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Abstract

The Realm of Science claims to be an autonomous entity, governed by its own rules and institutions. In practice it is difficult to test the extent to which different enveloping political systems affect economics of basic research, as too many cultural and historical differences would distort such a comparison. Unique historical circumstances make East and West Germany the best available ground for setting up an experiment with both experimental and control groups within societies and organizations. Testing the influence of socialistic pressure on economic performance of scientific institutions, the analysis of East German Academy of Sciences and West German Max Plank Society is performed. Possessing many public good properties, basic research in natural sciences was supported by the government in both countries and was similar across the borders in its structure, goals and culture. Systematically comparing basic research in two institutions at its four stages of conceptualization, experimentation, evaluation and implementation, this paper seeks to identify significant qualitative influences of researcher, organizational, political and economic structures on the research process. In addition to an American and German literature review, personal interviews with scientists and administrators of several East and West German research institutions are drawn upon in the analysis. Ultimately, the analysis leads to the rejection of the preliminary hypothesis that the research process is independent of influences of surrounding political and economic systems and concludes that Socialistic political system and central-command economy have influenced basic research process directly as well as through organizational structure.

I. Introduction

Advancements in the field of natural sciences have long ceased to be the sole products of individual ingenuity. The so-called invisible colleges, personal relations and correspondence between individual scientists in the Middle Ages have developed into tangible institutions and highly *visible* colleges supporting teams of scholars conducting both basic and applied research. Economic rather than scientific differences between the two types of research lead to their separation into two distinct though interconnected branches.

Results of applied research in the natural sciences like physics and mathematics often take the form of inventions or innovations, which can, theoretically, be developed into marketable products directly. Most of the time, applied research is profitable and returns on investments can be collected in the short run. In addition, a research program of applied research can be planned to a large extent, like a production process, and most of the positive externalities can be internalized. It is, therefore, attractive to many industrial entrepreneurs who make a research divisions a part of their industrial organizations. Today most applied research is conducted in the R&D departments of manufacturing and technology companies. This arrangement also determines the financing, internal structure, and performance of applied research. In particular, Research and Development create a strong link between an economic system within which research is conducted and the results of this research.

Basic research, on the other hand, possesses many qualities of a public good. It has a higher degree of uncertainty than applied research and rarely yields profits in the short run. Because of its uncertainty, it may not yield desired results under planned timing and financing. It also carries potentially large positive externalities in the form of knowledge that cannot be immediately applied, and would not be internalized properly by industry. To insure an adequate "supply" of basic research, the government has to support pure research financially, either by establishing its own scientific institutions or by financing independent research centers.

These basic research institutions, their organizational structure, incentive system, and even morale become insulated to a degree from the existing economic system, market conditions or lack thereof. The above characteristics lead a young scholar like myself to test the degree of insulation of basic research institutions from the surrounding economic system.

Economic considerations cannot be ignored altogether by anyone studying scientific institutions. Although the private sector in most societies may play only a minor role in the conduct of basic research, the public economic sector influences it directly. Even after a role for the government as a modern patron of basic research is established, the vast amounts of required funding still raise a lot of questions. For example, was the more than one billion Deutsche Marks spent for basic science in West Germany in 1986 enough and if not, has an increase up to 1.7 billion DM in 1993 been sufficient for conducting basic research? (vom Brocke, 11). As everybody learns in elementary economics, resources are limited and any government faces a problem of optimally allocating these resources. Due to the uncertainty and unpredictability of basic research, it is difficult to calculate an optimal amount of funding for the support of science. This problem, however, is too large to be included in full in the scope of this paper, and will only be mentioned briefly.

When financed by the government, basic research is often influenced by political goals of the government, such as national security. Many people believe that only totalitarian regimes like the former Soviet Union have utilized science in the military purposes. This is, however, a worldwide phenomenon and not a unique feature of the socialist system. Astrophysics research done during the Space Race, for example, was marked by pressure on scientists as strong in the United States as that in the former Soviet Union. This pressure often took an economic form of increased funding for basic research, opening up scientific frontiers while pursuing strategic defense goals. In this sense, pure research has benefited greatly from ultimate goals of its implementation, and vice versa -- in the long run, industry has benefited from basic research findings, for example in the case of nuclear power stations. It should be noted once again, however, that basic research findings rarely find immediate applications in the industry. Short-term basic-applied research link for security purposes was artificial and could exist mainly due to political security priorities and additional governmental funding.

Political influence on pure science was not uniform across the borders, nor has it taken the same forms. What distinguished government influence in the East from that in the West was mainly the scope of interference and its inertia, or inflexibility. Both in the U.S. and the former Soviet Union, high security and “Red Tape” (similar to the *confidential materials* mark attached to secret documents and operations) policies were implemented in regard to nuclear research projects. In the U.S. these policies covered only strategic projects, leaving civil research open and flexible in communication. In the former USSR, the Red Tape policy was institutionalized and extended to every form of strategic and non-strategic research, restricting researchers' access to information and communication among themselves at the national and international levels.

It should be noted, however, that in spite of the strong governmental control, the former Soviet Union had a very advanced standing in basic research, particularly in natural sciences. Only since the 1970s has its scientific performance been decreasing. The reasons for this decline are beyond the scope of this paper; as seen from the title, I will be writing about German science, but perhaps this insight would shed light on a larger picture.

II. The Hypothesis

To understand "what went wrong" in Soviet science one could compare it to the Western system and see which deviations in the organization or political pressure had the greatest impact on the scientific decline. Such a comparison between any Western country and the USSR, though, would be fraught with difficulty, as differences in historical development, social system and culture are too big to ignore. However, if it could be done, constructively and precisely, its use would be tremendous: by examining the corpse against a healthy living body we would be able to find a cure for the illness that killed the sick man, or in our case, the scientific sector. Many scholars believe that socialistic ideology and central-command economy were at the root of the problem (Menske, 7). Using another medical analogy, however, removing the tumor does not necessarily make one healthy. After a head tumor has been removed, an adult may be left half-paralyzed from various side effects created by the tumor, or by the surgery. A doctor must, therefore, learn the full functioning of the organism and its interaction with the tumor to design a cure for side effects that remain after the tumor is removed. Similarly, a policymaker that wants to construct a more efficient economic structure for basic research must first understand why has the old system broken down.

Unfortunately, such a precise comparison between the former Soviet Union and the United States would be virtually impossible to conduct, as the basic unit of analysis, a researcher, has different culture, mentality and aspiration in the U.S., incomparable with those of his or her colleague in the USSR. Instead, a comparison between scientific institutions of East and West Germany can be drawn. Several assumptions would have to be made, such as to the "good health" of the West German science (represented by the Max Planck Society institutes) and poor one of the former GDR's (State Academy of Sciences institutes). Comparative advancement of Western Science over Eastern supports these assumptions. This economic research would require the fewest assumptions (in comparison with other possible pairs for such a study) as common history and culture are the variables that can be kept constant across the borders. The goal of the comparison would be first of all to examine the in-depth operation of both systems, and then to determine the cause-and-effect path of the downfall of the East German science. A virtual hypothesis (H0) is proposed: political and economic systems have not affected the work of the East Germany's scientific sector by influencing organizational structure of research and researcher himself. A contrary (H1) could then be stated: political and economic systems have negatively affected the work of the East Germany's scientific sector by influencing the research process directly, bypassing researcher and organizational structure, the latter remaining basically the same in the 40 years of its existence. I would then conduct a virtual experiment, viewing the East German institutions under the Soviet influence as an "experimental group" and West German institutions as a "control group".

As with any social science experiment, however, this one would have a large degree of uncertainty. In economics and econometrics, unlike in physics and chemistry, one can rarely determine the cause-and-effect relationship between two phenomena. For example, the Phillips curve was believed to represent an unchanging inverse relationship between inflation and unemployment; later studies showed that it "vanished" in the 1970s and some scholars believed it to be little more than coincidental statistics. Friedrich Hayek comments on the theory behind the Phillips curve as “largely the product of a mistaken conception of the proper scientific procedure” (Hayek, 25). Generalizing this misconception, Hayek concludes that

> In economics (and in other disciplines that deal with ... “essentially complex” phenomena), we can obtain quantitative data for only certain aspects of the events to be explained, and thus necessarily limited number may not include the important aspects. While in physical sciences it is generally assumed, probably with good reason, that any important factor that determines the observed events will itself be directly observable and measurable, in the study of such “essentially complex” phenomena as the market, which depends on the actions of many individuals, all the circumstances that will determine the outcome of a process *will hardly ever be fully known or measurable*. (Hayek, 24)

Numerous externalities affect economic relations and cannot be disregarded in a complete study. However, a thorough account of all possible side effects would distort, rather than complete, the picture. All the conclusions drawn from this study, therefore, are rhetorical rather than factual and should not be blindly implemented in government policies towards scientific institutions.

III. Historical Background

Germany has long been known for its technological advancement both in research and implementation. At the beginning of the century, however, the need for more basic research in the natural sciences was recognized. To fill this vacuum, in 1911 a scientific organization called the *Kaiser Wilhelm Gesellschaft* was established. It consisted of several basic research institutes, mostly in natural sciences and medicine, covering traditional and non-traditional areas, like corn research (KWG, 633). In the beginning this scientific society was controlled by the government, but financed mostly through industry; it had strong connections with manufacturing companies and a large part of its research was done for production purposes.

In the 1920s, German industry experienced heavy losses from the hyperinflation and couldn't support Kaiser Wilhelm Gesellschaft any longer. The government took over the responsibility for this, recognizing the high value of basic research done in the KWG institutes. As industrial pressure was lifted from the scientists, they received greater freedom in choosing their research areas. Perhaps this liberalization of science played the biggest part in a notable increase of inventions and innovations in Germany in the next years: this period in German history could be called "The Golden Twenties" not only for the general well being of the decade.

Although financial support of basic research is usually undertaken by the government, it should not be taken for granted that the poor, economically and socially unstable Germany would have supported Kaiser Wilhelm Gesellschaft instead of dismantling and destroying it. The importance of this society, therefore, cannot be overestimated. It became the major basic research institution in Germany. "Neither the Academy [one of German scientific societies], nor institutions of higher learning [in the West Germany] ... could match the role played [later] by the State Academy of the GDR and perform the function of the national Academy" (vom Brocke, 10-11). Kaiser Wilhelm Gesellschaft filled the niche of performing basic research, and its heir, Max Planck Gesellschaft (MPG), played a role of the national academy, which in East Germany was delegated to the Academy of Sciences (AdW). This functional similarity gives an additional reason for our comparison of the two institutions.

During the 1930s Kaiser Wilhelm Gesellschaft fell under control of the Nazi Party in Germany; this dark period until the end of W.W.II is still barely illuminated by historians. During that period many renowned scientists left the country to escape the totalitarian regime and cruelty of the decade. Others were forced to leave, either because of their liberal views or Jewish nationality. When asked by a Nazi functionary how the mathematics institutes were doing since they had been relieved of Jewish members, the famed mathematician David Hilbert is said to have replied: "Mathematics in Goettingen? There is none anymore." Furthermore, basic research sector suffered more heavily than its applied research/industrial counterpart that was converted to work for Hitler's military purposes (Beyerchen, 133).

After World War II, the Germany was left demoralized, economically ruined and occupied by troops. Furthermore, the distribution of "damages" varied across not yet existing border between East and West. An East German source says that

> Some 70% of the industry of the former German Reich were located in the zones occupied by the Western powers. The remaining 30% of industrial plant on the territory of the former Soviet Occupation Zone -- today the GDR -- was to 45% destroyed, on the average. The extent to which production capacity was destroyed in constructional engineering, for example, was 70%, and in metallurgy -- 80%. In contrast to this, the level of destruction of the industry located in the West German territory amounted on average to 20% (GDR: Science, 19)

This statistics is apparently distorted by the Eastern propaganda, diminishing the industrial ruin of the West; destruction of heavy industrialized Rein region is averaged with light damage of non-strategic manufacture of the South-West. East Germany, however, carried even greater losses in the process of military advancement and post-war dismantling for the spoils. As a result, after the break-up of Germany the two states faced different resources. United States has helped West Germany to recover financially by the famous Marshall Plan; industry was revitalized quickly in what became known as the "German Miracle." Morally, however, guilt and ambiguity about the Nazi past has long plagued the country. Surprisingly, it played a positive role for the development of Western fundamental research. Thus "Nazi abuse of science and glorification of technology became basic tenets of postwar assessments of the German war effort, as well as implicit legitimization of the importance of support for basic research" (Beyerchen, 133).

Moral considerations supported the allocation of funds for basic research, when the country was still recovering economically. Close to 3 trillion Deutsche Marks were spent between 1948 and 1955 on science and technology, of which 2.243 trillion DMs came from the Laenders (FRG states). Under what has become known as Koenigstein Agreement, the Laenders pledged to "collaborate in the provision of the necessary funds for scientific research programmes of nation-wide importance, specifically, Max Planck Gesellschaft"

(Stifterverband, 23) The Max Planck Society was transformed from KWG, yet more than just a name has changed. Several institutes in relatively less prominent fields were closed while new ones in interdisciplinary or specialized areas like protein research were established (KWG, 40-44). Further, the main goals of the new institution were redefined and purified. Though MPG remained committed to conducting basic research and in many respects performed a role of the national academy, its scope of activities has changed. In particular, the founding fathers of MPG envisioned a research institution that would fill a gap between universities and industry,

> To take up promising, new fields of research which cannot or cannot adequately be pursued at universities -- due either to their interdisciplinary character which does not fit into the organizational framework of universities, or the fact that they require equipment which is so expensive that it can neither be provided nor maintained by universities (MPG, 13).

In East Germany the justification for conducting basic research was politically stronger. There "a flourishing state of the sciences in all fields was accordingly regarded as the essential condition that will lead finally towards the transition to a communist social system (S&T Policy, 23). " As an immediate result of this official policy, an Academy of Sciences was established soon after the end of the war, in 1946. Former KWG Institutes became the backbone of the Academy. It is difficult to say to what extent goals and ethic of the KWG were altered in the reformation due to Soviet influence, yet it is plausible that the organization of research remained the same, since the Soviet Academy of Sciences originally took KWG as a model (vom Brocke, 15). Therefore, whatever structural influence the Soviet Union might have had, it had an effect of "integrating the derivative," imposing a similar, if not the same system, with the higher degree of uncertainty.

Additionally, other research establishments, formerly existing separately, were appended to the Academy of Sciences in 1950s (e.g. the Babelsberg Astronomical Observatory, the Geodetic Institute in Potsdam, the Astronomical computing center at

Babelsberg, and the Medical biological institutes at Buch). New institutes were moreover founded within the Academy. "As a result, it was given an independent research staff in natural and social sciences. By 1955, it grouped no fewer than 47 institutes and working parties with 4,000 workers, among them 1,000 scientists" (S&T Policy, 18). Unlike in the West, each new AdW institute was founded in a traditional field for advancement of already existing knowledge. In the 1950's, interdisciplinary vs. traditional advancement of science constituted perhaps the greatest difference between the two systems spread from the roots of former Kaiser Wilhelm Gesellschaft.

When discussing basic research, it is impossible to omit its applied counterpart, especially from the a dynamic perspective. Yet after the war, the restoration of industry was a higher priority. Applied research was more important for the economic survival of GDR, and more resources were pulled in that direction. Proportional to the needs, there existed the problems facing industrial R&D:

> When after 1948, in the territory of the present GDR, democratic reconstruction began and the large industrial undertakings were nationalized, there was a complicated situation for the R&D institutions of industry. Many of them had been destroyed as a result of the war. There were major disproportions, because many branches of industry had their main centres and therefore their most important industrial research establishments in the western part of Germany. Research documents available in the nationally owned enterprises were in many cases stolen and carried abroad, and numerous scientists and technologists induced to emigrate. Extraordinary differences obtained as between the individual branches of industry in respect of the number of scientists active in these various branches. At first it was only possible to use the available material to begin construction (S&T Policy, 20).

I do not know how many resources were poured into restoring GDR's industrial R&D potential. In the West, only one to five percent of the total science-allocated funds spent in FRG (Stifterverband, 23) went to industrial research. In the East it is likely to have been more than that. Efforts on both sides were rewarded, and rewarded quickly. Western Europe praised "the German miracle" of FRG industrial revitalization, while GDR has built from scratch a miraculously efficient and strong production sector comparative to the other countries of Socialist Block.

After the first years of rebuilding, both Germanys stepped on the path of balanced scientific development. The number of basic research institutes and applied research laboratories steadily grew on both sides of the border. Higher education improved alongside as new universities opened and more and more students prepared to enter all branches of research. There were no excesses, like Lysenkoism in the former Soviet Union, and no major booms or depressions in the East German scientific life. Research was conducted, and discoveries made, patents filed and new products created, though not necessarily in that linear order. The period did not bring a scientific boom to East Germany, perhaps, as it was considered by the former Soviet Union more of a periphery, too small to have its own strong science. As seen from Moscow,

> At present no major scientific achievement in the GDR is conceivable without the cooperation of the research establishments of the USSR. As a small country the GDR is not in a position to advance scientific and technological progress on its own and to cope with the wide range of problems connected with it (USSR-GDR, 29).

The Former Soviet Union was patronizing its “little brother”, providing for students and researchers' exchange, sending an East German astronaut on a Russian space mission (S&T Policy, 35). The latter, however, occurred only in 1978, while general agreement on cooperation in science was reached as early as 1951 (USSR-GDR, 18). Cooperation with the former Soviet Union, nevertheless, was fruitful in that the necessary exchange of ideas and information has taken place to insure development of natural sciences in GDR. FRG scientists have worked closely with their colleagues from America and Western Europe; and yet across the Berlin Wall an intangible net of cooperation, collaboration, and ethics has connected scientists from all over the world.

The nineteen sixties passed in the same quiet manner. Minor reforms did not change either AdW or MPG Institutes. In the West, two major reforms, in 1964 and 1972, saw the introduction of more democratization and employees' participation in the administrative decision process (Gerwin, 11-12). These positive changes, however, did not significantly improve the relations or communication between the institutes or within them, as the hierarchical structure has remained securely in place, supported by the strong majority of conservative scientists (Gerwin, 12). Some programs were introduced in the East as well, making just as little impact.

The late 1960's and early 70's, however, saw a spur of scientific activity created not by scientists, but administrators. What in the East became known as "Suedenfall", in the West was christened simply as *gigantomania* – often unjustifiable growth of research institutes, foundation of new ones, doubling and tripling of scientific and technical personnel. Simultaneously in the East, scientific planning was attempted by the government to secure further development:

> In the early 1970s two long-range schemes were drawn up at national level. These were (I) the "Scheme for the development of natural sciences and technology in important sections of the national economy until 1990" and (II) the "Scheme for the long-term development of fundamental research in natural sciences and mathematics, as well as in selected technological directions within the range of the Academy of Sciences of the GDR and of the Ministry for Higher and Technical Education until 1990". The purpose of these Schemes has been to chart out, for the two decades ahead, the main directions of research and technological development (S&T Policy, 39).

Both countries looked like they were preparing for the bigger challenges and major breakthroughs.

Surprisingly, the next decade brought new achievements for the applied rather than basic research. Industrial laboratories and research centers were set up on a large scale in both East and West Germanys. In the East they took the form of the Academy-Industry Complexes (Akademie-Industrie Komplexes, AIK), which conducted research for industry on "concerted R&D projects, for example in certain fields of medical products, of microbiology, and of organic polymer compounds" (S&T Policy, 47). These complexes were seen as a link between basic research and industry and, like many socialist undertakings, were built on a large scale. In addition to that, the so-called construction bureaus, in effect R&D departments, were opened at almost every production center. In 1977 in industry and in civil engineering, there were almost 130 production complexes in which more than 110,000 employees were engaged in R&D, accounting for about 90% of the industrial potential in R&D (S&T Policy, 29). In 1980s the share of R&D conducted at these production complexes has shrunk as more and more applied research was done at AIKs. It is difficult to evaluate AIKs' performance, as relevant statistics were most likely exaggerated for ideological reasons.

In the West, the so-called Science Parks were created. Similar in purpose to Silicon Valley in the United States, these technological centers had nevertheless substantial distinctions. First of all, Science Parks did not grow in and out of themselves, but were set up by the government. As Sunman and Lowe notice, "the pattern and speed of development has strongly been influenced by government -- especially regional government -- policies (Sunman, ix)". Laenders have once again stepped in to increase their economic potential; this time through applied rather than basic scientific research. In that, as in an initiative to create Science Parks, West Germany was more alike with East Germany than with the United States. Perhaps because of the top-down approach, Science Parks have performed rather poorly compared to their American prototypes, though nevertheless increasing technological potential.

Another difference between Silicon Valley and, for example, Dortmund Science Park, was a poor industry-university link on the German side. While in California Stanford and Berkeley are quoted for their contribution to the creation of Silicon Valley (and its leading companies Apple, Sun, and Hewlett-Packard, to name a few), in Germany

> One interesting feature common to virtually all the parks is that companies usually expect to gain more benefit from each other, than from the associated higher educational institute, through the simple presence of like-minded people, to opportunities for sub-contracting and for undertaking joint projects (Sunman, ix).

The same poor link between AIKs and universities can be traced in the GDR. Universities, though places of academic research, were not connected to industrial R&D labs, primarily because the two were governed by two different ministries.

Just as AIKs worked as a joint effort of the Industry and the Academy of Sciences, West German Science Parks often collaborated with MPGs on projects with common interest, for example, in biological and nuclear physics technologies (Sunman, 51). In a general trend in the 1980s, applied research strongly dominated basic research conducted in MPG and AdW. More and more resources from the Institutes were pulled to support Industry. It is difficult to say whether this trend would have continued smoothly if Germany had not been reunited.

In 1989 the Berlin Wall fell, and with it the tangible barrier separating the two parts of the German science. Reunification of the scientific sector proceeded no more smoothly than that of the social or political sectors. Wissenschaftsrat -- West German Scientific Council -- has made assessments of the performances of the AdW institutes and published a set of recommendations to the new unified government regarding these institutes. Some, such as the laboratory for high energy research in physics in Zeuthen, were given very high ratings and transferred under administration of the West German institutions, such as high-energy particle physics DESY Lab, or saved under the so-called "Blue List" initiative (Wissenschaftsrat (a), 52). Others were dissolved by the special commission (KAI, 32). This, of course, created high unemployment among the best-educated citizens of the former GDR. Partially to prevent a brain drain, and partially to utilize the new human and capital resources, MPG has extended its activities to the newly added eastern states and has already founded five new institutes. It is still uncertain, however, whether Max-Planck-Gesellschaft would become for the new united Germany what Kaiser-Wilhelm-Gesellschaft was for the old Germany -- the national academy for sciences, or whether MPG will peacefully co-exist with the transformed AdW (Blue List Institutes). The goal of the new united German government is to find the most effective system that would insure a smooth and efficient functioning of the German research institutes.

V. The Analytical framework

It is always difficult to say precisely what determines the performance of such a creative and uncertain process as scientific work. As mentioned in the beginning, much more than a researcher's talent or desire for work goes into the research, but available equipment, access to information, and outside pressure also play their part in the outcome. To analyze what determines the performance of a researcher in absolute terms would be difficult, but we can try to compare several sources of influence to understand which phenomena are more important to the research process in relative terms.

I start by identifying four main factors determining a research outcome. The first one would naturally be a researcher himself, his talent and creativity. The second one would be an internal organization structure in which a researcher must work. The third would be the extent of government participation (mostly for political reasons). The last factor would be the economic system which envelops the scientific sector and within which it operates. Specific influences on the research process will be identified later; for structural purposes, they can be viewed as *subcategories* of the four main categories.

Each of the four factors and numerous forces placed in their respective subcategory affect the research process at different stages with different intensity. I call these stages of research *conceptualization*, *experimentation*, *interpretation*, and *implementation*. During the conceptualization stage, a scientist formulates a new idea into a hypothesis, in the second stage he or she tests this hypothesis either through direct experimentation or by gathering more materials related to the hypothesis. In the natural sciences such as chemistry or physics, the second stage usually takes the form of laboratory experiments, while in mathematics it would include software development of computer simulations. Various items of software are also used for data analysis in laboratory experiments, but interpretation of any data or computer-generated data analysis is done by a scientist on the third stage of the research process. Implementation, or application of results is not a part of basic research, but many believe it to be an integral stage of scientific process, and its examination, therefore, might bring valuable insights into the overall research process.

The two identified aspects of any research, its procedural stages and various factors influencing its progress can form a matrix, where interaction of different factors at different stages of the research process can be traced and analyzed in a Research Stages/Research affecting Factors Matrix (Fig 1). Each element identified by a letter and a number refers to the section with a discussion on the influence of a corresponding factor on a research process stage.

	Conceptualization	Experimentation	Interpretation	Implementation
Researcher	A1	A2	A3	A4
Organizational Structure	B1	B2	B3	B4
Political System	C1	C2	C3	C4
Economic System	D1	D2	D3	D4

Fig. 1 Research Stages/Research-affecting Factors Matrix

Ideally, an intensity of this interaction could be measured as well, but as Hayek has observed, such information would never be measured precisely. I analyze the influence of the aforementioned factors on each step of the research process comparatively and therefore uncertainly, drawing information from various publications and personal interviews with the researchers and administrators at MPG and former AdW institutes. The views expressed by each of these people are subjective, sometimes contradictory depending on their experience within the system, thus adding even more uncertainty to this study. Uncertainty deforms the presented structure already in the definition of subcategories of the four main factors.

This particular paper, for space considerations, presents only the evaluated and structured results of the research. One "cell" of the evaluation matrix is presented for the demonstration purposes. The full text of the research paper with the completed matrix is available directly from the author.

VI. Evaluation

A1. The role of a researcher at the conceptualization stage

All the subcategories (vaguely) defined, I shall now examine each one in relation to the research process. At the conceptualization stage, the individual mind, its creativity, inquisitiveness, and imagination play the crucial role in every scientific field in any country. Education and experience are important as necessary requirements for bringing creative thinking to a scientific level. Although such intangible concepts as talent and creativity cannot be measured accurately at a national level, we can assume that the East and West Germanys due to the common history and culture contained populations with the same or very similar national characteristics with respect to innate abilities and inclination towards natural sciences (after all, forty years of socialist regime could not mutate the genes of the East German population). As to acquired abilities, measured by education and experience, many Western observers "who by no means love the GDR... can no longer avoid the fact that the educational system... in the GDR [is] exemplary" (Meeting, pg. 19), although working experience was probably of a lower quality due to the equipment deficit in the former GDR. I would conclude that, on average, the role a scientist played at the conceptualization stage of development was roughly the same both in East and West Germany.

VII. Systematization

Filling up the Research Stages/Research-affecting Factors Matrix alone does not show which one of the stated hypothesis about GDR natural sciences research are correct. To get closer to the answer we would have to examine first the interaction between the Factors affecting Research and see their possible relationship, dependence and relative importance for the research process. Instead of drawing up another matrix, I will conceptualize the entire research operation process in a dynamic diagram (Fig. 4) and later examine the most interesting links between the five main concepts as they operated in the former GDR.

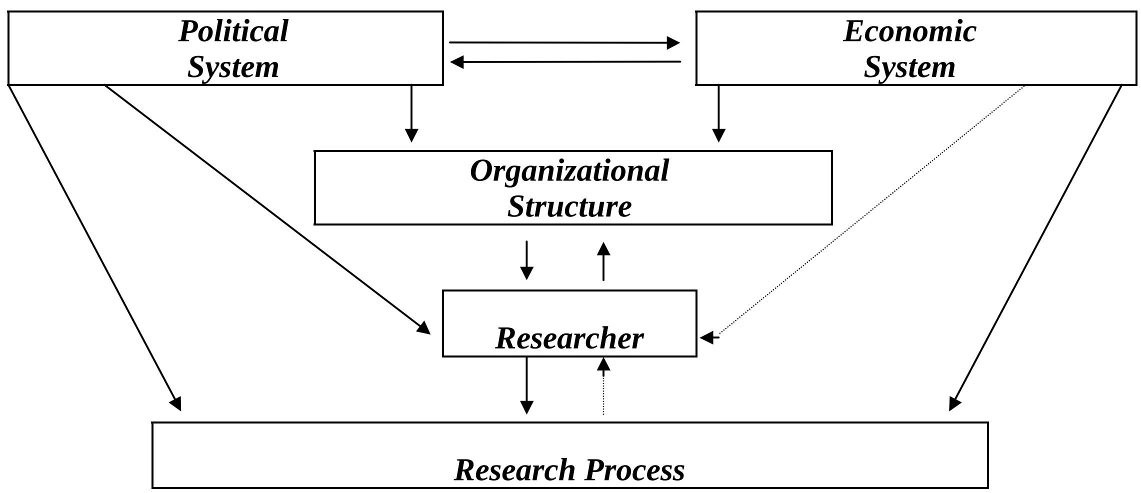

Fig. 4 Basic Research Operation System

Most of the links in the diagram are immediately recognizable as visual representations of the influences of research-affecting factors on the research process itself, discussed in the evaluation. A *Researcher* influences the *Research Process*, for example, but the *Political System* acts on several levels, through *Organizational Structure* and the *Researcher* as well as directly influencing the *Research Process*. Except three instances, arrows point only one way. The *Researcher*, his or her *Research Process* or *Organizational Structure* are relatively too small to have a significant influence respective *Political* and *Economic Systems*. Possible influence of smoothness or quality of the *Research Process* on the *Researcher* is too psychological to be measured in an economic study; therefore, an arrow pointing from the *Research Process* to the *Researcher* is not solid. Another broken line connects the *Economic System* and the *Researcher* boxes also to show possible psychological effects.

The two solid lines going both ways deserve special attention. An arrow from the *Researcher* to *Organizational Structure* could in theory be drawn also broken or dotted, for in the age of institutions a single person cannot fight an entire structure. In the former GDR, though, with its personalized bureaucracy it could become more real than in the West, and therefore I left the arrow solid. Interaction between *Political* and *Economic Systems* was not discussed before and will be touched upon later in this section to the extent that it relates to the operation of basic research in the former GDR.

A "broken" economic influence on the researcher is due to my (and perhaps everybody else's) inability to measure accurately an effect of worse living conditions in the central-command economy on a researcher. It was perhaps the psychological pressure of constant food and products shortages, small apartments "issued" by the government and so on, especially in comparison with the Western abundance that has distracted East German scientists at home and affected their efforts in research. The incentive system, which was placed in the organizational structure category for structural purposes (low opportunity costs, though being an influence of an economic system, are nevertheless part of the incentive system, and are consequently placed in the same organization section), has both positive and negative effects. Thus, in the above diagram the economic system affects a researcher through organizational structure (not only in the former GDR). There remain, however, many more immeasurable ways in which economic environment influences a researcher's psyche, and for those a broken line is left between the two boxes.

The influence of a researcher on organizational structure should be examined more carefully. As a group, scientific community may exert a lot of pressure, influence some political decisions, such as environmental protection, but will not significantly alter either political or economic structures. Joining together in their demands, however, scientists are able to restructure permanently their own environment, an internal organization of their institutes, or found a new scientific organization like the Kaiser Wilhelm Gesellschaft. A single researcher, on the other hand, will have little influence even inside his own scientific sphere without the support of his peers. There are some notable exceptions to this statement. Professor Harnack, for example, founder of one of the Kaiser Wilhelm institutes, has established there a hierarchy that is still present in the Max Planck Gesellschaft institutes referred to previously as the Harnack-Prinzip. Without other directors instituting the same system in their laboratories, however, the Prinzip would not survive longer than Harnack's lifetime. Moreover, without general trends in German society for social, political, and economic hierarchy outside the scientific sector, Harnack's principle would have died out as well or not even been instituted in the first place.

Let us turn to another example briefly mentioned in the evaluation section. I have claimed that the Zeuthen Laboratory performed incredibly well, according to a high rating from the Wissenschaftsrat especially due to the efforts of Dr. Lanius, Zeuthen' director since 1972. In particular, Special Commission of the Scientific Council has noted on a high scientific expertise and competitiveness, and recommended further operation of the institute (Wissenschaftsrat (a), 54), unlike that of the Einstein Laboratory for Theoretical Physics, which was later dismantled. Among difficulties that plagued Einstein Laboratory, "no access to Western publications, inability to attend Western conferences (though holding numerous invitations)" were mentioned (Wissenschaftsrat (a), 56-57). These problems were solved to a larger extent in Zeuthen only by the influence of Dr. Lanius (from an interview with P. Soeding). By being a good diplomat, a "trusted communist", and a good player in the Party bureaucracy's corruption game, Lanius was able to get favors from his superiors, such as access to Western publications for Zeuthen. Due to his efforts, approximately a quarter of Zeuthen scientists could go to DESY or CERN for joint projects and to attend conferences;

that strengthened the incentive and communication systems, two integral elements of the scientific organizational structure. One can only speculate, of course, at what costs these favors were bought -- personal bribes, an occasional paper written by the scientist for an administrator to be published or presented on the Western conference. The important thing is that Lanius's efforts were rewarded. Although he was not able to change the entire organizational structure of the former GDR, he has done it inside the walls of his own institute and that allowed Zeuthen to become a world-class research institute. The influence of one person, therefore, should not be underestimated: if several other AdW's natural science research institutes had had similar directors, greater freedom in communication and personnel mobility might have become a norm, having a significant impact on the GDR's organizational structure.

It is important to recognize, though, that energy and able management by Dr. Lanius have greatly contributed to, but did not determine fully, the success of Zeuthen Institute. Many of the aforementioned communication features such as e-mail and an open library carrying both Eastern and Western publications have paved the road to success precisely because they were enthusiastically and extensively used, alongside with many innovations in working equipment (i.e. computers replacing drawing boards). A workshop, where necessary equipment was often produced by scientists' craftsmanship, was probably a unique feature of the Zeuthen Institute (from interview with Dr. P. Soeding). This home-made equipment gave Zeuthen scientists a competitive advantage over their Eastern, and sometimes Western, colleagues and could be considered as one of the "success-determining factors". Personal contributions of Dr. Lanius, no doubt significant, have thrived only because of hard work, creativity and talent of the entire Institute staff.

Economics and politics operate through mutual interactions, like church and state in the Middle Ages. Although the latter pair was functionally separated long ago, the former is likely to continue its symbiotic relationship. Interaction between politics and economics in the former GDR would be a useful topic to explore, yet it lies beyond the scope of this thesis. S. Kornai has studied the mutual relationship between the socialistic government and central-command economy in his extensive work The Socialist System, and I direct everybody to that book for further insights.

It may be interesting, however, to see what other scholars have added to the question of politics-economics interaction particularly in relation to scientific research. Prof. Menske believes that

> Whereas in West Germany a strongly differentiated system with functionally specialized and mostly autonomous institutions emerged, East Germany science is characterized by hierarchical structures and the endeavor to integrate various functions. GDR policy was dominated by ideologically determined conceptions of a linear model of innovation. This conceived of utilizing the "productive force science" especially along a chain from basic research to production:

Basic Research → Applied Research → Experimental Development → Manufacture → Production

> The entire management system of the GDR was accordingly constructed in the form of a pyramid. Both the economic and scientific sectors were integrated in the management system. (Menske, pg.5)

This explanation contains some serious flaws. The linear model of innovation, so popular after WWII both in the West and in the East, has recently been found to "distort(s) the reality of innovation and most serious students of innovation have no come to recognize these distortions. In the linear model there are no feedback paths with the ongoing work of development processes" which are "essential to evaluattion of performance, to formulation of the next steps forward, and to assessment of competitive position" (Kline, 286). A pyramidal organizational structure described by Menske, characterizing the production rather than innovation was present in East and West Germany, reinforced historically by the vertical hierarchy of the Nazi regime. The pressure from industry on the AdW was also very weak in the East Germany, contrary to the Menske assessments (except in strategic research).

Despite this criticism, Menske's argument should be taken into account. Integration of the economic and scientific sectors under one all-planning management system was one of the main causes of rigidity of the socialistic basic research sector. An attempt to create an integrated linear flow of basic research into applied and so on has failed because there is no natural mechanism insuring implementation of basic research results. The latter can be achieved only with direct government intervention. Basic research in natural sciences has another "peculiarity" -- it is hard for non-scientists (in my example, for Party *apparatchiki* occupying high administrative posts, who rarely were able scientists as well) to evaluate new developments in science, arising need of inter-disciplinary research, and so on. Flexibility of Max-Planck-Gesellschaft, on the other hand, could stem only from its autonomous position as a scientific society. Rigidity of the AdW structure, an effect of the socialistic government and central-command economy, could in turn be a cause of the AdW's downfall and eventual dismantling.

Let me now turn back to the stated hypotheses and use the systematic diagram as an evidence, or rather as the result of testing the hypotheses. Despite a relative isolation of basic research in natural sciences from an enveloping political economy, H(0) does not hold: political and economic systems have affected research process not only directly, but through influence on organizational structure and on the researcher himself. The latter two were significantly altered by the former in the 45 years of Soviet domination. Such a simple and even obvious result could nevertheless be meaningful. In particular, it could be used to analyze a performance of basic research institutions in Eastern Europe and particularly in the former East Germany today. After the two influencing factors -- socialistic government and central-command economy -- are removed from the picture, several constraints and disincentives, no doubt, disappear with them as well. A distorted organizational structure, nevertheless, remains in place, and to a lesser extent mentality of a scientist. Letting research institutes operate today as they did under old conditions would not increase their productivity to the highest desired potential. New economic and political conditions, in other words, are not enough; something has to be done about old institutes.

In the former GDR a solution was found to “cut out sick tissue and replace it with healthy tissue” by closing a majority of the AdW institutes and opening new MPG centers instead. This solution might not have been the best in the short run, leaving thousands of qualified scientific personnel jobless, but in the long run it may bring its benefits. Newly founded institutes, not hindered by the remnants of organizational disfunctionings would be a better, healthier environment for further advancement of German science. If the Blue List institutes -- non-closed former AdW institutes -- will not be restructured, a further comparison between their performance and the MPG would be possible for a better insight on which of the two systems has fared better. Other Eastern European countries, however, don’t have alternative systems of basic research operating as the new unified Germany does. These countries either have to restructure their existing systems or build entirely new ones on one of the Western models. Either way, the crucial question will be one of funding. Countries in transition simply will not have (now or in the near future) any money to spend on their scientific basic research sector, especially on restructuring. Restructuring, however, has to be done, sooner or later.

VII. Conclusion

I began this thesis with a brief discussion of the former Soviet Union and would like to end it on the same subject. The problem of funding is critical in today's Russia: unemployment among scientists is higher than ever, and one may point out that it is not the time to seek problems that existed in the past and call for restructuring. In a few years (I hope, and fear that it may take decades rather than years), the transitional period will be over. By then, a new democratic government would have time and resources to look at its basic research sector and act to improve it. What would be the best thing to do? Perhaps these future administrators would look upon Germany for a solution, like Peter the Great had once done to speed up Russia's development.

What would the German example show? One of the main conclusions from studying the two systems, MPG and AdW, concerns the importance of autonomy in scientific operations. For the best results, administrative management of basic research should be done from within and organizational structure should be formed according to the structural demands and conditions of basic research. Another, no less important factor, would be the need for flexibility in the system, as most of the problems that plagued AdW basic research could be summarized into one word -- rigidity. Flexibility, however, should not be imposed from above. Such interference would conflict with the autonomy necessary for the most optimal operation of the research. The third lesson from this analysis is the importance of inter-disciplinarity in basic research. Although traditional areas still hold large scientific potential, the majority of discoveries are made on the edge, at the intersection of two fields that often grow into a field of its own, like biotechnology[1].

The lack of inter-disciplinarity might not have been the *primary* reason behind East Germany's poorer performance as compared with the West, but it has severily limited the overall scientific framework. It is possible that even without the political restrictions that existed, the basic research system would have stagnated, reaching a dead end in traditional scientific areas. Under the "supervision" of the Communist Party, however, day-to-day research processes were slowed down through communication obstacles, etc. so that the scientific dead end would not be reached for several decades.

Last but not least, the internal problem that Russian government has to face is its incentive structure. Under current economic difficulties, the question of competitive salaries

[1] Nanotechnology is just one of the examples of the field that could not be created in biology or engineering alone.

for scientists must be solved first. Financial resources in the form of salaries, facilities and equipment, however, will not provide sufficient incentive alone. The entire structure has to be changed. Old incentives, i.e. ability to work or travel to the West, have disappeared as the Iron Curtain fell. The newly emerged private sector on the other hand provides new disincentives to go into basic research as more jobs in industry are opened to scientists. Other incentives for the fundamental research sector have to be created, economic as well as ideological. A better system of grant and fellowship distribution is needed, perhaps through non-profit organizations, perhaps, once again, through the government.

Besides internal transformations within the scientific sector, external actions by the government are needed badly. Although financial resources are hard to find at present, tax incentives may motivate the industry to spend more money on basic research (as mentioned, in the U.S. 25% of basic research is done by private sector). This or a similar policy might kill two birds with one stone. On the one hand, it will promote conduct of basic research under a tight public budget; on the other hand, it will reinforce research-industry ties and lead to higher implementation rate of research findings. That, in turn will lead to higher economic performance and larger funding for publicly-supported science. This science and technology cycle is essential to bring the Russian economy forward to economic prosperity, and keep her there alongside other developed nations.

Annex A

Sample questions asked on interviews with scientists and administrators of various research institutions in the former FRG and GDR

Travel/Personal Mobility:

How would you describe overall your connections with other scientific institutions in your field and in the related fields both inside and outside the former GDR?

How often were your scientists invited on the national and international conferences? How often did they attend? What determined their attendance, or, rather, what prevented it -- lack of time or personal desire, institutional constraints or difficulties with the government authorization?

What other means of communication existed between the scientists of your institution and their colleagues in other institutions nation-/world-wide, besides conferences? How restricted were those means of communication) for example, did every scientist had an access to a work telephone, were the calls paid for by the institute)?

How easy was the access to scientific literature, especially the Western one, for the members of your institution? How easy was an access to the scientific information (research reports, library materials) in the different departments and different national institutions for your researchers?

Harnack-Printzip

How much power was delegated to the director of your institution? How much did the director participate in the scientific activity of the institute? Financial? Administrative? How much "veto power" did the director had over decisions of heads of departments and separate laboratories? Did all the decisions and resolutions of the institute have to be channeled through the director's office?

How would you describe the so-called Harnack Prinzip and to what extent do you believe it has operated in your institution? What do you see as major changes in the internal structure of your institute and why? How would you describe the structure of your institute in terms of rigidity/flexibility? What changes would you personally introduce if you were the head of the institute and operating under Harnack Prinzip?

Institute-Industry links

Did you have close contacts with any of the industry branches? Did you have any special contracts for basic research from the Applied Research offices of the industrial plants? If yes, were there strict deadlines, high standards and other forms of pressure felt from the industry?

How well do you think your research findings were utilized by the industry? As a scientist conducting basic research, to what extent do you believe the goals set by the industry should influence the direction of basic research, and how did the industry objectives actually influence the mission setting at your institution? What other forces besides the researcher's desire to pursue his research have influenced the choice of the research projects and directions?

What kind of equipment do you need to conduct your research successfully? Where did this equipment usually come from, home or abroad? How quickly did the equipment was installed and exploited, and how was it maintained?

Political Pressure

Did you ever feel any kind of political pressure from your supervisors or directly from the authorities? What forms did it take? At what step of the research process do you believe this influence was most significant: mission setting, research process, and research implementation?

Incentive/Reward Structure

What do you think were the main incentives for the scientists to join your institution and participate actively in its activities, i.e.. moral, material. For example, if you have this kind of information, what were the salaries of the junior/senior scientists, in the 1970's -- 80's, especially in comparison with the national average wage at that time. Were there any additional benefits from the government provided to the members of your institute, for example, free housing, transportation, etc. How would be a successful scientist rewarded in the beginning of his career -- would his name be mentioned in the papers, would he be given a separate laboratory or special equipment? What would happen to a scientist who did not produce any particular results? To what extent do you believe Matthew's effect was operating in your institution? What would you improve in the incentive structure to insure an even better performance of the German scientists?

What do you think has contributed the most to your success?

Annex B

Summary of the interview with Paul Soeding, director of Institute for High Energy Physics at Zeuthen, Germany (former GDR)

Zeuthen Laboratory was a successful research institute even under the socialist regime in former East Germany. This was due mainly to Dr. Lanius, who was the director for more than 25 years (1962 - 1988). Lanius recognized the importance of communicating with the outside world for scientists and did everything he could to promote freedom of scientific information and contact within the institute (but not any political information, of course!). One of such achievements was the library, open to all including visitor scholars, since Western scientific literature usually was not available to scientists in other institutions. Of course, to enter the institute one had to have an invitation, and once a member of the institute got into trouble because a Western scientist, hearing about his colleague's work, wanted to visit him at Zeuthen.

This shows that connections with the West and generally with "foreign" scientists were closely monitored. Contacts not only with the West German or "capitalist world" scientists, but even with the Russian colleagues in Dubna were restricted. To visit one's international correspondents in Dubna or DESY, Hamburg, an East German scientist (and Zeuthen members were no exception) had to apply for the government permission and wait at least a year while all his invitations and recommendations would be examined and his party loyalty checked. Thanks to Lanius's influence in the party circles, where he had a very high position, Zeuthen had one very important mean of communication -- e-mail, which had kept it connected with the Western world and allowed the scientists to go along with their Western colleagues in the avant-garde of science. Though it was monitored by the authorities, scientific information could pass freely across the borders.

Generally, all information was monitored, conversations were reported to the special government officials by special informants. This created a lack of trust and collaboration among the members of the institute. People wanted to free themselves from the atmosphere of mutual suspicion by going to DESY, Hamburg, to CERN, or to Dubna. Mainly scientists could travel. Also some engineers, occasionally also technicians. Of those, about 2/3 were allowed to go to Russia or generally to the socialist countries, and 1/4 to the West for the prolonged periods for cooperative projects. These numbers were still considered to be very high among AdW natural sciences institutes.

As far as the equipment goes, it was mostly produced with Zeuthen Lab's own resources inside special workshops. An exception was the computational technology, personal computers, for example. Since they were underproduced in the Eastern bloc countries and were immediately exported to the former USSR, so the computers for Zeuthen Lab would have to be imported from the West. But this was not possible for two reasons. First, they would have cost hard currency that was notoriously very short, and, secondly, the better computers really needed for the work done at Zeuthen were all embargoed by the West. So the computers came from Russia or Czechoslovakia or Bulgaria, etc. It took years for the orders to go through, and computers arrived already outdated.

Ironically, this had a positive side as well, as the scientists at Zeuthen, sick of the outdated technology, were more creative to designing their own software, for example, or embracing the new technology. At DESY, Hambourg, for example, engineers and electronics designers were reluctant to switch from the old-fashioned framing boards to the computers with special software and had to be persuaded to this innovation. At Zeuthen, on the other hand, engineers were curious and enthusiastic about working with new equipment.

Generally, there were few links with the industry, close to none, since in the short run the basic research performed at IfH Zeuthen was “useless”. However, there was enormous pressure work hard and show good results, because otherwise the institute would be in danger to be closed for its “uselessness”.

Director's efforts, as we have seen, have kept the institute afloat and quite successful. The director was not omnipotent, however: he could not fire a person, for example, but all the financial, scientific, and administrative papers had to go through his office and further up the bureaucratic ladder. Director had his own Academy and Party bosses in front of whom he was answerable. But, contrary to the opinion, there was in some respects less bureaucracy in the East than in the West Germany, because some of the decisions were made by inter-personal deliberations rather than through administrative routine.

Still, due to his position and strong Harnack-Prinzip retained in the system mainly because it was favorable to the hierarchical structure of the socialist administration, a director had a lot of power and could do almost anything inside his institute, as shown in the example with the libraries. For that, of course, he had to be a good diplomat, like Lanius was, and he had to have very good friends in the high echelons of the Socialist Party.

Though people have changed, the internal structure had remained basically the same until 1989. But one part of the internal structure had deteriorated greatly, that is, the incentive structure. Though Zeuthen Lab research was successful, it could have been three times as successful, was it done in the West. There are many reasons for this. Foremost, it was a lack of freedom, free scientific exchange, the whole depressing atmosphere of a country run by a party system repressing individual freedom and initiative; second, lack of resources (i.e. computers), and in general a lack of a good industrial basis. Many people wasted their valuable time designing and building things that in the West one simply buys. Even primitive materials were often hard to come by. People also wasted infinite time waiting for deliveries, searching for sources, etc. Third, progress was pronounced to be for the sake of advancing the socialist doctrine as defined by the party, and people knew that it was all lies and hypocrisy and corruption, and they became extremely frustrated.

Frustrated and disenchanted, many scientists did not make an effort to work harder than necessary, especially since they were not materially awarded for extra efforts. Junior researchers received significantly less then the factory worker, and only a half of what his director would get. The only prize for hard work would be the recognition of the senior staff and the possibility to travel abroad to Dubna or Hamburg on their recommendation. Even that required political obedience or at least lip service as well, at least as far as traveling to the West was concerned. Possibility to work in the atmosphere of relative trust was an award in itself, to escape the frozen society, though to work in the West a scientist had to leave his family back home as an insurance of his eventual return. But there were many scientists who for political reasons were not allowed to exit the country and they finally lost the little incentive there was to work hard. There always remained, of course, the few scientists who worked for the science itself, and they were always the ones to conquer the new frontiers in their field.

Annex C

Summary of the interview with Leo Stodolsky, scientist at Max Planck Institute for Physics at Munich, Germany (former FRG)

MPP (Max Planck Institute for Physics) is a theoretical and experimental basic research institute, mostly publicly funded. It is one of the leading research centers in the scientific world. Its members are often invited to the conferences and for collaboration projects in other institutes, such as DESY, Hamburg, and CERN, Geneva. Even before 1989 MPP had contacts with other research institutions in the East. Its scientists went to DUBNA, Moscow, and Yerevan, had regular meetings in Krakow and participated in occasional formal collaborations etc., particularly with Krakow. There was no pressure from the Western authorities to restrict East-West scientific contacts.

With the Western partners scientific communication and exchange was well established. Since early 80s the institute has received Internet access and gradually all the scientists had e-mail, telephones were available, though not long distance in every office. Duration of international calls was monitored because of the costs, but it was nevertheless allowed to call international for scientific purposes. The same financial limitations allowed a senior scientist to attend a conference only about three times a year (without any restrictions to the location.)

The library was full with scientific journals (including translated major Russian publications) and open to everybody within the institute and visitors. It was quite easy to enter the institute and use the library for the outsiders, they just had to register with the secretariat. For research facilitation, a copy machine was available in the library.

Despite strong connections with the scientific world, MPP had little links to the industry, because basic research performed there had none or close to none immediate applications. Under "basic research" are meant not only theoretical findings, but also experimental research. The institute had strong experimental groups and a big workshop that took up most of the budget and about 2/3 of the scientific personnel.

Once a project was approved it was generally well supported. Influential directors, however, could get better support for their projects. Directors had a lot of power also due to a strong influence of the Harnack principle. A director could not fire a person, of course, because of the strong union and government. regulations, but short of that he could do everything within his institute, and all the papers went through his office. The "Betriebsrat" [work council] approval was necessary for personnel decisions, but usually it does not influence them. In that sense, and in many others the internal structure has remained the same and little has changed during 60's -- 90s.

Political pressure was almost non-existent, even though some influence could be exerted by individuals who wanted to implement their political opinions, i.e. against nuclear research.

Government did not set any goals or monitored any project; however, sometimes it contracted institutes to participate in a specific project with government monitoring and supervision.

Annex D

Summary of the interview with Leon Mishanaevsky, scientist at MPA Institute for Metallurgy at Stuttgart, Germany (former FRG)

Materialprufungsanstalt (MPA) is an applied metal research institute. It has strong links with the industry and often receives industrial orders. It is, therefore, only partially funded by the government and receives most of its operational revenue from industrial orders. There was no strong connection wit the government and no political pressure was felt.

Relationship with the industry has taken a form of traditional meetings once every four months. Researchers read their papers, their colleagues in business in turn express their desires as to the direction/ betterment of further research, and in this discussion a plan for the next few months is worked out.

Deadlines are strict, “do it or die.” If the job is not done in time, penalties would be imposed by the ordering company on the institute, and the scientist at fault would get punished by his or her superiors. This is an incentive system that takes a form of stick rather than carrot. Carrots would be director’s recognition, salary raise, etc.

Harnack Prinzip still operates on a high level -- inside the MPA there is a strict hierarchy. Director is quite strong and has a lot of power. He is not omnipotent and does not have a “veto power” over heads of laboratories, but his word carries the heaviest weight in any decision.

A working atmosphere is easy and relaxing (to an extent that people would not slack off). During lunch an entire team would sit down to chat about outside things, but hierarchy would be so strong that nobody would stand up and leave before the team head.

In terms of equipment there never were any problems. Scientists perform mainly computations and simulations on their work stations. Equipment is either home industry-produced or foreign-made in U.S. or Japan.

In general research done at the MPA is very good, but it is not utilized fully by the industry.

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