SCIENTIFIC EXPLANATION, NECESSITY & CONTINGENCY

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1. *Introduction*

In this paper I shall discuss the relations between contemporary theories of scientific explanation and general "images of science" (i.e. more or less articulated views on the essential characteristics of scientific theories). More specifically, the results of studies in the domain of explanation will form my basis for criticizing a generally accepted image of science, viz. the idea that science is a system of natural (or social) laws that express relations of physical (or social) necessity between subsequent or simultaneous events. In general, images of science may be identified by means of the modalities that are crucial in it. To clarify this, it is useful to give the following definitions:

□A = the occurrence of A is necessary
□'A = □~A (= the occurrence of A is impossible)
◇A = ~□~A (= the occurrence of A is not impossible)
◇'A = ~□A (the occurrence of A is not necessary)
ΔA = ~□~A&~□A (= the occurrence of A is contingent)

Science then may be seen as a system of phrases of the form "If A, then □B". Scientific progress means to move from a situation where ΔA to a context in which □A. The opposition between the modalities □A and ΔA therefore is crucial in the image of science I just sketched. Throughout this paper, it will be necessary to refer to other images of science. For sake of clarity, I shall define them by referring to a crucial opposition between two modalities, as I have done here.

My main thesis is that the image of science I described is not compatible with any adequate theory of scientific explanation. Arguments for this thesis are given in section 2 of this paper. Section 2.1 includes some general remarks about the structure and the components of theories of explanation. In section 2.2, I describe the relevant aspects of two such theories: Hempel's

DN-IS model and Salmon's causal approach. In section 2.3, the main argument is developed: I shall point out that the theories of Hempel and Salmon lead to images of science in which the contingency-necessity opposition is not essential. For both theories, I shall propose a characteristic pair of modalities to replace this opposition. In section 2.4, I will clarify my thesis by making a complete turn in the argumentation: I'll start from a theory of explanation which corresponds to the contingency-necessity image, and show that such a theory is always inadequate.

Section 2 deals with science in general. But since the subject of this volume is above all social science and history, section 3 will deal with two major sociological research traditions. The aim is to show that our general conclusions are valid here too, and to give these general conclusions more substance.

2. *Explanation and modalities: general account*

2.1 *Elements of a theory of scientific explanation*

My starting point is the theory of scientific explanation that is developed by Bas Van Fraassen in "The Scientific Image". According to Van Fraassen, an explanation is an answer to a question (Q) of the form "Why P_k?", where P_k states the phenomenon or fact that is to be explained (i.e. the explanandum). P_k is also called the "topic" of the why-question. But why-questions cannot be identified completely by means of their topic alone. The question "Why did John steal a car?" may have different interpretations: "Why did *John* (and not Jack) steal a car?", or "Why did John steal a *car* (and not a bicycle)?". To cope with this problem, Van Fraassen introduces the concept of the "contrast-class" of a why-question. A contrast-class X of a why-question Q is a set of propositions P_1, P_2, P_k, ..., P_n where P_k is the only member of X that is true. In our example, the (false) proposition "Jack stole a car" would be a member of the contrast-class, at least for the first interpretation of the question, while "John stole a bicycle" would be a member of the contrast-class for the second interpretation. Taking these considerations into account, the canonical form of a why-question is: "Why P_k, and not $P_1 ... P_n$ (i.e. the rest of X)."

The canonical form of an answer to such a why-question is: "P_k in contrast to the rest of X, because A". Of course there are some conditions to be met to have an adequate answer. Van Fraassen's conditions are:

(1) P_k is true.

(2) In X, only P_k is true.
(3) A is true.
(4) A bears relation R to $\{P_k, X\}$.
The relation R is a relevance relation, which Van Fraassen does not specify because he's convinced that such relation is never context-independent. So Van Fraassen thinks that there is no relevance relation which is valid in all scientific disciplines. Relations like intentionality and functionality e.g. may be important in social sciences, but they are of no use in physical explanation. Of course there are many authors which disagree with Van Fraassen on this topic. They maintain that there is a general relevance relation, valid for all sciences, e.g. a causal relation between A and P_k (Salmon 1984, Cartwright 1983), statistical relevance (Salmon 1971, Gärdenfors 1980), derivability (Hempel).

The two aspects of Van Fraassen's theory we mentioned (viz. contrast-classes as tools for identifying why-questions, and the relativity of the relevance relation) cover two main issues which any theory of scientific explanation must deal with. To my view, there is one more such issue, so we may say that a theory of scientific explanation must have the following three components:
(1) An analysis of the context of explanation: When do we ask for an explanation? What are the presuppositions of explanation seeking questions? Van Fraassen's concept of a contrast-class and everything connected with is a part of such an analysis.
(2) In a second part of the theory, we have to specify the relevance relation between the explanans and the explanandum. According to Van Fraassen, no general answer can be given. On the other hand, several other philosophers have proposed such relevance relations.
(3) When we have dealt with the context of explanation (1) and minimal requirements on explanations (2), we may turn our attention to the evaluation of competing minimally sufficient explanations. Criteria to select the best explanation are to be described. Because Van Fraassen's criteria are quite complex, I shall not mention them. A less complex solution is Hempel's: deductive derivability and high a posteriori probability.

It is quite clear, I suppose, that the second component – the definition of the relevance relation – is the one that is important for us here. What we mean when we say that A explains B, depends on the way in which the relevance relation is specified. In section 2.2, two such specifications will be described, resp. to be found in Hempel (1965) and Salmon (1984).

2.2 *Hempel and Salmon on relevance relations*

In Hempel's theory of explanation, there are four criteria of adequacy for explanations:[1]

(1) An explanation is an argument with correct (deductive or inductive) logical form.
(2) At least one of the premises must be a (universal or statistical) law.
(3) The premises must be true.
(4) An explanation must satisfy the requirement of maximal specificity.

If we try to schematize this concept of explanation, we get the following well-known schemes:

(H1)	$L_1....L_n$	(general laws)
	$C_1....C_n$	(particular explanatory conditions)

	E	(fact to be explained)

and the statistical version

(H2)	$L_1....L_n$	(general laws, at least one statistical)
	$C_1....C_n$	(particular explanatory conditions)
	========r	
	E	(fact to be explained)

The essential characteristic of Hempel's analysis is that each explanation is considered to be an *argument*. If we translate this into Van Fraassen's terminology, we have a question "Why E?" and the answer "E, because C". Such an answer is correct if and only if we can construct an argument with C as singular premise and E as conclusion. So for Hempel the relevance relation is identical to the relation of (deductive or inductive) derivability.

Salmon's criticism of Hempel's definition of the relevance relation may be summarized as follows:

(1) Hempel's definition is too restrictive, because it excludes low probability explanations.
(2) Hempel's definition is too loose, because he doesn't take the a priori probability of the explanandum into account.

Ad 1: Hempel requires that the a posteriori probability of the explanandum (i.e. the probability of E, given C and L) is very high (in scheme (H2) this means that $1-r<\epsilon$, where ϵ is very low). This "high probability requirement" (HPR) is a corollary of Hempel's main thesis that each explanation is an argument: if the a posteriori probability of E is low, we don't say that a construction of the form (H2) is an argument for believing that E is true. Besides some practical problems (for instance: what is the value of ϵ?), Salmon has pointed out a more fundamental problem. By means of several examples, he shows that there are adequate explanations in which the a posteriori probability of the explanandum is very low. As a consequence, not every explanation is also an argument.

Ad 2: Salmon's second problem is best illustrated by the following examples[2]:

"John Jones was almost certain to recover from his cold within a week, because he took vitamin C, and almost all colds clear up within a week after administration of vitamin C."

"John Jones avoided becoming pregnant during the past year, for he has taken his wife's birth control pills regularly, and every man who takes birth control pills avoids pregnancy."

In both cases, the explanans is irrelevant: colds almost certainly disappear within a week *without* vitamin C, and men *never* get pregnant. So these explanations are inadequate, though they meet Hempel's requirements perfectly. The reason for this is that the a priori probability of E (i.e. the probability of E when C and L are not known) and its a posteriori probability are identical.

Salmon introduces the concept of statistical relevance (SR) to cope with these problems. A is statistically relevant for B in circumstances C if and only if $P(B|A,C) \neq P(B|C)$. From his (1971) paper, we can derive the following definition of the relation of explanatory relevance:

(S1) C is explanatory relevant for E if and only if
- (i) C is statistically relevant for E (in circumstances A)
- (ii) C is not "screened off" by a third factor B, for which $P(E|A,B,C) = (P(E|A,B)$
- (iii) C preceeds E in time

The first condition constitutes the main difference between Hempel's and Salmon's theory. This requirement solves the two problems we just described. It is therefore the main reason why Salmon's theory is to be preferred. The two other conditions are not crucial, because they are compatible with Hempel's definition (so they may be added as supplementary requirements).

In his (1984) book, Salmon makes a "causal turn". The relation of explanatory relevance is identified with the causal relation:

(S2) C explains E if and only if C is a cause of E.

Though the definition of the relevance relation is completely different, the criteria for adequate explanations included in (S1) are still valid. The three conditions of (S1) are now seen as *evidence* for the presence of a causal relation. In other words: these conditions are Salmon's answer to the question: "How can we prove that there is a causal relation between two phenomena C and E?" As a consequence, the causal turn has no implications as to the adequacy of explanations: the concrete criteria to eliminate inadequate explanations are the same.

The results of our discussion of Hempel and Salmon may be summarized as follows:

(1) We know how the relation of explanatory relevance is defined by Hempel.
(2) We know Salmon's first definition (1971).
(3) We know that Salmon's first definition is superior to Hempel's approach.
(4) We know that Salmon's second definition is also superior, because the criteria for the adequacy of explanations do not change.
(5) What we do *not* know yet is the meaning Salmon gives to the word "cause". We know how we can, in Salmon's opinion, *detect* a causal relation and *prove* its existence, but we do not know his *definition* of causation.

Do we need this definition? We can establish the superiority of Salmon's theory without using it. But if we want to discover which image of science Salmon's theory of explanation supports, it is necessary to pay some attention to his definition of causation.

In Salmon's view, the causal structure of the world has three fundamental aspects[3]: causal *processes*, causal *interactions* and *common causes*. A causal process is the means by which structure and order are propagated (transmitted) from one space–time region to other times and places. Causal interactions are the means by which modifications of a structure (as it is propagated in a causal process) are produced. Obviously, causal propagation (i.e. the essential characteristic of a causal process) represents the conservative aspect of causation (conservation of structure), while causal interaction represents the innovating aspect (production of new structures). An electromagnetic wave propagating through a vacuum, or a material particle moving without any net external forces acting upon it are examples of causal processes: in the absence of external influence, the existing structure is preserved. Various sorts of collision, or, in general, the fact that an external force acts upon a material particle, are examples of causal interactions.

Our common causal talk may be analysed in terms of causal processes and interactions. If, for instance, we say that a window was broken by boys playing baseball, we have a collision of a bat with a ball (causal interaction), the motion of the ball through space (causal process) and the collision of the ball with the window (interaction). I don't think we need *common causes* (Salmon's third concept) to complete this picture. In Salmon's view, common causes, like causal interaction, play a vital role in the production of structure and order. I will not explain here why I'm convinced that we don't need this third concept, since this is not important for our discussion. What is more important is that two of the three aspects of causation, viz. common causes and causal interaction, are defined in terms of *production*: these aspects are two specific ways in which a structure may be produced. The other aspect, causal propagation, is defined as "the ability of transmitting marks", which means that the essential characteristic of causal processes is their capability of mark transmission. Mark transmission (MT) is defined by Salmon as follows[4].

> MT: Let P be a process that, in the absence of interactions with other processes, would remain uniform with respect to a characteristic Q, which it would manifest consistently over an interval that includes both of the space-time points A and B (A ≠ B). Then, a mark (consisting of a modification of Q into Q'), which has been introduced into process P by means of a single local interaction at point A, is transmitted to point B if P manifests the modification Q' at B and at all stages of the process between A and B without additional interventions.

The elements of Salmon's theory of causation I sketched here will be sufficient, I think, to allow us to answer our main question, viz. what is the image of science that corresponds to Salmon's concept of explanation. Together with the analogue question for Hempel's theory, this will be the topic of section 2.3.

2.3 *Explanation and modalities*[5]

2.3.1 Hempel

It is typical of Hempel's account of explanations that there are no structural differences between explanatory and predictive arguments. Let's return to scheme (H1):

L:	$(x)F(x) \supset G(x)$
C:	$F(a)$

E:	$G(a)$

If, as Hempel requires, L and C are true, (H1) can be used as a prognostic argument, i.e. as an argument which tells us what we should believe (or should accept or expect). Consequently, Hempel's theory may be interpreted in terms of deontic modalities, or better: in terms of epistemic modalities ("believe", "expect" etc.) which are subordinate to deontic modalities. For the further development of this idea, I shall use the following deontic modalities:

$\Box !A$	= it is obligatory to do A
$\Box' !A$	= $\Box !{\sim}A$ (= it is forbidden to do A)
$\Diamond !A$	= ${\sim}\Box !{\sim}A$ (= it is not forbidden to do A)
$\Diamond' !A$	= ${\sim}\Box !A$ (= it is not forbidden to do A)
$\Delta !A$	= ${\sim}\Box !{\sim}A \& {\sim}\Box !A$ (it is permissible to do A)

In a next series of definitions we make the epistemic modality "expectation" subordinate to these deontic modalities:

$\Box {*}A$	= it is obligatory to expect A
$\Box' {*}A$	= $\Box {*}{\sim}A$ (= it is forbidden to expect A)
$\Diamond {*}A$	= ${\sim}\Box {*}{\sim}A$ (= it is not forbidden to expect A)
$\Diamond' {*}A$	= ${\sim}\Box {*}A$ (it is not an obligation to expect A)
$\Delta {*}A$	= ${\sim}\Box {*}{\sim}A \& {\sim}\Box {*}A$ (=it is permissible to expect A)

Using this terminology, Hempelian explanation may be described as follows:

> "Starting from a knowledge situation in which $\Box' {*}E$ or $\Delta {*}E$, we construct an argument which results in a new knowledge situation, in which $\Box {*}E$."

We have to conclude that there is no *immediate* link between Hempelian explanation and necessity or contingency. The only modalities that are immediately involved are deontic, and in a subordinate role, epistemic.

The general image of science which may be derived from Hempel's theory of explanation is that of a system of "imperatives of expectation" of the form "If C, then $\Box {*}E$". It is only a small step from the practical concept of an imperative of expectation to the theoretical concept of a natural law: the natural laws are supposed to be the grounds for our imperatives of expectation.

In other words: "Nature" is the legislative power. In this way, it is possible to establish as indirect link between Hempel's concept of explanation and the necessity/contingency image. But, as we already said, the theory itself does not give us any elements to support this interpretation. Replacing $\Box^*A$ by $\Box A$ is a metaphysical decision, which is to be warranted by ontological principles.

We can now formulate a first, partial conclusion: if we adopt Hempel's theory of explanation (which is actually seriously inadequate), there is no immediate link between explanation and physical necessity. We need ontological principles to establish this link. In other words: Hempel's view is compatible with the necessity/contingency image, but does not favour it.

2.3.2 Salmon

If we want to find a modal operator which corresponds to Salmon's concept of causation, our first task is to find out what "production of a structure" (causal interaction or common causes) and "causal propagation" have in common. As a matter of fact, Salmon uses only two crucial concepts in his definition of mark transmission (MT): (absence of) causal interaction and the "auto-reproduction of a structure" (or: the "spontaneous reproduction of a structure"). So the problem is: what do "production of a structure" and "auto-reproduction of a structure" have in common? The answer is easy if we look at this problem from a technical point of view. If we want to reach a certain goal, we (i) produce some new structures, and (ii) we count on spontaneous reproduction of these structures (because our aim may be located in other space-time regions). Let's consider the baseball example again (cfr. section 2.2). Suppose we deliberately want to break the window. We produce a collision of the ball with the bat, and count on auto-reproduction of a structure to cause a second collision, which is our aim. We may conclude that what "production" and "spontaneous reproduction" have in common is that they jointly determine whether some goal G is attainable. Therefore, Salmon's concept of explanation may be represented by means of the following modalities:

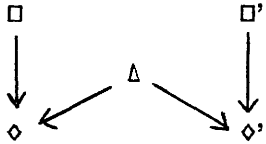
Att(A)	= A is attainable, i.e. there is a method (a combination of production and spontaneous reproduction) that results in A.
Av(A)	= Att(~A) (= A is avoidable)
Unav(A)	= ~Att(~A) (= A is unavoidable)
Unatt(A)	= ~Att(A) (= A is unattainable)
Nctrl(A)	= Unatt(A) & Unav(A) (= A can't be controlled)

Using this terminology, Salmon's concept of explanation may be formulated as follows:

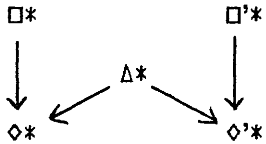
> "Starting from a knowledge situation in which Nctrl (E) we look for a factor C so as to reach a new knowledge situation in which Att (E)."

We may draw a first conclusion, which is parallel to what we said about Hempel's theory: there is no immediate link between Salmon's concept of explanation and the modal operators necessity and contingency. For Hempel's concept, it was possible to establish an indirect link (by means of ontological principles). That this is not true for Salmon's concept, is illustrated by the following implication schemes:

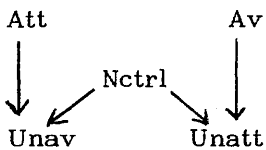
□:



□:



Att:



In these schemes the arrows indicate valid derivations, at least in the first two. Indeed, the problem is that the schemes for □ and □* are valid, and that the same scheme for Att is not. Since A can't be both necessary and impossible, □ and □' are exclusive: the truth of one of them excludes the truth of the other. As a consequence, □ implies ◇, and □' implies Δ'. The other implications in the scheme are valid by definition. In the same way, □* and □'* are exclusive, which makes the corresponding implications valid. In the third scheme, on the contrary, the implications "Att → Unav" and "Av → Unatt" are not valid because attainability and avoidability do not exclude each other. "Att(A) & Av(A)" is not a contradiction, and may be indicated as "Ctrl(A)". So moving from Att to $\Box$ is not just a matter of ontological decision: these modalities must not be interchanged, because they have completely different characteristics. As a consequence, Salmon's concept of explanation is incompatible with the necessity/contingency image of science.

Our conclusions may be summarized as follows:

(1) Even if we adopt Hempel's theory of explanation (though it is inadequate) there is no immediate link between explanation and physical necessity. An indirect link is possible: Hempel's theory is neutral.

(2) If we (rightly) start from Salmon's concept of explanation, we are confronted with a more fundamental problem: Att (A) and $\Box$A are not interchangeable in the same way as $\Box$*A and $\Box$A. The reason for this is that Att (A) is in some way "paraconsistent". As a consequence, Salmon's concept of explanation is incompatible with the necessity/contingency image.

2.4 *The modal conception of explanation*

In his "Scientific Explanation..." Salmon distinguishes three basic conceptions of explanation: the epistemic conception (e.g. Hempel), the causal-ontic conception (e.g. his own theory) and the modal conception. In theories of this latter kind, it is assumed that the relation of explanatory relevance is identical with the relation of conditional physical necessity. In other words: constructing an explanation means to move from a knowledge situation in which ΔE to a context in which $\Box$E. An explanation shows that the explanandum-event is physically necessary relative to the explanatory facts. G.H. von Wright gives expression to this idea as follows[6]: "What makes a deductive-nomological explanation 'explain', is, one might say, that it tells us why E *had* to be (occur), why E was *necessary* once the basis (body of explanatory facts) is there and the laws are accepted". It will obvious that such conception of explanation perfectly matches the image of science we are arguing against in this paper. Unfortunately for the adherents of this view, a modal theory of explanation is always inadequate in indeterministic contexts. Statistical explanation always leaves room for additional questioning, because one has to admit that E might have failed to occur, though, on this particular occasion, it actually did occur. Hempel tried to solve an analoguous problem by imposing a high probability requirement. The problem with this solution is that the distinction between high and not high is completely arbitrary. The analogon of this solution in a modal theory would be the definition of concepts like "almost necessary" and "nearly impossible". But this can't be done in a non-arbitrary way: each dividing-line between " almost necessary" and mere contingency is artificial and completely arbitrary. Therefore modal theories of explanation are always inadequate.

2.5 *General implications*

In this section, I have argued that Salmon's theory of explanation is incompatible with an image of science in which the modal operators necessity a contingency play a crucial role. Hempel's theory, on the other hand, is not incompatible with this image, but does not favour it either. Because Salmon's theory is superior, our general conclusion is that the results of the analysis of scientific explanations force us to give up the so-called 'realistic' image of science (characterized by the modal operators $\Box$ and Δ) in favour of a more instrumentalistic image. This instrumentalistic image must be based on the modal operators "Att" and "Nctrl", or, if we are more tolerant with respect to Hempel, also on deontic (obligation) and epistemic modalities (belief).

I am not sure whether Hempel would accept my conclusion, and I am quite sure that Salmon would *not*. As I already mentioned, Salmon distinguishes three conceptions of explanation: epistemic, causal-ontic and modal. Hempel's theory is classified as an epistemic approach. This means, I think, that Salmon would agree with my interpretation of this theory. But his own theory is classified as a causal-ontic conception of explanation. No one can deny that his approach is causal, but I think his approach is rather causal-instrumentalistic than causal-ontic: causation is, if we adopt Salmon's definition, a practical concept, related to the domain of production, and not an ontological concept.

3. *Explanation and modalities in social sciences*

3.1 *Functionalism*

3.1.1 Analysis of functional explanation

Consider the following question-answer pair:

> Question: Why is there pulsation of the heart in mammals?
> Answer: The function of heart-beating is to make the blood circulate in the organism.

In functional explanations, the explanandum is a characteristic of a system or the behaviour of a subsystem. In the example above, the behaviour of the subsystem "heart" is to be explained. Since the question is answered by stating the function of the characteristic or behaviour, it is assumed that the functional relationship has explanatory relevance. A question which arises immediately is whether this new relevance relation can be reduced to the relevance relations we already know (derivability and causation). Therefore we will try to analyse functional explanations resp. from Hempel's and Salmon's point of view. Our final aim is to demonstrate that Salmon's approach is to be preferred in this area too, which will allow us to expand the conclusions of 2.3 to the area of functional explanation.

In the tradition of Hempel, functional explanations are analysed as follows:

(F1) C_1: For system S an equilibrium is reached at time t_1.
L_1: For all t_x: an equilibrium may be reached at time t_x only if condition N is fulfilled.
L_2: Whenever a system has characteristic D, the condition N is fulfilled.

E: At time t_1, system S has characteristic D.

The argument in this scheme is not conclusive. To have a valid argument, we must either replace L_2 by the stronger law L_2' ("Whenever .... fulfilled, and vice versa"), or replace the explanandum by a disjunction of E with analogue sentences for the other sufficient conditions of N. If the second solution is chosen, the explanatory value of the argument is almost reduced to zero, and we certainly didn't give an answer to the initial question. The first solution is theoretically correct, but in most cases empirically worthless, because laws of the form L_2' are seldom found. The well-known concept of 'functional substitutes' is the conceptual translation of this empirical datum. Since both solutions are defective, it is *impossible* to reduce functional explanations to deductive arguments. This means that Hempel fails to make functional explanation a subspecies of explanation in general, which is a first drawback of his approach.

If we look at functional explanations from Salmon's point of view, the following description can be given:

(F2) Question: Why E? (E = characteristic of a system or behaviour of a subsystem).
Answer: The function of E is N.

> An answer is adequate if and only if (i) there is a C (= a description of an equilibrium) which is an effect of N, and (ii) E is a cause of N.

Is functional explanation in this sense a subspecies of Salmon's general concept of explanation? The answer to this question depends on how strictly Salmon's "causality requirement" is interpreted. Functional explanations are no causal explanations if this term is supposed to denote explanations in which the explanans is a cause and the explanandum the effect. Indeed, N (and C) are effects of E, and not causes. On the other hand, functional explanations *always* use causal relations in the opposite direction (the explanans is always on the "effect side"). As a consequence, it is impossible to analyse functional explanations without reference to causal propagation and causal interaction. Therefore, I think, it may be considered to be a subspecies of explanation in general.

To my view, there are three reasons why Salmon's concept of explanation must be preferred for the analysis of functional explanations. The first reason is that, as we just showed, Salmon's general concept is adequate for functional explanations too, which is not so for Hempel's concept. The other reasons are parallel to those we gave in section 2.2 when comparing the general theories of Hempel and Salmon: Hempel's analysis is too restrictive because he uses necessary and sufficient condition relations while excluding analogue relations with low probabilities. Hempel's analysis is also too wide, because it does not exclude certain irrelevancies, similar to the examples we presented in section 2.2.

3.1.2 Functional explanation and modalities

The conclusions with respect to functional explanation and modalities can be given now without much further argumentation, since they are obtained by combining the results of section 3.1.1 with the conclusions in section 2.3. We must conclude that

(1) Hempel's account of functional explanation cannot be translated into the $\Box^*$ terminology, since (F1) is not a correct argument. This means that we even don't have a basis from which to jump to an interpretation in terms of $\Box$.
(2) If we start from Salmon's concept of explanation, the conclusion is analogue to 2.3: functional explanations must be interpreted in terms of the modalities Att(A) and Av(A).

3.2 *Materialism*

3.2.1 Analysis of materialistic explanations

For practical reasons, I shall confine myself to the following Marxian principles:

(M1) "The production relations are determined by the means of production".

(M2) "The political-ideological 'superstructure' is determined by the socio-economic 'basis' (i.e. by the production relations)."

To my view, both explanatory principles are compatible with Salmon's concept of explanation. But I think they are to be used in different kinds of explanation. In my opinion, the first principle must be used in simple causal explanations, where a cause is used to explain its effect. The interpretation of the principle is that there is causal interaction between the means of production and the production relations. The second principle must be used in functional explanations. Its interpretation is not that the superstructure is a mere effect of processes in the basis, but that the superstructure must be functional with respect to the equilibrium of the socio-economic basis. I don't want to get involved here in the discussion about the empirical adequacy of historical materialism, or about the correct interpretation of Marxist theories. Consequently, I shall not try to support my interpretation by giving a list of quotations, nor shall I discuss the empirical adequacy of these theories. What I do want to show here is that each Marxist principle (not only the two we're dealing with) may be seen as describing either a simple causal process in Salmon's sense, or a functional relationship. If someone would maintain that (M2) is also to be seen as expressing a simple causal relation, this would not be in contradiction with my main thesis. Only if someone would say that there is something special about materialistic explanations, something that can't be reduced to causal processes and/or functional relations, we would disagree. The strategy I am following here is probably quite obvious: if there is nothing in materialistic explanation which we can't reduce to functional and causal explanations, our conclusions about explanations and modalities are valid for materialistic explanations too. But before reformulating these conclusions, I shall elaborate my interpretation of the principles (M1) and (M2) in order to make it more plausible.

In my interpretation, (M1) means that there is causal interaction between the means of production and the production relations. I suppose that it is quite clear what is meant here by "means of production". On the other hand, the term "production relations" needs some clarification. In his unachieved introduction of "Zur Kritik der Politischen Ökonomie"[7], Marx analyses the relations between three socio-economic phenomena: (i) the distribution of production instruments, (ii) the structure of the production itself, and (iii) the distribution of the surplus value (the result of the production). According to Marx, the distribution of production instruments determines the organisation of the production, which in its turn determines the distribution of the surplus value. In a 19th century industrialised society, this means that the opposition (at the level of distribution of production instruments) between capitalists (owners) and proletarians (not-owners) determines a second opposition (at the level of the organisation of the production) between managers and factory workers, which in its turn determines the way in which these people share in the distribution of the surplus value (resp. interest and wages). In Marx' view, these levels are three ways in which we may approach the same phenomenon, viz. the production relations. Because of the complete parallelism between the three levels, and because of the dominance of the first level, the terms "production relation" and "distribution of production instruments" are interchangeable. This will facilitate the discussion of both (M_1) and (M_2).

Let's now return to (M1). In my interpretation, there is, at a certain moment, an interaction between the means of production and the production relations: there is a quantitative or qualitative change ("modification" in Salmon's terminology) of the distribution of the production instruments, as a consequence of the technical evolution of the means of production. This modification is propagated till there is a new causal interaction. I think this is what Marx had in mind, because, in his view, the feudal social structure (i.e. the antagonism between landlords and serfs) is replaced by the capitalistic structure (the antagonism between capitalists and proletarians) as a consequence of industrialisation, i.e. as a consequence of the use of *machines* instead of *tools* in production processes. While certain other characteristics are preserved (e.g. the antagonism in the social structure) the introduction of machines causes a replacement of landlords by capitalists as the main owners of the means of production. As to the second principle (M2), the functional relations may be determined as follows. The system we are analysing is the socio-economic basis of a society. As we have seen, this may be reduced to the analysis of one level, viz. the distribution of production instruments between the members of this society. Such system can't function normally, unless the way in which the production instruments are distributed is accepted by each individual member of the society (i.e. *acceptance* as a necessary condition for an equilibrium). Acceptance may be brought about by means of external pressure or by means of motivation. External pressure is the function of the political part of the superstructure. Motivation is the task of the ideological part of the superstructure.

3.2.2 materialism and modalities

Because historical-materialistic explanations are either simple causal explanations or functional explanations, they must be analysed in terms of the modalities Att(A) and Av(A). This means that Marx' theory, like the functionalist model, is incompatible with the necessity/contingency image of science.

3.3 *General consequences for the social sciences*

In the same way as I have done at the end of section 2, I would like to pay some attention to the general consequences of what I have argued for here. It is clear that most of what I said at the end of section 2, is valid here too: functionalism and materialism are to be approached from a more instrumentalistic point of view. To conclude this paper, I will try to indicate how this instrumentalistic approach must be understood. Traditionally, Marxism is interpreted as a deterministic theory, describing a necessary evolution of social phenomena. In the same way, functionalism is often understood as a theory that proves the necessity of certain social phenomena. From an instrumentalistic point of view, these theories become sets of techniques to bring about modifications in the social structure. The technological implications of a theory are crucial. If we compare the social sciences with the natural sciences, we have to admit that the transformation of pure science into technological application is very poorly developed in the social sciences. If social scientists want to reach the same level of application, an instrumentalistic turn is, I think, a first step in the right direction.

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NOTES

1. See Hempel (1962) and (1965). The formulation of the criteria and the schemes are taken from Salmon (1984) pp. 29-30.
2. Salmon (1971) pp. 33-34.
3. Salmon (1984) pp. 179.
4. Salmon (1984 p. 148.
5. The modal concepts Att(A), □!A, and □*A, that will be defined in this section, are taken from Paul Lorenzen's article in vol. 35 in this journal (Lorenzen, 1985).
6. Von Wright (1971) p. 13.
7. This introduction was published, together with some other manuscripts, as "Grundrisse der Kritik der Politischen Ökonomie" (first edition 1939).

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