Punched-Card Systems and the Early Information Explosion, 1880–1945

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Decline of Punched Cards for European Census Processing

In the spring of 1889, Hollerith was struggling to attain the order to process the United States census in 1890.[1] He eventually succeeded in this endeavor in late 1889, but in the spring of that year his limited income derived from his only customer, the Office of the Surgeon General of the Army. Late the previous year, Hollerith had postponed his wedding as he was not able to afford to establish a family.[2] However, this did not prevent him from traveling to Europe from April to May 1889 where he visited Paris and Berlin. By doing this, he entered on a well-established route of expanding his technology-based business in the United States to other countries. He traveled to find customers for his census machine, not to find inspiration for additional capabilities or applications. He was looking for more scale in his business, not greater scope. Hollerith considered punched cards as a tool to process population census returns, and he saw the international statistical community as an extension of the United States' statistical community, where punched cards originated. He sought out the various European national statistical offices, in the same way that he tried public statistical offices in the United States. This strategy was based on the assumption that the problems and opportunities in the United States also applied in other advanced nations.

Hollerith had prepared for his visit to Europe by filing patent applications in several countries in Europe, as he wanted—like numerous other inventors—to protect his invention on foreign markets.[3] Even before this, he had filed two patents on railway brakes in Germany, which indicates that it was an established practice by 1890 to file patents in Europe, even for independent American inventors.[4] These patents were filed by local

patent attorneys, which show that international patent attorney networks already existed.

Foreign patent protection made it possible to adopt the low-cost strategy of producing the machines at home and relying on patent protection on foreign markets. But a foreign patent was neither an easy nor an adequate tool. Obtaining patent protection in Europe required patents in all the countries, and patent laws varied. For example, Austria, Belgium, and France required local production to make a patent valid.[5] The alternatives for Hollerith had been either to organize foreign marketing through independent agents or via subsidiary companies.

Hollerith received a guarded reception in Europe in the spring of 1889, and he returned empty-handed to the United States. Over the following years, he gained orders to process censuses in Norway, Russia, and France, but most European countries did not embrace his census-processing equipment. Hollerith's foreign business became a substantial part of his activities only about twenty years later. This raises the question of the reasons for his limited initial success in contrast with the success of his second campaign that started in 1902.

Early Punched-Card Users in Europe

While in Europe in the spring of 1889, Hollerith exhibited his tabulator in Paris at the Great Exhibition commemorating the centenary of the French Revolution. At this exhibition, he was awarded one of the five gold medals that were given to American exhibitors.[6] The first Great Exhibition had taken place at the Crystal Palace in London in 1851 and was a huge success. Scores of Britons and visiting foreigners enjoyed the great entertainment that was intended to display Britain's world supremacy. Several European countries and the United States contested this position, and a succession of "great exhibitions" followed at only few years' interval. Domestic and foreign inventors displayed the products of their endeavors, and the great exhibitions became important fora for technological exchange. The Paris gold medal demonstrated that Hollerith was noticed. He exhibited the same machine in Berlin, probably because Hollerith's parents were German immigrants.

Though Hollerith had prepared for his visit by filing patent applica-

tions in several European countries, he still needed local support. Punched-card machines were precision devices requiring qualified technicians. From the outset, Hollerith exclusively rented out tabulators, which shows his early appreciation of the importance of support and of the income from card supply. When installations became scattered over a wider area in the United States, even the ability to provide technical support within a couple of days necessitated the establishment of a support organization. Organizing support became crucial when foreign contracts emerged, and Hollerith could choose between using locals and Americans living in those countries. He initiated no subsidiaries in the 1890s.

Although Hollerith returned empty-handed to the United States in May of 1889, seeds were sown that would be germinated by references in American periodicals of the punched-card processing of the United States census in 1890. The eventual outcome was an Austrian clone production and orders from Norway, Russia, and France.

The location of the Austrian clone production was the precision making shop of Theodor Heinrich Otto Hermann Schäffler in Vienna.[7] In 1890, Schäffler requested and received a license to produce Hollerith's punched-card system for processing the Austrian census of 1890.[8] Probably, Otto Schäffler had seen Hollerith's exhibit at the Paris exhibition in 1889.

Schäffler had been trained as a mechanic and studied precision making in Württemberg, Paris, and London. In 1865, he established his shop in Vienna and for the next twenty-five years, his business was based on implementing foreign inventions of telegraph and telephone equipment in Austria.

In 1890 Schäffler repeated this business strategy by adopting production and support of Hollerith's punched-card equipment. As he had done earlier, he cooperated closely with the state, this time the Austrian statistical bureau. Based on the contact with Hollerith, Schäffler acquired a contract for the new production in his workshop. Hollerith furnished the plans and shipped a tabulator to ease the technology transfer, while Schäffler's company would build the machines for the Austrian census. In Austria, the arrival of the American-produced tabulator was considered a violation of the Austrian patent law that required patented devices to be domestically produced.[9] The patent was annulled, but Hollerith traveled across the Atlantic to Vienna and made a deal with Schäffler who then built the twelve tabulators used for the Austrian census in 1890.[10]

Schäffler improved the tabulator significantly by adding plugboard programming.[11] At that time, Hollerith programmed his tabulators by screwing wires to contact points. The inspiration for Schäffler's refinement was close at hand. His main production was telephone equipment, and telephone operators established electrical connections by use of plugs on switchboards. Plugboard programming eased the tabulator adjustments for a new application. In 1895, Hollerith also introduced plugboard programming in the United States.[12] This shows how the one-way transfer of punched-card technology as early as the 1890s prompted new inventions by the receiver, thus transforming the transfer into an exchange of technology.

Schäffler's version of Hollerith's punched-card system processed the Austrian census in 1890. The Imperial and Royal Statistical Commission (Kaiserliche und königliche statistischen Zentralkommission) had been established in 1863 as a joint statistical office for the area governed by the Habsburg monarchy. Following the segregation of Hungary as a separate kingdom in 1867, a new statistical office was organized in Budapest, while the former joint office in Vienna remained the national statistical office for Austria. The first Austrian census had been held in 1869 and the next followed in 1880. Processing both censuses was decentralized and based on household lists, which limited the accuracy of the returns and resembled the situation in the United States prior to 1850. Corresponding to the development in the United States, punched cards were introduced in Austria in 1890 as an instrument to enable central processing of individual records in the census, and the processing was centralized in Vienna.

Like in the United States, the Austrian tabulators were rented out but, after the completion of the census, the Vienna statistical office kept a few tabulators for processing various smaller statistical assignments. However, this application of punched-card processing ended in 1896 when Schäffler sold his company, and its punched-card business was discontinued. The next Austrian census was in 1900 but, based on their experiences ten years earlier, the Austrian statistical office did not consider punched-card processing a sufficient advantage to cause them either to find a local maintenance successor to Schäffler's company or to acquire equipment from the United States. They only resumed punched-card processing for the census in 1910 when they rented improved equipment for general statistics pro-

cessing from the newly established agency in Germany of the Tabulating Machine Company.

During the 1890s the national statistical offices in Norway, Russia, and France adopted punched-card processing. The Institut international de statistique was the international statistical organization at that time and held a conference in Vienna in 1891, which was attended by statisticians from Europe and North America. Among the participants were the heads of the national statistical offices in Norway, Russia, and France, who also attended a presentation of Schäffler's version of the Hollerith original punched-card machine from 1890; this became the starting point for their punched-card deliberations.[13] But Hollerith—not Schäffler—came to supply equipment to these three countries, and no other country in Europe acquired a punched-card installation before 1904.

In Norway, Anders Nicolai Kiær headed of the national statistical office (Det statistiske Centralbureau). In addition to the Vienna conference in 1891, he participated in the international statistical conference in Chicago two years later, which shared a venue with a great exhibition. At the exhibition, Kiær saw Hollerith's punched-card system, and Hollerith offered Kiær a tabulator free-of-charge for tests in Norway. The machine arrived in 1894—as did Hollerith to assemble it—and the statistical office contracted with a Norwegian engineering office for maintenance. By then the Norwegians had completed processing the 1890 census.[14] Although it is true that the Norwegians had introduced individual records on the schedule at that census, processing by hand was manageable as there were only 2 million Norwegians. As the result of a test, the Norwegian statistical office bought the tabulator at a price of $1,100 (NOK 4,000), which was a little more than a one-year rental in the United States.[15]

Subsequently, this original Hollerith tabulator was used to process the Norwegian census of 1900 and for several small projects over the following years. It only proved advantageous to use this tabulator for large projects. For small projects, planning for punched-card processing, punching the information, programming, and manual reading of counters consumed too much time, compared with manual processing using written index cards or the original statistical forms. To process the Norwegian census in 1910, the statistical office rented improved equipment for general statistics processing from the newly established agency in Germany of the Tabulating Machine Company.[16]

Russia held its first general census in 1897, which was late compared with other European countries. Previous censuses had been held in various parts of the empire, and their returns had been counted locally. For the 1897 census, central processing of the returned record on each person was the major reason for introducing punched-card-based processing.[17] The inspiration originated from the international statistical conference in Vienna in 1891, which had been attended by the director of the Russian Central Statistical Committee, Nicolas A. Troïnitsky. The Russian government explored both possible punched-card suppliers: Hollerith in the United States and Schäffler in Austria. As Hollerith had no Russian patents, Schäffler was free to supply a punched-card system to Russia. However, Schäffler's punched-card business ended in 1896, as mentioned earlier, and Hollerith was awarded the contract to process the Russian census the same year.[18]

Of the foreign projects emerging in the 1890s, only processing the Russian census was comparable to the United States census in 1890. Russia's territory was 2.32 times bigger than the United States, and Russia had 129 million inhabitants, 70 percent more than in the United States at the census seven years earlier. The size of the Russian contract compelled Hollerith to organize delivery and maintenance differently from what he did in Austria and Norway. The Vienna installation used local production and maintenance, and his small Norwegian business was based on production in the United States, Hollerith's personal assembly of the tabulator, and local maintenance. For the Russian census, Hollerith chose a third solution. He used machines produced in the United States that were assembled in St. Petersburg and maintained by Western Electric's agent, an expatriate national of the United States. Hollerith approached Western Electric, as they produced some of his punched-card machines.

The French statistical office (Statistique générale de la France) approached Hollerith in 1896 to acquire punched-card equipment to process some of the returned data in their census that year. This became the last contact from one of the European national statistical offices that had been represented at Schäffler's punched-card demonstration in Vienna in 1891. The French statistical office had been represented by its head, Victor de Turquan. He also attended the international statistical conference in Chicago two years later and probably saw Hollerith's punched-card machine at the great exhibition there.

The French request once more opened the issue of assembly and maintenance in Hollerith's foreign business. Hollerith received the French request at a time when he had no income and, thus, no money to travel to France. Two years earlier, a futile attempt had been made to form an English stock company based on British capital to sell and support Hollerith's equipment in the British Isles. Now, he decided to rely on an American company in a neighboring field that was established in the foreign country, as he had done for his Russian business. He chose to organize his French business through the Library Bureau in the United States, which had locations in Paris and London.

Founded in 1876, the Bureau was an offspring of the American Library Association. By 1896, the company supplied all kinds of office machinery and equipment. Its growth was based on the systematization wave, which gained momentum in the United States in the decades around 1900. Hollerith arranged for the Library Bureau to supply and support punched-card equipment abroad. On this basis, the Library Bureau contracted with the French national statistics office to supply punched-card equipment to process the statistics of residents' occupation in the French census of 1896. Maintenance in Paris was provided by French master of mechanical engineering Lucien March.[19] However, the Library Bureau did not acquire any additional punched-card customers abroad, and Hollerith terminated his contract with their company in 1899.

French census processing before 1896 had been carried out by local authorities. For the census in 1896, statistical authorities outside the French national statistical office recommended centralizing census processing based on punched-card processing to obtain more detailed statistics, like those in St. Petersburg, Vienna, and Washington, D.C. Most of the 1896 census processing was done as usual by local authorities, but processing occupation statistics was centralized in Paris.[20] Thus, also in France, the punched card became a tool to facilitate detailed and centrally processed statistics.

Central processing of occupation statistics went well, but Lucien March considered the initial transcription of data to punch cards unnecessary. He also found the Hollerith system expensive and difficult to maintain.[21] Therefore, March built an exclusively mechanical machine, the *classi-compteur*, which applied a different principle than punched cards. The *classi-compteur* was used to process the French census of 1901, which

was the first census to be entirely processed in Paris and was used for successive French censuses until the 1930s.

Dynamics of Punched-Card Diffusion in the 1890s

The accounts of the application of punched cards for census processing in Austria, Norway, Russia, and France can be complemented by the refusal of Germany and Great Britain to apply punched cards for census processing before 1910. The inclusion of these two countries extends the basis of analysis to information on six European national cases out of the about twenty nations. The rejection of the technology in Germany and Great Britain came in spite of canvassing by Hollerith and his associates in both countries.

Germany was a federation under Prussian leadership that had first been established in 1871. Prussia had 24.7 million inhabitants in 1890, which constituted 59 percent of the total population of the federation, and Germany had twenty-five additional states.[22] The various German states had held censuses before unification, and census processing remained the responsibility of the various states until 1939; the census endeavor was thereby divided into smaller, more manageable tasks. Prussia had introduced individual records as a basis for census processing as early as 1874, and this approach was applied in several additional German states for the census in 1890.[23] The state statistical office in Prussia found the price of $1,000 (marks 4,182) to rent a tabulator for a year exorbitant, and the task of census processing had an additional social objective; a thousand people with disabilities and recipients of unemployment benefit were employed to assist in the processing.[24]

Similar to the situation in Germany, the censuses in Great Britain were conducted separately in Scotland, England, and Wales. England and Wales had 29 million inhabitants in 1891.[25] The country had had a census every ten years since 1801, all of which had been processed in London and based on individual records from 1841. Consequently by 1890, they had managed to process five censuses with individual records, without any problems that could justify introducing punched cards in 1891. Every British census was enacted by Parliament as a special law, but processing was done by the office of the Registrar General, whose main task was the

national register of births, marriages, and deaths.[26] Though census processing was not a permanent assignment, a few managers remained from one census to the next and who, together with papers kept in the institution, constituted the organizational memory.[27]

Furthermore, after the initial punched-card projects in Europe had been completed, activities died out. After 1900, no new European census was processed by use of the first Hollerith equipment from 1890. This was not caused by the emergence of improved systems, but by the limited success of Hollerith's original punched-card system.

The poor outcome was caused by the Europeans' assessment of technology and price and by Hollerith's limited sales efforts. The diffusion of the technology in Europe was curtailed by the sizes of the individual nations. In 1890, only four European states had more than 20 million inhabitants: France (38.1 million), Italy (30.5), Prussia (30.0), England and Wales (29.0), and Austria (23.5),[28] but this did not prevent Norway (2.0 million) from acquiring a punched-card installation. In addition to size, three factors were decisive in the assessment of punched cards by the European census offices: the introduction of central processing of census returns, the use of the individual as census unit, and the fact that permanent institutions had already been established to house censuses. Austria, France, and Russia introduced punched cards to manage the introduction of central processing and of the individual as the census unit. Austria and France both abandoned punched cards once they had assisted the introduction of these two features. Russia's next census was not held until 1926. Austria and England saw no decisive reason to change their way of processing the census returns, as they managed several times the central processing of individual census records by use of simpler means.

In contrast to the United States, the basic distinction was that all six European states had permanent institutions to house their censuses, which (except for Russia) maintained the expertise of census processing between two censuses. No state statistical office used their first punched-card system to process more than one census. Therefore, the original Hollerith punched-card system from 1890 only got a chance in Europe as a means to ensure the transition to centralized processing of one record per individual.

Hollerith's limited sales efforts constitute the second factor in the dynamics of census processing in Europe in the years from 1889 to 1900. He relied on his personal efforts and his positive customer references.

Europe was far away from his company in Washington, D.C., and his main sales effort was to write letters with attached copies of articles praising the technology. These efforts were not sufficient to conquer the highly atomized European census processing market of the approximately twenty national statistical offices.

When foreign business emerged, Hollerith organized his business on an ad hoc basis, and he did not develop a more general business strategy encompassing an organization in Europe to attend to maintenance. Some kind of representation in several European countries was needed to attract customers, but the size and number of the national statistical offices hardly enabled them to provide a basis for a durable organization.