The tradition of Friedrich List

French political economy from Jean Bodin to Charles Dupin—part 3

The mediation for development, says Chaptal following Leibniz and Carnot, is the use of increasingly efficient machines, efficiency being measured by the free-energy ratio of the functioning machine. Well aware of the need for polemics, he mocks the fears of his ecologist-romantic contemporaries in the following terms:

> Unenlightened people have always feared that the use of machines would rob most industrial workers of their jobs: the same fears were experienced at the time of the introduction of the plough and of the printing presses. But, if we go back to the origins of the mechanical arts and follow their progress up to our own time, we can see that the hand of man has always been equipped with machines which underwent a continuous perfection, and that the prosperity of industry has always depended on these progressive improvements. The reason is that machines, by reducing the cost of manpower, diminish the cost of the product, and that consumption increases, because of the low prices, proportionally more than manual labor is reduced. Besides, by increasing production, more subcontracting activities are generated, which demand manpower and employ more men than could be hired in an unmechanized plant, which would necessarily be of a lesser size.

It is to foster such economic growth against France's London-led enemies that Chaptal enforced, following Sully, Laffemas and Colbert, a "flexible protection":

> A good customs' legislation is the true protection of the agricultural and manufacturing industry; it means to increase or reduce taxes according to circumstances and needs ... protect nascent industries through prohibitions, so as to avoid confrontation with foreign competition until national industry has reached such a degree of perfection that it can grow independently, and finally enrich that industry with labor power which is, as I say many times, the main source of wealth....
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> In this sort of hierarchy of all national imperatives, industry occupies the first place ... The merchant gives no value to the goods he trades, whereas the manufacturer creates almost all the value won by the raw material on which he works.

Chaptal's conclusion is that there are no given medicines or magic formulas to establish the level of protection for the national industries, but that the customs policies depend primarily on the *political intentions* of France's competitors and on the relative advancement of foreign industries. In such an approach, the customs tariff is a key political element in the process of industrialization, which is primary—exactly the conception of Friedrich List. The first industries to be protected and promoted through a state-controlled system of bonuses are, in Chaptal's terms, the *seminal industries* (industries fécondantes)—those industries whose role is primary in the process of higher rates of energy transformation and transmission through the economic whole.

The first task of a competent Minister, says Chaptal, is to plan the development of such seminal industries and organize around them infrastructural networks—Trudaine's conception again. This is also the conception that should guide the development of nuclear energy today. Fusion, the most advanced aspect of the process, should have priority in terms of research and investment, but fusion cannot work in itself. The support of fission and fast breeder energy production is crucial, if only to shape up the world economy for the future use of fusion. Nuclear energy development is not a fixed goal, but a whole seminal process. Similarly, nuclear energy cannot be developed successfully if only produced for one part of the world (the advanced sector) and not the other: the process of development cannot be but whole-encompassing.

Making his approach quite explicit, Chaptal polemicizes against those who want to establish a "golden number" quantifying the best level of absolute protection. Once more taking economic motion as primary, Chaptal explains that protection cannot be reduced to a fixed level of customs taxation, such as 15 percent. Arguing in Leibnizian terms that motion cannot be located in an unvarying substance (the Cartesian "flaw" of Forbonnais himself), he attacks such a conception of "protection" as dangerously inadequate.

Education of labor was the determining point in Chaptal's industrial policies, together with supply of cheap energy. He located the main French problem in those two interconnected features: a too high cost of energy because of England's Malthusian monopoly on

the technologies of coal extraction, and a still too inexpensive manpower in France itself because of the acceptance of low wages by peasants coming to the cities. Giving the best lesson that present day capitalists can dream of, Chaptal emphatically stresses that only high wages can determine industrial development: a low-paid manpower does not generate labor power and therefore does not induce the industrialist to mechanize his firm, which in turn reduces his actual rate of profit. Low wages, in Chaptal's terms, put industrialists under merchants' control.

Industrial education

The founding principle of List's industrial Zollverein was the industrial education of the nation: energy transformation (i.e., "protected" industrialization) is and can only be achieved through the perfecting of creative mentation to continuously raise the cognitive power of labor. To organize and direct such a process, List conceived of a centralized educational institution following the original conception of Monge, and later of his students Carnot and Dupin. This was the notion embodied in the original *Ecole Polytechnique,* before Napoléon's 1804-1807 reductionist blunders: creation of an educational environment to foster scientific discoveries for industrial practice and irradiate progress throughout the whole nation from the standpoint of the higher hypothesis. It was from the principle of that higher order that the education of the whole nation was to be organized to build up the Zollverein conception on its necessary social basis.

Here again, the point is that Monge's approach to science was not that of some abstract game, but determined by his commitment to progress. His purpose was to develop French industry through the use of general scientific method adequate to the different fields of technology. Descriptive geometry, the "theory of machines," physics and chemistry represented for him "not sources of study as such" but an approach to improve the general conditions of human life through the progress of industrial methods and utilization of energy sources to replace human physical force.

Monge, as proved by his conception of descriptive geometry, concentrated his work at the level of the higher hypothesis. What he accomplished was the transformation of a merely empirical graphic method into a new branch of geometrical science: extension of the restricted Cartesian geometry to a new order by an accurate representation of three-dimensional space-objects by two-dimensional designs, opening thus a new era for creation of machines and architecture. Monge was led to that conceptualization by his moral understanding of the need for a general, superior method subsuming all the apparently dissimilar processes used by technicians, so as to achieve the greatest productive efficiency. His accomplishments in infinitesimal and analytical geometry as well as in the theory of machines and heat (later developed by Carnot as the laws of thermodynamics), were guided by the same principle: to master processes of development by focussing on their "productive generation" ("higher energy transformation" as represented by "projection" in descriptive geometry). This was made clear when Monge, teaching descriptive geometry at the Ecole Normale, refuted the Condillac approach peddled by one of his students on "the given logical order of geometrical elements" and proved instead that surfaces can only be classified according to "their *mode of generation.*"

The perspective of technological development in which he placed his descriptive geometry is confirmed by a project he conceived around 1793 (he mentions it in the 5th section of his treatise on descriptive geometry) which called for the creation of schools for workers and artists who, from the age of 14 to 16, would be taught applications of descriptive geometry, physics, chemistry, morals and civics. Such schools would be opened in every important city in the country, so as to rapidly develop a highly skilled industrial labor force. This is what was later developed by Dupin as the Conservatoire et Métiers movement.

This same perspective was that of the Lafayette-Condorcet-Monge Société Patriotique, a Leibnizian "Society" sponsored by Benjamin Franklin whose political aim was to issue a constitution in the framework of which men would realize their freedom by organizing other men into progressive social and educational policies.

It was this same conception that generated the Ecole Polytechnique. Prior to and during the 1793 scientific mobilization, Carnot and Prieur de la Côte d'Or had often discussed the need for a single school of engineers which would embrace all the existing "corps" of the Army and State Administration. Four schools existed at that time: the military Engineering School of Mezières (where Carnot had been a student of Monge), the Châlons-sur-Marne School of Artillery, the Ecole des Ponts et Chaussées and the Ecole des Mines in Paris. The severe partitioning of all those different schools was obviously detrimental to all of them, and especially to that of Châlons, as the engineering officers were forbidden to communicate their conceptually more advanced knowledge to the artillery men who had to go to Paris to catch up with private lessons.

Lambardie, the head of the Ecole des Ponts et Chaussées in Paris (the successor of Trudaine the Elder) had been repeatedly pushing for a preparatory-type school where both civilian and military engineers would be taught "the general principles of sciences." Monge and Carnot supported this approach.

The commission in charge of working out the educational and organizational plan for the Ecole Centrale des Travaux Publics (as the Ecole Polytechnique was

first called) was selected among those scientists who had worked with the Convention's Comité de Salut Public and the members of the Comité d'Instruction Publique, where the best minds of the Leibnizian tradition were gathered: Monge, Bertholet, Chaptal, Lamblardie, Guyton-Morveau, Fourcroy, Prieur, Hassenfratz and Vauquelin. Their common conception was that all public services should intersect one another in their theory and practice; that they all require the same overall knowledge in graphic arts and science; and that such general studies "can only be carried out under the greatest scientific authorities, in the very center of the arts, and under the supervision of the most distinguished scientists."

Monge's cadre conception

Monge played the principal role in the founding of the School. "It was an eminently philosophical, eminently useful and eminently rational idea, that of giving each student in a public service a sufficiently general knowledge of all the other services," Charles Dupin exclaims, describing the Ecole as that of "Pythagoras and Plato."

National education, Monge was saying, should be oriented toward the kind of knowledge which forms the mind to exactitude, while giving a sense of the different magnitudes and their measurements" so as to hasten the progress of industry and consolidate the Republic. Jean-Baptiste Blot, Pasteur's future chemistry teacher and Monge's student, writes that the Ecole was founded "1) to train engineers; 2) to spread enlightened men among the whole society; 3) to arouse the talents which can advance science."

The key problem to solve, similar to the present day problem set to educators in the developing sector, was to accelerate the process of learning the higher scientific knowledge ("general instruction") to students of different intellectual and cultural levels, of which only one-third had really received high-level education. Monge solved this in the most brilliant and dedicated way, and thereby made it actually possible for the Ecole to get underway altogether, through his "would-be instructors" system. The 396 students admitted for the first time as a result of national examinations were divided into 25 "brigades" and given "chiefs of brigades," whom Monge selected from among the most developed and to whom he personally gave the most intense training—through a cadre school he directed and for which he worked day and night. The conception was that the "chefs de brigade" would be in a position to make sure that all students would move forward, by immediately helping those who would display any problem in understanding. This humanist concern for a true democracy was also reflected in the fact that the state provided the material means through which any qualified citizen would have access to scientific competence.

It was during those initial 3 months that Monge trained the would-be instructors through massive efforts. He was simultaneously teaching his descriptive geometry for the first time, giving a course every day, circulating manuscripts he had from Mezières and his notes on Bernouilli, Euler, Leibniz and Huyghens to remedy the lack of textbooks, creating wooden and stone models—always aiming at the best pedagogical results.

The founders of Polytechnique had insisted that the students should live in the best environment to develop their minds: outside the school, in Republican families all over the capital, where they would find moral backing and adequate material conditions. Prior to Napoléon's militarization of the Ecole, internal discipline rested on the chefs de brigade, not as watchdogs, but on the basis of their higher level of development.

Although Monge was personally attached to Napoléon, for whom he had conceived the Egypt campaign according to Leibniz's African development conception, he fought hard to defend the Ecole against the Emperor's attempts to water down the essential humanist plan of the institution. But unfortunately, Napoléon issued an 1804 militarization decree enforcing formal, bureaucratic discipline and requiring the students to pay an annual fee. The content of the teaching rapidly sank and courses were cut down, while grammar and liberal arts professorships were introduced. The 1815 Restoration government closed the school altogether for one year in 1816 and discharged all its students after a provocation bearing the pawprint of Metternich. Charles Dupin managed to have it reopened, but after that the original Monge conception was never redeveloped in its full implications.

Chaptal was the direct collaborator of Monge at the economic command of the nation until Napoléon's 1804 Empire turn and Austrian alliance. He describes his 1802 *Society for the Advancement of National Industry* as the necessary complement for Polytechnique at the point of transformation of science into industrial practice. Its aim was to close the gap existing between a scientific discovery, its application as a new mechanical process (Polytechnique) and its accomplishment as machines produced and working for mass production. In particular, bonuses were secured by the Society for industrialists willing to introduce new processes in their plants, such as steel-maker Poncelet in Metz, later a collaborator of Dupin.

Linked to the Society Chaptal also created the *Ecole Centrale des Arts et Manufactures,* so as to further organize "immediate connections between the scientist and the manufacturer."

To publicize the discovery of new technologies and their successful application to industry, Chaptal supported the launching of a new industrial press represented by the *Journal des Mines* (1705-1815), later to become the *Annales des Mines*), the *Annales des Arts et*

Manufactures, Le Métallurgiste and the famous *Moniteur Industriel* (also with support of banker Jacques Laffitte).

To foster the development of industry, Chaptal mastered the entire notion of "technology transfer," so important today for the industrial take-off of the developing sector. Defining himself as a follower of Colbert, "who had brought to France the Van Robais, Hindret, Huyghens and others," Chaptal organized a systematic government policy of confrontation with British Malthusianism (prohibition to sell machines abroad) through imports of British engineers and industrial discoveries to France. With government moral and financial support, French engineer Dufaud thus brought back to France plans of British machines and set up a big factory at Fourchambault, and the top British engineer Douglass was called to France and had a plant equipped with government funds to develop the technology of cotton mill and drapery processes. Chaptal later encouraged French industrialists Decretot and Ternaux the Elder to follow the way opened by Douglass, and soon the Douglass machines were used throughout the national territory.

To further such advancements, Chaptal's associates supported workers' educationals, as a means for, not the learning of fixed sets of behavior, but as the "development of industrial judgement"—the capacity to understand the basic scientific processes behind the design of a machine, and therefore to use the machine safely and productively. Chaptal comments that "apprenticeship should never be limited to one task alone, but should instead start with a general education applicable to all manufacturing and mechanical arts." For that purpose, he used the Conservatoire National des Arts et Métiers in Paris as a model for the provinces, and took advantage of the fact that Monge and Carnot had transferred to the Conservatoire most of the machines of the former Académie Royale des Sciences to avoid their being looted or destroyed in the storms of the Revolution.

It is from such a framework that Dupin started his own educational drive after the fall of Napoléon. First, Dupin and his networks, despite Talleyrand's London influence, managed to convince Louis XVIII to broadly continue protecting and promoting French industry against England. In this, Dupin was directly supported by Prime Minister Decazes against Rothschild's agent of influence Baron Louis.

The point that Dupin made, following Ferrier's and Chaptal's analysis, is that Napoléon Continental Blockade had been, for all its reductionist flaws, an overall economic success and had favored the industrialization of not only France, but also of certain large portions of continental Europe, such as Lower Saxony. A network of French-centered republican technicians was implanted in the European hinterland, forming the potential basis for List's Zollverein.

Decazes, a European ally of List's protector Wangenheim, reestablished regular exhibitions of manufactured products in France, with a bonus system for the best of them, founded general councils of agriculture, manufacturing and trade, and sponsored the teaching of sciences applied to the industrial Arts at the Conservatoire. It was Decazes who appointed Dupin as professor of Geometry and Mechanical Arts at the Paris Conservatoire.

Dupin, who started his classes in 1824, continuing them till 1854, adressed himself to an audience of literate laymen and in particular to skilled and semi-skilled workers. His idea was, through quantitative and qualitative expansion of the social base for industrial development, to reverse the monarchy's industrial orientation toward production of luxury goods, the pathetically famous "articles de Paris"—especially since Decazes' forced resignation following the 1820 assassination of the Duke of Berry.

Dupin's drive was to put the central conception of the higher hypothesis consciously into focus for the instruction of the broadest possible audience. In his speech, *The Influence of the Working Class on the Progress of Industry,* he defines his immediate goal as the raising of workers who know only the basic four rules of arithmetic up to the level of being finally conscious agents of industrial progress. To achieve this, he locates in each man a potential to be mobilized:

> Nature limited the needs of man, but the creative power received by man from the Supreme Intelligence leads him to continously discover and perfect: it is to that power that we owe the successive advancements in agriculture, trade, industry and in our whole civilization.

A key supporter of the Dupin approach was the Duke of La Rochefoucauld-Liancourt, a close ally of Franklin and Lafayette, who had been the first to creat a School of Mechanical Arts and Manufacturing in his own Liancourt castle, and then founded a Practical School of Mechanical Arts and Manufacturing at Châlons-sur-Marne, basing the education of the workers on mathematics, designing and the analytical method, including Monge's descriptive geometry. Another collaborator of Dupin was the steel-maker Poncelet, who started a similar series of courses in Metz, a key industrial city of the time, from which the Dupin family also came.

Dupin conceived the Paris Conservatoire as the exemplary, seminal institution for the provincial schools. He was also aware of the necessity to create a link between Polytechnique and the Conservatoire movement, both to convey the higher conceptions to the Conservatoires from Polytechnique, and to stop short the developing "positivist" tendencies in Polytechnique, where the new politically isolated and militarily controlled students tended to see themselves as "great priests" of science, the absolute opposite of Monge's conception.

Following the Paris model, Dupin advised the provincial Conservatoires to organize exhibitions of machines and models so as to have in every city a *Museum on the Advancements of Industry*, where the arrangement of concrete scientific experiments would make the practical power of the higher discoveries sensuous to workers. A biographer notes "His conviction that the higher conceptions of science are linked to the perspectives most useful for the immediate progress of human society." Dupin was also a staunch defender of compulsory education provided by the State until the age of 14-16, this at a time when children from age 6 were bestialized in manual labor. His first classes in Paris brought an audience of about 500, to soon reach figures close to 1,000. His textbooks were translated and used in the U.S., Germany, Spain, Italy, South America and so forth.

The key point is that Monge, Carnot, Chaptal and Dupin, as hinted by Poe in his *Purloined Letter*, were before anything else, before any predicate, organizers of the human mind for the development of reason. This is what was the notion of "industrial education" as later understood by List.

This Zollverein-Polytechnique conception of "industrial education" is what is still lacking behind the otherwise correct nuclear policies of the French government and the European Monetary System initiative of Giscard d'Estaing and Helmut Schmidt.

—Jacques Cheminade