Chapter 2
Nancy Cartwright, Capacities and Nomological Machines: The Role of Theoretical Reason in Science

Abstract This chapter introduces Cartwright's thinking. She holds that explanation is the aim of science and that science should explain real causes using theoretical reason. Stable causes repeatedly linked originate what she calls "nomological machines". Cartwright also holds the singularity and indeterminism of causes. We find in Aristotle and in Anscombe's interpretations of causality adequate ground for this. From this perspective causality is a process of actualization of the power of an entity that may or may not occur due to internal or external factors. Cartwright assumes a greater difficulty in achieving causal explanations in the social realm than in the natural one. The greater complexity, the reflexivity and the lack of control have to do with singular human situations and human freedom. However, she leaves the door open to hope: "social science is hard, but not impossible." This hope stems from the stability or regularity produced by institutions, habits or routines. Finally, on the basis of Cartwright, this Chapter proposes to distinguish between different types of socio-economic machines and models: theoretical and practical machines and models. Practically-designed machines are governed by practical and technical reason and can be embodied in institutions. Models are the blueprints of those machines.

Keywords Nancy Cartwright • Explanation • Capacities • Nomological machines • Explanation in social sciences • Socio-economic machines • Models

2.1 Introduction

In Chap. 1, I claimed that Economics needs to recover an understanding of the role of theoretical reason in economic knowledge. This need goes from the necessity of a definition of Economics and its main concepts to the recognition of real causes of economic affairs.[1] It thus goes beyond the old positivistic concept of scientific

[1] L. Boland (2010) notes that causality does not matter for economists. Economics is dominated by model builders that only worry about which variables are "determined" by the model.

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explanation as "saving the phenomena". This concept consisted in delivering unified descriptions of natural regularities among things compatible with the observable, without trying to delve into unobservable underlying entities. Nonetheless, in order to save regular phenomena it is necessary to commit to causal mechanisms that can be detected from data, but that do not register directly on human perceptual systems or experimental equipment (see Bogen 2009). For James Bogen and James Woodward (see Bogen and Woodward 1988 and Woodward 1989, p. 393) phenomena are stable and general features of the world that are beyond data, and that can be explained and predicted by general theories. Theories, for them, are not about data, but about phenomena. Phenomena, explains Bogen (2009), are processes, causal factors, effects, facts, regularities and other pieces of ontological furniture. This implies that knowledge goes beyond observation; observations only help us arrive at the knowledge of those kinds of phenomena, a theoretical reason's knowledge.

In agreement with Bogen and Woodward (1988) and quoting them, Nancy Cartwright (1989, p. 169) states that "nature is full, not only of data, but of phenomena as well." She understands scientific explanation in terms of stable causes which she calls "capacities" or "natures" (Cartwright 1992, p. 71, nt. 7). This contention has Aristotelian roots, which she herself acknowledges. For her, those phenomena considered by Bogen and Woodward include capacities and interactions. Her general program aims at defining what capacities are (ontology), how they are understood (epistemology), and how we use them (Cartwright 2007b, p. 1). She also attempts—with a certain level of skepticism—to apply this conception of scientific explanation to the social realm, and specifically to economics. Thus, she is implementing theoretical reason in science.

> I chose deliberately the Aristotelian language of matter, form, and function because these terms are fundamental to a preliminary description of phenomena that appear in my image of science. This language is a thread to the neo-Humean covering-law theorist, and it is meant as such.

Otherwise, Cartwright agrees with John Stuart Mill's proposal about the existence of "tendencies" which she correlates with "capacities": "I suggest that the reader take my 'capacity' and Mill's 'tendency' to be synonymous" (Cartwright 1989, p. 170). According to Cartwright, Mill's tendencies are not tendencies of events but tendency factors or stable real causes. These tendencies or capacities give rise to Cartwright's "nomological machines" (NM), "stable configurations of components with determinate capacities properly shielded and repeatedly running" (Cartwright 2001, p. 292). Only when and where a NM can be built or shown to exist, can we speak of natural or of scientific laws.

As mentioned in the previous paragraphs, Cartwright combines elements from Aristotle with others from Mill. She also takes elements from Elizabeth Anscombe and Ian Hacking. I think that a good way of explaining Cartwright's thought is to analyze the influence of Mill, Anscombe, and Aristotle.

Cartwright is quite explicit about how her account is connected to Mill's: "[M]y views and arguments are essentially the same as Mill's in modern guise" (Cartwright 1989, p. 8). Her goal is to develop Mill's proposal to deal with causes in different causal situations (1989: Sect. 4.5, pp. 170–9). Mill's idea of tendency, according to Cartwright, corresponds to "the essential behaviour of a factor" (1989, p. 203).

In Book III, Chapter X of his *System of Logic*, "Of the plurality of causes, and of the intermixture of effects", Mill argues that one phenomenon can be produced by different causes: "it is not true, then, that one effect must be connected with only one cause, or assemblage of conditions" (1882, p. 311). One phenomenon may involve a concurrence of causes. This may happen in two different ways. In the first way, the different causes modify or interfere with each other's effects, thus constituting a compound causal action. Mill uses the joint operation of different forces in mechanics to exemplify this. In the alternative case, "illustrated by the case of chemical action, the separate effects cease entirely, and are succeeded by phenomena altogether different, and governed by different laws" (1882, p. 315). In the first case, Mill explains the action of each cause by saying that "it *tends* to move in that manner even when counteracted" (1882, p. 319: italics in the original). He concludes: "All laws of causation, in consequence of their liability to be counteracted, require to be stated in words affirmative of tendencies only, and not of actual results" (1882, p. 319). Cartwright (1989, p. 179) concludes from this that: "Mill's view has to be that the fundamental laws of nature are laws that assign stable tendencies to specific causes," which is Cartwright's notion of capacities.

However, Cartwright has been criticized for her interpretation of Mill: her concept of capacity would be different from Mill's concept of tendency. Christoph Schmidt-Petri (2008) argues that Cartwright's capacities are significantly different from Mill's tendencies, which he also believes to be problematic for Mill's entire thinking. According to Schmidt-Petri, Mill uses the concept of tendency for entirely practical methodological reasons rather than for metaphysical reasons (2008, p. 292). Hence, they do not support Cartwright's realist view of capacities (2008, p. 298). The key question is: are real causes internally consistent with Mill's Humean-like context?

Cartwright (1989, pp. 178–9) consider the afore mentioned point. She quotes Peter Geach on this, but she may underestimate the possible inconsistency. Recently, however, in her reply to Schmidt-Petri (2008), she has admitted that she was possibly wrong in applying her concept of capacity to Mill. Geach (1961, p. 103) argues that Mill, confronted with the facts, was obliged to affirm the existence of these real tendencies. But he complains that this doctrine is incompatible with Hume's invariable-succession theory.[2] In sum, the difference between Cartwright's capacities and Mill's tendencies is that while for her capacities are clearly and always real stable causes, for Mill the concept of tendency is only a

[2] He adds that Mill's tendencies are very close to Aquinas doctrine of *inclinationes* or *appetites* in nature—interestingly, because these *inclinationes* are also very close to Cartwright's capacities of nature (cf. Geach 1961, pp. 104–5).

methodological device that does not necessarily express an ontological reality.[3] That is, Cartwright's conception of capacity implies a metaphysical commitment.

Let us pass to Anscombe's influence on Cartwright's thought. At the beginning of the first chapter of her *Hunting Causes* (2007b, p. 11), Cartwright states: "The central idea behind my contribution to the project [on causality] is Elizabeth Anscombe's". Cartwright refers to Anscombe's paper "Causality and Determination" (Anscombe 1971).[4] In this chapter, Cartwright highlights the singular nature of causality and the plurality of causes. She concludes asserting: "I have presented the proposal that there are untold numbers of causal laws, all most directly represented using thick causal concepts, each with its peculiar truth makers" (2007b, p. 22).

In *The Dappled World* (1999) Cartwright dedicates Chap. 5, "Causal diversity; causal stability", "to Elizabeth Anscombe, from whom I learned" (1999, p. 135). The context of this chapter was to show the particularity and multiplicity of causes: there are very different kinds of causes and causes of the same kind can operate in different ways (cf. 1999, p. 104). She also quotes Anscombe (1971) in *Nature's Capacities and their Measurement* in this context: "often the operation of a cause is chancy: the cause occurs but the appropriate effect does not always follow, and sometimes there is no further feature that makes the difference" (1989, p. 105).

In the essay quoted by Cartwright, "Causality and Determination" (Anscombe 1971), Anscombe "refuse(s) to identify causation as such with necessitation" (1971, p. 88). This refusal involves both an argument against determinism as well as for indeterminism. She distinguishes between being determined in the predetermined and determinate senses. What has happened is determined once it happens and this is obvious (this is the sense in which Aristotle asserts that the past and present are necessary). What she is concerned with is pre-determination. Here she proposes this distinction: there are non-necessitating causes, or causes "that

[3] It can well be argued that Mill was fundamentally a Humean when he came to causality. The Humean concept of cause in its most basic sense, according to Fred Wilson (2007, p. 12), stems from our experience of matter-of-fact regularity. It relates phenomena to phenomena, not phenomena to *noumena*. A law is a regularity; to explain a fact is to put it under a law. For Hume a causal judgment is a judgment of regularity (Wilson 2007, p. 18). Craig Dilworth (2006, p. 14) thinks that in the spirit of Hume Mill identifies causality with succession. He also explains how N. R. Campbell attacked Mill for his Humean conception of causality as succession (2006, p. 27). John Skorupski (1989, p. 175) also asserts that Mill regards causation exclusively as a relationship between phenomena. All we know are uniformities in the spatio-temporal relations among phenomena. We know nothing about 'metaphysical' causes and we do not need to take them into account in inductive reasoning. Geoffrey Scarre (1998, p. 114) considers Mill's scientific project as metaphysically abstemious about causes. They are mere constant conjunctions.

[4] It is the Inaugural Lecture for the chair that had been held by Ludwig Wittgenstein at Cambridge. Anscombe studied with Wittgenstein and was one of his literary executors (she translated some of his works and wrote *An Introduction to Wittgenstein's Tractatus*). She was an Aristotelian and her most famous book, *Intention*, inspired by Aristotle, became a philosophical classic.

can fail of [their] effect without the intervention of anything to frustrate it" and necessitating causes, or causes that can only be frustrated by interference.[5] Indeterminism, then, is the thesis that not all physical effects are necessitated by their causes. This does not mean, however, that indeterminate effects have no causes (1971, p. 101).

Anscombe's account of causation fits with Cartwright's ideas. For Cartwright, first we observe singular causality, then we search among the causes we observe for those that are stable, and finally we say we have a law and a set of causal laws or capacities—a nomological machine—that would hold if there were no interferences with them. There is a plurality of causes, and indeterminism may hold even in the physical realm (see Newman 1995, p. 277 on Cartwright's denial of ontological determinacy).

Cartwright also considers necessitating and non-necessitating causes. We find an example of her consideration of necessitating causes when Cartwright states (1995, pp. 179–180):

> I would say that our central usage of tendency terms supposes that the association of tendencies with properties or structures (…) need not be universal; it may hold across certain regimes or domains. But within the domain in which the claim of association can be regarded as true, the tendency when appropriately triggered will always operate unless there is a good physical reason why not.

In this respect, Cartwright distinguishes the interferences of tendencies specified by rules of composition (or cases of "co-action", e.g., 1995, pp. 179 and 180) and interaction, "when the tendencies associated with a given factor are changed in the presence of another" (1995, p. 180). Cartwright refers to Anscombe's non necessitating causes when she asserts that "the exercise of a capacity need not occur universally upon triggering even when nothing interferes" (2007a, p. 20; cf. also 2, 4, 50–1). She gives a physical (the quantum capacity of an excited atom to emit a photon) and a "human" example: "triggering my irritability *can* produce anger but it *may not* (…) It may even happen that the capacity is there all my life and never exercised" (2007a, p. 20). This kind of cause evidently entails a difficulty for scientific explanation and an even greater one for prediction.

In conclusion, Cartwright supports a notion of non-deterministic singular real causes and she holds that scientific explanation is the knowledge of these causes. The influence of Aristotle's thought on Cartwright's goes beyond this Introduction and is the topic of the following section. Section 2.3 will deal with Cartwright's skeptical position about the possibility of explanation in social science. In Sect. 2.4 I will develop a proposal for socio-economic machines based on her thought in order to overcome the reasons of her skepticism.

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[5] For example, tetanus is a necessitating cause of death because without treatment it is not possible for one who has tetanus to survive.

2.2 The Cartwright–Aristotle Connection

I have divided this section into three sub-sections: in the first sub-section I will present the connections between Aristotle and Cartwright, and in the second and third sub-sections I will offer an Aristotelian account of Cartwright's ontology and epistemology of capacities.

2.2.1 The Connection

Aristotle is an author often quoted by Cartwright. The references she makes to the Greek philosopher show how ontologically radical her conception of capacities is, because she identifies them with Aristotle's concept of nature, a radical inner principle of things. For both Aristotle and Cartwright, if we do not consider natures we do not arrive at a real explanation of things and events. Cartwright cites the *Physics*, the *Metaphysics*, the *Nicomachean Ethics* and his scientific treatises. Her acknowledgment of Anscombe might also be regarded as Aristotelian.

Cartwright explains in Chap. 6 of *The Dappled World* (reprinted with slight changes in 2001):

> [The thesis that] I am most prepared to defend, follows Aristotle in seeing natures as primary and behaviours, even very regular behaviours, as derivative. Regular behaviour derives from the repeated triggering of determinate systems whose natures stay fixed long enough to manifest themselves in the resulting regularity (1999, p. 149; 2001, p. 290), [i.e., a NM].

In Chap. 3 of *The Dappled World* she asks: "What facts then are they that make our capacity claims true?" She concludes:

> [T]he best worked out account that suits our needs more closely is Aristotle's doctrine on natures, which I shall defend in the next chapter. Capacity claims, about charge, say, are made true by facts about what it is in the nature of an object to do by virtue of being charged. To take this stance of course is to make a radical departure from the usual empiricist view about what kind of facts there are (1999, p. 72).

Instead of the usual empiricist view, she adopts an "Aristotelian empiricist" view. Let me explain what I mean by this expression. The view that most scholars hold about Aristotle's doctrine of science originates in his account of a necessary, deductive science. Aristotle, however, only exceptionally—for example in logic and mathematics—deals with science in the way detailed in the *Posterior Analytics*. This is the book where Aristotle characterizes that kind of science. It is one of the books in the set of books on logic, called *Organon* (i.e. "instrument" of thinking). Jean Marie Le Blond, in his classic *Logique et Méthode chez Aristote*, maintains that "the books composing the *Organon*, are more concerned with *explaining* science in a rigorous way than with *doing* science. His scientific books, on the other hand, focus on research and they are the ones that reveal the method" (1939, p. 191). That is, the *Organon* contains a theory of science, while the scientific books are actual science that does not always follow the precepts of the theory. In fact, in his scientific studies—especially the biological (*On the Part of Animals*, *The History of Animals*), physical (*Meteorology*), and practical ones (Ethics and Politics)—Aristotle allows plenty of room for experience, and he does this in order to discover and also verify scientific principles (see Lloyd 1974, pp. 99–124). He says in *Generation of Animals* (concerning his observations about the generation of bees) that "credit must be given rather to observation than to theories, and to theories only if what they affirm agrees with the observed facts" (III 10, 760b 31; cf. also *De Anima*, I, I, 639b 3 ff. and 640a 14 ff.). Causes are grasped by a sort of intellectual intuition—called abstraction—that presupposes experience but is not based on a complete enumeration of cases. Moreover, sometimes, one or a few cases suffice to abstract the universal (see Jaakko Hintikka 1992, p. 34). But they still have to pass the test of verification. Le Blond shows how Aristotle uses experience in detailed observation as well as in experiment: it is a "flux and reflux of the research going from facts to theories and from theories to facts" (1939, p. 242). This clearly explains why Aristotle states in *Nicomachean Ethics* (VI, 8) that "a boy may become a mathematician but not a philosopher or a natural scientist." The reason, he adds, is that the philosopher and the natural scientist need experience. He states in *On Generation and Corruption* (I 2 316a 5–8):

> [l]ack of experience diminishes our power of taking a comprehensive view of admitted fact. Hence those who dwell in intimate association with nature and its phenomena are more able to lay down principles such as to admit of a wide and coherent development.

In other words, experience plays a fundamental role in Aristotle's real science, an experience that allows us to reach real causes. This is my interpretation of Cartwright's proposal. For Cartwright (2007c), in Aristotelianism "the laws of science describe the powers that systems in Nature have by virtue of certain facts about them" (2007c, p. 21). She adds: "I endorse this kind of pre-Cartesian/pre-Humean empiricism and I have spent a lot of effort trying to show that notions like powers and causings are not only compatible with an empiricist view of science but that we cannot make sense of science without them" (2007c, p. 22).

On "Aristotelian Natures and the Modern Experimental Method" (1992), Cartwright persuasively shows that what science actually does by studying "the inner constitution [of things and events] is a study of an Aristotelian-style nature" (1992, p. 69):

> Still, I maintain, the use of Aristotelian-style natures is central to the modern explanatory program. We, like Aristotle, are looking for 'a cause and principle of change and stasis in the thing in which it primarily subsists' [*Physics* II, 1, 192b22], and we, too, assume that this principle will be 'in this thing of itself and not *per accidens*' (1992, p. 47).[6]

[6] She adds three differences between Aristotle and modern science: (1) the change for substances to structures; (2) that causes often do not reveal themselves directly but by experiments; (3) coming back to (1) stressing the stability of structures (1992, p. 47; 1999, p. 81). She emphasizes that the properties studied by modern scientists do not reveal the essence of that to which they belong (1992, p. 48; 1999, p. 82).

However, nature is captured by its empirical manifestations. We arrive at nature through its acts:

> I want to recall the Aristotelian idea that science aims to understand what things are, and a large part of understanding what they are is to understand what they can do, regularly and as a matter of course (Cartwright 2001, p. 277).

This is why for her it is important to look at the actual practice of science.[7]

We may draw a parallel between this search for inner causes and Woodward's search for phenomena through data. This is an Aristotelian empiricism: through observations the mind captures something that is beyond it and that is the real explanation of the observed object and its actions. This is the work of theoretical reason. This is why, according to Cartwright's conception of empiricism, we need powers and causes: they are the real support and the explanation of the observable.

Having presented the connections between Aristotle and Cartwright's thoughts I think that deepening her Aristotelian roots is valuable because it will consolidate and bring more strength to her position. First, I will analyze the ontology of Cartwright's capacities from an Aristotelian perspective. Then I will tackle the topic of the knowledge of capacities.

2.2.2 The Ontology of Capacities

According to Cartwright, capacities, natures, or "powers to do" are real causes (cf., e.g., 1989, p. 182). They have three elements: (1) potentiality: what a factor can or tends to do in the abstract; (2) causality: they are not mere claims about co-association; (3) stability (Cartwright 1998, p. 45). She calls them "natures" (1992) and quotes—as already noted—Aristotle's definition of nature as "the cause and principle of change and stasis in which it primarily subsists in virtue of itself" (*Physics* II 1 192b 22–3). She then argues that this is what she intends to mean by capacity (1992, p. 71, nt. 7). Hence, capacities are then internal forces, or 'inner causes'.

According to Aristotle, a capacity or *Dynamis* is a "power to do". He defines it as "a source of movement or change, which is in another thing that the thing moved or in the same thing *qua* other" (*Metaphysics* V, 12, 1019a 15–6). *Dynamis* is an "urge of nature to grow to maturity, to realize form, and to perform the due

[7] This argument is central to her philosophy of science, as argued by Hands: [T]he final court of appeal for philosophical debates about science is the actual practice of science (…). [W]hat science is must be regulated by the practice of science, and she argues repeatedly that real practicing scientists actually do presuppose that capacities and causal powers exist in systems they study (2001, pp. 313 and 315). Hands attributes this to Otto Neurath's influence.

function” (Guthrie 1967, p. 140).[8] With respect to causes, Aristotle uses the idea of potentiality in reference to material cause. However, for Cartwright and also for Aristotle, the causal structure of a nature (formal cause) is the most relevant cause in the very being and in the scientific explanation of a concrete phenomenon. Causes, in any case, are the four kinds of causes considered by Aristotle, material and formal, efficient and final (*Metaphysics* I, 3–10; *Physics* II, 3) that allow different types of explanations, “a doctrine of four becauses” (John L. Ackrill 1981, p. 36) that answers to these questions: of what is this made? (material cause), why is it this thing and not other? (formal cause), who made it? (efficient cause), and for what is this made? (final cause).[9] Aristotle explains it in the *Physics* (II, 3 194b 16–35):

> In one sense, then, (1) that out of which a thing comes to be and persists, is called ‘cause’, e.g., the bronze of the statue (…). In another sense (2) the form or the archetype, i.e., the statement of the essence, and its genera, are called ‘causes’ (…). Again (3), the primary source of change or coming to rest; e.g., the man who gave advice is a cause, the father is the cause of the child (…). Again (4) in the sense of end or ‘that for the sake of which’ a thing is done (…)..

According to Aristotle, the way to explain these causes is through theoretical knowledge. According to Cartwright, there are different kinds of causes: “causation is not one monolithic concept” (2007b, p. 44). Aristotle also maintains this conception (*Physics* II, 3). However, Cartwright sustains that there is a common characteristic to the plurality of causes: “the idea that causes allow us to affect the world” (2007b, p. 46).

A capacity, for Aristotle, may also be a habit or disposition (*Categories* VIII) and an action or passion (*Categories* IX)—physical as well as human—i.e., kinds of accidents that admit variations of degree (a way of measuring).

When she refers to capacities’ stability and applicability (1989, p. 146; see also 1992, p. 51), Cartwright states that “capacities are much like essences”. In this regard, she asserts that her conception of capacities has Aristotelian resonances (1992, pp. 45–8, 69, 1999, p. 72; 2001, p. 277, 290). Among the Aristotelian causes, she assigns priority to the *form*, which is similar to causal structure (1989, p. 223). It seems then that capacities act necessarily, because if a natural thing has an essence or formal cause it will act according to it. But in nature, Aristotle holds, necessity is not absolute, but hypothetical.[10] The necessity of, for example, a specific matter is conditional on those formal and final causes (*Physics* II, 9; see also Richard Sorabji 1980: Chap. 9). He asserts (*Physics* II, 9, 200a 10–15):

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[8] *Dynamis* is a power, might, strength; an ability to do something, a faculty, a capacity: Greek-English Lexicon of Lydell—Scott (Oxford, Clarendon Press, 1900).

[9] For the Aristotelian doctrine of the four causes see, e.g., Anscombe and Geach 1961, pp. 44–54, Henry Veatch 1974, pp. 41–55, William Wallace 1996, pp. 3–34, or W. D. Ross 1959, pp. 74–78.

[10] On this topic see, e.g., Mansion 1913, pp. 169–178.

> For instance, why is a saw such as it is? To effect so-and-so and for the sake of so-and-so. This end, however, cannot be realized unless the saw is made of iron. It is, therefore, necessary for it to be of iron, if we are to have a saw and perform the operation of sawing. What is necessary then, is necessary on a hypothesis; it is not a result necessarily determined by antecedents.

That is, a specific matter is necessary given the end; but the end itself is not necessary. In nature events are generated by a conditional convergence of causes that do not always occur simultaneously. In the example of the saw the material and the end might not fit. In another passage he states that "some cases, moreover, we find that, at least, for the most part and commonly, tend in a certain direction, and yet they may issue at times in the other or rarer direction" (*On Interpretation* IX, 19a 20–3). What is material is contingent. This is an ontological matter. The constitution of natural material things is such that a convergence of principles is required to produce the very thing and its activities. "Those things that are not uninterruptedly actual exhibit a potentiality, that is, a may be or may not be. If such things may be or may not be, events may take place or not" (*On Interpretation* IX, 19a 10–3). One of those principles is matter "which is capable of being otherwise than as it usually is" (*Metaphysics* VI, 2, 1027a 14). This case corresponds to Anscombe's non-necessitating category, "one that can fail of its effect without the intervention of anything to frustrate it" (1971, p. 101). In addition, Aristotle also considers the possibility of defects, both in arts (technique) and nature (*Physics* II, 8, 199a 33–199b 6). This is a first reason for the contingency of causes in the natural field, but that also applies in the social field. Indeterminism, I asserted with Anscombe and Cartwright, is the thesis that not all effects are necessitated by their causes. That is, the effect could not be produced, not because of the action of an outside influence, but rather due to the inaction of the very internal cause of the effect.

A second reason for contingency is found in causes acting from outside. Aristotle considers luck (*týche*) and spontaneity (*automáto*) (*Metaphysics* XII, 3, 1070a 6–7; cf. also VII, 7, 1032a 12–3). Both terms express an event that results from coincidence (*apo symptômatôn*: *Physics* II, 8, 199a 1–5). But, does coincidence rule out causality? Aristotle's answer is "no"; lucky or spontaneous events have causes; but they are indefinite: "that is why chance is supposed to belong to the class of the indefinite and to be inscrutable to man" (*Physics* II, 5, 197a 9–10). Causes acting from outside might be unexpected because they are not known, or because they are known but cannot be shielded. In the former case, they are a source of contingency. Instead, in the latter case, they are not, because though undesired, they are known.

Aristotle maintains that when chance enters there is no regularity (*Physics* II, 8, 198b 35). However, as Ackrill (1981, p. 40) notes in reference to *Physics* II 7 198a 5–12, "luck and chance, he [Aristotle] is claiming, presuppose patterns of normal, regular, goal directed action". Thus, both luck and chance does not impede the tendency of capacities towards their ends. Let us hear Aristotle again:

> Those things are natural which, by continuous movement originated from an internal principle, arrive at some completion: the same completion is not reached from every principle [each one has its own], and it is not by chance; but always the tendency in each is towards the same end, if there is no impediment (*Physics* II, 8, 199b 15–19).

We have then an ontological foundation for both necessitating and non- necessitating causes; now for Cartwright's defense of indeterminism and singular causation.

2.2.3 The Epistemology of Capacities

How do we recognize capacities? This is not an easy task. Cartwright maintains that stable causes or capacities are known by intellectual abstraction (1989, p. 8, Chap. 5). She also shows that capacities—under specific (and difficult to achieve) conditions—can be deduced from probabilities, and that they can be measured (1989, pp. 1.4 and 2.4). However, this way of proceeding always assumes that we have some causes to begin with: "no causes in, no causes out" (1989: Chap. 2).

To measure capacities is not to understand capacities. We may measure some effects, or some things that cause other things, but not the causation itself. "We cannot, of course, tell by measurement itself that what we are measuring is a real capacity" (Cartwright 2007a, p. 42, nt. 57). Here, theoretical reason is needed. However, measurement is crucial in order to have initial experimental contact with data that manifest causes and effects and thus allow us abstract knowledge of them. As the classic dictum states, "nihil est in intellectus quod prius non fuerit in sensu"; this initial experimental contact is necessary. Perception and abstraction are closely related and are difficult to distinguish. In actual knowledge, the senses and the intellect intervene together. Causes are perceived by senses and understood by the mind.[11] This can also be applied to experiments. The cause may be assimilated to what Aristotle calls a "common sensible": "objects which we perceive incidentally through this or that special sense, e.g. movement, rest, figure, magnitude, number, unity" (*De Anima* III, 1, 425a 16–7). This perception is the basis of abstract knowledge of concrete causes and is complemented by it. Measures induce or allow us to infer an abstract knowledge of causation (Cartwright 2007b, p. 178). This involves a process of subtracting the concrete circumstances and the material in which a cause is embedded and all that follows as a result of this (Cartwright 1989, p. 187). In conclusion, this Aristotelian analysis confirms the real and profound nature of Cartwright's capacities and the need for them to be known by theoretical reason.

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[11] On the knowledge of causality see William Minto 1997, p. 36 ff..

2.3 Cartwright's Skepticism About Capacities in the Social Realm

Cartwright, however, is more skeptical about the possibilities of causal explanation in the social realm than in natural science.[12] I will first introduce the problem, the reaction of economists, and the problems with this reaction. Then, I will present Cartwright and Julian Reiss' proposed solutions. Finally, I will discuss Aristotelian arguments for Cartwright and Reiss's solutions.

2.3.1 Cartwright's Skepticism

In *Nature Capacities*, Cartwright sustains that both the natural and social sciences belong to a world that is governed by capacities that cannot be made sense of without them (1989, p. 2). However, it seems that there are some differences between the two types of science.

In the Introduction of this Chapter I presented Cartwright's notion of a nomological machine. She defines it as "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behaviour that we represent in our scientific laws" (Cartwright 2001, p. 292). That means that nomological machines might fail for three possible reasons: (1) lack of fixed enough arrangement of its components, (2) lack of stability in capacities, and (3) lack of stability in environment or circumstances (1999, p. 49). In the social field, capacities, their combination and circumstances are more prone to change.

Also in reference to the Anscombe–Cartwright connection in the Introduction, I mentioned the case of interaction, "when the tendencies associated with a given factor are changed in the presence of another" (Cartwright 1995, p. 180). She considers this case in *Nature's Capacities*: "the property that carries the capacity interacts with some specific feature of the new situation, and the nature of the capacity is changed" (1989, p. 163). As Julian Reiss (2008b, p. 265) notes, Cartwright even employs John Maynard Keynes ideas about a "holistic" world in order to support her skepticism about social capacities for this reason (Cartwright 1989, pp. 156–8). Circumstances leading to particular combinations affect the stability of causes. Cartwright asserts: "most of what happens in the economy is a consequence of the interaction of large number of factors" (Cartwright 2001, p. 279). She recently noted the "peculiar nature of the capacities at work in economics" (2007a, pp. 75 and 209: 50). She posits that Mill's analogy does not apply to economics: "this idea falls apart in typical economic cases" (ibid.). The results of economic events depend on structural circumstances. She adds that this

[12] For a discussion of Cartwright's skepticism see Boumans 2005, p. 102, Kevin Hoover 2002, pp. 157–8, 173 or Reiss 2008b.

point is apparent in Mill's work on psychology: "the capacity will not display itself in the 'expected' manifestations unless it is nurtured, trained and allowed to display itself freely" (2009, p. 51). She stresses that this is something that she has only newly discovered (2009, pp. 47 and 50). Her doubts about the appropriateness of Mill's analogy were already present in her 2001 paper (2001, p. 290): "there is no guarantee that the analytic method is the right method for all the problems that economics wants to treat." Things, however, are never black and white. Cartwright helps us arrive at a solution. She has recently stated:

> Social science is hard, but not impossible. Nor should that be surprising; natural science is exceedingly hard and it does not confront so many problems as social science—problems of complexity, of reflexivity, of lack of control. Moreover the natural sciences more or less choose the problems they will solve but the social sciences are asked to solve the problems that policy throws up (2007b, p. 42).

Although practicing social science is harder than practicing natural science, it is not impossible.[13] We are confronted with the additional problems of complexity, reflexivity and lack of control, which are another way of expressing the consequences of interactions. Without stability of causes we do not have capacities and without this, we cannot build social nomological machines. Cartwright fears that "causal interactions are interactions of causal *capacities*, and they cannot be picked out unless capacities themselves can be recognized" (1989, p. 164).

What do economists say when confronted with this problem? Economists are well aware of the necessity of stability of causes. Cartwright presents the example of the Cowles Commission's vision of econometrics: "Econometrics arises in an economic tradition that assumes that economic theory studies the relations between causes and effects" (1989, p. 149). Econometricians also assume that these causes are stable, like Mill's tendencies or Cartwright's capacities, always acting though not always observable (1989, p. 150ff.). They also assume that those causal relations are autonomous, i.e., they do not depend on other relations (1989, p. 155). In contrast, she notes that Keynes conceives of a world of causes but not of capacities (1989, p. 157). That is, the problem is not the absence of causes but

[13] What difficulties are added for Aristotle in the social realm? Concerning "chance", which is one of the roots of unexpected results, I mentioned that Aristotle distinguishes luck (*týche*) and spontaneity (*autómaton*), as different kinds of it. What is the criterion for this distinction? Luck pertains to the human and social realm, being a specific difference of spontaneity, the genus: "They differ in that 'spontaneity' is the wider term (…) Chance [luck] and what results from chance are appropriate to agents that are capable of good fortune and of moral action generally. Therefore necessarily chance is in the sphere of moral actions" (*Physics* II, 6, 197a 36–197b 2). This specific meaning of chance has a reason. According to Aristotle, the practical realm is more contingent than the natural realm. He identifies two reasons for this: "variety and fluctuation" (*daiphoran kai planen*) of actions. That is, there are many possible situations and the human being may change his decisions, i.e., it is free. Summing up, we have different Aristotelian reasons for uncertainty regarding the working of causes: (1) they might simply not act by themselves, (2) they might be modified by disturbing causes and (3) specifically in the social realm human, freedom might change or disturb causes; this is a realm of reflexivity, complexity, and singularity. On the role of freedom in social science and specifically economics, see Giorgio Israel 2007, pp. 19 and 21.

their instability. This is why she asserts that her claim is "not that phenomena of economic life are governed by capacities, but rather that the method for econometrics presuppose this" (1989, p. 158).

In addition, for Cartwright economists build "over-constrained" models (2007a: Essay V, especially 73–74, 2007b: Chap. 15, especially 219, and 2009, pp. 48–50) that are too "simple" or "sparse", not "simplified" representations of reality (2007a, p. 70, 2009, p. 46), in the sense that they are not Galilean idealizations. Galilean idealizations are abstract theories that put away disturbing causes to look for a key causal factor. Let us explain why economic models are not like this. Unlike physics, Cartwright notes, economics has very few uncontroversial principles or basic—not derived—capacities at its disposal. In economic models we thus use only a few principles (usually, the maximizing principle). Then, given that paucity of economic principles with serious empirical content, economic models need to make many unrealistic assumptions "in just the wrong way" (2007a, p. 78, 2009, p. 57). Why is this way wrong? We cannot build a model with the maximizing principle as the only constraint. We need to postulate several assumptions. "But then," Cartwright asserts, "we can read out only special-case conclusions, not general claims about the manifest results of the capacity" (2007a, p. 75, 2009, p. 50). As a consequence, "the results of the model are over-constrained [and] (…) the manifest results depend intimately on 'extraneous' factors—factors beyond those that define a Galilean experiment" (2007a, p. 74, 2009, p. 49). As a result, the conclusions of economic models are not applicable to real situations (2007a, p. 78 and V *passim* and 2007a, p. 57): "the unrealistic structural assumptions of the model are intensely relevant to the conclusion. Any inductive leap to a real situation seems a bad bet" (2007a, p. 70, 2009, p. 45). The models "buy internal validity [rigour: 2007b, pp. 234–235] at the cost of external validity" (2007b, p. 221).

Then, according to Cartwright, given the paucity of economic principles, economists moves the wrong direction by adding assumptions instead of looking at the structural circumstances that give rise to particular economic interactions. Cartwright asserts:

> The natural thought about the difference between the most fundamental capacities studied in physics and the capacities studied in economics is that the economic capacities are derived whereas those of fundamental physics are basic. Economic features have the capacities they do because of some underlying social, institutional, legal and psychological arrangements that give rise to them. So the strengths of economic capacities can be changed, unlike many in physics, because the underlying structures from which they derive can be altered (2007a, p. 54).

She then suggests that we should try to understand how these structures affect outcomes (2007a, p. 79, 2009, p. 57).

In conclusion, given that economic causes are highly dependent on structural circumstances and that we do not have many principles in economics, we need to find out how these circumstances affect the outcomes. These outcomes will consequently be "special-case conclusions, not general claims about the results of the capacity" (2007a, p. 75, 2009, p. 50). Let us consider Julian Reiss' view of the matter (Reiss 2008b).

2.3.2 Julian Reiss's Interpretation and Proposal

Based on his reading of Cartwright, Reiss first agrees that she is skeptical about the existence of social capacities: "to be consistent she cannot believe that the social world is actually governed by capacities" (Reiss 2008b, p. 265). Reiss's arguments concern the special nature of the social world (full of complex, unstable and interactive phenomena) and that social science methods (theoretical economics, natural experiments and singular causes analysis—or bootstrapping) fail to yield knowledge about social capacities. But, Reiss reasonably adds, although there is no good reason to believe in the existence of social capacities, there is also no good reason to believe they do not exist. He thus declares himself as an agnostic but not an atheist regarding social capacities (2008b, p. 278). Thinking in terms of capacities presupposes the applicability of a method of analysis and synthesis (composition law):

> Situations are broken down to tractable parcels, the behaviour of these parcels is analysed severally, and finally, the bits are synthesised to let us know about the initial situation (…) In the social sciences, by contrast, the method of analysis and synthesis (in this sense) seems less applicable. No factor produces anything on its own (…) We need a thick network of causal conditions to produce any result. Furthermore, the result that is actually produced very often depends crucially on the conditions that are present when the factor operates (2008b, p. 274).

Given that this method is less applicable in the social sciences, what are we to do? Reiss (2008b, pp. 280–5) first proposes a more empirically based detection of capacities. He holds that we should pursue a more empirical form of social science. For him, the empirical road has not been sufficiently traveled (2008b, p. 283). He brings up Gustav Schmoller's methodological principles of inductively proceeding situation by situation and says that he does not see a better way of finding social capacities. Cartwright agrees: "we need to look on a case-by-case basis" (2008b, p. 290).[14]

Second, Reiss also suggests we try "to find a number of "off-the-shelf" principles that are informative about how to export claims established by a natural experiment to other contexts" (2008b, p. 282). He offers as an example Geoffrey Hodgson's proposal for general biological, psychological, anthropological and sociological principles abstracted from history (Hodgson 2001, pp. 326–7).

Putting together Cartwright and Reiss's suggestions we reach a sensible strategy for dealing with the social field: to pursue more empiricist work, to analyze the influences of underlying structures (which act as occasional causes if not

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[14] This local character of economic truths recalls Keynes' advocacy of the role of economics concerning models: "Economics is a science of thinking in terms of models joined to the art of choosing the models which are relevant to the contemporary world (…) *Progress* in economics consists almost entirely in a progressive improvement in the choice of models (Keynes 1973, p. 296). (…) Good economists are scarce because the gift for using 'vigilant observation' to choose good models (…) appears to be a very rare one (Keynes 1973, p. 297). The specialist in the manufacture of models will not be successful unless he is constantly correcting his judgment by intimate and messy acquaintance with the facts to which his model has to be applied" (Keynes 1973, p. 300).

capacities), to look for "off-the-shelf" possible principles, and to be conscious of the context dependence of conclusions.[15]

Given these constraints on social sciences, in the next Section I will propose a proceeding to deal with social phenomena which, though elaborated on the basis of Cartwright's thought, goes beyond it. This proposal is related to the specific role that Cartwright assigns to social sciences: they are "asked to solve the problems that policy throws up" (2007b, p. 42).

2.4 Socio-Economic Machines

Suggestions for a positive proposal were introduced in the last Section. A synthesis of those conclusions is that, on a case by case basis, we need to focus on local conditions of economic events thus looking for the *specific capacities* acting in those situations. That is, I am relaxing the condition of the stability of Cartwright's capacities. We should look for a set of very diverse local causes interacting as opposed to a kind of almost universally stable capacity. As Raymond Boudon (1998, p. 72) asserts, "social mechanisms tend to be idiosyncratic and singular." Extra principles would be helpful for this work. In addition, we can conclude that stable institutions might be of great assistance by bringing structural stability to social events.[16] Once institutions are consolidated, those local causes may acquire the stability proper of a capacity, however, never as stable as physical capacities.

Cartwright speaks about complexity, reflexivity and lack of control as causes of additional difficulties in explaining causes in the social realm (2007b, p. 42).

[15] Concerning Aristotle we find in his work: (1) a justification of uncertainty in the natural and social fields and of the consequent hard character of natural and social science, (2) a case-by-case analysis of particular practical situations, (3) some general principles or capacities of human beings and (4) an emphasis on institutionalized behaviors that may give rise to stable causes. That is, we find in Aristotle arguments for the Reiss-Cartwright strategy. For Aristotle, complexity and reflexivity imply "variety and fluctuation", and rule out general analyses of social matters. These "problems" are related to human interpretations and freedom, which paradoxically are some of the most valuable human characteristics. These "limitations" entail the definition of well-delimited subjects if we want to explain. The perspective on prediction is even more limited because conditions are always prone to change. However, all these difficulties do not rule out capacities, though their contents surely change depending on the underlying institutional structures.

[16] This view is also held by Aristotle. For him the stability of causes of social phenomena presupposes their embodiment in institutions (in the broad sense of the term that includes habits, routines and institutions in a narrow sense). Generalizations in practical science are based on actual dispositions or habits. The more stable the habits and tendencies the more predictable the outcomes. Aristotle develops a theory about the stability of habits (*Nicomachean Ethics*, VII, 9, 1151b 25–7 and VII, 10, 1152 a, 26–7). When habits are sufficiently stable as to constitute social institutions, practical science is firmly based. Therefore, institutions are very important for they consolidate tendencies and habits and facilitate a more accurate practical science. Thus, we can predict better when social institutions are solidly consolidated.

She also speaks about the derived nature of social capacities. They depend on social, institutional, legal and psychological arrangements that give rise to them, i.e., underlying structures that can be altered. Thus the social field entails a special kind of NM, a socio-economic machine (Cartwright 2001 and 2002). These socio-economic machines, given the nature of the economy, should be highly local: they are associations "generated by particular social and economic structures and susceptible to change by change in these structures" (Cartwright 2002, p. 141). Referring to one of the examples that she provides, she asserts:

> Each of the countries studied has a different socio-economic structure constituting a different socio-economic machine that will generate different causal relations true in that country and concomitantly different probability measures appropriate for the quantities appearing in these relations (Cartwright 2002, p. 143).

For Cartwright (2002, p. 143), we need arguments both at the phenomenological and theoretical level to gain knowledge of those local particularities. Models are blueprints of those socio-economic structures (Cartwright 2002, p. 150). On the one hand, these blueprints must maintain a close relation to the specific situation they aim to explain. In this regard we have Aristotle, Keynes and Cartwright together in agreement. On the other hand, the greater the scope of the related institutions, the greater will be the universality or scope of the socio-economic machine.

This story, however, does not end here. I propose that we deepen Cartwright's concept of a NM. What kind of reality is it? It is a real configuration of stable causes, a system of components with stable capacities (1999, p. 49). However, there is a nuance in Cartwright's concept of NM when it refers to the social field. In these cases, rather than an established arrangement that is "there outside" and that is only explained, a machine is a system that we build as a way of producing a result. Consider the following passages:

> In building the machine we compose causes to produce the targeted effect (1999, p. 65). …you give me a component with a special feature and a desired outcome, and I will design you a machine where the first is followed by the second with total reliability (1999, p. 72). … [W]e always need a machine (…) to get laws—(…). Sometimes God supplies the arrangements—as in the planetary systems—but very often we must supply them ourselves, in courtrooms and churches, institutions and factories (1999, p. 122). Just as the science of mechanics provides the builder of machines with information about machines that have never been constructed, so too the social sciences can supply the social engineer with information about economic orders that have never been realised. The idea is that we must learn about the basic capacities of the components; then we can arrange them to elicit the regularities we want to see. The causal laws we live under are a consequence—conscious or not—of the socio-economic machine that we have constructed (1999, p. 124).

That is, while in subjects such as physics we have one kind of machine, another kind of machine that could be labeled "practical" is more suitable for technical and practical fields. This is an arrangement meant to achieve a particular result. Thus, the machine suitable for the physical field may be called a natural machine in the sense that it stems from a natural arrangement and naturally produces its effect, without intervention of outsiders. It is also a "theoretical" machine in the sense that we do not intervene or try to change it. "Practical" machines are especially relevant for Cartwright. She stresses the importance of the *construction* of regularities (see, e.g., 1989, p. 182). As she states in the Introduction to *the Dappled World*, "I am interested in intervening". So the question is: "how can the world be changed by science to make it the way it should be?" (1999, p. 5). In the Introduction to *Hunting Causes and Using Them* (2007b, p. 1) she adds that the three questions, what are our causal claims, how do we know them, and what use can we make of them, play a central role.

In this second kind of machine, i.e., practical, with its correspondent design, there are roles for theoretical, practical and technical reason. By using theoretical reason we learn about the basic capacities of the components (1999, p. 124) of the practical machine, and about the relationships among them. We need to develop concepts and rules for combination that work properly in tandem. It is not easy but possible (cf. 1999, p. 56). These concepts and rules are known by theoretical reason. We also make use of technical and practical reason to design rules. Both uses of reason are implied in the quoted statement: "how can the world be changed by science to make it the way it should be?" (1999, p. 5). We have to define how the world should be—practical reason's role—and how this can be achieved—the task of technical reason in combination with practical reason in the way we organize productive actions.[17]

How do we design these practical machines? Their design starts with their blueprints. For Cartwright, theory is not enough because it gives purely abstract relations between abstract concepts. We need to develop *representative* models to represent what happens in specific situations. If the situation modeled is regular and repeatable, these models are like blueprints for nomological machines (1999, p. 180). This kind of model, Cartwright holds, may "provide precisely the kind of information I identify in my characterization of a NM" (1999, p. 53).

Theoretical reason also has a key role in the formulation of models. We must take into account all the relevant factors and their relationships. As Cartwright argues that the situation must resemble the model and nothing too relevant should occur in the situation that cannot be put into the model (cf. 1999, p. 187).

[17] In the *Metaphysics* Aristotle distinguishes between two kinds of human actions. First, *immanent* actions, that is, actions whose aim is the action itself such as seeing, thinking or living. The results of immanent actions remain in the agent. Second, he notes *transitive* actions where the "result is something apart from the exercise, (and thus) the actuality is in the thing that is being made" (*Metaphysics* 1050a 30–1). Transitive actions are actions the results of which transcend the agent and are something different from the agent as, for example, a good produced. Aristotle calls immanent action *prâxis* and transitive action *poíesis* (*Nicomachean Ethics* VI, 4, 1140a 1). Practical and technical reasons regulate the practical and *poietical* aspects of actions. All actions are both immanent and transitive except in the case of a fully immanent action (to think, to love). Let me provide an example: when somebody works there are two results, i.e., an 'objective' result, such as the product or service (transitive), and the 'subjective' result such as the increase in ability or the self-fulfilment of the agent as well as the morality of the act (immanent). Technical perfection may not be enough. We may be demanded to fulfil other goals different from the very product during its production. There is a continuum of practical and technical reasoning in the performance of a transitive or productive action.

Models can have explicative (theoretical) or productive (practical) roles, depending on their subject. Practical and technical reasons intervene in the design of the latter category of models. For Cartwright, in economics, we often use these latter models:

> Models in economics do not usually begin from a set of fundamental regularities from which some further regularity to be explained can be deduced as a special case. Rather they are more appropriately represented as a design for a socio-economic machine which, if implemented, should give rise to the behavior to be explained (2001, p. 278).

One task of economics is the explanation of economic events. Another is the prescription of individual or economic behaviors in order to reach a goal, a normative task. This normativity may be practical (related to ends) or technical (related to means). Hence, we might postulate different types of socio-economic machines and models: theoretical and practical machines and models. Practical models have two tasks: determining and prescribing ends and means. Theoretical reason provides the concepts and knowledge of causal links for both kinds of machines. Practical and technical reason enters into the second kind of machine and model.

Human and social ends are not simply data but tasks to be performed. Thus, they are normative. We can assume that man is rational, but he is also often irrational. As an empirical postulate, rationality often fails. This is why socio-economic theoretical models will frequently fail. Instead, we can always use rationality as a normative postulate.

Practically-designed machines are also local but they share some common principles. In Chap. 4, I will propose these common general principles (Sect. 4.1.2). There are two types of these: 1. a few general anthropological constants of human beings that are capacities, and 2. some capabilities that can be assumed as ends in practically-designed socio-economic machines. I will also argue that these capabilities are in themselves capacities and, in addition, they are capacities of the human realm (Sect. 4.2). Then, we will look for the specific derived principles for each situation.

In sum, socio-economic machines assume general principles but need to be local, adapted to the conditions and institutional arrangements of each situation. That is, the stress of Julian Reiss (2008a) in a more evidence-based methodology is highly relevant. However, as mentioned, the broader the institutions, the more universal in their applicability, because, in fact, institutions are practically-designed devices that insert predictability into the realm of hazard and freedom. We need theoretical reason to know their specific natures and conditions that affect their working. A specific economic policy, for example, is a design of a socio-economic machine. It defines goals and means to attain them. Both the goals and the means may or may not coincide with social and individual goals. Then, disturbing causes may interfere. The alignment of policy and personal goals is the difficult task of practical reason; once achieved, the road of technical reason is more straightforward. This alignment of goals and design of the way to attain them is the task of practical models.

Practically-designed socio-economic machines are the work of practical reason concerning ends and of technical reason concerning means, also using theoretical concepts. The contingency of the practical field is overcome by its design and by continuous adjustments and hyper-careful tuning. Institutions may manage and provide legitimacy to this work of theoretical, practical and technical reason. Institutions actually are socio-economic machines from which stem other socio-economic machines. A Central Bank originates monetary policies and consequently monetary facts, and it is continuously checking the results and making policy modifications to reach at the desired results.

2.5 Conclusion

The search for causes serving as the way of arriving at explanations in science has not been the usual position in the philosophy of science of modern times. However, some philosophers have not abandoned this classical goal. Cartwright is one of them. She has clearly held that explanation is the aim of science and that science should explain real causes using theoretical reason.

She originally regarded Mill's concept of tendencies as a similar attempt. Nevertheless, Mill is not a good ally for Cartwright's project. He has interesting insights but they are blended with seemingly inconsistent positions. His theory of causality appears to be inconsistent and he adheres to determinism.

In Aristotle and in Anscombe's interpretations of causality we find more adequate companions to sustain an alternative doctrine of explanation by real causes in sciences—about their singularity and about indeterminism. This proposal entails the acceptance of metaphysics, i.e., that causes are ontologically real, not mere products of the senses or the mind. From this perspective causality is a process of actualization of the power of an entity that may or may not occur due to internal or external factors. Matter, as conceived by Aristotle, is open to different actualizations. "What desires the form is matter, as the female desires the male" (*Physics* I 9 192a 22–3); but the adequate form is not always present. And that may be either because there is no agent, or because the agent is not capable, or it does not have the proportionate end to produce the effect. Additionally, disturbing causes often interfere with capacities; they are eliminated when they are mixed together; and even affected by freedom in the human field. We may know sometimes, but the richness of reality is such that it is often impossible to know. We are not gods. Our limited knowledge, however, is enough to manage our lives in an appropriate way.

Nancy Cartwright assumes a relatively greater difficulty in achieving causal explanations in the social realm than in the natural one. Given the similarity of her conceptual framework for causal explanation to that of Aristotle and Anscombe, I have suggested that they could offer good philosophical arguments to justify this difference. The greater complexity, the reflexivity and the lack of control have to do with singular human situations and with human freedom.

The specific limitations of the social realm have led economists to design specific formalized models. But Cartwright offers a warning. The social scientist must be careful about stating which real capacities are presupposed in his/her models as blueprints of NM (Cartwright 1999, p. 53 ff.). This care entails a careful observation and verification. Let us hear again from Aristotle: "credit must be given rather to observation than to theories, and to theories only if what they affirm agrees with the observed facts" (*Generation of Animals* III 10, 760b 31).

Indeed theories are often too general and do not achieve real explanations: we thus need models. Although those models need "hyper-fine tuning" (Cartwright 2002, p. 146), they leave the doors opened to hope: "social science is hard, but not impossible." This hope stems from the stability or regularity produced by institutions, habits or routines (Cartwright 1999, p. 138). It seems then that the correct way of practicing social science should start by studying the underlying structure of social capacities and events (Cartwright 2007a, p. 79, 2009, p. 57).

Finally in this Chapter, based on Cartwright, I proposed that we distinguish between different types of socio-economic machines and models: theoretical and practical machines and models. Practically-designed machines are governed by practical and technical reason and can be embodied in institutions. Models are the blueprints of those machines. This set of conceptual tools will be fundamental in Chap. 5 for the formulation of a proposal of socio-economic practically-designed machines and practical models, a proposal that points to one of the hypotheses of this book: we can combine Cartwright's NM with Sen's capabilities and thus get a way of inserting theoretical and practical reason into social science—specifically economics. Given the ontologically based difficulties of the practical realm the way of dealing with it is by impressing on it a normative order that respects its natural order and human freedom. This is the role of practical reason.

In conclusion, Cartwright reinfuses science, including social science, with theoretical reason. To explain by causes requires the use of theoretical reason. This does not mean that this knowledge is universal; it recognizes the changing nature of some subject-matters, and concentrates on local knowledge in these cases. Theoretical knowledge is a key element because it provides the concepts that practical and technical reasons need to operate. There are, as noted, some tensions in Cartwright's thought. However, here we take consistent elements from her, very well fitting with the aim of the book; specifically, in this case, the need for using theoretical reason. The next two Chapters will focus on the reinsertion of practical reason in economics and Chap. 5 will apply the three types of rationality to a case study: The Human Development Index.

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