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Interdisciplinary Science - Political Globalization: Parallel and Integrated Processes

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The purpose of this paper is to analyze the social forces that fuel the advancement of science and mathematics. I hope to demonstrate that this advancement is not just due to "internal" forces created only by a need for more scientific knowledge. The energy pushing science and mathematics forward has an important social component determined by the growing political and social relevance of scientific knowledge. I hope to show that this component is connected and parallel to the political and economic forces that are behind the move towards greater political globalization in the European Community. This has important implications for science policy makers and for scientists, both in Europe and in the United States. These implications will be discussed at the end of this paper.

It is widely accepted that, historically, scientific and mathematical knowledge can be divided into three phases: the early phase extends to the sixteenth century and is characterized by a search for universal knowledge, the second phase sees the differentiation of the sciences as we know them today, and the third phase is the modern period where there is meaningful and productive interaction between the disciplines. This three-phase evolution of scientific knowledge is parallel to the evolution of the notion of "State". This is not so surprising considering that science and society are, in part, shaped by mutual osmosis.

The first phase in the history of scientific knowledge could be called the "Greek" period. During that time science and mathematics were viewed as one unified field. In fact, science and mathematics were not differentiated from philosophy and religion. Science and mathematics were viewed as tools to be used for philosophical purposes, and scientific activity was considered divine. In this phase, science was parallel to myth, and shared a similar root: the need to create representations of the natural world. Scientific curiosity, as we understand it today, was present, but it was used to justify and confirm the already created "mythical" representations of the world. For example, the Greeks thought of the circle as the "perfect" curve, and concluded that the planets and stars (or "heavenly" bodies) moved on circular trajectories. And even when their measurements pointed out some serious contradictions, they preferred to create another model that involved even more circular paths than to admit that the circle might not be the right curve to consider. Scientific thoughts were also colored by a demand of "purity", not a purity of values but the purity of abstract thought. This purity was a sign of the strong influence of philosophy, which implied that science was far from people's real life. Science had little practical purpose and little influence in society.

This condition persisted into the early Christian era when moral philosophy played a more important role than secular science. In fact theologians used the logic of the Greeks in their philosophy. For example, Thomas Aquinas based his "Thomism" on Aristotelian principles. It took until the sixteenth century for logic to be applied to secular fields, and for science to become a real force in shaping the society it sprang from.

Let me note that the history of the notion of "State" also begins in ancient Greece. Plato and Aristotle wrote of the "Polis" as the ideal form of society. This "State" was characterized by and created for self-sufficiency and self-preservation. Not until the sixteenth century did the modern concept of the State emerge.

The second phase in the history of scientific knowledge saw the differentiation of the sciences, and the beginning of the organization of science as we know it today. This differentiation was not done arbitrarily, but reflected the evolution of the way scientific knowledge is obtained: from a "universal" approach to a more and more focused approach. For example, in the early nineteenth century, physicists focused on the study of temperature. This created the field of Thermodynamics, which formulated the laws of conservation and transformation of energy. The divisions of science, such as the one described in the example above, provided an efficient structure for organizing scientific inquiry (before one can study a phenomenon, it must be broken down into small parts). One could argue that these divisions were parallel to the division of labor that was occurring at the social level. Clearly, these divisions were necessary for any significant scientific progress to be achieved. However there was another driving force behind this process (as in the division of labor): it was the fact that society found profit from these divisions. The laws of thermodynamics (because of their applications to steam engines) had a clear impact on society at the time, and it would be an oversimplification to consider the science - society relationship to be only one way, even then. A discovery does not come in a social vacuum. It needs a scientific basis of course, but it also needs a social force to push it forward.

We are now in the third phase of the evolution of scientific knowledge. Scientists question whether the division of science is a barrier to more progress, whether the modes of inquiry specific to each discipline (and the jargon specific to each discipline) are so foreign to each other that the identification and resolution of modern and very complex problems have become difficult, if not impossible. To face this situation, science and mathematics are evolving in new directions. Science and mathematics have been very responsive to the internal needs of the specific disciplines, but also responsive to the external needs of society. This can be explained by the very nature of Science and Mathematics: Science and Mathematics solve problems (from the Greek προβλημα which means cape, bluff overlooking a lowland, a high point). When faced with a problem, the scientist and the mathematician, in the same way as the navigator, want to attain the cape, the high point. To go beyond that point they need to move in unknown and unexpected directions. The "linear" relationships between the sciences are not sufficient anymore, and meaningful interactions between the disciplinary boundaries are being created.

To illustrate this, let me use the example of the division between pure and applied research, a division now viewed as useless and counterproductive. Scientists now differentiate between research for new knowledge and research for new technology, but these two types of research are not opposite to each other. On the contrary, research for knowledge helps in the creation of new technology, and conversely, an industrial need can generate a better understanding of a certain knowledge, and in some instances, can generate a new scientific field. For example, as mentioned above, steam engines helped in the growth of Thermodynamics; but also, the food industry helped in the growth of Microbiology, and the telephone helped in the growth of Information Science. Moreover, during the last twenty years, a large number of links have been created between academic research laboratories and private research laboratories from industries, further eliminating the frontier between pure and applied research.

This third phase of the evolution of scientific knowledge also coincides with a time when we rethink the notion of the State, the notion of frontiers. From the sixteenth century until the beginning of this century, the State was viewed as a way to obtain general welfare (this was also created by a need for self-protection). The national aspirations were considered a source of security, progress and moral values. The State was viewed by some as a means to stability and by others as a source of oppression. The trauma produced by the world wars (wars which were inspired by nationalistic feelings), created a new meaning to the notion of "State". The State is now defined as a legal entity, and is seen in the context of its interaction with the rest of the world.

Let me restate here the parallel between the evolution of science and the evolution of the notion of State that I have presented above. These seem to follow the same kind of "entropy": from the separate and self-preserving, to the global and interdependent. But this does not come without "pains".

The "State" of today is in a situation of flux. It must be able to function in a constantly changing world, a world that creates and transforms. The State must allow for a continually changing network of relationships and communications. It must be compatible with a knowledge driven economy and a knowledge driven society which force it to open its boundaries; at the same time, it must guarantee its sovereignty and the welfare of its population. It must recognize and value the diverse communities that interact with it, while not neglecting its national characteristics and traditions. In particular, the balance between Europe's diversity, which has traditionally been one of its strengths, and the need for its cohesion is extremely delicate. This is a situation that is familiar to the sciences.

Scientists find themselves facing the difficulty of wanting to integrate and specialize: they specialize to solve problems, but they also want to integrate their understanding in a bigger framework. This is parallel to the political difficulty of creating a community but still supporting the individual groups within that community. It is easier to specialize than to integrate; similarly it is politically "easier" to call on people's nationalistic and provincial feelings than to promote political unification.

For example, in Europe, the structures for research, and development are very complicated, for historical reasons. The "new" European structures have been imposed on top of already existing national structures, which have each their own logic. Moreover, the European initiatives have their roots in fundamental research. CERN deals with particle physics, EMBO deals with molecular biology, and ESO deals with astrophysics. This is partly due to the fact that the countries of Europe do not have a history of developing technologies together. But the truth is that it is much more difficult for political reasons to agree on technology issues.

Modern science is now trying to integrate the benefits of specialized research with the need for interdisciplinary work. How can it successfully do these seemingly contradictory tasks? Scientists and policy makers must take a pragmatic approach: only do what is profitable; i.e., interdisciplinary projects should be started, funded, and supported only if there is significant benefit from those projects. These benefits may be purely scientific, economic, or political. Projects of an interdisciplinary nature should not be started for the sake of interdisciplinarity alone. Interdisciplinarity is not just a concept, it is a method of achieving scientific knowledge that has evolved naturally like any other human activity. It needs to prove itself and to continue its evolution. In the political arena, it can be compared to the situation in the European Community. The political achievements toward integration are determined by the same pragmatic approach: we only do what is profitable and what people are ready to accept. Of course one must sometimes be able to see long term benefits, not just short term profits. This is intimately connected to our modern understanding of the notion of State.

Science is a human activity, and therefore parallels the social and political domains. It would be shortsighted to think that the changes towards interdisciplinary work are fueled only by internal forces. Scientific knowledge belongs in the social realm as it is a collective social product. In fact, when we speak of interdisciplinary work, it is not just about research in the so-called "hard" sciences. It is also about research between these sciences and the social and political sciences. As I have tried to demonstrate here, Science and Technology issues are not independent of the economy (clearly), and of the social and political contexts. Scientists shape society in the same way as philosophers or social scientists, perhaps now more than ever. Scientists need to take their full place in the political debate and the political decisions.

Science, in particular interdisciplinary science, and political forces toward unification will fuel each other to achieve greater benefit for our society. Both processes are unstoppable because they are both products of the very nature of our society.