are on the one hand the components (i.e. organisations and institutions)[5] and on the other hand the interactions among these[6] (Edquist, 2005).

The emergence of the evolutionary approach and the consequently related system framework has led to rethink the role of the policy intervention. Whereas according to the neoclassical framework public support has to promote individual innovation events by allocating in an efficient way resources to firms, according to the evolutionary and system perspectives policy should enhance innovation opportunities and capabilities and promote framework conditions in which innovation systems can better self-organize themselves (Metcalfe, 2005). Innovation policy is not simply justified by an under-supply, and underproduction, of knowledge and innovation, but by the presence of areas of 'systematically weak performances' (i.e. system failures) (Smith, 2000). Drawing on some recent contributions it is possible to identify a list of six possible system failures. These failures pertain to: *problems in learning processes and accumulation of capabilities* (Malerba, 2009), *unbalanced trade-offs between exploration and exploitation and between selection and variety* that can lead to problems in the transition processes or to lock-ins (Smith, 2000; Malerba, 2009), *weak institutional performances and settings* (Smith, 2000), *missing or inappropriate components* (Metcalfe, 2005; Malerba, 2009), *missing or inappropriate connections* (Metcalfe, 2005; Malerba, 2009), *problems in infrastructural provision and investment* (Smith, 2000).

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[5] "Organisations are formal structures with an explicit purpose and they are consciously created. They are players and actors" and "institutions are sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organisations" (Edquist and Johnson, 1997, p. 46-47)

[6] Edquist (2005) refers to market and non-market interactions as competition, transaction and networking.

2.2 Defining behavioural additionality

What emerges looking at the contributions dealing with the concept of behavioural additionality is that there is not a clear-cut definition. A first and simple way of dealing with this notion is basically to complement the linear and strict nature of input additionality (G□k and Edler, 2010) with questions related to the scale and the scope of the funded R&D projects (Lukkonen, 2007) or considering also the acceleration of the beneficiaries' innovative activities (Falk, 2007)[7]. The evaluation in these cases is concerned, respectively, on whether the funded project has increased the scale of the R&D activity of the beneficiaries in the chosen area, has expanded the coverage of their R&D activity to a wider range of applications and markets or has brought forward in time their R&D activity (Georghiou, 2002, 2004; Georghiou and Clarysse, 2006). As noted by G□k and Edler (2010) this simple version of the behavioural additionality mainly pertains to effects that are limited in time and occur only during the funded project and in its immediate vicinity.

However, the concept of behavioural additionality can be used far beyond the extension of the input dimension and can be employed to assess the changes in the behaviours of the agents supported by the policy intervention. This is clear in the seminal contribution by Buisseret et al. (1995) that coined the concept of behavioural additionality as "the change in a company's way of undertaking R&D which can be attributed to policy actions" (p. 590). Similarly Georghiou (2004, p. 7) defines behavioural additionality as "the difference in firm behaviour resulting from the intervention". By focusing on the behaviours of the beneficiaries it is possible to overcome a limitation which is implicit in the evaluations based on the measurement of the input and output additionality: the fact that economic actors are considered as 'black-boxes'. In this sense one of the aim of the behavioural additionality evaluation is to open these 'black-boxes' (Clarysse et al. 2006; Hall and Maffioli, 2008) and to look at the micro-effects occurring within the innovation process of the beneficiaries.

It is evident that this kind of definition is quite flexible and can encompass a number of behavioural changes induced by the policy. These can pertain to the acquisition and improvement of knowledge, capabilities, organisational routines and strategies (Georghiou and Clarysse, 2006; Breschi et al., 2009). Furthermore, as noted by Geroghiou (2004) and Georghiou and Clarysse (2006), focusing on the behavioural changes related to the acquisition of competences in new or extended technologies and market areas it is also possible to assess whether a given policy intervention has been able to overcome lock-ins. Similarly Bach and Matt (2005) stress the importance of focusing on the ability

[7] Falk (2007) includes in the definition of behavioural additionality also four types of scope additionalities and the cognitive capacity additionality (Bach and Matt, 2005), however this latter is not included in the empirical analysis provided.

of the policy to create cognitive capacity additionality, which encompass effects that are fundamental to solve lock-ins as the creation of novelty and capacity to adapt to future situations that cannot be envisaged. Another important set of effects that can be analysed using the concept of behavioural additionality is that related to the networking of the beneficiaries and to their connections and interactions with other organisations. Drawing on the evaluation model proposed by Hall and Maffioli (2008), behavioural additionality evaluation, in addition to effects that occur in the internal organisation, can capture also changes that pertain to external relations. In this sense it is possible to assess whether the policy has helped to build networks or co-ordinate systemic innovations (Georghiou, 2004; Georghiou and Clarysse, 2006), creating new partnerships, involving not only firms but also research organisations, and favouring the persistence of these interactions even once the public funding has ended (Fier et al., 2006). Breschi et al. (2009) stress the great importance of assessing the effects of the policy on partnerships and networking. According to the authors large part of the behavioural additionality is realised through interactions as these can provide access to external knowledge, while valorising internal competences and expanding learning capabilities.

However, as the concept of behavioural additionality is quite flexible, evaluators may take into consideration a range of behavioural changes that can be even too wide. As noted by G□k and Edler (2010) the concept can be used also to evaluate effects that are not strictly or directly related to innovation activities but to the more general conduct of the beneficiaries. This is quite evident looking at the list provided by Georghiou (2004) and Georghiou and Clarysse (2006) of six types of possible effects that can be taken into consideration in the behavioural additionality evaluation. These pertains to: i) knowledge acquisition (e.g. R&D organisation and networking), ii) human resources (e.g. hiring of researchers and acquisition of management skills), iii) capital investment strategy (e.g. acquisition of equipment and location of companies' facilities), iv) market positioning (e.g. introduction to new market or customers and acquisition of leadership positions), v) strategies for manufacturing or service provision (e.g. changes in the production or service delivery methods) vi) corporate responsibility and environmental sustainability. With respect to this list it seems relevant to mention that the inclusion of a broad range of behavioural and strategic changes, which can be not directly related to the innovative activities of the beneficiaries, may lead to a risk. This emerges when focusing on changes that are not directly pertinent with the aims of the innovation policy intervention. More precisely, the changes pertaining to the investment strategy, to the strategies for manufacturing and service provision, to the corporate responsibility and

environmental sustainability might not be immediate objectives of the innovation policy[8]. In this sense in order to have a proper and clear-cut specification of the concept of behavioural additionality it is useful to be focused on the ability of the policy to reach its goals. This means that, as the aim of the policy is to overcome system failures, it is important to be focused on those changes in behaviours and strategies that can solve these failures.

This is not a novelty in the literature. In opposition to the "ideal" and "narrow" incrementality tests, which are consistent with the neoclassical approach, Lipsey and Carlaw (1998) claim for the use of the "weak test of incrementality" to evaluate the innovation policy with a structuralist-evolutionary perspective. This latter, with no attempt of optimality, should be focused on the evaluation of structural changes and the enhancement of beneficiaries' capabilities (Georghiou, 2002; 2004; Georghiou and Clarysse, 2006). Bach and Matt (2005) state that the cognitive capacity additionality, which seems to be a further specification of the behavioural additionality, is able to assess the policy intervention in an evolutionary and structuralist approach. More explicitly Georghiou (2002) states that, to an extent, the behavioural additionality can be used to assess whether the policy has been able to overcome system failures. However, according to him, the fact that the natural operational level of the additionality test is the firm implies a limitation in the use of the concept of behavioural additionality for this purpose: on the one hand there are failures that do not pertain at all to firms, but occur only at the system level, on the other hand there are failures that occur both at the level of the firm and of the system. This limitation can be partially reassessed. In a system perspective it is necessary and possible to consider the behavioural changes induced by the policy on all the systemic organisations targeted by the innovation policy, including not just the firms but also the other beneficiaries (e.g. research institutes, innovation centres, universities, etc...). However, even with this broader definition of the unit of analysis, the use of the behavioural additionality to assess the ability of the policy to solve system failures in not so unproblematic. First, some system failures still occur both at the organisation and at the system levels. These are the failures pertaining to learning processes and accumulation of capabilities, to missing or inappropriate connections and to unbalanced trade-offs between selection and variety and between exploration and exploitation. With respect to these failures, behavioural additionality evaluation can be employed but, as it is focused on the effects on the beneficiaries, it is possible at the most to evaluate the sum of the single additional effects. This is only partially correct from a theoretical point of view, as the effect on the whole system, due to synergies and interactions, can be different

[8] Furthermore the effects on the market positioning give the impression to be more related to the output dimension of the concept of additionality.

from the sum of the effects on the single organisations. A second problem emerges for those failures pertaining to weak institutional performances, infrastructural investment and missing components. In these cases it seems that the behavioural additionality cannot be properly employed, as it is very complicated to assess whether the policy has been able to solve these failures by looking at the behavioural and strategic changes of the beneficiaries of the innovation policy; the operational level of the evaluation, in other terms, cannot be the supported organisation but need to be the system. In order to solve these problems a solution could be to integrate the analysis of the effects on the single components with the analysis of the effects on the system as a whole (Bellandi and Caloffi. 2010). However, although some methods, as the social network analysis, allows this kind of investigation, it would be quite difficult to create a counterfactual due to the problems in finding a system that has not been treated by any type of innovation policy and is exactly similar to the supported one.

2.3 Issues and criticalities in the behavioural additionality evaluation

In addition to the problem related to the unit of analysis other issues and criticalities of the behavioural additionality evaluation should be taken into consideration. One of these is related to the fact that behavioural additionality cannot capture the strategic relevance of funded projects as it is perceived by the beneficiaries. These latter may carry out highly additional projects, in terms of behavioural changes achieved, just to fulfil policy requirements and obtain the funding, rather than because they perceive these changes as strategically worthwhile. The fact that beneficiaries are encouraged by the policy to do something that they do not perceive as strategically relevant could be a positive result of the intervention assuming that policy-makers have a clearer and better understanding of the future perspectives and evolutions (Lukkonen, 2000). However, in evolutionary and system perspectives this assumption does not hold completely: policy-makers, as the economic actors, are bounded rational and operate in a surrounding changing and evolving environment, characterized by a number of micro-complexities (Malerba, 2009). Due to this there can be no presumption that policy-makers have a superior understanding of markets and technological information: policy proceeds by trials and errors as innovation proceeds by trials and errors (Metcalfe, 1994). As stressed by Geroghiou (2004) and Georghiou and Clarysse (2006), high level of behavioural additionality does not necessarily means that the policy has been successful. On the one hand, even in case of high additionality, policy might have induced beneficiaries to move towards the wrong direction. On the other hand, in case the policy has tempted beneficiaries to move beyond their competences, high additionality can be associated with an increased risk of failure of funded projects.

Another criticality in the behavioural additionality evaluation is related to the difficulty in isolating

the effect of policy. As stated by Buisseret et al. (1995) and Georghiou (2002) the funded project should not be seen in isolation but within a portfolio of other innovative activities, a wider programme that is likely to be started before the funded project, continues even after the end of the public support and that integrates other privately financed activities. This limits the possibility to isolate the effect of single funded projects and claims for the analysis of the effect of the policy on the overall strategy of the beneficiaries (Buisseret et al., 1995). A similar conclusion can be reached considering the displacement phenomenon (Davenport et al., 1998). Given the investment portfolio perspective and assuming that applicants tend to present projects that are more likely to be funded (i.e. more promising in terms of output achievement and well planned), there results that beneficiaries may be funded for a given project and then use the money to finance other innovative activities, which are more marginal in terms of government funding, maybe of higher risk but just as strategically important.

Other problems that might emerge in evaluating the behavioural additionality are due to the fact that in some cases the policy intervention can affect even non-funded companies and organisations. First of all it is relevant to stress that even the application phase of a support scheme[9] can induce behavioural changes in the potential beneficiaries, by calling to their attention the existence of opportunities or stimulating them to present projects and set the stage for activities to be carried out according to the policy requirements (Georghiou, 2004). The result is that it is possible to have some additionality effects also on non-beneficiaries that have presented projects then rejected in the selection process. A similar outcome can emerge considering the presence of spillovers taking place from funded organisations to non-beneficiaries. Though not referring directly to the behavioural additionality, the review provided by Klette et al. (2000) points out that non-beneficiaries may be affected by the policy due to the spillover effects, especially if the distance, in terms of technology and knowledge, with the supported organisations is not too high. The fact that some additional effects can occur also on non-beneficiaries implies a serious drawback in the possibility to create a control group of non-treated units to estimate the counterfactual.

Another issue that might emerge is related to the fact that the behavioural additionality cannot be expected to be an homogeneous phenomenon. Georghiou (2004) proposes to differentiate the evaluation according to the different types, in terms of size and knowledge-intensity, of beneficiaries as the additionality effects on these are supposed to be different. This reasoning is supported by some empirical evidences. Hsu et al. (2009), with respect to R&D programmes in Taiwan, point out the existence of some different patterns of behavioural additionality in different

[9] Georghiou (2004) refers in particular to grants.

sectors and innovation categories. Different behavioural additionality effects in different types of beneficiaries, especially in terms of size, emerge also from the analyses provided by Falk (2006, 2007) with respect to the Austrian case. Apart from the empirical evidences it seems relevant to stress that heterogeneous patterns of behavioural additionality are also theoretically justified. As the economic actors are heterogeneous and behave differently according to their particular strategic, cognitive, and organizational aspects (Metcalfe, 1995), it is quite unlikely that their response to the policy support is similar.

The last point concerns the fact that the behavioural additionality cannot be considered in a separated way but within a set of relations involving also the input and output dimensions. As stated by Bach and Matt (2005), only analysing together the different dimensions it is possible to have a clear understanding of the effect of the policy. Considering that market failures can coexist with system failures the three types of additionality should be evaluated together in order to understand whether the policy has been able to reach its objectives[10]. Apart from this general statement it seems to be interesting to consider the synergic relationships that might exist between the three dimensions. A first and quite obvious one can exist between the input and output additionality. Considering the linear model of innovation, the more the policy stimulates the investment in R&D the more this is expected to result in a higher level of innovative output[11]. However, also the other causality direction could be possible: the more the policy has favoured the achievement of innovative outputs and economic outcomes, the more this could result in higher resources and incentives to invest more in R&D. It is possible also to consider relations involving the behavioural dimension. The first one, originally investigated by Davenport et al (1998), is related to the effect of the behavioural changes on the output additionality. In particular, desirable behavioural changes induced by the intervention, especially if considered as persistent, are seen as a sort of latent ability of the policy to influence the possibility to achieve more outputs[12]. Some contributions investigates also the relation between input and behavioural additionality (Autio et al. 2008; Clarysse et al. 2009[13]), starting from the assumption that an increase in the R&D investment induced by the policy

[10] Bach and Matt (2005) in addition to the input, output and behavioural dimension refer also to the cognitive capacity additionality that instead we consider as a further specification of the behavioural additionality.

[11] Empirical investigations of the impact of the input additionality on the output additionality can be found in Czarnitzki and Hussinger (2004), Czarnitzki and Licht (2006) and Cerulli and Potì (2010).

[12] The evidence for behavioural aditionality identified by Davenport et al. (1998) is related to changes related to the management of R&D. Another contribution (Magro et al., 2010), analyses the impact of behavioural changes induced by the policy, in terms of collaborative arrangements, on the output additionality, in terms of patenting activity.

[13] Autio et al. (2008) use a slightly different terminology. Instead of input and behavioural additionality they refer to first-order additionality and learning outcomes. Clarysse et al. (2009), due to a data constraint, cannot provide a causality test.

can have a positive effect on the beneficiaries' learning. However the relation between these two dimensions is quite complex and also the other causality direction, going from the behavioural to the input additionality, cannot be excluded. Assuming that behavioural additionality can capture persistent changes in firms strategies and behaviours (G□k and Edler, 2010) it could be that these stable changes affect the R&D investment of beneficiaries. One can think at two examples. The first is a case in which the policy intervention has favoured the collaboration with external partners. In this circumstance beneficiaries may need to invest more in R&D in order to increase their absorptive capacity. Another example is a situation in which beneficiaries, due to the enhancement of competences induced by the policy, are more willing and able to invest in R&D. In sum, considering together these relations there emerges a situation in which virtuous circles and synergies involving the three dimension of the additionality can occur. Of course this hypothesis should be further investigated and tested properly.

3. Empirical issues

The present section deals with the empirical issues in the (ex-post) evaluation literature concerning the innovation policies and especially the subsidization of R&D activities, with a dominant focus on the issues related to the measurement and assessment of the *behavioural dimension* of *additionality*. The section is purposely free of mathematical notation because we mainly intend to provide an overview of the econometric strategies used in the evaluation literature in order to anchor the review of works dealing with behavioural additionality to such econometric strategies.

The main issues in evaluating the effectiveness of an innovation policy are related to the *causal inference* at a broad general level and the *selection* issue that may be due also to policy *endogeneity* (among several studies we refer the interested reader to the recent contributions of Heckman and Vytlacil, 2007; 2007a)

The first problem is essentially a missing data problem, which always exists in evaluation procedures. Considering policy intervention as the treatment, the firms[14] as the units of analysis and the additionality indicator (e.g. R&D expenditure in case of input additionality) as the outcome variable, the net effect (i.e. the additionality of the policy) can be defined as the difference between the actual outcome reached by treated units and the counterfactual, which is the outcome that would

[14] From now on the term firm is used almost exclusively to define the beneficiaries of funding schemes, even if other organisations could be the target of the policy.

have been reached without the treatment. However, the counterfactual is not observed for the treated firms. Each single firm is in one (treated) or the other (untreated) state of the world once the policy has been implemented. For such a reason in non experimental frameworks, like those regarding innovation policies, the fundamental problem faced in the process of assessing additionality can be considered as a missing variable problem.

In a more formal way let assume that the state associated with receiving treatment is "1" and the state associated with not receiving treatment is "0". Thus a unit is treated or not treated if D=1 or D=0 respectively. Associated with the two state we have two outcomes: Y_1 and Y_0. The outcome (or response) observed for an individual is $Y=DY_1+(1-D)Y_0$. This represents the Roy Model as labour economists are used to call it or Quandt Switching Regression Model or Rubin Model for statisticians. The effect of interest is constituted by the gain from program participation $\Delta=Y_1-Y_0$. The evaluation problem is generated by the fact that we cannot see at the same time the two outcomes for the same individual (missing data problem), if we could there would be no evaluation problem. If the parameter of interest is the average treatment effect for the treated (ATET) ATET = $E(\Delta| D=1) = E(Y_1 - Y_0| D=1) = E(Y_1| D=1) - E(Y_0|D=1)$ we can straightforwardly estimate $E(Y_1|D=1)$ by the mean outcome of treated units, but we do not observe $E(Y_0|D=1)$, the potential outcome in absence of treatment for the same set of treated units. The latter could be estimated by the mean value of the outcome of non treated units $E(Y_0|D=0)$ if the assignment to treatment were random, the "gold standard" in statistics. Indeed, in such case we would have $E(Y_0|D=1)= E(Y_0|D=0)$.

However, it is pretty obvious that perfect randomisation is a sort of chimera in social sciences. In the context of innovation policies it is unlikely, to say the least, that firms receiving the subsidies represent a random sample of the whole population of potential beneficiaries, rather it is likely that some mechanisms that bias the resulting group of beneficiaries is at work. As an example the firms may self select into treatment. In other words, participants to a call for public subsidization of innovative activities and R&D constitute a sample of firms that does not have the same distribution of the population. This may arise because certain firms expect to gain more by R&D and innovation activities or because of the managerial attitudes that influences the decision to participate. In synthesis, some firm specific characteristics influence in a systematic way the probability to participate to the public program and receiving the treatment.

In the same vein the bias may also arise because the assignment is ruled by specific strategies of the public actors. The subsidy is granted according to the characteristic of the project presented by each applicant or the funding choice may be taken according to the "picking the winner" or "aiding the

poor" strategies. In the first case a potential upward bias emerges in estimating the effect of the policy without using appropriate econometric techniques. On the contrary we should find downward biased results if the government strategy is of the second kind (Cerulli, 2010).

The econometric strategies to be implemented differ according to the possibility to observe the relevant factors that influence the selection, as the latter may be due to observable factors (selection on observables) and/or unobservable factors (selection on unobservables) (Cameron and Trivedi, 2005).

The way on how to model the selection mechanism has spur a quite harsh debate between econometricians and statisticians (Heckman, 2005, 2005a; Sobel, 2005), in the past few years, and it essentially encapsulates the weakest and strongest aspects of the two approaches of analysis.

On this point we can follow Heckman (2008) and Heckman and Vytlacil (2007; 2007a) when they distinguish between two broad typologies of approaches in the literature concerning the evaluation of social programmes: structural models and matching models. In the first class of models the counterfactuals are constructed on the basis of explicit assumptions derived from the theory and, thus, they allow a more insightful interpretation from an economic point of view. As put forward by Heckman "the econometric framework is explicit about how counterfactuals are generated and how interventions are assigned (the rules of assigning "treatment")" (Heckman, 2005, p.6). The same cannot be said about the matching models, a class of methodological devices mainly derived by the statistical literature that remain on other general but quite restrictive assumptions. The major two are: (i) the so called stable unit-treatment value assumption (SUTVA), which means that the outcome for individual i must be independent to the treatment given to individual j; (ii) the strongly ignorable treatment assignment (also known as conditional independence assumption) that implies, when verified, that the conditional distributions, on a vector of pre-treatment characteristics X, of the outcomes of participants and non participants are the same, and the missing counterfactual mean can be inferred since $E(Y_0|X, D=1)= E(Y_0|X, D=0)$ (Rosenbaum, Rubin, 1983). Thus, the condition of strongly ignorable treatment assignment allows us to identify with nonexperimental data the same parameter we can identify with experimental data, which presumes perfect randomization. It must be noted that such assumption holds if D is a deterministic function of X and for such a reason some authors have called it selection on observable assumption. Accordingly, it can be said that the main drawback of the matching models lies in neglecting the unobservables that may drive the selection process. Put it another way, it is assumed that the researcher observes all the relevant factors determining the selection into treatment. Hence, the nature of matching approaches is more data-driven rather than being based on the ex-ante theoretical formalization, which guides the

construction of the behavioural functions in structural models. Indeed, the advocates of the matching class of models consider some assumptions needed to settle up structural models to restrictive, invoking a more objective view provided by matching results[15]. In addition, the statistical methods, as the matching approach, claim to be more attached to the data and to what they have to say; in so doing they encounter the favour of heterodox/evolutionary economists, more akin to data driven analysis than to formal analytical models (Cerulli, 2010). Structural models based on the latter may contain behavioural equations that differ according to the theory the researcher has in his mind, thus resulting in different estimation of the treatment effect.

Provided that biases in estimations may result if the selection issue is not taken into account in the estimation strategy we have briefly illustrated, to avoid overlapping with recent reviews (Cerulli, 2010), the two main approaches used in the literature on the ex-post evaluation of social programs through some main points emerged by the debate between econometrician and statisticians. This constitutes a preliminary step that is functional to the attempt to frame the empirical works concerning the behavioural additoinality, while it is beyond the scope of the present work assessing the superiority, if any, of one approach compared to the other.

3.1 Operationalizing the behavioural additionality: a review of the empirical literature

In addition to facing the problems related to the standard ex-post evaluation literature on social programs the behavioural additionality needs to cope with some (still) blurriness in the transition between conceptual theorizing and empirical specifications. The main problems in the operationalization of behavioral additionality clearly lie on the left hand side (LHS) of the econometric specification, notwithstanding the type of methodology adopted. In other words, it still lacks a consistent measure of behavioural additionality coherently adopted in the empirical studies. The issue concerning the measurement of the LHS variable is not a trivial one, as its high heterogeneity leads to differences in the results and to difficulties in comparing them.

To start with a dichotomous distinction between the works here considered we may classify them according to their perspective in considering behavioural additionality: as a dependent of the outcome equation the evaluation for a direct additionality effects or as a factor with specific determinants or relations with other additionality dimensions and aspects related to the innovation activities.

[15] For other radical views see Dawid (2000).

On the side of direct analysis about the policy impact on the firms' behaviour[16] it is possible to distinguish three broad sets of empirical papers in terms of the methodologies discussed above. The first group (Fier et al., 2006; Hall and Maffioli, 2008; Magro et al. 2010; Marino and Parrotta, 2010) conducts the analysis on the exclusive basis of matching models, while the second group employs reduced forms or structural models[17] (Falk 2006; Busom and Fernandez-Ribas, 2008) (tab.1). Finally, more recently, some few studies also explore the potential of social network analysis in investigating the behavioural additionality dimension (Breschi et al., 2008; Bellandi and Caloffi, 2010).

Fier et al. (2006) base the empirical analysis on CIS data for Germany and integrate relevant lacking information with an ad-hoc survey. Their main objective is to capture if publicly funded firms R&D projects lead to higher level of cooperation with other firms and research institutions. A change in collaborative behaviour is the indicator of the policy capacity to impact the behaviour of the firm. However, the authors question whether or not such a change is permanent or transitory, that is to say if it lasts also after the end of the project subsidized. In order to answer such questions they apply at first a non-parametric matching procedure that allow them to identify the positive impact of the policy on the firms' behaviour and then a bivariate probit to compare new collaboration, activated because of the policy, with collaborations that represent a continuation of an already existing activity and it was not activated because of the policy. The general results point to a policy effectiveness in stimulating the birth of new collaborations between firms and scientific institutions. However, such newly devised activities of cooperation are less likely to continue at the end of the policy when compared to cooperations already existing at the beginning of the policy. The change in firms' behaviour is, thus, only transitory.

The second study considered is by Magro et al. (2010) who start from the consideration that the rationales behind the policy evaluation have evolved from a neoclassical to an evolutionary perspective, which point its attention on the behavioural dimension of additionality. They focus their analysis on a policy program for the Basque Region in Spain and applying a matching technique (although they admit it might be problematic because some relevant unobservable factors are not captured by their set of information) aim at verifying whether public funding rises the propensity to collaborate, increases the capacity of the firm to participate in international R&D programmes, leads to systematic R&D behaviour within the firms. The evidence provided by the authors tells that the policy program has a positive effect on all the three aspects of behavioural

[16] Some of the papers considered in the review investigate both the effect of public polizie on the firms' behaviour and the relations between the dimension fo additionality, thus enter in both the two parts of the review.
[17] Busom and Fernandez-Ribas (2008) jointly use structural models and matching.

additionality considered.

The third work, by Hall and Maffioli (2008), which complete the review of those using matching approaches, is a survey of evaluations conducted in several countries of Latin America (Argentina, Brazil, Chile and Panama). As stressed by the authors all the studies adopt quasi-experimental econometric techniques (matching) in order to reduce the selection bias. All the dimensions of the additionality are considered and not only the behavioural one. However, sticking on the latter, which is of interest for the present work, the general evidence point to a positive effects of technology and development funds on the innovation strategy of the firms. In particular, the capability of the firms to cooperate with external sources of knowledge and finance is improved by the policy scheme (Chile and Panama).

The last work for the first group, by Marino and Parrotta (2010), is about Danish firms. It aims at evaluating the impact of the policy on the endowment of human resources devoted to R&D (share of R&D workers). Differently from the works previously considered the treatment variable used is not a participation dummy, rather it is a continuous measurement of the subsidy received by the firm. A generalized propensity score matching approach shows that firms receiving public funds for their R&D activities increase the shares of R&D workers, implying a likely change in managerial attitude in terms of management of innovation strategies. Such a positive effect is persistent and significant for funds up to 1.8 million of DKK.

In synthesis, the first three studies show another commonality, besides the application of matching methodologies: the main variables of interest used to capture behavioural additionality are measures of cooperation/collaboration with other institutional agents, such as universities or scientific research centres. A change in collaboration attitude is seen as a measure proxing a change in the strategic behaviour of the firm.

Among the studies that do not adopt a matching approach we here report that by Falk, published in the OECD report on measuring behavioural additionality (OECD, 2006), which considers the FFF Austrian R&D support scheme. The data analysis is conducted on two levels. The first is a descriptive one, which is nonetheless useful to single out some relevant characteristics of the supported firms. The second one is an econometric approach that exploit the panel structure of the data, without explicitly defining a selection equation. The availability of panel data allow the implementation of both a fixed effects model with time-invariant variables and a dynamic panel model (partial adjustment model) that are used to estimate a reduced form equation. The variable adopted to measure behavioural additionality is given by R&D personnel, which capture, according to the author, an “increase in awareness of R&D opportunities, establishment of informational

network, improve firm's absorptive capacity with respect to new knowledge" (Falk, 2006, p.67). The results lead the author to say that FFF sponsoring has only a marginal effect on the firm demand for high skilled R&D personnel.

The second work within those not exclusively applying matching procedures is by Busom and Fernandez-Ribas (2008). This study is focused on the cooperation dimension of the behavioural additionality, as the majority of the studied here surveyed, which represent, at the best of our knowledge, the totality of empirical works aimed at evaluating behavioural additionality by the use of econometric methods. The econometric approach is based, at first, on the specification of a structural model of cooperation in which the determinants of partner selection are explicitly taken into consideration. More specifically a system of equations is specified where the decision to participate to the policy program is modelled as well as the equations of partners selection: customer and suppliers, on the one hand; public research organisations on the other hand. However, because of the lack of appropriate instruments they are not able to estimate the structural model in order to verify the different impact of the policy on the likelihood of establishing private or public partnership. They use reduced-form estimates and then they turn to the matching approach. The results of the matching is that subsidizing firms' R&D projects has a positive impact on the likelihood to establish public-private partnerships, and it also has a positive effect on private-private cooperation.

The studies we have classified among those using structural models have shown the inherent difficulties in estimating through fully parametrized models the effect of interest. As a matter of facts both the studies turn to apply reduced-form estimations.

Finally we want to provide an overview of two studies that apply an even different way of testing for the existence of behavioural changes for firms subsequently to the application of policy program aimed at supporting R&D and technological development. The relevance of such studies mainly rely in the perspective adopted, which is no longer focused on the single economic actors, as the firms, rather they adopt a system view, which methodologically translates in the implementation of social network analysis, more akin to the systems of innovation perspective.

The first one of this works is by Breschi et al. (2008), who conduct their study at level of organisations: private companies, higher education institutions and public research organisations. The authors consider the Information Society Research, Technological Development and Demonstration (IST-RTD) programmes of the Sixth Research Framework Programme focusing on the knowledge networks and partnerships spur by the R&D activities related to these policy interventions. The analysis shows the existence of knowledge networks that may be influenced

positively by innovation policies in a varieties of way: attraction of key actors to the European IST knowledge networks; creation and strengthen of relations among actors; effectively diffusion of new knowledge. The other work, by Bellandi and Caloffi (2010), is focused on a set of policies implemented by the Tuscany Region in Italy. Also in this case the systemic perspective may help in assessing the impact of innovation policy in a way that partially depart from the traditional empirical studies. The relations between actors at regional level present characteristics derived by the economic structure of the geographical location taken into consideration (e.g. districts), but the results show that they are also partially boosted by the presence of public funding.

The social network analysis emerges as a tool that may complement, in our opinion, the more traditional analysis, offering a systemic perspective and an insightful representation of the linkages between social actors. However, the likelihood almost null of finding a counterfactual (untreated system) for a system analysed in the network analysis represent the main drawback, that makes it impossible to verify the existence of additionality.

As far as the "indirect" studies about behavioural additionality are considered it is possible to distinguish at least three categories of interesting empirical investigations of the behavioural additionality; at least according to the aspects of relevance for the present work, but in the awareness that the studies here reported investigate several other aspects concerning the additionality phenomenon and the behavioural additionality itself.

The first of these aims at studying the determinants of particular aspects of the behavioural additionality. Falk (2007) implements a series of probit regressions to estimate the effect of firm's characteristics (i.e size, sector, age, obstacles to innovation) and of the number of support schemes in which the firm has been enrolled on a set dependent variables capturing different forms of additionality. In addition to project and input additionality, also the behavioural dimension is considered. With respect to this latter three types of effects are considered. These pertain to the scale, the acceleration and the scope (in terms of more cooperation, more risk, more basic research and more applied research) of the supported innovative activities. The main findings reveal that large firms are most likely to realise various forms of additionality and that multiple policy interventions are necessary to produce scope additionality in terms of more cooperation or willingness to undertake risky basic research. Another attempt to identify the different determinants of behavioural additionality is provided by Fier et al. (2006) as described above.

A second category includes works that employ the factor analysis to organise behavioural changes in a limited number of behavioural additionality sub-dimensions. This is particularly relevant due to the fact that, as noted in the theoretical part of the paper, the concept of behavioural additionality is

quite flexible and can encompass a large number of effects. Hsu et al. (2009) starting from 19 items identify one factor for project-level behavioural additionality (i.e. project enlargement behaviour) and three factors for firm-level behavioural additionality (i.e. strategic formulation behaviour, cost-effectiveness behaviour and commercialisation behaviour). Similarly Autio et al. (2008) implement a factor analysis to use multi-item scales as measures of four types of learning: direct technological related learning, technological distinctiveness, market learning and internalisation learning.

The third category of empirical investigations includes analyses of the relations between the behavioural and input or output additionality. Autio et al. (2008) carry out four regressions in which the four learning outcomes are the dependent variables and input additionality is the predictor. The findings reveal a positive and significant impact of the input additionality on direct technological learning and interorganisational learning. Clarysse et al. (2009) investigate the correlation between input and behavioural additionality. Without attempting any causality test, they implement a test of the correlation coefficients and a Heckman selection model to address the selection bias; the results support the hypothesis according to which the two dimensions are strongly related. Finally, Magro et al. (2010) investigate the impact of the behavioural additionality, in terms of R&D collaborations, on the output additionality, in terms of patenting. Adopting a matching procedure that compares firms funded following a collaborative schemes to similar firms that are individually funded, the results do not statistically give evidence of the effects of the collaborations on patenting.

Tab.1- Methodologies and measures in behavioural additionality studies

Study	Econometric/Statistical Methodology	Policy intervention variable	Behavioural additionality measures
Aschhoff, Fier and Löhlein (2006);	Matching	Subsidy dummy	Collaborations with other firms, with scientific organisations, both with other firms and scientific organisations.
Magro, Aranguren and Navarro (2010)	Matching	Subsidy dummy	Internationalisation of R&D activities, systematisation of R&D activities, long-lasting collaborative arrangements
Hall and Maffioli (2008)*	Matching	Subsidy dummy	Product and process innovation, access to external sources of knowledge, training and organisational activities, external financing.
Marino and Parrotta (2010)	Matching	Continuous subsidy (treatment) variable	Share of R&D personnel
Falk (2006),	Fixed effect model with time invariant variables and dynamic panel specification	Log R&D subsidies Δlog subsidies (t), Δlog R&D subsidies (t-1)	R&D personnel (as a "proxy" for: increased awareness of R&D opportunities, establishment of informational networks, firm's absorptive capacity)
Busom and Fernandez-Ribas (2008)	Structural model and matching	Binary participation status and subsidy dummy	Cooperation with suppliers and customers and public research organisations
Breschi, Cassi, Malerba and Vonortas (2008)	Social Network Analysis	The paper analyses the network of the beneficiaries of the support programmes (IST-RTD), their participation in the network of strategic alliances and in the network of patent citations.	Creation of knowledge linkages and connectivity, nurturing of key actors and knowledge leaders.
Bellandi and Caloffi (2010)	Social Network Analysis	The paper is focused on the configuration of the publicly-funded network(s) of innovation.	Interactions among actors having different nature, knowledge and competences; balance between strong and weak ties; balance between stable and temporary members of the network; nurturing of bridging organizations

Notes: *The work is a meta-analysis of evaluation studies.

4. Conclusions and remarks

The paper has investigated the use of the concept of additionality in the evaluation of innovation policies, devoting most of the attention to its behavioural dimension, which is focused on the behavioural and strategic changes induced by the policy on the beneficiaries. The discussion presented in the theoretical part of this work has tried to stress the ability of this dimension to complement the more traditional input and output additionality. One of the most important advantage related to the use of the behavioural additionality pertains to the possibility to provide a deeper analysis of the effects that occur within the 'black-boxes' of the beneficiaries, considering also their networking activities and relations with external sources of knoweledge. However, the concept of behavioural additionality is quite flexible and its definition risks to be too broad or vague due to the large number of behavioural changes that can be taken into consideration. This is particularly evident in those contributions (e.g. Georghiou, 2004; Georghiou and Clarysse, 2006) that claims for the analysis of a set of effects that might be not directly related to the objectives of the policy. In this sense, in order to reduce the potential width and vagueness of the definition of behavioural additionality, it is advisable to be focused on the ability of the policy to reach its objectives; according to the evolutionary and system perspectives this means that it is important to be focused on those changes in behaviours and strategies that can help to solve or mitigate existing or potential system failures. Through the paper it has been stressed that the concept of behavioural additionality can be used to assess whether the policy has been able to solve or mitigate failures pertaining to problems in learning processes and accumulation of capabilities, to the unbalanced evolutionary trade-offs and to missing or inappropriate connections. However, as the natural units of analysis of the behavioural additionality are the organisations supported by the policy, this type of evaluation can be hardly employed to assess whether the public intervention has been able to solve or mitigate failures related to missing components, weak institutional performances, and problems in infrastructural investment.

A main open question has been raised at the end of the theoretical part. This pertains to the relations that can exist among the three dimensions of the additionality. In particular, the hypothesis to be further investigated pertains to the idea according to which input, output and behavioural additionality should not be seen as separate results of the policy intervention, but as parts of a framework of synergies, in which, due to the existence of a circular causations, each dimension can affect the others. The next step towards a clearer understanding of this framework of synergies is to review the strands of literature, not necessarily related to the evaluation of innovation policy, that

can shed some lights on the relations among the R&D investment, output and outcomes of the innovation process and behavioural and strategic changes.

As far as the empirical literature about behavioural additionality is concerned we stress, at first, the fact that it shares the usual econometric and statistical issues of the evaluation literature. The choice between structural models that identify both selection and outcome equations and matching models, which are quasi-experimental/non parametrical tools, is always in the hand of the researcher that has to choose the most appropriate method according to the data at his/her disposal and to the objective of his/her study. For sure, structural models may allow the identification of policy impacts of more relevance than the simple treatment effect resulting by the implementation of matching methods; however, the identification of structural equations is not always feasible because of data shortcomings.

In addition, there are also specific criticalities in assessing behavioural additionality still unresolved, although in the last few years the literature has increasingly started to solve the issues involved in the crucial passage between theory and empirics. One main point is given by the measurement issue. As emerged through the paper the concept of behavioural additionality is quite flexible and can encompass a large number of effects, thus, almost by definition, it is not possible to determine an univocal measure. A way out of the impasse is to capture the several behavioural and strategic changes induced by the policy through a set of variables that proxies such changes. This strategy comes at a cost: it potentially increases the number of dependent variables. Another strategy is to assess the presence of additionality on few focused variables that capture only those changes that are of main interest, as the empirical works we have surveyed seem to do, although the need for securing better data also allowing consistent international analysis, for comparison purposes, seems to be strong. An additional strategy to measure in a comprehensive way the behavioural dimensions could be that of collecting information on the various sub-dimensions behaviour and then applying multivariate statistical techniques such as factor analysis and principal component analysis, which reduce the initial vector of sub-dimension in a smaller one without loosing too much variance of the original data.

A second main issue regards again the relation between conceptualization and empirical methods. Because of the nature of behavioural additionality the unit of analysis should not be only the supported organisation; rather, the micro level of analysis, which captures individual effects, should be complemented with systemic analysis, capable of assessing systemic effects. The very recent applications of social network analysis in the assessment of behavioural additionality represent a promising instrument in such a direction.

Finally, in line with the conclusions emerging from the theoretical part of the paper, a suggestion for future researches can be advanced. This concerns the investigation of possible empirical methods that can be used to analyse the framework of synergies that might exist among the three additionality dimension. A first step in this direction could be to understand whether a system of simultaneous equations can be applied for this purpose.

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