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THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 601322 Telefax 601753

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Timo Myllyntaus

CHANNELS AND MECHANISMS OF TECHNOLOGY TRANSFER: SOCIETAL ASPECTS FROM A RECIPIENT'S VIEWPOINT

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ABSTRACT: Technology transfer is not just a matter of transporting some piece of hardware from one place to another. On the contrary, it is a complex process of transformation which takes place in a specific economic, societal, and cultural context. The aim of this paper is to clarify some key concepts and outline a theory on technology transfer. The model for technology transfer presented in the paper is composed of five components. The two main parties of the transfer process are suppliers and recipients of technology. The third component is the channel apparatus through which machinery and technological know-how are moved from one country to another. The fourth component is the societal and cultural filter. It is very important because it defines the rules of the game. The fifth component consists of external factors. The function of a certain transfer model can be radically changed by some major outside influences, such as war, economic crisis or ecological calamity. The success of a transfer mechanism depends on the way how these components interact with each other.

As an example of how the filter operates, some plans are presented regarding construction of hydroelectric plants along the River Vuoksi in the grand duchy of Finland at the turn of the century. Russian-based but foreign-owned power companies put forward two types of proposals to harness this major river for producing electricity primarily for St. Petersburg. One called for construction of a series of medium-sized hydroelectric plants along the Upper Vuoksi. The other would have closed the original bed of the river and built an artificial channel for directing the outflow of Lake Saimaa to one huge power plant. Due to political reasons, Finns opposed all plans for harnessing the river Vuoksi to produce hydroelectricity for St. Petersburg. They considered that in this case, the transfer of modern technology threatened the political autonomy of their country. Because of disagreements and inefficiencies on the Russian side, Finns managed to delay and finally prevent all attempts to transmit electricity from the grand duchy to Russia.

KEY WORDS: Transfer of technology, technology policy, underdeveloped areas, Finland, Russia.

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CHANNELS AND MECHANISMS OF TECHNOLOGY TRANSFER:

SOCIETAL ASPECTS FROM A RECIPIENT'S VIEWPOINT

Timo Myllyntaus

Points of Departure[1]

Technology has several definitions. A short and pithy definition has been formulated by a Swedish historian of technology, Svante Lindqvist. According to him, technology comprises man's methods of meeting his wishes by utilising physical means.[2] Hence in the case of technology, it is a question of know-how which is related to both physical means and target-oriented activity.

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[1] An earlier version of this paper was presented at the "Symposium on Theories and Methods in Recent Nordic History of Technology", hosted by the University of Umeå, Sweden, on 2 - 4 April, 1990.

[2] Svante Lindqvist, "Vad är teknik?", I teknikens backspegel. Antologi i teknikhistoria, ed. Bosse Sundin (Malmö, 1987), pp. 11-33.

The transfer of technology denotes, in my opinion, the flow of technological expertise and technical equipment from one country to other or from one economic region to other which has a different institutional framework or which is on a different level of development. This definition for international technology transfer is, in a way, wider than the definition formulated by UNCTAD, which excludes pure trade or leasing transactions from technology transfer if they are not connected to other services.[3]

The spread of a technology within a country or an economic region is what I refer to as diffusion. In the transfer process, the role of a recipient is generally more active and target-orientated than in the diffusion process. In the event of technology transfer, the recipient cannot avoid evaluating likely consequences for the economy and society. When a diffusion process is set in motion, the technology in question is usually already present in society, while in the case of transfer, society has first to decide whether it accepts or rejects a new optional technology.

In technology transfer there are two parties: the suppliers of technology, who possess technical expertise, and the recipients of technology, who would like to share that expertise. These are the main actors in the transfer process. Most theoretical considerations of technology transfer - not only Anglo-American but also Finnish ones - approach the issue from the viewpoint of suppliers.[4] By contrast, I aim to examine this phenomenon from the viewpoint

[3] UNCTAD, Draft for an International Code of Conduct on the Transfer of Technology TD/CODE/TOT/33 (Geneve, 1981).

[4] As an example of Finnish contribution, I could mention Sampsa Saralehto's Ph.D. thesis "International Transfer of Technology into the Industrialization Process of Developing Countries". Sampsa J. Saralehto, Teknologian kansainvälinen siirto kehitysmaiden teollistumisprosessiin, ETLA A series no 9 (Helsinki, 1986).

of a recipient economy and in an historical perspective. The difference of these viewpoints is not marginal; the whole issue seems quite dissimilar, when evaluated from contrasting angles.

Technology transfer is not just a matter of transporting some piece of hardware from one place to another. On the contrary, it is a complex process of transformation which takes place in a specific economic, societal, and cultural context. If certain conditions are not fulfilled, the same technology that has worked somewhere with success, may completely fail in a new setting. In less developed countries, the pivotal problem in technology transfer is often their inability to supply sufficient material and societal infrastructure for new technology. The recipient economy should possess adequate prerequisites to adopt, use and maintain a new kind of technology, such as embodied in an electrochemical factory. However, a material infrastructure, such as water and electricity supply, transport and telecommunication facilities, is not enough. There must also be a sufficient nonmaterial infrastructure with components, such as a stable functional political system and a pool of skilled labour.

Channels for Technology Transfer

Countries setting out to industrialise generally can create only a tiny fraction of the modern technology they need. Therefore, they are compelled to obtain foreign technology in order to modernise their economies.

Those vehicles by means of which machinery and technological know-how are transferred from suppliers to recipients are called transfer channels of technology. Within specific limits, technology is a very multiform phenomenon and it can be transferred from one country to another in many forms and through various channels. Regarding economic and societal effects, it is significant in what form technology is transferred into a country and by whom. If it is obtained in such a way that the recipient country is able to control neither the transfer nor utilisation, then there is a risk that the recipient becomes dependent on the supplier of technology. Some types of technological know-how are also available without any obligation or at low cost easily from the world market. In that case, there is, however, a danger that the recipient cannot exploit the acquisition of technology composed of separate, poorly compatible fragments, because the result may be an unworkable technological unit.

Technology can be transferred in a kind of "guaranteed package," such as in machinery, equipment or a whole plant as a turn-key delivery. In such a case, the recipient can expect to receive new technology that works. Each vintage of capital stock, however, gets old and obsolete over time. A country that imports machinery is not necessarily itself able to update and improve it as it grows obsolete.

New technology can also be adopted in forms such as ideas or human capital. Updating this kind of know-how becomes a continuous process leading to a more meaningful adoption of technology. The mastery of various aspects of a specific technique may lead to avoiding dependence on a few oligopolistic suppliers.

In practice, machinery and expertise supplement each other, and they tend to appear together. Which type of technology transfer a country utilizes most seems to depend on its prerequisites and goals as well as its relations with foreign countries.

In the eighteenth and nineteenth centuries, the innovation of new technology was concentrated in a few major industrialised countries: Britain, France and, later, Germany and the United States. A great many other countries attempted to follow the example of these forerunners and to adopt their modern technology. The channels that transmitted innovations from industrial centres to the peripheries of the world can be classified in many ways. I argue that the following six channels, depicted in Table 1, were the most important during the previous century.

Table 1. The Main Channels of Technology Transfer from Industrial Centres to the Periphery in the Nineteenth Century

1. Importing foreign machinery and equipment
2. Receiving direct foreign investments
3. Acquiring foreign licences and patents
4. Recruiting skilled workers, artisans, engineers, teachers, and consultants from abroad or permitting mass immigration containing a large spectrum of various craftsmen and professionals.
5. Encouraging and supporting journeys abroad by nationals for studying at foreign schools and universities, training in factories and offices, or visiting trade fairs, congresses, and other places where technological knowledge was exchanged
6. Utilising natural and low cost diffusion: the spread of know-how through trade and scientific publications, analyzing foreign products, etc.

Sources: Stanislaw Gomulka, Inventive Activity, Diffusion, and the Stages of Economic Growth, Aarhus University, Institute of Economics (Aarhus, 1971); Ole Börnsen, Hans H. Glismann, and Ernst-Jürgen Horn, Der Technologietransfer zwischen den USA und der Bundesrepublik, Kieler Studien no 192 (Tübingen, 1985), pp. 32-70.

It is often claimed that the efficiency of the channels mentioned in Table 1 decreases from number 1 to number 6; in other words, know-how successfully transferred through the top channels will boost the economy of the recipient country in a shorter period of time than know-how brought in through the bottom channels.[5]

Although many experts and influential institutions, such as the OECD, support this hypothesis, it also met criticism. There are examples about less developed countries which have relied in their technology transfer on other channels than direct foreign investments and managed to boost their industrialisation. Such success sharply contradicts a common conviction on the critical role of transnational companies. The Italian Antonio Murolo questioned the general belief that foreign-owned subsidiaries have made notable contributions to countries like Greece. "The conviction that the presence of foreign subsidiaries is beneficial to the economy of the host country is one of the basic themes of nearly all the studies that have been written on the transnational corporation, but it is seldom asked whether these benefits outweigh the costs imposed on the local economy".[6]

Some proponents of the conviction are as categorical as Roger Seymour (IBM) who formulated it with the words: "This is purposeful - to underline the fact that, today, it is virtually only the MNCs that have state-of-the-art technology and the means of transferring it". ..."A basic fact in today's world (is): Transfer of technology takes place as a result of the international investment

[5] "Teknologian siirto ja kansainvälinen työnjako, Teknologiakomitean mietinnön liite no 5", Komiteanmietintö 1980:55 (Helsinki, 1981), pp. 20-22; Edwin Mansfield et al. Technology Transfer, Productivity and Economic Policy (New York, 1982), p. 29.

[6] Antonio Murolo, "The Greek Economy: The Role of the Transnationals and the EEC", Mezzogiorno D'Europa 2 (1982) 2, pp. 197-220.

decision, not without it and not in spite of it".[7] The American Peter Cory drew an opposite conclusion comparing technology transfer into Yugoslavia and Mexico. He claimed that "the principal proposition being considered in the dissertation - that MNC presence speeds the inflow of new technologies - does not receive any support at all. ... In general, it appears that those technologies acquired by developing countries can be, and indeed are, introduced equally rapidly whatever the predominant transfer mechanism involved".[8]

Rarely has some type of technology been transferred through only one channel. Those involved in technology have always evaluated various alternative vehicles for transferring technological expertise, and they have generally chosen a mix of channels depending on the characteristics and needs of the individual project. Accordingly from an historical perspective, the multi-channel approach launched by Harri Luukkanen, a Finnish consultant specialized in technology transfer, does not seem to be a new innovation; however, the approach may be a useful educational instrument and an interesting theoretical model simplifying the variety of actual business transactions carried out in world history.[9] Compared to the circumstances of the nineteenth century, nowadays it is, of course, possible to provide much more comprehensive packages for the delivery of technology which comprise everything from the licensing package of a

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[7] The abbreviation MNC denotes multinational company. Roger Seymour, 'A Comment on Arthur W. Lake's paper', The Economic Effects of Multinational Corporations, Ed. R.G. Hawkins, Research in International Business and Finance, vol. I 1979 (Greenwich, Connecticut, 1979), pp. 184, 186.

[8] Peter F. Cory, The Transfer of Technology to Developing Countries and the Role of the Foreign Corporation: A Comparison of Yugoslavia and Mexico, (Microfilmed Ph.D. thesis, University of California, Berkeley, 1979), pp. 150, 283.

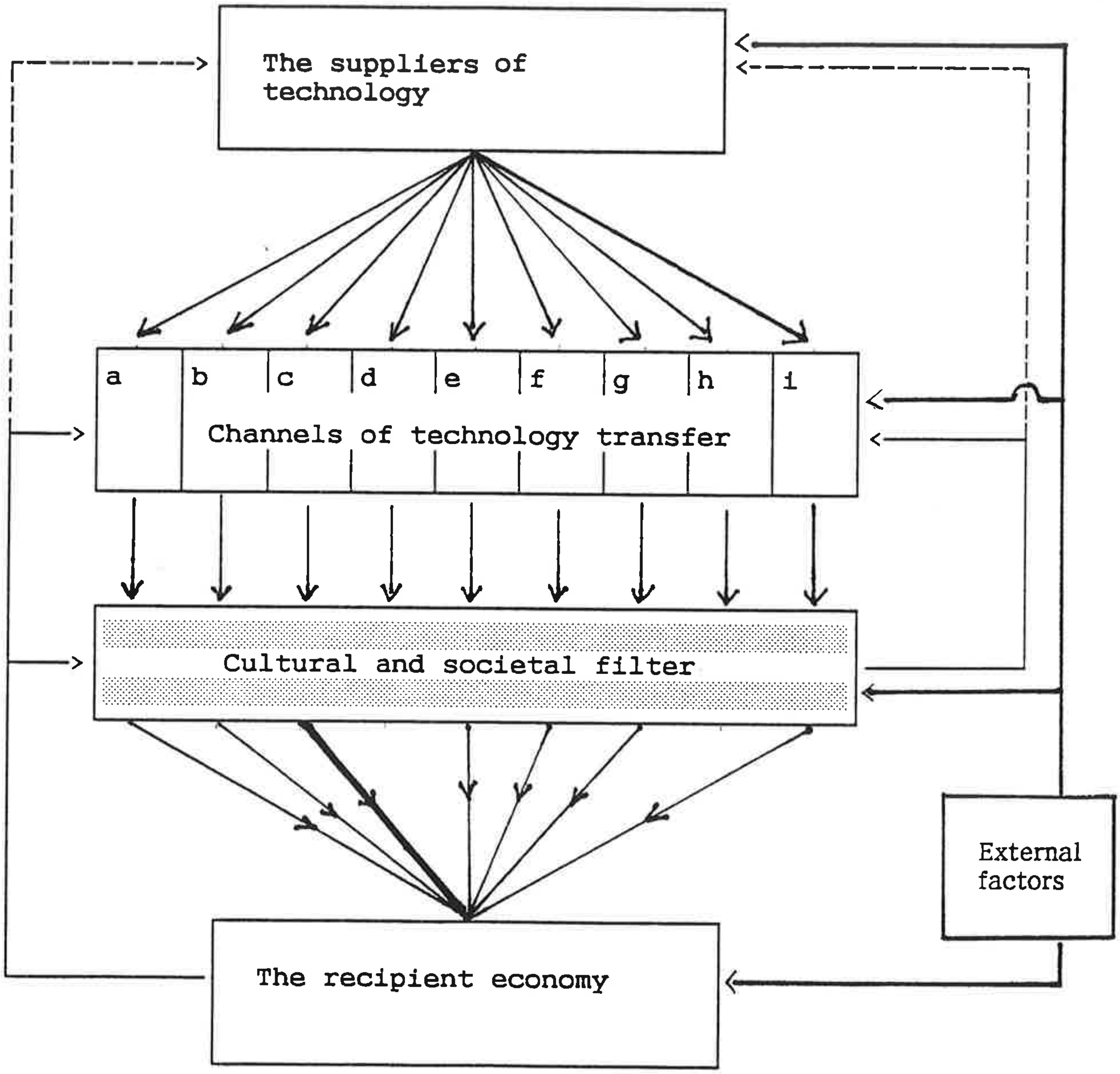
[9] Harri Luukkanen, Towards the Theory of Technology Transfer, Teräs-Kari Oy Consulting, Mimeograph 15.5.1989.

trademark product, turnkey deliveries with tailor-made equipment, and detailed engineering and design of production lines to equity joint ventures, expatriate technical managers, management consulting, training programmes for native workers, in-plant services, etc. Transfer channels generally complement each other, while if necessary, some channels could be supplemented by others. The channel apparatus is, as a rule, a fairly flexible "tool-kit," and there are other factors defining what channels are economically and societally acceptable.

Societal and Cultural Filter

The channels of Table 1 were utilised all over the world. If, however, an international comparison is made to determine to what extent various countries used these channels, some clear differences in emphasis can be observed. Discrepancies can also be found in how the governments have favoured or discouraged the use of certain transfer channels. Many societal features of the recipient country - not only the government - have profound effects on the transfer of technology. As a result, it can be claimed that when a new technology is being transferred into a country, it should, in a way, be filtrated through a "sieve" composed of various economic, political and cultural layers. This contextual filter affects the choice of technology as well as the channel through which it is transferred. The choice may essentially influence the pattern of adoption and its success. I have condensed my theory on the mechanism of technology transfer from the recipient's viewpoint in Figure 1.

Figure 1. The Mechanism of Technology Transfer.



At least in theory, the assortment of potential channels for technology transfer are roughly the same for all countries, but the contextual filter is always unique and nationally defined. This filter is very polymorphous. It can selectively close one channel completely, obstruct the functions of another, give the third a free-hand, and overload the fourth. It does not generally remain stable over time, but keeps shifting as a result of changes in government, trade relations, and the economic situation.

The cultural and societal filter of technology transfer is an ambiguous combination of various elements from unconscious popular attitudes to strict laws. As examples, of how a socio-cultural filter works I could mention that the Russian tsar stipulated statutes in the first part of the nineteenth century which prevented Finnish businessmen and factory owners from recruiting foreign craftsmen and workers in groups. It was, however, possible for industrial plants to hire individual foreigners but even these persons came under suspicion of the Russian authorities. The tsarist regime, by contrast, did not hinder Finns from studying and training abroad. For few decades prior to World War I, the Finnish government favoured such travelling by granting scholarships for studies abroad. Perhaps this contributed to the fact that study tours abroad became a fashion among young Finnish intellectuals. Consequently, the filter promoted Finns' study trips abroad (Channel 5) but disfavoured recruiting foreign craftsmen and technical experts in the grand duchy (Channel 4).

The societal and cultural filter comprises the autonomous mechanism that regulates the transfer and application of technology. The introduction of an innovation is successful only if the social environment of the recipient country is supportive of it. Therefore, technology transfer is not only a technical operation but also a societal procedure. The crucial factor is whether or not there are effective and socially accepted methods of carrying out the process. The technology itself and its transfer channels should be coordinated with the existing cultural and societal environment.

The function of a certain transfer model can be radically changed by some major outside influences such as war, economic crisis, or ecological calamity. External factors may have a considerable impact on the economies of the supplier or the recipient or both; they may also affect the modification of some channels or the entire transfer mechanism. The cultural and societal filter is very sensitive to alterations in external circumstances; it may react even if an external shock had practically no impact on the recipient economy or the channel apparatus. A crisis in the opposite hemisphere may change societal values, behaviourial patterns, or government policy, and thus remodel the filter.

The success of a transfer mechanism depends on the way how components interact with each other. In the normal situation, the societal and cultural filter is dominating the whole mechanism. Technology transfer is more or less a smooth process if the filter's demands are in balance with the qualities of channels and the requirements of the economy. The filter might be a significant stimulator of technology transfer in one country, while it is a barrier in another. Therefore, the societal and cultural filter plays the key role in the technological modernisation of less developed countries.

A Case Study: Plans to Harness the River Vuoksi prior to 1917

In respect to technology transfer, Finland has not institutionally been one of the most open countries. Consequently, it is easy to find from Finnish economic history a number of examples related to societal controlling and filtrating the transfer of technology. Among the most colourful examples, there are early attempts to harness the Upper Vuoksi for electricity generation.

The river Vuoksi was located in the south-eastern part of the grand duchy of Finland (1809 - 1917). It is about 160 kilometres long and connects Lake Saimaa to Lake Ladoga. In its natural state - before development - the upper stretch of the river had very steep banks and numerous rapids. For a distance of the first 25 km, the total vertical drop between water surfaces in the river was about 64 metres, whereas in the 135 km downstream, the drop was only 6.3 metres. In terms of the mean flow of the river, 556 cubic metres of water per second, it can be considered the most sizeable river of the country. The seasonal variations of Vuoksi were much smaller than those in the other Finnish rivers. Apart from the canal between Lake Saimaa and the Gulf of Finland, the river was the only outlet of the watercourse of Lake Saimaa which was, with an area of 4,400 square kilometres, the fourth largest lake in Europe. Even in the natural, unregulated state, the annual discharge of the river Vuoksi was outstandingly constant due to the good storage capacity in the considerable catchment area of 61,560 square kilometres of which as much as 21 per cent was covered by lakes.[10]

[10] Erinäisten ulkomaisten ammattimiesten lausuntoja Imatran voimalaitosyrityksen suunnitelmista, Koskivoimakomitean toimiston julkaisuja v. 1922 no 3 (Helsinki, 1922), pp. 4-6; Lasse Nevanlinna and Gunnar E. Lax, 'Development of Hydro Power', Waterpower in Finland (Tampere, 1969), p. 22; Heikki

The first to propose harnessing the river Vuoksi for producing electric energy for the capital of the Tsarist Empire was the Russian engineer Veniamin Feodorovitsh Dobrotvorskii. In May 1894 at a meeting of the Russian Technical Society, he presented a proposal to construct hydroelectric plants on the river Vuoksi in the Karelian Isthmus and on the river Narva in Estonia to generate electricity for St. Petersburg, which then was the fifth largest city in Europe. The proposal was based on the recent models of the power plants at Niagara Falls in the United States and the 175 kilometre transmission experiments with three-phase AC-current between Lauffen and Frankfurt-am-Main in Germany. St. Petersburg and its outskirts were to receive 24 MW from the two hydro-power plants transmitting electricity at the tension of 15 kV.[11]

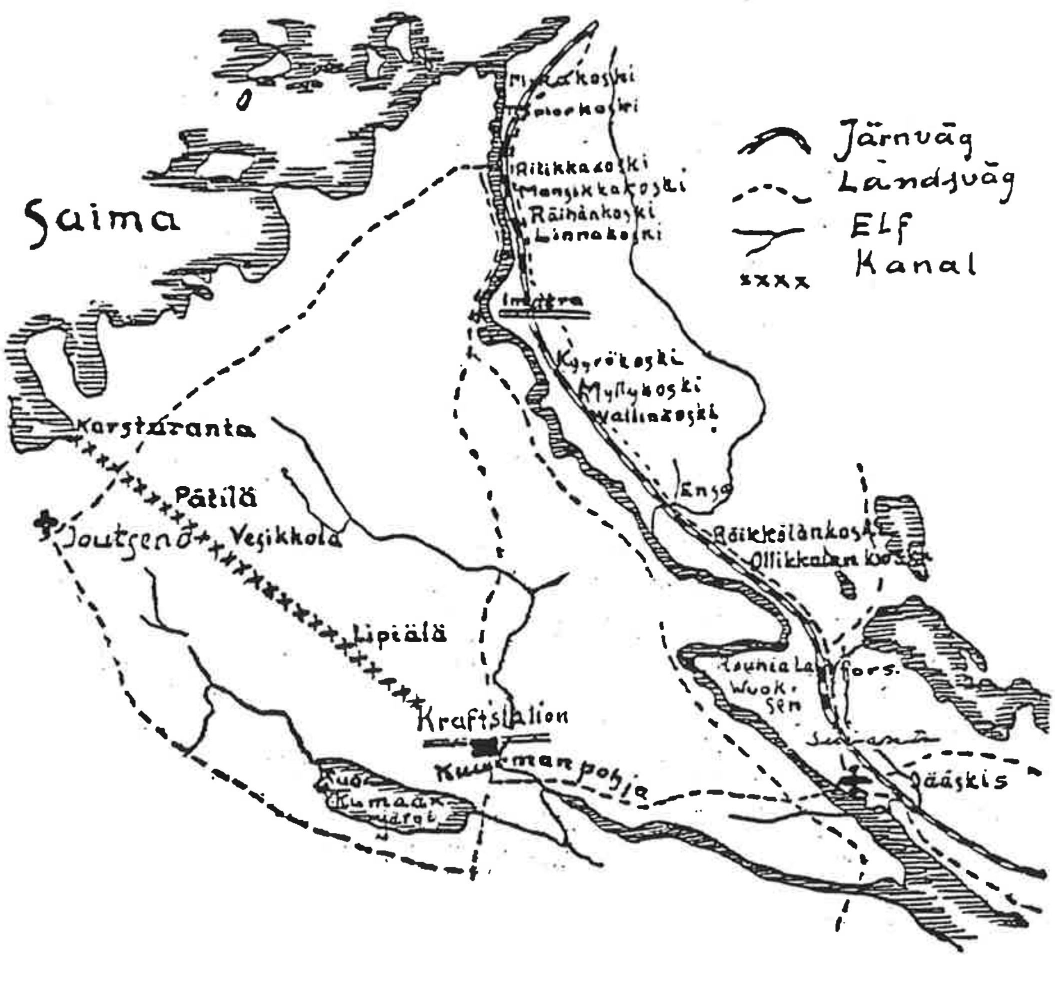
Although Dobrotvorskii's proposal was criticized for its technical uncertainties and unrealistic economic assessment, the idea to construct major hydropower plants in the Karelian Isthmus did not die. During the following two decades, several firms and individuals put forward similar plans which had a tendency year after year to become more colossal and technically more detailed. The largest and most carefully prepared plan was drawn up by a power company from the Russian capital, "Société S:t Petersbourgeoise de Transmission Electrique de la force de chutes d'eau" (SPTE). In the early 1910s, this company, which Dobrotvorskii had recently reorganised, had hired the German engineering firm Gebrüder Hallinger from Munich to work out a grandiose plan, known as "the Kuurmanpohja-plan" (Figure 2).

Simojoki, 'Hydrology in Finland', Waterpower in Finland, pp. 38-42.

[11] Wiborgsbladet 12.10.1894, 5.6., 7.6., 12.9., 16.10., 1.11., 2.11.1895, 1.2., 19.11.1896, 26.1., 8.9., 7.12.1897, 26.1.1898; Sven Hirn, Imatran tarina (Imatra, 1978), pp. 124-25.

Figure 2. The Kuurmanpohja Plan: Channel and Hydroelectric Power Plant

Ett förslag om Saima-vattnens inledande i ny fåra.



Source: <u>Mercator</u> (November 29, 1913)

The idea of the plan was to close the natural bed of the Upper Vuoksi by an upstream dam, to build a canal of 18 kilometres from Karsturanta, a neighbouring village on the shore of Lake Saimaa, and to concentrate all the water of the river in one big waterfall with a 64 metres drop at a natural precipe of granite in the valley of Kuurmanpohja. The tailrace canal of 12 km was to lead water back to the original bed of the Lower Vuoksi. This hydroelectric plant of 300,000 - 400,000 hp (221 - 294 MW) would then have been the largest in the world; larger than the Niagara hydroplant with its 40 m waterfall.[12]

The construction of the plant was to have been started in April 1914. The SPTE company proposed that as compensation for using Finnish natural resources, it would sell electricity to the Finnish State Railways at a marginal price, pay an annual rent which was gradually to rise to 1.5 million Finnish marks within six years, and turn over the plant to the Finnish government after 90 years free of charge.[13]

In harnessing the river Vuoksi, there was a question of really sizeable projects for technology transfer which seemed to have both technical and economic opportunities to be carried out. Most big companies which were planning to build hydroelectric plants on the river Vuoksi had a solid financial background, because they had close contacts with large Russian and central European banks. By 1914 foreign companies had acquired two thirds of the hydropower of the Upper Vuoksi under their ownership.

[12] Compared to the present power plants, Kuurmanpohja would have accounted for more than half of the capacity of the Loviisa I nuclear power plant (440 MW). Uusi Suometar 18.1.1914; Helsingin Sanomat 19.1.1914.

[13] Kauppalehti 4.1.1914; Mercator 3.1.1913, 9.1.1914; Uusi Suometar 20.1.1914.

At the time, Finland had an extraordinary opportunity to receive considerable foreign investments and the most modern technology. In addition, it also a chance to start setting up large-scale electricity intensive factories in Karelia and begin the electrification of the railways. Over two decades Finland, however, obstinately rejected this kind of technology transfer. Repeatedly, it said no to direct foreign investments in the generation of hydroelectricity and offers to introduce electricity intensive industry and import up-to-date technology. From the viewpoint of our time when less developed countries are competing to attract direct foreign investments, the policy of the grand duchy of Finland seems odd and absurd. The situation is possible to understand only if we take into account the societal context of technology transfer. In this case, the societal filter was strictly against direct foreign investment and it was strong enough to prevent hydropower projects in the Karelian Isthmus despite support from the Russian government.

Before gaining political independence, Finns opposed harnessing of the river Vuoksi and the transmission of electricity to Russia first of all due to political reasons. Finns were afraid that granting foreigners the right to use one of the most important natural resources of the country and to transmit electric power from the Karelian Isthmus to St. Petersburg would lead the further transfer of political power to Russia and stimulate the tsarist government's territorial demands in the south-eastern part of the grand duchy.

Finnish public opinion and the press were quite unanimously against the large hydroelectric plants on the River Vuoksi. An interesting thing is that although it have been considered that the senates just before World War I became more and more pro-Russian, they still opposed all applications to transmit electricity from the Upper Vuoksi to St. Petersburg. Several applications were turned down by setting up a committee to investigate the matter or they were for years circulated for comment. This was the fate of the Kuurmanpohja plan, too. It finally fell through because after the outbreak of World War I, the tsarist government decided that a company under German ownership would not be allowed to carry out such a large project.

For Finns, the pivotal issues were whether to allow foreign-owned companies to build any power plant in the grand duchy and export hydroelectricity at all to Russia. For Russians, the main issue seemed to be which companies should be allowed to carry out hydroelectricity projects and whether to construct one big power plant or a series of several small ones along the river Vuoksi. To solve the latter problem, the Finnish National Board of Public Roads and Waterways hired a Swedish engineering firm *Vattenbyggnadsbyrån i Stockholm* to investigate which one of the two alternatives was better. In its lengthy report, the firm stated that from the technical point of view, the plan to concentrate all outflow from Saimaa to one big hydroelectric plant at Kuurmanpohja was more advantageous but the series of five power plants along the natural bed of the River Vuoksi was better from the economic point of view. The firm's main argument against the Kuurmanpohja-plan was that in St. Petersburg and its surroundings, there was not enough demand for electric energy from such a huge hydroplant. While working with low capacity, the plant would produce expensive electricity due to high capital costs. It would soon met serious financial difficulties, because it would not have been able to repay capital loaned from central European banks.[14]

[14] Förslag till utnyttjande af vattenkraften i Wuoksen, Uppgjorda af Vattenbyggnadsbyrån i Stockholm (Helsingfors, 1917), pp. 228-29.

As a result of various factors, the Russians seemed to give up the Kuurmanpohja plan during the first years of the Great War. Nevertheless, the Finns did not feel relieved: the idea to supply St. Petersburg with Finnish hydroelectricity lived persistently. In 1916, the tsarist regime itself put forward a new plan. According to it, the Russian government would have confiscated some rapids under private ownership on the Upper Vuoksi and constructed a medium-sized hydroelectric plant within one and half years to supply electricity for the capital stricken by a shortage of energy. The March revolution of 1917, in turn, foiled this plan.

Hence politics proceeded technology and the economy - and the Finns managed to escape from a type of technology transfer which they were so frightened of.

ELINKEINOELÄMÄN TUTKIMUSLAITOS (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, SF-00120 HELSINKI

Puh./Tel. (90) 601 322 Telefax (90) 601 753
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